International Energy Agency

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Energy Policies of IEA Countries

# European Union

## 2014 Review

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International Energy Agency

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## 2014 Review

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# 1. EXECUTIVE SUMMARY AND KEY RECOMMENDATIONS

## EXECUTIVE SUMMARY

Since the first International Energy Agency (IEA) in-depth review in 2008 of the energy policy of the European Union (EU), the European Union has taken significant steps towards reaching its energy and climate objectives for 2020 and integrating the fragmented electricity and natural gas markets into a single energy market. As the current report shows, progress is evident in many areas of EU energy policy since 2008, but challenges also abound.

Energy policy in the European Union aims to address the three objectives of economic competitiveness, security of supply and environmental sustainability. In 2008, sustainability – notably, mitigating climate change – was the key driver for EU energy policies. However, the context for EU energy policy has changed dramatically. Today, concerns of energy security and industrial competitiveness have become more pressing.

Domestically, the European Union has been suffering from a major economic and financial crisis, which led to a reduction in energy demand. Indigenous oil and gas production and refining capacity have been declining even faster than the fall in EU demand. Imports continue to rise with implications for energy security. The outlook for unconventional gas and oil exploration in the European Union remains uncertain.

During 2008 to 2013, the European Union has been directly feeling the impact of global energy developments: the vast increase in energy demand in emerging economies; the turmoil in North Africa, Middle East and Ukraine, threatening oil and gas production or supplies; the surge of unconventional oil and gas production in North America; ample and low-cost international coal supplies; and the nuclear accident in Fukushima Daiichi, bringing back concerns about the use of nuclear power, while at the same time, leading to increased pressure on the global liquefied natural gas (LNG) supplies.

### PROGRESS AND CHALLENGES TOWARDS 2020

At the time of the first review in 2008, the European Union had embarked on two major reforms in energy and climate policy: first, the progressive liberalisation of the internal electricity and gas markets through the third internal energy market package, the so-called “Third Package”; and second, ambitious climate and energy targets and policy measures as part of the so-called “2020 Climate and Energy Package”.

### THE INTERNAL ENERGY MARKET

The implementation of the Third Package led to three main achievements: 1) more harmonised cross-border trade and network rules; 2) greater independence of national regulators and transmission system operators and their co-operation through newly created European bodies – the Agency for the Cooperation of Energy Regulators (ACER)

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and the European Networks for Transmission System Operators – Gas and Electricity; and 3) the enforcement of competition in the energy sector, following the sector inquiry of 2006, supporting further market opening.

Since 2008, energy markets in the European Union have become more integrated with increasing trade flows. Gas markets in Western Europe saw higher liquidity at larger gas trading hubs, thanks to ample gas supplies, new gas import and storage capacity and shorter-term contracts, partly mitigating the pressure from the oil price link. In electricity, an integrated day-ahead market is now set up across the European Union through price coupling of the regions: the Nordic and Baltic markets, Central Europe, North West Europe, and recently South West Europe (Portugal and Spain).

However, the European Union has yet to create a fully integrated EU energy network and energy market. Both gas and electricity markets suffer from low cross-border capacity at many interconnections and from congestion. Large parts of the market in Eastern and Southern Europe remain isolated. The European Union is addressing these challenges by harmonising network rules and speeding up investments in priority energy infrastructure projects, the so-called "projects of common interest". The process has recently started, and continued implementation will be needed in the years to come. Another challenge relates to the transformation of the energy system to accommodate higher shares of variable renewable energies. In electricity, harmonising rules for trade and network operation has been difficult, as system operation remains largely confined to national grids. Further, despite increasing cross-border trade and decreasing wholesale prices, retail prices are on the rise. Wholesale market opening has not favoured the retail market level, which remain national in scope, as the fall in wholesale prices has been largely compensated by higher green levies, taxes and network cost. Consumers do not feel the benefits from switching suppliers. Indeed, regulated prices and market power exercised by the historic incumbent persist in many member states.

## CLIMATE AND ENERGY TARGETS FOR 2020

In 2009, as part of the 2020 climate and energy package, the European Union adopted three unilateral targets for 2020: 1) reduce its greenhouse gases (GHG) emissions by 20% in 2020 below 1990 levels, 2) increase the share of renewable energies to 20% in its gross final energy consumption and to 10% in transport, and 3) reduce its total primary energy consumption by 20% in 2020, relative to the 2007 projections of energy consumption in 2020.

Strong progress has already been strong towards a low-carbon economy, and the European Union leads efforts among IEA member countries, but further efforts will still be needed to achieve the expected outcomes by 2020.

First, the European Union is on track towards achieving its GHG emissions reduction goals. In 2012, GHG emissions had decreased by 19.2% compared to the level of 1990, as a result of lower demand during the economic crisis, fuel switching, the growing deployment of renewable energies and energy efficiency action.

Second, the European Union's share of renewables in final energy consumption increased to 14.1% in 2012 from 8.7% in 2005, thanks to renewable support schemes encouraging investment, in particular in solar photovoltaic (PV) and onshore wind. Trends to 2020 will lead to a continuing growth in electricity generation from renewable sources. IEA analysis based on current national ambitions) suggests, however, that there may be a shortfall in meeting the 2020 target, unless policy initiatives are taken to stimulate the market in some countries and for some technologies.



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Third, the European Commission estimates that the European Union could achieve 18% to 19% of energy savings up to 2020, with measures in place today, notably the Energy Performance of Buildings Directive, Eco-design and Labelling Directives, the Energy Efficiency Directive, and EU funds with a focus on energy efficiency. A third of the savings will result from lower demand amid the economic crisis. Progress towards the 20% target will depend on further implementation of energy efficiency policies by the member states and the scaling-up of energy efficiency investments to finance retrofits in existing buildings and encourage demand-side management by consumers through smart meters and grids. In this context, to achieve the 20% energy efficiency target by 2020 remains a challenge.

At the same time, the variety of EU-wide and national instruments employed to meet climate and energy objectives has brought about challenges and unintended results. Increased electricity generation by renewables and reduced electricity demand, arising in part from energy efficiency policies and the economic crisis, has reduced the need for allowances to meet the carbon emissions limits set under the EU-Emissions Trading Scheme (EU ETS).

Since 2008, the EU ETS has been plagued by a surplus of allowances, resulting in the collapse of the carbon price from EUR 30 per tonne of carbon dioxide ($tCO_2$) in 2008 to EUR 6 per $tCO_2$ in 2014. The system was not designed flexibly enough to adapt to lower demand. As a result, the EU carbon market did not stimulate investment in the decarbonisation of the power generation or other sectors and only contributed to a small extent to meeting GHG targets. In 2012, the power sector remained the largest emitter (38%) when comparing total EU $CO_2$ emissions per sector.

Instead, national support policies and subsidies for energy efficiency and renewable energies have been driving decarbonisation. The IEA *World Energy Outlook 2014* estimated the total value of subsidies to renewable energy in the European Union of around USD 70 billion or EUR 52 billion in 2013, which equals 57% of the global subsidies to renewable energy, with solar PV accounting for over USD 30 billion or EUR 22 billion, followed by wind with over USD 15 billion or EUR 11 billion. The support schemes had a strong impact on the wholesale electricity market, pushing down prices and reducing operating hours for conventional thermal plants. Together with changes in the relative international commodity prices, power generation moved towards coal, away from natural gas, amid changing economics of power plant dispatch.

The European Union saw a revival of coal use in power generation, at a time of cheap international coal prices and high EU natural gas prices, while gas-fired power plants are being mothballed in several countries. Since 2008, prices for natural gas increased, while coal and carbon prices turned out lower than expected. The growth of solar PV was much quicker than expected. Taken together, this has led to falling wholesale electricity prices, lower utilisation and low revenues from thermal plants, notably gas-fired power plants. At the same time, increasing deployment of supported renewable technologies continues to push up electricity retail prices, as support is charged to end users through green surcharges or taxes.

As the examples illustrate, there has been a lack of integration of climate and energy policies at EU level and between EU and national energy policy decisions, which could not address the interplay and trade-offs between different targets and policy measures.

## RECONCILING CLIMATE AND ENERGY OBJECTIVES

While sustainability and climate change were the drivers of EU energy policies in 2008, the competitiveness of the Union's industry has more recently gained prominence.

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Energy security concerns have also come to the fore following the disruption of Libyan supplies and the Russia-Ukraine crisis.

While the European Union continues its efforts towards meeting the 2020 targets and completing the internal energy market, maintaining the balance among the three goals of the EU energy policy – competitiveness, energy security and environmental sustainability in the longer term – in the new global context is more important than ever before.

## COMPETITIVENESS

The relative competitiveness of the European Union vis-à-vis its trade partners has changed as a result of the shale gas revolution in North America and energy demand growth in Asia.

Structural price differences between the European Union and its trading partners are growing. The United States is experiencing an era of cheap gas as a result of booming unconventional gas production, while Asian countries' rising demand drives up global import prices for LNG.

During 2013, EU gas import prices at major hubs (in Germany, the Netherlands, and the United Kingdom) were around USD 9 to 10 per million British thermal units (MBtu), compared to gas prices of USD 4 per MBtu in the United States and Asian average LNG prices of around USD 12 to 15 per MBtu. Despite the overall decrease in EU wholesale electricity prices since 2008 (around 35%-45%), however, according to IEA and Eurostat data, in 2013, EU electricity prices for industry remained 40% above the United States prices; although they are only two-thirds of Japanese industry prices. These differences are likely to persist, despite the recent convergence of international gas prices in mid-2014, with EU spot gas prices falling to a seasonal record low of USD 7 per MBtu. Price differentials matter greatly for the energy-intensive industries, using gas as feed stock, or consuming large amounts of electricity and facing international competition.

The European Union is experiencing the restructuring of its refining capacity and manufacturing base. This is set to continue in the coming years. The EU refinery sector is challenged by falling oil demand and chemical production, declining local crude production and shrinking export markets for gasoline. Over the period 2007 to 2013, 15 refineries have closed in the Union and further restructuring is expected. The impacts of restructuring are felt differently across the European Union, with some member states successfully emerging from the restructuring thanks to process innovation, access to cheap feedstock and global commodity markets. Experience in IEA member countries shows that where the refining industry has invested in energy efficiency and process innovation, and where it is well integrated with the petrochemical sector, it can remain competitive.

The IEA *World Energy Outlook 2013* underlined that the EU share in the global export market for energy-intensive goods, especially for chemicals, is expected to fall (by around 10% across all energy-intensive goods, i.e. cement, chemicals, pulp and paper, iron and steel), more than Japan (-3%), while United States and emerging economies are expected to be able to increase their shares in the export markets.

To stimulate the growth of the EU economy, the competitiveness of its industry is a key priority on the strategic agenda. In the current economic context, cost-effective action is an essential. Energy-intensive industrial sectors which are exposed to carbon leakage and international competition can under the EU ETS receive free allowances or be compensated by other means for the associated cost up to 2020; nevertheless, global



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competition is increasing and margins are tight, thus costs of operation, including from environmental compliance, can have an important impact.

First, the European Union has to reduce compliance costs through a more integrated energy and climate policy at EU level which balances economic, environmental and security of supply goals. Investment in energy technology innovation is a crucial component for reducing the cost of capital and operations, thus helping the competitiveness of the European Union's industry.

Second, a fully functioning internal energy market with a single energy network can bring substantial economies of scale, welfare benefits and incentives for market-driven investment in the energy sector. The European Union should give priority to completing the internal energy market and investing in energy infrastructure.

The price reductions in the wholesale market should be transferred to consumers at retail level by abolishing regulated prices and activating consumers to manage their demand. The distortion of the markets should be reduced by making public interventions, including energy support schemes, more cost-effective. The trade-off between competitive markets and the need for public intervention, in the pursuit of climate and energy policies, should be reconciled in the future. The European Commission decided to address the issue through new guidelines for energy and environmental state aid which came into force in July 2014.

## STRENGTHENING EU ENERGY SECURITY

The European Union is the largest energy importer in the world, importing 53% of the energy it consumes. As domestic fossil fuel production continues to decline, gas imports are expected to increase between 2020 and 2030, while oil imports are projected to remain stable, even in a decarbonisation scenario.

Indeed, energy security concerns have increased for gas, oil and electricity, since the last in-depth review.

### Security of gas supply

Perceptions in the European Union of the security of gas supply changed with the 2009 gas dispute between Russia and Ukraine which caused a disruption of gas supplies to the European Union. During 2014, a renewed conflict has been threatening winter gas deliveries to Europe and brought EU gas security again to the forefront, as roughly 15% of EU gas imports arrive through Ukraine. On 30 October 2014, an agreement between Russia and Ukraine was brokered by the European Commission to secure winter gas supplies to the EU.

In the aftermath of the 2009 crisis, the European Union already reformed its gas emergency policies and today benefits from new gas pipelines and reverse flows, higher LNG import and gas storage capacity. Storage sites are filled above historic levels in winter 2014-15. Hence, the resilience of the EU gas market to short-term disruptions has partly improved. However, several shortcomings remain.

First, reverse flows are not available at all interconnections between market areas, and access across borders to storage and LNG is hampered. Many interconnection points remain congested due to long-term bookings under existing contracts.

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Second, despite investment made in new LNG terminals, the European Union depends on imports of pipeline gas, notably from Russia. This is linked to the fact that LNG supplies to Europe are re-exported to Asia, while EU LNG supplies saw a record low. This is the result of project delays in global LNG investment, strong Asian gas demand, pushing up import prices and reverting LNG to Asia and the unavailability of supplies from North Africa. The return of LNG supplies to Europe will depend on future price differentials and new liquefaction development in supplier countries. New US LNG is largely contracted by Asian markets and has limited swing capacity or market incentive to serve EU markets in the medium term.

Third, the Union has seen a fast decline of its indigenous gas production, notably in the Netherlands and Denmark. As a consequence, it is losing swing production capacity in the Netherlands, which limits its resilience in the short term. However, in the medium term, indigenous resources from unconventional gas could contribute to meeting the energy security goals of the member states. The *World Energy Outlook 2012* Special Report *Golden Rules for a Golden Age of Gas* estimated that the European resource base is capable of producing up to 80 bcm per year of unconventional gas by the 2030s; in comparison, EU annual gas demand was 477 bcm in 2012. There are many above-ground regulatory and political reasons why even the 80 bcm production is unlikely to materialise in practice. Several member states have decided to ban the exploration and production of shale gas, citing environmental concerns. The European Union has been cautious on the matter and provided guidelines for best practice. However, technology innovation and environmental performance are evolving with growing experience in North America which should be harnessed and shared across the European Union.

The European Union will continue to depend on Russian pipeline gas imports for the foreseeable future. It therefore remains important to diversify gas supplies, particularly for those countries dependent on a single supplier and/or a single supply route. Reducing dependence will require policy action across different sectors: to complete the gas market liberalisation; to re-evaluate the potential of natural gas production in the European Union; and even to reduce the role of gas, where possible, by continuing the deployment of low-carbon technologies, including renewable energies; and to promote energy efficiency. Energy efficiency can partly mitigate import dependence, by fostering efficient district heating in cities, fuel-switching capabilities in power generation, and energy-efficient retrofits in existing buildings and more efficient appliances.

LNG imports are essential for the European Union to ensure diversified gas supplies. By enhancing gas market integration, the European Union can ensure the efficient use of current LNG import capacities.

Increasing competition and gas market integration in Eastern and Southern Europe could be achieved by scaling up pipeline supplies through the Southern gas corridor beyond 2019.

Importantly, the European Union has to boost its engagement in international co-operation, in the dialogue with producer, transit and consumer regions, and be fast to adapt to changing global markets. To be successful, the European Union needs to achieve greater negotiating power and consistency in its external energy policy.

## Security of oil supply

Indigenous crude oil production in the European Union has been falling markedly, declining by more than 50% during the last decade, at a faster rate than the decline in



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EU demand. With regard to security of oil supply, the European Union is increasingly reliant on oil product imports, notably diesel and kerosene, while EU refining capacity is declining. Since 2008, EU crude processing capacity has decreased by around 8% with 15 refineries closing and three reducing their output. This increases the exposure of the European Union to global supply disruptions in product markets. In addition, over one-third of crude oil supplies to the European Union is supplied by Russia via pipeline and some EU members are highly dependent on these imports.

To address oil security concerns, the European Union has revised its oil emergency and stockholding policy and relies on the co-operation with the IEA. Despite the overall alignment of EU and IEA rules, with the entry into force of the Oil Stocks Directive, the oil stock monitoring carried out by the European Union and the IEA will need to be closely co-ordinated to ensure an effective action under any possible IEA collective action.

As further restructuring of the refining industry is under way, unnecessary burden on its competitiveness should be avoided. The swift adoption of the proposed energy taxation directive would bring excise duties for diesel and gasoline closer to each other and help mitigate the imbalance of demand for these fuels. There should be greater political to will to adopt important energy taxation measures by the member states with a view to ensure greater levels of oil supply security.

## Electricity security

Electricity security in Europe will largely depend on the way the European Union can: 1) accommodate the integration of variable renewable energy, 2) support investment in the transformation of the electricity system in the longer term, while 3) ensuring generation adequacy in the medium term.

Decarbonising the energy system involves a major transformation. Ensuring generation adequacy in a system with high shares of variable renewable energy and very low marginal operating costs is uncharted territory. As demand growth in the European Union is expected to remain flat, higher shares of low-carbon electricity reduce the total utilisation of fossil fuel power plants, but require more back-up generation. In an integrated electricity market the effects of the variability of generation are felt across national borders at the level of interconnected systems. Electricity trade flows have increased. The assessments of system adequacy need to review the system as a whole and to cover both domestic demand-side response and interconnections. Close co-ordination of system security and adequacy across the European Union and its regions will be needed.

Power plants in the European Union are ageing and almost half the electricity generating capacity is likely to be shut down in the coming decades, notably the plants using coal and nuclear, which today provide base-load electricity supply, with shares of 28% and 27% in 2012, respectively. There is a risk for Europe of losing the diversity of its electricity generating capacity. Investments are needed to modernise the power fleet in the longer term, while maintaining diversity from coal and nuclear in power generation in the transition, amid gas security and electricity adequacy concerns.

This is an opportunity for Europe to further decarbonise its power sector in the longer term, however, current market design may fall short of providing appropriate signals for investment. In any low-carbon scenario, the European Union will still need substantial dispatchable electricity capacity, which variable renewables will not provide. The EU electricity market design will need to be adapted. In an electricity system with high

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shares of renewables, the overall value that power plants (dispatchable or not) provide to the system is crucial. In this context, generation investment can be encouraged by rewarding electricity generation depending on the time, the location and their contribution to the energy system services (e.g. balancing energy).

Half of the European Union's 131 nuclear power plants have been operating for more than 29 years. The ageing of the EU reactor fleet requires immediate decisions regarding new plant construction, safety, upgrades and uprates, licence extensions, retirements, and decommissioning as well as spent nuclear fuel and radioactive waste management. Given the significant role that nuclear plays in the electricity system, an EU policy is important to support these decisions, including addressing safety and security concerns, notably linked to nuclear waste management.

In the longer term, Europe is likely to see a decrease of its coal capacity, as the outlook for carbon capture and storage (CCS) remains gloomy, and as there are no strong incentives from the EU carbon price or enhanced oil recovery in the European Union. Promoting the transition of Europe's coal sector towards clean coal technologies is crucial. It will require further research development and demonstration (RD&D) support, including to CCS, and the adoption of even more stringent environmental performance standards. While coal has a limited outlook under any ambitious climate policy, it has security benefits, given the abundance of the resources and diversified global coal markets. While ensuring the closure of inefficient old plants under the Large Combustion Plant Directive, as a temporary measure, the extended use of older plants as reserve capacity in those countries which face external gas supply risks might need to be examined.

## ENVIRONMENTAL SUSTAINABILITY IN THE LONGER TERM

In 2008, the European Union had agreed on its climate and energy targets for 2020, but detailed proposals were yet to be adopted. In 2014, the European Commission proposed a Policy Framework for Climate and Energy in the period from 2020 to 2030. EU heads of state and government have endorsed these proposals in the conclusions on the 2030 Climate and Energy Policy Framework at the October 2014 European Council. However, the governance and legislative frameworks are yet to be developed.

In the conclusions the European Council of October 2014 agreed to an EU-wide domestic GHG reduction target of at least 40% below 1990 levels, an EU-wide target of at least 27% of renewables in energy consumption, and an EU-wide indicative, non-binding ambition of at least 27% energy efficiency by 2030, based on 2007 projections of future consumption, with an option to review the target towards 30% by 2020, which was the originally proposed target by the European Commission. By 2030, sectors covered by the EU-ETS would be required to cut emissions by 43% and non-ETS sectors by 30% from 2005 levels.

These are the key pillars of the 2030 Climate and Energy Framework. The energy efficiency target is broadly in line with the energy consumption reduction of 25%, consistent with cost-effectively meeting the 40% greenhouse gas target. The European Commission estimate that a 27% energy efficiency target could be delivered at no additional EU energy system cost, while maintaining a strong EU-ETS carbon price and increasing security benefits, reducing gas imports.

A governance framework on the basis of national GHG reduction, renewable and energy efficiency ambitions is envisaged, but questions remain as to how EU-wide targets can be delivered in absence of national targets, and how energy markets and public support can work together to deliver these goals.



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Experience from the 2020 climate and energy package has shown that meeting multiple EU-wide targets with different national and EU instruments requires co-ordination of national policies and alignment with the EU internal energy market, competition and industry policies, but also between the member states and the European Union. The forthcoming 2030 Climate and Energy Policy Framework needs to strike the balance between sustainability, competitiveness and security of supply. The IEA sees the need to strengthen the market-based measures to deliver the expected outcomes for 2030, including a strong EU-ETS and a competitive electricity market as well as stable regulatory framework for low-carbon technologies.

The October 2014 Council conclusions refer to domestic action alone. EU heads of state and government have kept the option open to review the minimum targets for 2030 in the light of the possible global climate commitments at the Conference of the Parties in 2015.

The EU will consider whether to increase the energy efficiency target to 30% in 2020. A review in 2020 would be welcome, having in mind a 30% target, given that 1) technological and economic conditions are likely to change, and 2) there are multiple benefits associated with energy efficiency that are not always factored in to energy system modelling (e.g. health benefits). The EU should aim to quantify the multiple benefits of energy efficiency at EU level to support a higher target level. It will be important to prove to consumers and other energy market decision makers that energy efficiency policies are more than just a way to improve energy security or to mitigate climate change – they are also crucial to delivering economic and social outcomes to consumers and to the economy as a whole.

One clear benefit is energy security. Strengthening the energy efficiency target could contribute to reducing concerns about the security of gas supply that have increased, particularly in the wake of the Russia-Ukraine gas crisis. The European Commission considers that an additional 1% in energy savings can reduce EU gas imports by 2.6%. There is large potential to reduce gas consumption in heating and buildings. Around 40% of natural gas is consumed for heating in the European Union. Therefore, a priority objective should be energy efficiency in buildings, through effective renovation.

The proposed EU-wide renewables target of at least 27% of renewable energy in total final consumption in 2030 could help further the deployment of renewable energy in the European Union. The proposed target is neither binding, nor national, and is not backed up by any specific sectoral targets in heat and transport sectors. However, any EU-wide target has to be based on bottom-up ambitions. This raises questions about the responsibility for the delivery of the target and how renewable energies will develop in the transport and heat sectors. For instance, there is a large potential in improving the energy efficiency of the heat sector by using renewables, primarily bioenergy, but also solar heat collectors and geothermal systems and heat pumps.

The swift start of the EU-ETS reform, to make it flexible to account for varying economic developments, remains crucial to ensure a strong $CO_2$ price signal. The proposed back-loading of allowances and the market stability reserve should be swiftly introduced. This can encourage support investment in the modernisation of the power sector, the switch from coal to natural gas and can partly enable renewables energies to compete without support. The strength of energy efficiency and renewables targets has a direct impact on the carbon price and the functioning of the EU-ETS will need to be aligned to the target.

Strong interim $CO_2$ targets and robust carbon prices are necessary, but not sufficient alone. Experience of global carbon markets shows that short-term markets are not enough to encourage investment in low-carbon technologies. Efficient carbon markets

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need to be complemented by sector- and technology-specific regulation and by support to energy research, development, demonstration and deployment (RDD&D). This is particularly important for new renewable technologies, nuclear and CCS. The forthcoming 2030 Climate and Energy Framework has to deliver an investment policy for low-carbon technologies, consistent with the European Union's long-term decarbonisation pathway to achieve 80% to 95% GHG emission reductions by 2050, according to the Energy Roadmap 2050, and the global climate change agenda.

The IEA applauds the increase in the funding of energy RDD&D in the new framework programme, the Horizon 2020. This represents progress compared to the previous seventh framework programme. The European Investment Bank (EIB) plays a role in the financing of projects and the leverage of EU funds; new financial instruments are envisaged under the EU budget 2014-20.

However, the challenge remains of co-ordinating and raising significant EU funding for energy RDD&D projects among the EU institutions, member states and industry. The experience with new EU demonstration and deployment funding, such as the New Entrants Reserve (NER300) or the European Energy Programme for Recovery (EEPR), to fund a small number of capital-intensive projects, has illustrated the need to leverage large-scale funding at EU level, to increase risk guarantees and to design appropriate policy instruments to remove technology barriers and risks, including new financial instruments, and other tools for encouraging private and public co-financing, as well as the monitoring of the contribution of EU RDD&D efforts to competitiveness, innovation and European Union's energy and climate goals. These elements are even more important in the light of the stated ambitions by EU leaders to create new EU funding mechanisms, using the revenues of EU-ETS auctions.

In 2014, the European Union is entering a new institutional cycle, with the start of the new European Parliament and the five-year term under Commission President Jean-Claude Juncker and Donald Tusk as the President of the European Council. Among the key priorities of the EU's Strategic Agenda is the work towards an Energy Union with a forward-looking climate policy towards 2030.

At the heart of this Energy Union, the core priorities should focus on enhancing energy security, by the completion of the internal energy market, ensuring competitive and affordable energy prices for business and consumers, as well as the reduction of GHG emissions and improvements in energy efficiency, while promoting the leadership of the EU in low-carbon technologies.

## *KEY RECOMMENDATIONS*

*The European Union should:*

- *Re-confirm the commitment to a fully functioning EU internal energy market and the implementation of EU rules through actions to:*
  - *Further integrate EU electricity markets across borders (in particular intra-day and balancing markets) in order to enable more effective accommodation of variable renewable energy and to enhance the adequacy of generation. Enlarge co-ordination of system operation and adequacy assessments to the level of regionally interconnected systems. Ensure that under market rules the value to the system of the time and location of the electricity generated is reflected in the level at which it is remunerated.*



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- *Secure effective use of natural gas storage and LNG capacity across borders, develop (un-)conventional gas production potential in the European Union, and diversify gas supplies, in dialogue with consumer and producer countries.*
- *Boost the level of interconnectivity of the EU energy network by implementing infrastructure investment into projects of common interest.*
- *Phase out regulated retail prices and create more competitive retail markets, with stronger consumer engagement in energy markets through demand-side response, smart meters and grids, and greater choice of products and tariffs.*

☐ *Set out the legal and governance structures for the 2030 Climate and Energy Framework as a milestone towards reaching a low-carbon economy by 2050 and give priority to market-based instruments.*

- *Periodically strengthen and expand requirements for cost-effective energy-efficient buildings (including renovations), appliances, lighting, equipment, transport and district heating and cooling systems in cities, ensuring that these are enforced by member states. Quantify the multiple benefits of energy efficiency for social and economic purposes.*
- *Track all energy subsidies and reduce distortive impacts of public intervention.*
- *Swiftly reform the EU-ETS to reduce the surplus in allowances, enhance its responsiveness to ensure a consistent carbon price signal under varying economic conditions and varying abatement from other policies.*
- *Complement the EU-ETS with policies to attract critical investment in low-carbon technologies, including renewable energies, nuclear and CCS, through sector-specific measures to enhance technology innovation and address non-economic barriers.*
- *Regularly evaluate social and economic outcomes while tracking the progress of the European Union with regard to competitiveness, security and sustainability objectives towards 2020 and beyond.*

☐ *Enhance EU-wide co-operation on uprates, safety upgrades, and extensions of the lifetimes of European Union's existing nuclear power plants to ensure highest safety standards and regulatory stability, while ensuring appropriate incentives can be used in those member states who wish to maintain the nuclear option as part of the energy supply diversity and security.*

☐ *Ensure co-ordination among member states to consider the disposal of all forms of radioactive waste, particularly high-level waste, including the possible creation of regional repositories.*

☐ *Ensure adequate energy RD&D funding to meet EU energy policy goals. Regularly monitor and assess outcomes of energy RD&D programmes based on a set of indicators on competitiveness and innovation.*

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# PART I
# POLICY ANALYSIS

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# 2. GENERAL ENERGY POLICY

**Key data (2012)**

**TPES:** 1 643.6 Mtoe (oil 32%, natural gas 23.9%, coal 17.5%, nuclear 14%, biofuels and waste 8.3%, hydro 1.8%, wind 1.1%, solar 0.6%, geothermal 0.3%, peat 0.4%), -4.9% since 2002

**TPES per capita:** 3.2 toe (IEA average: 4.5 toe)

**TPES per GDP:** 0.11 toe/USD 1 000 PPP (IEA average: 0.14 toe/USD 1 000 PPP)

**Electricity generation:** 3 264.1 TWh (coal 28.1%, nuclear 27%, natural gas 17.8%, hydro 10.3%, wind 6.3%, biofuels and waste 5.2%, oil 2.2%, solar 2.3%, peat 0.5%, geothermal 0.2%), +5% since 2002

**Electricity and heat generation per capita:** 7.8 MWh (IEA average: 10 MWh)

## OVERVIEW

The European Union (EU) is a deeply integrated economic and political partnership of 28 member states. Its political system and its common European institutions are historically unique and have been constantly evolving with subsequent treaties over more than 50 years. The European Union builds on supranational and intergovernmental co-operation.

The European Union is one of the largest economies in the world by gross domestic product (GDP) of EUR 13 474 billion in 2013 (EC, 2014a). It has 509.6 million consumers or 7% of the world's population.

In comparison, the United States had a GDP of EUR 13 256 billion or USD 16 800 billion. In terms of GDP per capita, according to the World Bank (WB, 2014), the European Union (USD 34 256) was behind trade partners, like Australia (USD 67 468), the United States (USD 53 143), Canada (USD 51 958) and Japan (USD 38 492) in 2013. The value of the energy sector in the European Union (excluding energy-intensive industries) was around 2.5% of total GDP.

The financial and economic crisis of 2008-09 led to a strong decline of Europe's energy demand, falling by around 8% from its peak in 2005-06. It strongly impacted industrial production and energy demand as well as investment in the European Union. The crisis also impacted the availability of private and public financing for energy infrastructure projects and, in some countries led to the delay in necessary investment.

At the same time, many energy efficiency policies also started to have a visible impact on curbing the demand. While the energy demand recovered in the year 2010, it never reached the peak of the year 2006. After two decades of sustained growth in energy demand and supply, the slow economic recovery and energy efficiency policies resulted in the European Union returning in 2012 to its energy consumption levels of 1990.

After the recovery of the economy in 2010-11, the European Union has been going through repeated recessions and has yet to emerge from the economic crisis. In its latest

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autumn forecast 2014, the European Commission (EC) indicated that economic recovery is going to be slow with low inflation and growth expectations of 0.8% in 2014 to 1.1% in 2015 for the euro zone and real GDP growth from 1.3% in 2014 to 1.5% in 2015 for the European Union as a whole (EC, 2014b).

The EU economy is the largest exporter of manufactured goods and services, but also the largest energy importer in the world, importing 53% of the energy it consumes. The European Union's primary energy demand makes up 13% and its energy production only 6% of the world's total (EC, 2014c). However, amid rapid changes in the global energy landscape, the analysis from the IEA *World Energy Outlook 2013* underlined that the European Union's share in the global export market for energy-intensive goods, especially for chemicals, is projected to fall in the coming two decades, compared to today by around 10% across all energy-intensive goods, i.e. cement, chemicals, pulp and paper, iron and steel). This reduction is much higher than Japan (-3%), while the United States and emerging economies are projected to increase their export market shares.

At the same time, EU indigenous production of oil and gas has declined faster than expected and at a faster pace than the decline in demand during the economic and financial crisis. With that, the EU import bill and import dependence are increasing. And so is Europe's exposure to global energy commodity market trends.

Energy has played a crucial role in the European integration process from its very early days and continues to do so. The European Community for Steel and Coal (1951-2002) was the first international organisation to be based on supranational principles and helped, through the establishment of a common market for coal and steel, to expand the economies, increase employment, and raise the standard of living within the Community.

The European Atomic Energy Community (Euratom) was founded in 1958 and initially created to co-ordinate the member states' research programmes for the peaceful use of nuclear energy. It continues to maintain a legally distinct personality from the European Union, although it has the same membership and is governed by the EU institutions. Today the Euratom Treaty helps to pool knowledge, infrastructure, and funding of nuclear energy. It ensures the security of atomic energy supply within the framework of a centralised monitoring system.

The 1992 Internal Market Agenda actively promoted the integration of national markets into one single European market. Starting in 1996, the European Community/European Union applied these concepts to European energy markets to ensure liberalisation, independent regulation and supranational integration of electricity and natural gas markets, via successive rounds of internal market legislation.

The Treaty on the Functioning of the European Union (TFEU) included for the first time a dedicated legal base for energy policy (Art 194 TFEU). Under the TFEU energy is a shared competence.

In 2014, the Union is entering a new institutional cycle, with the start of the new European Parliament in July 2014 and the five-year term under Commission President Jean-Claude Juncker on 1 November 2014 and the appointment of Donald Tusk as the new President of the European Council. Among the key priorities of the European Union's Strategic Agenda is the work towards an Energy Union with a forward-looking climate policy, in the horizon 2030.



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## SUPPLY AND DEMAND

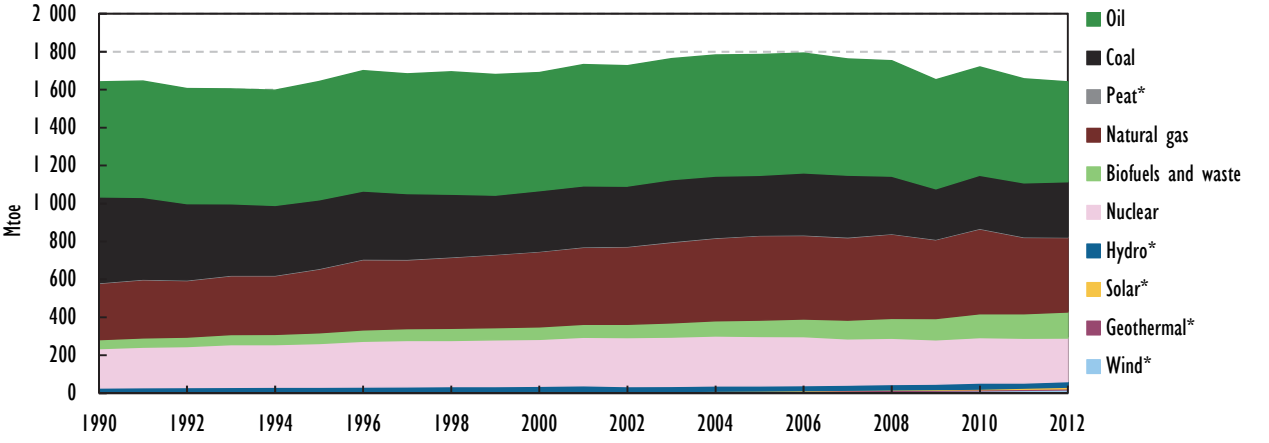
### SUPPLY

Total primary energy supply (TPES) in the European Union was 1 643.6 million tonnes of oil-equivalent (Mtoe) in 2012. It declined for a second consecutive year during 2012, down from 1 720.7 Mtoe in 2010, reflecting declining production in the European Union. Energy supply reached a peak of 1 793.7 Mtoe in 2006 and has been on a downward trend since. In the five years since 2007, TPES contracted by a total of 6.8%. During the economic recession in 2009, TPES fell by 5.7%, recovering by 4% in 2010.

Oil is the main fuel in European Union's energy mix, accounting for 32% of TPES in 2012. Natural gas represents a further 23.9% share, while 17.5% is from coal. Together these three fuels account for 73.4% of TPES. Since 2007, the supply of fossil fuels has declined by 11.9% with a decline in the supply of natural gas, coal and oil. Nuclear energy supplies had a stable share of 14% of total energy in the European Union over the past decade.

Renewable energy accounts for 12.1% of TPES, including biofuels and waste (8.3%), hydro (1.8%), wind (1.1%), solar (0.6%) and geothermal (0.3%). The share of renewables in TPES has increased from 8% in 2007, mainly owing to a surge in wind and solar power generation. Energy from biofuels and waste has grown by 38.9% over the five years while hydro power generation increased by a moderate 6.8% in total.

**Figure 2.1** TPES, 1990-2012




* Negligible.

Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

The overall EU energy mix is changing slowly, individual member states have very different energy portfolios and some rely more on coal, oil or gas or renewable energies, depending on their endowment with natural resources and the national energy policy. The EU total share of fossil fuels in TPES is at a similar level to that of the Czech Republic Hungary and Spain (Figure 2.3).

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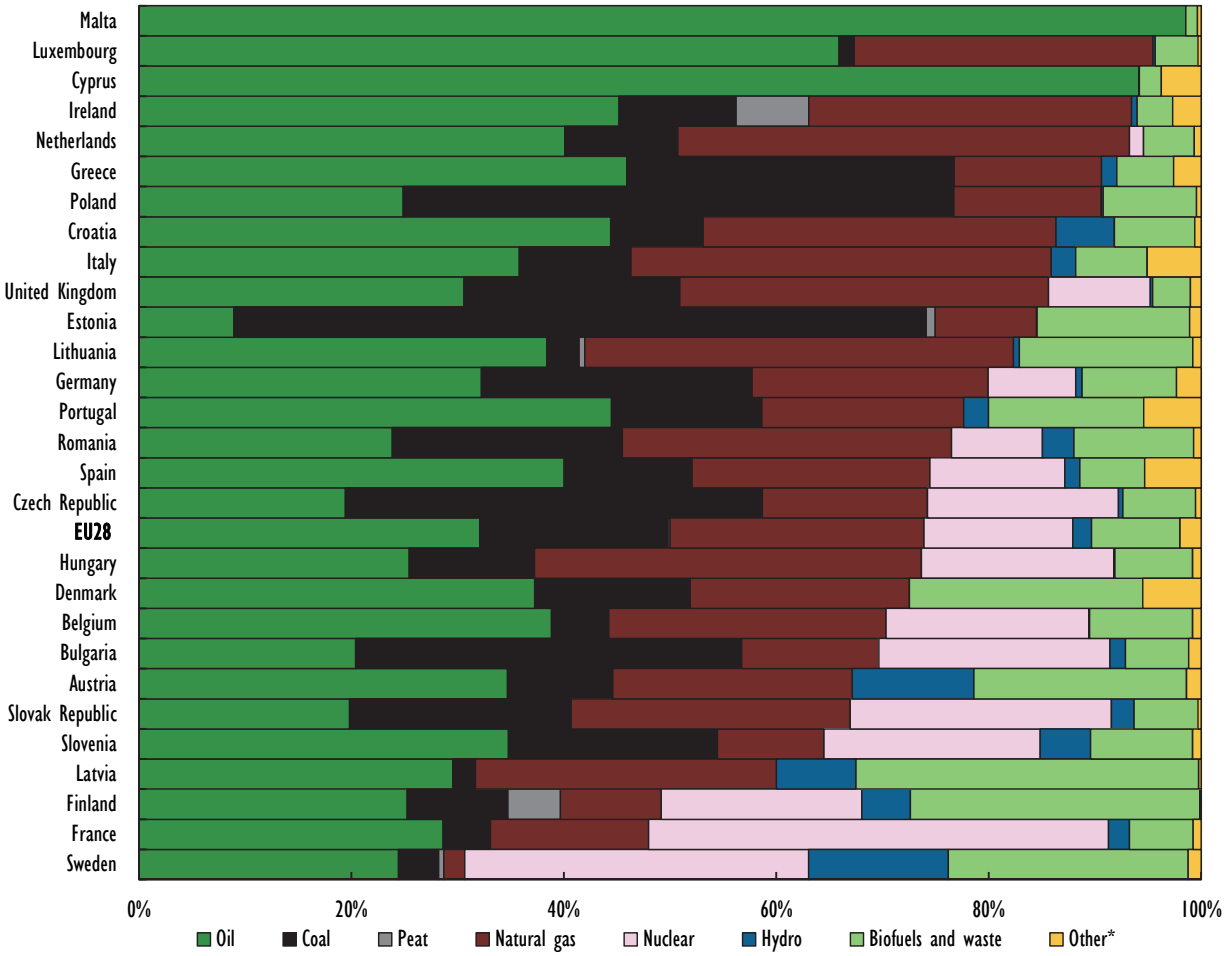
Small member states, including Cyprus,[1] Luxembourg and Malta, have a high share of oil in TPES. Shale oil is the major fuel in Estonia (classified as coal in statistics), while Poland has the largest share of brown and hard coal in TPES. Peat is only used at significant levels in Finland and Ireland. France is the member state with the highest share of nuclear in its energy mix, followed by Sweden. Sweden and Austria have a high share of hydro power in TPES. Denmark, Finland, Latvia and Sweden have a high share of biofuels and waste in their energy mix.

**Figure 2.2** Breakdown of TPES in EU member states, 2012




* *Other* includes geothermal, solar, wind, and ambient heat production.

Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

**1.** Two footnotes: 1. **Footnote by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue". 2. **Footnote by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.



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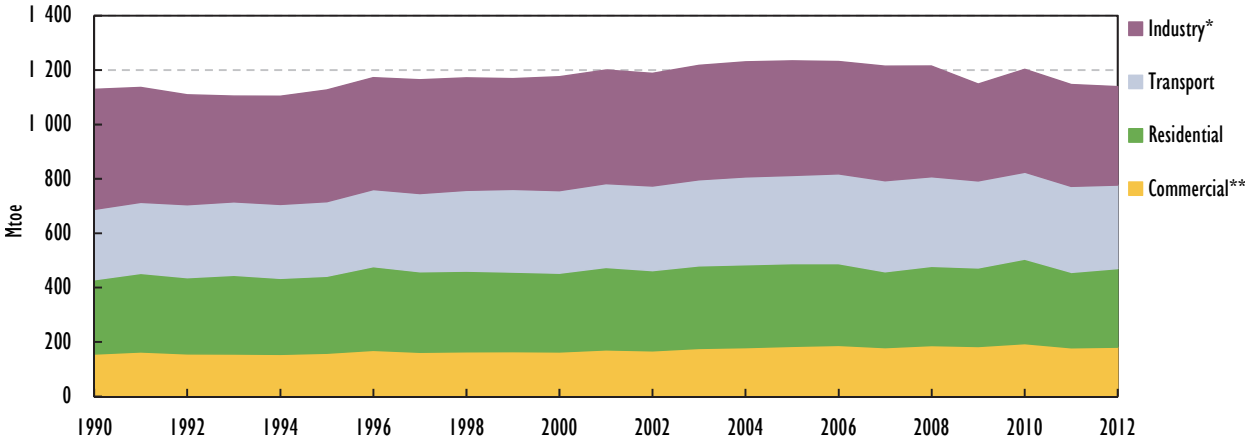
## DEMAND

Total final consumption (TFC) of energy was 1 139.2 Mtoe in 2012, 6.2% lower than in 2007. Demand peaked in 2006 (1 234.2 Mtoe) and has been on a downward trend since then. It declined by 5.4% during 2009, increasing by 4.7% during the recovery period in 2010.

**Figure 2.3** EU TFC by sector, 1990-2012

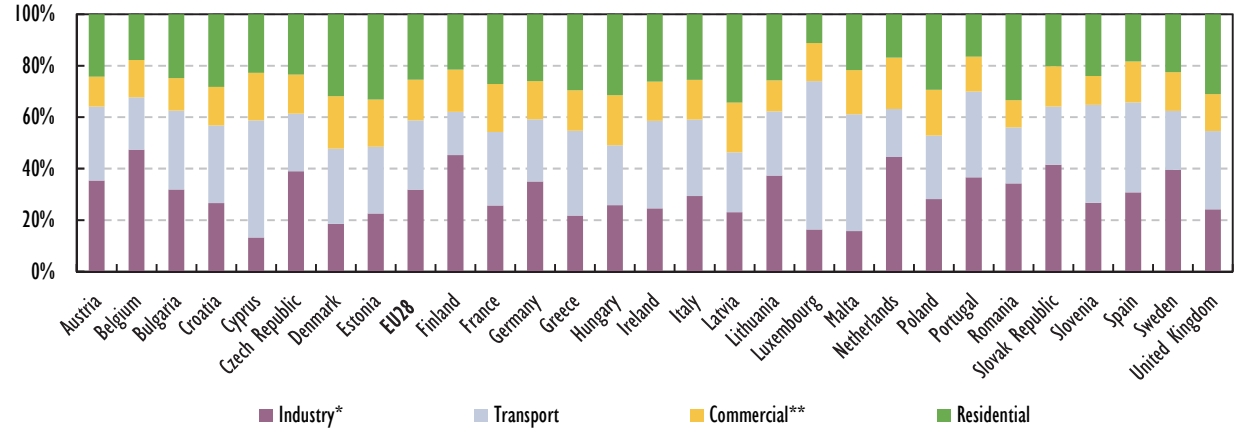



* *Industry* includes non-energy use.

** *Commercial* includes commercial and public services, agriculture/fishing and forestry.

Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

**Figure 2.4** TFC by sector in EU member states, 2012




* *Industry* includes non-energy use.

** *Commercial* includes commercial and public services, agriculture/fishing and forestry.

Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

Industry is the largest consuming sector in the European Union with 31.8% of TFC. The transport and the residential sectors account for 26.9% and 25.4%, respectively. The remaining 15.9% is consumed by commercial and public services, including agriculture/fishing and forestry. The breakdown of TFC by sector has remained relatively unchanged in the European Union over the past five years. However, during this period, the residential sector and commercial and other services sectors increased energy demand by 3.7% and 1% respectively, while transport and industry reduced consumption.

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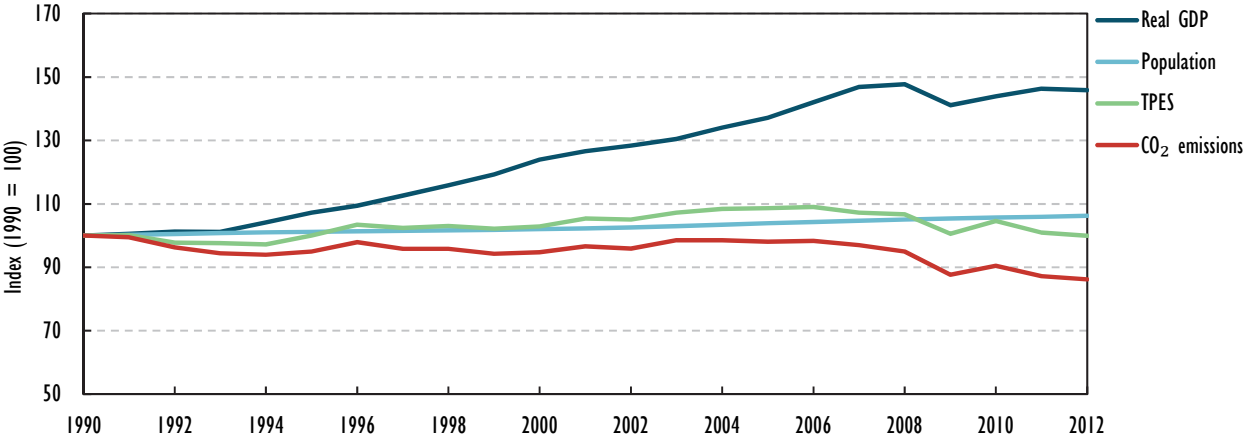
Consumption in industry fell by 14% from 2007 to 2012, decreasing by 8.4% in transport. Among EU member states, Finland, Belgium and the Netherlands have a higher share of industry in TFC than the EU average, while the residential sector is the more significant consumer in Denmark, Estonia, Hungary, Latvia, Poland, Romania and the United Kingdom. Transport is the most significant consumer of energy in Cyprus, Luxembourg and Malta.

The general drivers of $CO_2$ emissions in the European Union can be seen in Figure 2.5. TPES peaked in 2006 and has decoupled from economic growth since then. While the financial and economic crisis impacted all indicators, leading to a decline in GDP, $CO_2$ emissions and TPES; however, real GDP decline in 2008-09 has recovered and consolidated after 2010.

**Figure 2.5** EU $CO_2$ emissions and drivers, 1990-2012




Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

## INSTITUTIONS

Depending on the policy matter and the scope of EU competence, decision-making in EU energy policy requires different degrees of co-operation between the institutions. Energy policy is a shared competence between the EC and the member states. The general rule in energy policy is decision-making through ordinary legislative procedure.[2] In this procedure, the EC initiates legislative proposals of law, and the member states adopt them in the Council together with the European Parliament. Representatives of the 28 member states in the Council, the EC and the European Parliament thus work together to adopt EU secondary legislation in the field of energy, but the scope of their involvement depends on the subject matter (see the Legal Framework section below).

Within the new Juncker Commission, energy policy is also a shared competence. There are several commissioners working together on energy, security, climate and environmental policies, notably the Vice-President for Energy Union, Maroš Šefčovič, Commissioner Miguel Arias Cañete, dealing with Climate Action & Energy, and Commissioner Karmenu Vella, in charge of Environment, Maritime Affairs and Fisheries. The commissioners are overlooking several Directorate-Generals (DGs) to ensure co-ordination.

**2.** There are two caveats to this rule: Art. 194 II clarifies that "such measures shall not affect a member state's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply, without prejudice to Art. 192 (2) c3 and Art. 194 (3): unanimity is required for measures which are primarily of fiscal nature".



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The competence for energy policy lies mainly with **DG Energy**. It is in charge of the general energy policy strategy, the regulatory framework for the internal energy market in gas and electricity, energy networks, including trans-European networks, security of supply, the legal framework for renewable energies and energy efficiency as well as ensuring safe and sustainable use of nuclear energy across Europe.

Emissions trading, international climate policies and climate change mitigation and adaptation, including carbon dioxide ($CO_2$) standards in transport, fall within the responsibility of **DG Climate Action**.

Important competences and polices with impact on energy issues lie also with other DGs. In the area of EU competition and trade policy, the competence of the EC is exclusive for the Commission. **DG Competition** oversees EU competition policy, i.e. merger control, antitrust and state aid, in all sectors, including energy. **DG Trade** is in charge of trade and investment policies and negotiates on behalf of the member states EU bilateral and multilateral trade agreements, for instance for the Trade in Services Agreement (TiSA) within the World Trade Organisation (WTO) or bilaterally, e.g. with the United States (Transatlantic Trade and Investment Partnership, [TTIP]).

**DG Health and Consumers (DG SANCO)** deals with consumer-related aspects of EU energy and climate policies, including the continuous evaluation of the energy markets performance vis-à-vis delivering satisfactory outcomes for consumers through annual scoreboards and initiatives for transparency and consumer awareness-raising. **DG Taxation and Customs Union** is responsible for the Union framework for taxation of energy products and electricity. **DG Enterprise and Industry** co-ordinates industry policies and product legislation and has a strong focus on economic growth and the role of small and medium enterprises (SMEs). It also is in charge of the free movement of goods in the internal market (Art. 34, TFEU).

In the area of energy, **DG Research and Innovation** supports EU-wide and international energy technology co-operation and administers EU funding in the field of energy, notably under the Horizon 2020 programme. Since January 2014 the newly created **Innovation and Networks Executive Agency (INEA)** manages the energy part of the new Connecting Europe Facility (CEF) and the Horizon 2020 programme.

As the Commission's in-house science service, **DG Joint Research Centre (JRC) and its energy institutes,** are in charge of direct scientific and technical support to EU energy policy making, and provides analytical support, modelling and research capabilities.

**DG Environment** deals with environmental impacts, ensures the application of EU environmental law, represents the European Union on environmental matters at international level, and supports environmental action through EU funding programmes.

The **European Environment Agency (EEA)** provides environmental information and data and helps the EC – DG Energy, DG Environment, DG Climate Action – policy makers and the public to take informed decisions. Headquartered in Copenhagen, the EEA is responsible for co-ordinating the European Environment Information and Observation Network (EIONET) and producing the State of the Environment Report (SOER) every five years next to a range of environmental, impact assessment, technical and strategy reports. The EEA evaluates progress on meeting the EU 20-20-20 climate and energy objectives, compiles the Union's inventory and the European Union's report to the United Nations Framework Convention on Climate Change UNFCCC (EEA, 2014).

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The **Council of the European Union** (also known as the Council of Ministers) is the European Union's main decision-making body. The EU member states take turns to hold the Council Presidency for a six-month period. The European Council, represented by the heads of state and government and the EC president, decides on the main directions of EU energy policy, notably through European Council meetings. It is chaired by Mr. Donald Tusk, the President of the European Council. Ms Federica Mogherini is the High Representative of the Union for Foreign Policy and Security Policy/Vice-President of the European Commission in 2014.

The **European Parliament** exercises political supervision over the European Union's activities and takes part in the legislative process. Energy matters are dealt with in several of its 20 committees: in the Industry, Transport, Research and Energy Committee (ITRE), the Environment Committee (ENVI), the Internal Market Committee (IMCO) and the Foreign Affairs Committee (AFET).

The **European Investment Bank (EIB)** in Luxembourg is owned by the EU member states. Representing their interests and supporting the EC, the EIB provides loans and guarantees. Amid the economic and financial crisis, its capital was increased by EUR 10 billon to support financing of energy sector activities, including energy infrastructure and energy efficiency projects. With the European Investment Fund (EIF), majority owned by the EIB and the European Union, the EIB is providing risk finance to SMEs.

## LEGAL FRAMEWORK

Under EU primary law, two treaties define energy policy: the Treaty on the Functioning of the EU (TFEU) and the Euratom Treaty. The general EU energy policy is set out in article 194 TFEU. The Treaty defines EU energy policy as matters relating to 1) the functioning of the energy market; 2) the security of energy supply in the Union; 3) the promotion of energy efficiency, energy saving and the development of new and renewable forms of energy; and 4) the promotion of the interconnection of energy networks. It places energy policy within the context of the establishment and functioning of the internal market, the preservation of the environment and the spirit of solidarity between member states.[3] Under the TFEU, energy policy is a shared competence between the European Union and member states. Thus the member states may legislate and adopt legally binding acts to the extent that the European Union has not exercised its competence.

The Euratom Treaty is a sectoral treaty (*lex specialis* in relation to the TFEU) which applies to the nuclear energy sector. It covers all policy aspects (research, development of standards) relevant for the civil use of nuclear energy: nuclear safety, protection against ionising radiation, radioactive waste management, international agreements, security of supply of ores and nuclear materials, and safeguards. It empowers the Commission to prepare legally binding acts to be adopted by the Council after consultation of the Parliament. The Euratom Community has kept a separate legal personality from the European Union, but it is fully integrated with the European Union, by sharing common institutions, most of the procedural and financial rules, and having the same member states.

Apart from the explicit competences for energy in the TFEU and Euratom, Union action in the area of energy is guided by EU primary law on the harmonisation within the internal market (Articles 24 and 114 TFEU), environmental protection (Articles 191-193 TFEU),

**3.** Solidarity decisions are also explicitly mentioned in Art. 122 of the TFEU (severe difficulties in the supply of certain products, notably in the area of energy).



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taxation (Article 113 TFEU), competition (Articles 101-102 TFEU) and state aid (Articles 107-108 TFEU), EU trade policy (Article 206 TFEU) and the trans-European networks (TEN) policy, covering transport, energy and telecommunication networks (Articles 170-172 TFEU).

The TEN policy places energy infrastructure under the core Union objectives in Article 170 TFEU, in the framework of the internal market integration (Article 24 TFEU), interconnectivity and interoperability, linking isolated regions as well as economic, social and territorial cohesion (Article 174 TFEU). Articles 170-172 TFEU oblige the Union to propose guidelines and priorities for the identification of projects of common interest and measures on interoperability. Member states have to approve the projects of common interest that are located in their territory.

Secondary EU law on energy is presented in the following chapters.

## EXTERNAL ENERGY RELATIONS

Under the TFEU, the European Commission has gained the exclusive competence on trade and investment negotiations for bilateral trade talks and negotiates on behalf of EU member states.

### BILATERAL DIALOGUES

The European Union expanded its external energy relations by establishing a large number of bilateral energy dialogues with key consumer and producer countries (EC, 2011a). The European Union has also started negotiations on major trade agreements, notably with Canada, Japan and the United States, the so-called TTIP, however energy does not feature as the major element. In addition, the European Union intensified its external energy relations with China as energy policy is a key area of the co-operation.

### CO-OPERATION WITH NEIGHBOURING REGIONS

The European Union strengthened the energy co-operation with its neighbouring regions. The Energy Community, complemented by the Eastern Partnership, have been paramount in ensuring the continuous co-operation with the Eastern neighbourhood and South East Europe, notably on trade and energy security.

Since 2009, the Eastern Partnership supports both political association and economic integration. The Energy Community has set in motion a process towards the harmonisation of energy laws and to link the markets of the contracting parties with each other and with the internal market of the European Union and new supplies from the Caspian Region. The Energy Community expanded its membership and extended its mandate until 2023. It now includes eight contracting parties (Albania, Bosnia and Herzegovina, Kosovo, Former Yugoslav Republic of Macedonia, Moldova, Montenegro, Serbia and Ukraine) and Armenia, Georgia, Norway and Turkey as observers. Georgia is in the process of joining. The co-operation is underscored by the European Union's signature of the Association Agreements and Deep and Comprehensive Free Trade Areas with Georgia, the Republic of Moldova and Ukraine in June 2014.

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The INOGATE Programme[4] supports those activities with technical assistance to the partner countries in the Eastern neighbourhood, the Caucasus and Central Asia.

The European Commission has significantly stepped up the work with Ukraine on the gas sector reforms and on increasing the reliability, transparency and modernisation of the Ukrainian gas transmission system, including the safeguarding of gas storage and the availability of reverse flows to Ukraine. The EC also successfully supported trilateral talks with Ukraine and Russia with regard to re-negotiation of gas contracts.

In 2008, the European Union launched the Union for the Mediterranean; however, regional co-operation on energy is very small in scope given the political instability in North Africa, the Eastern Mediterranean and the Middle East.

Since 2009, the European Commission started negotiations on behalf of the member states with Central Asia on the Southern Gas Corridor, the construction of the Trans-Caspian Pipeline, and with Belarus and Russia on the integration of the Baltic States into the EU electricity system (desynchronisation).

## THE EUROPEAN UNION'S EXTERNAL POLICY APPROACH

Decision-making policy on energy in the European Union strikes the balance between shared competence and member states sovereignty to decide on their energy mix and resources. Aligning 28 interests on energy and foreign policy objectives remains a challenge for the European Union. Since the gas crises in 2006, 2009 and 2014 with Russia and Ukraine, the European Union has gradually strengthened its internal co-ordination and solidarity.

New co-ordination mechanism are essential tools for future co-ordination. With regard to intergovernmental agreements between member states and third countries in the field of energy, the European Union has created a new mechanism for information exchange (Decision No 994/2012/EU of 25 October 2012) with a view to increase transparency among the member states and the European Union to ensure that EU internal market rules and energy security policy goals are respected in bilateral intergovernmental agreements.

EU external energy action should seek to foster member states' and industry's strategic interests. In a world of growing economic and energy trade impacts, the need for the European Union to co-ordinate its member states positions on external energy relations remains of utmost importance, to convey consistent messages and take a coherent approach, as the Council provides the Commission with mandates for trade and investment as well as climate change talks. Such a co-ordinated approach is even more important, as the European Union seeks to increase its negotiating power *vis-à-vis* its trade partners and energy suppliers.

There is an opportunity for the European Union to achieve greater coherence on the trade and energy policy and raise its international profile on energy. Current EU trade talks and the international climate change negotiations for the period beyond 2015 are an opportunity to integrate energy and climate policies into a wider international perspective, in particular with regard to GHG emission reductions in the sectors outside of the European Emission Trading System (EU-ETS) and technology co-operation.

**4.** The INOGATE Programme is an energy technical assistance programme funded by the European Union. It started in 1996 and works within the policy frameworks of the Baku Initiative and the Eastern Partnership. INOGATE co-operates with 11 partner countries to support a reduction in their dependence on fossil fuels and imports, improve the security of their energy supply and mitigate overall climate change. The INOGATE partner countries are located in three geographical regions: 1) Eastern Europe: Belarus, Moldova and Ukraine, 2) Caucasus: Armenia, Azerbaijan and Georgia, and 3) Central Asia: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.



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## KEY EU CLIMATE AND ENERGY POLICIES

The Europe 2020 Strategy, adopted in 2010, places energy within its headline targets and two flagship initiatives – the Resource-Efficient Union and the Innovation Union – as part of a ten-year growth strategy (EC, 2010a). The three core objectives of EU energy policy continue to guide EU key climate and energy policies: a) competitiveness, b) sustainability and c) energy security, as set out in the Energy 2020 Strategy (EC, 2010b).

## ECONOMIC GROWTH, COMPETITIVENESS AND AFFORDABILITY

Since the first IEA in-depth review in 2008, there were two main directions of EU internal energy market action: 1) the introduction of harmonised cross-border trade and network rules through the third liberalisation wave, the third internal energy market package of 2009 (hereinafter: "the Third Package") and 2) the enforcement of EU competition rules in the energy sector following the sector inquiry of 2006.

### The internal energy market

The first and second liberalisation waves opened up the EU energy market and increased cross-border trade and business activities during the 1990s and 2000s. The first liberalisation directives were adopted in 1996 (electricity) and 1998 (gas) and were to be transposed into member states' legal systems by 1998 (electricity) and 2000 (gas). The second liberalisation directives were adopted in 2003 and were to be transposed into national law by member states by 2004, with some provisions entering into force only in 2007) (EU legislation applicable to the electricity and gas markets). They introduced the basic principles which characterise today the EU regulatory framework:

- differentiation between competitive parts of the industry (e.g. supply) and non-competitive parts (e.g. operation of the networks) – *ex ante* regulation and unbundling
- obligation on operators of the non-competitive parts of the industry (e.g. the networks and other infrastructure) to allow third parties to have access to the infrastructure (TPA)
- freeing up the supply side of the market (e.g. removal of barriers preventing alternative suppliers from importing or producing energy)
- freedom of consumers to choose their supplier and the removal of restrictions on customers from changing their supplier
- creation of independent regulators to monitor the sector and enforce TPA.

In line with these principles, the approach was a gradual one. In the area of unbundling, the directives stepped up the level of separation from accounting unbundling to legal separation and structural unbundling (including ownership unbundling) of production-supply and network activities. In addition to the establishment of independent national energy regulators under the first directives, their stronger independence and their co-operation within the new EU Agency for the Cooperation of Energy Regulators (ACER) was added in a third step. The third internal energy market package is fundamental in reinforcing the further market opening in the EU energy market.

The Third Package consists of two directives, one concerning common rules for the internal market in gas (2009/73/EC), and one concerning common rules for the internal market in electricity 2009/72/EC) together with three Regulations, one on conditions for access to the

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natural gas transmission networks (EC No 715/2009), one on conditions for access to the network for cross-border exchange of electricity (EC No 714/2009) and one on the establishment of ACER (EC No 713/2009). Member states had to transpose the two directives into national law by 3 March 2011. The Regulations entered directly into force. By end 2014, 14 member states lag behind in the transposition of the Third Energy Package (EC, 2013a).

The European Union has strengthened the harmonisation of the regulatory framework towards the objective of completing the internal energy market by the end of 2014, a deadline which was agreed by heads of state and government at the European Council of 4 February 2011. Rules for cross-border trade of gas and electricity are being harmonised, and requirements for transparency of operational information and the independence and European co-operation of national energy regulatory authorities (NRAs) became stricter. The role and EU-wide co-operation of the transmission system operators (TSOs) have been reinforced, as TSOs are in charge of the network rules and EU-wide network planning (see Box 2.1).

**Box 2.1** Key elements of the Third Package

- Stricter rules on the structural unbundling of energy production and supply interests from the transmission networks. The Third Package provides for three basic models for unbundling of TSOs: ownership unbundling (OU), the independent system operator (ISO) and the independent transmission operator (ITO), leaving the choice between different models to member states. OU is mandatory for new TSOs. National regulatory authorities have to carry out a certification of the TSOs, taking into account an opinion by the European Commission.
- More effective regulatory oversight by the NRAs. The Third Package strengthened the independence and the powers of NRAs, in particular with regard to their duties in relation to tariffs and conditions for access to networks.
- Establishment of ACER to ensure effective co-operation between national regulatory authorities and to take decisions on cross-border issues.
- EU-wide co-ordination of EU network development through the new European Network for Transmission System Operators (ENTSO) bringing together EU electricity and gas grid operators to co-operate and develop common commercial and technical codes and security standards, and to promote co-ordination in infrastructure investments. The EU Regulation (EC) 714/2009 requires the development of non-binding Ten-year Network Development Plans (TYNDPs) every two years. The objectives of the TYNDP are to ensure transparency regarding the electricity transmission network and to support decision-making processes at regional and European levels. The TYNDP identifies significant investments in the European power grid in order to help achieving the European energy policy goals with regard to the share of renewables, the completion of the internal market and ensuring security of supply and system reliability.
- Legally binding framework guidelines and harmonisation of the network and market rules for cross-border networks.
- Increased transparency of the energy markets and strengthening of consumer protection rules, including for vulnerable consumers and fast supplier-switching procedures.



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At the end of 2013, the EC took stock of the progress of the internal energy market and concluded that there are three main areas of actions needed with a view to complete the energy market integration: 1) ensuring the implementation and application of the legal framework, 2) guiding public intervention towards the cost-effective and least distortive support of low-carbon energy transition, and 3) ensuring the benefits from liberalisation for the consumer (EC, 2013b). Wholesale market liberalisation has led to market opening and the emergence of large European utilities, active in several countries, benefitting from a larger market area.

There has been, however, slow progress in creating a market place for all participants, in particular for the retail market particiants, the consumers, as retail markets lack competition and consumers are actively participating only in a few countries (see Chapter 5, "Electricity" and Chapter 7, "Natural Gas"). In overall terms, consumers do not actively participate in the market and are not making full use of the opportunities created by market liberalisation. This largely depends on the consumer engagement policies adopted in the member states, the integration of demand-side participation at the wholesale and retail markets, the ability of consumers to control their consumption with smart meters, to switch supplier and the level of regulation of retail prices.

The roll-out of smart meters and the integration of demand response made slow progress in the European Union. There are close to 45 million smart meters already installed in four member states (Estonia, Finland, Italy and Sweden) and the completion is expected by 2020 in Austria, Denmark, France, Greece, Ireland, Luxemburg, Malta, the Netherlands, Poland, Romania, Spain, and the United Kingdom. According to the Commission (EC, 2014d), the roll-out commitments amount to an investment of around EUR 45 billion for the installation by 2020 of close to 200 million smart meters for electricity (representing approximately 72% of all European consumers) and 45 million meters (around 40% of consumers) for gas. The figures demonstrate that, where roll-out of smart metering is positively assessed, the expected penetration rate for electricity in these member states exceeds the legal minimum requirements of the target of 80%, but to date, the European Union falls short of an overall penetration rate of 80%. This also indicates that the business case for rolling out smart metering is not yet overwhelming throughout Europe, and is an even more substantial challenge in the case of gas.

The EU Consumer Markets Scoreboard 2014 (EC, 2014e) shows that consumers continue ranking the electricity and gas markets among the poorly functioning markets, where supplier switching was most difficult, compared to other markets. In 2014, the electricity market ranked 27th out of 31 services markets, with market performance differing significantly from one country to another and particularly low scores in Southern European countries.[5] The gas market ranked 16th out of 31 services markets.

According to the 2014 market monitoring report by the Agency (ACER) and the Council of European Energy Regulators (CEER) (ACER/CEER, 2014), regulated prices in electricity were still applied in 16 member states in 2013: Belgium, Bulgaria, Croatia, Cyprus, Denmark, France, Greece, Hungary, Latvia, Lithuania, Malta, Northern Ireland, Poland, Portugal, Romania, the Slovak Republic and Spain. In fact, these countries are also the ones with the highest or lowest electricity retail prices in the EU28 (see Figure 5.19). With regard to gas prices, Belgium, Bulgaria, Denmark, France, Greece, Hungary, Ireland,

**5.** There is a 33-point difference (on a scale for up to 100 points) between the top ranked country (Germany) and the bottom ranked country (Bulgaria).

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Latvia, Lithuania, Poland, Portugal, Romania, the Slovak Republic and Spain applied retail price regulation for household consumers.

In 2013, Austria, the Czech Republic, Estonia, Finland, Germany, Luxembourg, the Netherlands, Slovenia, Sweden and Great Britain did not apply any retail price regulation (ACER/CEER, 2014). End-user price regulation for households was removed in 2013 in the Czech Republic, Estonia and Ireland.

In 2013, supplier-switching rates were above 10% in Belgium, the Czech Republic, Ireland, the Netherlands, Portugal, Spain, Sweden and the United Kingdom for electricity. For gas, this was the case for Belgium, the Czech Republic, Ireland, the Netherlands, Spain and the United Kingdom (ACER/CEER, 2014). Energy regulators found in their 2014 market monitoring report that few consumers had a contract with an alternative supplier to the incumbent in the majority of countries (the exceptions being Great Britain, Belgium and Portugal in both markets, the Czech Republic in electricity and Germany, Spain and Ireland in gas markets).

## EU competition policy in the field of energy

As markets remained largely national, with relatively little cross-border trade, and highly concentrated, the Commission launched a sector inquiry in 2005 to identify the barriers preventing more competition in these markets. The results were published in 2007 and strongly supported the adoption of structural rules, with the Third Package and its entry into force in 2009.

In the field of energy, EU competition policy fostered the break-up of national monopolies and the creation of a level playing field for market integration and cross-border trade as well as the implementation of unbundling (of generation/supply and networks).

The Commission has increased its efforts to control mergers and the abuse of dominant position for the benefit of increasing competition in the evolving internal market. Several high-profile cases include using commitments (Art 9 of Regulation 1/2003) from vertically integrated utilities to divest their ownership of networks or limiting the duration of long-term contracts in exchange for dropping antitrust charges. The commitments had a major structural impact on competition in the energy internal market. Regarding merger control in electricity and gas markets, the Commission has prohibited several planned mergers and imposed significant remedies on many others (see Box 2.2).

**Box 2.2** Overview on key EU energy competition cases

In 2008, the Commission decision K(2009)824 of 5 March 2008 was delivered on the Greek lignite case – subsequent Cases C- 553/12 P and C- 554/12 P Commission v DEI – appeals to the Court of Justice of the General Court: judgments annulling the Commission decisions relating to the application of Article 106 TFEU in conjunction with Article 102 TFEU (date of judgment: 17 July 2014).

On 26 November 2008, the Commission adopted a decision against E.ON, rendering commitments offered by E.ON legally binding. The concern of the Commission was that E.ON may have abused its dominant market position as a wholesaler on the electricity market, by strategically withholding production capacity of certain power plants on the wholesale market in order to drive up the price and to deter third parties from investing in electricity generation; and secondly that, as a transmission system operator, it was favouring its own production in the secondary electricity balancing market.



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**Box 2.2** Overview on key EU energy competition cases (continued)

On 18 March 2009, a decision was adopted in the RWE Gas foreclosure case rendering divestiture commitments proposed by RWE legally binding. In the same vein, commitments offered by GDF Suez were made legally binding. Those commitments will make it easier for competitors to enter the German, or the French gas market. On 8 July 2009, the Commission imposed fines of EUR 1 106 million on E.ON and GDF Suez for market sharing. These were the first fines the Commission has imposed for an antitrust infringement in the energy sector and represented the highest fine imposed in 2009.

In 2010, in the EDF Customer Foreclosure case, the Commission had concerns that EDF may have abused its dominant position in France by concluding supply contracts which foreclosed the market given their scope, duration and exclusive nature and by including resale restrictions in its supply contracts. EDF offered, for a period of ten years, to ensure that other suppliers could compete for 65% on average of the electricity EDF contracts with large French industrial users each year and to limit the duration of any new contract concluded with large industrial users to five years. In addition, EDF committed to remove all resale restrictions in its supply contracts and to assist customers wishing to resell electricity. These commitments, planned to come into effect on 1 July 2010, were postponed to 1 January 2011.

In the Svenska Kraftnät (SvK) case, the Commission had concerns that SvK may have abused its dominant position in the Swedish electricity transmission market by limiting the export capacity available on interconnectors in order to relieve internal congestion on its network and to reserve domestic electricity for domestic consumption. SvK offered to operate the Swedish electricity market on the basis of several flexible bidding zones from 1 November 2011 on. This will allow electricity trading to adjust to available transmission capacity through market prices rather than through arbitrary measures.

In the E.ON gas case, the Commission's investigation showed that E.ON had reserved, on a long-term basis, the largest part of the available transport capacity at the entry points to its gas transmission networks, thereby potentially preventing other gas suppliers from accessing the German gas market. The Commission reached the preliminary view that the long-term reservations may have infringed EU rules on the abuse of a dominant market position. E.ON undertook to release about 15% of pipeline capacity at the entry points to its gas networks by October 2010. From October 2015, E.ON will further reduce its bookings of entry capacity in the NetConnect Germany grid to 50% and in E.ON's grid for low-calorific gas to 64% of the pipeline capacity.

In the ENI case, the Commission had concerns that ENI may have abused its dominant position in the gas transport markets by refusing to grant competitors access to capacity available on the transport network, by granting access in an impractical manner and by strategically limiting investment in ENI's international transmission pipeline system. ENI may also have had the incentive to foreclose rivals to protect its margins in the downstream gas supply markets. ENI committed to the structural divestment of its international transport activities for the import of gas into Italy from Russia and from Northern Europe.

In June 2012, the Commission made legally binding commitments offered by Siemens AG and AREVA S.A. to reduce the product scope and duration of a non-compete obligation in the market for nuclear technology.

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**Box 2.2** Overview on key EU energy competition cases (continued)

On 7 February 2012, the Commission also carried out inspections at the premises of power exchanges, which provide services that facilitate electricity trading at wholesale level. The Commission had concerns that the companies concerned may have violated European antitrust rules that prohibit cartels and restrictive business practices.

In 2012, the Commission also investigated several practices in Eastern Europe. More specifically, in Bulgaria, the Commission is investigating potential foreclosure by the national company BEH (Bulgarian Energy Holding) gas, as well as obstacles to cross-border trade in electricity.

In 2012, the Commission opened antitrust proceedings against Gazprom. The Commission's concerns were that Gazprom may have and continue abusing its dominant position in upstream gas supply markets in some countries of Central and Eastern Europe, in some of which Gazprom is virtually the sole supplier. The proceedings focus on whether Gazprom has divided gas markets by preventing the free flow of gas between EU countries and whether it is imposing conditions relating to the use of infrastructure that prevent the diversification of sources of gas supply. The scope of the proceedings also covers the possible imposition of unfair prices on customers.

On 10 April 2013, the Commission rendered commitments offered by the CEZ Group, the Czech electricity incumbent, legally binding. The Commission's preliminary view was that CEZ may have hindered entry into the Czech market for the generation and wholesale supply of electricity, in particular through making a pre-emptive capacity reservation in the transmission system network which it did not need at that moment, and CEZ offered structural remedies to address that concern.

In May 2013, a Statement of Objections was addressed to the Romanian power exchange OPCOM and its parent company CNTEE Transelectrica regarding OPCOM's business practice of requiring OPCOM's electricity spot market participants to hold a Romanian VAT registration. The Commission's preliminary view is that OPCOM is discriminating against companies on the basis of their nationality/place of establishment. In 2014, the European Commission imposed fines totalling EUR 5 979 000 on the two leading European spot power exchanges, EPEX Spot ("EPEX") and Nord Pool Spot for having agreed on market sharing, so as not to compete with one another for their spot electricity trading services in the European Economic Area.

## State aid and public intervention

The trade-off between the need for competitive markets, on the one side, and the need for public intervention (including public support to low-carbon investment) in the pursuit of climate and energy policies, on the other side, is an emerging issue for the European Union to tackle in the coming years.

In the past years, internal energy market rules and energy and climate policies at EU and national level have been increasingly diverging from each other. In the years to come, the European Union needs to acknowledge that public intervention is a reality in energy markets. The European Union needs to ensure competition in the market but also a regulatory framework to provide a level playing field for all energy infrastructures in the competition for the market.



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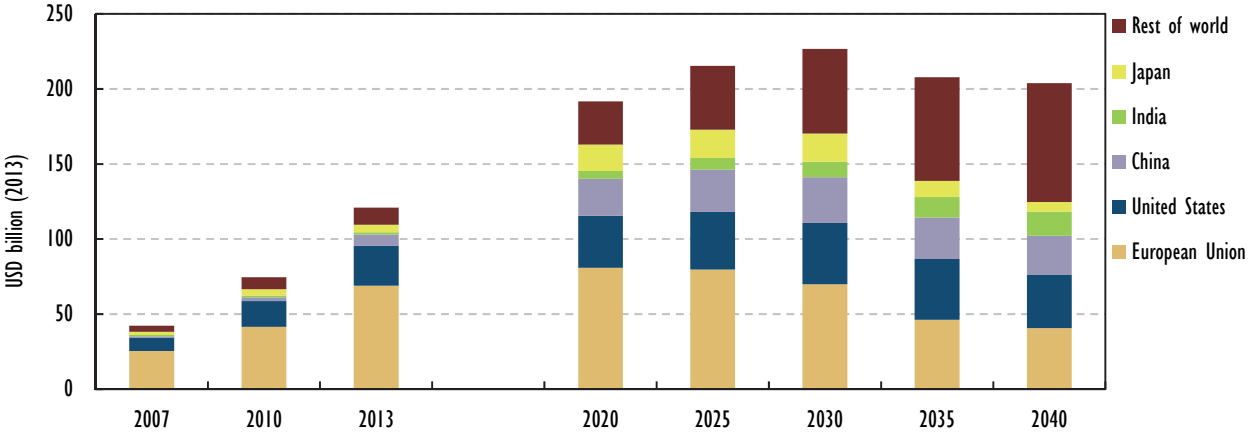
Since 2008, public interventions are on the rise in the European Union. Since 2000, in the European Union, electricity generation from renewables-based technologies (excluding hydropower) has increased almost seven-fold and the use of biofuels in the transport sector about 20 times, mainly thanks to policies to support their deployment and use. The amount of subsidies[6] in the European Union reached around USD 70 billion or EUR 52 billion in 2013 (IEA, 2014c), accounting for 57% of the global subsidies to renewable energy (Figure 2.7), with solar PV accounting for over USD 30 billion or EUR 22 billion, followed by wind with over USD 15 billion or EUR 11 billion.

In the New Policies Scenario, renewables subsidies in the European Union continue to grow, albeit at a slower pace than the increasing use of renewables, due to increasing wholesale prices (that bring renewables closer to competitiveness) and the reduction of investment costs for renewable energy technologies. EU subsidies reach a plateau at around USD 80 billion, and start declining in the second half of the 2020s, reaching about half of current levels in 2040, mainly as the subsidies granted to the large amount of solar PV capacity commissioned in recent years come to an end.

**Figure 2.6** Renewable-based generation subsidies by source in the New Policy Scenario




Note: the New Policies Scenario: A scenario in the World Energy Outlook that takes account of broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse gas emissions and plans to phase out fossil-energy subsidies, even if the measures to implement these commitments have yet to be identified or announced. This broadly serves as the IEA baseline scenario.

Source: IEA (2014c), *World Energy Outlook 2014*, OECD/IEA, Paris.

Following the EC guidance on public interventions, including the design of renewable support schemes, capacity mechanisms and demand-side response (EC, 2013a), the EC concluded a review of the EU state aid rules. Expanding environmental state aid to energy, the new Guidelines on Environmental and Energy Aid (EEAG) for the years 2014-20 are in force since 1 July 2014 (EC, 2014f).

The new rules aim to limit market distortions that may result from national subsidies, including renewable energy subsidies. The guidelines provide criteria on how member

**6.** The subsidy estimates in the *World Energy Outlook* are calculated based on support schemes in each country, taking the difference between the average cost of electricity generated by the renewable energy technology (or the relative support policy) and the regional wholesale electricity price. This level of subsidy is paid for each unit of electricity generated by the installed capacity over the lifetime of the policy. For biofuels, they are calculated by multiplying the volumes consumed by the difference of their cost to the reference price of the comparable oil-based products. See www.worldenergyoutlook.org for the complete methodologies on how renewables subsidies and fossil-fuel consumption subsidies are calculated.

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states can relieve energy-intensive companies from the costs of renewable energy subsidies. Furthermore, the guidelines allow state aid for energy infrastructure and power generating capacity to strengthen the internal energy market and security of supply.

Key features of the guidelines include:

- Gradual introduction of market-based mechanisms: This includes the gradual introduction of competitive bidding processes for allocating public support for renewable energy and the gradual replacement of feed-in tariffs by feed-in premiums for future facilities.
- Promoting competitiveness of European industry: Allowing for reducing the burden of renewable energy subsidy costs for a limited number of energy-intensive sectors defined for the whole Union.
- Supporting cross-border interconnections.
- Permitting aid to secure adequate electricity generation when there is a real risk of insufficient electricity generating capacity. This will guide member states' design of the so-called "capacity remuneration mechanisms", for example to encourage producers to build new generation capacity or prevent them from shutting down existing plants or to reward consumers to reduce electricity consumption in peak hours.

On substance, the main changes of the modernised state aid with regard to energy include: 1) harmonisation and simplification of rules in particular in the General Block Exemption Regulation (Commission Regulation EU 651/2014 of 17 June 2014); 2) inclusion of energy infrastructure; 3) mechanisms for system stability and generation adequacy; 4) support to low-carbon energy sources; 5) exemptions from environmental taxes and other charges on electricity consumption. The enlarged scope of the general block exemptions reduces the need for member states to notify in advance in specific cases.

## EU energy taxation policy

Member states are free to design their own fiscal policies, as in general environmental taxation is not harmonised at the EU level, although taxation of energy products and electricity is subject to a harmonised legal framework so as to ensure the proper functioning of the internal EU market.

Under EU law, decisions in taxation policy require unanimity of all EU member states in the Council which makes the adoption of EU tax legislation a challenging process.

The EU energy taxation framework is set under Council Directive on the taxation of energy products and electricity (2003/96/EC). It sets minimum tax levels for energy products used for heating or as motor fuel, and for electricity. In 2011, the European Commission proposed a revision of the directive to bring it in line with environmental and climate change objectives by splitting the existing energy tax into a tax on the carbon content and one on the energy content of the product. However, there has been no progress on the adoption of this directive (see Chapter 6, "Oil").

In the past years, EU member states have increased the application and use of carbon taxes and fuel taxation for environmental purposes; such taxation serves as a driver for retail gas and electricity prices and is not fully reflected in the level of overall EU state aid and energy sector subsidies. Greater transparency and co-ordination of taxation policies towards sustainability results should be an area of future focus for the European Union.



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SUSTAINABILITY POLICIES

## The 2020 climate and energy package

In the context of the global fight against climate change, the European Union took the lead in the transition to a low-carbon economy. In 2007, EU-wide objectives were fixed with binding emission and renewable energy targets and indicative energy saving ambitions by an agreement of heads of state and government. These energy and climate objectives are framed around three headline targets for the horizon of 2020 with a view to:

- Reduce greenhouse gas (GHG) emissions by 20% compared to 1990 levels and conditionally by 30% in the context of a future international climate agreement.
- Increase the share of renewable energies to 20% in gross final energy consumption and to 10% in transport.
- Reduce the total primary energy consumption by 20%, projected for 2020 in the 2007 reference scenario.

Following this agreement, the European Union adopted the legal framework for the implementation of the targets through the following legislative measures (hereinafter: "the 2020 Climate and Energy Package"):

- **GHG reduction effort-sharing decision:** Decision 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the efforts of member states to reduce their GHG emissions to meet the Community's GHG emissions reduction commitments up to 2020 as amended by Protocol 12012JN03/08.
- **Renewable Energy Directive:** Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directive 2001/77/EC and 2003/30/EC as amended by Directive 2013/18.
- **New EU-ETS Directive:** Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC as to improve and extend the GHG emission allowance trading scheme of the Community.
- **Carbon Capture and Storage (CCS) Directive:** Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EDC, 2001/80/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 as amended by Directive 2011/92.
- **Biofuel and Fuel Quality Directive:** Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gasoil and introducing a mechanism to monitor and reduce GHG emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EC.
- **Emission Standards Regulation:** Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce $CO_2$ emissions from light-duty vehicles as amended by Regulation No 397/2013, and repealing Regulation No 63/2011.

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- The framework was complemented by the existing Energy Services Directive (Directive 2006/32/EC) which was repealed by the new **Energy Efficiency Directive** (2012/27/EU).

The legislative measures are analysed and explained in detail in the sectoral chapters, notably Chapter 3, "Climate Change" and Chapter 4, "Energy Efficiency".

## Long-term vision for decarbonisation towards 2050

At their European Council in 2009, as a pledge in favour of a low-carbon economy EU leaders endorsed the objective of reducing the European Union's GHG emissions by 80% to 95% compared to 1990 levels by 2050, as proposed in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report in 2007. They have endorsed this target range as an EU objective which is conditioned by the fact that developed countries as a group make the reductions needed.[7]

**Table 2.1** Overview of needed GHG emission reductions by sector, up to 2030 and 2050 under the Low-Carbon Roadmap

| GHG reductions compared to 1990 | 2005 | 2030 | 2050 |
|---|---|---|---|
| Total | -7% | -40% to -44% | -79% to -82% |
| Power ($CO_2$) | -7% | -54% to -68% | -93% to -99% |
| Industry ($CO_2$) | -20% | -34% to -40% | -83% to -87% |
| Transport (including aviation, excluding maritime) | +30% | +20% to -9% | -54% to -67% |
| Residential and services ($CO_2$) | -12% | -37% to -53% | -88% to -91% |
| Agriculture (non-$CO_2$) | -20% | -36% to -37% | -42% to -49% |
| Other non-$CO_2$ emissions | -30% | -72% to -73% | -70% to -78% |

Source: EC (2011b), *Communication from the Commission, A Roadmap for Moving to Competitive Low Carbon Economy in 2050*, COM/2011/0112 final, Brussels.

As a long-term vision for the decarbonisation of the European economy, in March 2011, the European Commission presented a cross-sectoral *Roadmap for Moving to a Competitive Low-Carbon Economy in 2050* (EC, 2011b), which set out how the European Union can achieve emissions reductions by 2050 of 80% below 1990 levels through domestic action alone.[8] The main sectors responsible for European Union's GHG emissions – power generation, industry, transport, buildings and construction, as well as agriculture – will have to contribute according to their technological and economic potential (see Table 2.1).

On the basis of this low-carbon roadmap in 2050, the EC adopted sectoral roadmaps for transport (Transport 2050 White Paper) and for energy (Energy Roadmap 2050). Several EU member states are implementing policies for an energy transition towards a low-carbon economy by 2050 (Germany, France, the Netherlands, Nordic countries, Lithuania and the United Kingdom).

**7.** Brussels European Council, Presidency Conclusions, 1 December 2009, 15265/1/09 REV 1. Countries in Central Eastern Europe, consider this target therefore conditional upon a global climate agreement, and not as a unilateral European Union target.

**8.** There is controversy as to what extent the European Union can decarbonise unilaterally with regard to the achievement of 2050 goals. Poland has not endorsed the Energy Roadmap 2050.



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### Policy framework for climate and energy in the period from 2020 to 2030

On 22 January 2014, the European Commission presented "A policy framework for climate and energy in the period from 2020 to 2030" (EC, 2014g), with three key energy and climate objectives, and new policy proposals including:

- an EU-wide, binding target for the reduction of GHG in 2030 by 40% below the 1990 level through domestic measures alone – split between the European Emissions Trading Scheme (EU-ETS) sectors (a reduction of 43% below 2005 levels) and the sectors outside the EU-ETS (a reduction of 30% below the 2005 level to be shared between the member states)
- an EU-wide, binding renewable energy target of at least 27% in 2030 (with neither binding national nor new sectoral targets for renewable energy in transport or other sectors)
- an EU-wide 30% energy efficiency target with savings below the 2007 reference projections for the year 2030 (EC, 2014h)
- the reform of the EU-ETS through the creation of a market stability reserve after 2020 to address the current surplus of emission allowances by automatically adjusting the supply together with an increase in the EU-ETS linear emission reduction factor from 1.74% to 2.2% in line with the -40% GHG emissions reduction target
- a new governance framework based on national plans for competitive, secure and sustainable energy, prepared by the member states under a common approach proposed by the Commission
- a set of key indicators to assess over time: energy price differentials between the European Union and major trading partners; the diversification of energy imports and the share of indigenous energy sources used in energy consumption over the period up to 2030; the deployment of smart grids and interconnections between member states; intra-European Union coupling of energy markets; competition and market concentration in energy markets; technological innovation.

## PROJECTIONS

In the latest energy and climate reference scenario 2013, which sets out projections to 2020, 2030 and 2050 (EC, 2013), the European Commission expects a further reduction of energy intensity and a fast increase in renewable energies (notably solar PV, less so offshore wind). Assuming the implementation of all adopted energy policies and current macro-economic projections, primary energy consumption is set to decline by around 17% in 2020 and by 21% in 2030 in the Reference Scenario (compared to reference projections made for these years in 2007). Under the Reference Scenario 2013, the energy efficiency target of 20% energy savings by 2020 would thus not be reached without further measures.

In July 2014, the European Commission re-evaluated energy efficiency progress and is optimistic that current measures and revised macro-economic projections would lead to 18%-19% savings. If all newly envisaged energy efficiency actions at European and national levels would be fully implemented, the European Commission considers that the European Union could achieve its target of 20% by 2020 (EC, 2014h).

Declining domestic energy production would slightly push up the overall import dependence from currently 53% towards 55% in 2030 in the Reference Scenario – despite the projected

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decline in consumption and the steady growth of (mostly domestic) renewables. The share of renewable energies in final energy consumption continues to rise to 20.9% in 2020 and 24.4% in 2030, with solar PV experiencing the largest capacity additions, together with wind power.

**Table 2.2** Overview of energy and climate projections up to 2030 and 2050, EU28

| | | Reference Scenario 2013 | | GHG40 2030* | | EE30 EER** | |
|---|---|---|---|---|---|---|---|
| | 2010 | 2030 | 2050 | 2030 | 2050 | 2030 | 2050 |
| GHG reductions vs. 1990 | -14.7% | -32.4% | -43.9% | -40.6% | -79.6% | -40.1% | -78.5% |
| GHG reductions in EU-ETS versus 2005 | -13.3% | -36.1% | -59.3% | -43.3% | -87.1% | -42.2% | -85.7% |
| GHG reductions in non-ETS sectors versus 2005 | -5.0% | -20.3% | -22.9% | -30.5% | -70.3% | -30.5% | -69.4% |
| Share of renewable in gross final energy consumption*** | 12.4% | 24.4% | 28.7% | 26.5% | 51.4% | 27.7% | 50.6% |
| Share of oil in gross inland energy consumption | 35.1% | 32.3% | 30.5% | 32.8% | 13.5% | 33.0% | 15.3% |
| Share of gas in gross inland energy consumption | 25.1% | 24.6% | 24.3% | 22.5% | 17.9% | 21.0% | 18.3% |
| Net oil imports (2010 = 100) | 100 | 93 | 96 | 90 | 41 | 84 | 43 |
| Net gas imports (2010 = 100) | 100 | 105 | 122 | 91 | 74 | 78 | 69 |
| Primary Energy Consumption savings relative to 2007 baseline projections for 2030 | - | 21% | - | 25.1% | - | 30.7% | - |
| Import Dependence (% net imports to total gross inland energy consumption) | 53 | 55.1 | 56.6 | 53 | 38.1 | 52.8 | 38.3 |
| Fossil fuel net imports, average annual value (EUR billion) | 332 | 461 | 548 | 452 | 377 | 395 | 358 |

* GHG40 scenario is the central scenario of the proposed Policy Framework for Climate and Energy in the period from 2020 to 2030 with proposed targets of 40% GHG reduction and at least a 27% share of renewables.

** EE30 is the central scenario of the July 2014 Communication (EC, 2014h) combining the targets of 40% GHG reduction, at least a 27% share of renewables and 30% of energy savings (compared to 2007 reference).

*** Gross final consumption of energy is defined in Directive 2009/28/EC on renewable sources as energy commodities delivered for energy purposes to final consumers (industry, transport, households, services, agriculture, forestry and fisheries), including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission.

Sources: EC (2013c), *European Union Energy, Transport and GHG Emissions Trends to 2050: Reference Scenario 2013*, Brussels, EC (2014i), *Impact Assessment accompanying the document Communication from the Commission to the European Parliament and the Council, Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy*, SWD(2014) 255 final, Brussels. EC (2014j), *Impact Assessment accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A policy framework for climate and energy in the period from 2020 up to 2030*, SWD(2014) 015 final, Brussels.

In the 2013 reference scenario, gas imports are expected to increase between 2020 and 2030 as domestic production continues to decline. Oil imports are projected to remain stable. Overall GHG emissions are set to decrease; and would be 24% less than in 1990 by 2020 and 32% less in 2030. The EU28 is expected to see a further decrease of the carbon intensity of the economy, reaching 1.96 $tCO_2$ per tonne of oil-equivalent (toe) of gross inland consumption in 2020 and 1.78 $tCO_2$ per toe of gross inland consumption in 2030.

Against this new reference scenario, the European Commission proposed two scenarios for 2030, the first scenario in January 2014 (GHG40 scenario), based on a 40% domestic



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GHG emissions reduction target (below 1990 levels) and an EU-wide binding, renewables target of at least 27%. This scenario was complemented by an additional EU-wide 30% energy savings target in July 2014 (EE30 scenario). The projections for the different EU ambitions with regard to energy efficiency and GHG emissions reductions and their impact on the key energy policy indicators are presented in Table 2.2.

## THE EU ENERGY SECURITY STRATEGY

The political crisis involving Ukraine and Russia in early 2014 once again brought the European Union's vulnerability and dependence on Russian energy, notably supplies of natural gas, into sharp relief.

The European Union is highly dependent on energy from abroad and exposed to external shocks, importing 53% of the energy it consumes with an import bill of EUR one billion per day. The European Union imports 88% of crude oil, 66% of its natural gas, 42% of its solid fuels such as coal and 95% of its uranium. While coal, oil, uranium and liquefied natural gas (LNG) supplies are well diversified at global scale, the European Union however relies on pipeline imports of more than a third for gas and oil from Russia. Many member states are heavily reliant on a single supplier including six that are entirely dependent on Russia for their natural gas. Three member states – Estonia, Latvia and Lithuania – also rely on a single external operator for the operation and balancing of their electricity network, and for a large share of their electricity supply.

In this context, the European Council of March 2014 asked the Commission to conduct an in-depth study of EU energy security and to present by June 2014 a comprehensive plan for the reduction of the Union's energy dependence. On 28 May 2014, the European Commission presented a new European energy security strategy (EC, 2014k) based on eight pillars:

- carrying out energy security stress tests to identify risks and assess measures to mitigate a major disruption of gas supply during the winter 2014-15
- strengthening emergency/solidarity mechanisms including co-ordination of risk assessments and contingency plans, and protecting strategic infrastructure
- moderating energy demand
- building a well-functioning and fully integrated internal market
- increasing energy production in the European Union
- diversifying external supplies and related infrastructure
- further developing energy technologies
- improving co-ordination of national energy policies and speaking with one voice in external energy policy.

The energy security stress tests were carried out during August 2014 in EU member states, the Energy Community countries (including Ukraine) and Georgia. The United States, Canada, Japan, Switzerland, Turkey, Norway, the ENTSO-G and the IEA contributed.

The results of the stress tests were presented in October 2014 (EC, 2014l). The EC concludes that the overall energy security situation is comfortable. In the event of a major gas supply disruption (of Russian gas supplies to the European Union) the Eastern EU countries and Energy Community countries would be very much affected. If no

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additional measures were taken (demand-constraint or cross-border co-operation), Finland, Estonia, the Former Yugoslav Republic of Macedonia, Bosnia and Herzegovina, and Serbia would have to mitigate a loss of at least 60% of the gas consumption.

At their October 2014 European Council, EU member states reached an agreement on their ambitions for the 2030 Climate and Energy Policy Framework, largely endorsing the January 2014 proposals of the European Commission (see Box 2.3), and preparing the EU position for international climate negotiations in 2015, together with key conclusions on the European Union's energy security.

**Box 2.3** The 2030 Climate and Energy Policy Framework – Conclusions of the European Council of October 2014

At the Brussels European Council of 23-24 October 2014, EU heads of state and government endorsed their European ambitions for a 2030 Climate and Energy Policy Framework (European Council, 2014).

The European Council endorsed a binding EU-wide target to reduce GHG emissions by at least 40% by 2030, below 1990 levels, to be achieved to 43% by the EU-ETS sectors and to 30% by non-ETS sectors from 2005 levels (i.e. buildings, transport and agriculture). At this stage, the domestic target of a 40% reduction effort does not take into account international carbon offsets. The target would need to be shared by all member states with individual GHG targets ranging from 0% to -40%. The European Council adopted this GHG emission reduction target as the European Union's collective pledge to the twenty-first United Nations Conference of the Parties (COP) 21, thus securing EU leadership. At the same time, the European Council secured the opportunity to review the ambition in the light of a possible global climate agreement.

EU leaders committed to a binding EU-wide target of at least 27% of renewable sources in energy consumption by 2030, without national targets for member states or sectors. The Council retained an indicative EU-wide ambition of at least 27% of energy efficiency by 2030, compared to 2007 projections of future energy consumption, staying below the Commission proposal of 30%, but in line with the minimum target of 25% to achieve a longer-term decarbonisation by 2050. EU leaders are to re-examine progress by 2020, having in mind a 30% target by 2030.

The EU-ETS has been reconfirmed as central instrument for reaching cost-effective emissions reductions, including in the transport sector, an option which member states have under current rules. The EU-ETS should be strengthened, with a market stability reserve and an increased linear reduction factor (from 1.7% to 2.2% from 2021 onwards), while ensuring measures to avoid the risk of carbon leakage after 2020. Measures include the free allocation of emission allowances to the energy industry in countries which have a GDP below 60% of the EU average in 2013.

The European Council also agreed to create new funding instruments at EU level to support the modernisation and promotion of low-carbon energy technologies in EU member states. This includes the continuation of the new entrants' reserve, with a higher amount of allowances, as so-called NER400, and a new EU investment fund to be set up with the auction revenues of 2% of the EU-ETS allowances. Out of the total, 10% of auction revenues are to be allocated to projects in EU member states with a GDP below 90% of EU average in 2013.



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**Box 2.3** The 2030 Climate and Energy Policy Framework – Conclusions of the European Council of October 2014 (continued)

As a fourth ambition, the European Council noted the fundamental importance of a fully functioning and fully interconnected internal energy market and an interconnection level of 15%. Re-confirming the 10% interconnection target, agreed at their Barcelona 2002 Summit, the Council supported the work of the Commission to ensure together with member states the implementation of the priority infrastructure projects (so-called projects of common interest) to meet the current 10% interconnection target by 2020 at the latest. Connecting the Baltic States, Portugal, Spain, Malta, Cyprus, and Greece, were noted as priorities. The Council invites the Commission to report to the European Council on options for new financial instruments and/or new projects necessary to reach a 15% interconnection level by 2030.

As part of the 2030 Climate and Energy Policy Framework, the Council supported the following actions to foster energy security in the European Union, while underlining the importance of indigenous, safe and sustainable low-carbon sources:

- gas market integration through the implementation of priority infrastructure projects along the North-South corridor from Finland, the Baltic states to the Southern Gas Corridor, and a new gas hub in Southern Europe
- better utilisation of regasification and storage capacities in emergency situations
- stronger co-operation on projects of common interest, supported by the Commission in the regional groups and streamlined procedures as well as a new policy to address the protection of critical energy infrastructure, including information technology risks
- stronger role of the Energy Community
- enhanced information exchange with regard to intergovernmental agreements between EU member states and third countries in the field of energy and their ex-ante compliance with EU law
- consistent external energy policy by European Union and member states, in particular vis-à-vis strategic partners and major energy suppliers.

The European Council underlined the importance of a reliable and transparent governance system without unnecessary administrative burden to help ensure that the European Union meets its energy policy goals, while providing flexibility for member states and respecting their freedom to determine their energy mix.

## ASSESSMENT

Since 2008, when the IEA conducted a first in-depth review of the European Union's energy policy, the European Union has set in motion several impressive policy and legal actions to consolidate its energy policy, notably to collectively meet the three headline targets under the 2020 Climate and Energy Package and to complete the creation of an internal energy market for electricity and natural gas.

The European Emission Trading Scheme (EU-ETS) and the new legal framework for renewable energy sources (RES) and energy efficiency provide the main instruments for achieving the 2020 targets, while the third internal energy market package (hereinafter: Third Package) and competition law further developed an open energy market. EU competition

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policy action has been paramount in these efforts and its actions are commendable. EU external energy policy is gradually moving towards more solidarity amid repeated gas crises with Russia and Ukraine in 2006, 2009 and 2014 and through new co-operation mechanisms at EU level to enhance the transparency and compliance with internal market laws with regard to intergovernmental agreements of EU members with third countries.

## SUSTAINABILITY: PROGRESS WITHIN THE 2020 CLIMATE AND ENERGY PACKAGE

Between 1990 and 2012, greenhouse gas (GHG) emissions (without land use, land-use change and forestry, LULUCF) in the EU28 have decreased by 19.2%, partly as a result of the economic slowdown and action on energy efficiency, the promotion of renewables and energy efficiency.

Europe has seen substantial investment in renewable energies with growing deployment of renewable energies in electricity, heat and transport. The share of renewable sources in total final energy consumption in the EU28 increased from 8.7% in 2005 to 12.5% in 2010 and 14.1% in 2012. Higher efficiencies of renewable energy technology and mass market penetration are driving down the costs. While the European Union has met its interim 2011/2012 RES targets, the trajectory towards 2020 grows steeper and the cutting back of national support schemes as well as reduced investment due to slow economic recovery could impact the capacity of the European Union to meet the individual and overall targets.

Progress has also been made towards the 2020 energy efficiency ambitions, defined by the 20% non-binding target. The energy intensity of EU industry decreased by almost 19% between 2001 and 2011, new buildings consume half as much energy today as they did in the 1980s and in transport, substantial reductions in GHG emissions are reflected in the fleet average $CO_2$ emission of new cars from 172 g per kilometre in 2000 to 127 g per kilometre in 2013. Energy savings against the 2007 reference scenario are expected to reach 18%-19% by 2020 (EC, 2014h), but 20% if all member states reinforce their actions. To achieve 20% savings by 2020, 13 member states will need to make additional efforts to meet their respective national 2020 targets under the Energy Services Directive, or make use of the flexibility mechanisms foreseen in the legislation.

The European Union has achieved substantial GHG emissions reductions and is on track to meet and even exceed the 20% target. The reduction of GHG emissions is driven by development of renewables, energy efficiency and the EU-ETS. The EU-ETS creates a carbon price, which should create a basis for business decisions, and would be the cost-effective instrument for carbon reductions across many sectors, including aviation and energy-intensive industries. However, since 2008 the EU carbon price has collapsed from EUR 30 to EUR 6 per $tCO_2$. The EU-ETS suffers from a high surplus of allowances as a result of economic slowdown and the inflow of international credits and the inability of the scheme to adjust supply and demand of allowances to economic development. Due to the surplus and currently low prices it currently does not provide sufficient incentives to investors to deploy low-carbon technologies based on carbon markets alone, increasing the risk of “carbon lock-in”.

Emissions reduction in the non-ETS sectors progresses, but this progress is uneven and slow across the member states. Emission savings are most challenging to achieve in the transport sector, as well as buildings and agriculture.



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Overall, the policies implemented under the 2020 Climate and Energy Package are delivering results in terms of energy intensity and energy-related $CO_2$ emissions per GDP. In comparison to European Union's major trade partners (Australia, Canada, Japan, United States), the EU28 stand out in terms of low-carbon performance.

While there are many successes in EU energy policy, there is, however, an insufficient alignment of European-level policies, for example, between the EU-ETS, renewable energy and energy efficiency. Another challenge is the strictly nationally focused subsidy policy in a European internal energy market, as can be seen regarding the use of capacity mechanisms for electricity generation at the national level. In addition, the European Union faces diverging ambitions and progress, in how EU member states implement EU energy market rules. There is a need to reconcile energy market and sustainability policies. Nationally designed climate change policies might increase the cost of the transition towards a low-carbon economy, if they are not integrated into a market-based regime. For example, where renewable energy subsidies act at national level but the EU electricity and carbon markets are at European level, both policies are at risk of incoherence.

The 2020 Climate and Energy Package pursued several objectives with a mix of EU-wide instruments, including the EU-ETS and the internal electricity market, and national targets and subsidies as well as a wide range of harmonised energy efficiency measures (eco-design, building codes, $CO_2$ standards for light-duty vehicles).

The 2020 Climate and Energy Package did not provide sufficient co-ordination of the policies to align the multiple objectives and instruments. Neither the 2020 Energy Strategy nor the umbrella of the Europe 2020 Strategy, making energy part of the overall economic perspective, provided the tools for adjustment to the economic development, cost control and co-ordination among member states and across several energy markets (carbon, gas and electricity). The country-specific recommendations under the Europe 2020 Strategy have increased the level of co-ordination within the European Commission but overall recommendations are not binding and not necessarily focused on energy and climate policies.

## 2030 CLIMATE AND ENERGY POLICY FRAMEWORK

In January 2014 the European Commission proposed the main pillars and targets of a Policy Framework for Climate and Energy in the period from 2020 to 2030. It has drawn the lessons from the progress towards the 2020 targets. Largely backing the proposals by the European Commission, the European Council of October 2014 agreed on a shared vision for 2030 ("2030 Climate and Energy Framework") with three new headline targets of at least 40% of GHG reductions, compared to 1990 levels; of at least 27% of renewable energy in EU energy consumption; and at least 27% energy efficiency by 2030, based on projections of future energy consumption. In addition, EU leaders reconfirmed the existing ambitions to meet the interconnection target of 10% by 2020 at the latest and increase it to 15% by 2030.

A 40% economy-wide emissions reduction target sets the European Union on the track towards meeting the 2050 objective of an 80% emissions cut, as set out in the Commission's Low-carbon Roadmap. The target also sets a strong example to the international community in the negotiations on the new global climate agreement for the Paris Conference of the Parties in 2015. The target will also result in strong benefits in terms of energy independence, the European Union's external fuel bill, health impacts, employment and competitiveness.

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A 40% emission reduction target is ambitious, given that current emission reductions of 19% achieved since 1990 are partly the result of the structural changes in member states that joined in 2004 and 2007 as well as severe financial and economic crisis in Europe.

The proposed EU-wide 40% target is domestic. Depending on the outcome of the international climate negotiations for the period post-2015, a more ambitious target could be proposed with the additional effort balanced by allowing access to international credits.

While the reform is proposed for the EU-ETS (Market Stability Reserve), the emission reduction outside of the EU-ETS will need to be met to a significant extent with new energy efficiency measures as well as the national efforts allocated among member states as appropriate. The option provided for by EU leaders to review the agreed target of at least 27% to 30% in the coming years is very welcome in this respect.

National targets for renewables are no longer envisaged under the 2030 Climate and Energy Policy Framework, as the intention is that in the future renewable energy must be promoted in a way which is – to the greatest extent possible – market-driven. Flexibility is left to member states to choose policies and set ambitions that are most adequate to their national energy mix. This raises questions about the responsibility for the delivery of the EU-wide target. The governance framework to be developed is therefore crucial.

Member states will be expected to prepare national plans covering their overall greenhouse gas reduction targets for 2030. These will include commitments to renewable energy. Once countries have volunteered commitments to renewables within their carbon action plans, and these have been scrutinised by the European Commission with regard to their ability to be aggregated towards the overall target, these targets should become binding on member states, which would then face sanctions if the targets are not achieved. For the policy to be effective it is thus paramount that a similar level of policy confidence can be created with the national plans and supporting framework as have been provided by nationally binding targets.

Creating a market-based framework for delivering a coherent and efficient energy policy towards 2030 should be the overarching objective. This requires four institutional elements: leadership at EU level, sufficient funding, a shared vision for 2030 and co-ordination of all efforts, with a view to reap the benefits from open energy markets, competition, innovation and international technology partnerships. A clear and stable governance framework should help to ensure better co-ordination.

As the European Union continues its policy pathways towards a low-carbon energy economy up to 2030/50, the 2030 Climate and Energy Policy Framework will need to ensure much more robust carbon pricing, the better control of the overall cost of the energy transition, including greater cost-effectiveness of technology subsidies and an EU energy market design which provides stability for investors to commit to the necessary substantial long-term engagement in Europe. At the same time, greater co-ordination should be ensured by the new governance framework that will take into account not only national but also the regional dimension of renewables promotion, energy efficiency and security of supply.

## ENERGY SECURITY

The European Union's declining indigenous oil and gas production pushes up its import dependence in the coming decades. EU dependence on pipeline imports from Russia determines its policy options.



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The forthcoming 2030 Climate and Energy Policy Framework can contribute to energy security, as renewable energy and energy efficiency can help mitigate the European Union's import dependence. However, there are several trade-offs between low-carbon ambitions and energy security goals, which need to be addressed in the follow-up to the EU energy security stress tests and the EU energy security strategy. Security of supply considerations should be integrated with the climate and energy goals. This is underlined by the conclusions reached by the EU heads of state and government at their 2014 October Council.

One example is coal use in the European Union. While coal use in power generation may not have a future under climate change considerations, its use has clear energy security benefits, given low international coal prices and well-diversified supplies, as well as EU indigenous production potential in lignite. The deployment of clean coal technologies, equipped with CCS, is therefore the most desirable solution. An EU system based on renewable energy and natural gas alone would also push up the dependence on gas imports. Environmental regulation and the strengthening of the EU-ETS regime are needed to support effective signals for coal and gas use in power generation.

The exposure of the European Union to changes in the global energy landscape is growing; the European Union thus needs to boost its external energy policy, including on energy trade matters, to reinforce its negotiating position. At the same time, the exposure of EU countries varies, depending on their geographical location, energy mix and supply situation. Some countries benefit from good access to global trade with ports and terminals, while others are landlocked. Therefore, further market integration within the European Union reinforces the collective security of supply.

## COMPETITIVENESS: RETAIL ELECTRICITY AND GAS MARKETS

Due to the sustained economic crisis, EU energy demand has seen a decline; however energy prices increased, with significant impacts on energy market dynamics and the European Union's competitiveness.

From 2008 to 2013, global oil markets are in a sustained period of high oil prices which is without parallel in market history. Where long-term gas contracts were still linked to oil prices, oil price trends were also reflected in traditional gas prices. And gas prices have been on the rise in the European Union since 2008. Higher energy prices add to the pressure on policy makers.

While wholesale electricity prices have, however, in general been decreasing, reflecting increasingly some benefits of functioning wholesale gas and electricity markets, retail prices are running ahead of inflation, despite the economic downturn. Indeed, household and industry retail prices recently increased, due to taxes, levies and higher network costs (EC, 2014m).

As a matter of priority, there is a significant need to improve retail market performance in the European Union.

Despite retail market opening, the benefits from price decreases in the wholesale gas and electricity markets are yet to be translated into final retail prices. This needs to be urgently addressed. Indeed supplier competition and consumer switching are extremely limited to around 6%-8% per year, due to regulated prices, a lack of awareness by consumers, loyalty to incumbents, the perceived complexity of switching processes and passive consumers. Retail energy markets in Europe are nascent, and there is much to be done to deliver economically sustainable benefits to consumers. It is critical that:

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- households and industry can keep their costs down by improving their energy efficiency as well as implementing demand response techniques to reduce energy demand and cost
- innovative investments are enabled and made in an efficient and competitive way
- consumers can access new opportunities to lower their prices by switching to cheaper suppliers.

Member states need to complete their respective retail energy market reforms with urgency in order to enable effective progress to these outcomes and achieve EU objectives.

So far, the roll-out of smart meters and the integration of demand response have made slow progress in the European Union.

Member states should ensure that where smart meters are installed they include functionalities with direct benefits for consumers, such as real-time information on current and historical consumption, enabling implementation of demand-side options and distributed generation. They should aim to review the application of smart meter and smart grid systems, and to report on their utility to consumers, and the degree to which they stimulate innovative sustainable energy service options for consumers.

The challenges are complex: preserving the privacy of consumers, while ensuring market players and operators have open access to anonymous end-use information and data on prices, costs, consumption and investments in energy and energy efficiency for all classes of consumer; and ensuring consumers have free access to their own data, effective comparative information, and that data security and privacy are managed by independent data providers. Review of the actual performance of retail energy billing, meter reading and charging accuracy is crucial.

So far, roll-out of smart meters and the integration of demand response have made slow progress in the Union. In more than 50% of EU member states retail gas and electricity prices remain regulated (ACER/CEER, 2014). State intervention is often warranted for vulnerable citizens. But it should not be applied in a manner that distorts economic delivery of sustainable outcomes in a constrained resource, such as energy or water. And effective response to social needs can be more effectively delivered by targeted social measures than by distorting energy market retail prices. Total energy costs for consumers can be minimised, while improving social well-being and health by providing assistance with household energy efficiency.

Where a member state identifies a need for social support, it should transfer energy price subsidies to targeted energy efficiency aid creating a sustainable reduction in ongoing household energy costs. It is crucial to expand the understanding of the concept, extent and implications of consumer vulnerability for European society. The work of the Vulnerable Consumer Working Group under the London Forum provides essential guidance, and this should inform decision-making on improved targeting of support at European and member state levels.



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## RECOMMENDATIONS

*The European Union should:*

- *Set out clear and stable governance and market-based legal structures for the 2030 Climate and Energy Policy Framework to deliver a consistent European climate and energy policy to integrate sustainability, competitiveness and security of supply goals.*
- *Accelerate the implementation of market reforms, notably with regard to gas and electricity retail markets, in close co-operation with the European Commission services (DG Energy, DG SANCO, DG Competition) and stakeholders by:*
  - *Promoting cost-reflective marginal pricing for retail electricity and gas in member states and encouraging the deployment of innovative technologies (smart meters, grids and information technologies) and tariffs to all classes of consumers, including time of use, progressive tariffs and bulk rate options.*
  - *Phasing out regulated prices while ensuring targeted social aid to vulnerable consumers and redirecting remaining energy price subsidies to energy efficiency policies that reduce the energy costs to consumers and improve social, health and comfort outcomes.*
  - *Preserving the privacy of consumer data, while ensuring market players and operators open access to anonymous end-use information and data on prices, costs and consumption.*
  - *Regularly reviewing progress and identifying the incentives for market-based demand-side management and energy efficiency solutions for consumers and energy service obligations for utilities.*

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# 3. CLIMATE CHANGE

**Key data (2012)**

**$CO_2$ emissions from fuel combustion:** 3 504.9 Mt, -13.8% since 1990

**Emissions by source:** oil 40.2%, coal 32.4%, natural gas 25.6%, other 1.8%

**Emissions by sector:** power generation 37.5%, transport 24.6%, industry 15%, residential 11.5%, commercial and other services 6.6%, other energy industries 4.8%

**Carbon intensity:** 0.25 $tCO_2$ per USD 1 000 PPP (IEA average: 0.31 $tCO_2$ per USD 1 000 PPP), -40.9% since 1990

## OVERVIEW

The European Union (EU) has put forward ambitious climate change policies since the first IEA in-depth review for the implementation of the 2020 Climate and Energy Package: domestic greenhouse gas (GHG) emission reduction targets, the largest multi-sector EU emission trading scheme (EU-ETS) in the world, close co-operation with international mechanisms, and financial commitments to support mitigation and adaptation in developing countries.

In 2009, the European Union took on a unilateral target to reduce its GHG emissions by 20% in 2020 below 1990 levels and is currently on track towards achieving it. The European Union has lower carbon intensity than non-European IEA members, including Australia, Canada, Japan, Korea, New Zealand and the United States. Carbon intensity in the European Union has declined by 40.9% since 1990. The European Union is on track to exceed its Kyoto target for 2008-12. Economic growth and emissions have largely been decoupled. In 2012, the EU real GDP was 45% higher than in 1990, while its GHG emissions decreased by 19.2% in the same timeframe.

The power sector is the largest emitter of $CO_2$, although its emissions and those of the residential and industry sectors have been falling. Transport emissions (nearly a quarter of the total), have, however, risen since 1990. By fuel, oil consumption is responsible for the largest share of emissions but these and emissions from coal have fallen. Conversely emissions from gas combustion have risen, accounting for 40% of emissions.

At the same time, the EU carbon market under the EU-ETS has experienced a major price collapse from around EUR 30 per tonne of carbon dioxide ($tCO_2$) to EUR 6 per $tCO_2$ since 2008. These price levels did not act as a signal for the decarbonisation of the power sector or the investment in low-carbon technologies, including carbon capture and storage (CCS). Despite EU efforts to co-ordinate commercial-scale CCS developments through harmonised permitting rules and some project funding, progress is far off track compared to stated ambitions. This puts at risk the achievement of longer-term emissions reduction goals in the non-ETS sectors to the horizons 2030 and 2050.

A contribution to actual GHG emissions reductions came from the industrial slowdown, but notably from the goal of increasing the share of renewable energy in gross final

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energy consumption to 20% by 2020.[1] It has resulted in more than doubling the share of renewables (from 6% in 1990 to 14% in 2012). Growing policy support for energy efficiency has also started to be reflected in accelerated energy efficiency improvements, and reduced emissions. The interactions and synergies between these policies remain, however, largely unco-ordinated.

Internationally, the European Union has placed climate change at the heart of its external relations, and in particular in its relations with developing countries, where the European Union leads efforts to fast-start financing of climate action around the globe. Recognising that climate change affects all social and economic development activities, the European Union is introducing climate change mitigation and adaptation at the core of its work. It addresses this through policies and strategies at the EU level and in member states, and through the work with partner countries.

The European Union and its member states have been actively participating in the United Nations Framework Convention on Climate Change (UNFCCC) climate negotiations, including in the current efforts towards a new global agreement beyond 2020, which is hoped to be agreed at the Conference of the Parties (COP) 21 in 2015. In October 2014, EU leaders have taken the lead at global level and put forward a commitment under the 2030 Climate and Energy Policy Framework with a target of at least 40% GHG emission reduction by 2030, below 1990 levels.

## ENERGY-RELATED $CO_2$ EMISSIONS

### $CO_2$ EMISSIONS BY SECTOR AND BY FUELS

$CO_2$ emissions from fuel combustion form the greatest contribution to GHG emissions in the European Union, with 3 504.9 million tonnes (Mt) in 2012. This is 11.2% lower than in 2007 and 13.8% lower than in 1990. $CO_2$ emissions have been declining since the early 1990s, but showed a slight increase during the early 2000s.

Transport is the only sector where emissions are on the rise, reaching 24.6% of the total in 2012, which was an increase by 14.4% since 1990. The power generation sector is the largest $CO_2$ emitter (Table 3.1), it accounted for 37.5% of emissions from fuel combustion in 2012. Emissions in this sector have declined by 12.9% compared to 1990. Industry and the residential sector accounted for 15% and 11.5% of total emissions in 2012, respectively. Emissions in industry were 36.7% lower in 2012 compared to 1990, while emissions by households were down by 18.1%. Other energy industries, including transformations, represented 4.8% of $CO_2$ emissions from fuel combustion in 2012.

In relation to all $CO_2$ emissions from fuel combustion in 2012, oil consumption was responsible for 40.2%, coal for 32.4%, natural gas for 25.6%, and industrial waste for 1.8%. Since 1990, emissions from the use of oil and coal have reduced, by 15% and 34.4%, respectively. Conversely, emissions from natural gas have increased by 35.6%.

**1**. Gross final consumption of energy is defined in Directive 2009/28/EC on renewable sources as energy commodities delivered for energy purposes to final consumers (industry, transport, households, services, agriculture, forestry and fisheries), including the consumption of electricity and heat by the energy branch for electricity and heat production, and including losses of electricity and heat in distribution and transmission. The gross final consumption of energy from renewable sources is calculated as the sum of: (a) gross final consumption of electricity from renewable energy sources; (b) gross final consumption of energy from renewable sources for heating and cooling; and (c) final consumption of energy from renewable sources in transport.



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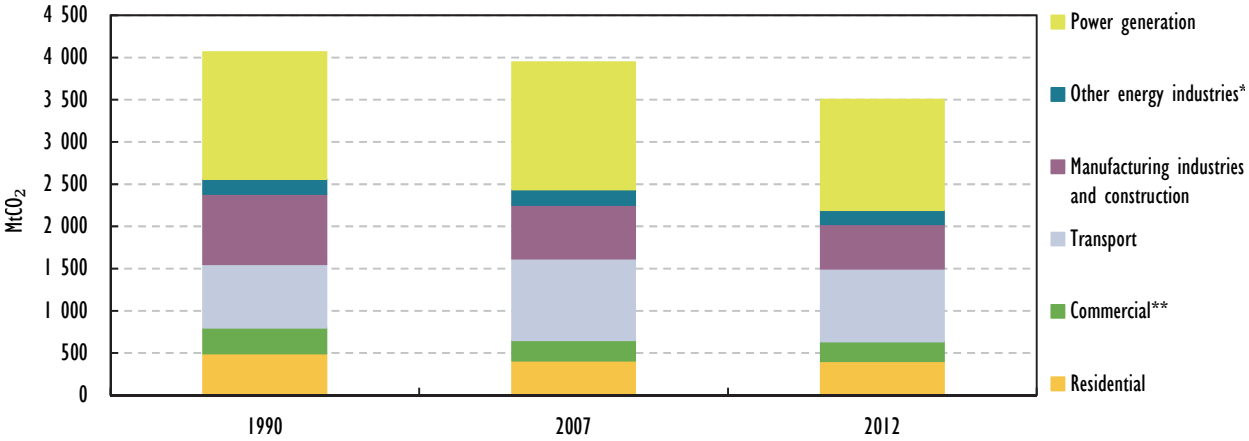
**Figure 3.1** $CO_2$ emissions in the European Union by sector, 1990-2012

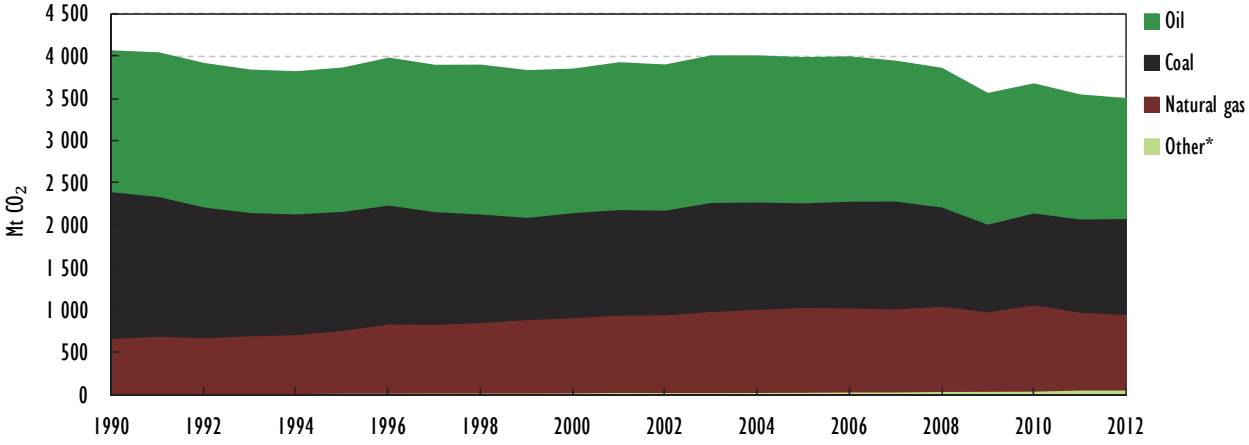



* *Other energy industries* includes refining/other transformations and energy own use.

** *Commercial* includes commercial and public service, agriculture/fishing and forestry.

Source: IEA (2014), *$CO_2$ Emissions from Fuel Combustion*, OECD/IEA, Paris.

**Figure 3.2** $CO_2$ emissions in the European Union by source, 1990-2012




* *Other* includes industrial waste and non-renewable municipal waste.

Source: IEA (2014), *$CO_2$ Emissions from Fuel Combustion*, OECD/IEA, Paris.

## CARBON INTENSITY

Carbon intensity in the European Union, measured as tonnes of $CO_2$ ($tCO_2$) emissions per unit of gross domestic product at purchasing power parity (GDP PPP) using 2005 USD prices, was 0.25 $tCO_2$ per USD 1 000 at PPP of real GDP ($tCO_2$/USD 1 000 PPP) in 2012. This is lower than the IEA member country average of 0.31 $tCO_2$/USD 1 000 PPP. The European Union has lower carbon intensity than non-European IEA members Australia, Canada, Japan, Korea, New Zealand and the United States (see Figure 3.3).

Carbon intensity in the European Union has declined by 40.9% since 1990. Energy-related $CO_2$ emissions per capita in the European Union dropped by 19% between 1990 and 2012, from 8.5 t per capita to 6.9 t per capita, lower than IEA average (see Figure 3.4). Largely because of the economic and financial crisis and the introduction of energy and climate policies, a 3.3% emissions decrease took place in households, power generation and industry alone between 2010 and 2012.

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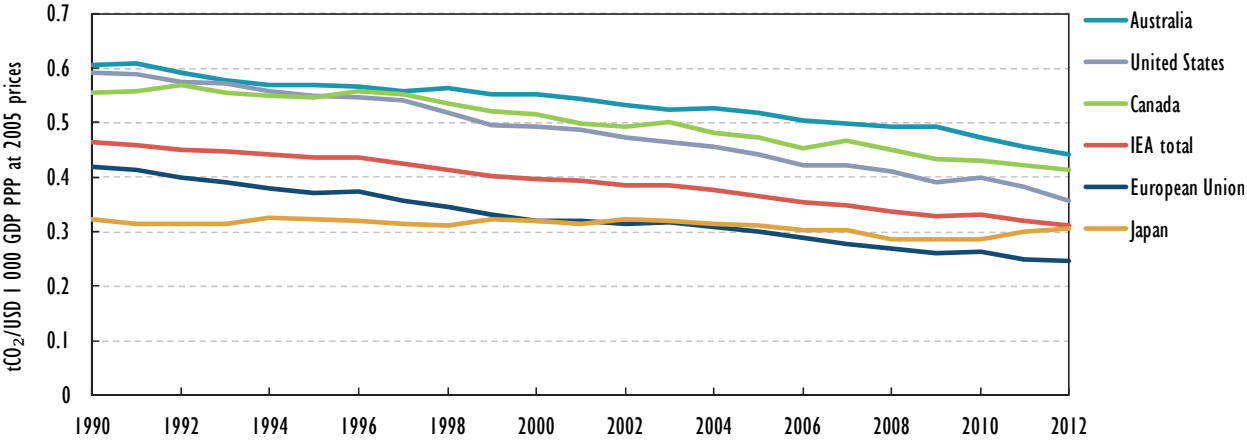
**Table 3.1** Overview of $CO_2$ emissions by sector, 2012

| $CO_2$ emissions (in $MtCO_2$) | 2012 |
|---|---|
| Power generation | 1 314.5 |
| Other energy industries | 166.5 |
| Manufacturing industries and construction | 527.3 |
| Transport | 861.7 |
| Residential | 232.2 |
| Commercial | 402.7 |
| **Total** | **3 504.9** |

Source: IEA (2014), *$CO_2$ Emissions from Fuel Combustion*, OECD/IEA, Paris.

**Figure 3.3** Energy-related $CO_2$ emissions per real GDP in the European Union and selected IEA member countries, 1990-2012




Source: IEA (2014), *$CO_2$ Emissions from Fuel Combustion*, OECD/IEA, Paris.

Carbon intensity in electricity and heat generation is measured as grams of electricity- and heat-related $CO_2$ emissions per kilowatt hour of electricity and heat generated ($gCO_2$/kWh). This parameter has been steadily declining in the European Union, demonstrating a certain degree of decarbonisation of the electricity sector (see Figure 3.5). Average carbon intensity of the EU electricity and heat sector was slightly above 300 $gCO_2$/kWh in 2012, while the IEA average was above 400 $gCO_2$/kWh.

Although the EU average carbon intensity of the electricity and heat sector does not look too bad compared to some other IEA member countries, progress of decarbonisation in the EU electricity sector has been slow. The sector has become only 28% less carbon-intensive in the last 20 years.

The IEA analysis suggests that, in order to be consistent with an ambition of a two degree scenario (2DS) trajectory,[2] all new-built power generation around the world before 2020 needs to be of a low-carbon intensity of 200 $gCO_2$/kWh.

**2.** The two degree scenario (2DS) describes an energy system consistent with an emissions trajectory that recent climate science research indicates would give an 80% chance of limiting average global temperature increase to 2°C. It sets the target



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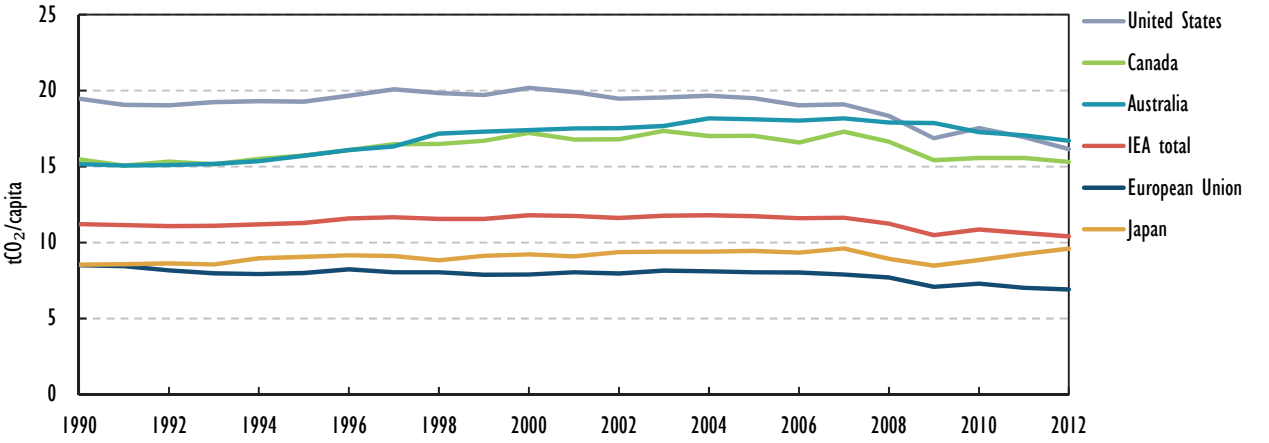
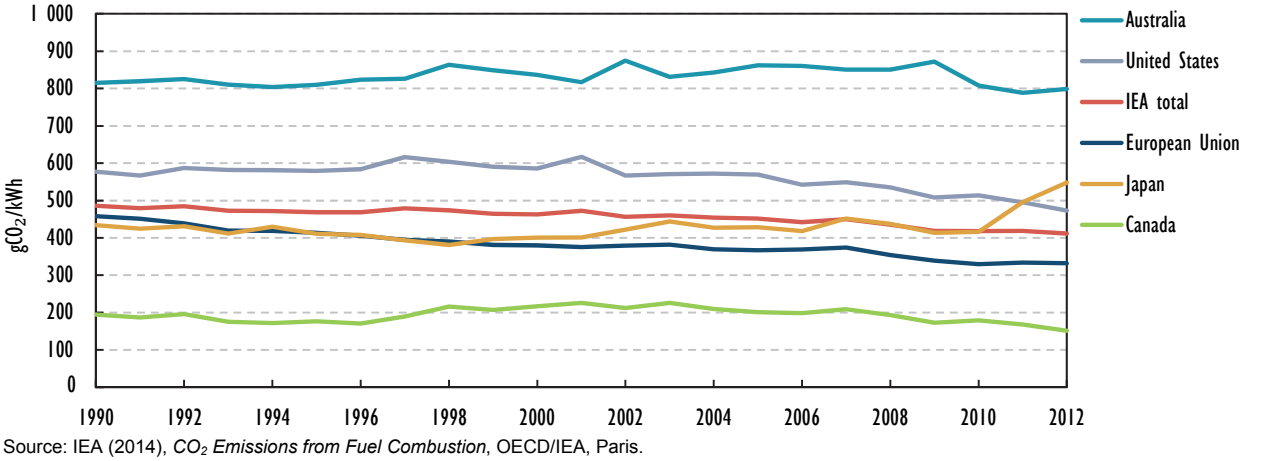
**Figure 3.4** Energy-related $CO_2$ emissions per capita in the European Union and selected IEA member countries, 1990-2012




Source: IEA (2014), *$CO_2$ Emissions from Fuel Combustion*, OECD/IEA, Paris.

**Figure 3.5** $CO_2$ emissions from electricity and heat generation in the European Union and selected IEA member countries, 1990-2012




Source: IEA (2014), *$CO_2$ Emissions from Fuel Combustion*, OECD/IEA, Paris.

## POLICIES AND MEASURES

The central framework of the European Union's energy and climate policy is the 2020 Climate and Energy Package (see also Chapter 2, "General Energy Policy").[3] The Package includes a set of legislative acts to implement the three headline targets: to reduce European Union's greenhouse gas (GHG) emissions by at least 20% by 2020 compared to 1990 (Decision 406/2009/EC), the commitment to supplying 20% of energy from renewable sources in gross final consumption by 2020 (Directive 2009/28/EC), supplemented by a target to achieve a minimum of 10% renewable transport fuel in final consumption. The

of cutting energy-related $CO_2$ emissions by more than half in 2050 (compared with 2009) and ensuring that they continue to fall thereafter. Importantly, the 2DS acknowledges that transforming the energy sector is vital, but not the sole solution: the goal can only be achieved provided that $CO_2$ and GHG emissions in non-energy sectors are also reduced. The 2DS is broadly consistent with the *World Energy Outlook* 450 Scenario through 2035.

**3.** Directives 2009/28/EC, Directive 2009/29/EC, 2009/30/EC, 2009/31/EC and Decision 406/2009/EC.

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European Union has also committed to a 20% reduction of total primary energy consumption by 2020, compared to the 2007 Business-as-Usual baseline projections,[4] as specified under the subsequent Energy Efficiency Directive (Directive 2012/27/EU) in 2012.

At EU level, this overall effort of 20% GHG emission reduction is divided between a 21% reduction target compared to 2005 for the emissions from the sectors covered under the European Emission Trading Scheme (EU-ETS) and a 10% reduction target compared to 2005 for the remaining non-ETS emissions. The 21% target is largely implemented at EU level through the EU-ETS, while the 10% reduction target is split into national sub-targets for the non-ETS sectors (see Figure 3.6). Emission reductions in the non-ETS sectors, amounting to 60%, are set under the so-called Effort-Sharing Decision; they remain the responsibility of individual member states that are committed to binding annual targets for reducing their GHG emissions for each year from 2013 to 2020 from the sectors not covered by the EU-ETS, such as housing, agriculture, waste and transport (not aviation or maritime transport). The revised and strengthened Monitoring Mechanism Regulation (MMR), which entered into force in 2013, sets out the reporting rules on GHG emissions to implement the 2020 Climate and Energy Package and to meet requirements arising from international climate agreements.

The 2020 Climate and Energy Package also included the legal framework for safe and environmentally sound storage of $CO_2$ under the CCS Directive[5] and a communication highlighting the need to support CCS projects at commercial scale.

The Package is further complemented by two legislative acts: a regulation requiring a reduction in $CO_2$ emissions from new cars (Regulation (EC) No 443/2009) and a revision of the Fuel Quality Directive (2009/30/EC). $CO_2$ regulations were strengthened over time (Regulation No 397/2013, Regulation No 63/2011).

Future legislation is being considered. In 2013, the Commission adopted the Clean Power for Transport Package, which supports the deployment of alternative-fuels vehicles and vessels and the relevant infrastructures. The Commission also adopted a strategy for progressively including GHG from maritime transport. As a first step, a proposed legislation for the monitoring, reporting and verification of emissions from large ships is under consideration by the Parliament and the Council. In 2014, the European Union has agreed new targets for a 2030 Climate and Energy Policy Framework (see Table 3.2). For the non-ETS sectors, Cyprus[6] and Greece have the lowest reduction targets of -5% and -4% respectively, while Denmark, Ireland and Luxembourg committed to the highest emission reductions of -20% each by 2020.

**4.** Under the Energy Efficiency Directive the European Union 2020 target is specified as capping consumption at 1 483 Mtoe primary energy or 1 086 Mtoe of final energy, after the accession of Croatia.

**5.** Directive 2009/31/EC of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 (Text with European Economic Area (EEA) relevance).

**6.** Two footnotes: 1. **Footnote by Turkey**: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue". 2. **Footnote by all the European Union Member States of the OECD and the European Union**: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.



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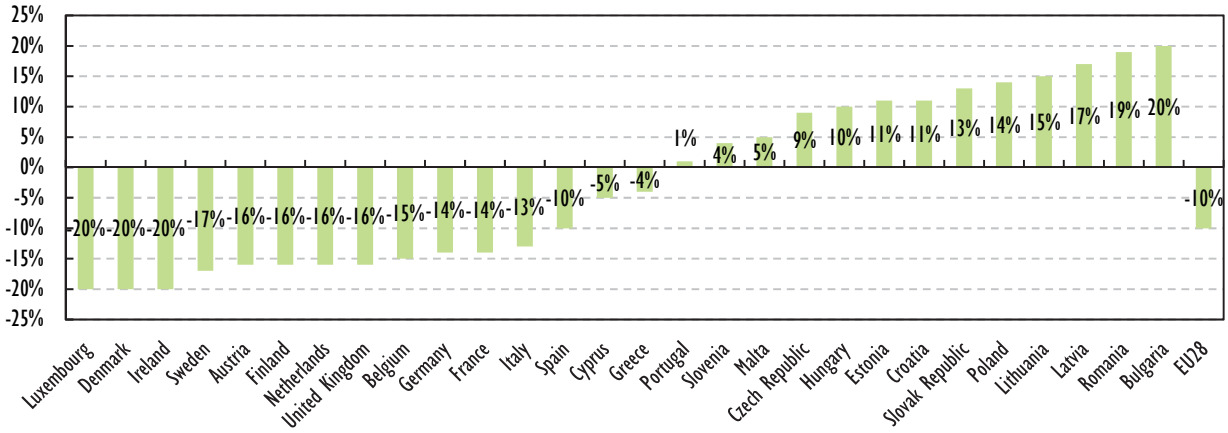
**Figure 3.6** EU member states emissions reduction targets for 2020 in non-ETS sectors




Source: Based on the targets set in Decision 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the efforts of member states to reduce their GHG emissions to meet the Community's GHG emissions reduction commitments up to 2020 as amended by Protocol 12012JN03/08.

**Table 3.2** Summary of EU commitments to reducing its GHG emissions

| Date | Commitment | | Nature of commitment | Target date for achievement | Reduction in GHG below 1990 level: % | Progress to meeting target |
|---|---|---|---|---|---|---|
| 1997 (into force 2005) | Kyoto Protocol | EU15 | International treaty; binding | 2008-12 | 8 | Probably over-achieved |
| 2012 | Doha Amendment to Kyoto Protocol | EU | International treaty; binding* | 2013-20 | 20 | - |
| 2009 | 2020 Climate and Energy Package | EU | Self-imposed; binding | 2020 | 20 | On track to meet |
| 2014 | 2030 Climate and Energy Policy Framework | EU | Self-imposed; binding | 2030 | 40 | - |
| 2011 | 2050 Roadmap for a competitive low-carbon economy | EU | Aspiration | 2050 | 80-95 | - |

* Pending adoption/ratification.

## PROGRESS ON GHG EMISSIONS, TARGETS AND PROJECTIONS

As a contribution to climate change mitigation, the European Union has taken on a series of commitments to reduce its greenhouse gas (GHG) emissions. The European Commission with the support of the European Environment Agency (EEA) evaluates progress towards its targets every year and sets out projections for 2020.

- Under the Kyoto Protocol, the 15 countries that were EU members before 2004 (EU15) agreed to reduce their GHG emissions together by 8% compared to base year levels,[7] during the first commitment period (2008-12). On the basis of the latest

**7.** Article 3 sets 1990 as the most important baseline, but allows economies in transition to choose another year. Depending on the greenhouse gas, the parties can use 1995 as base year for hydrofluorocarbons (HFC), perfluorocarbons,(PFC) and sulphur hexafluoride ($SF_6$).

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available inventory data for 2012, total GHG emissions in the EU15 were on an annual average 16.3% below base year levels without emissions and removals from land use, land-use change and forestry (without LULUCF). The EU15 is set to over-achieve its target for 2012. In 2012, total EU28 GHG emissions without LULUCF and excluding emissions from international aviation, were 19.2% lower than 1990 levels.

- The European Union also supports the Doha Amendment to the Kyoto Protocol that extends the Protocol from 2013 to 2020. Ratification of the Doha agreement by the European Union and its member states is necessary to help ensure its formal entry into force as an international agreement. The Commission sees a timely ratification of the amendment in early 2015 as an important milestone in the UN climate negotiations. This would impose a commitment to reduce GHG emissions by 20% below 1990 levels during the second commitment period (2013-20).
- EU leaders have endorsed as their pledge for a low-carbon economy the objective of reducing Europe's GHG emissions by 80% to 95% below 1990 levels by 2050, as proposed in the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report in 2007, at their European Council in 2009. They have endorsed this target range as an EU objective in the context of developed countries as a group making the reductions needed.[8]
- In 2008 the European Union took on a unilateral domestic target of reducing GHG emissions by 20% by 2020 compared to 1990 levels. The latest available GHG projections by member states (which take into account the implementation of the climate and energy package) show that the EU28 will collectively over-achieve its 2020 target.
  - Under the "With Existing Measure" (WEM) scenario, total GHG emissions (excluding international aviation) are projected to be 22% lower in 2020 than in 1990 and 24% lower in 2030 compared to 1990.
  - Under the With Additional Measures" (WAM) scenario, as reported by member states, the projected GHG emissions compared to 1990 would decrease by 26% in 2020, and by 30% in 2030.
  - The WEM sensitivity analysis confirms the projected 2020 target achievement. The 2030 results are more uncertain and more dependent on the assumptions made. However, the sensitivity analysis confirms for 2030 the order of magnitude indicated by the WAM scenario results. The most significant sectoral contribution in absolute GHG emission reductions in the EU28 WEM scenario between 1990 to 2020 is projected to stem from the energy sector (1 051 Mt $CO_2$eq).
- As part of the 2020 Package, an amendment to the Fuel Quality Directive (Directive 2009/30/EC) introduced a binding target for fuel suppliers to reduce the GHG intensity of fuels in transport by up to 6% by 2020, compared to a 2010 baseline. There has been no progress in implementing the measure, pending the adoption of a common methodology for GHG intensity.
- Significant progress has been made to reduce the average $CO_2$ emissions of the new passenger car fleet and meet the binding targets set at 130 $gCO_2$/km by 2015 and 95 $gCO_2$/km by 2020. Average emissions decreased to 132.2 $gCO_2$/km in 2012, compared with the 2007 fleet average of 158.7 $gCO_2$/km.

**8.** European Council, Presidency Conclusions, 1 December 2009, Brussels, 15265/1/09 REV 1. It is important to underline that this means the target is not unilateral.



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- In January 2014, the European Commission proposed the main elements of a Policy Framework for Climate and Energy in the period from 2020 to 2030 (EC, 2014a), including a binding GHG emissions reduction target of 40% below 1990 levels by 2030, a binding EU-level renewable energy target (of at least a 27% share of renewable energy in gross final energy consumption), and an EU-level energy efficiency target of 30% savings compared to a baseline projected from 2007, which was added in July 2014 following the review of the Energy Efficiency Directive (EC, 2014b). The sectors covered by the EU-ETS would be required to cut emissions by 43% in 2030 (versus 2005). The emission reductions in non-ETS sectors are set at 30% in 2030 (compared to 2005) which is to be shared equitably among the member states in the form of binding national targets. It also includes a reform of the EU-ETS post-2020 with a market stability reserve. The European Council of October 2014 largely endorsed these goals in its conclusions on the 2030 Climate and Energy Policy Framework, but stayed at a minimum indicative EU-wide ambition for energy efficiency of at least 27% savings by 2030.

## EU-EMISSIONS TRADING SCHEME (EU-ETS)

The EU-Emissions Trading Scheme (EU-ETS) is one of the key climate policy instruments implemented in the European Union and is aimed at helping the achievement of GHG reduction targets of the European Union and its member states in a cost-effective manner. Established by Directive 2003/87/EC (the Emissions Trading Directive), the EU-ETS is in force since 1 January 2005. With the 2020 Climate and Energy Package, the Emissions Trading Directive was revised (Directive 2009/29/EC, the amended EU-ETS Directive) in order to help the European Union achieve its commitment to cut its GHG emissions by 20% compared to 1990 levels by 2020. The EU-ETS is the first and by far the largest multi-sector international scheme for trading GHG emission allowances. The EU-ETS is set to undergo another reform (see Box 3.1).

During this second trading period from 2008 to 2012 the scope of the EU-ETS was enlarged and covered on average 40% of total GHG emissions in the EU28 and three European Economic Area–European Free Trade Association (EEA-EFTA) states (Iceland, Liechtenstein and Norway).[9]

The EU-ETS included approximately 12 000 stationary installations in the energy and most industrial sectors, including power stations and other combustion plants, oil refineries, coke ovens, iron and steel plants and factories making cement, glass, lime, bricks, ceramics, pulp and paper. Since 2012 about 1 200 aircraft operators have also been included in the scheme. In principle the EU-ETS covers all flights arriving at and departing from airports in all EU member states, Norway, Iceland, and Liechtenstein. However, in 2012 only flights within the EU member states, Norway, Iceland, and Liechtenstein and closely related territories are part of the scheme. This “stop-the-clock decision” was taken in order to facilitate the negotiation of a global agreement on aviation emissions under the International Civil Aviation Organisation (ICAO).

Other additional sectors and gases covered from 2013 onwards include: capture, transport and geological storage of GHG emissions, $CO_2$ emissions from petrochemicals, ammonia and aluminium production, nitrous oxide ($N_2O$) emissions from the production of nitric, adipic and glyoxylic acid, and perfluorocarbon (PFC) emissions from aluminium production.

[9] See www.efta.int/eea.

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## Allocation and auction of allowances

During the first two trading periods, most emissions allowances were allocated for free by governments according to national allocation rules and a small amount of allowances was auctioned.

In 2013, the EU-ETS entered its third trading period, which will run until 2020. Starting from the third trading period, a single, EU-wide emissions cap, auctioning of new allocations as the default allocation method, harmonised allocation rules for industries deemed to have competitiveness concerns based on EU-wide performance benchmarks for free allocation, and additional sectors and gases were included. From the third trading period onwards, a single EU-wide cap determines the amount of emissions allowed by EU-ETS sectors. Furthermore, from 2013 onwards, a linear reduction factor of -1.74% per annum applies.

During the first trading period, almost all emission unit allowances (EUAs) were allocated for free to EU-ETS installations (less than 1% was auctioned or sold). In the second trading period, 95% of EUAs were freely allocated, with the remainder auctioned or sold. The volume of auctioned EUAs increased from 53 million in 2008 to 125 million EUAs in 2012. In the third trading period, auctioning is the default method for allocating allowances instead of free allocation: more than 40% of allowances will be auctioned in the 2013-20 period with progressively rising shares each year:

- For the power generation sector, the rule is that operators no longer receive any free allowances but have to buy them.
- In sectors other than power generation, the transition to auctioning is taking place progressively. In the aviation sector, however, only 15 % of aviation allowances will be auctioned over the whole 2013-20 period.

The auctioning of allowances is governed by the EU-ETS Auctioning Regulation. Five percent of the total quantity of allowances will be put into a reserve for new installations or airlines that enter the scheme after 2013 ("new entrants").

## Risk of carbon leakage

Process industries may receive part, or, if subject to carbon leakage,[10] all of their allowances for free at the level of harmonised industry best practice benchmarks. These benchmarks and the allocation rules were adopted by the European Commission for the whole third trading period.

According to the EU-ETS Directive (Article 10a), a sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage if: 1) the extent to which the sum of direct and indirect additional costs induced by the implementation of the directive would lead to an increase of production cost, calculated as a proportion of the gross value added, of at least 5%; and 2) the trade intensity (imports and exports) of the sector with countries outside the European Union is above 10%. A sector or sub-sector is also deemed to be exposed to a significant risk of carbon leakage if: a) the sum of direct and indirect additional costs is at least 30%; or b) the non-EU trade intensity is above 30%.

**10.** Carbon leakage describes the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries which have laxer constraints on greenhouse gas emissions. This could lead to an increase in their total emissions.



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The so-called "carbon leakage list" was adopted for five years. The existing list was adopted in 2009. A new list is currently being prepared for the period 2015-19.

Under state aid regimes, EU member states can compensate companies faced with significant risk of carbon leakage for up to 85% of the cost increase of electricity resulting from the EU-ETS borne by the most efficient installations in 2013-15, falling gradually to 75% by 2019-20.

### Use of EU-ETS auction revenues

The revised ETS Directive stipulates that at least half of the revenues from the auctioning of general allowances and all of the revenues from auctioning aviation allowances should be used to combat climate change in Europe or other countries. Member states are obliged to inform the Commission of how they use the revenues, but have no obligation to use the revenues for domestic energy and climate measures. All auction revenues are managed by the member states and several have created climate funds to leverage those revenues.

At EU level, the NER300, so-called because it is funded from the sale of 300 million emission allowances from the New Entrants' Reserve set up for the third phase of the EU-ETS, was created to support innovative low-carbon energy demonstration projects. The programme was conceived as a catalyst for the demonstration of environmentally safe CCS and renewable energy source (RES) technologies on a commercial scale within the European Union (see also Chapter 11, "Energy Research, Development and Demonstration").

The European Commission, the member states and the European Investment Bank (EIB) jointly manage the instrument. Projects developers apply to the member state, in which they want to situate their project. Member states, on the basis of the received proposals, provide the EIB with eligible candidates for consideration in the selection process. The EIB carries out the sales of the emission allowances through auctions and performs the technical and financial assessment of the project proposals, as basis for member states to confirm their projects and relevant funding. The final list of projects for award is established and the funding decision adopted by the European Commission following the vote by the member states in the Climate Change Committee. The funds available to support projects depend on the carbon price.

The funding is to be distributed to projects selected through two rounds of calls for proposals, covering 200 million and 100 million allowances respectively, and must be complemented by equal funding from member states or private companies for each successful project. NER300 funding is not part of the general budget of the European Union and may be combined with other EU funding instruments.

Under the first call for proposals in December 2012 the European Commission granted funding to 23 renewable energy projects, totalling EUR 1.2 billion. This amount is estimated to have leveraged additional funding of over EUR 2 billion from private sources. The second call, in spring 2013, resulted in the award of EUR 1 billion to 19 projects, including EUR 300 million to one CCS project. Despite the initial recognition that CCS projects required an EU-wide support mechanism, only one CCS project was awarded funding by NER300. The funding conditions present a challenging timeline for this CCS project to enter in operation by 2018.

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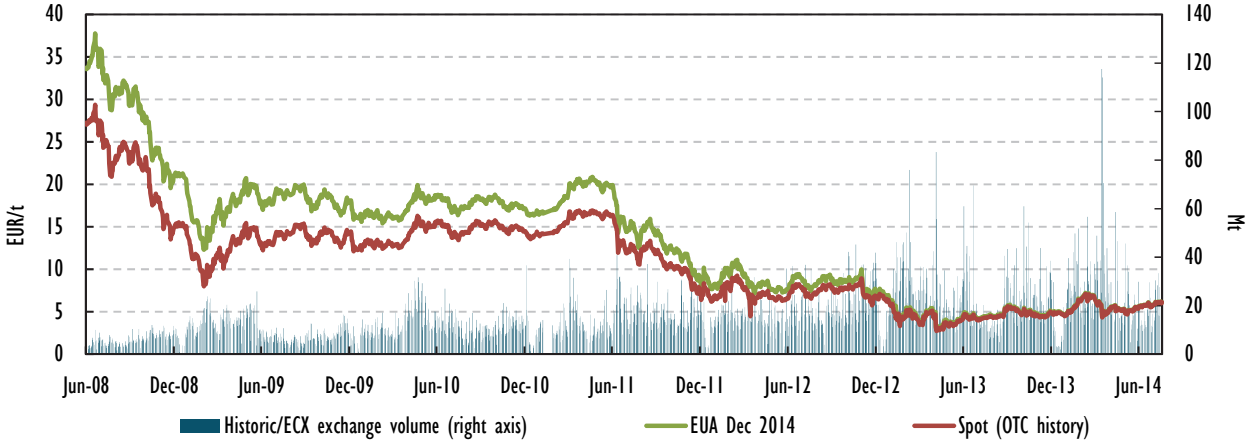
**Figure 3.7** Historic evolution of volumes (Mt) and spot prices for emission allowances (EUR/t) under the EU-ETS




Source: Thomsom Reuters Eikon (2014), Research and Forecasts for Energy database (formerly Point Carbon): www.pointcarbon.com/news/marketdata/euets/forward/eua, Date of access: 1 August 2014.

**Box 3.1** Reforming the EU-ETS

The potential of the EU-ETS and its practical impact on companies' behaviour and investment patterns have been challenged in recent years with a decline of the (spot) $CO_2$ price from around EUR 30 $tCO_2$ in 2008 to around EUR 6 $tCO_2$ in 2014 (see Figure 3.7). The volumes have increased over time, notably with the start of the auctioning in the third period. However, prices remained at a record low. This is the result of several factors that impacted the current EU-ETS current design.

- The significant reduction of energy demand and emissions amid the financial and economic crisis starting in 2008.
- The large inflow of international credits: most of the international credits available until 2020 have already been used by 2012 given the very low credit prices.
- The current cap and the 1.74% annual linear reduction factor are not sufficient to keep the emissions trajectory on the right path towards 2050 objectives.
- The multiple policy objectives and their inter-linkages can also have an impact on the EU-ETS price with an increasing share of renewables and progress on energy efficiency under EU 2020 targets. However, the 20% renewables target was part of the analysis underpinning the ETS revision in 2009 and there is no evidence of an impact of energy efficiency improvements on current price decrease in the EU-ETS.
- The current design of the EU-ETS does not allow the adjustment of supply of allowances in reaction to the changes in demand except in the case of significant price spikes.

As a result, a surplus of nearly 1.8 billion emission allowances (EUAs) has been accumulated at the end of the second trading period. Since banking is allowed between the second (2008-12) and third trading period (2013-20), this surplus is carried over to the next stage of the scheme. The surplus of EUAs is likely to total 2 to 2.5 billion by 2020.



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**Box 3.1** Reforming the EU-ETS (continued)

The EU-ETS reform is vital to ensure a functioning carbon market in the European Union. As a short-term measure, the European Union has agreed in early 2014 that the auctioning of 900 million allowances should be postponed from the years 2014-16 until 2019-22, when it is expected that demand will have picked up. This "back-loading" of auctions is accomplished by the amended ETS Auctioning Regulation. In 2014, about 400 million allowances will be withdrawn from the scheme.

Back-loading may temporarily address the problem of over-supply but releasing allowances back into the market at a later date will dilute the signal that the market sends to investors. A more effective measure would have been the cancellation or "set-aside" of a portion of this surplus acknowledging the fact that grandfathering of initial emission rights by member states was generous.

The EU-ETS surplus is not the fault of energy policies (e.g. specific renewables support schemes) that were introduced to stimulate uptake of technologies and markets. However the large share of abatement delivered by these policies and absence of flexibility in the time profile of putting allowances on the market left the scheme more vulnerable to changing economic conditions. The renewable energy target would account for a large share of the abatement required in order to meet the 20% emission target, and the 20% energy efficiency target could imply a similar amount if fully achieved. So, by design, the residual emissions reductions required from the EU-ETS market were expected to be small. The economic recession has more than eliminated this small margin.

As a longer-term measure to strengthen the EU-ETS in the period after 2020, the European Commission proposed on 22 January 2014 to establish a Market Stability Reserve at the beginning of the next EU-ETS trading period in 2021. The reserve is intended to address the surplus of emission allowances that has built up and improve the scheme's resilience to major shocks and impacts of other policies by automatically adjusting the supply of allowances to be auctioned. In addition, the Commission also proposes to change the linear factor to 2.2% from 2021 onwards. These reforms should be introduced without delay.

There has been discussion about enlarging the scope of the EU-ETS to other sectors, including transport. Bringing in transport fuels under the EU-ETS would create a minimal price signal but risk undermining the use of taxation by member states as primary environmental instrument in transport. Again the price signals from the EU-ETS would not deliver the transformation of the transport infrastructure.

While these reforms are intended to improve the performance of the EU-ETS, the question remains of what degree of decarbonisation the EU-ETS is expected to drive given other policy measures for renewables and energy efficiency. Analysis by the IEA and business groups shows that for the EU-ETS to become instrumental in changing decisions of power plant operations under the current energy market conditions, it needs to present a carbon price of about EUR 40 (the threshold for coal-to-gas switching at current commodity prices). To drive capital investment in power generation, a carbon price of around EUR 30 would be needed for onshore wind investments without additional subsidies. These higher price perspectives are unlikely to materialise while the EUA surplus comparable to the current size persists.

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## International measures and trading of emission allowances

The EU-ETS is directly linked to the Kyoto Protocol's project mechanisms according to Directive 101/2004/EC. Operators that are liable under the EU-ETS are allowed to use credits from both Clean Development Mechanism (CDM) and Joint Implementation (JI) projects to comply with their legal obligation.

The use of these flexible mechanisms in the period 2013-20 is limited to 3% of its 2005 emissions. The Effort-Sharing Decision also allows certain member states that have emission reduction targets, or which are allowed to increase emissions by up to 5% of 2005 levels, to use an additional 1% of credits. These credits can come only from CDM projects in least-developed countries and small island developing states, and are not bankable or transferable. The member states concerned are Austria, Belgium, Cyprus, Denmark, Finland, Ireland, Italy, Luxembourg, Portugal, Slovenia, Spain, and Sweden.

The exact quantity of CDM or JI credits (certified emissions reductions (CERs) or emissions reduction units (ERUs)) that can be used by operators is regulated on an installation level. Up to 1.4 billion CERs or ERUs could have been used by all participating countries in the second trading period. This corresponds to 14% of the total free allocation (in all 30 countries in the International Carbon Action Partnership (ICAP)) in the second trading period. At the end of the second trading period 76% of the allowable offsets had been used, adding up to 11% of verified emissions for the whole period 2008-12. Operators in the EU27 used 663 million CERs and 376 million ERUs for the period 2008-12 to comply (EU15: 528 million CERs and 281 million ERUs).

EU-ETS participants will be entitled to use international credits during the 2008-20 period up to the higher of either the international credit entitlement specified in the National Allocation Plan for the second trading period or 11% of the free allocation of EU allowances granted to them in that period. Operators of stationary installations which were new entrants during the second trading period and operators of stationary installations newly included in the scope of the EU-ETS in the third trading period which did not receive free allocations nor entitlements for international credit use in the second period, will be able to use international credits up to a maximum of 4.5% of their verified emissions in the third period.

The EU-ETS has been the dominant source of global demand for CERs. With little further remaining entitlement to use CERs in phase III, demand for CERs from EU-ETS entities has dropped, and the global CER market price has collapsed.

The European Union recognises that linking the EU-ETS to GHG emission trading systems in third countries will increase the cost-efficiency of achieving the EU-emissions reduction targets. In October 2007 the first such linking was effected by the European Union and Iceland, Liechtenstein and Norway. Switzerland and the European Union are currently discussing the possibility of linking their two schemes, which would operate on the basis of mutual recognition of emission allowances. Since the beginning of 2013, the Swiss ETS is based on a new and revised $CO_2$ Act, which was devised with a view to making the two trading schemes more compatible and hence making linking possible. Plans for a link with the Australian ETS, have, however, been impacted by recent Australian changes of government.

The European Commission is a founding member of the ICAP which was set up in October 2007. ICAP is a partnership of 30 governments with the aim of providing a forum to share experiences and knowledge among countries and regions that have implemented or are actively pursuing the implementation of carbon markets through mandatory cap and trade schemes.



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## CARBON CAPTURE AND STORAGE

In its proposals for a "Policy Framework for Climate and Energy for 2020 to 2030", the European Commission noted that "*CCS may be the only option available to reduce direct emissions from industrial processes at the large scale needed*" and that "*increased R&D efforts and commercial demonstration of CCS are, therefore, essential over the next decade*". Unless CCS can be made available, the European Union's medium- to long-term security of energy supplies will remain an issue because of a persisting energy import dependence and reliance on fossil fuel usage. As noted by the European Commission, if CCS deployment is delayed the costs of emissions mitigation (as represented by the carbon price) could rise rapidly from EUR 100 to over EUR 300 per tonne of $CO_2$ between 2040 and 2050 (EC, 2011).[11]

CCS R&D has been supported by the Commission since the 1990s and CCS has been considered as a key tool for climate change mitigation in the European Union since 2007 (EC, 2006). Despite this, the aspirational EU target of up to 12 demonstration plants by 2015 will be missed.[12] The first CCS demonstration project in the European Union is likely to be operational only after 2018. More than three projects by 2020 – the date foreseen for commercialisation of the technology – would now be very challenging. This would place the European Union almost five years behind North America for CCS operation at commercial scale, despite a promising position a decade ago.

According to the Commission, commercial CCS deployment is driven by the EU-ETS prices and, unlike renewable energy and energy efficiency measures, does not yet benefit from additional supportive EU legislation with the exception of innovation funds. EU-ETS prices on their own have not yet sent a signal to fossil fuel producers or users that low-carbon technologies will become a competitive necessity. In the power sector, other competitive pressures on fossil fuel generation have further reduced the attractiveness of CCS in the near to medium term.

In terms of technology development, between 2007 and 2014 the European Commission spent EUR 700 million on CCS out of its total energy RD&D budget of EUR 9.6 billion. EUR 1.1 billion was earmarked to CCS in 2008 under the European Energy Programme for Recovery (EEPR) funding, but only around EUR 375 million had been spent by November 2014. None of the six projects has taken a final investment decision and four are no longer proceeding, with one project having encountered significant public opposition. By end of 2014, only two projects are continuing under the EEPR: the ROAD project in the Netherlands and the Don Valley project in the United Kingdom. Reasons for this slow progress include insufficient funding, (the EEPR was intended to cover only a part of the additional costs of a CCS plant), low EU-ETS prices, regulatory difficulties and public opposition. CCS projects were eligible for funding via the NER300 scheme, the second round of which awarded EUR 300 million to include a CCS project in the United Kingdom, where CCS is supported as a cost-effective mitigation technology. One non-financial condition of the NER300 is regular sharing of resulting knowledge, which the Commission has facilitated for CCS projects through its CCS Demonstration Project Network.

Geological $CO_2$ storage is regulated at EU level by Directive 2009/31/EC, which had a transposition deadline of June 2011. As of November 2013, six member states had not notified complete transposing measures, six had communicated that they would not allow $CO_2$ storage and two had prohibited it on the basis of unsuitable geology. For CCS

**11.** See also the related impact assessment to the EC 2011, SEC(2011) 288.

**12.** Brussels European Council, Presidency conclusions, 8-9 March 2007, 7224/1/07 REV 1

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operators to benefit under the EU-ETS from reduced emissions, compliance with the directive's provisions is required.

Despite the apparent lack of progress in the last seven years with demonstrating CCS technologies at commercial scales, the Commission has reaffirmed commitment by saying that "*An urgent policy response to the prime challenge of stimulating investment in CCS demonstration is required to test whether the subsequent deployment and construction of $CO_2$ infrastructure is feasible. The first step on this path is therefore to ensure a successful commercial-scale demonstration of CCS in Europe*" (EC, 2013a).

Furthermore, the European Energy Security Strategy published in May 2014 notes that CCS could potentially contribute to increased energy security through supply diversification (EC, 2014c).

The Commission is currently considering options for realigning CCS developments with long-term ambitions. The CCS Directive is currently under review and revisions could be proposed in 2015. The forthcoming 2030 Climate and Energy Policy Framework offers additional opportunities to place CCS alongside other low-carbon technologies in accordance with their potential contributions to GHG emissions reductions and national preferences; for example for indigenous coal, natural gas or biomass. In this context, the national plans to be submitted by member states to outline their preferred routes to a sustainable energy system will provide more clarity on which member states and sectors will benefit most from CCS. While all fossil fuel owners and users will benefit in the longer term, these plans will show where support for first-movers can be directed to start generating reliable premiums for low-carbon industrial and electricity production with CCS.

## CLIMATE CHANGE VUNERABILITY AND ADAPTATION

Policies on climate proofing and climate change adaptation have become a new competence under the Barroso II Commission (2009-14). Since the first IEA in-depth review there has been considerable progress in creating related EU policies, including the impacts of climate change on the energy sector.

According to the EU analysis and its reports to the UNFCCC (EC, 2014d), significant changes in climate and its impacts are already visible in Europe today. Increasing temperatures, rising sea level, and melting of glaciers, as well as more intense and frequent extreme weather events, are among the challenges for Europe already triggered by climate change. Further climate change impacts are projected for the future which can increase existing vulnerabilities and deepen socio-economic imbalances in Europe.

Impacts of climate change, such as an increased frequency of extreme weather events or changing water and air temperatures have effects on all three major parts of the energy system: transmission and distribution, supply/generation and demand. Transmission and distribution of energy (mainly electricity) is challenged by new demand patterns, as well as by direct physical destruction due to a higher magnitude and frequency of extreme weather events; explicitly under threat are overhead transmission/distribution facilities, but also other infrastructure – e.g. substations, transformers or fragile supply infrastructure. The generation and supply of electricity is affected by efficiency decreases due to climate change and the more complex vulnerability of renewable energy (as compared to fossil fuel based energy supply) to changing climate parameters. Increased demand for energy is already particularly triggered by periods of extreme weather (heat waves, floods/mass movements, droughts, causing demand-driven over-



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stress of energy infrastructure, its direct destruction and consequent interruptions in energy supply. In particular, more intense and frequent heat waves can shift demand patterns to critical constellations at times when energy supply is low, e.g. as a result of decreased efficiency of thermal plants due to temperature increases of ambient and cooling water. This coincides with increased demand for cooling for private households, offices, and storage of, for example, food and pharmaceutical products. Milder winters, on the other hand, result in reduced demand for heating during winter months.

Water stress is spreading in Europe, affecting one-third of the territory all year round. The frequency and intensity of floods and droughts and their environmental and economic damage appear to have increased over the past 30 years. The ClimWatAdapt project investigated the future water situation and developments in the water sector in Europe until 2050 in terms of "vulnerability to water scarcity", "vulnerability to droughts", and "vulnerability to floods". The project concludes that changes in future water scarcity are mainly driven by changes in water withdrawals. Regarding water temperature in major European rivers and lakes, an increase by 1-3°C has been recorded over the last century. The combination of increased temperatures and altered river flows are already affecting freshwater ecosystem and water quality.

A European information platform, which was launched on 23 March 2012 as the "European Climate Adaptation Platform" (Climate-ADAPT), contains information on impacts, vulnerability and adaptation policy across Europe, and also includes adaptation case studies as well as a number of software tools to facilitate access to this information. Climate-ADAPT is the EU entry point for information on adaptation, and it complements other initiatives implemented or planned at national and subnational levels.

An EU strategy on adaptation to climate change (EC, 2013b) was adopted by the European Commission in 2013. The overall aim of the strategy is to contribute to a more climate-resilient Europe, enhance the preparedness and capacity to respond to the impacts of climate change at local, regional, national and EU levels, develop a coherent approach and improving co-ordination. The strategy sets out eight actions to be taken to meet three specific objectives: 1) promoting action by member states, 2) better informed decision-making, and 3) climate-proofing EU action and promoting adaptation in key vulnerable sectors.

In addition, the European Commission adopted a Green Paper on insurance in the context of natural and man-made disasters, launching a wide debate on the adequacy and availability of existing insurance options.

The energy sector is one of the priority sectors identified by the European Commision for mainstreaming climate change adaptation in sectoral policies. The Commission has tabled legislative proposals on integrating adaptation in energy, and in 2013 it launched a mandate for European standardisation organisations to start mapping industry-relevant standards in the area of energy, transport and buildings, identifying standards to be revised for better inclusion of adaptation considerations.

The European Union seeks to ensure that its international assistance is systematically integrating climate change considerations, from investments in social and physical infrastructure to national sector programmes. The new EU development policy strategy, "An Agenda for Change", proposed by the European Commission in 2011, considers sustainable energy to be one of the factors with the strongest multiplying impact on developing countries' economies while, at the same time, ensuring environmental protection and climate change prevention and adaptation. The European Union and its member states provided substantial international climate fast-start finance, dedicated to mitigation and adaptation, in the

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order of EUR 7.34 billion in the period 2010-12, surpassing their original pledge at the Copenhagen and Cancun Climate Summits to invest EUR 7.2 billion during the period.

## ASSESSMENT

Setting a consistent path for achieving the EU long-term climate objectives for 2050 is paramount for creating the certainty needed by investors and shifting investments towards low-carbon technology solutions. A global climate agreement envisaged for the UNFCCC Conference of the Parties (COP 2015) meeting in Paris will also be critical for stimulating aggressive decarbonisation actions. The European Union plays an active and constructive role in making progress in these negotiations and designing a strong agreement that is in line with the overall global and EU climate objective of keeping emission increases below the two degree scenario (2DS).

Policies on climate proofing and climate change adaptation have become a new competence under the Barroso II Commission during 2009-14. Commendably, since the first review, the European Commission mainstreamed climate proofing and adaptation in EU energy policies, adopted an EU strategy on adaptation to climate change in 2013, created an EU-wide information platform, the "European Climate Adaptation Platform" (Climate-ADAPT) and is driving standardisation to include adaptation.

Since the first IEA in-depth review, the European Union has made significant progress in advancing its energy and climate change policy agenda. The European Union is on track to meet its 2020 targets to reduce GHG emissions by 20% below 1990 levels, and to increase the share of renewable energy in final energy consumption to 20%. In 2012, GHG emissions were 19.2% below 1990 levels. Under the existing trends and policies, emissions are projected to be reduced by 24% by 2020 and by 32% by 2030.

### STRENGTHENING AND COMPLEMENTING THE EU-ETS

The EU-ETS has led to cost-effective carbon reductions and created a level playing field across the European Union. The economic crisis and collapse of energy demand, the efficiency gains, the success of renewable energy policies and increased fuel prices have exerted significant downward pressure on emissions, while international credits have been used to an unexpected extent as a result of very low credit prices. The current surplus of allowances in the EU-ETS, however, fails to give sufficient incentives to investors to select low-carbon technologies based on carbon markets alone. Since the lead-up to the end of the second trading period, the EU-ETS has been plagued by a surplus of allowances, which has resulted in a consistently low carbon price.

The largest emission reductions were achieved by the deployment of renewable energies. In contrast to the downward trend in the carbon price, national support policies for renewable energy have however increased retail electricity prices for households in some countries and delivered GHG reductions, but at effective carbon prices well above that of the carbon market.[13] Policies introduced by the European Union and, above all, the binding targets for renewable energy played an important role in reducing GHG emissions and bringing them to the levels consistent with the set objectives. Slower progress on energy efficiency until the Energy Efficiency Directive was

**13.** Where renewable energy policies serve other objectives than immediate emissions reductions, such as technology learning or unlocking future emissions reductions, their higher costs may be justified in terms of these other benefits.



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introduced also demonstrates that strong binding targets supported by policy measures create the necessary pull and push for actions that result in emission reductions.

The future progress of the European Union towards a low-carbon economy to 2050 will depend on the strength of the 2030 targets and the governance of the forthcoming 2030 Climate and Energy Policy Framework.

An ambitious EU-wide emissions target is the driver for investment into low-carbon technologies and energy efficiency measures. A priority for the European Union should be to strengthen the EU-ETS scheme. The swift implementation of the ambitious carbon reduction target and proposed EU-ETS reforms, including the back-loading and the market stability reserve are therefore vital instruments to ensure cost-effective carbon reductions.

An additional benefit of a stronger carbon market would be the possibility to use auction revenues from the EU-ETS to support emerging energy technologies. Lessons learnt from the NER300 and the use of auction revenues at national level should provide insights for the design of future mechanisms.

There should also be an improved understanding of the objectives of the EU-ETS, what it can deliver given its design (coverage, acceptable emission target, interaction with other policies such as renewable energy target and energy efficiency target) and the overall long-term climate objective requiring a substantial decarbonisation.

## DRIVING EMISSION REDUCTION IN NON-ETS SECTORS

IEA analysis consistently shows the importance of complementing a carbon price with energy efficiency and technology support policies. Carbon markets can stimulate marginal lowest-cost mitigation actions in the short term, while tolerating development of high-carbon infrastructure in parallel. This is especially the case under political uncertainty about long-term carbon price developments and where substantial emissions occur in sectors outside the carbon market, notably in transport and buildings. Efficient carbon markets need to be complemented by sector- and technology-specific regulation.

The European Union needs to evaluate what support policies are required to complement the effects of a carbon price and how to avoid an overlap of objectives set for the EU-ETS and other policy tools. When designing policies targeting specific technological solutions (e.g. renewable energy, CCS, energy efficiency) the maturity and individual characteristics of the technologies in question need to be taken into account. CCS, early stage renewable energy sources and electric vehicles are examples of technologies that need to be assisted to reduce long-term mitigation costs and enable timely scale-up (overcome market barriers and reduce lock-in). In some cases, the absence of early stage support could compromise the actual availability of the technology in the long-term. There is substantial scope to combine funding instruments to lower project risks. Support for specific technologies should phase out as they mature and risks should be transferred to the private sector. Without a clear policy framework or risk financing in the early stages, projects are high-cost, high-risk and do not return proportional benefits to investors.

Policy co-ordination of interactions between the objectives and measures is vital. An absolutely critical issue for the future 2030 Climate and Energy Policy Framework will be to reform the EU-ETS so that is takes full account of the other policy instruments in the area of renewable energies and energy efficiency. This can be done by providing clarity on the reductions expected from energy efficiency and technology support policies, so that these can be better taken into account in EU-ETS cap setting.

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The European Union needs to carefully design a governance framework on the basis of national carbon mitigation plans where various policy tools reinforce each other, while overlaps that come at an extra cost are avoided. State aid rules must not constrain the development of the appropriate long-term solutions, but at the same time they will need to support the functioning of the open and competitive internal market and level playing field for investment.

For emissions currently falling into non-ETS sectors (large parts of transport, buildings, agriculture), the realisation of the EU-wide reduction targets is left to the member states. The European Union could play a stronger role in defining harmonised codes and standards for cars or appliances. Energy and carbon taxation could be a complementary cost-effective short-term instrument, but at EU level such measures are currently not supported by the member states. The European Commission should work together with member states to share best practises and identify options for effective taxation policies.

With a view to regularly review low-carbon investment cycles, the European Union should track and monitor all energy infrastructure investments and assess whether the existing policies put investment on track with decarbonisation goals, including towards meeting the 2050 energy roadmap trajectories. If uncertainty around current and future carbon prices is negatively impacting investment in low-carbon infrastructure, the European Union should consider options to guide investment.

## CARBON CAPTURE AND STORAGE

CCS in the European Union is an example of a technology that would benefit from co-ordination between member states. The benefits of the availability of CCS would be EU-wide in the longer term, and the near-term costs of development are considered high for each member state to bear independently. Previous EU leadership on CCS confirms its ability to take a collective and longer-term perspective on technology development. Yet the challenge of co-ordinating funding between member states and industry to support a small number of capital-intensive demonstration projects has illustrated that a need to find more appropriate policy tools if the Roadmap for moving to a competitive low-carbon economy in 2050, is to remain a guiding template for decarbonising industrial sectors and electricity.

The poor success of CCS projects in the NER300 was largely due to the reliance of the scheme on co-funding from other parties (member states or industry) whose timelines for financial commitment were not well matched to the process. Given the large capital costs of CCS projects and the absence of existing instruments for supporting such projects in many member states, aligning national and EU budgetary timetables was challenging and this was compounded by risks faced by CCS projects in terms of: the uncertain post-2020 climate policy; an untested regulatory environment; political and social preferences in some member states for non-fossil fuel based technologies; and an almost unprecedented expectation in terms of scale-up.[14] Project risk under the NER300 is almost entirely allocated to the project operator or the host member state rather than the EU level.

**14.** At the time of the announcement by the European Council of the target of up to 12 CCS demonstration projects each capturing around 1.4 million tonnes of $CO_2$ per year, no pilot projects had operated in the European Union for either the capture or geological storage of $CO_2$. The first project to reach one twentieth of demonstration scale began operation only in late 2008.



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The European Commission proposals for a Policy Framework for Climate and Energy In the period from 2020 to 2030 (EC, 2014a), calls on member states with fossil reserves and/or high shares of fossil fuels in their energy mix to support CCS. It proposes the continued use of auctioning revenues in this regard. While this would be welcome support, a gap has opened in the 2014 to 2020 timeframe in terms of guiding CCS through the innovation process at increasingly larger scales of operation. This places policy requirements firmly at a junction between innovation policy – e.g. project funding and market risk reduction – and broader EU mitigation policy, such as target setting and carbon pricing. Targeted combinations of these two types of instruments continue to be required in the short and medium term.

The coming years are likely to see increasing attention to CCS for industrial applications in Europe, in particular cement, steel, hydrogen and hydrocarbons production, in addition to coal use. The link between CCS development and support for firms at risk of carbon leakage may be strengthened, as well as the link between security of fuel supplies and emissions management through CCS.

In the short term, "CCS-ready" provisions could be strengthened to prevent infrastructure lock-in and procedures for the ongoing support of realisable and appropriately-sized CCS projects using EU-ETS auctioning revenues could be outlined. Key elements will also include the creation of a credible threat of future emissions regulation (in case continued investments in fossil fuel infrastructure without CCS in member states risks lock-in to a high emissions path), funding of advanced capture and storage technologies and projects via Horizon 2020, and the incentive to launch pre-commercial $CO_2$ storage site exploration and development. In the area of coal, such emission regulations are already in place with the Large Combustion Plant Directive and proposals for new regulations for other combustion plants (see Chapter 8, "Coal"). These emission performance standards can create a push for modernisation, but they do not replace a cost-effective carbon market.

## *RECOMMENDATIONS*

*The European Union should:*

- *Strengthen the EU-ETS as an instrument for global action to achieve decarbonisation goals in a technology-neutral and cost-effective manner while driving investments in low-carbon technologies.*
  - *Ensure the EU-ETS provides a stable, progressively growing and technology-neutral price signal by swiftly implementing the measures to reduce the surplus of allowances.*
  - *Enhance the flexibility and responsiveness of the EU-ETS to ensure a consistent carbon price signal under varying economic conditions and varying abatement from other policies.*
- *Closely examine market interactions with non-ETS sectors to prevent price distortions and ensure an integrated energy and climate policy with coherence of actions to reduce emissions outside the EU-ETS.*
- *Work with member states to stimulate greater investment of EU-ETS auction revenues in the development of low-carbon technologies, including CCS, advanced biofuels, renewables and energy efficiency.*

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- *Learn from the successes and shortcomings of the NER300 process for the design of future mechanisms, in particular with respect to CCS, targeting strategic projects in key member states and sectors at risk of carbon leakage.*
- *Establish criteria as part of an open and transparent selection process to determine where auction revenues should be directed.*
- *Regularly review technology support schemes to consider changes in technology/process costs and estimates of mitigation potential.*

☐ *Work with member states to develop environmental taxes and standards, in non-ETS sectors to discourage investments in highly carbon-intensive technologies.*

☐ *Complement the ETS revenues with policies to bring forward critical low-carbon investment through sector-specific measures to enhance innovation and to address non-economic barriers.*

☐ *Use the opportunities of the CCS Directive review, the 2030 Climate and Energy Policy Framework and energy security considerations to establish a common objective and timeframe for CCS in the European Union. Scrutinise national carbon emission plans and facilitate a sustainable European $CO_2$ storage business (or $CO_2$ utilisation where appropriate for climate change mitigation), complemented by regulatory certainty that fossil fuel users will have to significantly reduce GHG emissions on a 2030 horizon.*

☐ *Regularly monitor investment in key infrastructure (electricity, industrial plant, transport and buildings) to track whether existing policies are consistent with long-term decarbonisation pathways or whether policy measures are needed to guide investment.*

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# 4. ENERGY EFFICIENCY

**Key data (2012)**

**Energy supply per capita:** 3.2 toe (IEA average: 4.5 toe), -8.2% since 2002

**Energy intensity:** 0.12 toe/USD 1 000 PPP (IEA average: 0.14 toe/USD 1 000 PPP), -16.3% since 2002

**TFC:** 1 139.2 Mtoe (47.7 EJ) (oil 41.2%, natural gas 22.7%, electricity 21.1%, biofuels and waste 7.2%, heat 4.2%, coal 3.3%, solar 0.01%), -4.1% since 2002

**Consumption by sector:** industry 31.8%, transport 26.9%, residential 25.4%, commercial and other services 15.9%

## OVERVIEW

The European Union (EU) has seen an overall decline in energy intensity of 31.5% since 1990. In 2014, the European Union has lower energy intensity than its major trade partners Australia, the United States and Canada. In addition to energy efficiency improvements, the collapse in industrial demand amid the economic crisis in 2008 added to lower energy consumption.

In 2008, the European Union set out an indicative target to achieve 20% energy savings by 2020. In 2014, the European Union expects to achieve energy savings of 18% to 19% by 2020. Progress will depend on the implementation of EU energy efficiency policies by the member states. Progress remains slower than estimated because of constraints, such as tight public and private budgets and slow implementation of measures during the economic crisis.

The approach to energy efficiency is shifting in the European Union. Energy efficiency is gaining new momentum in the European Union amid concerns about decreasing industrial competitiveness and energy security. Energy efficiency is identified as a key instrument with strong benefits for ensuring better competitiveness, security of supply and social outcomes, as well as fostering energy and climate objectives. The European Commission (EC) estimates that 1% in additional energy savings (beyond the 25%) can decrease EU gas imports by 2.6%.

Future EU ambitions on energy efficiency have been subject to lively discussion. In July 2014, the EC presented an ambitious energy efficiency target of 30% (from the 2007 baseline scenario) for the 2030 horizon, going beyond the 25% effort, which would be necessary to meet greenhouse gas (GHG) emissions reduction goals of 40% by 2030, while assuming current progress on energy efficiency action and delivering a cut in gas imports.

In October 2014, the European Council agreed to a non-binding EU-wide target of at least 27% energy efficiency by 2030, based on current criteria, but kept the option open to review the target in 2020, having 30% in mind.

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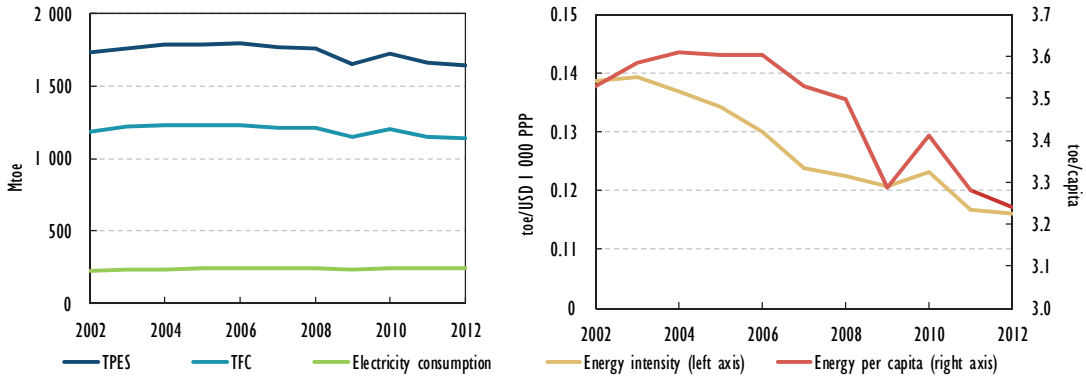
## TOTAL FINAL CONSUMPTION

Over a decade, EU energy demand has been relatively stable compared to most other regions of the world. Following the economic crisis of 2008-09, a slow recovery is under way in the European Union and modest economic growth (1.3% to 1.5%) is expected for the next two years. Total final consumption of energy (TFC) was 1 139.2 million tonnes of oil-equivalent (Mtoe) in 2012, below its 2005 peak of 1 234 Mtoe.

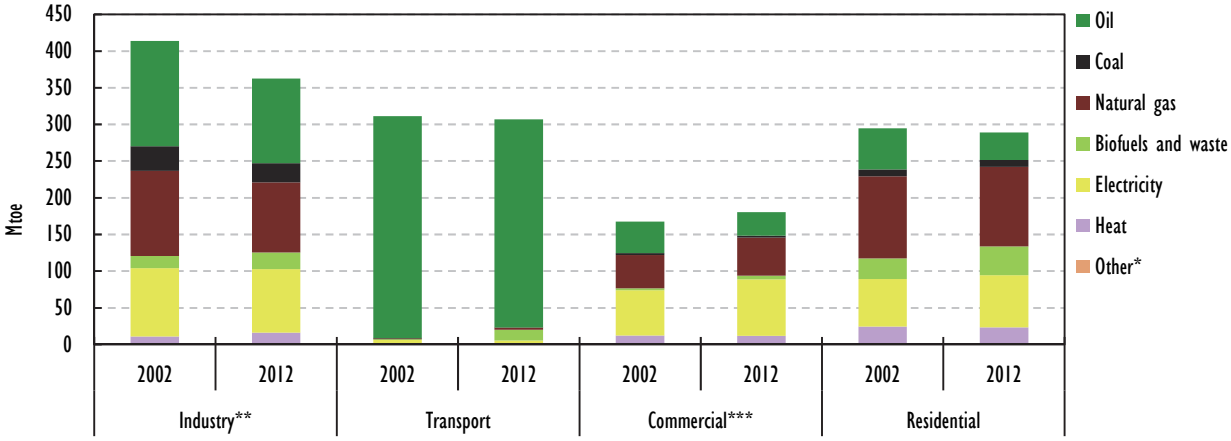
**Figure 4.1** Energy supply, consumption, intensity and use in the European Union per capita, 2002-12




Note: TPES = total primary energy supply.

Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

**Figure 4.2** TFC in the European Union by sector and by source, 2002 versus 2012




* *Other* includes peat, geothermal and solar (negligible).

** *Industry* includes non-energy use.

*** *Commercial* includes commercial and public services, agriculture, fishing and forestry.

Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

In 2012, the breakdown of TFC between sectors was: industry (31.8%); transport (26.9%); residential (25.4%) and commercial (15.9%). Comparing to the time before the crisis, TFC in the industry sector has decreased by 13.9%, and demand in transport has decreased by 8.4% since 2007. The residential and commercial sectors collectively experienced an increase of 2.5%.



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Oil and oil products represent 41.2% of TFC, of which transport accounts for more than 60%. Natural gas represents 22.7% and its use is mainly in the commercial and residential sectors, with one-third used in industry. Coal is used in industry and accounts for 3.3%. Biofuels and waste which account for 7.2%, are used in all sectors and account for 4.8% of fuels used in transport. Heat supplied to third parties accounts for 4.2%, of which, one-third is used in industry. Electricity represents 21.1%.

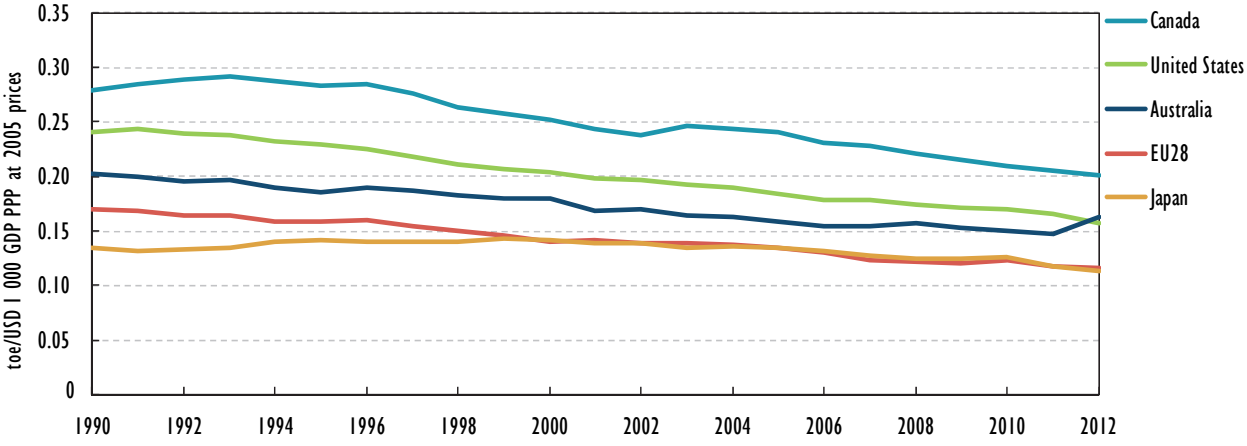
## ENERGY INTENSITY

Steady improvements in energy intensity have been made in most member states, with an overall decline in intensity of 31.5% since 1990. Collectively, the European Union has lower energy intensity than its major trade partners (Figure 4.3), and a similar level to Japan.

Energy intensity, measured as the ratio of energy supply to GDP, was 0.12 tonnes of oil-equivalent (toe) per 1 000 USD at purchasing power parities (toe/USD 1 000 PPP) in 2012, which is lower than the IEA member country average of 0.14 toe/USD 1 000 PPP.

Energy supply per capita, measured as TPES per capita, was 3.2 toe in 2012, which is 8.2% lower compared to 2002.

**Figure 4.3** Energy intensity in the European Union and in selected IEA member countries, 1990-2012




Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

## INSTITUTIONS

EU energy efficiency policy is the responsibility of the Energy Efficiency Unit in Directorate-General (DG) Energy of the European Commission. The Energy Efficiency Unit was established in 2011, bringing together sector related expertise. It is currently staffed with 30 full-time equivalent employees and is responsible for all matters related to developing energy efficiency policy, monitoring member state implementation and evaluating progress.

**DG Energy** co-ordinates policies with other relevant DGs including **DG Climate Action, DG Environment, DG Mobility and Transport, and DG Enterprise and Industry**. For example, responsibility for the Eco-design Directive is split between DG Energy and DG Enterprise, depending on the product group concerned. **DG Regional Policy** manages investment in energy efficiency via the EU structural investment funds. **DG Research and Innovation** is responsible for co-ordinating energy efficiency technology research and development.

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The **Joint Research Centre of the European Commission (DG JRC)** and its energy institutes in Karlsruhe, Ispra, Petten, and Sevilla conduct studies and analysis related to energy efficiency technologies. The **European Environment Agency (EEA)** provides independent information and analysis on energy efficiency and climate change, including the performance of the transport sector.

## TARGETS AND OBJECTIVES

Improving energy efficiency is an important part of the EU strategy to reduce energy import dependence, improve productivity and competitiveness, reduce greenhouse gas (GHG) emissions, moderate the impact of growing energy prices and enhance health and well-being. Energy efficiency is one of the pillars of the 2020 Climate and Energy Package adopted in December 2008 that called for a 20% reduction in GHG emissions, a 20% increase in the share of renewable energy and 20% energy savings by 2020 which requires a cap of EU primary energy consumption of 1 483 Mtoe in 2020.

**Box 4.1** The multiple benefits of energy efficiency

As energy efficiency continues to gain importance as a key resource for economic and social development across all economies, understanding its full value is increasingly important. Recent research emphasises that energy efficiency brings multiple benefits (Figure 4.4), going beyond traditional outcomes of energy demand and greenhouse gas emissions reduction, to support strategic objectives for energy system security, economic and social development and environmental sustainability.

A "multiple benefits approach" to energy efficiency calls for closer attention to the assessment of impacts in a broader range of benefit areas, drawing on a rapidly growing body of experience to measure, quantify, and monetise them so that they can be built into policy planning and target setting. The European Union is commissioning its own investigations into the multiple benefits of energy efficiency and is working with the IEA to develop more complete information to be taken into account in the revision of energy efficiency targets.

By better quantifying the impacts of energy efficiency, the multiple benefits approach can help to re-position energy efficiency as a mainstream tool for economic and social development, and has the potential to substantially increase ambition for improving energy efficiency in the member states and beyond.

Source: IEA (2014c), *The Multiple Benefits of Energy Efficiency: Measuring the Positive Impacts*, OECD/IEA, Paris.

Of the three 2020 targets, the energy efficiency target is the only one that is non-binding, and the only one that the European Union is currently not on track to meet (EC, 2014a). On the basis of an analysis of member state actions, the EC expects the European Union to achieve energy savings of around 18% to 19% by 2020, with about one-third of those savings due to lower than expected growth during the financial crisis. The EC estimates, however, that if all member states work equally hard to fully implement agreed legislation, the 20% target can be achieved without putting in place additional measures (EC, 2014a). In January 2014, the European Commission presented proposals for a Policy Framework for Climate and Energy in the period from 2020 to 2030 (EC, 2014b). It is estimated that a 25% of energy savings by 2030 is needed, if the European Union aims to reach a 40% GHG emissions reduction target for 2030 and a share of renewable energy of at least 27%.



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Energy efficiency plays a key role in reaching EU energy policy objectives, including: *competiveness* (reducing energy costs for households and businesses); *security of supply* (reliable supply, reducing energy import dependence); and *sustainability* (notably limiting environmental impacts and creating jobs from energy sustainability). These objectives represent some of the multiple benefits of energy efficiency, and work is already underway to investigate the potential for capturing a broader range of benefits (Box 4.1 and Figure 4.4).

**Figure 4.4** The multiple benefits of energy efficiency improvements

Note: This list is not exhaustive, but represents some of the most prominent benefits of energy efficiency identified to date.

Source: IEA (2014c), *The Multiple Benefits of Energy Efficiency: Measuring the Positive Impacts*, OECD/IEA, Paris.

During a consultation by the EC on progress towards the 2020 energy efficiency target between February and April 2014, a majority of stakeholders supported new energy efficiency targets and measures, while others favoured reaffirmation of existing legislation through penalties for infringements. Seven member states officially requested that the European Union had a binding energy efficiency target. In July 2014, following a review of the Energy Efficiency Directive, the EC recommended that member states improve energy efficiency so that actual consumption in 2030 would be 30% below the 2030 levels that were projected from 2007. A 30% target is above the 25% required for meeting the Union's longer-term objectives of a reduction of 80% to 95% GHG emissions by 2050, as modelled under the EU Low-Carbon Roadmap for 2050. EU leaders agreed in October 2014 on an indicative EU-wide target of at least 27% of energy efficiency.

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**Table 4.1 Synergies between energy efficiency ambitions, EU-ETS price and net energy imports**

| Energy efficiency target options (in %) | EU-wide impacts | | |
|---|---|---|---|
| | Additional annual energy system costs, relative to 40% GHG target in 2030 (in EUR billion) | ETS Carbon Price in 2030 (in EUR) | Net energy imports 100=2010 levels |
| 25 | - | 42 | 87 |
| 27 | - | 39 | 86 |
| 28 | 5 | 35 | 85 |
| 29 | 13 | 30 | 83 |
| 30 | 20 | 25 | 82 |
| 35 | 55 | 13 | 78 |
| 40 | 112 | 6 | 74 |

Source: EC (2014c), *Impact Assessment accompanying the Communication from the Commission to the European Parliament and the Council, Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy,* SWD(2014) 255 final, Brussels.

## POLICIES AND MEASURES

To scale up energy efficiency investments, to tap the savings potential of energy efficiency across all sectors and to meet the targets agreed by member states, the European Union has adopted a range of directives and regulations. The most important ones are described in the following sections.

The Energy Efficiency Directive 2012/27/EC (EED, replacing Directives 2004/8/EC on Combined Heat and Power and 2006/32/EC on Energy Services) was developed in response to concerns that the European Union was unlikely to achieve the 20% energy efficiency target. The EED comprises a series of binding measures rather than binding targets and requires each member state to:

- Set an indicative national energy savings target for the period 1 January 2014 to 31 December 2020 in line with the EU-wide 20% by 2020 target.
- Carry out a comprehensive assessment of national heating and cooling systems to identify and implement the cost-effective potential for deploying high-efficiency co-generation, efficient district heating and cooling and other efficient heating and cooling solutions by the end of 2015.
- Undertake an assessment of the energy efficiency potential of its gas and electricity infrastructure in particular regarding transmission, distribution, load management and interoperability and identify measures and investments for the introduction of cost-effective energy-efficient improvements in the network infrastructure by 30 June 2015.
- Oblige energy providers to achieve cumulative end-use energy savings by 2020 equivalent to 1.5% of annual energy sales over the period 2014-20. Member states have the flexibility to pursue alternative ways to achieve equivalent energy savings.
- Ensure the metering and billing of actual energy consumption in all sectors occurs at a frequency that enables end users to take informed decisions about their energy consumption; and that meters are installed for all energy sources at end users' premises, if technically possible and economically feasible.



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- Develop public procurement rules ensuring that central governments purchase only high-efficiency products.
- Facilitate the development of national financing facilities for energy efficiency measures.

## INDUSTRY

The energy prices in the European Union are some of the highest in the world. While providing incentives to save energy, energy efficiency measures in the industrial sector are considered to be increasingly important for improving the competitiveness.

EU-wide energy efficiency activities for industry are guided by the EU-Emissions Trading Scheme (EU-ETS) (described in Chapter 3, "Climate Change") and the EED.

An over-allocation (in phase I) of emission allowances and the recession (in phase II) have constrained the direct impact of the EU-ETS on improving energy efficiency in industry, but the combination of rigorous monitoring and awareness campaigns, together with a positive carbon price, has driven some abatement, including energy efficiency measures (Laing et al., 2013). However, the carbon price will need to be higher and allocations lower if the scheme is to work as intended.

The EED requires large enterprises to carry out an energy audit at least every four years, with the first one to be completed by December 2015. These audits should take into account relevant European or International Standards, such as EN ISO 50001 (Energy Management Systems), or EN 16247-1 (Energy Audits). Under the Directive, member states should also encourage the development of training programmes for energy auditors.

Small and medium enterprises (SMEs) are also an important area for energy efficiency policy attention. More than 99% of all European businesses are SMEs. They provide two out of three private-sector jobs and contribute more than half of the total added value created by businesses in the European Union (EC, 2014d). Owing to low levels of awareness of energy efficiency, SMEs provide a key energy productivity opportunity, despite their low energy intensity compared to heavy industry. To help SMEs identify the potential for reduced energy consumption, the EED encourages member states to offer incentives for SMEs to undergo energy audits.

Most member states are already encouraging energy efficiency improvements in industry at a national level through financial measures in the form of subsidies, loans and tax benefits (EC, 2014a). Some have put in place successful voluntary agreements where industry accelerates energy efficiency investments in return for tax exemptions, rebates and other incentives.

With regard to the evaluation of the progress in industry, the IEA notes, however, that, energy audit programmes do not require energy-savings measures to be implemented. Measures are needed to accelerate the development of a market for industrial energy efficiency. This requires new financial mechanisms, framework conditions to enable existing mechanisms (e.g. performance contracting) and guarantees and other measures to ensure the active participation of private-sector financial institutions.

## BUILDINGS

Buildings account for 40% of TFC in the European Union and represent the largest energy savings potential of any sector. The Energy Performance of Buildings Directive (EPBD, 2002/91/EC) in 2002 and its 2010 revision (2010/31/EC) sets out the EU-wide legal framework.

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EPBD requires member states to establish and apply minimum energy performance requirements (MERS)[1] to new buildings and existing buildings undergoing renovation. The 2010 revision requires all new public buildings to be at least "near-zero energy"[2] by the end of 2020, and all new buildings to reach this target by the end of 2020.

While some member states established MERS for thermal performance of building envelopes in the 1970s, the EPBD requires all member states to follow a similar framework for setting building energy code requirements based on the integrated performance of the whole building and all energy uses (BPIE, 2011). Once adopted, MERS need to be regularly strengthened and enforced.

The IEA considers that the European Union could play an important role in setting guidelines for, and providing proven-practice examples of, building code enforcement in member states. Moreover, other measures such as supporting the training of architects, engineers and the building trades (carpenters, bricklayers, plumbers, electricians, etc.) would improve energy efficiency uptake and compliance.

The EPBD also requires member states to introduce mandatory energy performance certificates (EPCs) that provide clear information on building energy performance to prospective tenants and buyers. EPCs must include reference values that allow consumers to compare and assess energy performance. They must also be accompanied by recommendations for cost-effective improvement options to raise the energy performance and rating of the building. The 2010 revision of the EPBD strengthens the role of EPCs by requiring that they are published at the time of advertising a building's sale or rental, rather than only at the time of signing a purchase agreement or rental contract.

To date, all member states have introduced EPCs, but their level of ambition and implementation varies across countries. Some member states use EPCs as criteria for access to incentives, others use them to monitor improvements in the building stock and still others combine EPCs with additional information including advice on websites. Higher EPC ratings are beginning to have a positive impact on sales and rental prices, indicating that better energy efficiency is rewarded by the market (Bio Intelligence Service et al., 2013).

Other key elements of the EPBD are the requirement that member states: a) ensure the regular inspection of boilers and air conditioning systems in buildings; and b) draw up a list of complementary measures and financial instruments – according to national context – to support energy efficiency improvements in the buildings sector.

According to the EC, energy efficiency improvements are being achieved in new buildings which now use half the amount of energy per square metre they consumed in the 1980s (EC, 2014a). But EPCs are not regulating existing buildings, which however present more difficult challenges.

## Focus on existing buildings

A large share of the European building stock is over 50 years and many buildings are hundreds of years old. In fact, more than 40% of residential buildings in Europe were

**1.** Minimum energy performance requirements are more often referred to as minimum energy performance standards outside the European Union.

**2.** A near-zero-energy building is defined in Article 2 of the EPBD recast as "a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby".



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constructed before the 1960s when building energy efficiency regulations were not widely applied. The 1960s, 1970s and 1980s saw a large construction boom during which housing stock more than doubled, but energy performance did not necessarily improve. In some cases, buildings from the 1960s have a lower energy performance than buildings built in earlier decades. Existing buildings are thus a priority area for policy attention. The EPBD introduces requirements for existing buildings, including the mandate that major renovation projects incorporate the minimum energy efficiency requirements set in building codes.

The EED complements the EPBD by requiring member states to establish strategies for the renovation of their national building stock. It also requires member states to improve the energy performance of 3% of the total floor area of heated and/or cooled buildings owned and occupied by the central government every year.

From IEA analysis it becomes apparent how difficult it is to evaluate member states' progress in achieving energy savings in the buildings sector as there is no standard evaluation approach implemented across countries (some countries report rough estimates, others provide detailed modelling).

Moreover, few member states conduct ex post evaluations and measurements and even fewer provide cost-benefit analysis or cost-effectiveness indicators. Non-energy benefits (health, employment, etc.) of energy efficiency measures in the buildings sector are rarely calculated or communicated. The IEA considers that the EC could play a stronger role in providing guidance for the assessment methodologies with indicators.

## APPLIANCES AND EQUIPMENT

In September 1992 the European energy labelling scheme (Directive 92/75/EEC) established the first energy efficiency requirements relating to appliances across the European Union. The scheme rated the energy efficiency of a range of household appliances on a scale from A to G, with A being the most efficient. The directive has been superseded several times; the current edition being the Energy Labelling Directive (2010/30/EC) in which ratings of A+, A++ and A+++ have been defined for some appliances such as household refrigerators and clothes washers. These were the first products to be labelled under the original scheme, and the additional ratings have been necessary to accommodate the improvements in efficiency that have been made over a period of nearly 20 years.

The first MERS for appliances were applied to household refrigerators through Directive 96/57/EC in September 1996, four years after the introduction of the Energy Labelling Directive. The successor to that first MERS Directive is the Eco-design Directive (2009/125/EC), first adopted in 2005 and updated in 2009 to make provision for MERS for both energy-using products and energy-related products (e.g. windows) with the objective of reducing their environmental impacts and energy consumption on a life-cycle basis. To date, MERS have been developed for 16 product groups. In some cases MERS have driven a change in technology. For example, the so-called ban on incandescent lighting is really a technology-neutral MERS that conventional incandescent lamps cannot achieve.

In addition to household appliances the Eco-design Directive is also applied to industrial equipment. The first four eco-design implementing measures on industrial products (motors, circulators, fans and water pumps) are expected to lead to annual energy savings by 2020 equivalent to the current TFC of Hungary and contribute significantly to the 2020 targets.

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The legislation has already led to significant technology development and triggered a European standardisation process that is influencing international standards processes. The latest measures being developed take into account an extended product or system approach as well as user needs and use patterns.

**Box 4.2** Compliance with the Eco-design and Energy Labelling Directives

Levels of compliance with the Eco-design and Energy Labelling Directives clearly impact their ability to achieve their projected energy savings. Within the European Union, market surveillance is the responsibility of individual member states and there is a range of activities across the European Union. Denmark, Sweden and the United Kingdom spend the most on compliance but some member states do not undertake any compliance activities at all. The European Commission has funded a series of collaborative compliance activities since 2009. The most recent of these, "Come on Labels", involved three rounds of surveys in a total of 900 shops in 13 countries between 2011 and 2013.[3] About two-thirds of the products surveyed were correctly labelled, another 14% to 19% were partially or incorrectly labelled and 18% to 21% of products were not labelled at all. Between the first and final surveys the energy label changed from a two part label to a single label, resulting in a reduction in the number of incorrectly labelled products. Compliance with MERS is more complex and costly to ascertain as products need to be taken from stores and tested, so less information is available about MERS compliance compared with labelling. The EC-funded ATLETE II project (Appliance Testing for Washing Machines Energy Label and Ecodesign Evaluation) collected information on testing from member states and compliance rates were reported to vary from 50% in Spain to 100% in the Czech Republic, although it should be noted that member states do not use a consistent methodology or reporting structure for these data.[4] The original ATLETE project that involved the testing of 80 refrigeration appliances for all the parameters required by the Eco-Design Directive using a consistent methodology found that only 43% of the products tested passed on all parameters.[5]

Most of the non-regulatory activities associated with appliances and equipment such as information and procurement programmes vary across the Union but there is a role for the Commission to play in identifying best practice and promoting it across the European Union.

One voluntary programme that is pan-European is the high-efficiency endorsement label known as ENERGY STAR. This is based on a long-standing United States government programme that has very wide product coverage. In Europe, ENERGY STAR is used to identify the most efficient office equipment. It provides a tool for consumers, whether individuals or businesses, to choose the most efficient products without needing any knowledge of the products or their performance. It is particularly useful for businesses or government agencies that have procurement policies requiring them to buy efficient products.

**3**. See www.come-on-labels.eu/.

**4**. See www.atlete.eu/2/doc/Report%20on%20implementation%20and%20national%20legislation\.

**5.** See www.atlete.eu/index.php?option=com_docman&Itemid=111.



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## HEATING AND COOLING

The EED defines efficient district heating and cooling (DHC) as a system that uses at least 50% renewable energy, 50% waste heat and 75% cogenerated heat or 50% of a combination of such energy and heat. Member states are obliged to make an assessment of the potential of high-efficiency combined heat and power (CHP, also known as co-generation) and efficient DHC by the end of 2015 (and every five years thereafter), including a cost-benefit analysis (CBA) at the level of each individual installation (with a total thermal output above 20 MW) and the entire territory of the state to identify the economic potential of CHP and/or connection to DHC.

Overall heating energy consumption in the European Union is the largest of any major region in the world. Most of the heat is consumed in buildings to counter the effects of the cold European winter climate. The European Union also has some of the most advanced district heating systems in the world, mostly in the Nordic countries, that have very high performance and that use renewable energy and waste heat resources. District heating systems are mostly in dense urban areas, with over 5 000 systems currently serving 62 million people (13% of Europe's population) with 1 500 petajoules (PJ) of heat, distributed through 140 000 km of piping. However, the European Union also has some of the worst-performing systems, with inefficient heat-only boilers that distribute heat through poorly insulated pipe networks resulting in low levels of efficiency.

IEA analysis outlines that with increased deployment of CHP systems, overall system efficiency compared to traditional central power plants has improved significantly but there remain large opportunities for energy savings through modern, integrated solutions that combine the best energy efficiency measures with the best district heating networks (efficient supply and distribution).

## TRANSPORT

Road transport accounts for the majority of the 26.9% (306.9 Mtoe) of EU TFC used in transport, it represents about 23% of EU TFC and about half of all oil consumption. As well as being significant in absolute terms, the transport sector has substantial potential for cost-effective reduction of energy use and GHG emissions.

### Vehicle regulations and pricing

In broad terms, vehicle regulations, transport infrastructure and pricing are the key policy measures to reduce transport energy use. Many member states rely heavily on the minimum requirements set in European legislation as the primary means of addressing energy efficiency in the transport sector.

Since May 2009, new passenger cars in the European Union have been subject to a regulation that limits $CO_2$ emissions (Regulation No 443/2009 setting emission performance standards for new passenger cars). The weight-based fleet average to be achieved by manufacturers for all new cars is 130 grams of $CO_2$ per kilometre ($gCO_2$/km) by 2015, with the limit phased in from 2012, and 95 $gCO_2$/km by 2020.[6]

A similar regulation for new vans was introduced in 2011 (Regulation 510/2011 setting emissions performance standards for light-duty vehicles), with a limit of 175 $gCO_2$/km by

**6.** In terms of fuel consumption, the 2015 target is approximately equivalent to 5.6 litres per 100 km (L/100 km) of petrol or 4.9 L/100 km of diesel. The 2020 target equates to approximately 4.1 L/100 km of petrol or 3.6 L/100 km of diesel.

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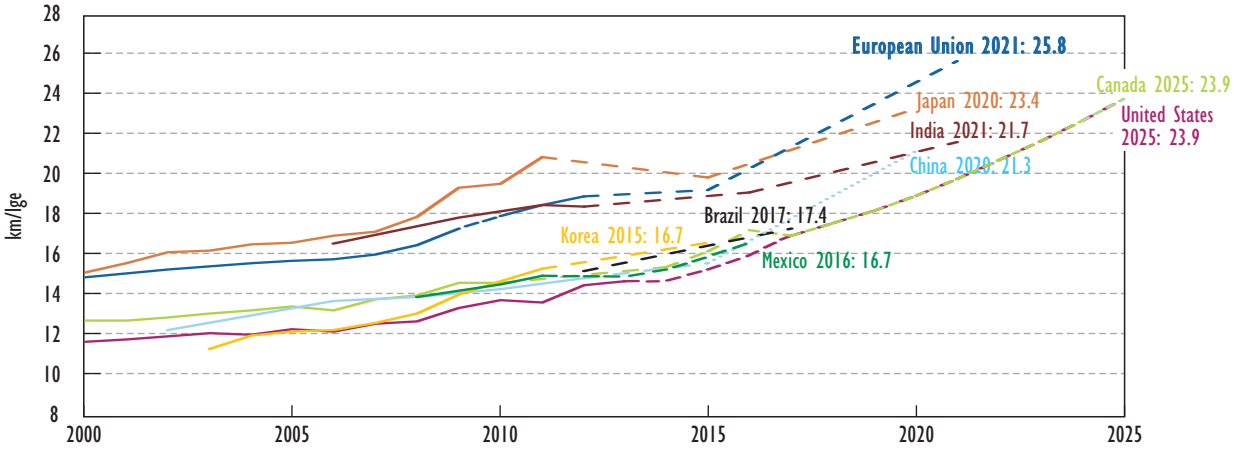
2017 and 147 $gCO_2$/km by 2020.[7] With regard to heavy-duty vehicles (HDV), the European Commission has so far only adopted a strategy, setting out its intention to cut emissions in this sector and proposing further options for study, including modern transport infrastructure or mandatory limits on average $CO_2$ emissions for newly registered HDVs. Emissions from trucks, buses and coaches (HDVs), according to the EC, represent currently around 25% of road transport $CO_2$ emissions or around 5% of EU total GHG emissions (EC, 2014e).

According to EC, the emissions from new passenger cars sold in 2013 had already fallen to an average of 127 $gCO_2$/km, which was below the target of 130 $gCO_2$/km set for 2015. On average fuel economy has improved, with current fuel economy levels in some member states leading the world efforts and are in step with other global leaders, Japan and China (see Figure 4.5). While EU fuel economy standards are expressed in terms of $CO_2$ limits, they are in effect a measure of vehicle energy efficiency.

There are also EU Regulations on labelling of tyres (Regulation [EC] 1222/2009, Commission Regulation [EU] 228/2011 and Commission Regulation [EU] 1235/2011). Meanwhile, Directive 2009/33/EC on the Promotion of Clean and Energy Efficient Road Transport Vehicles aims at broad market introduction of environmentally friendly vehicles (including energy impacts) via public procurement. It is important to continue and further strengthen all of these regulations and reassess them to ensure their continued effectiveness.

**Figure 4.5** Fuel emission standards in the European Union and selected countries




Source: IEA (2014d), *Energy Efficiency Market Report 2014*, OECD/IEA, Paris.

The regulations may even be beneficial for automotive industry competitiveness. Vehicle manufacturers in the European Union have a demonstrated capacity to innovate and produce fuel-efficient vehicles, but the world automotive market is challenging, with increasing competition on many aspects of vehicle features and performance. EU fuel economy policy can be developed to enable an innovative vehicle industry, including electric and alternative-fuel vehicles, while helping to ensure future access to world markets. Global growth in electric vehicle sales is faster than expected and some manufacturing is occurring in Europe.

Investments in transport infrastructure, including public transport infrastructure, are planned and implemented by member states and regional governments. The European Commission's

**7.** In terms of fuel consumption, the 2017 target is approximately equivalent to 7.5 L/100 km of petrol or 6.6 L/100 km of diesel. The 2020 target equates approximately to 6.3 L/100 km of petrol or 5.5 L/100 km of diesel.



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ability to create a more constructive policy environment for energy-efficient transport modes is therefore somewhat limited. However, initiatives adopted by the EC, following the 2011 White Paper on Transport (2011) – Roadmap to a Single European Transport Area – aim at encouraging the use of more energy-efficient transport modes, through better quality and more choice in railway services and greater exploitation of inland waterways. The recently agreed Directive on the Deployment of Alternative Fuels Infrastructure and the new Urban Mobility Package will further support new trends of using more efficient modes of transport such as electric vehicles, public transport, cycling and walking.

As regards pricing, the European Commission tabled a proposal in 2011 to revise the outdated Energy Taxation Directive. However, some member states have concerns with respect to the minimum rates applicable to certain motor fuels, as well as the tax treatment of biofuels. As taxation legislation requires the unanimous approval by all EU28 member states, the adoption of the proposals seems to be unlikely by the time of writing.

Finally, the 2011 White Paper set the following main goals to be achieved by 2050:

- Phase out "conventionally-fuelled" cars in cities, complemented by the development of appropriate charging infrastructure for electric vehicles.
- 40% use of sustainable low-carbon fuels in aviation; at least 40 % cut in EU $CO_2$ emissions from maritime bunker fuels.
- 50% of road freight transport over 300 km should shift to other modes such as rail or waterborne transport by 2050.
- By 2050 the majority of medium-distance passenger transport should go by rail.

The EC expects that all of these are to contribute to a 60% cut in transport emissions by the middle of the century compared to 1990 levels.

## ENERGY PROVIDERS

As mentioned previously, the EED requires energy providers to achieve cumulative end-use energy savings by 2020 equivalent to 1.5% of annual energy sales over the period 2014-20 although member states can pursue alternative ways to achieve equivalent energy savings.

Energy suppliers (electricity, gas and heat services retailers or utilities) are ideally placed to deliver energy efficiency services and products to consumers. They have operational, technical and financial capabilities as well as direct relationships with consumers. Energy efficiency obligations for utilities currently play a role in delivering energy efficiency in many member states.

Member states are required to ensure the implementation of smart metering under EU energy market legislation contained in the third internal energy market package, the so-called Third Package. This implementation may be subject to a long-term CBA. In cases where the CBA is positive, there is a roll-out target of at least 80% market penetration for electricity by 2020.

## ENERGY EFFICIENCY FUNDING

During the new programming period from 2014 to 2020, energy efficiency funding (together with renewable energy expenditure) is expected to increase substantially under the low-carbon economy investment focus with a minimum allocation of EUR 38 billion in the cohesion policy. Moreover, along with ramped-up funding for energy efficiency, the 2014-20 Multi-annual Financial Framework (MFF) provides for tailored financial instruments and other mechanisms to attract private capital and bring longer-term,

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affordable financing to the energy efficiency market. The MFF also imposes obligatory minimum percentages for energy efficiency on investments from one of the European Structural and Investment Funds (ESIF), the European Regional Development Fund, including at least 12% in less developed regions, 15% in transition regions and 20% in more developed regions. Over the 2006 to 2013 period, ESIF had only allocated EUR 5.6 billion to energy efficiency, co-generation and energy management.

Financial support to energy efficiency projects is also provided through the European Energy Efficiency Fund (EEEF). EEEF was established in 2011 and capitalised with EUR 265 million. A EUR 20 million Technical Assistance Facility was also established. EEEF finances, and provides technical assistance to, municipal, local and regional authorities and energy service companies (ESCOs). EEEF will seek to leverage its ongoing contributions to target a total volume of EUR 600 million to 700 million in investment from public and private actors at the EU, national and subnational levels.

Further, a new risk-sharing facility, "Private Finance for Energy Efficiency" is being set up, together with the EIB. The Facility will enable the EIB and consequently commercial banks to extend their lending capacity for energy efficiency projects through partial coverage of associated risk. The Facility is financed by the LIFE Programme, with initial allocation of EUR 80 million.

The European Union promotes energy efficiency research and innovation through its Horizon 2020 Programme. More than EUR 840 million has been allocated to energy efficiency research and innovation over the period 2014 to 2020. This includes the continuation of the Project Development Assistance (PDA) Facilities, namely the ELENA Facility implemented via International Financial Institutions (e.g. EIB) and a PDA call for proposals implemented by the Executive Agency for SMEs (EASME). By March 2014, EUR 81 million has been provided for technical assistance, expected to leverage investments worth just over EUR 4 billion. This marks a substantial increase since the previous EU budget. Between 2006 and 2013, the RD&D programme, the so-called 7th Framework Programme), had allocated EUR 285 million to energy efficiency.

## ASSESSMENT

Since the first IEA in-depth review in 2008, the European Union has been able to streamline its energy efficiency policies, notably through the adoption of the Energy Performance of Buildings and the Energy Efficiency Directives. In addition, financial and non-economic support has been strengthened to guide energy efficiency investment across the European Union, within the new EU budget, which makes energy efficiency investment a cross-cutting economic priority. The non-binding 2020 target of 20% energy savings has also guided national policy measures through the adoption of national energy efficiency action plans, which are regularly reviewed and analysed at EU level.

In the proposals for a Policy Framework for Climate and Energy in the period from 2020 to 2030 (EC, 2014a), the European Commission strengthened its commitment to energy efficiency as a key strategy to achieving social and economic outcomes as well as meeting energy and climate objectives. Following the review of EU energy efficiency progress towards 2020, the European Commission proposed a 30% energy savings target for 2030, which was however not endorsed by the European Council in October 2014. EU leaders decided to keep an indicative and non-binding target at EU level, without national binding targets, and sought a compromise level of at least 27% savings,



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compared to 2007 projections of future consumption. However, heads of state and government have kept the option open to review the 27% target in 2020, having a 30% target in mind.

The 27% target is in line with the minimum requirements of 25%, needed for the EU to meet its longer-term decarbonisation goals under the Energy 2050 Roadmap. A 25% energy efficiency target is considered as consistent with cost-effective delivery of the 40% greenhouse gas target. A 27% energy efficiency target could be delivered at no additional EU system cost, but with increased fuel import benefits (i.e. a reduction in gas imports). The Commission's analysis showed a 30% target would have reduced the carbon price from EUR 40 to EUR 25 per tonne $CO_2$ in 2030, while a 27% target still maintains a price of EUR 39.

The main drivers of the delivery of the energy efficiency target are likely to be through revising the existing legislative framework, e.g. energy-using product standards (Ecodesign and Labelling Directives), the Energy Efficiency Directive, the EPBD, and new vehicle emission standards.

A review in 2020 would be welcome, having in mind a 30% target, given that 1) technological and economic conditions are likely to change; and 2) there are multiple benefits associated with energy efficiency that are not always factored in to energy system modelling (e.g. health benefits). The EU should aim to quantify the multiple benefits of energy efficiency at EU level to support a higher target level. It will be important to prove to consumers and other energy market decision makers that energy efficiency policies are more than just a way to improve energy security or to mitigate climate change – they are also crucial to delivering economic and social outcomes to consumers and to the economy as a whole.

## ACTION IN INDUSTRY, BUILDINGS AND TRANSPORT SECTORS

Despite the energy intensity of EU industry decreasing by 19% between 2001 and 2011 (compared with 9% in the United States) (EC, 2014a), more could be done to improve energy efficiency in this sector, particularly by encouraging industry to implement the energy saving measures recommended as a result of energy audits. This should be supported by creating an enabling environment to accelerate the use of such mechanisms, as energy performance contracting and loan guarantees, to ensure the active participation of private-sector financial institutions. The European Union could thus strengthen the role of energy efficiency in industry to cut cost and respond to challenges to the competitiveness.

Much energy efficiency investment will also need to take place in the buildings sector, where significant untapped energy savings potential remains. The EPBD has gone a long way to require member states to put in place MERS for new buildings and buildings undergoing renovation. It has also led to scaled up energy efficiency renovations in public buildings. The European Union could further facilitate energy efficiency savings in the buildings sector by providing guidelines to member states on how to strengthen local and regional verification of national building codes and EPCs. Other IEA recommendations to improve energy efficiency in buildings include:

- an instrument to drive comprehensive energy efficiency retrofits in the most vulnerable households by 2030 (this will achieve the best social and economic return from improved health and comfort as well as reduced household energy costs)
- where appropriate, support for the roll-out and modernisation of DHC in cities

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- a review of energy pricing in district heating to identify policies that can deliver cost-reflective price signals to all players to drive investment and motivate an economic mix of end-use efficiency, system efficiency improvements and supply-side options
- appliance efficiency can be improved by accelerating implementation of the eco-design directive, expanding the number of products covered and strengthening market surveillance, all of which require adequate resourcing to ensure a level playing field for industry (EC, 2014a).

The transport sector is also an area with significant energy savings potential. Average fuel economy of light-duty vehicles is improving across the European Union, helped by the phase in of regulations for new passenger cars and vans. HDV $CO_2$ regulations should also be introduced. While options such as converting part of the truck fleet to gas are emerging, member states could explore longer-term strategies for improved freight and logistics performance coupled with improved energy efficiency. The European Union, with a number of HDV manufacturers and sound experience in low-emissions engine technology, is in a position to take a leading role in implementation of HDV standards. Software is under development that will allow monitoring and measurement to improve transparency in HDV fuel economy and emissions.

## FINANCING ENERGY EFFICIENCY

Scaling up energy efficiency efforts in support of the 2020 and 2030 objectives will require significant financial investment. Commercial banks are beginning to develop energy efficiency portfolios but often struggle to identify projects; meanwhile project developers report that they cannot attract finance. This is a global challenge and there is a need to better understand the issues behind this market failure; however progress is being made as governments learn to leverage private-sector funds, development banks leverage local intermediaries, and new finance models are piloted and scaled up.

As part of the energy market liberalisation, energy subsidies (state aid) that are still often used to lower energy unit prices should be phased out. Instead the role of state aid should be further strengthened to support investments in energy efficiency measures driving down the cost of capital in parallel with operating costs and thereby lowering consumer energy costs.

Since the first IEA in-depth review, the EC and the member states have stepped up the resources dedicated to energy efficiency policies, not only for the design of new policies but also for the implementation of EU policies and measures, notably on the national energy efficiency action plans. At the same time, funding levels in the EU programmes from 2014 to 2020, are expected to double or even triple. A major milestone is the creation of the EEEF. The IEA welcomes this stronger dedication of resources.

## EVALUATION AND GUIDANCE

The EC could scale up efforts to collect, review and publish member state evaluations of the progress and impacts of implementing EU directives and regulations. Data on energy efficiency investment performance, consumer responsiveness, and development of energy efficiency services and product markets can promote sharing of best practices and maximise the economic impact of energy efficiency policies. The ODYSSEE-MURE project has been an effective platform and already provides useful information on key energy efficiency trends, including end-use data. A key challenge is that, as energy efficiency policies advance, new and more detailed types of information will be required. The



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European Union should review the information that will be required to manage the next phase of energy efficiency progress and re-mobilise ODYSSEE to develop this data resource. This will likely require new country-level financial and socio-economic impact data.

The IEA believes that the EC can ensure better implementation of policies by providing guidance for the assessment of progress in energy efficiency in buildings and industry on the basis of common energy efficiency indicators and methodologies. Similar benefits can be achieved from common guidelines for the evaluation and enforcement of building codes.

## IEA 25 ENERGY EFFICIENCY RECOMMENDATIONS

The IEA 25 Energy Efficiency Recommendations offer a framework for a comprehensive portfolio of policies. Table 4.2 summarises progress with an overview of EU energy efficiency policy priorities against this framework and provides new recommendations.

**Table 4.2** IEA 25 energy efficiency recommendations

| Recommendation | Progress and implementation |
|---|---|
| 1. Energy efficiency data collection and indicators | *Eurostat collates and reviews member state data.*<br>This sound data collection effort should be maintained and efforts to address data gaps and identify new data priorities should be continued. |
| 2. Strategies and action plans | *An effective structure of regularly reviewed and updated member state NEEAPs that contribute to energy efficiency targets already exists.*<br>However, the energy efficiency target is not legally binding for member states. The EED is itself a result of revised priorities and has been reviewed in 2014. |
| 3. Competitive energy markets, with appropriate regulation | *A sound retail and wholesale market approach is prescribed in EU energy policies.*<br>Many member states have yet to move beyond central pricing to stimulate more sustainable outcomes from retail markets. Cost- reflective marginal retail pricing is now a priority to send effective price signals to motivate investment in efficient supply and demand-side management options. |
| 4. Private investment in energy efficiency | *Efforts to develop and catalyse private-sector funding for energy efficiency improvements in buildings, industry and transport are being made, for example under Horizon 2020.*<br>Such efforts could be expanded and mainstreamed. |
| 5. Monitoring, enforcement and evaluation of policies and measures | Priorities for evaluation include an accounting framework for energy efficiency investment and financing in member states as well as evaluation of social and economic impacts from all energy efficiency policies. |
| 6. Mandatory building energy codes and MEP requirements | Regularly reviewing and strengthening MEPS is critical, as is ensuring regulations do not place barriers on innovation. |
| 7. Aiming for net zero energy consumption buildings | Promote the emerging market for energy-neutral, low-energy buildings by researching how market leaders are creating new cost-effective construction options. Evaluate social and economic impacts. |
| 8. Improving energy efficiency of existing buildings | *Implementing the EED should increase private-sector investments and ensure comprehensive interventions for this priority end use.*<br>It is important to integrate building efforts with DHC policies, address the needs of vulnerable groups and evaluate the social benefits of energy efficiency improvements. |
| 9. Building energy labels and certificates | *An existing EU-wide building labelling scheme is in place.*<br>It is important to undertake an evaluation of the existing certification scheme to verify accuracy, and ensure effectiveness in motivating consumers. |
| 10. Energy performance of building components and systems | Maintain and develop emerging low-energy building techniques. Ensure EU standards align with global technical standards to enable EU industry access to world markets for efficient technologies. |

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| | |
|---|---|
| 11.Mandatory energy performance standards and labels for appliances and equipment | Ensure EU MEPS and labelling policies within the Ecodesign Directive evolve in concert with international standardisation processes and world-best regulatory practice to enable global access for EU manufacturers. |
| 12. Test standards and measurement protocols for appliances and equipment | Develop consumer and supplier confidence with an integrated European compliance system with high levels of information-sharing, co-ordinated check testing, and equitable non-compliance management. |
| 13. Market Transformation Policies | *Implementing the EED should develop private-sector energy efficiency market investments.* |
| 14. Phase-out of inefficient lighting products and systems | *Only medium efficiency halogen variants of general lighting service (GLS) incandescent light bulbs are legal for sale.* |
| 15. Energy-efficient lighting systems | Promote industry delivery of LED lamps / luminaires. |
| 16. Mandatory vehicle fuel efficiency standards<br><br>17. Measures to improve vehicle fuel efficiency<br><br>18. Fuel-efficient non-engine components | *Progress is driven by EU* light-duty vehicle *LDV $gCO_2$/km standards. These are currently in step with other global leaders in fuel economy standards.*<br>Two new LDV regulations that include air conditioning are currently under development. More attention should be paid to HDV. There is also a need to consider supporting polices that address usage practices. |
| 19. Improving operational efficiency through eco-driving and other measures; | Implement recognised eco-driving polices across member states. These provide highly cost-effective energy and safety outcomes. |
| 20. Improve transport system efficiency | Develop a framework of low-energy intercity and urban transport strategies that enable member states to develop effective mobility plans and implement investment in low-energy transport modes. |
| 21. Energy management in industry | Explore capacity building opportunities with member state energy management associations to develop best practice in energy management across the union. |
| 22. High-efficiency industrial equipment and systems | Advance MEPS for generic industrial equipment such as motors fans and pumps. Consider reporting of energy consumption and audit information. |
| 23. Energy efficiency services for small and medium enterprises | Work together with member states and stakeholders, including financial institutions, industry associations and energy service provider associations, to design financial and support mechanisms appropriate to scaling up implementation of energy efficiency in SMEs. |
| 24. Complementary policies to support industrial energy efficiency | There is clear need to co-ordinate energy productivity efforts with sector strategies. |
| 25. Governments should establish regulatory and other policies to ensure that energy utilities support cost-effective, verifiable end-use energy efficiency improvements | With half the member states opting for utility EE obligations, there is a role for the European Union to support information-sharing and identification of high-performing utility energy efficiency initiatives. A benchmarking effort with the utility industry would be useful. Ensure member states' utility regulatory policies do not inadvertently inhibit innovative demand-side management delivery. |

Notes: DHC: district heating and cooling; EE: energy efficiency; EED: Energy Efficiency Directive; HDV: heavy-duty vehicle: LDV: light-duty vehicle; MEPS: minimum energy performance standards; NEEAP: National Energy Efficiency Action Plan. The table sets out the progress made by the EU on the implementation of the IEA 25 energy efficiency recommendations in each subject area (in italic), where applicable. In addition, the summary table provides suggestions and recommendations for each area on how to improve implementation in the future (in non-italic).

## *RECOMMENDATIONS*

*The European Union should:*

- *Advance the EPBD by ensuring that energy efficiency retrofits in existing buildings are accelerated through a suite of integrated economic instruments and building regulations.*
- *Continue to ensure that the Eco-design Directive and Energy Labelling Directive remain relevant to consumers, keeping pace with technology developments and improvements in the efficiency of products in the market. Accelerate the roll-out of*



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*appropriately ambitious eco-design requirements, including to new product groups, by devoting additional resources if necessary. Collaborate internationally to harmonise product standards and improve compliance mechanisms.*

- *Ensure the roll-out of efficient DHC systems in cities, in close relation to building renovation, end-use efficiency and system efficiency improvements.*
- *Develop a strategic fuel economy policy continuing and extending the successful experience on light-duty vehicles, in particular cars, to HDV and implement eco-driving programmes across member states, in particular in the context of smart cities and e-mobility.*
- *Identify and clearly articulate how energy efficiency will contribute to the economic and social objectives in the 2030 Climate and Energy Policy Framework by expanding evaluations to identify key economic and social outcomes. Following on from this analysis, track progress towards: EU competitiveness, security and sustainability objectives; improvements in citizens' health; and demonstrate that all relevant Directive outputs are fully implemented and effective in meeting targets.*

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# PART II
# SECTOR ANALYSIS

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# 5. ELECTRICITY

**Key data (2012)**

**Installed capacity:** 952.1 GW

**Total electricity generation:** 3 264.1 TWh, +5% since 2002

**Electricity generation mix:** coal 28.14%, nuclear 27%, natural gas 17.8%, hydro 10.3%, wind 6.3%, biofuels and waste 5.2%, oil 2.2%, solar 2.3%, peat 0.5%, geothermal 0.2%

**Electricity consumption by sector:** industry 36%, commercial 32.1%, residential 29.6%, transport 2.3%

## OVERVIEW

The European Union (EU) has progressed towards the creation of an internal EU energy market. Harmonising technical and market rules in an area which spans across 28 national energy systems and jurisdictions with around 500 million inhabitants, is a unique undertaking. At the wholesale level, market and price coupling has been extended from Central West to North West Europe, Nord Pool, and recently to South East Europe, creating a large integrated day-ahead market. The EU member states are committed to implementing the new regulatory framework of the third internal energy market package by the end of 2014 and to connecting all "energy islands" by 2015, notably the Iberian Peninsula and the Baltic states.

Interconnection capacity within the EU member states is higher than in other regional electricity markets around the world. However, electricity system operation and control are largely confined to national borders and many markets remain isolated systems, lacking interconnectivity.

Despite two decades of liberalisation, the EU generation market remains concentrated. In eight member states more than 70% of power generation is still controlled by the historic incumbent. The generation mix is however slowly changing and with that the market structures and prices.

As carbon markets are EU-wide and electricity markets are regionally and EU-wide integrated, any national energy and climate policy decisions impact the cross-border energy markets. Renewable energy support policies are organised nationally but electricity is traded regionally. There is over-capacity in many markets, while EU wholesale electricity prices are low, zero or even negative, leaving conventional power plants un-dispatched, and raising concerns about medium- and long-term security of supply. In several member states in Central West and North West Europe, capacity mechanisms are being considered and/or introduced. This trend carries a serious risk of national fragmentation and reduced availability of capacity for cross-border trade and an increase of electricity cost and prices.

Europe is set to retire a substantial share of its power generating capacity, mainly coal and nuclear capacity, in the coming decade. The need for new builds presents a window

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of opportunity for the entry of competitive players and the development of low-carbon technologies. But for this transition to happen, energy markets will need to restore efficient pricing to signal long-term investment needs at the right location and time.

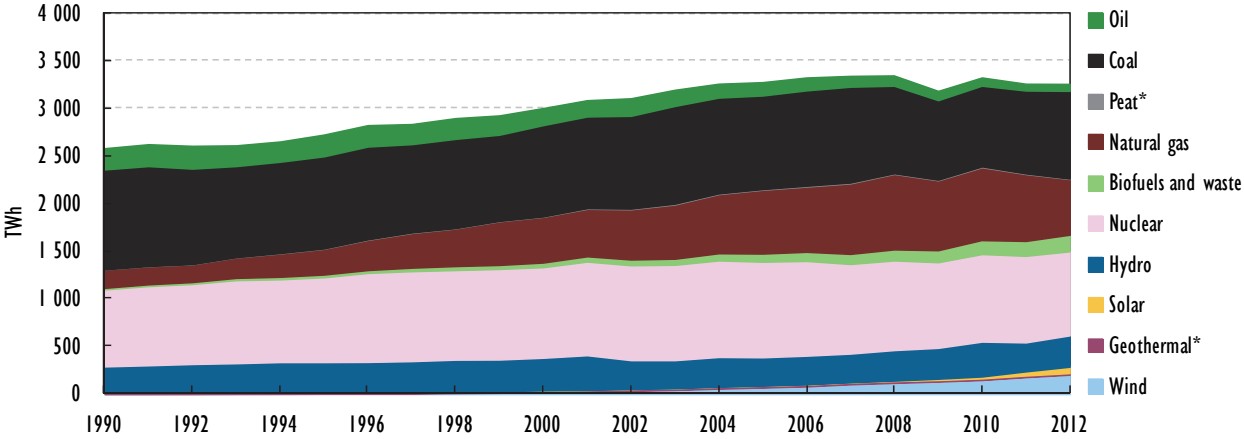
The rising share of variable renewable energies in the EU energy mix calls for fundamentally transforming the way electricity markets and grids operate. The requirement for adapted market rules has been widely acknowledged. There is a unique opportunity to reap the benefits from further market integration and fully functioning competitive EU electricity wholesale and retail markets. This next step of integration towards a fully efficient system operation at the level of interconnected systems requires cross-border co-ordination and integration of intra-day and balancing markets, generating capacities, and demand-side responses.

## SUPPLY AND DEMAND

### ELECTRICITY GENERATION

Total electricity generation in the European Union was 3 264.1 terawatt hours (TWh) in 2012 (excluding hydro pump storage). This denotes a second consecutive year of falling generation, down from 3 332.8 TWh in 2010. The overall trend since 2007 has been a slow decline, with total generation 2.5% lower in 2012 compared to 2007.

**Figure 5.1** Electricity generation in the European Union by source, 1990-2012




* Negligible.

Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014c), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

The electricity mix in the European Union is split fairly evenly between coal, nuclear power and natural gas. In 2012, coal accounted for 28.14% of generation, closely followed by nuclear (27%) while natural gas represented 17.8%. Electricity from these three fuels has declined by 8.3%, 5.7% and 21.3% since 2007, respectively.

Renewable energy sources (RES) amounted to 24.1% of electricity generation in 2012, made up of hydro (10.3%), wind (6.3%), biofuels and waste (5.2%), solar (2.3%) and geothermal (0.2%). The share of renewables has increased considerably from 16% in 2007, when the first in-depth review was carried out. This is largely due to a boom in investment in wind and solar capacity. Solar power generation grew eightfold in the five



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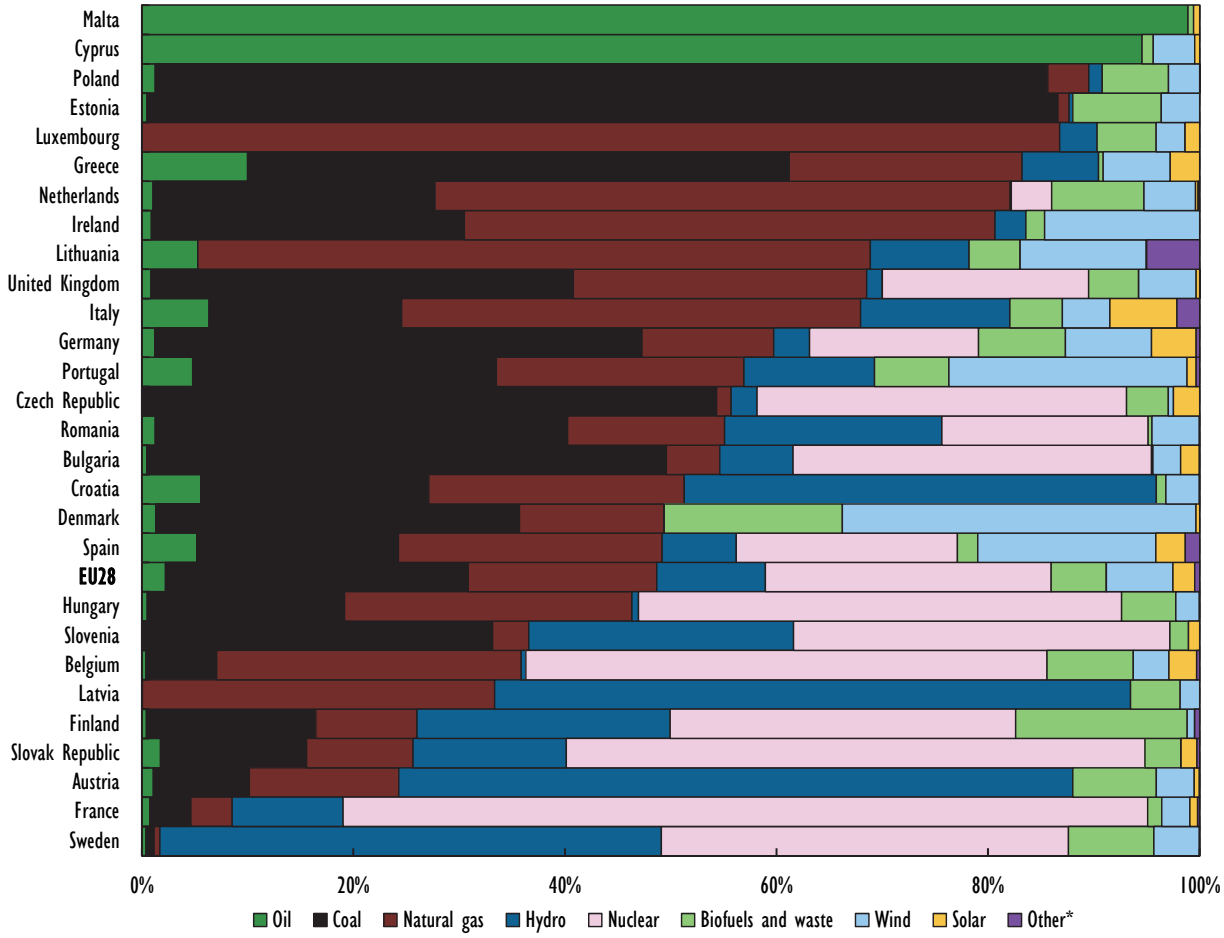
years, while generation of wind power nearly doubled. The increase in electricity from biofuels and waste was 63.7%, with 6.8% growth in hydro. Electricity from geothermal power has remained constant over the five years.

Over the ten years since 2002, solar power capacity has increased 200 times from 362 megawatts (MW) in 2002 to 68.7 gigawatts (GW) in 2012. Wind power capacity grew by 359.6%, from 23.1 GW in 2002 to 106.3 GW in 2012. This growth occurred in particularly in Germany, Spain and Italy.

Malta and Cyprus[1] have the highest share of oil in power generation, while France and Sweden lead with regard to low-carbon electricity production (Figure 5.2).

**Figure 5.2** Electricity generation in the European Union by country and source, 2012




* *Other* includes geothermal and ambient heat production. Peat is included under coal.

Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA, Paris; IEA (2014c), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

**1.** Two footnotes: 1. **Footnote by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue". 2. **Footnote by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

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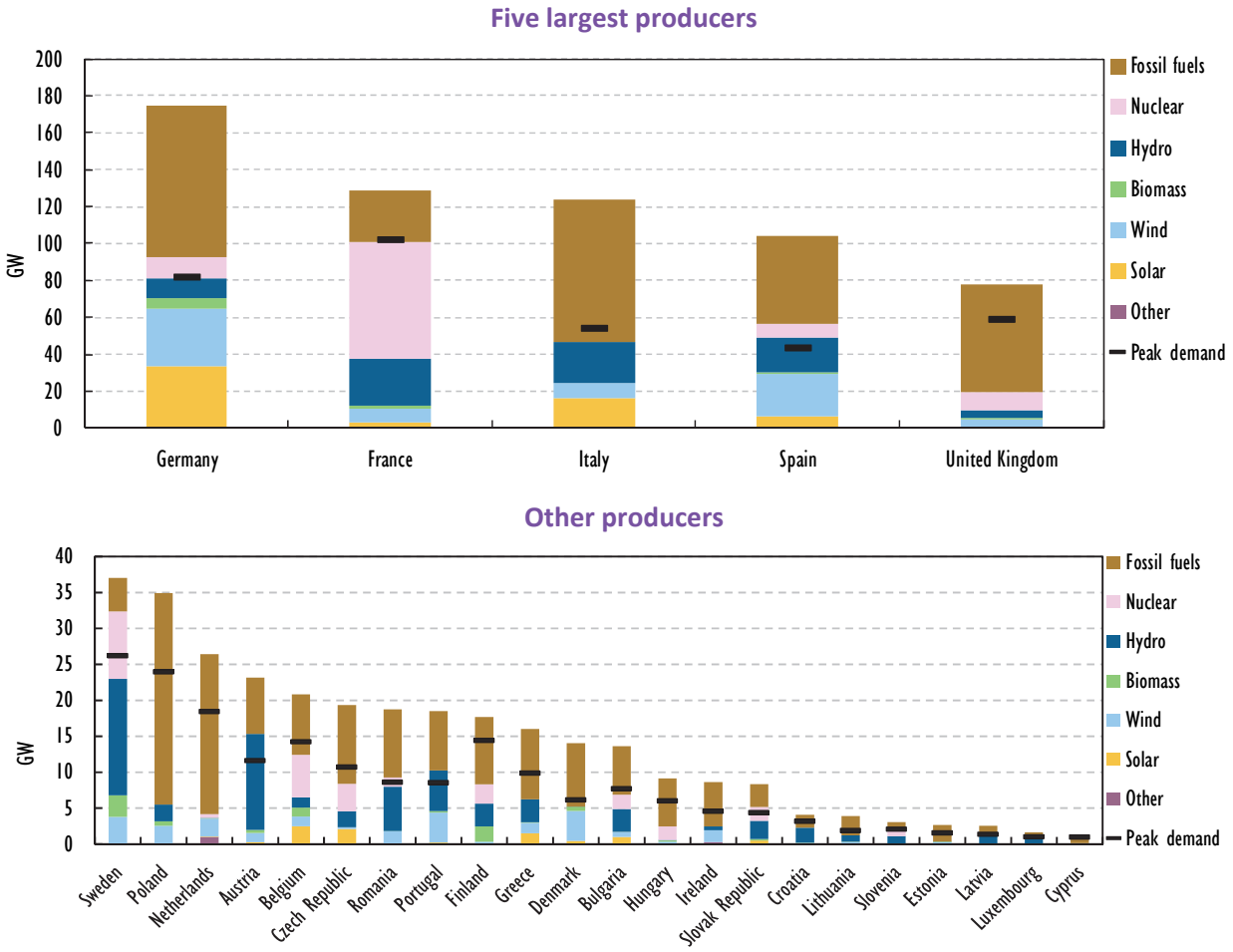
**Figure 5.3** Net generating capacity and peak demand in EU member states, 2013




Source: ENTSO-E (2014a), Statistical Factsheets 2013, 25 April 2014.

Total installed generation capacity in the European Union was 952.1 gigawatts (GW) in 2012. Capacity from combustible fuels accounts for 52%, followed by hydro (15.6%), nuclear (12.9%), wind (11.2%), solar (7.4%) and other (0.3%). Gas-fired plants and renewable energy installations saw a strong growth up to 2010. The European Union has a modern fleet of combined-cycle gas turbines (CCGTs), and since 1990 100 GW was added. There is a large diversity in the electricity mix in the EU.

In terms of installed capacity, Europe has a diverse generation mix with large-scale capacities installed in the large economies of Germany, France, Italy, Spain and United Kingdom (see Figure 5.3). In 2012, Germany had the highest installed generating capacity in total and notably in fossil fuels. With its large capacity of wind power, Germany needs to manage a high intermittency.

France has to cope with the highest peak demand of 102 GW. France had the highest installed capacity for nuclear (63 GW) and hydro (25 GW), followed by Italy with 22 GW and Spain with 19 GW in the European Union. Austria, and Norway and Switzerland, outside the EU28, have substantial capacities of pumped-hydro storage plants.

Germany leads in terms of solar (33 GW), biomass (6 GW) and wind (31 GW) for installed capacity.



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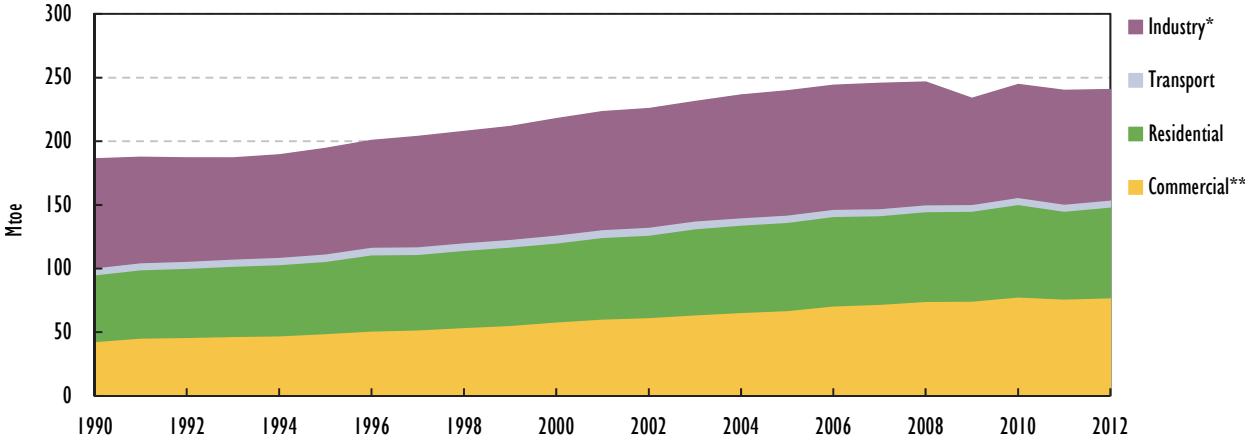
## ELECTRICITY CONSUMPTION

Industry is the largest electricity consuming sector across the European Union, and accounts for 36% of total consumption. This is closely followed by the commercial and residential sectors, which represent 32.1% and 29.6% of demand. Transport accounts for 2.3% of the total. Over the past five years, the pattern of electricity consumption by sector has experienced some changes, with a decline in demand from industry and transport and an increase in consumption in the commercial and residential sectors. Industry consumption has contracted by 11.9% in total from 2007 to 2012, including a dip of 13.6% during the economic recession in 2009, without a full recovery in the following years. Overall electricity consumption declined by 5.2% during 2009, mainly owing to a fall in demand from industry. The share of transport has been on a downward trend since the 2000s, while demand from the commercial and residential sectors has been growing.

**Figure 5.4** EU electricity consumption by sector, 1990-2012

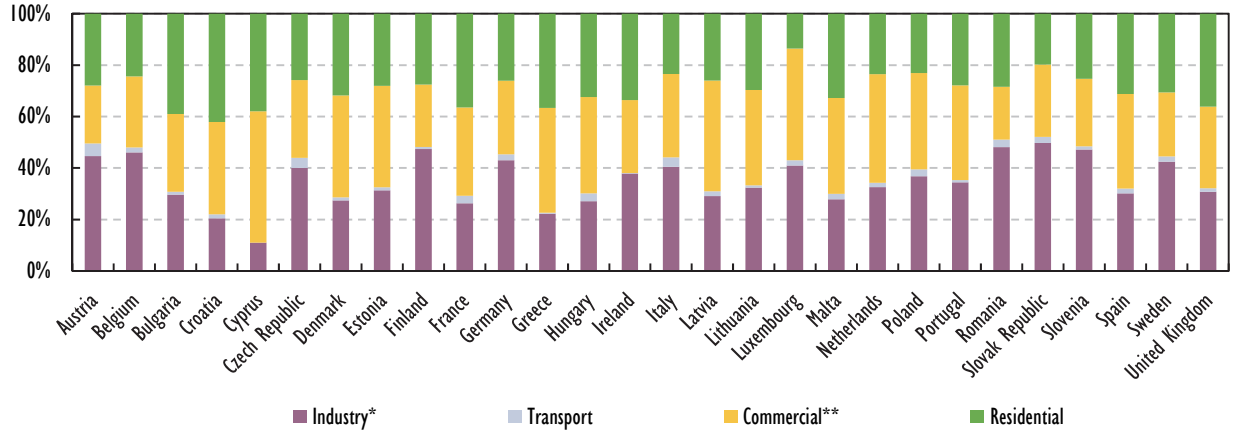



* *Industry* includes non-energy use.

** *Commercial* includes commercial and public services, agriculture, fishing and forestry.

Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA, Paris; IEA (2014c), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

**Figure 5.5** Electricity consumption by sector in EU28 member states, 2012




* *Industry* includes non-energy use.

** *Commercial* includes commercial and public services, agriculture, fishing and forestry.

Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA, Paris; IEA (2014c), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

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Within the EU member states, the share of industry consumption is the highest in the Slovak Republic, Romania and Finland, while commercial use has the highest share of the total in Cyprus, Luxembourg and Latvia. The share of residential use is the highest in Croatia, Bulgaria and Cyprus, while Austria, the Czech Republic and Italy have the highest share of transport in electricity consumption.

## IMPORTS AND EXPORTS

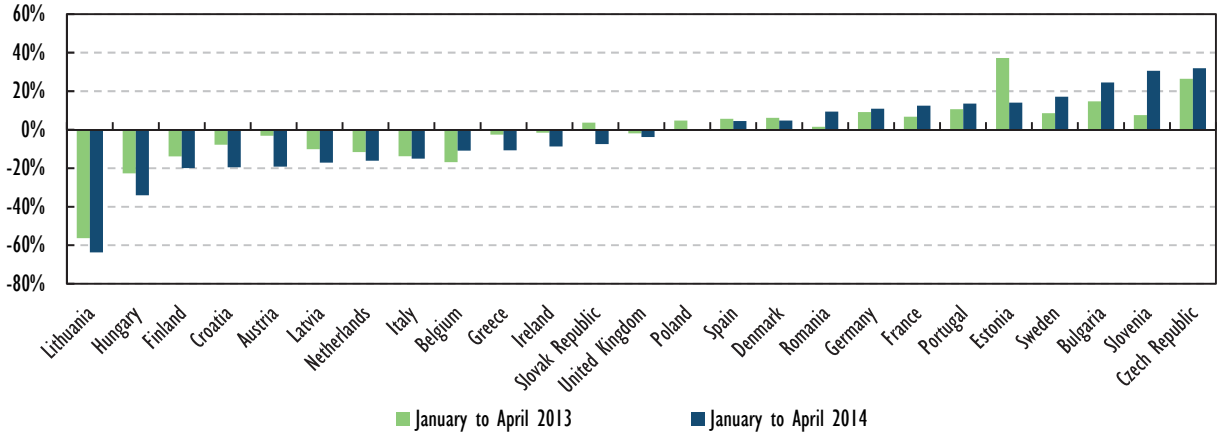
The flow of extra-EU imports and exports is marginal compared to the high volumes of intra-EU electricity cross-border trade and domestic electricity consumption. Within the European Union, countries are frequently changing from being a net exporter to a net importer position, depending on the wholesale price differentials. A snapshot of the positions of the countries is provided in Figure 5.6 for 2013 and 2014.

EU import and export flows of electricity from neighbouring countries have been growing in size in the past decade, notably from Norway (to the Netherlands, Denmark, and to a lesser extent to Sweden) and Switzerland.

The Baltic states run in synchronous mode with the Russian unified power system and are not integrated in the European market. Estonia has, however, increased its interconnections to Finland and the Nordic market (through direct current links Estlink 1 and 2), while Latvia and Lithuania, following the closure of the Ignalina nuclear power plant, increasingly rely on Russian imports. In 2012, Lithuania imported 29% of its annual power needs from Russia and 25% from Belarus. Latvia imported 18% from Russia.

In Central East and South East Europe, the net exporters of electricity are Poland, the Czech Republic, Bulgaria and Romania, while Greece imported around 3% of its needs in 2012 from the Former Yugoslav Republic of Macedonia (FYROM) and Turkey. In 2012 Croatia imported from Serbia 3.4% of its electricity consumption, and from Bosnia, 12.6% (EC, 2014a).

**Figure 5.6** Intra-EU power import and export positions, 2013 and 2014




Notes: data represents the difference between power generation and consumption. Data for Cyprus, Malta and Luxembourg are not included.

Source: EC (European Commission) (2014a), *In-depth study of European Energy Security*, *Commission Staff Working Document,* COM(2014) 330 final, Brussels.



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## REGULATORY FRAMEWORK

With the entry into force of the third internal energy market package (hereinafter: Third Package), EU member states are currently implementing a comprehensive framework which builds on the principles of complete and effective market opening, competition and liberalisation. The main focus during the past five years was on increasing electricity market efficiency and cross-border trade.

As regards electricity, the relevant EU directives and regulations in the Third Package are as follows:

- Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity and repealing Directive 2003/54/EC ("Electricity Directive")
- Regulation (EC) No 714/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003 ("Electricity Regulation")
- Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators ("ACER Regulation")
- Additionally in 2011 legislation governing wholesale energy market transparency and oversight was adopted in the form of Regulation (EU) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency ("REMIT Regulation").

The Third Package moved regulation of electricity networks on cross-border issues into an EU framework which builds on the strong responsibility and co-operation of the transmission system operators (TSOs) and the national regulatory authorities (NRAs). The Third Package also formalised the co-operation of TSOs and NRAs at EU level.

### INDEPENDENT REGULATORS AND THEIR EU-WIDE CO-OPERATION

The Third Package strengthened the independence of NRAs from the governments and promotes their co-operation at EU level through the Agency for the Cooperation of Energy Regulators (ACER). The creation of ACER by the Third Package boosted the independence and co-operation of NRAs at EU level. ACER is far from being a European regulator (linked to the delegation powers of the European Commission versus its EU agencies in line with the Meroni case),[2] as it essentially creates a framework for the co-operation and participation of the NRAs at EU level. ACER provides for the uniform application of the internal market rules in the European Union and deals with cross-border decisions involving at least two member states.

ACER governance relies on national regulators, a fact which in practise strongly determines ACER decision-making, which is ruled by the qualified-majority voting principle in the board of regulators, and the role of ACER to take decisions upon referral by the NRAs. For instance, with regards to access to and operational security of cross-

**2.** The competences and powers of ACER were designed in accordance with the Meroni doctrine. In the Meroni case, the European Court of Justice set out in 1958 the conditions that had to be met if delegations of power from the European Union public service to delegated bodies (including those not yet established under the Treaty) were to be admissible. The delegation of discretionary power, implying a wide margin of discretion is to be excluded in all cases. This case is used as guidance to frame the delegation of regulatory powers from the European Union to new European Union agencies.

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border infrastructure, such as for example the exemptions from third-party access, ACER can decide only on those regulatory issues that fall within the competence of NRAs in the cases: a) where the competent NRAs have not been able to reach an agreement within a period of six months from when the case was referred to the last of those regulatory authorities; or b) upon a joint request from the competent NRAs.

## INDEPENDENT TSOS AND EU-WIDE CO-OPERATION

The Third Package has also increased the independence of the TSOs and their co-operation at EU level, through the European Network of Transmission System Operators – Electricity (ENTSO-E).

Effective separation of network activities from supply, generation or production activities in gas and electricity, so-called unbundling, is the cornerstone of the Third Package. Unbundling aims to ensure TSOs take their decisions in an independent, transparent and non-discriminatory manner towards all network users.

The Electricity Directive sets out ownership unbundling (OU) as the default structure for new TSOs or where network operators were part of vertically integrated companies on 3 September 2009, two alternative options: the independent system operator (ISO) and the independent transmission operator (ITO) (and its specific exception, the so-called ITO+).

Under OU, the TSO has to be fully separated from any supply and generation interests,[3] to fully decide on the activity of transmission, including the transmission operation. Under the ISO model,[4] ownership of the assets and operation the network are fully separate from each other. Operators which choose the ITO[5] option have to put in place stringent compliance structures to ensure the autonomy of the ITO, with regard to the independence of assets, equipment, staff, management and identity, network planning and investment decisions.[6] Under the ITO+ model, member states can maintain their systems, where the transmission system belonged to a vertically integrated undertaking on 3 September 2009, but the independence has to be more effective than in the ITO structure.

Ownership unbundling meant the change of ownership, divestiture in some countries (following competition law cases). Changing ownership structure of the TSO would require re-certification in the future.

TSOs have to be certified by the NRAs, taking utmost account of the opinion from the European Commission, which can also request ACER to provide its opinion.

By July 2014, the majority of EU member states have transposed the Third Package provisions on TSO unbundling. In most countries, one main transmission system operator for electricity was certified by the NRAs (see Table 5.1), except countries with a derogation and pending certifications.

Most member states have opted for OU of their electricity TSOs, relying on the provision of the Third Package which ensures that public ownership is compatible with the rules of effective separation within the state. Apart from Latvia, Romania and Ireland, no member state has opted for ISOs and similar structures. Some countries have chosen the ITO model, where the vertically integrated company still owns the ITO.

**3.** Article 17(1)(a) of Directive 2009/72/EC.

**4.** Article 9(8)(a) of Directive 2009/72/EC.

**5.** Article 9(8)(b) of Directive 2009/72/EC.

**6.** This includes all measures outlined in Chapter V (Articles 17 to 23 of Directive 2009/72/EC).



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**Table 5.1** Status of implementation of the unbundling (ITO, OU, ISO)

| Member state | Transmission system operator | Unbundling (ITO, ISO, OU) |
|---|---|---|
| Austria | Austrian Power Grid AG (APG)<br>Vorarlberger Übertragungsnetze GmbH (VÜN) | ITO<br>OU |
| Belgium | Elia System Operator SA | OU |
| Bulgaria | Electroenergien Sistemen Operator EAD (ESO) | Certification pending |
| Czech Republic | ČEPS a.s.(electricity) | OU |
| Croatia | Croatian Transmission System Operator Ltd (HOPS) | ITO |
| Denmark | Energienet.dk (electricity) | OU |
| Estonia | Elering | OU |
| Finland | Fingrid Oyj | OU |
| France | RTE | ITO |
| Germany | 50Hertz Transmission GmbH<br>Amprion GmbH<br>TransnetBW GmbH<br>TenneT TSO GmbH | OU<br>ITO<br>ITO<br>OU |
| Greece | Independent Power Transmission Operator SA (ADMINE) | ITO |
| Hungary | MAVIR Magyar Villamosenergia-ipari Átviteli Rendszerirányító Zártkörűen Működő Részvénytársaság | ITO |
| Ireland | EirGrid plc | Article 9 (9) ITO+ |
| Italy | Terna S.P.A.- Rete Elettrica Nazionale | OU |
| Latvia | Augstsprieguma tikls (AST) | ISO |
| Lithuania | Litgrid AB | OU |
| Netherlands | TenneT | OU |
| Poland | Polskie Sieci Elektroenergetyczne (PSE SA) | OU |
| Portugal | Rede Eléctrica Nacional (REN) | OU |
| Romania | Compania Naționala de Transport a Energiei Electrice (Transelectrica) | ISO |
| Slovenia | ELES, d.o.o. | Certification pending |
| Slovak Republic | Slovenská elektrizačná prenosová sústava (SEPS) | OU |
| Spain | Red Eléctrica de España: SA | OU |
| Sweden | Affärsverket svenska kraftnät | OU |
| United Kingdom | National Grid Electricity Transmission<br>System Operator for Northern Ireland Ltd<br>Scottish Power Transmission Limited<br>Scottish Hydro Electric Limited | OU<br>Article 9 (9) ITO+<br>Article 9 (9) ITO+<br>Article 9 (9) ITO+ |

Notes: ISO: independent system operator; ITO: independent transmission operator ; OU: ownership unbundling. The list is non-exhaustive and dates August 2014. Certification procedures are ongoing in a number of member states and changes to some of the TSO certification can be expected.

Source: EC (2014b), *EC opinions to the TSO certifications notified by NRAs:* http://ec.europa.eu/energy/gas_electricity/interpretative_notes/doc/certification/certifications_decisions.pdf, (accessed on 1 August 2014).

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The opinions of the European Commission have raised a number of issues with regard to the involvement of financial investors, of the state, third-country vertically integrated companies and ITO compliance provisions.

A monitoring mechanism has been implemented in a number of countries to ensure that ownership changes, notably with regard to the participation of financial investors, can be re-assessed or re-certified by the NRA.

Where the state owns the TSO, member states need to ensure the activities are under the responsibility and control of separate public bodies within the state. The European Commission issued an interpretative note on the involvement of financial investors in transmission activities (EC, 2013b).

The ISO model is not widely used in Europe, unlike in the United States. Moreover there are important differences between the ISO as set out in EU legislation and the independent system operators in the United States, which usually integrate system and market operation across several system and state boundaries. As system operation and network ownership are separate from each other in the US ISO model, the operators need to ensure the co-ordination between these activities. ISOs ensure full transparency of the market and a competitive investment framework for generation and demand-response and network assets through the organisation of tenders for new investments.

In the European Union, there is no general integration of system operation and market operation, (except in some market areas, where both system and market operation are tightly integrated). Moreover, TSO control zones coincide with national borders in the majority of cases. This is why TSOs need to be regulated to maximise available transmission capacity, notably on the interconnectors, and need to be guided by clear rules for system security in a wider interconnected electricity market.

Some elements of the US ISO model may provide valuable lessons for increased integration of European systems and markets. National regulators will need to enforce strong regulatory supervision of ITOs to ensure effective separation of supply, production and network interests. In cases where the state owns national utilities, ownership unbundling (OU) within the state can be an obstacle to timely and efficient cross-border network investment, when supply interests are protected. The high level of public ownership also requires a much stronger independence of national regulators.

**Box 5.1** Framework guidelines and network codes in electricity

A new feature of the third package is the harmonisation of technical rules through the adoption of EU-wide framework guidelines (FG) and network codes (NCs) in line with Regulations (EC) No 713/2009 and (EC) No 714/2009. On the basis of an annual priority list, the European Commission asks ACER to develop a framework guideline (within 6 months) which sets the general framework for the principles and scope of the NC, to be developed by ENTSO-E to facilitate the development of the internal market, within a year. The NC by ENTSO-E is then submitted to ACER for a reasoned opinion to check the compliance with the FG and the fulfilment of the Third Package objectives. ACER submits the NC to the European Commission for adoption within a reasonable time period by the member states represented in the Electricity and Gas Committees through the so-called comitology procedure. The 12 areas in which the FG and NCs are to be adopted are listed by Article 8(6) of Regulation (EC) No 714/2009 are as follows:



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**Box 5.1** Framework guidelines and network codes in electricity (continued)

- network security and reliability, including technical transmission reserve capacity for operational network security
- network connection
- third-party access
- data exchange and settlement
- interoperability
- operational procedures in an emergency
- capacity allocation and congestion management
- trading with regard technical and operational provision of network access services and system balancing
- transparency
- balancing, including network-related reserve power
- harmonised transmission tariff structures including locational signals and inter-transmission system operator compensation
- energy efficiency regarding electricity networks.

To date FG and (draft) NCs in electricity have been developed in four areas: (1) the FG on grid connection, which includes three separate draft NCs for generation, load (including distribution system operators [DSOs]) and high-voltage direct current (HVDC); (2) the NC on capacity allocation and congestion management including the governance relates to the FG for capacity calculation, intra-day and day-ahead, as well as long-term capacity; (3) the FG on system operation comprises draft NCs with minimum standards and requirements for operational security and reliability rules, operational scheduling and planning, load-frequency control and reserves, as well as emergency rules and restoration; and (4) based on the developed FG on electricity balancing, the electricity balancing NC is now being prepared which will be of utmost importance for creating close-to-real time markets and flexibility for the integration of renewable energies and creating opportunities for demand-side response. The FG introduces a national balancing reserve, balancing energy procurement specifications and cross-border balancing exchanges. The FG also stipulates the roles and responsibilities of the TSOs and the Balance Service Providers. After review and revision by the Commission, the draft NCs for electricity, as developed by ENTSO-E, on capacity allocation and congestion management and on requirements for generators and demand connection are being introduced into the comitology process for formal adoption by end 2014.

A lesson learnt in the process from FG to the development of NCs is the need for intensive stakeholder consultation of all market participants, which requires time and procedures. The work highlighted the complexity and differences of the electricity systems particularly in the context of fast evolving electricity markets and systems. Stakeholders have expressed concerns about the manner in which some of the draft NCs were developed. Maintaining confidence in the process has required the European Commission and ACER to engage closely with stakeholders following the development of draft codes. In order

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to ensure regular updates of the codes in the future, the procedure for NCs and its governance can benefit from more transparency and streamlined consultations.

## DISTRIBUTION SYSTEM UNBUNDLING

At distribution level, the Third Package requires legal and functional unbundling, not OU. This is being implemented in practise by the creation of a separate corporate identity and rebranding. The unbundling process is still ongoing.

There are exemptions for DSOs and closed DSOs. Only the Netherlands opted for the introduction of distribution OU. It has been challenged by Eneco, Essent NV, Essent Nederland BV and Delta. In October 2013, the ruling from the European Court of Justice (ECJ)[7] confirmed that it is up to member states to decide on public versus private ownership. Any ban of privatisation can be a justified limitation to the freedom of movement of capital in the internal market, if it pursues EU-wide public interests, like greater market transparency and competition.

# WHOLESALE ELECTRICITY MARKETS

Cross-border electricity trade has been growing within the integrated EU internal energy market across Europe and with Norway and Switzerland.[8] International trade of electricity was already occurring in the 1970s and 1980s, but liberalisation in the 1990s bolstered electricity trade, representing 350 TWh or around 10% of gross production in 2011. Within OECD Europe major electricity physical imports/exports included:

- Germany, Europe's biggest power market with 513 TWh, imported some 43.8 TWh of electricity and exported 66.6 TWh, resulting in a surplus of 22.8 TWh in 2012.
- France remained Western Europe's leading electricity exporter in 2012 with 44 TWh, although this figure was down by 21% from 2011.
- Norway, Sweden, Austria and Switzerland have a strong hydroelectric installed capacity and have growing electricity exports.

## MARKET COUPLING

The integration of wholesale electricity markets in the European Union encompasses the day-ahead market (DAM) through the coupling of cross-border electricity exchanges. This section is dedicated to the EU market model and explains how market coupling has been developed since 2008.

**7.** Joined cases C-105/12, C-106/12, C-107/12, Staat der Nederlanden v Essent and others (16 April 2013), Opinion of AG Jääskinen, see: http://curia.europa.eu/juris/document/document.jsf?text&docid=143343&pageIndex=0&doclang=EN&mode=lst&dir&occ=first&part=1&cid=252828. The European Court of Justice considers the ban of privatisation of gas and electricity distribution networks compatible with both Article 345 TFEU and Article 63 TFEU on free movement of capital. The Attorney General argued that the European Union Treaties (Art. 345 TFEU) shall in no way prejudice the member states' rules governing property ownership. While group prohibition and side activities prohibition restrict the freedom of capital, such unbundling requirements can be justified under the economic objectives of the European Union Treaties to achieve the goals of energy market transparency and to prevent distortions of competition. However, member states have to act in a proportional manner, when putting forward public interest objectives.

**8.** Norway is not a member of the European Union but it enjoys close ties with the European Union as member of the European Economic Area. Switzerland is neither a member of the European Union nor the European Economic Area. Norway and Switzerland have an important role in OECD Europe electricity trade flows and have been therefore included in the analysis.



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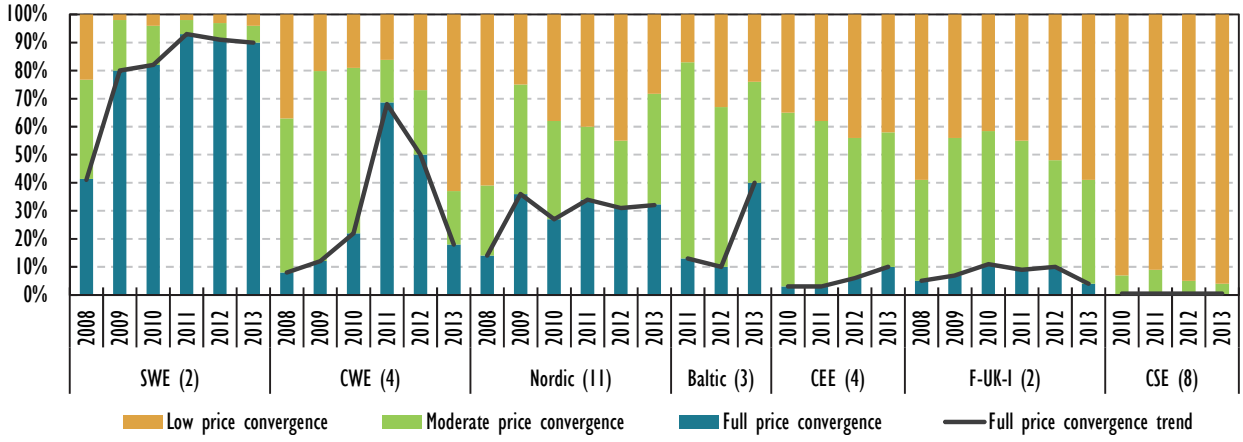
The current EU electricity target model, which sets out the rules for the EU wholesale market integration, relies on efficient cross-border capacity calculation, efficient long-term capacity allocation and efficient day-ahead and intra-day cross-border markets and efficient balancing markets. The target model is evolving and being implemented through the completion of the electricity NCs and guidelines and the price coupling process. The EU market model has evolved along the coupling of regional electricity markets, starting with the Nordic market, to Central West, North West Europe, towards the coupling of the regional DAM, (17 member states in 2013) towards a European DAM (2014).

During 2008-12, market coupling has improved liquidity, cross-border trade and price-convergence (see Figure 5.7), and has reduced volatility and increased transparency in traded electricity markets. The prices at wholesale markets decreased and converged over time.

Market coupling optimises interconnection capacity utilisation and ensures that electricity flows from low price to high price areas by the automatic linking of buyers and sellers on either side of a border. The DAM coupling applied in Central West Europe (CWE) allows hourly transactions between buyers and sellers on the exchanges, independent of their physical location. Cross-border capacity is used to eliminate price spreads between the markets, as long as capacity remains available. The cross-border capacity allocation is carried out together with the financial energy settlement in one single operation at the exchange, which renders prior reservation of cross-border capacity unnecessary. In cases of sufficient cross-border capacity, this so-called implicit auctioning process delivers one single market price across borders. In cases of cross-border capacity constraints, optimal trades become restricted and lead to price spreads. The evolution was from market coupling to price coupling and is to become even more integrated on the basis of flow-based market coupling.

Market integration in Europe started in the Nordic market area within Nord Pool, then with market coupling in the CWE region after the launch of the trilateral market coupling between the Netherlands, Belgium and France in 2007, and its extension to Luxembourg, Germany/Austria in 2010 and to Norway and the United Kingdom. Liquidity and depth was enhanced by so-called interim tight volume market coupling (ITVC) with the Nordic region via four direct current (DC) cables and the day-ahead coupling with the British market via the BritNed cable.

**Figure 5.7** Price convergence in Europe by region, 2008-13 (%)




Note: the numbers in brackets refer to the number of bidding zones included in the region in the calculations.

Source: ACER/CEER (2014), *Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2013*, Slovenia, http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER_Market_Monitoring_Report_2014.pdf

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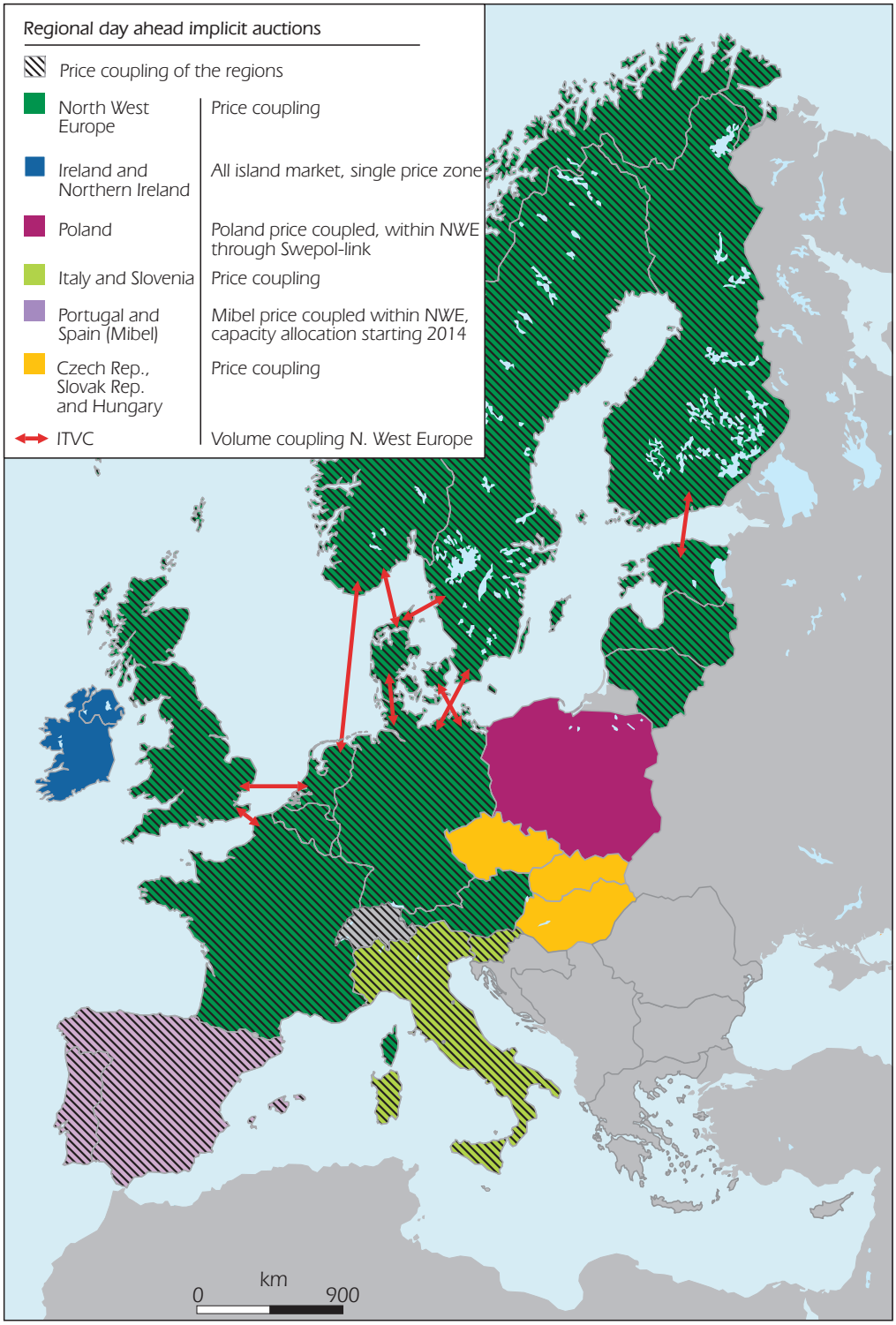
**Figure 5.8** Overview of market coupling towards a European DAM

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A northern European power market has been created through Nord Pool Spot as the marketplace for physical power contracts, with a spot market (Elspot) and an intra-day market (Elbas). The Nordic market is interconnected with Russia, Germany, the Netherlands, Estonia and Poland and is now fully integrated with other regional European markets, the United Kingdom, Belgium and the Netherlands, through new interconnections and price coupling – a development which will gradually lead to a single European market for electricity.

Nord Pool has increased its share in electricity trade every year. In 2013, physical spot market trading amounted to almost 500 TWh, or 84% of total consumption in the four Nordic countries, up from 307 TWh in 2010 and 297 TWh in 2011. The remaining 16% was traded on termed bilateral contracts. The market share of Nord Pool Spot AS is more than 50% in all the Nordic countries.

Following the deregulation in Estonia and Lithuania in 2012, the Nordic and Baltic markets have been integrated. In March 2012 Estonian, Latvian and Lithuanian electricity TSOs Elering, Augstsprieguma Tīkls and Litgrid signed a Memorandum of Understanding on the purchase of the shares of the Nord Pool Spot of 2% each. Nord Pool Spot AS is jointly owned by the Nordic TSOs, Statnett SF (28.2%), Svenska Kraftnät (28.2%), Fingrid Oyj (18.8%), Energinet.dk (18.8%) and the Baltic TSOs, Elering (2%), Litgrid (2%) and AST (2%).

On the spot market (Elspot), physical power contracts are traded hour by hour for delivery on the following day. The Elspot market comprises Denmark, Finland, Norway, Sweden, Estonia and, since 18 June 2012, Lithuania. Prices are determined on the basis of the balance between bids and offers from all market participants and implicit auctions are used to allocate cross-border capacity.

Building on Nord Pool, the Nordic market place has been integrated with the neighbouring markets and the Central West and Baltic market areas. At the same time, the continental regional electricity markets have been linked together via DAM coupling. Network operators, traders, power exchanges and utilities, together with member states and regulators and ACER have supported this process of market integration.

In 2012, the so-called European Price Coupling or Price Coupling of the Regions, was established for the day-ahead timeframe by seven power exchanges, APX, Belpex, EPEX SPOT, GME, Nord Pool Spot, OMIE and OTE; covering the day-ahead electricity markets in Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Italy, Latvia (June 2013), Lithuania, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

## ADJUSTING MARKET COUPLING TO A SYSTEM WITH RENEWABLE ENERGIES

In recent years, however, price convergence has been declining rapidly. In energy systems with high shares of renewable energy existing market coupling algorithms failed to reflect the cost and actual transmission network use (e.g. losses, loop flows or physical power flows). Taking greater account of these would facilitate even more cost-efficient trades across regions.

The introduction of flow-based market coupling (for implicit auctions) is foreseen to add greater accuracy to the market coupling method. Flow-based market coupling (FBMC) is meant to further enhance network integrity and price convergence to cope with growing electricity trade and unscheduled power flows (see below section on Security of Supply). It relies on a more detailed modelling of the underlying physical network and allows for a more precise evaluation of feasible financial trading.

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In April 2014, Austria, the Czech Republic, Germany, Hungary, Poland, Slovakia and Slovenia agreed within the ACER regional co-operation to couple their markets by using a flow-based method for calculating the capacities on the cross-border electricity interconnectors and by implicitly allocating these capacities on the basis of the Price Coupling of Regions (PCR) solution. By the end of 2014, FBMC is to be implemented across the European Union and is expected to deliver welfare benefits from increased price convergence, trade and reliability in the range of EUR 136 000 per day across all regions (APX Group, 2011). However, to ensure efficient grid integration of renewable energies, the flow-based algorithm is only one element; it will also require renewable sources to be fully integrated in the wholesale markets and merit-order dispatch and respond to balancing requirements.

## INTRA-DAY MARKETS

Market coupling has so far been limited to the DAM integration. Intra-day and balancing markets largely remain national or bilateral, as organised on a bilateral/regional level by TSOs, but they are small in scope and liquidity. They are:

- Dutch-German border (December 2008) – first-come-first served
- Dutch-Belgium border (May 2009) – implicit auctions
- Nordpool Elbas platform (February 2011) – continuous trading
- Dutch-Norwegian NorNed interconnector (March 2012) – continuous trading
- Great Britain on BritNed (May 2012) – explicit auctions.

Elbas is the physical intra-day balancing market for trading in the Nordic countries, Estonia and Germany. If transmission capacity is available, neighbouring countries can trade on the Elbas market. It is the only cross-border intra-day market in the world, with a total volume of 2.2 TWh in 2009. TSOs publish their daily power transmission capacity on Elbas and contracts are hourly and traded continuously around the clock up to 30 minutes before delivery to adjust power production or consumption plans. The balancing market is used by power producers, energy-intensive industry, portfolio managers and traders. In January 2011 the Nordic system operators and regulators started work on a common Nordic balance settlement. In 2011 Elbas was licensed to APX-ENDEX as the intra-day market in Belgium and the Netherlands.

The creation of a harmonised platform for continuous implicit cross-border intra-day trading in the CWE region is currently under development. The network code on balancing should provide for rules to enlarge the DAM co-operation on balancing markets. With the rising shares of variable renewables and more dynamic power flows, and close-to-real-time markets, integrated intra-day markets will play a strong role in providing flexibility and strengthening cross-border trade.

## LONG-TERM CROSS-BORDER CAPACITY TRADING

Intra-day capacity auctions as well as long-term (month or year ahead) auctions remain covered under the so-called explicit capacity allocation methodology. Explicit auctioning requires ex ante reservation of cross-border capacities to cover single financial transactions between supply and demand. In 2009, auction rules for the CWE region were harmonised and explicit allocation of cross-border capacity is carried out by one single auction operator (CASC.EU), based upon a harmonised set of auction rules across several regions, CWE, Central-South and Scandinavia.



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Explicit auctioning of long-term capacity rights risks reducing competition and increasing market distortion unless accompanied by a robust regulatory framework. The introduction of a functioning and liquid secondary market for trading of obtained physical cross-border capacity rights can provide greater transparency for the value of the rights. Such capacity trades, comparable to the concept of financial transmission rights, can also encourage the respective capacity holders to make capacity available to the market, as economically rational.

## EU ELECTRICITY MARKET DEVELOPMENTS

After a decade of regional wholesale market integration, electricity markets in the European Union are strongly impacted by national energy and climate policy decisions, including renewable energy support schemes, new capacity mechanisms, and retail market regulation as well as by the trends in international energy commodity markets, including coal and EU-wide carbon prices.

Three elements are crucial for building a well-functioning EU electricity market:

- improved functioning of national markets by limiting state intervention (support for renewables, capacity remuneration mechanisms, regulated tariffs)
- improved cross-border capacity (infrastructure investment, balancing and intra-day markets)
- optimised cross-border flows (market coupling).

### EU ELECTRICITY MARKETS AND THE BOOM IN RENEWABLE ENERGIES

As a result of the financial and economic crisis, reduced energy demand and continuous growth of renewable energy deployment, the European Union has currently comfortable levels of generating capacity, notably in the Central West markets. Net generating capacity over peak demand is substantial in these electricity markets (Table 5.2).

As highlighted in the *World Energy Investment Outlook 2014* (IEA, 2014f), the European Union has seen strong investment worth USD 100 billion or EUR 74 billion in power generation, in particular in renewable energies (USD 80 billion or EUR 60 billion) and gas-fired power generation (IEA, 2014f). As shown in Figure 5.9, during the period 2007-13 several investment projects for new nuclear power plants were introduced. The capacity in renewable energies increased, however, outside of market needs, as at the same time electricity demand growth decreased.

During the period 2007-13, the European Union experienced an unprecedented investment boom in wind and solar thanks to the generous national support schemes. Since 2012-13, investments are however on the decline; investment in RES decreased in the European Union by about 25% during the first quarter of 2013 and came to a halt or slowed down considerably in Spain, Italy and France. This is attributable to both cost reductions in renewable energy technology and reduced deployment levels.

The investment and large-scale additions of variable non-dispatchable renewable energies in Central and South Europe have brought about a number of new challenges for the wholesale electricity markets, the merit-order dispatch, system operation and grid management, as electricity trade flows across borders and at the distribution network level increased.

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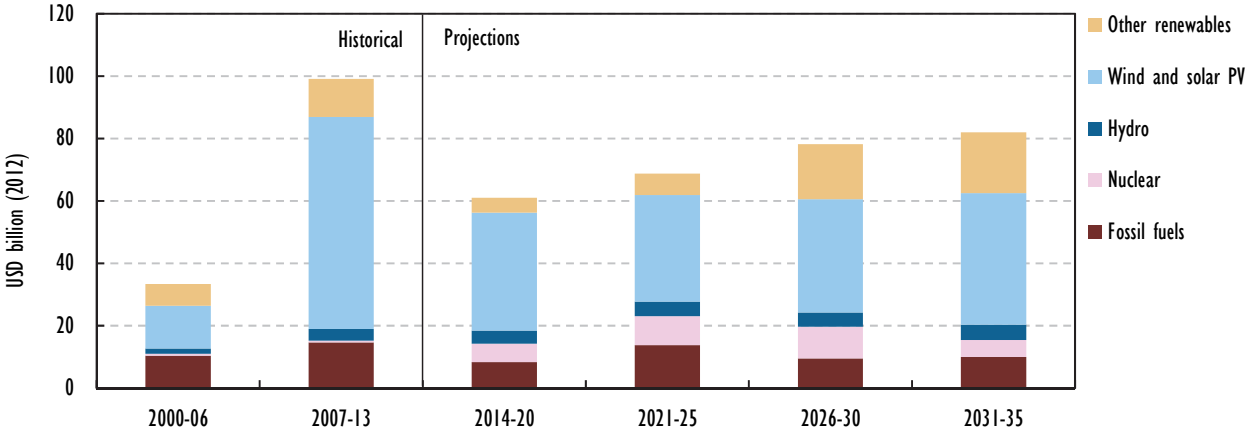
**Figure 5.9** EU investment in power plants by type, historical, New Policies Scenario*




* The IEA *World Energy Outlook 2013* uses a scenario approach to examine future energy trends out to 2035. It presents three scenarios: the New Policies Scenario, the Current Policies Scenario and the 450 Scenario. The New Policies Scenario takes into account broad policy commitments and plans that have already been implemented to address energy-related challenges as well as those that have been announced, even where the specific measures to implement these commitments have yet to be introduced.

Source: IEA (2013), *World Energy Investment Outlook 2013*, *World Energy Outlook* Special Report, OECD/IEA, Paris.

**Box 5.2** The power of transformation

Wind power and solar photovoltaic (PV) are expected to make a substantial contribution to a more secure and sustainable energy system, in particular in a number of EU countries. However, electricity generation from both technologies is constrained by the varying availability of wind and sunshine. This can make it challenging to maintain the necessary balance of electricity supply and consumption at all times. Consequently, the cost-effective integration of variable renewable energy (VRE) has become a pressing challenge for the energy sector.

After a thorough assessment of flexibility options currently available for VRE integration, the IEA considers that large shares of VRE (of 30% to 45% in annual electricity generation) can be integrated without significantly increasing power system costs in the long run. However, cost-effective integration calls for a system-wide transformation. Moreover, each country may need to deal with different circumstances in achieving such a transformation.

The EU 2020 Climate and Energy Package has kick-started a substantial deployment of VRE in the European Union. The continued integration of large amounts of VRE towards and beyond 2020 calls for a system-wide approach, with a view to transform electricity grids as a whole. Such a transformation has three main pillars: i) optimising the value that wind and solar PV bring to the entire system; ii) improved operational strategies (trading close to real time, EU market integration, optimised use of existing grids) and iii), co-ordinated investments to increase system flexibility via flexible generation (such as flexible renewable and fossil plant), demand-side response and management, electricity storage and grid infrastructure. In this new context, the efficiency gains from optimised and smart grids at EU level can allow the European Union to meet this challenge in a more cost-efficient way.

Source: IEA (2014e), *The Power of Transformation*, OECD/IEA, Paris.



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After a period of converging wholesale prices, prices at the Central West European spot markets are showing a wider spread (Figures 5.7 and 5.10), indicating the higher congestion on the interconnectors in the Central European market, a phenomenon which is largely attributable to unscheduled flows of variable renewable electricity in the grids and changing wholesale price differentials.

On the wholesale markets, the low or zero marginal production costs – compounded by the design of certain renewable energy support schemes that insulate generators from market signals – change the structure of the offer curve (merit order of power generation) such that wholesale prices are reduced and sometimes become negative (merit-order effect). In addition, plants with higher fuel costs, currently gas-fired plants, are displaced from the market and thus see fewer hours of operation (utilisation or compression effect).

At the same time, variable renewable energies require a power system that can accommodate them, be it from interconnector capacity (imports/exports), demand-side responses, thermal power plants as back-up or smart grids. A price depression on wholesale markets induced by over-supply can thus raise concerns about the adequacy of long-term generation, where short-term markets today do not cater for the longer-term investment needs to replace the ageing capacities.

**Table 5.2** Available generation capacity in the zones of ENTSO-E member TSOs

| GW | 2010 | 2011 | 2012 | Change 2012 to 2011 | |
|---|---|---|---|---|---|
| | | | | Absolute value (GW) | % |
| **Net generating capacity** | 910.7 | 935.5 | 981.1 | 45.5 | 4.9 |
| Fossil fuels power | 451.3 | 454.8 | 463.5 | 8.7 | 1.9 |
| Nuclear power | 133.9 | 125.7 | 125.4 | -0.4 | -0.3 |
| RES (including renewable hydro) | 263.4 | 303.7 | 354.8 | 51.2 | 16.8 |
| Non-renewable hydro power | 66.5 | 46.8 | 36.5 | -10.3 | -22 |
| Not clearly identifiable energy sources power | 5.7 | 4.5 | 0.9 | -3.6 | -8.4 |
| **Unavailable capacity** | 237.1 | 270.6 | 329 | 58.4 | 21.6 |
| Non-usable capacity | 155.7 | 189.4 | 232.5 | 43.2 | 22.8 |
| Maintenance and overhauls | 26.3 | 30.2 | 36 | 5.9 | 19.4 |
| Outages | 22.9 | 20 | 27.6 | 7.6 | 38.1 |
| System service reserve | 32.2 | 31.1 | 32.9 | 1.8 | 5.8 |
| **Reliable available capacity** | 658.5 | 664.9 | 652.1 | -12.9 | -1.9 |
| Load | 521.2 | 473.5 | 481.3 | 7.8 | 1.7 |
| **Remaining capacity** | 137.3 | 191.4 | 170.7 | -20.7 | -10.8 |
| Exchanges | -0.6 | -2.2 | -1.1 | 1.2 | -52.2 |
| Imports | 40.1 | 51.2 | 46.1 | -5.1 | -10 |
| Exports | 40.7 | 53.4 | 47.2 | -6.3 | -11.7 |

Source: ENTSO-E (2013), *Memo 2012*, April 2013; ENTSO-E (2012), *Memo 2011*, April 2012; ENTSO-E (2011), *Memo 2010,* April 2011; EC (2014a), *In-depth study of European Energy Security, Commission Staff Working Document,* COM(2014) 330 final, Brussels.

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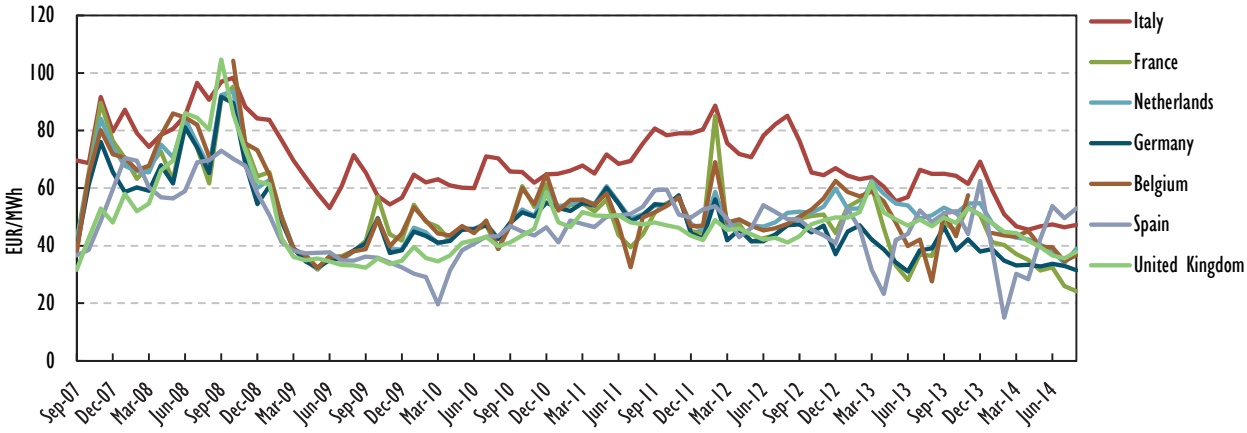
**Figure 5.10** Central Western European spot power prices for base-load capacity




Source: Bloomberg, 2014.

**Box 5.3** The loop flows in the European electricity market

In a meshed network, physical flows do not always follow contractual flows. Unscheduled flows can arise for a number of technical reasons. In the recent years, loop flows have become a growing concern for the technical operation of the network. A loop flow is a physical flow caused by an electricity exchange within one bidding zone flows through other bidding zones or networks (ACER/CEER, 2013). These flows have increased with the higher amounts of wind and solar power in the system. They result from the differences between the physically metered flows and scheduled flows at an interface over a defined period. They exist because the generation scenarios designed to predict network flows differ from real-time generation as a result of wind and solar prediction errors or conventional unit outages.

A recent study for the European Commission (Thema Consulting, 2013) concluded that bottlenecks within Germany are not reflected in the prices, as Germany does not apply bidding zone delimitation. Developing wind without proper co-ordination can pose a real problem to system security. High wind generation can create loop flows that conflict with existing rules for calculating and allocating transmission capacity between adjacent control areas. For instance, wind generation in northern Germany changes power flows across Poland and reduces the formerly available transfer capacity at the border between Germany, Poland and Slovakia. These modified power flows can also lead to new internal constraints in the Polish network.

Another issue is that loop flows can lead system operators to reduce cross-border capacity or so-called net transfer capacity (NTC) allocated during different timeframes. This occurs on a forward basis – reducing opportunities to use interconnectors to sign long-term energy contract across borders – as well as with day-ahead and intra-day time frames because capacity at the border is usually calculated before the day ahead, e.g. two days before real time in Europe. In the absence of harmonised rules at EU level, TSOs tend to take a conservative approach with regard to making available cross-border capacity at times of network constraints, and these situations are more and more frequent with stronger integration of variable renewables.



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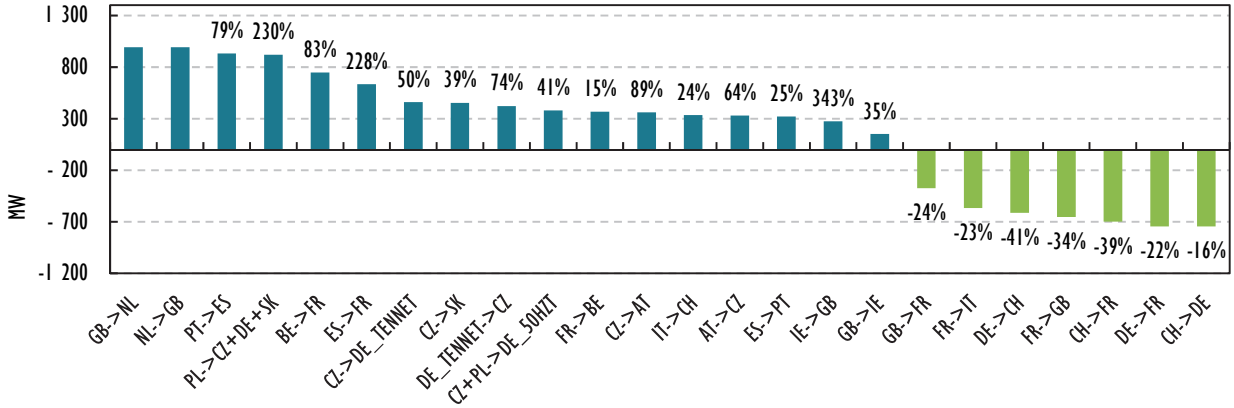
From an adequacy perspective, reliability is changing in a system with increasing shares of renewable energy. In 2012, out of a total EU net generating capacity of 981.1 GW only 652.1 GW was reliable available capacity, as around 354.8 GW were renewable (and non-dispatchable) energy sources and 329 GW unavailable because of maintenance, outages and other factors (see Table 5.2). In a system with high share of renewable capacity other resources are thus needed to ensure flexibility, be it from capacity across the border, demand-side response and flexible thermal power plants.

At the network level, renewable energy flows have also impacted the way power flows are managed and controlled (capacity calculation and congestion management).

In Europe, a new phenomenon has emerged, the so-called loop flows (see Box 5.3). The loop flows in Central Europe are largely the result of the unprecedented boom in renewable energy in Germany. These unforeseen flows require new ways of system operation, security management and price zone definition in an integrated wholesale market. The fast deployment of wind in northern Germany had a huge impact on co-ordination with neighbouring TSOs. It is perceived as a risk to security of supply – so much so that several TSOs have installed phase-shifters to better manage and control power flows. This is understandable from a system security perspective but is probably the least desirable event in integrated markets as it ultimately leads to physical fragmentation (Figure 5.12). To address these issues, Germany has proposed to increase the financial compensation included in the inter-TSO compensation mechanism.

**Figure 5.11** Change of NTC at selected EU borders, 2008 and 2012 (MW)




Source: ACER/CEER (2013), *ACER/CEER Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2012*, November, Ljubljana/Brussels.

Notes: AT= Austria; BE = Belgium; CH = Switzerland; CZ = Czech Republic; DE TENNET = Germany TSO zone of Tennet; DE-50HZT = Germany TSO zone of 50Hertz Transmission; ES = Spain; FR = France; GB = Great Britain; IE = Ireland; IT = Italy; NL = Netherlands; PL = Poland; PT = Portugal; SK = Slovak Republic. 46 border directions were initially included in the analysis. This figure shows only those directions where the observed variation was simultaneously higher than 150MW and the increase above 10% of the initial average value in 2008. The vertical axis represents the variation (MW), while the percentage variations are shown above each bar.

With large capacity additions from renewable energies in Germany, Spain, or Italy, the available capacity for trade at some borders even decreased (e.g. between France and Great Britain, Switzerland and France, Germany and France), while the available capacity for trade in the Benelux, Southern European and Central European market areas almost doubled thanks to increased cross-border interconnection capacity (see Figure 5.11).

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**Figure 5.12** Phase-shifting transformers installed and planned in Europe at a selection of borders (as of June 2012)

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Note: The phase-shifters in light pink colour are under preparation or analysis.

* Phase-shifters are planned in these countries.

Source: IEA adapted on the basis of data by ACER/CEER (2013), *ACER/CEER Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2012*, November, Ljubljana/Brussels.



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## COAL AND GAS IN POWER GENERATION

As a result of the widening gap between coal and gas prices and low carbon prices under the EU-ETS, coal has been much more competitive as a fuel for power generation. In 2014, in energy value terms, gas wholesale prices were three times higher than coal prices on average in Europe.

Adjusting for the different efficiencies of coal and gas-fired power plants, gas-fired generation is about 70% more expensive. The *World Energy Outlook 2014* (IEA, 2014f) considers that for the cost of gas-fired generation to fall to that of coal-fired generation, the gas price would need to fall by around 40%, to USD 5.9 per million British thermal units (MBtu).

Alternatively, the price of $CO_2$ in the ETS would need to rise almost five-fold from its current level of USD 7.6 per tonne to almost USD 35.1 per tonne for a typical CCGT (57% efficiency) to break-even with a typical coal plant (37% efficiency). Or in euro values: the price of $CO_2$ in the ETS would need to rise from its current level of EUR 6 per tonne to almost EUR 27.7 per tonne for a typical CCGT (57% efficiency) to break-even with a typical coal plant (37% efficiency). Environmental regulation and the strengthening of the EU-ETS regime are needed to support effective signals for coal and gas use in power generation (see Chapter 3, "Climate Change").

## ELECTRICITY NETWORK INTEGRATION

National electricity grids were built to respond to national needs and interconnections mainly served energy security or the export of surpluses to neighbouring countries. Over the past ten years, a few interconnectors were constructed to link the Nordic market to the continent and the interconnections in the Central European electricity market were reinforced. In Europe, interconnectors between countries have created a large synchronous frequency area extending deep into the eastern parts of Continental Europe. This is moving the European Union towards the genuine European network which is needed.

Interconnectors amount to a total 11% of installed generating capacities across OECD Europe (Figure 5.13). Figure 5.13 shows generation and demand in selected EU member states and Norway and Switzerland. It describes in percentages the interconnection indicators: the share of domestic installed generating capacity covered by interconnection capacity.

As outlined below, there are very few countries that could be able to meet essential parts of their domestic demand by generation capacity from neighbouring grids, because of limited interconnector capacity (see Figure 5.13).

Within the context of the new rules for EU-wide congestion management, the redesign of price zones across the European Union is under discussion. Today, price zones are mostly defined by national borders (with exception of the Nordic markets). The creation of bidding zones defined by congestion and not by national borders could help to better deal with congestion in the networks, both at national and cross-border levels. However, price zones tend to alter the distribution of cost and benefits and increase prices in one area, while lowering them in others. This raises substantial political concerns. Relying on improved congestion management and capacity allocation through the implementation of EU-wide NCs should enhance the use of existing grids. The investments envisaged in physical electricity network will eventually lead to removing congestion within the EU-wide network.

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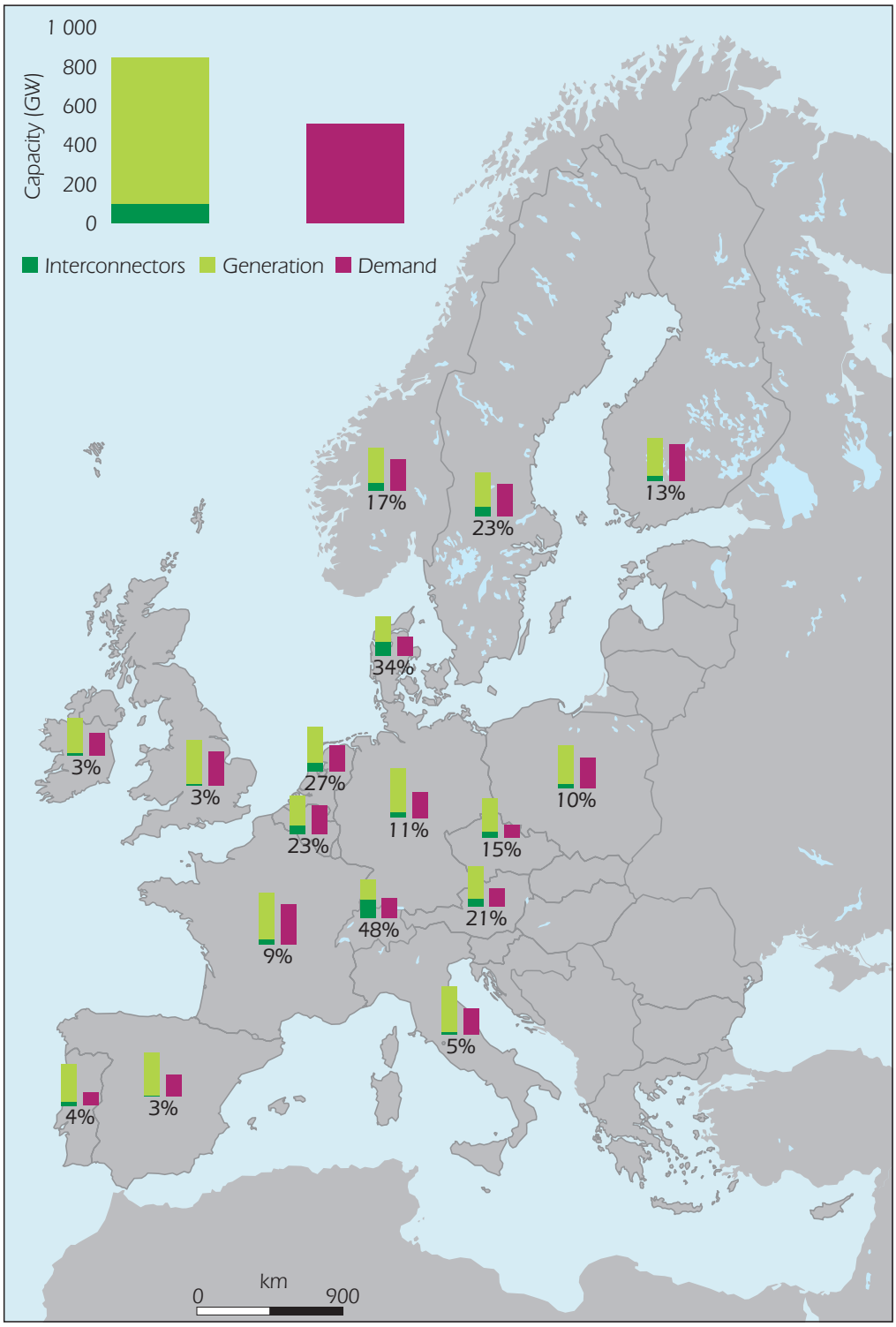
**Figure 5.13** Interconnections, generation and demand in selected European countries




This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Note: The interconnection level (in %) is calculated as the ratio of interconnection capacity to installed generation capacity. The level of domestic demand is described in addition.



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## SECURITY OF ELECTRICITY SUPPLY

IEA in-depth country reviews focus on the adequacy dimension of electricity security. Adequacy in this context refers to a power system's capability to meet changes in aggregate power requirements both in the present and over time, through timely investment, operational and end-use responses.

Security of supply was one of the key drivers of electricity market integration in Europe. Indeed, the first interconnections to neighbouring countries were built to mitigate emergency situations. In this context, EU market integration and higher electricity trade flows increases interdependence among jurisdictions. This constitutes a paradigm shift.

Integrating electricity markets does however diversify the generation mix and gives access to generating capacity in case of a shortage in any one country. Empirical evidence of the benefits associated with market integration abounds. For instance, Norway imports power from Sweden during dry years. In 2012, France imported up to 10% of the power needed to meet peak demand during cold spells. In 2013, Belgium imported power to compensate the temporary shutdown of its nuclear reactors.

In the past, Europe experienced two major blackouts, in 2003 South Europe (France, Switzerland and Italy) and 2006 in North West Europe (Germany and neighbouring CWE region). These blackouts were due to electricity network technical incidents and not because of generation capacity. Since the past in-depth review of the European Union in 2008, there has been no major incident, but high stress situations have occurred during winter periods in Germany and France.

On the downside, market integration brings about interconnection and exposure to market, price and generation development in neighbouring markets. European member states have very different generation mixes, partly because of differences in their initial resource endowment. Energy policy factors nevertheless play a strong role. Nuclear energy is an example of policy-driven divergences among countries. So is renewable energy that develops much faster in some countries than in others because of differences in the attractiveness of national subsidy schemes.

The lack of integrated policies regarding fuel security and fuel mix can create problems for supply security. In dry years, the Nordic countries cannot provide balancing power for Europe and need to rely themselves on a strategic winter reserve. The lack of a co-ordinated deployment of renewable energy in combination with a lack of interconnectors to transport renewable energy from production to consumption and to use the variability of renewable energy across geographical zones can have consequences on electricity supply security. When regions experience periods without wind and sun, it is not just the national markets that respond, but also the integrated electricity market. Rapid development by one country (e.g. Germany) of variable renewable energies impacts on neighbouring electricity systems, where they are strongly interconnected. Hence, governments should pay attention to the security implications of fuel policies (including renewables).

In the short-term electricity security needs to ensure grid stability with a constant frequency in the system. In the longer term, investment in generation, production, supply and networks ensure electricity security. While IEA emergency response reviews focus on the short-term emergency response, in-depth reviews focus on the medium- to longer-term outlook of generation and network adequacy.

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## EU LEGAL FRAMEWORK FOR SECURITY OF SUPPLY

The Treaty on the Functioning of the European Union (TFEU) introduced an explicit EU competence on energy policy in European primary law (beyond already existing intervention rights on environmental, competition and internal market grounds), but left the choice of their energy mix to EU member states.[9] (The same is true for North America, where each US state and Canadian province decides on its energy supply.)

Within the EU legal framework security of electricity supply is governed in general by the rules of the Third Package and in particular by the special requirements of Directive 2005/89/EC of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment.

In legal terms, there are several provisions describing the national competences of member states on security of electricity supply, notably 1) tender of new capacity or demand-side response (Article 8 of Directive 2009/72/EC*),* 2) rules for public service obligations (Article 3 of Directive 2009/72/EC) and 3) monitoring of security of supply (Article 4 of Directive 2009/72/EC).

NCs will also address security of electricity supply issues, notably the network security and reliability code and the code for operational procedures in an emergency. TSO co-operation has increased over the past five years, both within ENTSO-E, and outside ENTSO-E through bilateral and multilateral TSO co-operation within the network areas of adjacent TSOs (see Box 5.4).

With regard to the development of the European electricity grid, TSOs co-operate on EU-wide grid planning, through the so-called EU-wide ten-year network development plan (TYNDP), the annual summer and winter generation capacity and supply outlook. TSOs also prepare regional investment plans, at the level of interconnected zones, and national TYNDPs, where they are not ownership unbundled. In 2014, ENTSO-E published the second TYNDP (ENTSO-E, 2014b) which includes third-party projects for transmission and storage and an EU-wide cost and benefit analysis (CBA) methodology for assessing the projects. It creates a common framework for multi-criteria cost-benefit analysis for candidate projects of common interest (PCI) and other projects falling within the scope of the TYNDP. In line with Regulation 714/2009, ENTSO-E assesses on an annual basis the European generation outlook for the next five years as well as for the next five to 15 years, building on the national generation adequacy outlooks prepared by each transmission system operator.

Security of electricity supply is greatly enhanced in a larger market with access to more generating capacity, thus providing flexibility and lowering the risk of supply cuts and shortages. Given the national competence on the energy mix, there is a need for greater co-operation on electricity security at EU level, including generation adequacy and system operation, as regional markets are coupled into inter-regional trade and systems become more and more integrated. Such need for co-operation comes also from the fact, that market integration creates greater exposure to trends in regional markets.

**9.** In the Treaty on the Functioning of the European Union (TFEU), Articles 194(2) and (3) stipulate that measures in the field of energy taxation and member states' rights in deciding on the conditions for exploiting their energy resources, choices amongst different energy sources and the general structure of their energy supply are subject to unanimity. The Treaty of Lisbon sets four main aims for the European Union Energy policy: (i) ensure the functioning of the energy market; (ii) ensure the security of supply in the Union: (iii) promote energy efficiency; and (iv) develop new and renewable forms of energy and promote the interconnection of energy networks (EPIN, 2011).



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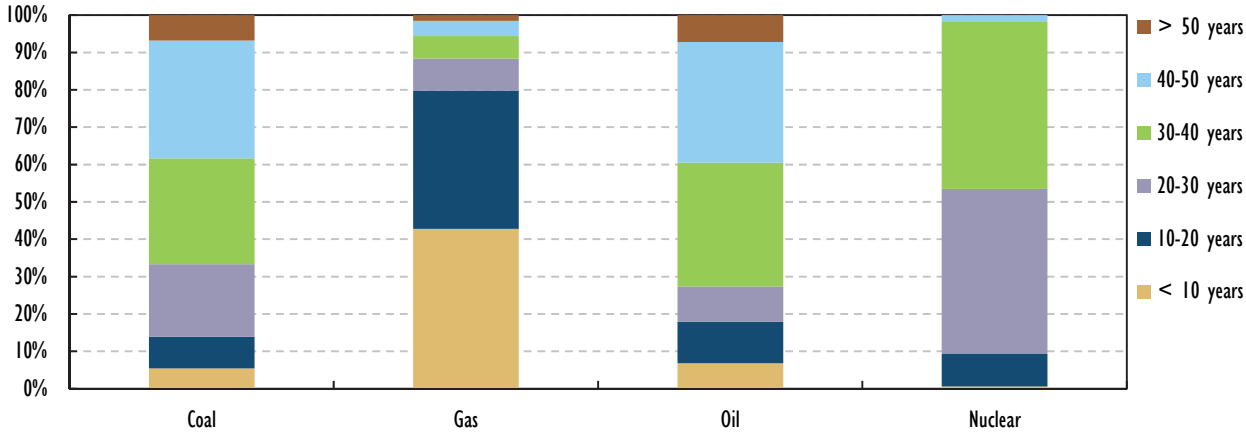
## GENERATION ADEQUACY

In an integrated electricity market, peak demand can be met by both cross-border trade and available domestic generation capacity or demand-side response. In coupled electricity markets, generation adequacy needs to be assessed both at national, regional or EU levels. In the European Union, ENTSO-E has begun work on broadening generation adequacy assessment to a more European-level assessment.

Today, the European Union is enjoying comfortable levels of capacity, as a result of lower demand in the economic downturn, but over-capacity may not continue in the future, as the European Union's power generation fleet is ageing. Further, weak economic conditions across Europe have not only reduced demand but also undermined the business case for new conventional generation projects in several countries. To illustrate those two concerns, the following section looks at the EU generation adequacy in the medium term 2020 and 2030.

Around 30% of coal- and oil-fired power plants were constructed 40 or 50 years ago. Almost half of the nuclear capacity already runs already for 30 or 40 years (see Figure 5.14). Depending on the extension of their lifetime, a substantial capacity is to be removed from the electricity system. During 2016 to 2025, thermal installed capacity of around 150 GW is expected to be retired.

**Figure 5.14** Age profile of installed thermal capacity, end-2013 (GW)




Source: Platts, McGraw Hill Financial (2013), *Platts World Electric Power Plants* (database), accessed December 2013, www.platts.com/products/world-electric-power-plants-database.

The *World Energy Investment Outlook 2014* (IEA, 2014f) expects retirements up to 2035 to amount to 500 GW (out of 952 GW of today's total capacity), including coal (129 GW), wind onshore (123 GW), solar PV (71 GW), nuclear (41 GW), oil (41 GW), gas (33 GW), biomass (33 GW), hydro (16 GW), wind offshore (11 GW) and wind onshore (123 GW). With a view to replacing the retirements of 501 GW and further decarbonising the economy, the IEA estimates investment needs of USD 2.2 trillion with capacity additions of 738 GW up to 2035.

During 2008 to 2012, electricity generation from renewable energies increased by 200 TWh, while fossil fuel power plants reduced their generation by 260 TWh to fewer hours at lower wholesale prices (Figure 5.15).

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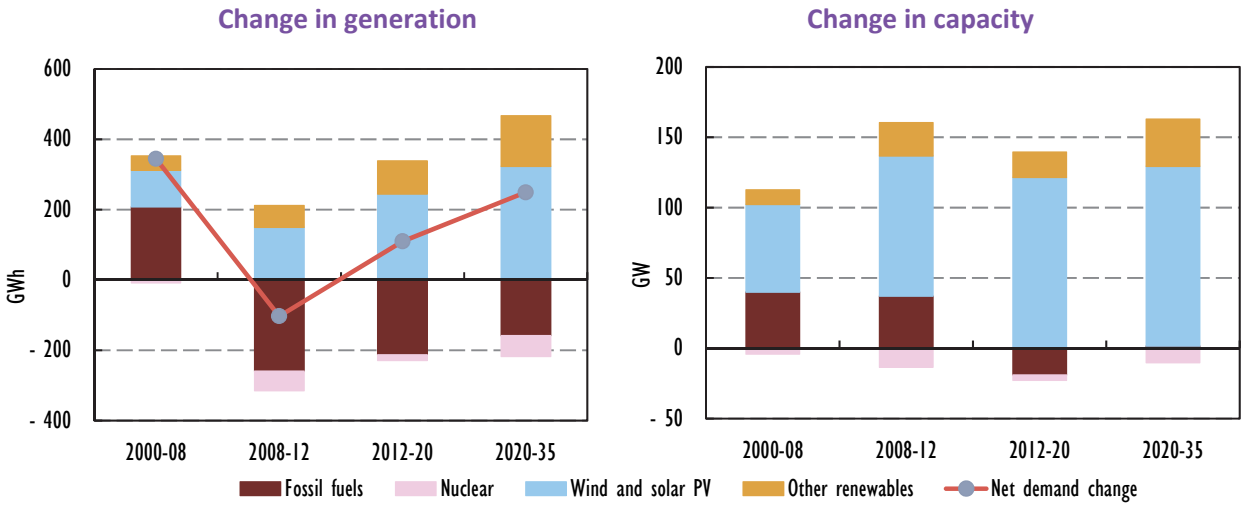
**Figure 5.15** Net capacity additions and net incremental demand and generation by type, 2000-35




Source: IEA (2014f), *World Energy Investment Outlook: Special Report*, OECD/IEA, Paris.

Investment in the conventional power sector in Europe to replace ageing infrastructure could be at risk under these market dynamics. As describe above, the large-scale deployment of variable renewable generation and its associated "merit order" and "utilisation or compression" effects are eroding the economics of conventional generation. The combination of these factors may result in significant investment delays and deferrals, and "mothballing" or premature closure of existing plants, which together could reduce levels of generation adequacy and diversity in the medium term. It remains to be seen if this trend can be reversed by additional energy efficiency, interconnections, a more robust EU-ETS with an expected higher carbon price or a combination of these factors.

Up to 2020, more renewable capacity will be constructed, while it is expected that for thermal capacity the retirements outpace the additions. More VRE capacity, notably wind and solar, could, however, require an even higher amount of back-up capacity where interconnectors, demand response or an inter-regional balance capacity are not available.

This is also confirmed in the latest *ENTSO-E Scenario Outlook & Adequacy Forecast* (*SO&AF*) for the period 2014 to 2030 (ENTSO-E 2014c) which finds that generation adequacy at an EU-wide system level can be met in most situations but adequacy margins are considerably decreasing until 2025. On the basis of the conservative scenario considering only confirmed generation investments, the level of adequacy is no longer positive beyond 2020 under the assumption that loads increase continuously. For the period 2014-25, ENTSO-E estimates that load is set to grow on an average forecast rate of around 0.9%, while generation is set to rise by a 60% increase of renewable installed capacity, with fossil and nuclear capacities slightly decreasing.

The ENTSO-E level assessment however is compiled on the basis of national forecasts by TSOs and does not consider capacity limitations between countries and/or regions. Today, generation adequacy assessments are carried out at national level and their scope and methodology largely differ across the European Union. In 2014, ENTSO-E has started the work on a European methodology. There is a need for an independent and consistent EU-wide analysis at the level of the interconnected zones.



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## Capacity mechanisms

To address concerns about adequacy and timely investment responses, several governments are considering regulatory mechanisms, including various forms of new capacity mechanisms. The Nordic countries have already had a strategic reserve in place for almost a decade.

Capacity mechanisms have been used in various IEA member countries in the past with a view to face inelastic power demand and/or weak investment incentives or energy constraints in small and/or isolated power systems (i.e. Ireland, Italy and Spain). Some mechanisms were introduced to solve the "missing money problem" and not adequacy problems.

As illustrated in Figure 5.16, by end of 2014, targeted capacity measures are in place as a strategic reserve in Belgium, Sweden, Finland, and Poland and in form of capacity payments in Spain, Portugal, Greece, and Ireland. Belgium has introduced an additional tender. The United Kingdom launched a centralised capacity market with market-wide capacity auctions in 2014. Following the adoption of primary legislation, France has plans to introduce a decentralised capacity obligation, pending finalisation of secondary legislation. Centralised capacity markets are to become a reality in the United Kingdom (2018), Italy (2017), and Romania. Ireland considers moving from capacity payments to reliability options. Discussions over the need for capacity markets are ongoing in Germany, Poland and Denmark-West. There is no capacity mechanism in place or under discussion in neither Austria nor the Netherlands. The Swedish system has a strategic reserve which is of temporary nature as the government announced plans to phase it out over time, as demand response has increased in the reserve.

IEA analysis shows that the European Union is a strongly integrated system of national energy markets across the borders which is unique and differs from other large jurisdictions, like the United States. Trade and liquidity across the borders play a much more important role in the European Union. Therefore generation and resource adequacy will need to be assessed at the level of the interconnected systems rather than the national systems. In a regionally interconnected market, capacity mechanisms have a cross-border impact and risk reducing the available transmission capacity on the interconnectors, which is already lower today on some borders than a decade ago. In absence of rules on cross-border reliability standards, TSOs tend to take a conservative approach, for system management and co-ordination, given that data and information-sharing across several control zones is still in its infancy. Apart from the strategic reserves in Sweden and Finland, there is no experience in the European Union with using a cross-regional reserve capacity, fully integrated in the wholesale market design, including demand bids.

Amid the appearance of new capacity mechanisms, the European Commission has set out several criteria in order to guide the member states and to avoid negative impacts on market coupling (EC, 2013a). The Commission has therefore included this analysis in the Guidelines on environmental and energy aid for 2014-20, which entered into force on 1 July 2014. Capacity mechanisms should:

- Be based on an objective, facts-based, and comprehensive prior assessment including of the impact of Union internal electricity market acquis, e.g. with regards to infrastructure, emissions trading and energy efficiency.
- Be preceded by an assessment of alternative measures such as the promotion and enabling of demand response and expansion of interconnection capacity.
- Reflect the objective of phasing out fossil fuel generation subsidies by 2020.
- Be open to cross-border supplies and consider interconnections.

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- Be technology-neutral.
- Be limited in duration.
- Not impose any import or export restrictions.
- Ensure the transparent distribution of their cost.
- Be organised in an open, transparent manner for all technologies and flexibility solutions, if tendering for new capacity is chosen as the mechanism, including demand-side response operators and operators from other member states.

Capacity mechanisms may be necessary and legitimate to face a generation adequacy problem. However, they also raise some substantial concerns. These mechanisms effectively replace market-driven investment with government intervention, which has the potential to add considerable regulatory risk and cost for investors and consumers alike. The impacts on electricity trade can be substantial; depending on the design of the mechanism and the way it accounts for and integrates cross-border flows. While fostering security of electricity supply, introducing capacity mechanisms can however distort competition, can lead to overinvestment and ultimately increase costs for European consumers. The most likely long-term risk is that it is difficult, once introduced, to phase them out.

The IEA analysis suggests that in this context, the introduction of capacity markets should be handled with caution, as there is still substantial room for improving the interconnectivity and efficiency of the energy markets in the European Union.

Looking towards 2020, capacity additions from wind and solar PV are to continue, even if at a lower growth rate, as the need to maintain flexible back-up from existing thermal power plants. The energy system transformation with higher shares of variable renewables seems to point to a much greater reliance on cross-border trade and higher network adequacy needs. Ultimately, new physical investment in the European network will be needed to adapt the grid towards greater electricity trade flows.

That is why electricity markets in Europe need to evolve to tackle the changing merit order by ensuring that wholesale markets are fully functioning. Through integrated cross-border balancing and intra-day markets, TSOs can efficiently source and share reserve capacity and balancing services from across national borders. The electricity markets need to include demand participation through smart grids and meters, and competitive players on the electricity balancing and intra-day markets (cross-border and demand-side participation).

Several other possibilities, as alternatives to capacity mechanisms, need to be examined in this context, including locational and scarcity pricing; programmes to more effectively harness demand-side response through a more dynamic tariff system, smart grids or time-of-use incentives; requiring large-scale variable renewable generation to manage their balancing costs and to bid for dispatch; and relying on well-functioning wholesale markets with integrated day-ahead and intra-day markets as well as functioning retail markets without regulated prices.

Increasing system co-ordination across borders is essential in an integrated market. A more dynamic intra-day re-calculation of cross-border capacity and the flow-based capacity calculation will make better wind and solar power forecasts that improve considerably a few hours before real time. However, such calculations require close co-ordination between adjacent system operators. In the absence of a single entity in charge of real-time security constraint dispatch, the proper co-ordination across control zones with high shares of wind and solar power is important.



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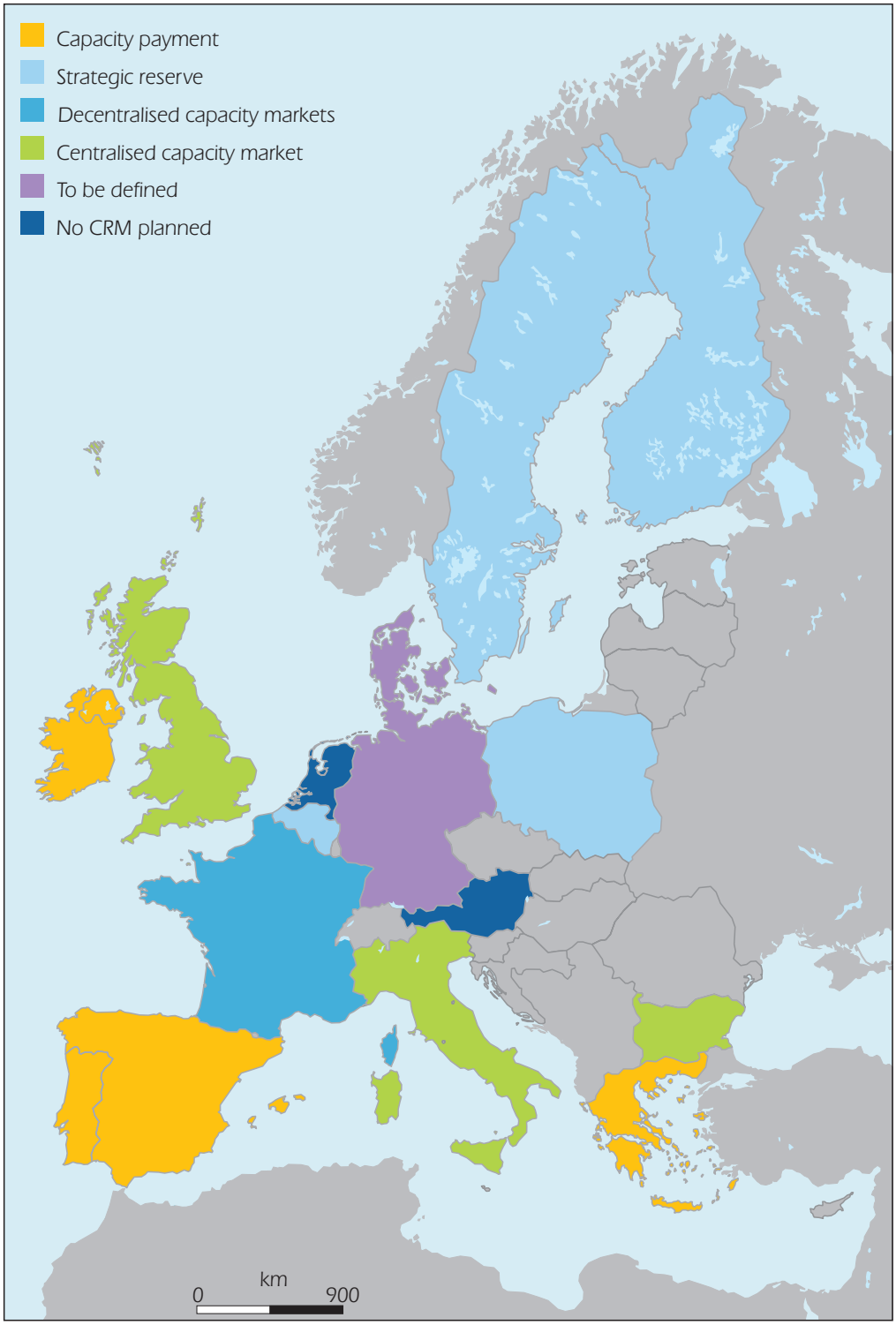
**Figure 5.16** Overview on existing and planned capacity mechanisms in Europe




This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

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The Third Package has strongly focused on making the utilisation of the existing interconnector capacity more efficient. The future challenge will be to secure the needed capacity investment in new energy infrastructure, including generation, demand-side management and interconnectors at the right capacity level, time and location. Concluding on the above, a gradual approach is required by:

- Maximising trade and use of existing interconnection capacity through system co-ordination across the control zones.
- Promoting investment in new interconnection capacity.
- Integrating the wholesale markets further by fostering the integration of intra-day and balancing services, including demand-side response.
- Reviewing capacity needs on the basis of an assessment of generation adequacy at the level of the regionally interconnected systems to design a harmonised approach to capacity mechanisms at regional level.

## NETWORK ADEQUACY

At the Barcelona European Council in 2002, heads of state and government envisaged an interconnection target of 10% of installed capacity. In 2014, the markets in Central West Europe have interconnection levels of around 15% to 30%, while six countries located at the periphery in the South West and the Baltic states remain energy islands with levels below 5% (see Figure 5.17). Since the 2002 Barcelona summit, electricity markets in the European Union have changed significantly, as outlined above. In 2014, the European Commission proposed to raise this interconnection target to 15% by 2030.

IEA analysis shows that a higher interconnection target is in line with increasing electricity trade across the European Union. However such a target should be complemented by an in-depth assessment of the adequate interconnection level, at each border on the basis of a European-wide network outlook. The interconnection capacity will certainly need to be higher than 15% on many interconnections, where markets are growing together, as Figure 5.13 shows.

Looking beyond 2020, focusing on 2030 and 2050, the European Commission identified in its Energy Roadmap 2050 (EC, 2011) the development of flexible energy infrastructure as a “no regret option”. With growing electricity generation from renewable sources and increasing trade across the European Union in the coming decades, the European Union needs to develop by 2020 new interconnections to increase the capacity by at least 40%.

The need for infrastructure investment in electricity networks is also underscored by the IEA *World Energy Investment Outlook 2014* (IEA, 2014f). The IEA has considered a New Policy Scenario (NPS)[10] of a continuing strong EU sustainability agenda and estimates investment needs (see Table 5.3) for transmission and distribution infrastructure to amount to USD 655 billion or EUR 490 billion by 2035. This includes a large proportion of refurbishment at transmission level, but even more so at distribution level (USD 516 billion or EUR 386 billion).

**10.** New Policies Scenario: A scenario in the *World Energy Outlook* that takes account of broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-energy subsidies, even if the measures to implement these commitments have yet to be identified or announced. This broadly serves as the IEA baseline scenario.



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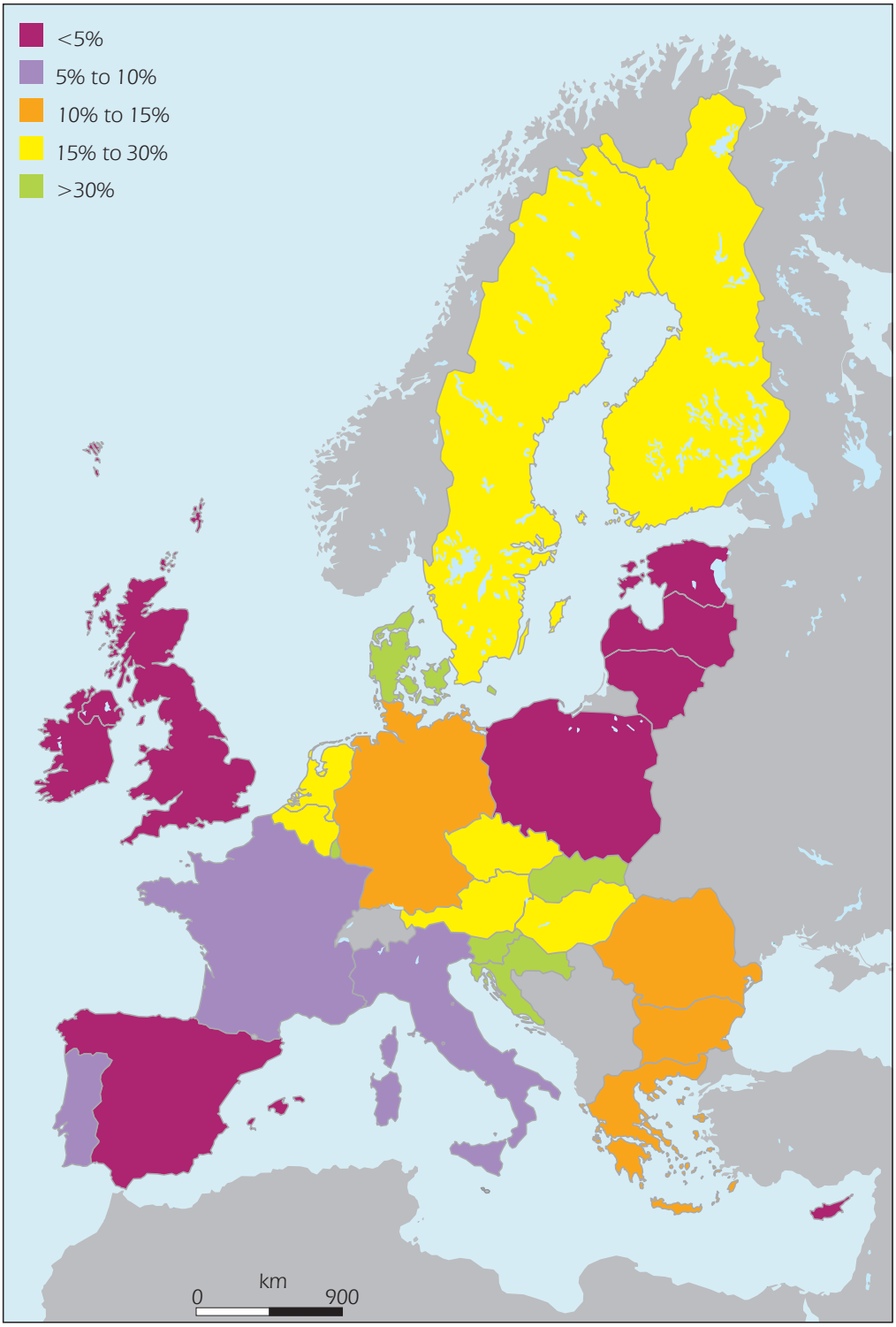
**Figure 5.17** Interconnection levels (Import capacity/net generating capacity) in Europe, 2014




This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: IEA based on data from the European Commission, DG Energy, submission to the IEA.

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**Table 5.3** Investments in NPS in T&D infrastructure, 2014-35 (2012 USD billion)

| Transmission | | | | Distribution | | | | Total |
|---|---|---|---|---|---|---|---|---|
| Total | Additions | | Refurbishment | Total | Additions | | Refurbishment | |
| | New demand | Renewables | | | New demand | Renewables | | |
| 139 | 17 | 35 | 87 | 516 | 105 | 23 | 388 | 655 |

Source: IEA (2014f), *World Energy Investment Outlook: Special Report*, OECD/IEA, Paris.

## MODERNISING THE POLICIES ON TRANS-EUROPEAN NETWORKS

To support trade flows, the European Union has stepped up its efforts and accomplished a milestone in the way the European Union supports the completion of a trans-European energy network with new guidelines[11] for trans-European priority infrastructure projects, so-called projects of common interest (PCIs). The guidelines are aimed at fostering the consensus among neighbouring system operators, member states and regulators of the importance of key infrastructure projects, at ensuring faster permit granting procedures with a time limit of 3.5 years, and the cross-border allocation of the costs and access to EU funding.

A list of PCIs is updated every two years in a bottom-up process which builds on the regional lists, as prepared by regional groups of member states and project promoters, and an opinion by ACER on the cross-regional consistencies. In 2014, the first Union-wide list of projects of common interest[12] was established with, in the area of electricity, 132 PCIs (see Figure 5.18) in four priority corridors, listed below, and two thematic priorities: smart grids and electricity highways.

- Northern Seas' offshore grid ("NSOG") development with the related interconnectors in the North Sea, the Irish Sea, the English Channel, the Baltic Sea and neighbouring waters.
- North-South electricity interconnections in Western Europe ("NSI West Electricity") to integrate renewable energy production in the member states of the region and with the Mediterranean area including the Iberian Peninsula.
- North-South electricity interconnections in Central Eastern and Southeastern Europe ("NSI East Electricity") to complete the internal market and integrate generation from RES.
- Baltic Energy Market Interconnection Plan in electricity ("BEMIP Electricity") to end isolation of the Baltic States and to foster market integration.

The guidelines also set out rules to ensure the fast implementation of PCIs by reducing delays in permit granting, fostering cost allocation across borders and ensuring better consultation to enhance public acceptance of new energy infrastructure.

The guidelines require procedures for granting permits to be reduced to around 3.5 years, to create a one-stop-shop at national level for all permits and ensure better public consultation of new infrastructure projects. In addition, there are rules included on how to allocate costs and benefits across borders for the PCI.

**11.** Regulation European Union No 347/2013.

**12.** Commission delegated Regulation (European Union) No 1391/2013 of 14 October 2013 amending Regulation (European Union) No 347/2013.



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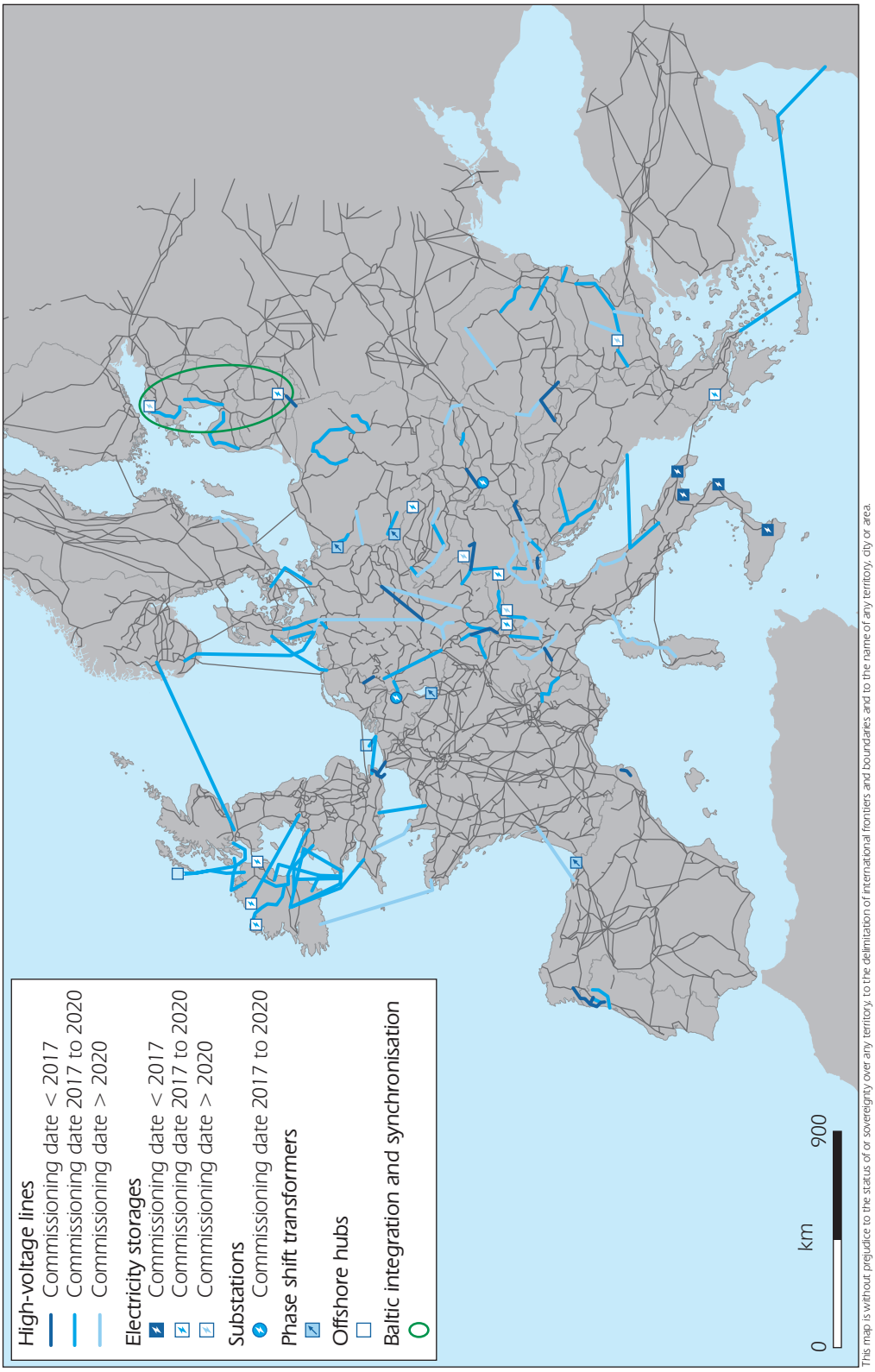
**Figure 5.18** PCI, electricity, 2014




Source: EC (2014c), *Projects of Common Interest – Electricity*, http://ec.europa.eu/energy/infrastructure/pci/doc/2014_pcielec_smart_grid_cef.pdf, (accessed on 20 October 2014).

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The basis for such cost split approved by NRAs is the European wide cost-benefit analysis in the framework of the TYNPD. This is the basis for the selection of PCIs and their ability to receive incentives from NRAs, a cross-border cost allocation or if needed EU funding under the Connecting Europe Facility (CEF) (covering transport, telecoms and energy) which provides financial support to energy projects with a budget of up to EUR 5.85 billion during 2014-20.[13]

The future development of a truly European electricity grid will be driven by the European grid planning framework of the TYNDP. Its non-binding nature upon the parties can limit the impact and efficiency of the process, when projects are approved in the investment plans by national entities, national TSOs and NRAs who can disagree with the European wide view. Given its nature and scope, the TYNDP naturally overrates the importance of grid expansion at transmission level vis-a-vis alternatives, such as demand-side response and generation investment, including at distribution level. The Union-wide identification of cost and benefits of new lines will now be part of the TYNDP 2014 for which ENTSO-E is developing the Union-wide cost-benefit analysis. Together with this analysis and the PCI identification process, involving member states and regulators, the discussion and a consensus on priority projects can be facilitated.

The Third Package also foresees favourable treatment of new infrastructure, including upgrades, by way of exemption for a defined period from Third Package rules on third-party access (TPA), unbundling and tarification.[14] This is open to energy infrastructure projects that enhance competition and security of supply but would not happen without the exemption given their project risks. National regulators may "exempt" them entirely or partially from the respective rules.

The European Commission identified in its European Energy Security Strategy of May 2014 (EC, 2014d) six electricity projects of crucial importance in the short to medium term to reinforce the security of supply and end the isolation of the energy islands in Europe, notably in the Baltic region and the Iberian Peninsula. Those projects relate to the completion of the interconnection between Lithuania and Poland; between Latvia and Sweden (via Nordbalt 1 and 2 and its reinforcement); a new interconnection between Estonia and Latvia; the synchronisation of Estonia, Latvia, Lithuania with the Continental European networks; and a new subsea cable interconnection between France and Spain.

## System co-ordination

Regulators and system operators have significantly improved the situation in Europe in recent years. At the regional level, Nordic TSOs via NordBER, CORESO and Transmission System Operator-Security-Cooperation (TSC) have emerged as co-ordination centres of TSOs on system security. They have reinforced exchange of data among TSOs and harmonised security procedures (Box 5.4). System security is currently not part of the core mission of ENTSO-E, as each TSO is responsible for ensuring reliability within its network boundaries.

These interrelations have prompted the European Union to set up an Electricity Coordination Group in 2013. In June 2013, the Pentalateral Energy Forum called for a strengthened governance and co-operation on security of supply, importantly on adequacy and network development, in the context of the energy transitions taking

**13.** Connecting Europe Facility Financing Regulation (European Union) No 1316/2013.

**14.** Article 17 of Electricity Regulation (EC) No. 714/2009.



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place in the region.[15] The Pentalateral Forum discusses proposals for a reinforced exchange and co-ordination process for risk management in black outs, as well as in an intra-day time in order to cope with the massive integration of renewable energy.

**Box 5.4** Regional co-operation on network security

Along with market coupling, TSOs have put in place co-ordination for network reliability and system stability. Today, there are different bilateral and multilateral platforms of TSOs, which are voluntary initiatives and not under a legal framework. The two main initiatives are CORESO and the TSC.

CORESO co-operation is carried out by TSOs from Great Britain (National Grid), France (RTE), Belgium (Elia), Northeast Germany (50Hertz) and Italy (Terna). The TSC includes 12 TSOs, from Germany (50Hertz, Amprion, TransnetBW, TenneT Germany), the Netherlands (TenneT BV), Denmark (Energienet DK), Austria (APG, VKW-Netz), Switzerland (Swissgrid), Hungary (Mavir), Poland (PSE), the Czech Republic (ČEPS), Slovenia (ELES) and Croatia (HEP).

Nordic TSOs also co-operate on security of electricity supply within the Nordic Contingency Planning and Crisis Management Forum (NordBER), which includes cross-border contingency planning and crisis management; risk and vulnerability assessment; a mutual contingency plan; resource planning and sharing of information; communication and experience exchange; as well as a training programme.

It could be beneficial to integrate those separate efforts into a larger regional Central West/North West Europe co-operation platform for security co-operation. There is a strong need for a consistent framework for information-sharing and improved co-ordination of system operation, which can help system operators to more effectively manage congestion and unscheduled power flows, enabling them to increase effective net transfer capability and resource adequacy.

IEA analysis suggests that further market integration in the European Union will require further integration and co-operation of system security policies along the following lines:

- consider revision to EU-wide legislation, such as the Directive on electricity security of supply
- clarify and harmonise reliability standards, such as loss of load expectation, used in jurisdictions which are part of the interconnected electricity system (Baritaud, 2013)
- clarify and improve the transparency of emergency protocols used by system operators in scarcity conditions, including contract prioritisation within and with adjacent control areas, load curtailment procedures between different areas, and other technical operating protocols that can impact on market prices
- continue the harmonisation of frameworks for competitive network service provision and use.

Recent IEA analysis shows the European Union that there is also room for competitive network service provision and use, as part of reliability provisions, to improve

**15.** Political declaration of the Pentalateral Energy Forum of 7 June 2013: www.benelux.int/pdf/pdf/201306_PoliticalDeclarationOfThePentalateralEnergyForum.pdf.

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co-ordination between network services and all market participants within and across borders to guide decision making of generators and loads (Volk, 2013).

The European Union is currently developing NCs on security and reliability to harmonise some aspects of system security. However, harmonising rules of 28 energy systems with very different networks will be a challenging task, as experience shows. Today, the various system operators are in charge of defining reliability rules and system operation procedures, and many institutional barriers across the borders exist.

From an IEA perspective, further harmonising system security operations and policies is a prerequisite for addressing major challenges to electricity market integration. Failure to do so would hinder efficient market integration, likely leading to less efficient utilisation of available infrastructure.

## RETAIL MARKETS AND PRICES

While full market opening for industry advanced at a rapid pace and household customers are free to choose their supplier, European retail markets remain fragmented, and regulated, with supplier switching at low levels and consumer awareness and activeness limited which was again highlighted in the EC 2014 Consumer Scoreboard (EC, 2014e).

IEA in-depth reviews of EU member states show that the introduction of price comparison tools and consumer empowerment is advancing. The Third Energy Package places NRAs at the forefront of consumer policies. While this might be a necessary component of their work, it is not sufficient to boost the creation of an energy market place, which covers non-regulated sectors. Greater synergies can be achieved from the co-operation of NRAs, competition authorities and energy and consumer information authorities, which support the deployment of energy efficiency and renewable energy at retail level.

Electricity tariffs tend to remain uniform and encourage large consumers, which counteracts energy efficiency goals. The tariff systems do not stimulate consumer participation or savings, where they remain flat and uniform. More dynamic tariffs (within-day-tariffs) could provide the signals to consumers to participate to the market through demand-side response.

## COMPETITION

Market opening and integration on the wholesale side has not necessarily been translated into greater openness of the EU electricity retail markets. The lack of effective entry and exit is related to a concentration on the generation side, low contestability and low consumer switching. Despite a decade of liberalisation and market integration on the wholesale markets, the EU electricity market in terms of supply remains concentrated and the presence of foreign suppliers in other than their own markets limited. ACER/CEER examined the effective cross-border entry to the household retail markets in major EU capitals as a measure of market openness.

Table 5.4 illustrates that the incumbent suppliers with a market share above 90% effectively prevents entry of foreign players in the capitals of Greece, Latvia, Luxembourg, Lithuania, Estonia, Poland and France (ACER/CEER, 2013). At the same time, the incumbent supplier dominates the market of the capitals in Bulgaria, Cyprus, France, Greece, Hungary, Luxembourg, Northern Ireland, Malta, Poland, Romania, Slovakia and the Baltic states, at 100% in Bulgaria and Romania.



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**Table 5.4** Overview of incumbent's presence and foreign supply-side substitution to promote retail market integration, December 2012

| Presence of foreign players (capital city) | Estimated incumbent market share in the household market – December 2012 (capitals) | | |
|---|---|---|---|
| | More than 90% | Between 50% and 90% | Less than 50% |
| More than 50% | Bulgaria (1/1); Hungary (1/2); Romania (1/1) | | |
| Between 20% and 50% | | The Czech Republic (5/24); Spain (4/16); The Netherlands (6/18); Portugal (2/4); Belgium (2/6) | Great Britain (4/14) |
| Between 0% and 20% | Northern Ireland (1/4); The Slovak Republic (6/16) | Germany (1/14); Finland (2/37); Ireland (1/4); Italy (2/7) | Sweden (4/41) |
| 0% | Cyprus (0/1); Malta (0/1); Greece (0/1); Lithuania (0/1); Luxembourg (0/6); Latvia (0/1); Estonia (0/1); Poland (2/7); France (1/9) | Austria (0/18); Denmark (0/19); Slovenia (0/8) | Norway (0/11) |

Source: ACER/CEER (2013), *ACER/CEER Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2012*, November, Ljubljana/Brussels. Note: The figures beside country codes represent, respectively, the number of foreign retailers active in the capital and the overall number of retailers active in the capital (household segment).

In 2012, in eight member states more than 70% of power generation were still controlled by the historic incumbent (Eurostat, 2014a), with high concentration in Estonia (87%), Latvia (86%), France (86%), Luxembourg (82%), and Slovakia (77.7%).

## ELECTRICITY RETAIL PRICES

According to IEA data, electricity retail prices across the European Union in 2013 showed a gap between household (EU28 average of EUR 140 MWh) and industry prices (EU28 average of EUR 90 MWh), as illustrated in Figure 5.19. These differences stem from different levels of taxation and renewable energy surcharges being imposed on retail household prices.

Since the in-depth review in 2008, the EC found that at wholesale level, electricity prices have been falling by one-third, while retail electricity prices for households have increased by 4% per year and industry prices by 3.5% per year (EC, 2014f), largely compensating for the declining wholesale levels.

In comparison to the European Union's major international trade partners, IEA data suggests (Figure 5.20), EU household electricity prices are almost twice those in the United States, but 20% lower than those in Japan. In general terms, the US shale gas revolution contributes to keeping costs and prices low, while high LNG imports and increased gas usage in the aftermath of the Fukushima Daiichi accident are putting a burden on final consumers in Japan. Despite the overall decrease in EU wholesale electricity prices since 2008 (around 35%-45%), however, according to IEA and Eurostat data, in 2013, EU electricity prices for industry remained 40% above the United States prices; although they are only two-thirds of Japanese industry prices (see Figure 5.20).

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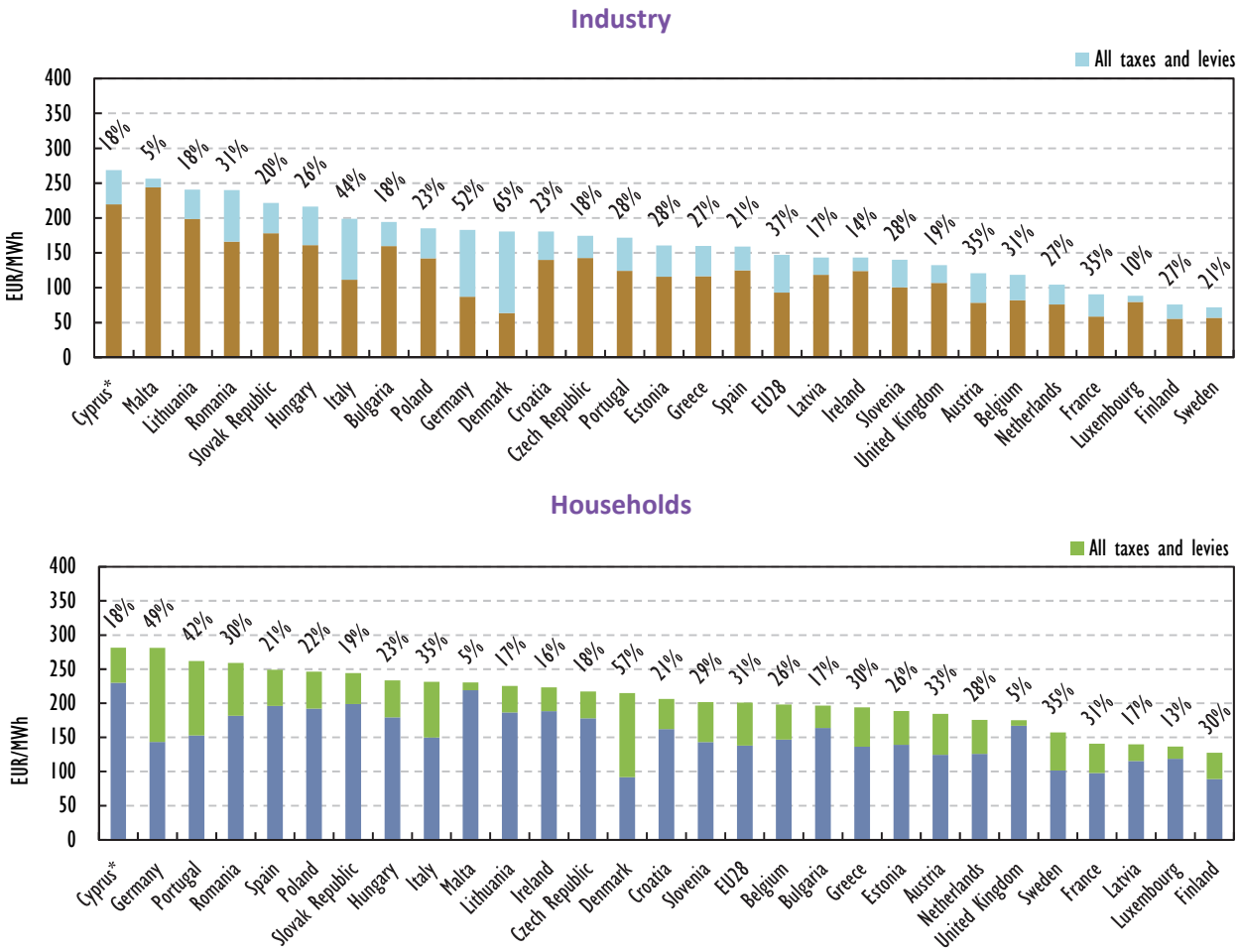
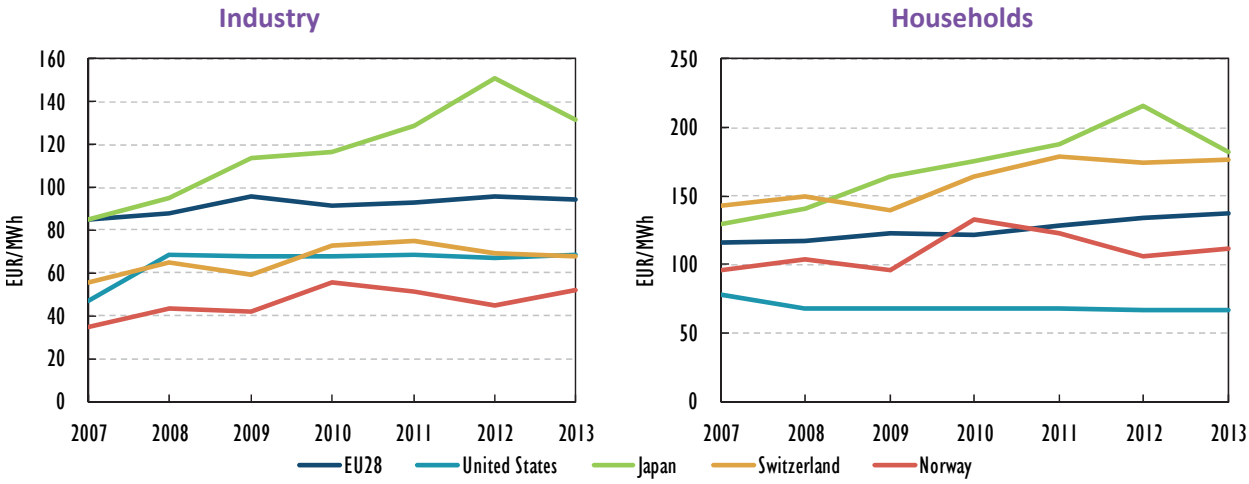
**Figure 5.19** Electricity prices in EU member states (EUR with purchasing power standards PPS), 2013




Source: Eurostat (2014b), *Electricity and natural gas price statistics*, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/electricity_and_natural_gas_price_statistics (accessed on 1 August 2014).

**Figure 5.20** Electricity prices in the EU/EEA countries and in selected IEA member countries, 2007-13




Sources: IEA (2014b), *Energy Prices and Taxes*, OECD/IEA, Paris; Eurostat (2014b), *Electricity and Natural Gas Price Statistics*, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/electricity_and_natural_gas_price_statistics (accessed on 1 August 2014).



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While higher prices in the European Union contribute to greater energy efficiency and energy saving they are a driver of increasing production cost. Governments therefore use exemptions from energy taxes and emission levies to secure competitiveness of their industries.

At household level, the persistence of regulated prices and market concentration, as shown above, the higher level of green levies, energy taxes and network cost, and the low responsiveness of consumers to switch suppliers to better offers are some of the reasons for the low pass-through of wholesale market price decreases to final consumers.

## SMART METERS AND SMART MARKETS

Progress in the deployment of smart meters across the European Union is underway but remains slow. Member states have committed to rolling out close to 200 million smart meters for electricity and 45 million for gas by 2020 at a total potential investment of EUR 45 billion (EC, 2014g). By 2020, it is expected that almost 72% of European consumers will have a smart meter for electricity while 40% will have one for gas. While estimates vary, the EC analysis considers the cost of a smart metering system averages between EUR 200 and EUR 250 per customer, while delivering benefits per metering point of EUR 160 for gas and EUR 309 for electricity along with, on average, 3% energy savings. IEA data on demand-side management confirms that the cost of the implementation of demand-side technologies vary significantly across the energy systems, reflecting different equipment functionalities, population density, nature and size of meter roll-out and geographic conditions (IEA, 2012; IEA, 2011).

However, there are a number of regulatory and legal decisions to be made in the coming years to ensure the good implementation of demand-side responses, including smart meters. Experience in markets that took the lead on the roll-out of the first generation of smart meters show evidence of the need for independent data and information management, guaranteed privacy, an accurate definition of the roles of suppliers and distribution operators, the transparency of market data for all consumers, and also real-time pricing with a view to create a transparent market place with a diversity of choice and dynamic price offers.

The development of smart markets and energy saving services will require regulatory and technology innovation. Providing business with a framework for innovative products, while securing consumers' privacy and security, will be a key task for policy makers in the coming years (see Box 5.5).

Experience with pilot projects in European markets and in other IEA jurisdictions demonstrates that the deployment of smart meters can be facilitated by establishing transparent and secure data management rules, effective switching procedures, strong regulatory oversight and more dynamic pricing for innovative retail product development. In order to develop well-functioning retail markets, OU of distribution and supply can effectively contribute to retail market opening, it is however not strictly necessary, if effective choice and transparent information are guaranteed, as set out in Box 5.5. There is a need for launching a retail market reform in the European Union and further market opening towards greater competition at retail level.

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**Box 5.5** Empowering consumer choice in electricity markets

International experience suggests that the key elements of an effective and integrated approach would include:

- Increasing customer exposure to real-time pricing, with protection of vulnerable consumers addressed through targeted transfers that do not unduly distort efficient price formation.
- A competitive, dynamic retail market to encourage the development of innovative products and services that can harness demand response effectively and at least cost.
- Ready access to detailed, real-time customer information, while ensuring privacy, to help stimulate competition, facilitate competitive entry, support the emergence of innovative business responses, and improve the quality of customer choice.
- A knowledgeable and well-informed customer base that has the capability and opportunity to take full advantage of available choices.
- Market processes for contracting, switching and billing that are as simple and seamless as possible to keep transaction costs to a minimum.
- Legal and regulatory governance frameworks that reduce uncertainty, establish clearly specified rights, responsibilities and obligations on contracting parties, promote greater harmonisation of standards and functionality specifications, and maximise scope for participation among potential service providers and customers.
- Enabling technologies that provide cost-effective, real-time metering information, verification and control capability to support the introduction of real-time pricing, the development of a wider range of innovative demand response products, and more effective customer choice.

Source: IEA (2011), *Empowering Customer Choice in Electricity Markets*, OECD/IEA, Paris.

## ASSESSMENT

The European Union has identified the development of a genuine single market in electricity as a policy priority since 1996. Policy and regulatory measures put in place since the first IEA in-depth review in 2008 have delivered impressive progress towards this objective, notably through the adoption and enforcement of the third internal energy market package; the establishment of ACER; independent national regulators and the ENTSO-E; and the development, adoption and implementation of EU-wide harmonised NCs.

### ELECTRICITY INFRASTRUCTURE

The European electricity transmission infrastructure was developed to link vertically integrated utilities that aimed for self-sufficiency in their service areas. This infrastructure was thus not designed to accommodate large-scale variable renewable energies and intra-European wholesale trade and remains segmented by bottlenecks on important interconnectors. Because of co-ordination and regulatory failures as well as local licensing resistance the past five years have witnessed little progress in physical transmission development. A large proportion of new interconnectors that succeeded were undersea DC cables, often with a merchant business model which did not face local



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resistance. Partly because of loop flows and procedures to handle variability generated by wind and solar production, available transmission capacity actually declined on some interconnectors.

With increasing cross-border electricity trade and ambitious decarbonisation policies, the European Union strongly focuses efforts on accelerating physical network investment by transmission operators on the basis of the ten-year network development planning. The Commission together with member states' regional groups identified also a range of PCIs that are deemed to be essential to complete the single market and connect isolated regions. PCIs are planned to enjoy a streamlined licensing procedure, with the respective member states under an obligation to complete licensing in 3.5 years. It remains unclear how this obligation will be implemented and enforced given the wide disparities in national legal systems. In addition, the European Union also plans to facilitate access to capital for infrastructure projects through the CEF. This facility will however be substantially lower in magnitude than the investment needs under the TYNDPs. Thus, it will not be able to and should not try to substitute private capital. Consequently, it is essential to design financial instruments that can be leveraged further with private capital. A crucial task is therefore to ensure that the licensing and regulatory environment is investor friendly and facilitates the access of these projects to private capital.

Today, six EU countries will not be able to reach the 10% interconnection target and remain energy islands. This concerns the periphery, including Portugal, Spain, and the Baltic states). The 2014 Energy Security Strategy (EC, 2014b) identifies critical projects to integrate energy islands in the European Union (six electricity projects); it also suggests a new indicative 15% interconnection target (in relation to installed generation capacity). The European Investment Bank (EIB) will need to act as a public mission bank and its shareholders need to support projects that would not be carried out by the private investors. Permitting and public opposition remain the main barriers to the implementation of energy infrastructure projects.

Most of the European electricity transmission operators are ownership unbundled, with strong public ownership, there are some ITOs. Despite its popularity in North America, the ISO model is not widely used in Europe. OU has led to a significant improvement of independence of TSOs with regard to access, transparency and grid investment planning. However, TSOs are mostly confined to their national borders, despite some ambitions of TSOs to create regional ISOs and work with adjacent TSOs to enhance collaboration on system security information and management.

## WHOLESALE ELECTRICITY MARKET

The European Union has achieved commendable progress towards the economically efficient and market-based utilisation of the existing transmission interconnection capacity. Bilateral contracts and explicit auctions are progressively being replaced by market coupling, which enables the simultaneous determination of wholesale market dispatch and interconnection capacity allocation.

Market coupling in the Central West region led to increasing wholesale price convergence (above 90%). Given that national markets remained highly concentrated in a number of European countries, better access to and more efficient utilisation of interconnectors helped create more efficient wholesale markets and encourage more competition. It also led to a better integration and liquidity of European power exchanges.

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In recent years, physical and commercial flows increasingly differ and price convergence has reduced, with congestion in interconnectors, as trade flows and renewable production increase. In the well-integrated North West European region, the variability of renewables generation is often netted out by responsive interconnector flows. This is not the case in Central and Southern Europe. Further benefits from price convergence can be reaped from investment in interconnections and the completion of market coupling.

Market coupling is operational in the DAM of the Central West European region and it is being rolled out across the European Union through the price coupling the regions and the introduction of FBMC in the medium term to cope with growing loop flows.

The methodology of market coupling inherently assumes that there is no congestion within an administratively defined price zone. Most often these price zones coincide with individual EU countries, whereas there are important cases of bottlenecks and congestion within a country. It is important to consider the introduction of location signals and bidding zones in order to optimise investment operational decisions where congestions occur.

So far, market integration is largely confined to the DAMs, while balancing and intra-day markets remain typically national and organised by TSOs. The increasing deployment of variable renewables is also increasing the scale and volatility of intra-day flows. To avoid efficiency losses, it is important that balancing and intra-day markets become integrated regionally and eventually at the European level.

The technical management, the economic efficiency and the transparency of intra-day cross-border flows are less than ideal given the increased levels of cross-border flows. Cross-border trade of both balancing and system services remains limited and segmented by regulatory barriers. New NCs being developed by ENTSO-E aim to address this and are expected to roll out a roadmap for a gradual transition towards a single, integrated European intra-day market.

The governance of the process of developing the NCs in terms of timeliness, ambitions and decision-making capability and accountability raises concerns by stakeholders. The European Union needs to ensure that the governance system delivers the timely transition to an integrated market, while retaining adequate flexibility. Given that the European Union already has a higher share of variable renewables than any other region of the world, further policy ambitions unavoidably involve experimentation and adoption of new practices in network operation and flexibility management. The lack of a ready-made solution highlights the need for a flexible and adaptable approach.

The NCs point towards the incorporation of renewable producers into a technology-neutral balancing regime. This is a departure from the priority dispatch regimes that have been prevalent among renewable energy policies of several European countries. This departure is justified, because a number of renewable energy technologies can be considered mature, and in any case the variability of renewable production is now a major component in balancing need. However, the EU Renewable Energy Directive (RED) still seems to be built on the principle of priority dispatch, and it is unclear whether the transition to technology-neutral balancing will be achieved simultaneously at the European level. This would be desirable, or else intra-day and balancing services markets may become segmented. Nevertheless, provided that network capacity allocation and intra-day and balancing markets are properly integrated, differences in the ambitions and support levels of national renewable policies do not appear to distort wholesale electricity markets.



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## SECURITY OF ELECTRICITY SUPPLY

In contrast to the experience of the United States, integration of system operation areas and control zones has not taken place in the European system; where the emphasis remains on enhancing the co-operation of TSOs. Some unbundled TSOs executed corporate transactions to buy TSO assets in other EU countries. However, regulation and network operation remains national. United States' experience suggests large potential gains in market efficiency and network operation from integrating control zones. It remains to be seen whether these efficiency gains can be achieved by enhanced co-operation only.

In most European countries electricity security policy and capacity adequacy assessments are conducted nationally, although around 10% of EU electricity consumption crosses borders and this share will likely rise with further renewable deployment and market integration.

Commendably, the Electricity Coordination Group enhances co-ordination among EU member states. Amid higher cross-border trade flows, it is important that the co-operation among TSOs is intensified with regard to operational procedures under all system conditions and cross-border system emergency preparedness (emergency restoration network code). Cross-border power flows require cross-border views, measures, responsibilities and enforcement capabilities.

Concerns as to what extent electricity wholesale markets provide adequate investment incentives for dispatchable power generation have led some countries to introduce capacity remuneration mechanisms, capacity markets or targeted contracting. Unfortunately, these mechanisms are nearly always designed for an individual national market. National capacity mechanisms with incompatible designs may distort wholesale markets and could segment the internal market. This needs to be avoided. The Commission addresses the issue through the Guidelines on environmental and energy aid for 2014-20, which entered into force on 1 July 2014.

Power plant locations are influenced by local geographical factors, such as renewable potential or availability of cooling water, or the political acceptance of nuclear. In a single electricity market, some countries could be consistent importers or exporters. IEA analysis suggests that interconnector capacity is an important flexibility source, and that cross-border flows may change frequently depending on generation patterns. Under such conditions, national self-sufficiency will come at the price of market distortions and excessive investment costs. The concept of purely national capacity adequacy is inconsistent with the integrated market. Intra-European trade and potential interconnector flows need to be incorporated into capacity adequacy assessments so that further welfare gains from trade and resource optimisation can be gained from the completion of the internal energy market.

Investment needs in transmission and generation are growing in a low-carbon economy, despite the current surplus of generation capacity. This is linked to the low availability of renewable capacity and the age of Europe's nuclear and coal fleet. Some member states have concerns about potential seasonal shortages. For the security of supply, there is a need to maintain diverse power generation capacities and fuel diversity while at the same time increasing the contribution of active consumers. Locational pricing at retail and wholesale levels is critical to motivate and reward all demand-side and supply-side players in energy markets to consider and implement economic levels of energy efficiency. This may require the introduction of locational differentiation of prices as well as a reform of system service markets. The European Union needs to ensure that market results factor in all relevant physical constraints of the system to minimise the need for out-of-market interventions.

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## *RECOMMENDATIONS*

The European Union should:

- *Continue to work towards a single market of electricity, notably*
  - *Complete the physical integration of the internal electricity market by removing bottlenecks through efficient congestion management and capacity allocation, investment in greater interconnection capacity, the integration of control areas or other means.*
  - *Ensure that the ENTSO-E NCs are swiftly finalised, adopted and implemented, notably the codes on intra-day, balancing and emergency restoration.*
  - *Ensure good governance, clear accountability, independence and transparency of the ENTSOs and ACER and review their mandates as required.*
  - *Foster the cross-border integration of intra-day and balancing markets. Ensure that renewable energy policies are compatible with a technology-neutral balancing regime with the appropriate close-to-real-time intra-day markets and wider price zones.*
- *Work towards the introduction of transparent locational pricing at wholesale (and retail) level to motivate all demand-side and supply-side players in the energy market to consider and implement economic investments and to reward them for doing so.*
- *Facilitate the integration of system operation areas, the harmonisation of emergency rules and the co-operation of system operators on security of electricity supply. Ensure transparency of electricity supply security, reliability and reserve margins and their assessment at EU level.*
- *Ensure through the application of EU state aid and internal market legislation that capacity mechanisms and similar policies contribute to an increasing level of security of supply as well as enhancing regional co-operation and cross-border trade*.
- *Foster the progressive transition towards a regional and European-level assessment of system adequacy with a proper incorporation of the potential contribution from demand-side response and interconnectors.*
- *Maintain a stable regulatory framework within the electricity market model which is conducive to power sector investment for the diversity of Europe's power generation and fuel mix.*

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# 6. OIL

**Key data (2012)**

**Crude oil production:** 70.8 Mtoe, -53.9% since 2002

**Crude oil net imports:** 524.2 Mtoe

**Oil products production:** 641.5 Mtoe, -10.1% since 2002

**Oil products net exports:** 7.4 Mtoe

**Share of oil:** 32% of TPES and 2.2% of electricity generation

**Consumption by sector:** 526.5 Mtoe (transport 53.9%, industry 21.9%, residential 7.2%, other transformations 7.1%, commercial and other services 6.1%, power generation 3.8%)

## OVERVIEW

Oil remains the most important source in the European Union's (EU) energy mix, making up 32% of the total primary energy supply (TPES). More than half of it feeds the EU transport sector.

The European Union is a large regional importer of diesel and exporter of gasoline. There is a growing imbalance in the European oil demand. In 2013, middle distillates accounted for 70% of OECD Europe's oil product imports, while gasoline represented more than 90% of oil product exports.

Refineries in Europe face substantial restructuring with weaker margins and lower utilisation rates, after a period of decreasing regional demand and increased competition from new capacities in the Middle East, Asia and the United States. Between 2008 and 2014, 15 refineries in the European Union shut and a further three reduced their capacity, reducing regional crude processing capacity by 1.8 million barrels/day (mb/d), or 8% of total capacity in the European Union. In the same period, total European oil demand declined by 1.9 mb/d, because of lower gasoline and fuel oil consumption. However, demand for middle distillates, including diesel, heating oil and jet fuel, is increasing.

As total EU refining capacity is falling, the dependence of the European Union on oil imports increased, notably on oil products and particularly on diesel. This dependence is set to grow further, while refinery closures impact production of oil products.

Another trend also boosts Europe's import dependence. Indigenous crude oil production in the European Union has been falling markedly, at a faster rate than the decline in EU demand. However, the contribution from the North Sea oil production, mainly through imports from non-EU member Norway, is expected to play its role to flatten the decline in the medium term up to 2019.

The European Union currently imports crude oil from a range of sources. Over one-third is supplied by Russia and a few EU members are highly dependent on these imports.

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## SUPPLY AND DEMAND

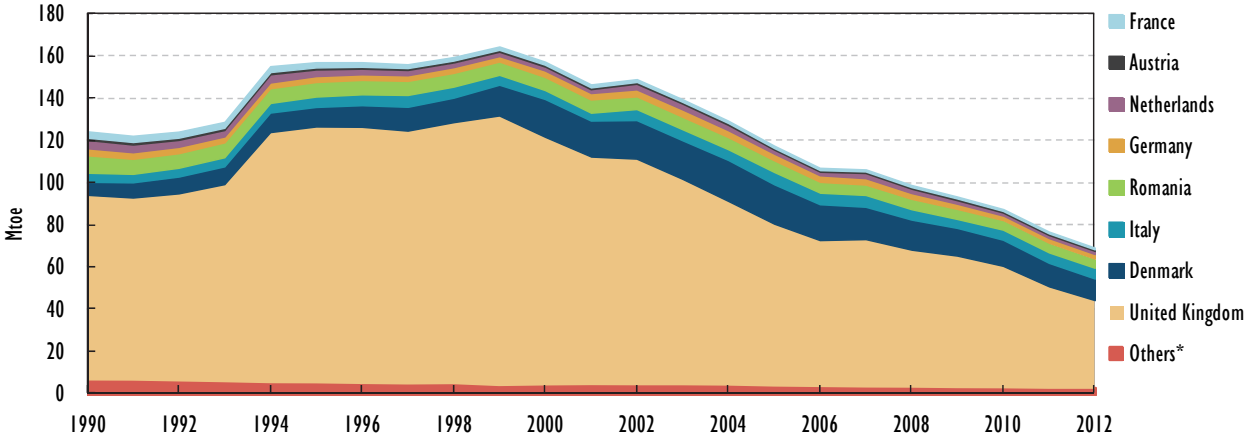
### SUPPLY

Oil (including crude oil and oil products) is the most significant fuel in the European Union's energy mix. Oil amounted to 526.5 million tonnes of oil-equivalent (Mtoe) in 2012, which represents 32% of TPES. Energy supply from oil has declined slowly, decreasing at an annualised rate of 3% from 2007 to 2012, or 14.1% in total. This is a faster decline compared to overall TPES and as such the share of oil in TPES has fallen by 6.8% since 2002.

#### Crude oil production

Crude oil production within the European Union amounted to 70.8 Mtoe during 2012, declining by 10% compared to 2011 and by 53.8% compared to 2002. Crude oil production has been falling each year since a peak in 1999. The United Kingdom is the largest producer of crude oil in the European Union with more than 61% of all production in 2012. Denmark and Italy make up 14.5% and 7.8% each, while Romania and Germany accounted for 5.6% and 3.8% of production. The remaining 7.5% came from 12 member states, mainly the Netherlands, France and Eastern Europe. Eleven countries of the European Union have no crude oil production, including the Baltics and small member states (Figure 6.1). In 2012, Belgium, Estonia, Finland, Ireland, Luxembourg, Portugal, Slovenia, Sweden, Cyprus,[1] Latvia and Malta did not produce crude oil.

**Figure 6.1** Crude oil production in the European Union, 1990-2012




* *Others* includes other European Union member states which produced crude oil each year.

Source: IEA (2014a), *Oil Information,* OECD/IEA, Paris.

**1.** Two footnotes: 1. **Footnote by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue". 2. **Footnote by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.



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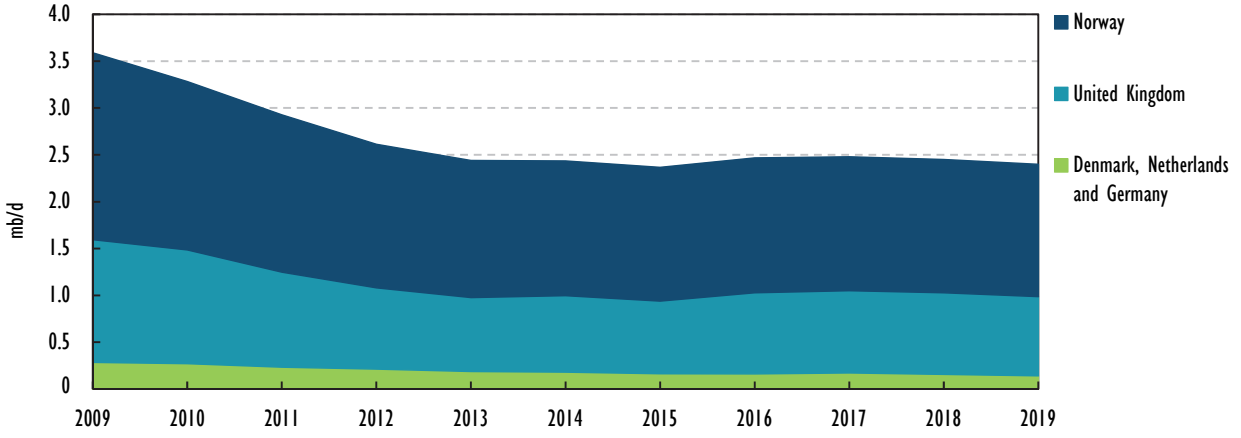
The European Union was estimated to hold 1 212 Mt of crude oil reserves in 2012, with 4 018 Mt of resources.[2] The reserves account for only 0.5% of the global crude oil reserves and the resources are higher at 1.2% of the world total. The United Kingdom holds 811 Mt of reserves which is 67% of the European Union total (Andruleit et al., 2013).

Crude oil production has declined in all significant producing member states over the past decade. The United Kingdom has experienced the largest decline in production, falling by 40.2% from 2007 to 2012. Over the same period, Denmark's production decreased by 34.2%. Most other countries in the European Union have seen production fall by more than 15%.

However, the decline in the oil production from the North Sea is set to slow down (Figure 6.2) in the medium term. After a steep decline during 2009-11, the first quarter of 2014 saw a first quarterly year-on-year increase since 2004. In the United Kingdom sector, the continuing steep declines from mature fields are expected to be countered by the output from several new fields coming on stream in 2014 and anticipated to ramp up in 2015, as well as from further new fields starting up that year. The output from the European Union's second-largest producer, Denmark, will, however, continue to diminish as no new fields are expected to be brought into production until later in the decade. The small growth the IEA expects in North Sea production in 2015, is mainly underpinned by strong growth in Norway, which is not a member of the European Union but a large supplier to the European markets.

**Figure 6.2** North Sea oil supply trends, 2009-19




Note: Norway is not a member state of the European Union but enjoys close relations through its membership in the European Economic Area and the European Free Trade Association.

Source: IEA (2014b), *Medium-Term Oil Market Report,* OECD/IEA, Paris.

## Production of oil products

The European Union's production of oil products is falling. The region produced 641.5 Mtoe of oil products in 2012, 1% less than in 2011 and 10.4% less than in 2002. This decline in refinery output stems not only from falling demand both in the European Union (residential and power sector), and in export markets, such as the United States, but also

**2.** Resources refer to all potentially valuable mineral resources which are available for eventual economic extraction. Reserves are the resources which are legally, economically and technically feasible to extract.

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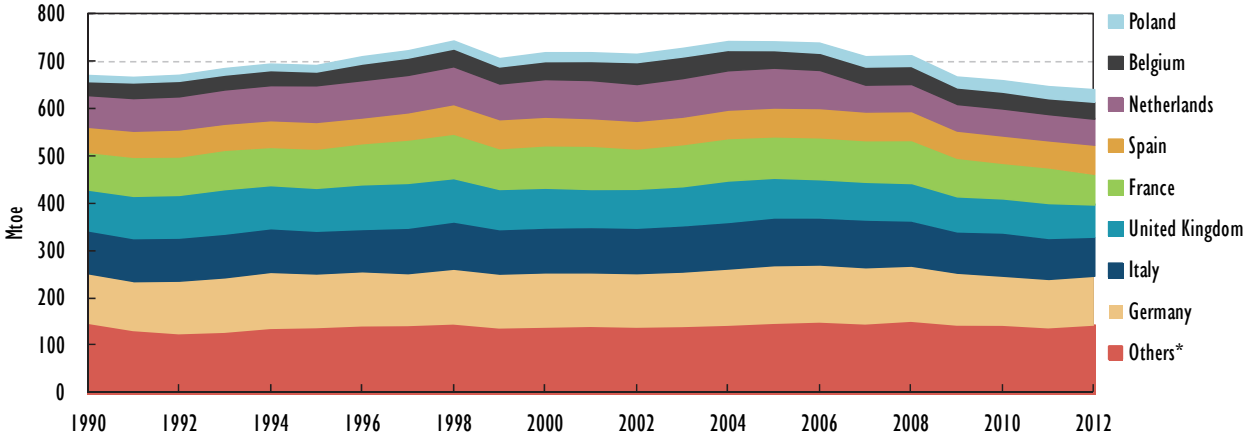
from increased competition from export refineries elsewhere. All but six countries in the EU refined crude oil into oil products in 2012, with the majority produced in Germany (16.3%), Italy (12.9%), the United Kingdom (10.9%), France (9.8%), and Spain (9.6%).

Production in France, Belgium, the Netherlands, Romania and Croatia has declined by more than 25% each between 2002 and 2012. This reduction was higher than the increases in Poland, Lithuania, Bulgaria and the Czech Republic (by more than 25% each) over the same period, as their combined share of total production is below 8%. Figure 6.3 indicates the changes in refinery output in major producing countries in the European Union during the period 1990-2012. The pattern of oil products produced by EU member states in 2012 is summarised in Figure 6.4. In 2012, Estonia, Luxembourg, Slovenia, Cyprus, Latvia and Malta did not produce oil products.

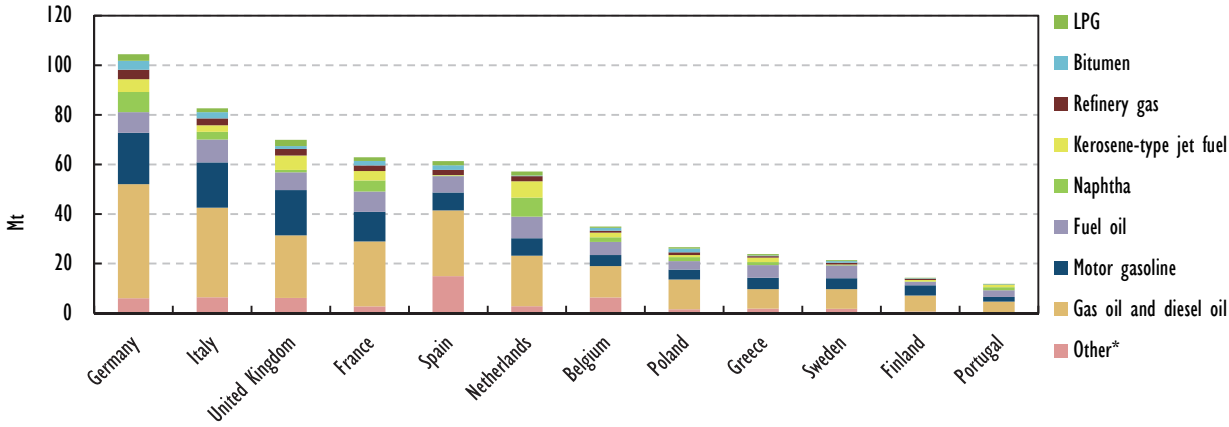
**Figure 6.3** Oil products production in the European Union by country during 1990-2012




* *Others* includes other European Union member states which produce oil products each year.

Source: IEA (2014a), *Oil Information,* OECD/IEA, Paris.

**Figure 6.4** Oil products production by country and by product, 2012




Source: IEA (2014a), *Oil Information,* OECD/IEA, Paris.

**Other* includes bitumen, white spirit, lubricants, paraffin waxes, petroleum coke and not specified.



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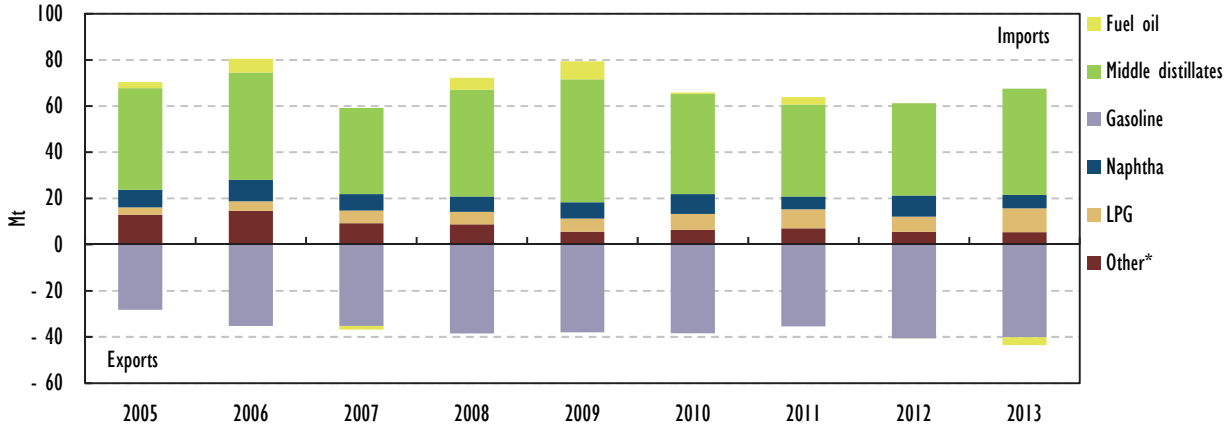
## IMPORT AND EXPORT

Europe is a net importer of crude oil and middle distillates (kerosene, diesel, heating oil and gasoil) and a net exporter of gasoline, as illustrated in Figure 6.5 for OECD Europe. The imbalance is structural and has been ongoing since the end the 1990s, as taxation continues to favour diesel which increases the number of new diesel-engine road vehicles. In 2013, the European Union was in fact a net exporter of fuel oil and 70% of its imports were middle distillates.

**Figure 6.5** OECD Europe net oil product trade, 2005-13




**Other* includes bitumen, white spirit, lubricants, paraffin waxes, petroleum coke and not specified.

Note: OECD Europe comprises all European OECD member countries. These are Iceland, Norway, Turkey and Switzerland next to the following EU member states: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden and United Kingdom.

Source: IEA (2014a), *Oil Information,* OECD/IEA, Paris.

Over the past decade, the dependence of the European Union on extra-EU imports increased, as the decline in oil demand did not fully compensate for the decline in indigenous crude oil production in the European Union.

On average, OECD Europe is a net importer of crude oil. In 2012, net crude oil imports amounted to 524.2 Mtoe in 2012 (562.4 Mtoe of imports and 38.2 Mtoe of exports). Total imports of crude oil in 2012 were, however, down by 5.3% compared to 2002, while exports were down by 62.5%. Demand for crude oil imports has been falling slowly owing to lower refinery output and refinery closures, while crude oil exports have declined as a result of falling indigenous production.

The European Union is sourcing its crude oil from a wide range of sources to supplement its indigenous production (see Figure 6.6.). In 2012, extra-EU crude oil and natural gas liquids were imported to a large extent from Russia (35%), Norway (12%), Saudi Arabia (9%), Libya (9%), Nigeria (9%) and Kazakhstan (6%), as shown in Figure 6.6. In terms of volumes, Germany, France, Italy, Spain and the Netherlands were the major crude oil importers in 2012.

Russia's role in the European oil supplies is changing. Russia is now exporting more refined oil products to Europe, which is encouraged by lower Russian export duties on products compared to crude oil. While Russia remains the largest source of European oil product imports, providing roughly a third of the total 3.2 mb/d imported in 2013,

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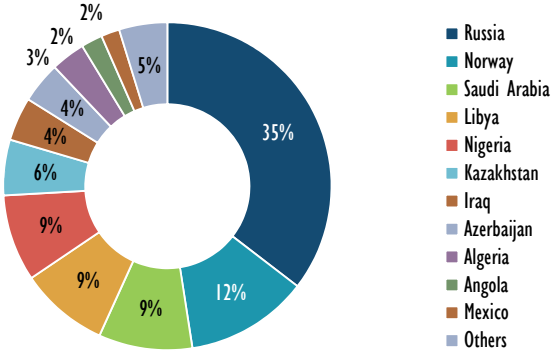
increasing volumes are coming in particular from the United States and the Middle East. For certain months in 2013, the United States overtook Russia as main supplier of middle distillates, providing 500 kb/d (compared with 430 kb/d from Russia) to Europe in the fourth quarter of 2013.

**Figure 6.6** Imports of crude oil to the European Union by country of origin, 2012

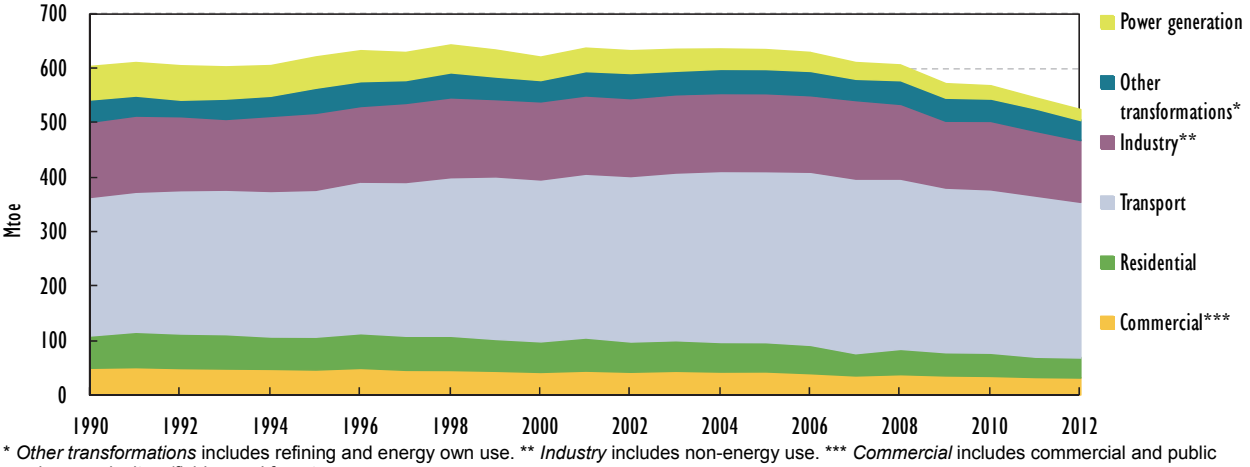



Source: EU (2014), *EU Energy in Figures: Statistical Pocketbook*, 2014.

## DEMAND

European Union demand for oil (526.5 Mtoe in 2012) is on a declining trend. Demand in the transport sector – the largest consumer of oil in the European Union – has declined by 6.2% over the ten years to 2012. This is, however, the slowest decline in consumption compared to other sectors (see Figure 6.7). As such, the importance of transport in total oil demand has increased from 47.7% of total consumption in 2002 to 53.9% in 2012.

**Figure 6.7** EU oil consumption (TPES) by sector, 1990-2012




* *Other transformations* includes refining and energy own use. ** *Industry* includes non-energy use. *** *Commercial* includes commercial and public services, agriculture/fishing and forestry.

Sources: IEA (2014c), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014d); *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

The industry sector accounted for 21.9% of consumption in 2012. In the trend since the previous in-depth review in 2008, demand from industry has declined by 14.1% over the five years. The residential sector, other energy industries (including refining) and the commercial sector represented 7.2%, 6.1% and 7.1% of oil consumption. Demand from



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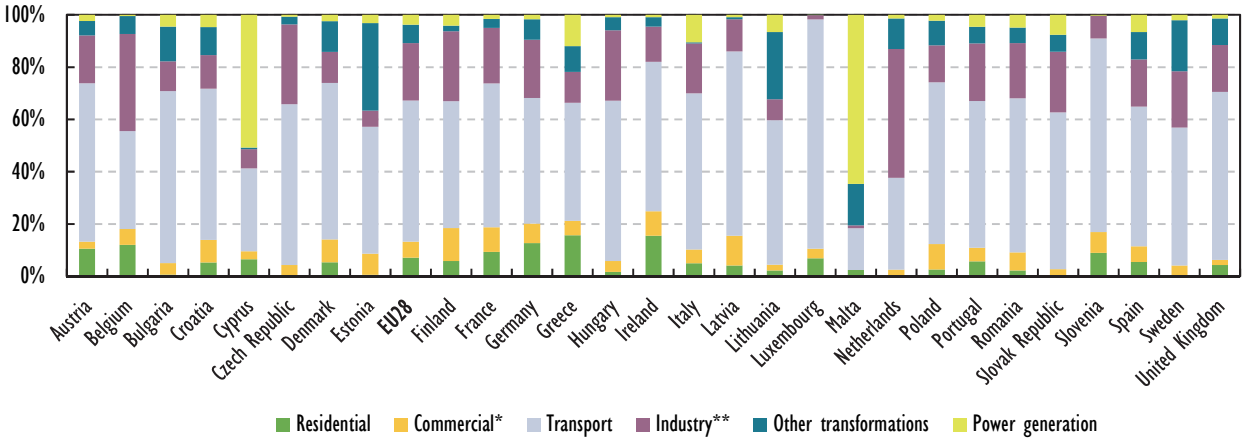
these sectors has contracted since 2007, down by 9.1%, 8.4% and 11%, respectively. The power generation sector accounts for 3.8% of oil demand and is the smallest source of demand. Its demand has declined by 34.8%.

Across member states, oil consumption varies by sector, as shown in Figure 6.8. The share of residential use is larger in Germany, Greece and Ireland compared to the EU average, while the share of transport is the largest in Luxembourg and Slovenia. Belgium, the Netherlands and the Czech Republic have a higher share of industry in total consumption compared to the EU average, while Cyprus and Malta use more than half of their oil supply for power generation.

When looking at the product demand in 2012, diesel accounted for 42% of OECD Europe's oil product demand, while gasoline only for 14% and fuel oil for 10% (IEA 2014b).

**Figure 6.8** Oil consumption by sector per EU member state, 2012




* *Commercial* includes commercial and public services, agriculture, forestry and fishing.

** *Industry* includes non-energy use.

Sources: IEA (2014c), *Energy Balances of OECD Countries*, OECD/IEA; Paris. IEA (2014d), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

## PROJECTIONS

As energy demand is expected to stay flat, the trends in oil demand in OECD Europe are expected to continue in the medium term, with total consumption forecast to fall by 0.3% per year through 2019 (IEA 2014b). Absolute declines in gasoline, residual fuel oil and other products are forecast to more than offset some fairly modest projected gains in liquefied petroleum gas (LPG), jet/kerosene and gasoil/diesel.

In the longer term, the latest energy and climate scenarios for 2030/2050, elaborated by the European Commission (PRIMES model), indicate only a slight change in oil demand and supply up to 2030, but strong long-term changes towards 2050 (see Chapter 2, "General Energy Policy", Table 2.3).

A 40% GHG emissions reduction target, as proposed by the European Commission under the Policy Framework for Climate and Energy in the period from 2020 to 2030, is expected to only reduce the share of oil in inland energy consumption from 35.1% in 2010 to 32.8% in 2030, however, to 13.5% in 2050. In the horizon to 2030, there is little impact on oil consumption to be expected from the 40% emissions reduction target, in comparison to the share of oil in the reference scenario 2013 which assumes 32.3%.

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Despite the introduction of biofuels and electric cars in the European Union, the contribution of oil-based fuels to transport is likely to remain unchanged up to 2030, particularly as heavy-duty transport has a large share in total transport and cannot be switched to electric vehicles and the use of biofuels remains limited because of sustainability concerns. With more stringent efficiency standards (and high excise taxes), oil demand is set to progressively decline further, and most of oil decline is expected for the period after 2030.

## OIL MARKET AND INFRASTRUCTURE

As a major player in the global oil market, the European Union has diverse supply routes and sources thanks to major ports and pipelines delivering oil to the European Union. Pipelines only transport 10% of total oil imports into the European Union, as the majority arrives by tanker.

Norway plays a key role in securing oil supplies to the European Union, both via Norpipe from Ekofisk and to Teeside in the United Kingdom as well as to key EU ports.

The majority (two-thirds) of total Russian oil imports is imported by European ports from the Russian ports in the Baltic Sea (Primorsk and Ust-Luga) and the Black Sea (Novorossiysk); around 30% of Russian crude oil arrives in Europe through the Druzhba pipeline system. An overview on the oil infrastructure in Europe is given in Figure 6.9.

### PORTS AND PIPELINES

There are a few large oil pipelines which link major EU ports to inland refineries, namely the Rotterdam-Rhine Pipeline (RRP) from Rotterdam, the South European Pipeline (SPSE) from Marseille and the Transalpine Pipeline (TAL) from Trieste.

Refineries in Central and Eastern Europe (the Czech Republic, Germany, Hungary, Poland, and the Slovak Republic) are supplied from Russia by the Druzhba pipeline.

Rotterdam, Marseille and Trieste are the major EU ports for importing crude oil, while the majority of oil products is imported/exported at the ports in London, Le Havre, Antwerp, Rotterdam and Amsterdam. The Dutch Amsterdam-Rotterdam-Antwerp port area (ARA) is the world's third-largest bunkering centre after Singapore and Fujairah.

### REFINERIES

At the start of 2014, the EU refineries had a total processing capacity of 15 million barrels per day. Most refineries are located near the coasts, with inland plants in Austria, Poland, the Czech Republic, the Slovak Republic, Hungary and Germany (see Figure 6.9).



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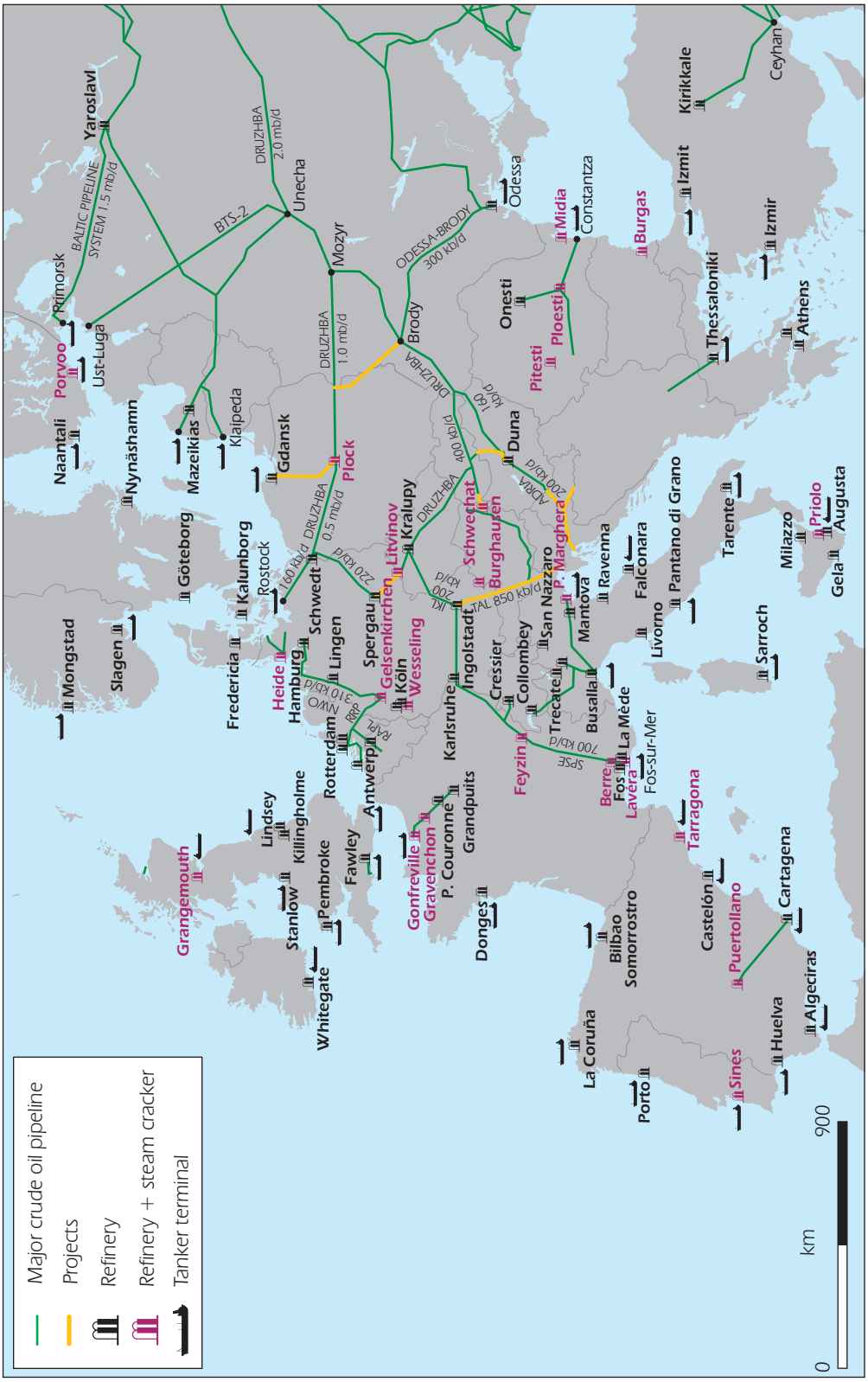
**Figure 6.9** Oil infrastructure in Europe




This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

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## REGULATORY FRAMEWORK

A number of EU laws affect the oil sector, directly or indirectly, mainly with regard to energy taxation, fuel specifications, environmental regulations, offshore safety, maritime transport- or infrastructure-related policies.

### OFFSHORE OIL AND GAS DRILLING

In the aftermath of the Deepwater Horizon accident in the Gulf of Mexico, the European Union adopted in 2013 new rules for the safety of offshore oil and gas platforms. Directive 2013/30/EU obliges member states to ensure adequate licensing of operators by the authorities, minimum conditions for safe offshore exploration and exploitation, as well as the independence of licensing authorities, notably the separation of the functions of environmental and safety regulation on the one hand, and revenue and economic regulation on the other.

The directive also includes rules on transparency and information-sharing, for enhanced emergency preparedness and response in case of a major incident and the co-operation of member states' authorities in a trans-boundary context. A new Offshore Oil and Gas Authorities Group was created at EU level.

### ENERGY TAXATION

The Directive on the taxation of energy products and electricity (Energy Taxation Directive 2003/96/EC, ETD) sets minimum tax levels for electricity and for energy products used for heating or motor fuel. Member states are free to decide on the taxation above these minimum levels. In 2011, the European Commission proposed a revised ETD to bring it in line with environmental and climate change objectives, by splitting the existing tax into two taxes depending on the carbon and on the energy content. This would bring excise duties for diesel and gasoline closer to each other (see Figure 6.10). At the time of publication, the revised proposal has not been adopted by the Council, as it has not received the required unanimous support by the EU member states. With the taxation decision pending, the imbalance of EU diesel and gasoline imports/exports is likely to persist.

### ENVIRONMENTAL REGULATION

Under the sustainability agenda of the 2020 Climate and Energy Package, several directives and regulations, directly or indirectly, affect oil demand and the oil market.

Within the context of the EU target to reduce primary energy consumption by 20% by 2020, stringent emission targets for the EU vehicle fleet of cars and vans and comprehensive energy efficiency regulations, for instance in the buildings sector, are set (see Chapter 4, "Energy Efficiency"). New vehicle standards gradually decreased the allowed levels of pollutant emissions from cars and vans, particularly for emissions of nitrogen particulates and oxides. The EU-ETS now includes aviation within the European Economic Area.

Under the Renewable Energy Directive 2009/28/EC the European Union promotes the use of biofuels in transport targeting a minimum of 10% in total final consumption in every member state by 2020. The directive supports the use of sustainable biofuels which generate a GHG saving without negative impact on biodiversity and land use



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(ILUC). In 2014, a revision of the directive is in the legislative procedure aimed at limiting the potentially negative sustainability impacts of conventional biofuels and preparing for the transition to second-generation biofuels.

As part of the European Union's overall commitment to a 20% reduction in GHG emissions by 2020, an amendment to the Fuel Quality Directive (FQD, Directive 98/70/EC)[3] was agreed. A 6% reduction target is set for 2020, from a 2010 fuel baseline standard of Union average GHG intensity of fuels, as reported to United Nations Framework Convention on Climate Change (UNFCCC) in 2010.[4] Article 7a requires fuel suppliers to reduce the GHG intensity of the road fuels used in the European Union. It leaves to the fuel supplier the choice of the most cost-effective way to achieve the target: biofuels, electric vehicle credits, upstream emissions reduction, or use of other alternative fuels. In October 2014, the European Commission presented an implementation measure[5] with a methodology to calculate and to report the GHG emissions from fossil fuels to the Council for adoption. The proposed fossil fuel GHG calculation methodology is based on GHG default values for each fuel type. With the boom of light tight oil in the global oil markets, the fuels qualities are changing. The reporting measure was therefore intensively discussed with domestic stakeholders and EU international trade partners. Under the proposed Policy Framework for Climate and Energy in the period from 2020 to 2030, the European Commission has declared its intention to discontinue the FQD.

The Clean Air Policy Package of December 2013 targets air pollution with a revised National Emission Ceilings Directive, with stricter national emission ceilings for the six main pollutants, rules to reduce pollution from medium-sized combustion installations, new air quality objectives by 2030, and measures to help cut air pollution, notably in cities. The package highlights the risks for human health and the environment from harmful emissions from industry, traffic, energy plants and agriculture.

## OIL PRICES AND TAXES

Member states are free to decide the tax levels above the EU minimum. As a consequence of national policies and the EU energy taxation law in force, diesel is taxed considerably less in most EU member states, a factor which supports domestic consumption and imports of middle distillates to the European Union. The prices for gasoline, diesel and heating oil are shown in Figure 6.10. Within the European Union, taxes vary very little, by around 10% and 15%. In most EU member states, taxes on transport fuels are a major source of government revenue, as well as serving environmental purposes.

In an international comparison, Figure 6.11 illustrates the prices (in USD), including taxes, that consumers in IEA and OECD member countries pay for premium unleaded gasoline. Taxation has a big impact on the pump prices, making up the largest share of the total price in 22 of the 32 countries surveyed. The lowest gasoline prices can be found almost exclusively in large non-European countries, the United States and Mexico,

**3.** Directive 2009/30/EC.

**4**. Article7a(5)(b) of Directive 98/70/EC requires the establishment of a methodology to determine the aggregate greenhouse gas intensity of fuels from non-biological origin used in the Union in 2010 (the "fuel baseline standard"). The baseline standard should be based upon the volumes of diesel, petrol, non-road gas oil, liquefied petroleum gas and compressed natural gas using data officially reported to the UN Framework Convention on Climate Change in 2010.

**5**. Proposal for a Council Directive on laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels, COM(2014) 617 final, 6 October 2014.

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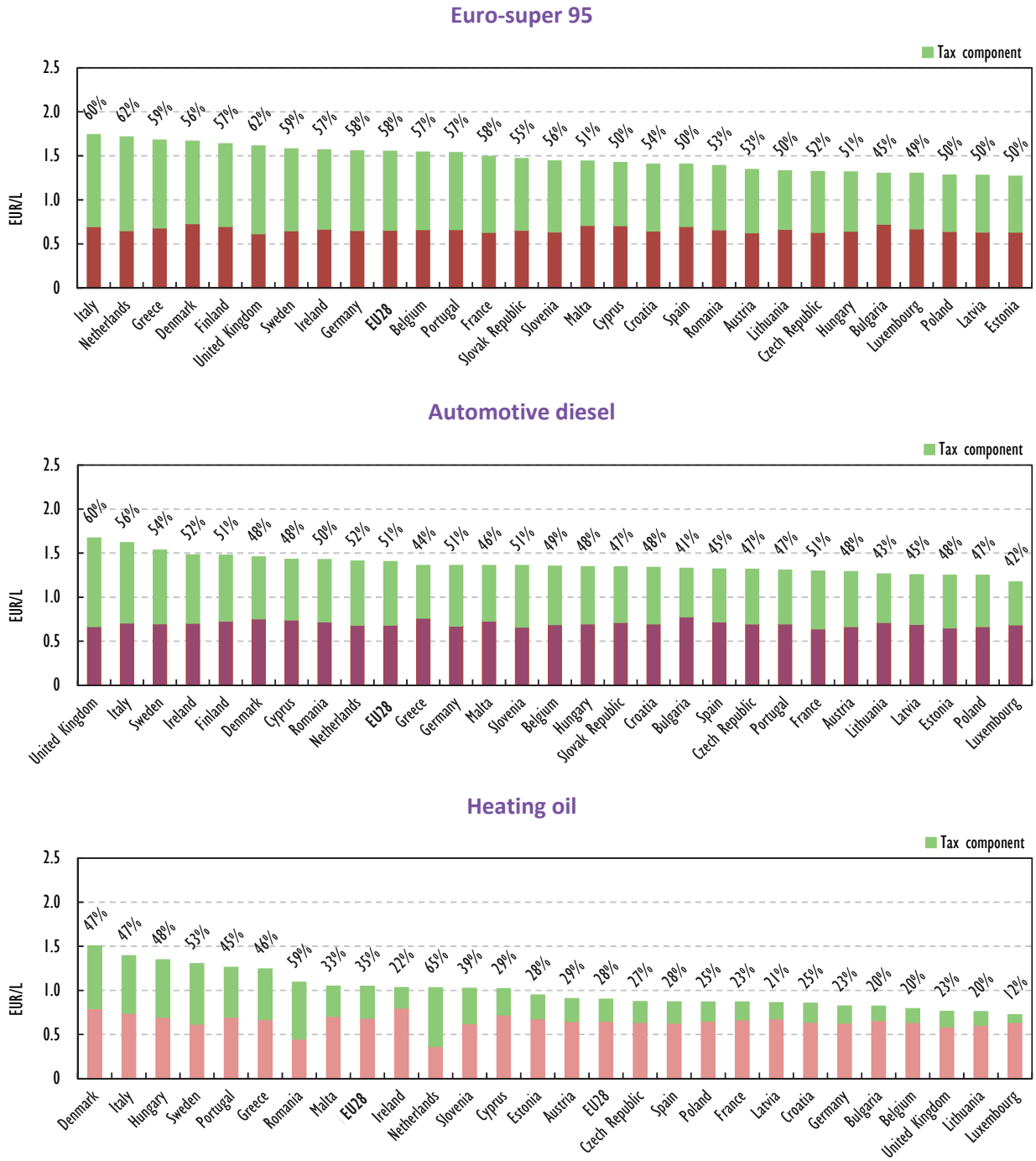
where taxes are around 15% of the total price. In contrast, countries like the Netherlands, Italy, Norway and Turkey levy taxes of around 60%, which make their prices to consumers the highest in the OECD area.

**Figure 6.10** Fuel prices in EU member states, August 2014




Note: data for the Slovak Republic for heating oil are not available.

Source: Eurostat (2014), http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/themes, date of access: 1 August 2014.



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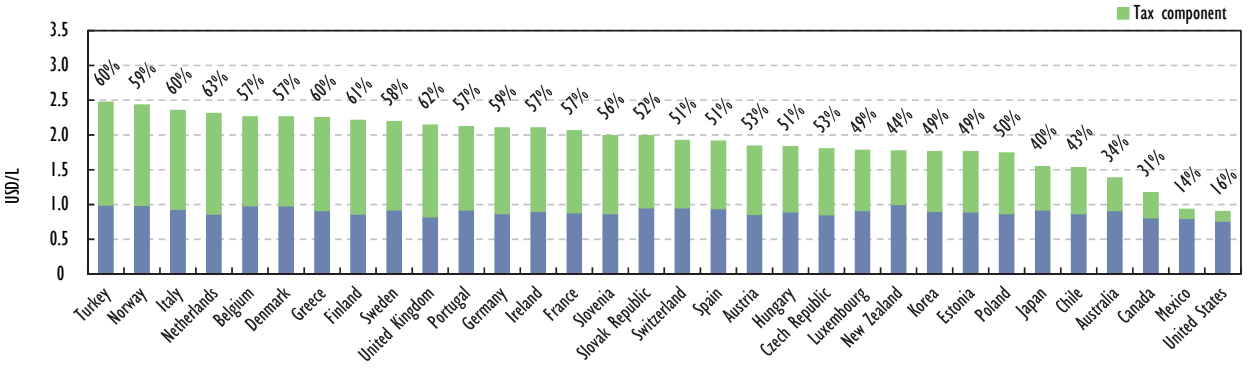
**Figure 6.11** Unleaded gasoline prices and taxes in selected OECD member countries, 1st quarter 2014




Notes: Regular unleaded for Australia, Canada, Japan, Korea, Mexico, New Zealand and the United States; premium unleaded 95 RON for other countries. Data cover 3rd Quarter 2013 for Turkey.

Source: IEA (2014e), *Energy Prices and Taxes: 2nd Quarter 2014*, OECD/IEA, Paris.

## SECURITY OF OIL SUPPLY

### EMERGENCY PREPAREDNESS

In 2009, the European Union has put in place new emergency and security of supply policies on oil with the adoption of the revised Oil Stocks Directive (2009/119/EC). The new rules were to be implemented by member states by 31 December 2012; however, full implementation is still on its way in a few member states (notably Luxembourg, Latvia, the Netherlands, and Slovenia).

The Oil Stocks Directive requires member states to hold minimum emergency stocks of oil and/or petroleum products equivalent to 90 days of net imports or 61 days of inland consumption, whichever is higher. Member states are obliged to have in place emergency measures for the release of these stocks in a major supply disruption. Other emergency measures include programmes for demand restraint (for instance in the transport sector, like car-pooling, driving bans or speed limits), possibilities for fuel switching (in transport or industry), temporary production increases and the allocation of oil products in case of a disruption to priority consumer groups.

EU countries have the option to create a so-called central stockholding entity (CSE) for the acquisition and management of the stocks or to delegate its stockholding obligations to other member states and their CSEs or to certain other economic operators which have surplus stocks. Under specific conditions, economic operators can delegate their stockholding obligations to the national CSE, to one or more CSEs in other member states or to other economic operators with surplus stocks. Member states have to hold at least one-third of their commitment in refined products; this is more stringent than IEA rules. The directive leaves member states to choose the composition of their emergency stocks between crude oil and oil products. In addition, they can hold “specific stocks” of at least 30 days of inland consumption. Specific stocks shall be owned by the member state concerned or the CSE set up by it.

The Oil Co-ordination Group was established as the main body for EU member states to discuss and co-ordinate their actions on oil security. The IEA regularly participates to the meetings of the group. The directive also introduces the possibility to carry out regular reviews of emergency preparedness and stockholding of EU member states.

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The European Commission recently evaluated the security of oil supply. At the end of 2013, the European Union held emergency stocks of 129 million tonnes (Mt) (59 Mt of crude oil and 70 Mt of oil products), equivalent to 100 days of net imports. In April 2014, EU member states' oil emergency stocks were equivalent to about seven months of crude oil and product imports from Russia (EC, 2014a). The Commission concludes that oil emergency responses in the European Union rely mainly on stocks, while measures, such as demand restraint, fuel switching or short-term production increases are likely to be very limited in practice. It also noted the limited flexibility to switch supply sources and routes with regard to crude oil imports from Russia.

The directive largely brings in line EU and IEA oil emergency requirements and enhances the review of emergency responses and the co-ordination of a possible international decision to release stocks. 20 out of 29 IEA member countries are EU member states and meet their IEA stockholding obligation through the EU regime described above.

However, there are differences between IEA and EU stocking requirements, such that a country's level of compliance can be different under the two systems. This is noteworthy for instance for net exporting countries (e.g. Denmark), or countries with relatively small levels of net imports compared to domestic consumption (e.g. Estonia, the United Kingdom), which are required to hold 61 days of consumption under the EU requirements compared to no obligation or only a minimal stockholding obligation under the IEA system.

Despite the overall alignment of EU and IEA rules, with the entry into force of the directive and the implementation of new EU rules, the oil stock monitoring carried out by the European Union and the IEA will need to be closely co-ordinated. The new EU reporting and monitoring rules are not the same as the IEA approach, notably in the way industry, public and specific product stocks are counted. Differences come primarily from a narrower definition under the directive for the stocks which are counted towards meeting the stockholding obligation. The IEA methodology counts all oil stocks in a country (net bilateral stockholdings), while the European Union counts only those oil stocks which would be available for the purpose of covering an emergency.

## REFINING

As outlined in the introduction, since the economic downturn of 2008, Europe's refining sector has seen a number of challenges, declining regional demand, more stringent EU environment legislation and wider market developments, i.e. the emergence of new export refineries in Asia and the Middle East as well as increased product exports from the United States.

### Declining EU refining capacity

Europe's refinery sector has been going through challenging times as a result of falling regional oil demand, a period of sustained high oil prices during 2008 and 2013, declining domestic crude production, North African supply disruptions and disappearing export markets for gasoline with the boom of unconventional oil and gas production in the United States. EU refineries have been impacted by increased global competition from new refineries in Asia and the Middle East as well as from United States' refineries which enjoy better margins thanks to lower feedstock and energy costs, lower environmental rules and other associated costs.



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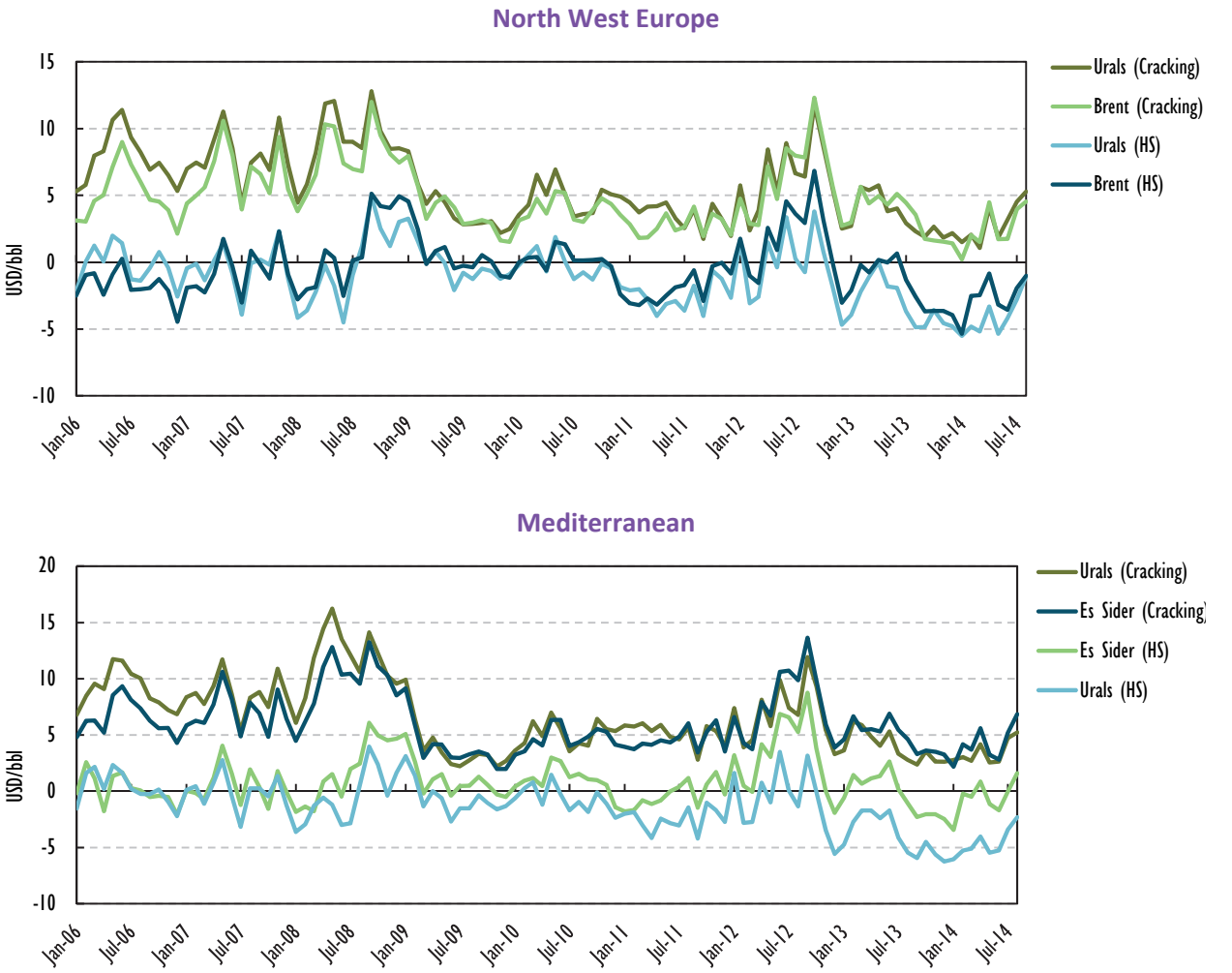
During 2009 and end of 2013, given excess capacity, utilisation rates and margins in EU refineries were on the decline with periods of negative margins, notably in 2013 and early 2014, leading to restructuring (see Figure 6.12). While demand fell by 1.9 mb/d between 2008 and 2013, 15 refineries with a total of 1.8 mb/d of capacity (8% of total EU capacity) were shut or reduced capacity in the European Union. This includes closures in France (585 kb/d), Germany (400 kb/d), the United Kingdom (455 kb/d) and Italy (320 kb/d).

Table 6.1 provides an overview of the current restructuring of European refineries. Several EU refineries have also changed ownership in the period, with Russian, Chinese, and Indian players, as well as trading companies (Vitol, Gunvor) entering the market. Lukoil took full control of the ISAB refinery on Sicily at the end of 2013 (after its joint venture with ERG in 2008).

In the medium term, the boom in light tight oil production in North America, and strong demand growth in the Middle East and Asia are set to drive refinery investment outside Europe. As a result, some further restructuring in mature markets with declining demand (such as Europe and OECD Asia Oceania) is expected by 2019 (IEA 2014f).

**Figure 6.12** Refinery margins, January 2006 to August 2014




Source: IEA/KBC, 2014.

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There are fears that the decline in refining capacities can have a direct impact on the security of oil supply in the European Union. Despite some delays and cancellation of new investment in refining capacity in Asia in the medium term, there is a continued risk of declining refining capacity in Europe, particularly as the imbalance between refinery output and demand are likely to persist. As demand for distillates is expected to increase modestly, the region's dependence on imports of diesel is expected to increase further.

This situation requires a re-evaluation of the security impacts by country and fuel, as impacts vary. The impact is not the same across the European Union.

So far, the Netherlands and Belgium have not seen their refinery runs impacted, while operations are on the decline in France, Germany and the United Kingdom. Spain and Portugal have increased their operations, thanks to investments made in upgrading and export opportunities in the Mediterranean region (see Figure 6.12). Figure 6.12 illustrates the refinery margins of refineries in Northwest and Mediterranean Europe, processing different crudes and price benchmarks, including Russian Urals, Atlantic basin Brent and Libyan Es Sider. Since 2008, Europe saw a consistent decline of refinery margins, with the exception of mid-2012. In particular for refineries, using high severity (HS), margins have been negative during most of 2013 in both regions.

With declining regional refinery activity, diesel imports have grown disproportionately. These import trends means that supply disruption risks can increase, as transportation ways are becoming longer, short-term flexibility lower and the needs for product storage as well as the exposure of suppliers to political risks increase.

Since early 2014, however, margins are on the rise again, partly a result of refinery consolidation, restructuring and lower global feedstock prices. European margins are rapidly increasing since August 2014.

**Table 6.1** Recent changes to European refining assets

| Country | Refinery | Sold by | Acquired by |
|---|---|---|---|
| Germany | Ingolstadt | Petroplus | Gunvor |
| Switzerland | Cressier | Petroplus | Vitol/Atlas Invest |
| Belgium | Antwerp | Petroplus | Gunvor |
| United Kingdom | Pembroke | Chevron | Valero |
| United Kingdom | Stanlow | Royal Dutch Shell | Essar Energy |
| United Kingdom | Grangemouth | Ineos | JV with PetroChina |
| France | Lavera | Ineos | JV with PetroChina |
| Sweden | Gothenburg | Royal Dutch Shell | St1 |
| Germany | Ruhr Oel | PDVSA | Rosneft |
| Germany | Heide | Royal Dutch Shell | Klesch |
| Germany | 45% Bayernoil | OMV | Varo Energy (Vitol and Carlyle) |
| United Kingdom | Milford Haven | Murphy | Klesch |
| Italy | ISAB | ERG | Lukoil |



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## Impact of EU legislation on the refining industry

National and European environmental legislation imposes strict sulphur limits on ship fuels. Legislation for the international shipping community (International Maritime Organisation – IMO) requires further desulphurisation of vessel fuels, so-called bunker fuels. Worldwide, the allowed 3.5% sulphur content is set to decrease to 0.5% in 2020.[6] In the Baltic Sea and North Sea areas, sulphur content will drop to 0.1% by 2015. More stringent future product specifications may create further challenges for the EU refining industry, as large investments in de-sulphurisation capacity may be needed to comply with the regulations.

Refineries are included under the EU-ETS and have to offset their $CO_2$ emissions. Most of the refineries are, however, compensated for their cost or receive free allocation, given that they face competition from industry in third countries that have less stringent environmental rules (carbon leakage).[7] According to the EU-ETS Directive (Article 10a), a sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage if: 1) the extent to which the sum of direct and indirect additional costs induced by the implementation of the directive would lead to an increase of production cost, calculated as a proportion of the gross value added, of at least 5%; and 2) the trade intensity (imports and exports) of the sector with countries outside the European Union is above 10%. A sector or sub-sector is also deemed to be exposed to a significant risk of carbon leakage if: a) the sum of direct and indirect additional costs is at least 30%; or b) the non-EU trade intensity is above 30%.

The 2001 Large Combustion Plant Directive and the 2010 Industrial Emission Directive replacing the 2008 Integrated Pollution Prevention and Control Directive, set minimum requirements for pollutants and increase environmental compliance cost.

Building on a roundtable on refining in 2012, the European Commission established in 2013 the EU Refining Forum which brings together representatives of all 22 EU member states that have oil refining, members of the European Parliament and representatives of the EU refining industry and trade unions. The forum discusses the impact of EU regulation on the EU refining sector and the EU security of supply of petroleum products. From the outset, the IEA has actively contributed to this process and discussed the oil market challenges with the industry and EU institutions.

In 2013, the European Commission started to run a so-called “fitness check” of the EU refining industry, in close co-operation with industry and across the EU institutions. The check aims to assess the combined impact of all EU policies, the costs and benefits, with regard to the impact on the cost of refineries and the oil product market as well as the impact on the competitiveness of the European refining sector. The checks are expected to be completed by end 2014. In the first instance, the fitness check examines ten pieces of legislation, including environmental legislation, maritime legislation requiring the reduction of sulphur contents (marine fuels quality) and climate laws (energy efficiency

**6.** In line with Annex VI, “Prevention of Air Pollution from Ships”, to the MARPOL 73/78 Convention, the highest sulphur content allowed in ship fuel will reduce globally as of 1 January 2012 from 4.5% to 3.5% and as of 1 January 2020 to 0.5%. Sulphur content allowed in Sulphur Emission Control Areas (SECA) that currently include the Baltic Sea, the North Sea and the English Channel will decrease as of 1 July 2010 from 1.5% to 1.0% and as of 1 January 2015 to 0.1%. This target is subject to review by 2018 by the international shipping community IMO with regard to a possible postponement until 2025.

**7.** Carbon leakage describes the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries which have laxer constraints on greenhouse gas emissions. This could lead to an increase in their total emissions.

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rules reducing energy and oil demand, the promotion of renewable energies, notably biofuels which accounted in 2012 for 5% of total road fuels), energy taxation, including fuel taxation, and standards for clean and energy-efficient vehicles.

## OIL SUPPLY DIVERSIFICATION

In 2012, the European Union reached a dependence on crude oil imports of 88%. However, the EU benefits from a diverse portfolio of import sources of crude oil and natural gas liquids, with imports coming from Russia (35%) and Norway (12%), followed by Saudi Arabia (9%), Libya (9%), Nigeria (9%) and Kazakhstan (6%), as shown in Figure 6.6. Russia is also the largest source of European oil product imports, providing roughly a third of the total 3.2 mb/d imported in 2013, as Russian tax rules favour oil product exports. The European Union receives about 10% of its total crude oil supplies by pipeline, but 30% of its Russian crude oil imports via the Druzhba oil pipeline. Alternative pipeline supplies and supply routes are not fully available to refineries in Central East Europe and they depend on the specifications of Russian crude oil.

In the past, Russian oil transit supplies have faced interruptions. In 2007, oil supplies were interrupted on the Druzhba pipeline through Belarus. The 2014 crisis in Ukraine, an important transit country for Russian crude oil to Central Eastern Europe, reconfirmed the need to diversify the routes and sources of EU oil imports. The European Union is therefore focusing on promoting investment in new oil pipelines and the expansion of existing ones in Central and Eastern Europe (see Box 6.1.).

Ukraine is a transit country for Russian crude exports to Central European countries. The southern leg of the Druzhba pipeline, Russia's main artery for supplying crude oil to central Europe, runs through Northern Ukraine and has capacity of 400 kb/d, but has been used at roughly three-quarters capacity for a few years. It is the largest source of crude oil supply for the Czech Republic, Hungary and the Slovak Republic. The Black Sea ports of Odessa and Feodosiya have in the past been important seaborne outlets for Russian crude and refined products, but export volumes steeply declined in 2013. Ukrainian ports shipped an average of 30 kb/d of Russian crude oil in 2013, a sharp decline from an average 190 kb/d over 2009-12. In 2013, Russia exported 60 kb/d of refined products via Ukrainian ports. Fuel oil accounted for 50 kb/d with gasoil making up the rest. These volumes were significantly lower than the 130 kb/d exported over 2009-12.

The southern Druzhba spur transported approximately 310 kb/d of crude in 2013, in line with volumes carried over 2009-12. Bosnia, the Czech Republic, Hungary and the Slovak Republic are highly dependent upon the Druzhba pipeline for crude imports. In 2013, the Slovak Republic imported 100% of its crude via the Druzhba, Hungary 94% and the Czech Republic 65%. Despite the fact that these three countries have significant emergency oil stocks, well above the 90-day IEA obligation, the further diversification of supply routes and sources can help secure oil supplies to these countries. Several priority projects have been identified by the European Union (see Box 6.1 and Figure 6.9).

The European Energy Security Strategy of May 2014 (EC, 2014b) raised several concerns with regard to security of oil supply to the European Union: the dependence of the European Union's refining industry on Russian crude oil; the increased concentration in the Russian oil industry, the increased ownership of EU refinery capacity by Russian oil companies; and the share of refined products consumed in transport.



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The Commission underlines the need to maintain competitive refining capacities in Europe by identifying EU-wide strategic assets in the oil value chain and co-ordinating action with member states and industry during the restructuring and consolidation period (including fitness checks and other measures). The main objective is to avoid overdependence on product imports and to secure processing capacity for crude oil in Europe. The Commission calls for a proactive trade policy to ensure access to oil export markets and the better co-ordination of its energy policy, including at international level through greater co-operation with the IEA and major consumers, like China and India, and the promotion of data transparency concerning oil stocks, oil markets and investments.

**Box 6.1** Overview of PCI for oil

The European Union marks diversified oil supply sources and routes for Central Eastern Europe a priority, as refineries depend on the Druzhba pipeline and Russian crude oil supplies. Several oil infrastructure projects have been identified by the European Union in 2014 as PCI to ensure more diversified supplies and routes for the region (see Figure 6.9):

- Bratislava-Schwechat-Pipeline: pipeline linking Schwechat (Austria) and Bratislava (the Slovak Republic)
- TAL Plus: capacity expansion of the TAL Pipeline between Trieste (Italy) and Ingolstadt (Germany)
- JANAF-Adria pipelines: reconstruction, upgrading, maintenance and capacity increase of the existing JANAF and Adria pipelines linking the Croatian Omisalj seaport to the Southern Druzhba (Croatia, Hungary, the Slovak Republic)
- Litvinov (the Czech Republic)-Spergau (Germany) pipeline: the extension project of the Druzhba crude oil pipeline to the refinery TRM Spergau
- Adamowo-Brody pipeline: pipeline connecting the JSC Uktransnafta's Handling Site in Brody (Ukraine) and Adamowo Tank Farm (Poland)
- Construction of an oil terminal in Gdańsk
- Expansion of the Pomeranian Pipeline: loopings and second line on the Pomeranian pipeline linking Plebanka Tank Farm (near Płock) and Gdańsk Handling Terminal.

## ASSESSMENT

Since the first IEA in-depth review of the EU in 2008, the Union's oil markets have undergone significant changes in the pattern of the European Union's demand for products, as a result of major changes in the global energy landscape.

### CHANGING GLOBAL OIL MARKETS AND THEIR IMPACTS

Market developments outside Europe have a strong impact on the European outlook. The global oil trade is undergoing a fundamental shift, away from consumers in the Atlantic basin – where overall demand for imported oil is falling – towards meeting the increasing needs of Asian importers. Russia's crude oil exports to the East are rising and its exports to the West are increasingly likely to be higher-value refined products rather than crude oil or intermediate products. Gulf Coast refineries in the United States are

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providing stiff competition for European gasoline exports while the United States' demand disappeared after the boom in light tight oil production. Some exporters in the Middle East are building, or looking to build, new export-oriented refinery capacity.

The declining trend in EU oil production is set to continue as consumption is impacted by some efficiency gains and fuel switching. Dependence of the refining sector on imported crude is already high, as internal sources of crude are dwindling.

In the *World Energy Outlook 2013* (IEA, 2013b), the New Policies Scenario,[8] total European demand for oil products declines by almost 2.5 mb/d over the period to 2035, with middle distillates strengthening their dominant position. Compared to other regions, EU oil product demand is heavily skewed towards diesel, an imbalance that is perpetuated to a degree by current EU energy tax regulation. Europe is not only a major importer of crude oil, but is now the largest importer of diesel and the largest exporter of gasoline in the world.

## IMPACT ON REFINING INDUSTRY

During the past five years, the EU refining industry has been facing competitive pressures. The European outlook was very difficult for refiners, as reflected in the *World Energy Outlook 2013* (IEA, 2013b) by a large projected decline in refinery operations to 2035, with the likelihood of continued pressure to shut refining capacity. In a situation of sustained very low margins and companies looking to leave the refining sector, any additional costs associated with the regulatory environment can have a material impact on the outlook for European refining.

EU policies have had to adapt to these new challenges. The European Commission is, in particular, to be commended on the establishment of the EU Refining Forum that contributes to the in-depth consultation and evaluation with stakeholders of EU policies with impact on the oil sector. The IEA welcomes this more strategic co-ordination of EU oil market-related policies.

The implementation of the amended EU FQD has illustrated the need to co-ordinate EU energy, climate and environment policies with industry and trade policies. EU fitness checks – examining how existing policies and regulation are affecting the competitiveness of European industries – are a useful tool to assess the impacts and streamline the effectiveness of EU legislation across different policy areas with regard to major industries, not least refining, and their global competitiveness, so that the oil markets can contribute to securing the security of oil supply.

## SECURITY OF OIL SUPPLY

A positive aspect of the outlook for Europe is that the European Union still has a reasonable diversity of potential sources of imported crude oil as well as of middle distillates.

Emergency preparedness has also been strengthened since the last review by a revised Oil Stocks Directive, adopted in 2009 and aligned with the IEA emergency response mechanism. For the implementation of the revised directive, some issues remain with

**8.** The New Policies Scenario in the *World Energy Outlook* that takes account of broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-energy subsidies, even if the measures to implement these commitments have yet to be identified or announced. This broadly serves as the IEA baseline scenario.



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the process of data collection, revision and publication. Once the implementation of the Oil Stocks Directive is finalised, including the data collection on industry and public stocks, oil stocks monitoring should be aligned between the IEA and the European Union, including elimination of definitional inconsistencies. Enhancing compliance and consistency of emergency policies, on gas and oil and electricity, across all EU and IEA members is desirable to enhance the collective energy security, through greater co-operation, in particular on oil stocks monitoring.

As import needs are growing, close analysis of changes in the mix and origin of imported crude and products will be needed to anticipate the implications for stocks and security of supply. The 2014 political crisis between Russia and Ukraine led to a greater vigilance by the European Union of the security of crude oil supply from Russia, its reliance on Russian crude and products imports as well as new Russian investment into the EU refinery downstream industry. Any disruption of Russian crude oil supplies to Eastern European refineries could not be compensated by products other than oil stocks. Today, the countries importing and refining Russian crude oil have adequate oil stocks well beyond their EU minimum obligations. This highlights the importance of reinforcing the diversification of the oil infrastructure in Central Eastern Europe. In 2014, the European Union has identified the PCI for the region.

In the past, the EU security analysis strongly focused on crude oil. However, the split between crude oil production and product imports is changing. Given the growing diesel imports of the European Union and reduced refining capacity, future security risks are much more related to developments in global oil product markets, rather than crude oil production and supply patterns. With the growing exposure of Europe to international oil product markets and decreasing refining capacity in Europe, the European Union is also more exposed to product market disruptions, which can be the result of natural disasters, such as Hurricanes Katrina/Rita (2005) and Sandy (2013).

With the current restructuring process of EU refineries, a result of excess capacity, there is a risk of losing not only capacity but also diversity. The European Commission identified those risks in its European Energy Security Strategy of May 2014. The IEA welcomes the call for a more active trade policy, a more strategic co-ordination of the oil policy at EU level, with more international co-operation. It is important for Europe to maintain a diversified and competitive refining industry. Some markets in the European Union do better than others, illustrating the results of innovation and investment. In a number of countries, refineries are successful, also thanks to good access to international trade and integration with the domestic petrochemical industry. Measures to identify strategic assets could prevent necessary market adaptation processes, deteriorating margins for all refiners. The IEA therefore supports a proactive trade policy to improve access to export markets and avoiding unnecessarily high regulatory compliance cost.

Diesel imports have grown disproportionately. As the trend is continuing, supply disruption risks are likely to increase with longer transport routes and potential bottlenecks, reduced short-term flexibility and higher needs for product storage as well as higher exposure of suppliers to political risk. The European Union should carefully monitor the oil product markets and ensure that its emergency preparedness, supported by adequate stocks within the European Union, is adequate and well-co-ordinated at international level in close co-operation with the IEA.

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## RECOMMENDATIONS

*The European Union should:*

- *Work to continue close co-ordination between the management of EU oil stocks and the IEA emergency response mechanism, notably for EU member states that are not members of the IEA. Ensure the implementation of a streamlined and responsive process of data collection, verification and publication under the Oil Stocks Directive.*
- *Assess and limit the cumulative impacts of European regulation on the competitiveness of the refining and petrochemical sectors, using the "fitness check" procedure and additional assessments on new policies and measures.*
- *Amid rapidly changing global oil markets, monitor regularly the sources and composition of EU crude oil and oil product imports and assess the implications for storage and refining needs with a view to evaluating and implementing measures that ensure security of supply. Ensure the diversification of oil supplies and supply routes through a proactive EU trade policy.*

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# 7. NATURAL GAS

**Key data (2012)**

**Production:** 173.7 bcm, -33.2% since 2002

**Total EU imports*:** 380 bcm

**Share of natural gas:** 23.9% of TPES and 17.8% of electricity generation

**Consumption by sector:** 477 bcm (392.5 Mtoe) with power generation 29.5%, residential 27.6%, industry 24.3%, commercial and other services 13.3%, other transformations 4.6%, transport 0.7%

* Total imports to the European Union from outside the European Union.

## OVERVIEW

Natural gas is the second-largest fuel in the energy mix of the European Union (EU), representing 23.9% of total primary energy supply (TPES), behind oil (32% of TPES). Natural gas demand accounted for 477 billion cubic metres (bcm) in 2012, up from 462 bcm in 2013. Despite a peak in gas demand in 2010, the role of natural gas in the EU energy mix has declined slightly over the past decade, decreasing at an annualised rate of 0.4% from 2002 to 2012, in line with the overall decline of energy demand. EU domestic gas production has been declining at a faster pace than overall demand (see Figure 7.1 and Figure 7.2), which raised the dependence on gas imports since 2010, notably on pipeline gas.

Around 30% of the gas demand stems from power generation. The EU saw investment in new gas-fired power plants and import infrastructure, marking years of strong demand. Since 2010, total gas demand in power generation has been decreasing as a result of the economic crisis and the collapse of gas demand in the power sector due to the strong growth of renewable energies and lack of competitiveness of gas-fired power plants as opposed to coal-fired ones. In the medium-term outlook to 2020, natural gas is the main fossil fuel to play a significant role in any decarbonisation scenario.

Thanks to further market opening and liberalisation, EU gas markets have become more liquid, with increased trading at hubs and short-term flexibility of gas contracts, lowering the link to oil prices over time and moving towards hub-indexed pricing. At the end of 2014, EU gas markets enjoy comfortable levels of gas supply with high levels of gas storage, thanks to some over-capacity after the fall in demand and the mild winter in 2013-14. The recurring gas crises between Russia and Ukraine have increased the risks to the European Union's security of gas supply, notably of the countries that still rely on one single supplier and supply route. Amid low gas demand, the EU has to compete for liquefied natural gas (LNG) in international markets and is exposed to price differentials in Asia and North America at a time when it aims to diversify its gas imports. Challenges abound when it comes to tapping into Europe's remaining indigenous gas production potential, including from unconventional gas, and defining a consistent external energy policy.

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## SUPPLY AND DEMAND

### RESOURCES AND RESERVES

The European Union is estimated to hold 1.4 trillion cubic metres (tcm) of proved gas (conventional) reserves,[1] notably, in Germany, Italy, the Netherlands, Poland, Romania and the United Kingdom (BP, 2014). This equals three years of EU gas demand and represents 0.8% of the world's total proved gas reserves.

The European Union has yet to evaluate its unconventional potential. Given the limited exploration experience in the European Union, it is uncertain what share of resources can be recovered on an economically and environmentally viable basis and turned into reserves. In comparison to the global unconventional resources (EIA, 2013), the European Union holds only 6.5% or 13.3 tcm (47.7 tcm in North America or total global of 203.8 tcm). Technically recoverable shale gas resources are even estimated to reach up to 16 tcm by the European Commission (EC, 2014a). In 2013, less than 1 bcm of coalbed-methane (CBM) was produced in the European Union. The IEA expects that, under current, less favourable conditions, around 17 bcm of shale gas could be produced in the European Union by 2040, according to the *World Energy Outlook 2013* (IEA, 2013).

### PRODUCTION

Gas output in the European Union has been falling since the mid-1990s due to depleting resources. Production reached its peak in 1997 and has been declining since, with moderate volatility. Natural gas production amounted to 173.7 bcm during 2012. Production has declined by 5.6% since 2011 and by 20.4% since 2007, the time when the last in-depth review was being prepared.

In 2012, the Netherlands was the largest producer of gas in the European Union with 80.2 bcm or 46.2% of the total. In that year, the United Kingdom produced 23.7%, Germany 7.5% and Romania 6.3%. Italy, Poland and Denmark produced 5%, 3.6% and 3.3% of the total, respectively. The remaining 4.5% came from member states in Eastern Europe.

Ten EU countries including the Baltic states have no gas production (In 2012, Belgium, Estonia, Finland, Luxembourg, Portugal, Sweden, Cyprus[2], Latvia, Lithuania and Malta did not produce gas.)

Production in the major producing countries has fallen sharply within the last ten years. The United Kingdom experienced the largest decline (by 45.9%), followed by Denmark (37.1%), Germany (35.3%) and Italy (11.3%). The smallest producers (Slovenia, Greece, Spain, Ireland and France) have also experienced large declines.

**1.** Resources refer to all potentially valuable mineral resources that are available for eventual economic extraction. Reserves are the resources that are legally, economically and technically feasible to extract.

**2.** Two footnotes: 1. **Footnote by Turkey**: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue". 2. **Footnote by all the European Union Member States of the OECD and the European Union**: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.



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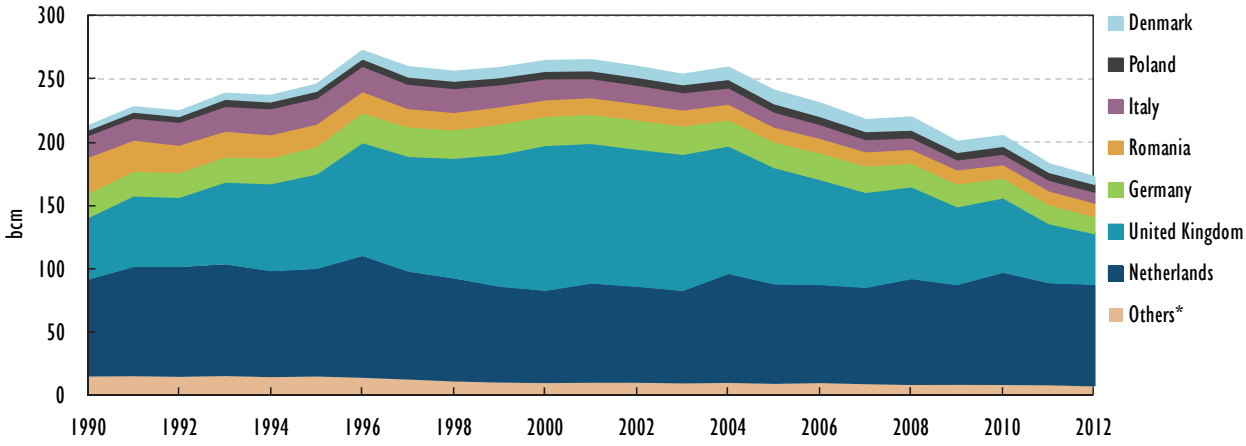
There is considerable volatility in EU production levels. For instance, from 2007 to 2012 the Netherlands had temporarily increased production by 5.6%, and so had Poland (by 2.5%). However, following earthquakes in the production region, the Netherlands decided in early 2014 to cap production from its largest field in Groningen at 42.5 bcm in 2014 and 2015, and at 42 bcm in 2016. In the past, the Groningen field acted as a swing producer, able to respond quickly to end-user demand changes. With the production cap in place in the Netherlands, the EU gas markets lose considerable flexibility of around 7.5 bcm per month. These developments show the importance of indigenous production trends in the European Union's gas supply security (see the Security of Gas Supply section below).

**Figure 7.1** Natural gas production, 1990-2012




* *Others* includes other European Union member states which produced gas in each year.

Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b); *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.

## DEMAND

Between 2008 and 2012, gas demand fell from its peak in 2010 (543 bcm) by about 10% to a level of 477 bcm. This decline stemmed from the economic crisis, reduced demand in industry and changing fuel use in the power generation sector. Demand in power generation declined by 19.9% from 2007 to 2012: a large share of electricity is now produced from renewable energies to cover the EU electricity demand, as gas-fired power plants were less competitive against coal-fired plants in the absence of a meaningful $CO_2$ price. In the same period, industry and other transformations reduced gas use by 11.9% and 17.6%, respectively.

The role of natural gas is not only important in heating and power generation, but also as fuel for the petrochemical industry. Forty percent of total EU gas consumption is for heating in the residential and commercial sectors. In 2012, 29.6% of natural gas in the European Union was consumed in electricity generation, half of it in the combined heat and power generation (CHP).

The residential sector accounted for 27.6% of consumption, while industry consumed 24.3%, including the use of gas for heating and as raw material in refining and chemicals. Commercial and other transformations represented 13.3% and 4.6% of consumption, respectively.

Natural gas use in transport is growing – but from a low base – and in 2012 reached a share of 0.7% of total gas consumption. Since the first in-depth review in 2008,

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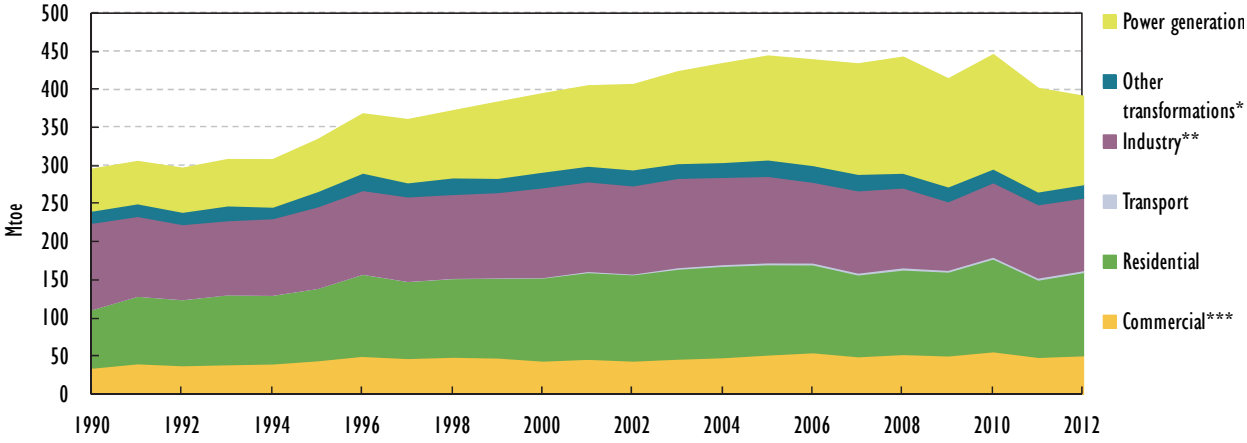
consumption by transport doubled, however, with lower growth rates (an increase of 1.4% from 2007 to 2012). In the same period, consumption in the commercial and residential sectors grew by 2.7% and 1.7%, respectively.

**Figure 7.2** Natural gas consumption by sector in the European Union, 1990-2012




Notes: TPES by consuming sector.

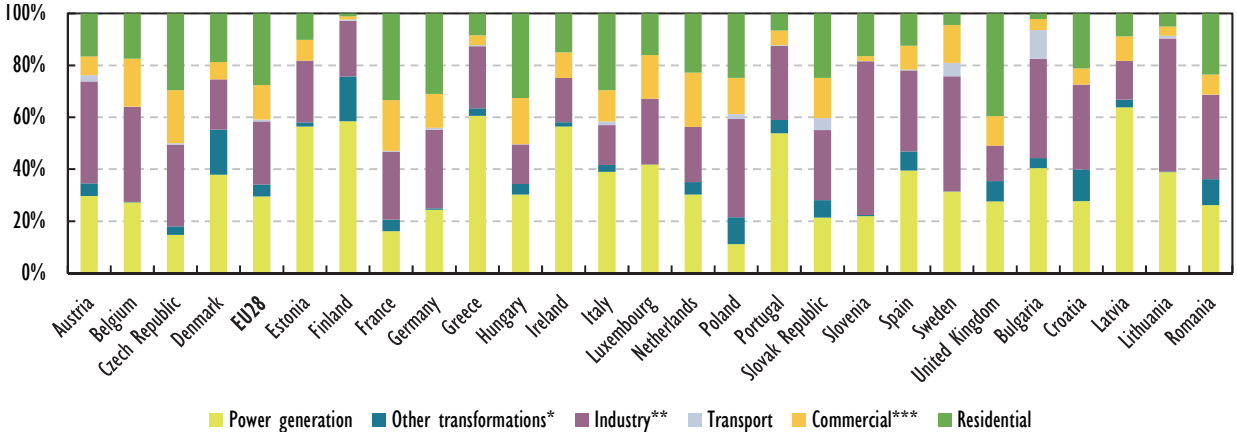
* *Other transformations* includes refining and energy own use.

** *Industry* includes non-energy use.

*** *Commercial* includes commercial and public services, agriculture/fishing and forestry.

Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

**Figure 7.3** Natural gas consumption by sector in the EU member states, 2012




Note: Only countries with natural gas consumption are included in the figure. Power generation includes combined heat and power and district heating.

* *Other transformations* includes refining and energy own use.

** *Industry* includes non-energy use.

*** *Commercial* includes commercial and public services, agriculture/fishing and forestry.

Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA; Paris. IEA (2014b), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

There are noticeable differences across EU member states in terms of gas use (see Figure 7.3). In 2012, Germany and the United Kingdom were the largest consumers of natural gas in terms of total volumes, followed by France, Italy and the Netherlands. In



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Austria, Bulgaria, Lithuania and Slovenia, the share of industry in gas consumption is considerably larger than the EU average. In Bulgaria, the transport sector is a significant user of gas, consuming more than the residential and commercial sectors together. In Finland, Greece, Ireland, Latvia and Portugal, the share of gas used for power generation is larger than the EU average. In 2013, Italy had the largest installed gas-fired power plant fleet (with 54.6 GW, compared to 124 GW total capacity). While gas use in district heating is around 2% at EU level, this share is above 10% in Eastern European countries, the Baltic states and Finland (EC, 2014a).

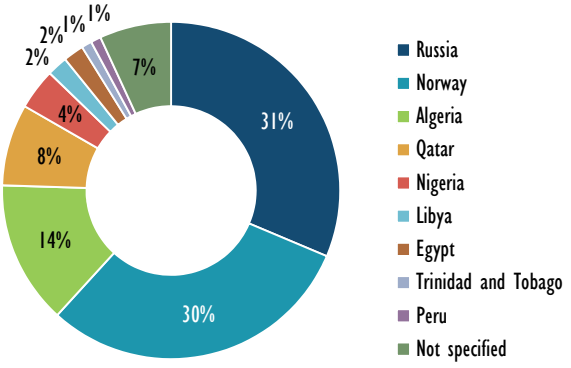
## IMPORT AND EXPORT

Amid declining domestic gas production within the European Union, the region increasingly relies on gas imports from outside the EU and is a net importer. In 2012, EU imports from outside the European Union amounted to 380 bcm (EC, 2014b).

In 2013, the European Union was the largest natural gas importing region in the world with an import bill amounting to EUR 87 billion in 2013 (Eurostat Comext database, 2014). The European Union is increasingly exposed to demand and supply trends in regional gas and global energy markets. The majority of imports reaches the European Union by pipeline. In 2012, imports were sourced from Russia (32%), Norway (31%), Algeria (14%) and Qatar (8%) as well as 15% coming from other countries, notably from Nigeria (3%), Trinidad, Tobago and others (Figure 7.4).

The European Union imported around 66% of its gas demand, which marks an increase in its import dependence from 43.4% in 1990 and from 57.1% in 2005 (see Figure 7.5). At a country level, Bulgaria's import dependence has dropped slightly from 92.6% in 2010 to 83.3% in 2012 (see Figure 7.5), thanks to an increase in natural gas production. In 2012, only around 15% of gas imports came from LNG. LNG import levels reached a low of around 57 bcm after the peak in 2011 when they were at 78 bcm (EC, 2014b).

**Figure 7.4** Gas imports to the European Union, 2012




Source: EU (2014), *EU Energy in Figures, Statistical Pocketbook*, 2014.

Denmark and the Netherlands are the only net gas exporters, while Germany and Italy are the largest importers to the European Union. Several EU countries – Bulgaria, the Baltic states, Finland, and the Slovak Republic – depend as much as 100% on gas imports from Russia as the single supplier.

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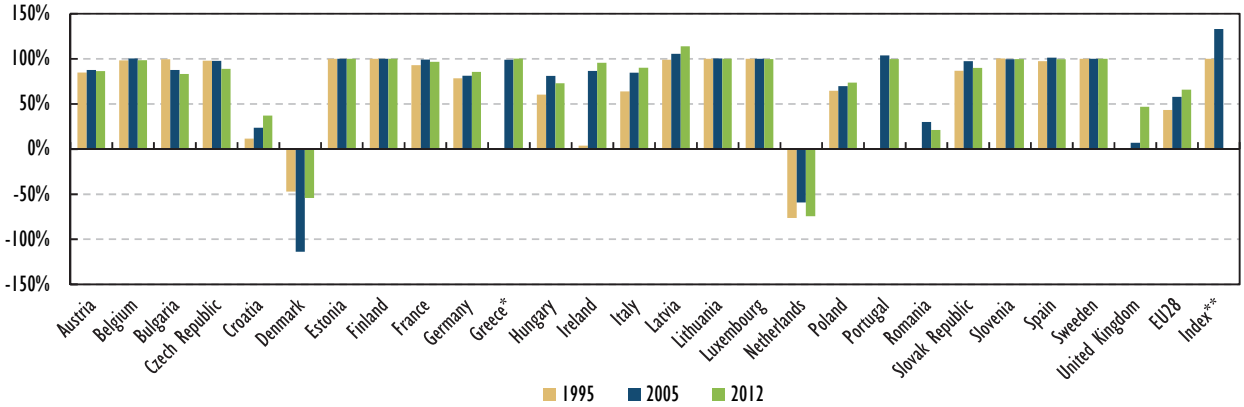
Increased imports of gas into the European Union arise from a combination of fast-declining domestic production within the European Union; the non-availability before 2019 of diversified supplies from the Azerbaijan through the Southern gas corridor; and lower gas supplies from North Africa. Egypt, Algeria and Libya faced production interruptions over the past decade due to the unstable political situation and gas shortages resulting from a combination of runaway demand and slow growth in production.

Pipeline imports to Europe – notably, Russian gas imports – have increased from 144.6 bcm in 2010 to 167.3 bcm in 2013 (IEA, 2014c). Transit through Ukraine slightly decreased from 93.9 bcm in 2010 to 82.3 bcm in 2013, due to the opening of additional supply routes from Russia such as the Nord Stream pipeline, which has a technical capacity of 55 bcm per year.

**Figure 7.5** Gas import dependence of EU member states, 1995, 2005 and 2012




Note: import dependence can be higher than 100% in case the country imported more gas to refill storage. Only countries with gas supplied are included.

* Data are not available for Greece for 1995.

** Index has 1995 as the base year.

Source: EU (2014), *EU energy in Figures, Statistical Pocketbook*, 2014.

## PROJECTIONS

The latest energy and climate scenarios 2030/2050 as elaborated by the European Commission (on the basis of the PRIMES model) indicate that natural gas is set to continue playing a significant role in EU energy scenarios up to 2030. A 40% GHG emissions reduction target, as proposed by the European Commission under the Policy Framework for Climate and Energy in the Period from 2020 to 2030 and agreed by the EU heads of state and government in October 2014, is expected to reduce the share of gas in gross inland energy consumption from 25% in 2010 to 22.5% in 2030 and to 18% in 2050.

Given dwindling indigenous gas reserves, the European Union's dependence on imports is likely to remain a key challenge. A stronger impact on gas consumption and thus imports could be achieved with a higher energy efficiency target of 30% by 2030 (see Chapter 2, "General Energy Policy"). The EC estimates that 1% in additional energy savings can decrease EU gas imports by 2.6%.



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## NATURAL GAS INFRASTRUCTURE

### TRANSMISSION PIPELINES

In 2013, the European Union had a total pipeline import capacity of 8 776 gigawatts per hour (GWh) per day or 397 bcm per year (ENTSO-G). Imports of Norwegian gas arrive in Belgium, France, Germany, the Netherlands and the United Kingdom. Algeria delivers natural gas by pipeline to Spain and Portugal directly (Medgaz) as well as through Morocco (Maghreb–Europe pipeline) and to Italy through Tunisia (Transmed). Gas from Libya is imported by Italy (Green Stream). Russian gas is imported and transported long distances in pipelines through:

- Ukraine (Brotherhood) to the Slovak Republic, the Czech Republic, Hungary and then to Western European markets
- Belarus (Northern Lights, Yamal) to the Baltic states, Poland and Germany
- the Balkan route to South East Europe and Western Turkey
- directly to Turkey (Blue Stream); directly to Germany (Nord Stream) and onwards to the Czech Republic; and directly to Finland, Estonia and Latvia.

Reflecting the historic East-West divide in Europe, the delivery points for the Western gas markets are located at the border with Germany (Waidhaus, Mallnow) and Austria (Baumgarten), while the delivery points for the Eastern European markets are located at the borders of Ukraine with Hungary, Poland, Romania and the Slovak Republic. Since 2009, only one new import pipeline came on stream (Nord Stream). The opening of the Southern Gas Corridor to access gas production in Azerbaijan will bring gas to the European Union through the Trans-Adriatic Pipeline (TAP), which will go through Greece, Albania and Italy. Many other import projects are still in the planning stages since they have experienced major delays (Galsi, White Stream) as illustrated in Figure 7.6.

### STORAGE

In 2013, total gas storage capacity in Europe amounted to 93 bcm with 142 underground storages. Around 2% of total storage capacity is above ground in the form of LNG storage. In 2013, storages covered around 20% of EU gas demand. The largest storage capacity in terms of total working volume is located in Germany, followed by Austria, Italy and France (see Figure 7.7). Short-range storages, like salt caverns, are abundant in Germany, while France relies on a large seasonal storage capacity in the form of aquifers. Italy relies on depleted gas fields. The Netherlands uses its Alkmaar gas storage as peak shaver, while the United Kingdom has LNG terminals as peak-shaving facility.

Total storage capacity grew by 15% from 2009 to 2013. Since 2008, storage capacity has been added in Austria, the Czech Republic, Germany, Hungary, the Netherlands, and Poland (see Figure 7.8). This trend is partly due to new storage sites but also reflects greater transparency on gas storage volumes and reported investments at existing sites.

In September 2014, storage levels were around 90%, slightly above the five-year average range thanks to the mild winter in 2013/14. Figure 7.9 shows the volume of gas in storage in July 2014 (as a percentage), in comparison to the five-year-average levels.

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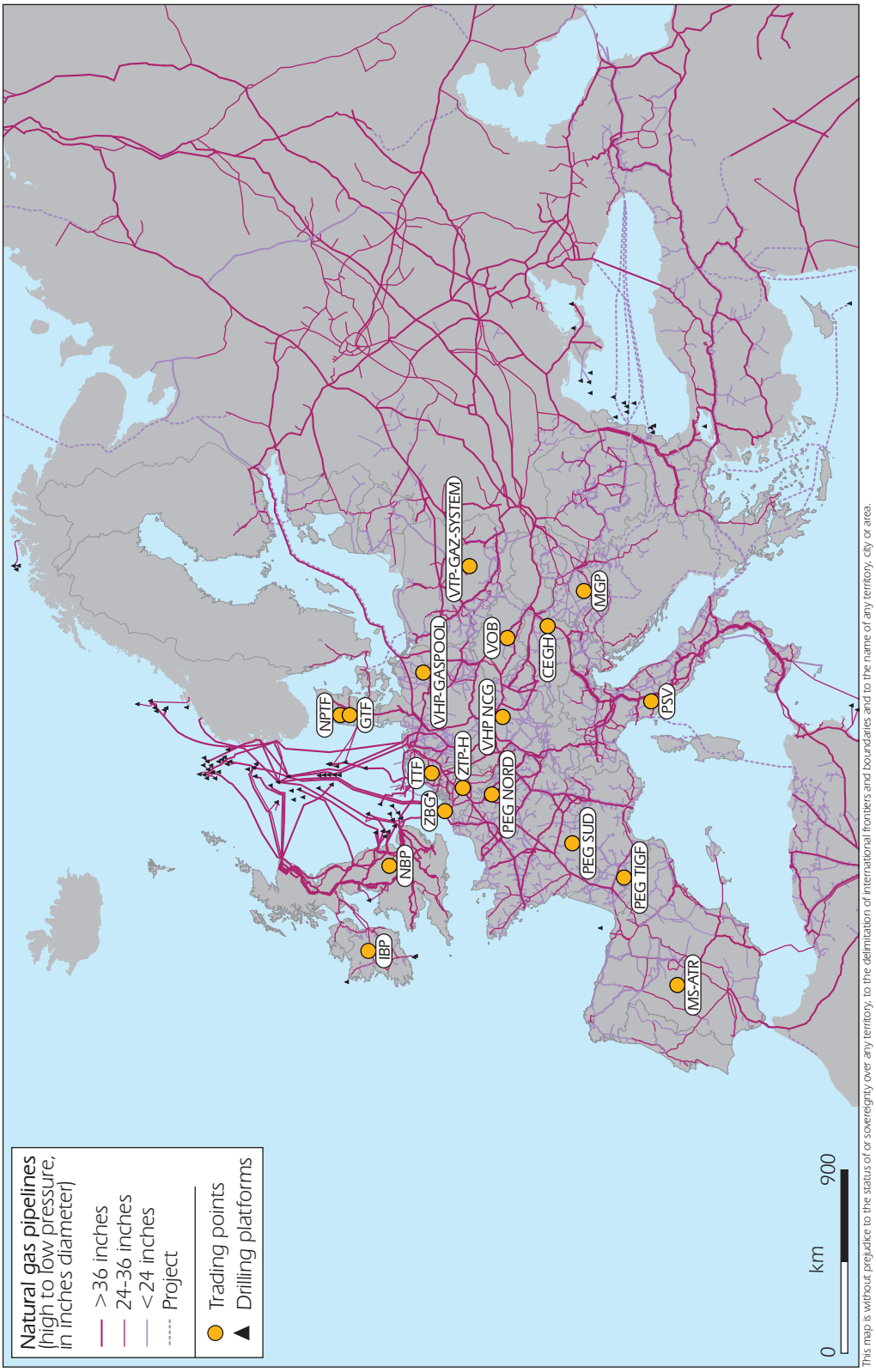
**Figure 7.6** Natural gas infrastructure in Europe, 2014




Source: IEA, based on ENTSO-G (2014), Capacity Map, www.entsog.eu/public/uploads/files/maps/transmissioncapacity/2014/ENTSOG_140612_CAP_JUNE2014.pdf.



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**Figure 7.7** Type of gas storage in OECD Europe, 2014

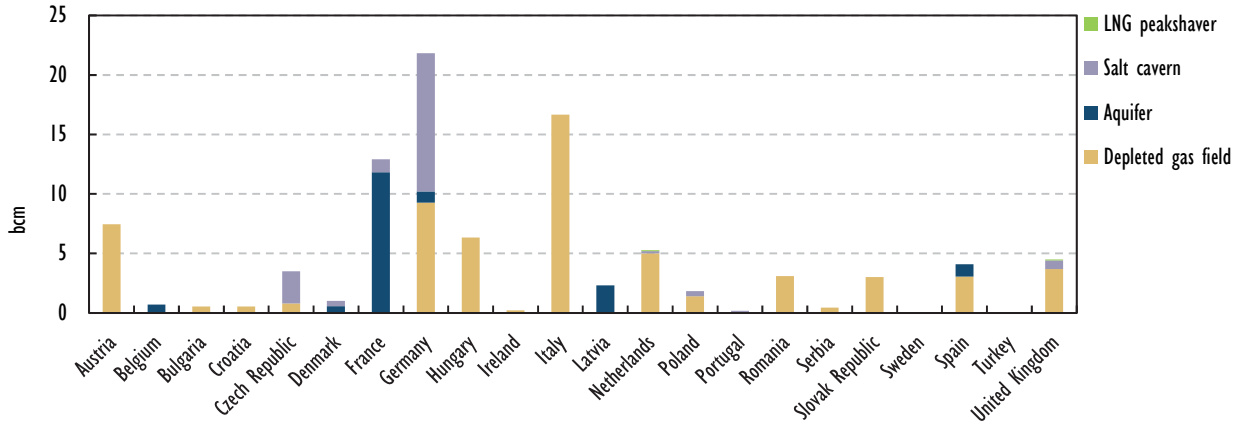



**Figure 7.8** Evolution of storage capacity in the EU and neighbouring countries, 2009-13

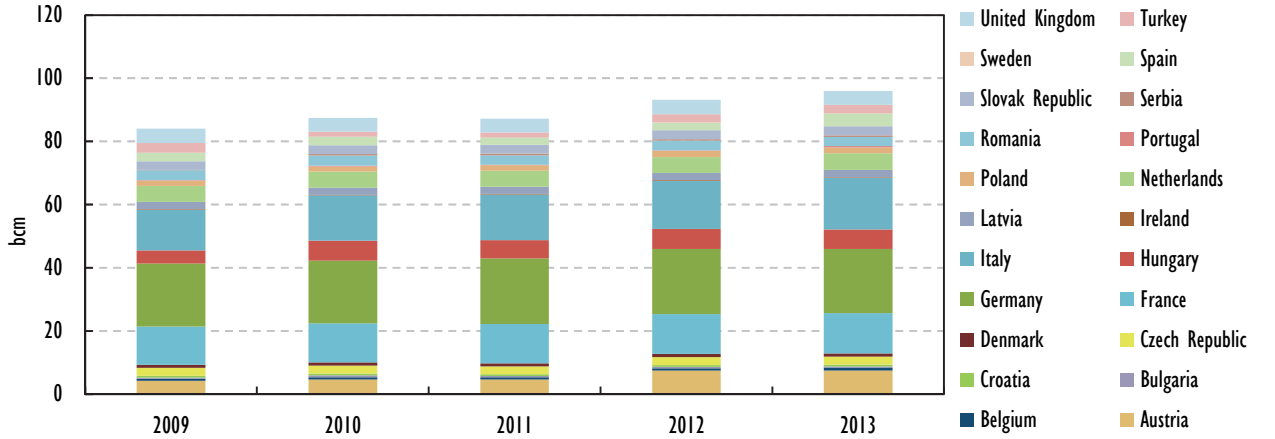
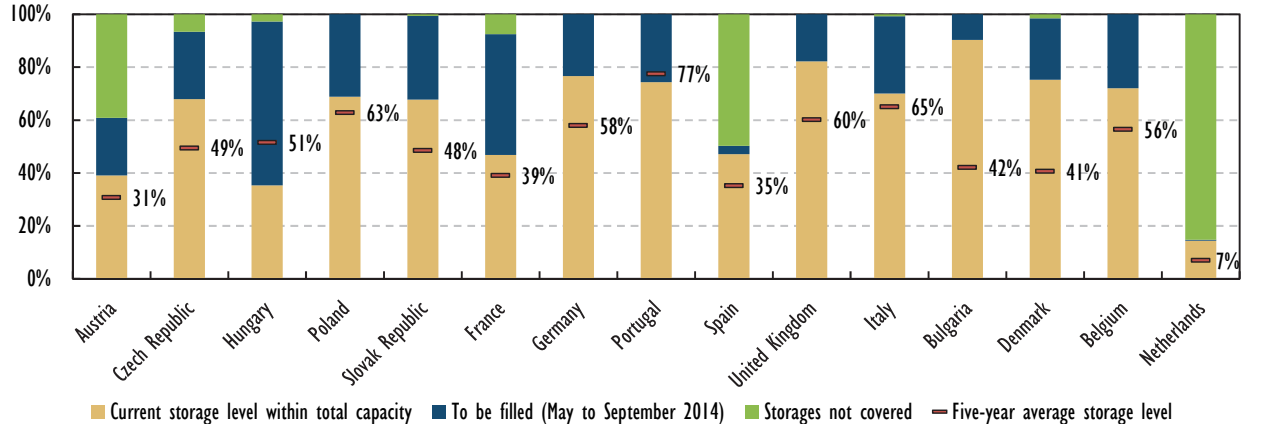



**Figure 7.9** Volume of gas in storage in the European Union, July 2014




Note: the basis of the five-year average is the filling rate of the total storage capacity and applied to the 2014 capacity. Storage not covered refers to storage sites that are not included in the Gas Storage Europe data base, as they are counted as production (Netherlands) or not available.

Source: IEA (2014d), *Natural Gas Information*, OECD/IEA, Paris, Gas Storage Europe (GSE), 2014, *Aggregated Gas Storage Inventory (AGSI)*, http://transparency.gie.eu/ (accessed in July 2014).

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In line with the EU regulatory framework, there are gas storages with third-party access (TPA); some operate under regulated TPA (Bulgaria, Italy, Hungary, Latvia, Romania and Spain), while others operate under negotiated TPA (Austria, the Czech Republic, Denmark, France, Germany, the Netherlands, Portugal and the Slovak Republic).

In line with the EU Gas Directive (Article 33), member states must define and publish the criteria determining the access regime to storage facilities or line pack where TPA is technically and/or economically necessary for providing efficient access to the system for the supply of customers and access to ancillary services.

Access to storage and LNG facilities is supervised by national regulatory authorities (NRAs) in line with the voluntary Guidelines for Good Third-Party Access Practise for Storage System Operators (GGPSSO). Under the EU Gas Regulation (Article 15), these rules have become binding for LNG and gas storages connected to the transmission network. The EU Gas Directive established legal and functional unbundling for storage system operators that are part of supply undertakings.

## LIQUEFIED NATURAL GAS

In 2014, there were 24 LNG terminals in ten EU member states with a total nominal regasification capacity of around 187 bcm of gas per year (see Table 7.1). Spain and the United Kingdom together represent the largest share, roughly 111 bcm.

Since 2008, five new LNG terminals and increased capacity in the United Kingdom at existing terminals added 44 bcm per year. New terminals include France (Fos Cavaou) and the Netherlands (Gate). In October 2014, in Lithuania the new Klaipedos FSRU (3 bcm) was put into operation. Two new LNG terminals are planned to come on stream in 2014-15. These include Poland (Swinoujscie, Gaz-System, 4.9 bcm) and France (Dunkerque, EDF/Fluxys/Total, 13 bcm). Sweden now has two small LNG terminals.

With lower LNG imports, the EU average utilisation rate of regasification terminals dropped to 23.5% in 2013, with individual rates ranging from 4% in the Netherlands to 37% in Portugal and Italy (see Table 7.1). This leaves Europe with a spare regasification capacity of 70% or 137 bcm. Despite the contribution to regional gas markets, the capacity in Spain cannot fully serve the European gas market since the interconnection to France is small, and French gas odorisation limits exports to Central European markets. The low utilisation of the LNG regasification terminals in Europe was the result of the less competitive position of natural gas in Europe and higher prices paid in Asia and Latin America (Brazil and Argentina entered the spot LNG market with substantial short-term demand due to droughts affecting hydro levels). The expectation is that this situation will persist in the medium term. There are two main consequences of lower utilisation: 1) growing re-exports of LNG to high price markets, and 2) higher unit cost of operation (including the boil-off effect).

Under the Third Package, LNG operators are subjected to TPA regulation unless they have been granted an exemption under the EU Gas Directive (Article 36 of Directive 2009/73/EC). Out of 18 LNG facilities, 13 are subject to regulated TPA, and the remaining five are exempt (South Hook, Grain, Dragon, Gate and Rovigo) (CEER, 2014).



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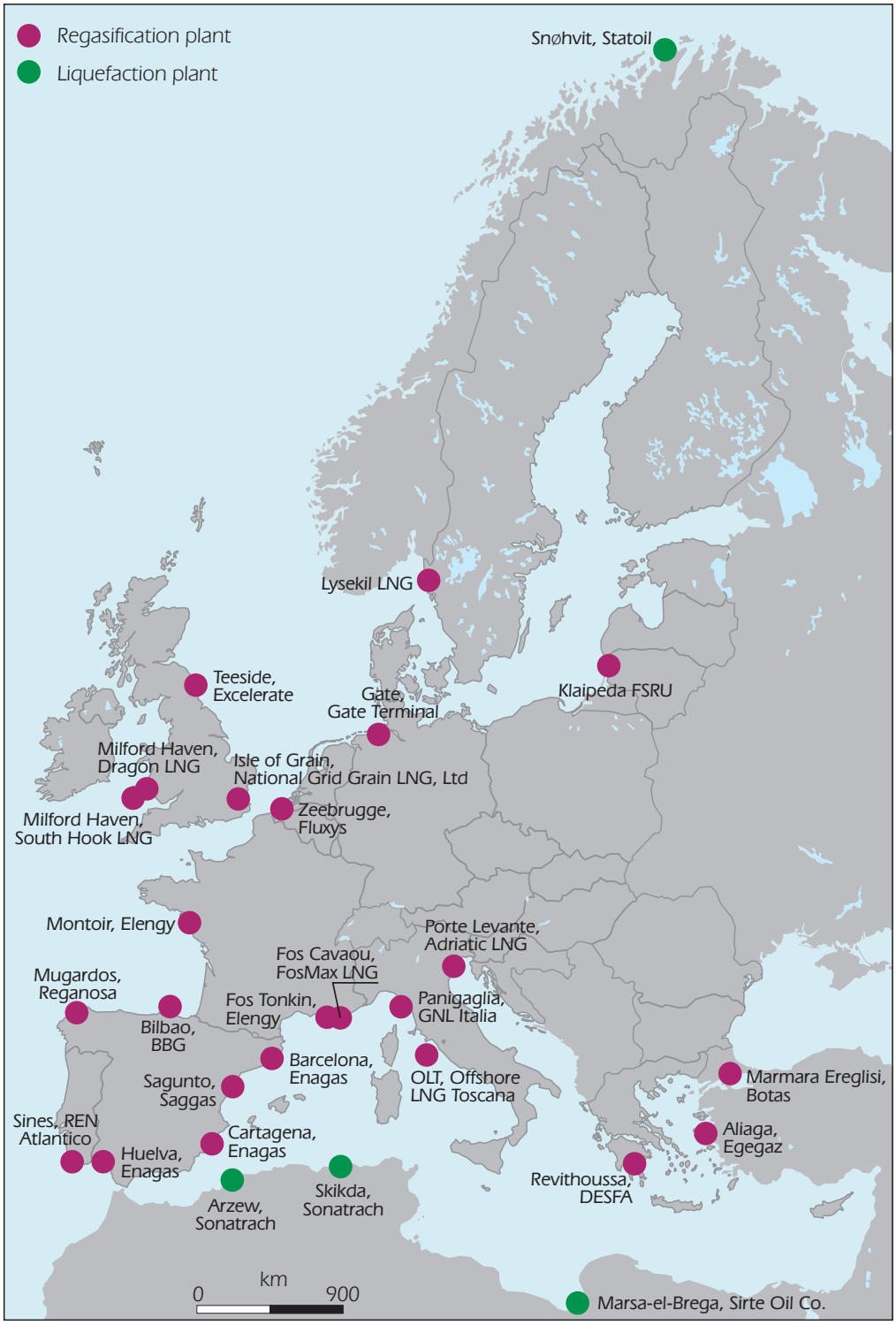
**Figure 7.10** LNG terminals in Europe, 2014




This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

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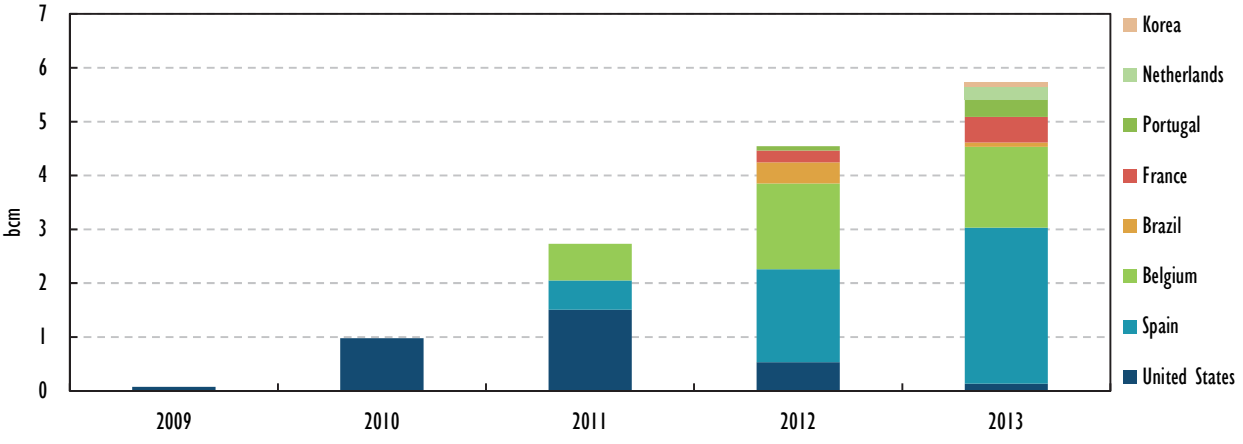
**Table 7.1** Utilisation of LNG terminals in the EU, 2013 (in bcm per year)

| Country | LNG terminal capacity | Net imports | Utilisation rate | Re-exports loaded |
|---|---|---|---|---|
| Belgium | 9.0 | 1.62 | 18.0% | 1.50 |
| France | 25.3 | 8.08 | 31.9% | 0.48 |
| Greece | 5.2 | 0.62 | 11.9% | - |
| Italy | 15.3 | 5.50 | 36.0% | - |
| Netherlands | 12.0 | 0.49 | 4.1% | 0.23 |
| Portugal | 5.5 | 2.03 | 36.9% | 0.33 |
| Spain | 60.2 | 12.42 | 20.6% | 2.89 |
| Sweden | 0.3 | - | 0.0% | - |
| United Kingdom | 50.7 | 9.40 | 18.5% | - |
| **Total EU** | **183.5** | **40.16** | **23.5%** | **5.43** |

Faced with take-or-pay obligations and under-utilisation, contractors of the terminals in Europe are looking for new opportunities to reduce costs and losses. Some of the measures taken are the re-exports of LNG and the increased focus on the use of LNG for the transport sector. Figure 7.11 illustrates for the world the countries which opted to re-route their LNG import contracts (or re-export) during 2009 to 2013. Among the main re-exporter are mostly European countries, next to Brazil, Korea and the United States. In 2013, Spain re-exported 2.9 bcm, Belgium 1.5 bcm, France 0.48 bcm and Portugal 0.33 bcm. Netherlands started re-exporting LNG in 2013 with 0.23 bcm (see Figure 7.11). A total of 5.4 bcm is not delivered to the EU market.

**Figure 7.11** LNG re-exports worldwide, 2009-13




Source: IEA (2014c), *Medium-Term Gas Market Report*, OECD/IEA, Paris.

As the contractual relations remain valid, the cargo has to be unloaded at its initial location before being re-loaded back into the LNG tanker. This is not possible at all LNG terminals in Europe.

In the case of low utilisation, maintaining the storage tanks at low temperature can be more costly than restarting the operations. The operator has to reduce the send-out



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capacity to the pipeline system to avoid fast depletion of the LNG storage. At low gas flows, the gas which is evaporating in the tank, the so-called "boil-off", needs to be flared, as it can no longer be injected into the gas grid.

In its review of the access conditions to LNG terminals in the European Union during 2009-13, the Council of European Energy Regulators concluded that (CEER, 2014) there was no contractual congestion and congestion management is working with secondary markets in many countries (Belgium, France, Greece, Portugal, Spain, the Netherlands and the United Kingdom). Unused capacity was released to the market, but hardly contracted by other shippers. The EU LNG industry is adapting to a low-utilisation context by offering new services, including truck loading, small ship loading, trans-shipment, storage as an unbundled service and bunkering.

## REGULATORY FRAMEWORK

The European Union has strengthened the harmonisation of the regulatory framework across the EU28 member states towards the objective of completing the internal energy market by the end of 2014. Since 2008, the European gas market has undergone significant changes in terms of market design and regulations with new EU rules on transparency, unbundling and entry-exit regimes.[3] The liberalisation has increased market effectiveness, liquidity and cross-border trade.

With the entry into force of the so-called third internal market package (hereinafter: Third Package), EU member states are currently implementing a comprehensive framework which builds on the principles of complete and effective market opening, competition and liberalisation. As regards natural gas, the relevant EU directives and regulations are as follows:

- Directive 2009/73/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in natural gas and repealing Directive 2003/55/EC ("Gas Directive")
- Regulation (EC) No 715/2009 of the European Parliament and of the Council of 13 July 2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005 ("Gas Regulation")
- Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators ("ACER Regulation")
- Additionally in 2011 legislation governing the transparency and oversight of the wholesale energy market was adopted in the form of Regulation (European Union) No 1227/2011 of the European Parliament and of the Council on wholesale energy market integrity and transparency ("REMIT Regulation").

The Third Package moved regulation of gas transmission pipelines on cross-border issues into an EU framework which builds on the independence and the EU-wide co-operation of the transmission system operators (TSOs) and the national regulatory authorities (NRAs).

**3.** Already the Second Gas Directive had covered third-party access and phased-out transit as a concept by treating equal all gas flows across the European Union. Regulation 715/2009 (Recital 19 and Article 13) formally introduced the entry-exit regime. It means that entry and exit capacity can be booked independently and tariffs are not based on point-to-point contract paths.

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## INDEPENDENT NRAS AND THEIR EU-WIDE CO-OPERATION

The Third Package strengthened the independence of NRAs from the governments and promotes their co-operation at EU level through ACER. ACER is far from being a European regulator (Meroni doctrine),[4] as it essentially creates a framework for the co-operation and participation of the national regulatory authorities at EU level. ACER provides for the uniform application of the internal market rules in the European Union and deals with cross-border decisions involving at least two member states. ACER governance relies on national regulators, a fact which in practise strongly determines ACER decision-making, which is determined by the qualified-majority voting principle in the board of regulators, and the role of ACER to take decisions upon referral by the NRAs. For instance, with regards to access to and operational security of cross-border infrastructure, such as for example the exemptions from third-party access, ACER can decide only on those regulatory issues that fall within the competence of NRAs in the cases: a) where the competent NRAs have not been able to reach an agreement within a period of six months from when the case was referred to the last of those regulatory authorities; or b) upon a joint request from the competent NRAs.

## INDEPENDENT TSOS AND EU-WIDE CO-OPERATION

At EU level, the Third Package has also increased the independence of the TSOs and their co-operation at EU level, through the European Network of Transmission System Operators for gas (ENTSO-G).

TSOs have to be certified by the NRAs, taking utmost account of the opinion from the European Commission, which can also request ACER to provide its opinion.

Effective separation of network activities from supply, generation or production activities in gas and electricity, so-called unbundling, is the cornerstone of the Third Package. Unbundling aims to ensure TSOs take their decisions in an independent, transparent and non-discriminatory manner towards all network users.

The Gas Directive sets out ownership unbundling (OU) as the default structure for new TSOs or where network operators were part of vertically integrated companies on 3 September 2009, two alternative options: the independent system operation (ISO) and the independent transmission operator (ITO) (and its specific exception of the so-called ITO+).

Under OU, the TSO has to fully separate from supply and generation/production interests,[5] to fully exercise the activity of transmission, including the transmission system operation. Under the ISO model, ownership of the assets and operation of the network are fully separate from each other. Operators which choose the ITO option have to put in place stringent compliance structures to ensure the autonomy of the ITO, with regard to the independence of assets, equipment, staff, management and identity, network planning and investment decisions.[6] Under the ITO+ model, member states can maintain their systems, where the transmission system belonged to a vertically integrated undertaking on 3 September 2009, but the independence has to be more effective than in the ITO structure.

**4.** The competences and powers of ACER were designed in accordance with the Meroni doctrine. In the Meroni case, the European Court of Justice set out in 1958 the conditions that had to be met if delegations of power from the European Union public service to delegated bodies (including those not yet established under the Treaty) were to be admissible. The delegation of discretionary power, implying a wide margin of discretion is to be excluded in all cases. This case is used as guidance to frame the delegation of regulatory powers from the European Union to new European Union agencies.

**5.** Article 17(1)a of the Gas Directive.

**6.** This includes all measures outlined in Chapter IV of the Gas Directive (Articles 17 to 23).



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**Table 7.2** Status of implementation of the unbundling (ITO, OU, ISO)

| Member state | Transmission system operator | Unbundling (ITO, ISO, OU)* |
|---|---|---|
| Austria | GAS CONNECT AUSTRIA GmbH<br>Trans-Austria Gasleitung GmbH (TAG) | ITO<br>ITO |
| Belgium | Fluxys Belgium NV SA | OU |
| Bulgaria | Bulgartransgaz | Certification pending |
| Czech Republic | NET4GAS | ITO |
| Croatia | Plinacro | Certification pending |
| Denmark | Energienet.dk (gas) | OU |
| Estonia | AS EG Võrguteenus | Certification pending |
| Finland | Gasum Oy | Derogation |
| France | GRTgaz<br>Transport et Infrastructures Gaz de France (TIGF) | ITO<br>OU |
| Germany | Bayernets GmbH<br>Fluxys Deutschland GmbH<br>Fluxys TENP GmbH<br>Gastransport Nord GmbH<br>GASCADE Gastransport GmbH<br>Gasunie Deutschland Transport Services GmbH<br>Gasunie Ostseeanbindungsleitung GmbH<br>Jordgas Transport GmbH<br>GRTgaz Deutschland GmbH<br>NEL Gastransport GmbH<br>Nowega GmbH<br>ONTRAS Gastransport GmbH<br>Open Grid Europe GmbH<br>Thyssengas GmbH<br>terranets bw GmbH | ITO<br>OU<br>OU<br>ITO<br>ITO<br>OU<br>OU<br>ITO<br>ITO<br>ITO<br>ITO<br>ITO<br>ITO<br>ITO<br>ITO |
| Greece | DESFA Hellenic Gas Transmision System Operator SA | ITO |
| Hungary | FGSZ | ITO |
| Ireland | Bord Gáis Éireann | OU |
| Italy | SNAM RETE GAS S.P.A.<br>Società Gasdotti Italia S.P.A.<br>Infrastrutture Trasporto Gas S.P.A. | OU<br>OU<br>ITO |
| Latvia | Latvijas Gaze | Derogation |
| Lithuania | AB Amber Grid | Certification pending |
| Luxembourg | Creos Luxembourg SA. | Derogation |
| Netherlands | Gasunie Transport Services BV. | OU |
| Poland | Gas Transmission Operator GAZ – SYSTEM SA. | OU |
| Portugal | REN Gasodutos SA. | OU |
| Romania | Transgaz | ISO |
| Slovenia | PLINOVODI d.o.o. | ITO |
| Slovak Republic | Eustream, a.s. | ITO |
| Spain | Enagas Transporte<br>Reganosa | OU<br>OU |

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| | | |
|---|---|---|
| Sweden | Swedegas AB | OU |
| United Kingdom | National Grid Gas plc (NGG) | OU |

Note: Countries that do not have natural gas infrastructure are not included in this table.

* The table includes the major TSOs in each country in 2014, but is not exhaustive. It lists the certification requests for the unbundling option concerned which is being reviewed by the national regulatory authority and the European Commission. The certifications are subject to change and reflect the status in August 2014.

Source: EC (2014c), *EC Opinions to the TSO Certifications notified by NRAs:* http://ec.europa.eu/energy/gas_electricity/interpretative_notes/doc/certification/certifications_decisions.pdf, (accessed on 1 August 2014).

Ownership unbundling (OU) led to a change of ownership or was adopted after forced divestiture following competition law cases. Future changes in the ownership structure of the TSO require re-certification. The Gas Directive mandates full ownership unbundling from supply or production of gas or electricity for new gas TSOs. This includes also operators which are owned by non-EU third-country entities. Certification requires in this case also an opinion from the European Commission with regard to the potential risks to the energy supply of the European Union. Where the state owns the TSO, member states need to ensure the activities are under the responsibility and control of separate public bodies within the state.

By September 2014, half of the operators have applied for ITOs, half for OU (see Table 7.2). In a few countries the final certification is pending, as compliance measures for the ITOs need to be implemented or ownership changed. In general, transmission systems are now operated in a more independent way and co-operation at EU level has strongly increased. With ITOs in place in many countries, the EU gas market is far from a situation, where the supply and transmission interests are fully separated.

The opinions of the European Commission have raised a number of issues with regard to the involvement of financial investors, the separation within the state, third-country vertically integrated companies and ITO compliance provisions. A monitoring mechanism has been implemented in a number of countries to ensure that ownership changes, notably with regard to the participation of financial investors, can be re-assessed or re-certified by the NRA. The European Commission issued an interpretative note on the involvement of financial investors in transmission activities (EC, 2013a).

## COMMON RULES FOR THE EU NATURAL GAS MARKET

Not all rules for the harmonised functioning of the EU gas market were included in the Third Package. As individual EU national gas markets have different network operation rules, the package includes a procedure to agree on harmonised technical rules through the adoption of EU-wide framework guidelines (FG) and network codes (NCs) (see Box 7.1). The codes are applicable to interconnection points (IPs) between entry-exit zones, either cross-border or within a country.

Thanks to this framework, the EU gas market has seen considerable progress on the harmonisation of technical rules, notably with regard to transparency, the management of capacity allocation and harmonised products for cross-border trade.

*Transparency rules* impose obligations on TSOs to publish data on gas flows, nominations, and storage levels.[7]

**7.** Rules were adopted under Commission Decision of 10 November 2010 amending Chapter 3 of Annex I to Regulation 715/2009.



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**Box 7.1** FG and NCs in natural gas

The European Union has been implementing harmonisation towards common network rules. The process is complex and started with the first priority NCs, but in the case of natural gas advanced swiftly and across all NCs. The European Commission asks ACER to develop a framework guideline (within 6 months) which sets the general framework for the principles and scope of the network code, which is to be developed by ENTSO-G within a year. The ENTSO-G network code is then submitted to ACER for a reasoned opinion to check the compliance with the FG and the fulfilment of the Third Package objectives. ACER submits the network code to the EC for adoption within a reasonable time period by the member states via comitology. The areas in which the FG and NCs are to be adopted are listed by Article 8(6) of Regulation (EC) No 715/2009. Those 12 areas are namely:

- network security and reliability rules
- network connection rules
- third-party access rules
- data exchange and settlement rules
- interoperability rules
- operational procedures in an emergency
- capacity allocation and congestion management rules
- rules for trading related to technical and operational provision of network access services and system balancing
- transparency rules
- balancing rules including network-related rules on nominations procedure, rules for imbalance charges and rules for operational balancing between TSOs' systems
- rules regarding harmonised transmission tariff structures
- energy efficiency regarding gas networks.

In the first iteration of this process, the most important NCs are now being finalised and are expected to be adopted by EU member states by end of 2014. However, the implementation of the rules will take time. Not all priorities listed above are implemented in EU-wide NCs depending on the subject matter and TSOs' roles and responsibilities. At the time of publication, three FG and NCs are still under preparation. They concern interoperability, rules for trading and tariff issues for the European gas transmission networks (with NCs being prepared by the end of 2014).

*Procedures to reduce and manage congestion* in existing European gas transmission pipelines.[8] These include procedures on how reserved but unused capacity should be placed back to the market ("use-it-or-loose-it") in the short term, notably at contractually congested IPs, and in the long-term. Despite entry into force in 2013, the short-term firm day-ahead use-it-or-lose-it mechanism is to be implemented by 2016.

**8.** Procedures were set out in the Commission Decision of 28 August 2012 on amending Annex I to Regulation (EC) No 715/2009.

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The *first EU network code on capacity allocation mechanisms* (*CAM*)[9] sets out rules for the efficient allocation of existing capacity on the gas IPs between high-pressure gas transmission systems through harmonised auctions (for capacity up to 15 years), online booking platforms and standardised products (yearly, quarterly, monthly, daily and within-day standard capacity products) and bundled capacity on both sides of the border. The network code on capacity allocation will only apply from 1 November 2015. 24 European TSOs have set up a joint European capacity booking platform, PRISMA, in April 2013 for booking primary and secondary capacity for gas traders. It offers harmonised capacity products, auction mechanisms and serves the different TSO backend systems.

In addition, work has been carried out to ensure incentives and procedures for market players to *book incremental and new capacity*. An amendment to the CAM Network Code and the future tariff network code is being prepared (incremental and new capacity) which includes harmonised approaches to market-based procedures on when an offer of incremental or new capacity shall be made.[10] Implementation will come forward in 2015.

The second network code refers to *gas balancing of transmission networks* and has the objective to boost liquidity and flexibility of short-term gas markets.[11] The code aims to harmonise the market-based signals in an entry-exit system through standardised short-term products, so-called virtual trading point trade notifications, and an information framework for market players to balance their portfolios for the daily balancing and for TSOs to implement within-day obligations according to certain criteria based on specific system requirements. The code will apply from 1 October 2015.

Despite good progress on common rules, there are remaining obstacles due to legacy contracts, including the non-compliance with the phase-out of transit contracts (ACER, 2103a) and contractual congestion at major interconnections – out of 350 IPs at least 118 were congested in 2013 (Figure 7.12, ACER, 2013b).

## NETWORK DEVELOPMENT

Since 2008, the European Union has stepped up its framework for cross-border infrastructure development both within the regulatory market framework of the Third Package and within the framework for trans-European networks for energy (TEN-E).

Within ENTSO-G, TSOs co-operate on the establishment of an EU-wide grid planning, through the so-called EU-wide ten-year network development plan (TYNDP), on the basis of gas regional investment plans and national ten-year network development plans.

The regulatory framework under the Third Package also foresees favourable treatment of new gas infrastructure, including upgrades, by way of exemption for a defined period from Third Package rules on TPA, unbundling and tarification (Article 36 of the Gas the Directive). This is open to energy infrastructure projects that enhance competition and security of supply, but, given their project risks, would not happen without the exemption. National regulators may "exempt" them entirely or partially from the respective rules. In the past, exemptions were approved for a number of LNG terminals and cross-border gas pipelines (for instance, the Balgzand Bacton Line (BBL), the TAP and connecting pipelines to Nord Stream, Gazelle I and II, and OPAL) and up to now for one gas storage (Damborice, Czech Republic, 2011).

**9.** Commission Regulation (European Union) No 984/2013

**10.** The rules are to lay out when an offer of incremental or new capacity shall be made, when running auctions where shippers bid for existing capacity, and when open season procedures can be used where integration into CAM NC allocation is impractical.

**11.** Commission Regulation (European Union) No 312/2014 of 26 March 2014.



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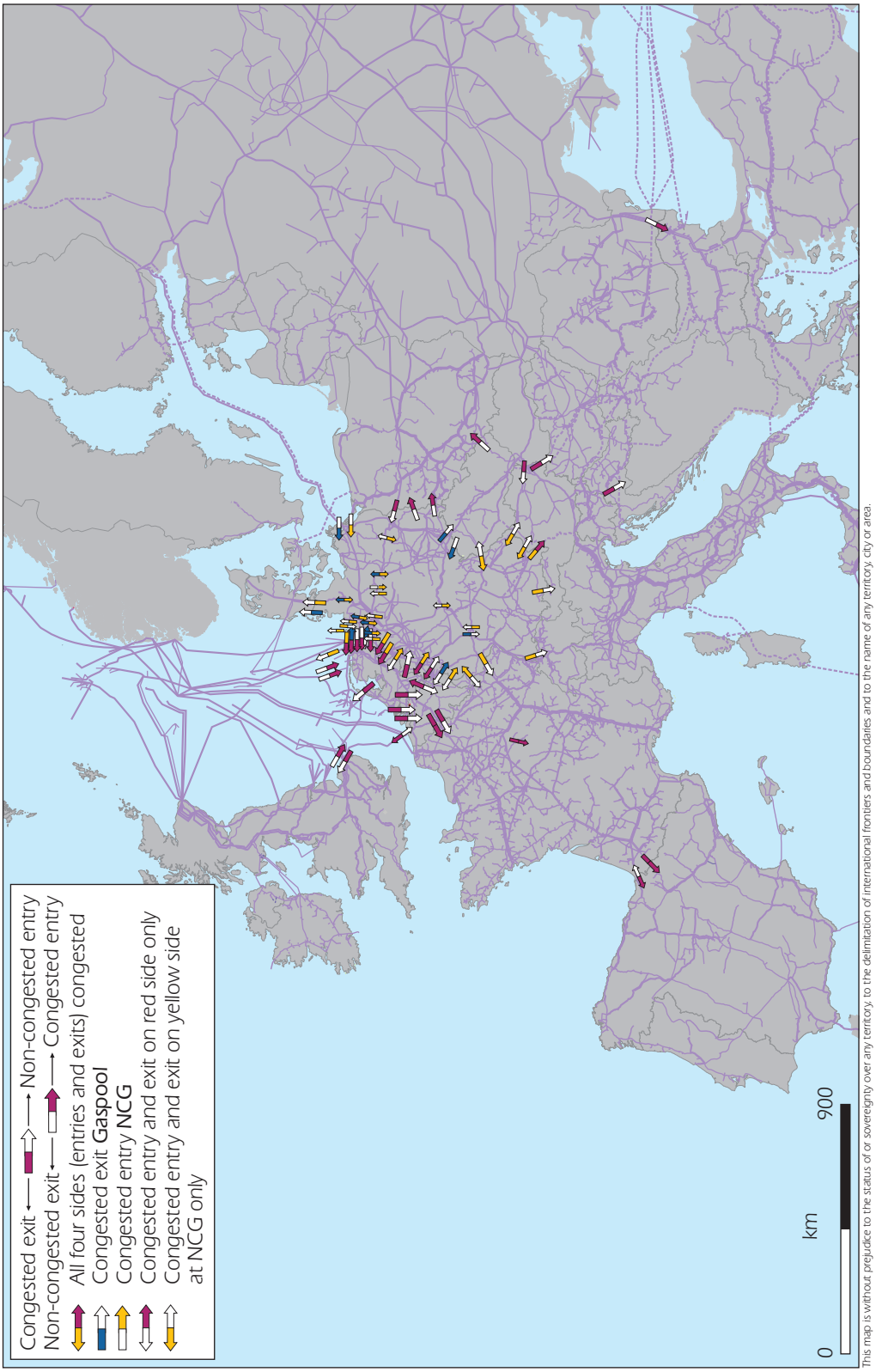
**Figure 7.12** Congestion at IPs, 2013




Sources: ENTSO-G, Congestion data from ACER, as TSO responses to the Agency's survey on CMP implementation and analysis of TSOs' data and ENTSO-G Transparency Platform, 2014; ACER (2013b), *ACER annual report on contractual congestion at interconnection points*, Ljubljana, Republic of Slovenia.

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Complementing the Third Package rules, in 2011 the European Commission adopted the Energy Infrastructure Package which enhances the way energy infrastructure of crucial importance for the European Union is discussed among neighbouring systems, regulated and financed. Today, these trans-European energy networks are governed by the Energy Infrastructure Guidelines.[12] The implementation of the guidelines establishes priority infrastructure projects in four corridors, as so-called projects of common interest (PCI). In 2014, the first EU-wide list of around 250 PCI (including gas projects) was established.[13] The list is updated every two years in a bottom-up process which builds on the regional lists, as prepared by regional groups of member states and project promoters, and an opinion by ACER on the cross-regional consistencies. In the area of gas, about 100 PCIs are identified (see Figure 7.13) in four priority corridors:

- North-South gas interconnections in Western Europe ("NSI West Gas") to further diversify routes of supply and for increasing short-term gas deliverability
- North-South gas interconnections in Central Eastern and South Eastern Europe ("NSI East Gas") to support regional connections between and in the Baltic Sea region, the Adriatic and Aegean Seas, the Eastern Mediterranean Sea and the Black Sea
- Southern Gas Corridor ("SGC") for the transmission of gas from the Caspian Basin, Central Asia, the Middle East and the Eastern Mediterranean Basin to the Union
- Baltic Energy Market Interconnection Plan in gas ("BEMIP Gas") to end the isolation of the three Baltic States and Finland and their dependence on a single supplier, to reinforce internal grid infrastructures in the Baltic Sea region.

The guidelines also set out rules to ensure the fast implementation of PCIs by reducing delays in permit granting, fostering cost allocation across borders and ensuring better consultation to enhance public acceptance of new energy infrastructure.

The guidelines require procedures for granting permits to be reduced to around 3.5 years, to create a one-stop-shop at national level for all permits and ensure better public consultation of new infrastructure projects. In addition, there are rules included on how to allocate costs and benefits across borders for the PCI. The basis for such cost split approved by NRAs is the European wide cost-benefit analysis in the framework of the TYNPD. This is the basis for the selection of PCIs and their ability to receive incentives from NRAs, a cross-border cost allocation or if needed EU funding under the Connecting Europe Facility (CEF) (covering transport, telecoms and energy) which provides financial support to energy projects with a budget of up to EUR 5.85 billion during 2014-20.[14]

The PCIs include gas interconnection projects which should connect "gas islands", such as the Iberian Peninsula and the Baltic states, to the European continental gas market.

**12.** Regulation European Union No 347/2013 on guidelines for trans-European energy infrastructure.

**13.** The list is established by Commission delegated Regulation (European Union) No 1391/2013 of 14 October 2013 amending Regulation (European Union) No 347/2013.

**14.** Connecting Europe Facility Financing Regulation (European Union) No 1316/2013.



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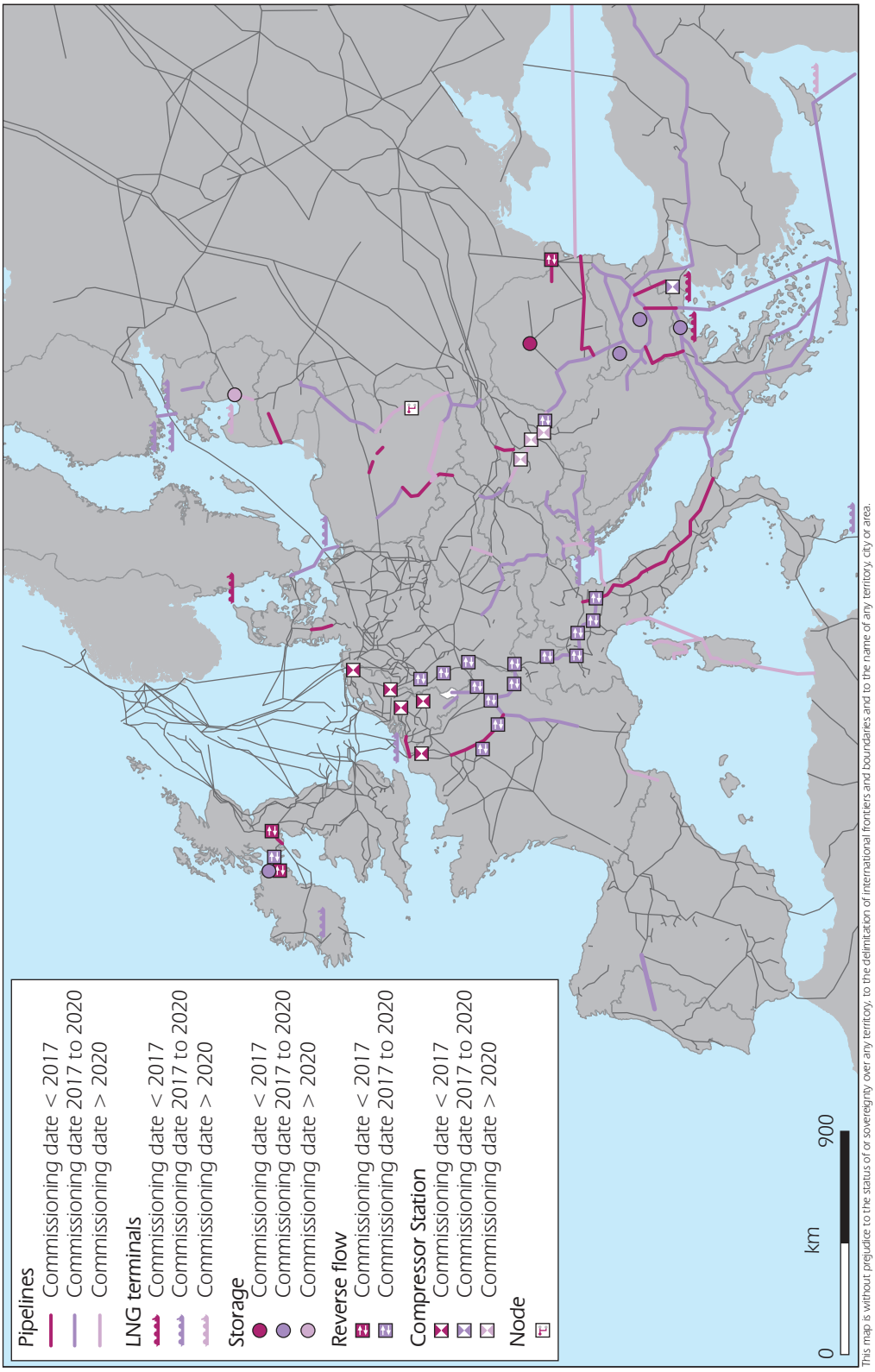
**Figure 7.13** PCI, natural gas




Source: EC (2014d), *Projects of Common Interest – Natural Gas*, http://ec.europa.eu/energy/infrastructure/pci/doc/2014_pci_gas_cef.pdf (accessed on 20 October 2014).

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## WHOLESALE GAS MARKETS

The EU Gas Regulation requires TSOs to establish entry-exit systems with virtual trading points (VTPs). Since 2007, a few major national gas hubs have emerged as spot markets in Europe (the National Balancing Point (NBP) in the United Kingdom, Title Transfer Facility (TTF) in the Netherlands or the Central European Gas Hub (CEGH) in Austria, Belgium Zeebrugge, German Gaspool and NetConnect Germany (NCG) to name a few of those shown in Figures 7.6 and 7.14). The EU gas market is currently in a transition phase towards full entry-exit regimes, thus replacing the previous point-to-point model.

Today, mainly Central and Western European gas markets have created national entry-exit regimes (Belgium, Italy, and the Netherlands, Spain and the United Kingdom). Some countries have one or more national zones, e.g. in Austria (East, West), France (TIGF, GRTgaz) and Germany (Gaspool, Netconnect Germany) which leads to different smaller VTPs and different gas price indexes. In Eastern Europe, the creation of VTPs has been slower and there are no gas hubs existing to date.

In 2011, the Council of European Energy Regulators (CEER) presented a target model for the European gas market. The gas target model (GTM) creates a vision of interconnected entry-exit zones with VTPs, which would span across the borders of several national gas markets. The model stipulates that these large wholesale gas hubs would need to be sufficiently liquid (churn ratio of eight) and competitive (HHI below 2000),[15] large in volumes (a total gas demand of at least 20 bcm per year) and diversified (with supplies sourced from at least three origins). The implementation of the target model is already a challenge for Western European markets and seems to be too ambitious for gas markets in Eastern and South Eastern Europe, where gas trades and diversification are lower.

Some enhanced cross-border co-operation is taking place in the EU gas market with cross-border mergers of smaller entry-exit zones or balancing zones, notably between Germany and the Netherlands, Luxembourg and Belgium, and Austria's gas markets in Voralberg and Tyrol with Netconnect Germany. To date, there has been no merger involving several national zones across their borders. In Central West European markets, gas market integration has been successful and led to an increase in trade and liquidity (with high churn rates of four to six) and price convergence at the major EU gas hubs, the NBP, TTF and Gaspool (Figure 7.15). However, liquidity is not always high and largely depends on the availability of physical volumes and gas infrastructure integration. The trading of energy-related products in cross-border exchanges and financial derivatives markets has increased. Progress has been made on increasing transparency in the European Union by preventing use of insider information and other forms of market abuse with new EU rules on wholesale energy market integrity and transparency of EU gas and electricity markets.[16]

In mid-2014, wholesale gas prices in Italy, Spain and France have been slightly higher than at NBP, TTF or Gaspool, reflecting the impact of higher cost of LNG imports (EC, 2014e, and see Figure 7.15) which is kept within their market areas amid low interconnectivity.

In the coming years, the main task for future gas market integration is to enhance the functioning of the gas markets in Central Eastern and Southeast Europe. In general, better physical integration across the borders of the national gas markets, more effective market

**15.** The Herfindahl-Hirschman Index or HHI is a measure for competition taking into account the size of firms in relation to the industry.

**16.** Regulation No 1227/2011 of 25 October 2011 on wholesale energy market integrity and transparency ("REMIT").



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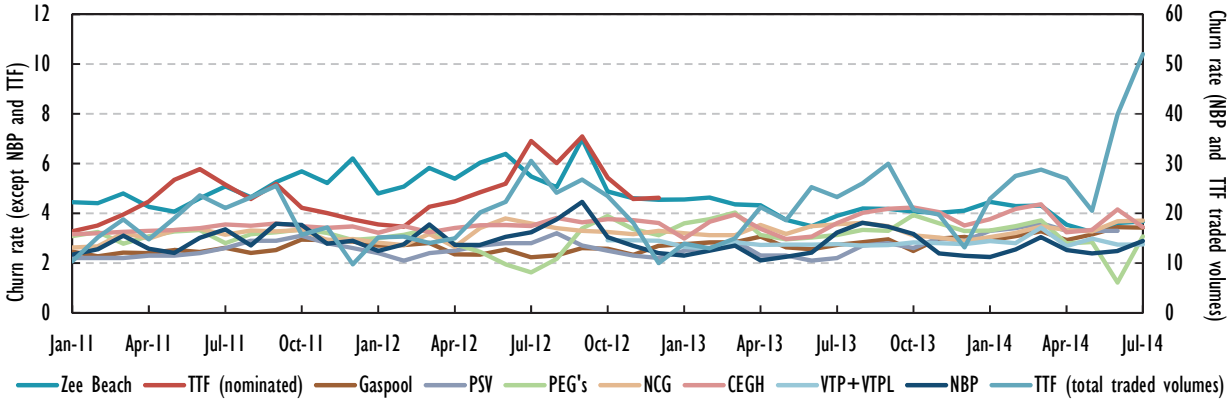
integration at wholesale level, greater forward market liquidity, efficient hub design, trading governance with harmonised trading rules could greatly improve the functioning of the European gas market. As a major import region, the European Union is likely to face challenges with regard to access to new gas supplies and competitively priced gas imports (see section below on Security of Gas Supply). The more important it is to enhance trading and hub-based pricing to benefit from trading within a more and more integrated EU gas market.

**Figure 7.14** Liquidity of major European gas hubs, January 2011 to July 2014




Note: The churn rate is the ratio of the traded volume to the physical volume, the figure is based on Over-the-Counter OTC data. The high rate at TTF is caused by more traded volume, as physical volume was rather normal. The churn rate of TTF is based on total volumes (Exchange and Over-the-Counter OTC), while all other hubs are based on nominated volumes. Nominated volumes are the volumes that are the net result of several trades between parties; it is thus lower than the total traded volumes.

Source: IEA (2014c), *Medium-Term Gas Market Report*, OECD/IEA, Paris.

Since 2008 international gas price differentials have been growing: the boom in indigenous oil and gas production in the United States led to a fall in prices, while the fast rising energy demand in Asia has pushed up prices for LNG imports, which are long-term contracts, largely indexed to oil prices. These international price differences are structural and likely to persist in the medium term. However, as Figure 7.16 shows, prices are subject to strong fluctuations in the short term. Indeed, weather events or energy policy decision (e.g. Japan's nuclear policy), can change the price relationship quite substantially.

In 2014 the international gas markets again show more convergence and prices have come down in early 2014. At the end of 2013, EU natural gas spot market prices were around USD 10.5 per million British thermal units (MBtu), US Henry Hub prices at USD 4 per MBtu and USD 16 per MBtu in Asia. However, thanks to the mild weather notably in Europe, European gas prices have further dropped to around USD 7 per MBtu as of mid-2014 (German Border Price [GBP] remaining at USD 9 per MBtu), while US gas prices stood at around USD 4 to 4.5 per MBtu and Asian spot prices dropped to less than USD 11 per MBtu (average Asian LNG prices were still higher at USD 16 per MBtu).

Gas contracts have become short-term, contributing to liquidity and trading in the EU gas markets, and many contracts have recently been under revision. Only around 17%-30% of the EU gas contracts remain long-term (KEMA, 2013).

Following international arbitration disputes, external suppliers to the European Union are now including a spot component into their long-term contracts as the gap between the spot market price and the oil-indexed gas price in long-term contracts increased strongly. Almost half of the EU gas sales is linked to hub prices and is no longer oil-indexed as of 2014.

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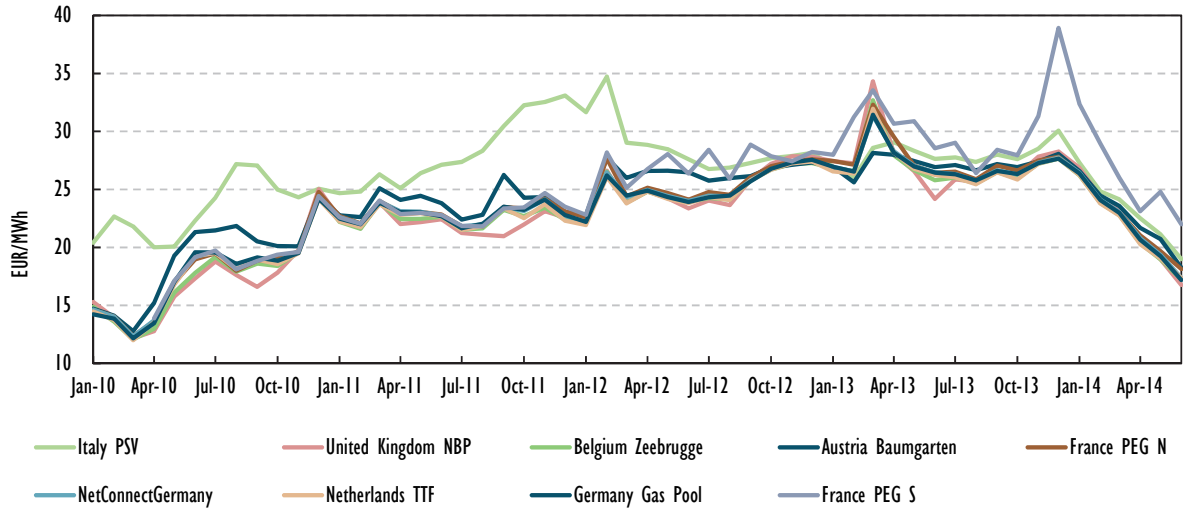
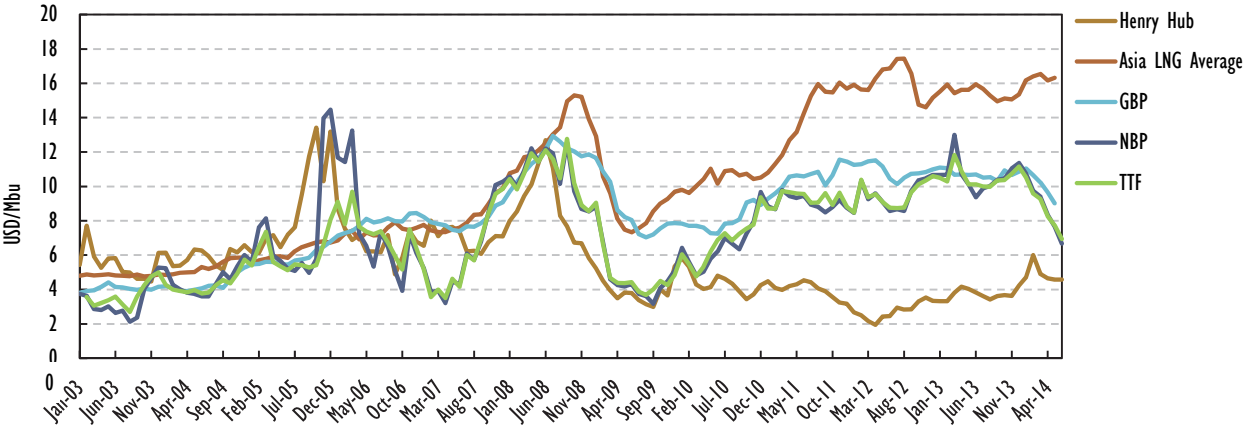
**Figure 7.15** Converging monthly European gas hub prices, January 2010 to April 2014




Source: IEA (2014e), *Energy Policies of IEA countries: The Netherlands 2014*, OECD/IEA, Paris.

**Figure 7.16** Trends in international gas prices in Europe, United States and Asia




Source: IEA (2014c), *Medium-Term Gas Market Report*, OECD/IEA, Paris.

The European Commission estimates that 47% of the long-term gas supply contracts will expire within 10 years, 45% within 10-20 years and 8% above 20 years – this information was provided by the member states to the European Commission under EU Regulation 994/2010 (EC, 2014a). The expiry of the contracts also provides for an opportunity for operators to renegotiate the terms and conditions for future supplies.

## NATURAL GAS RETAIL MARKETS

Despite the opening and integration of wholesale markets, retail gas markets in a number of EU countries show a lack of effective entry and exit of market players and limited options for consumers to switch suppliers, also hindered by the distortive signals of regulated prices.

In 2013, ACER/CEER examined the effective cross-border entry to the household retail markets in major EU capitals as a measure of market openness. The competition in natural gas markets is increasing, but the market share of the incumbent supplier in the retail



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household market remains very high in Romania and there are no foreign players present in Bulgaria, Finland, Greece, and the Baltic states nor in Poland or Portugal (see Table 7.3).

In 2014, Bulgaria, Croatia, Hungary, Latvia, Luxembourg and Poland remain the most concentrated markets in the European Union, while the British, Czech, Dutch, German, Slovenian and Spanish gas retail markets have a good performance (ACER/CEER, 2014).

**Table 7.3** Overview of incumbent's presence and foreign supply-side substitution to promote retail market integration, December 2012

| Presence of foreign players (capital city) | Estimated incumbent market share in the household market – December 2012 (capitals) | | |
|---|---|---|---|
| | More than 90% | Between 50% and 90% | Less than 50% |
| More than 50% | Romania (1/1) | | Spain (4/6); The Slovak Republic (9/12) |
| Between 20% and 50% | | Italy (4/8); France (3/8); Ireland (2/4); Belgium (2/4) | The Netherlands (6/18), The Czech Republic (4/18), Great Britain (4/14) |
| Between 0% and 20% | | | Austria (2/10), Denmark (2/11), Germany (4/74), Sweden (1/6) |
| 0% | Greece (0/1), Bulgaria (0/1), Estonia (0/1), Finland (0/1), Lithuania (0/1), Latvia (0/1), Poland (0/1), Portugal (0/3) | Slovenia (0/6) | |

Source: ACER/CEER (2013), *ACER/CEER Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2012*, November, Ljubljana/Brussels.

Note: The figures beside country codes represent the number of foreign retailers active in the capital versus the overall number of retailers active in the capital (household segment).

Gas prices for households show a large difference between EU member states, ranging from around EUR 30 per MWh in Romania to EUR 60 per MWh in Italy or EUR 95 per MWh in Bulgaria (Figures 7.17).

Industrial gas prices were more homogenous around an average of EUR 48 per MWh in 2013. Hungary, Bulgaria, Lithuania, Croatia and Poland had the highest gas retail prices for industry. In Portugal, Italy and Spain household gas prices are among the highest. Hub price indexes are increasingly used as a spot component also in regulated gas retail tariffs, for instance in Italy and France.

By the end of 2013, gas prices remained regulated in many member states. Households in 15 out of 26 member states (those who have gas markets) have regulated prices (ACER/CEER, 2014). These include France, Poland, Romania, Bulgaria, Latvia, Hungary, Greece, Belgium, Italy, Portugal, Spain and the Slovak Republic. In seven countries these regulated prices are for consumers with special needs. There are only few countries (France, Poland, Romania, Bulgaria, and Latvia) with regulated prices for large industrial consumers. Only in a few countries there is no price regulation: the Czech Republic, Germany, Great Britain, the Netherlands, the Nordic countries and Slovenia. Next to phasing out price regulation, these trends can be mitigated by enhancing the competition between suppliers in a more integrated gas market at competitive hubs and by fostering more diversified portfolios of suppliers. In an international comparison gas retail prices in the European Union, both for the household and industry segment, were

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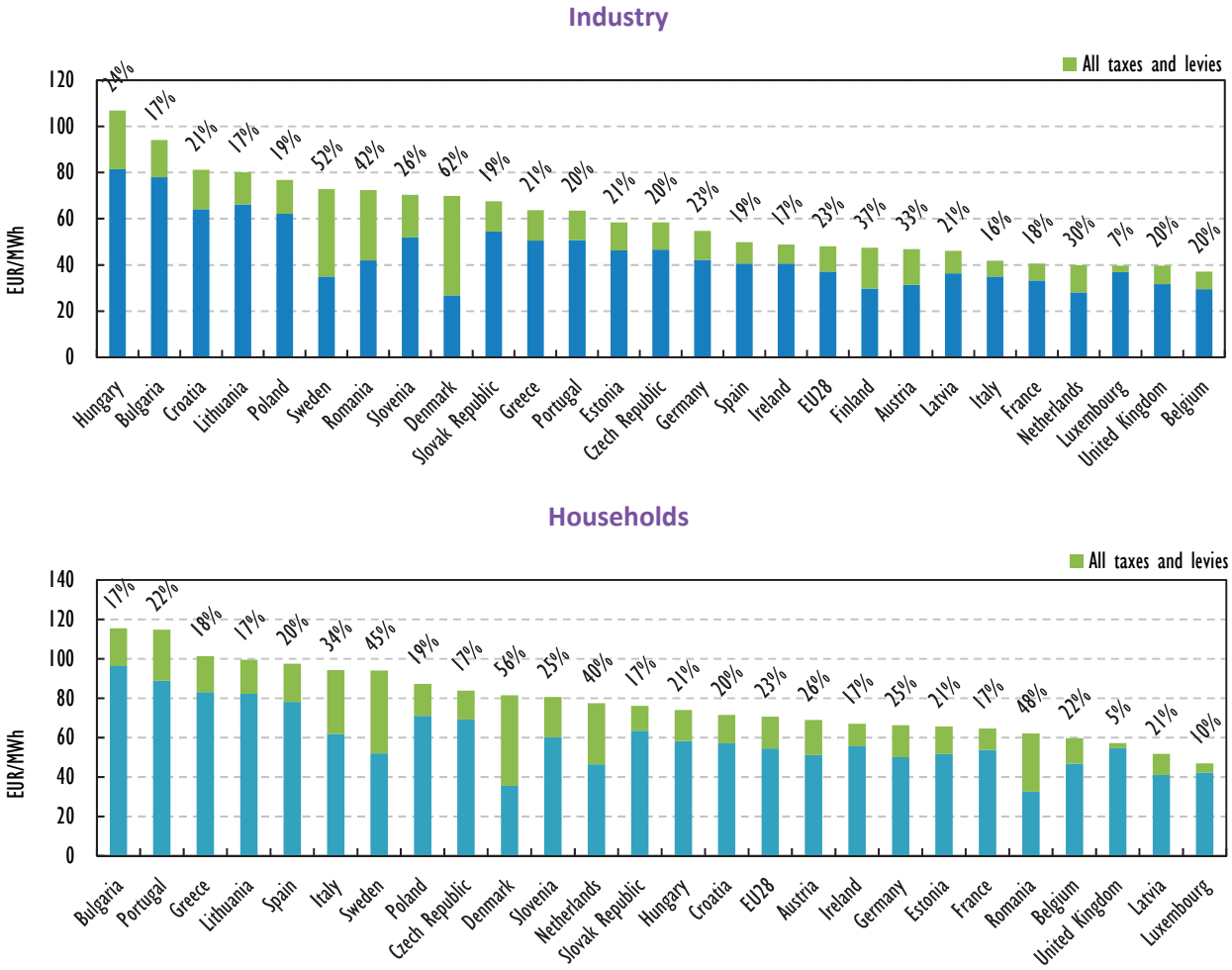
much higher than the gas prices in the United States and Canada (see Figure 7.18). The US shale gas revolution had a major downward pressure on gas prices in North American gas markets. These price differentials could undermine Europe's competitiveness, particularly for energy-intensive industries, notably petrochemical and chemical industry, using gas as feedstock.

**Figure 7.17** Gas retail prices for industry and households in EU member states (EUR with purchasing power standards PPS), 2013




Note: includes only countries where gas supply to industry and household consumers exists.

Source: Eurostat (2014), *Electricity and Natural Gas Price Statistics*, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/electricity_and_natural_gas_price_statistics (accessed on 1 August 2014).



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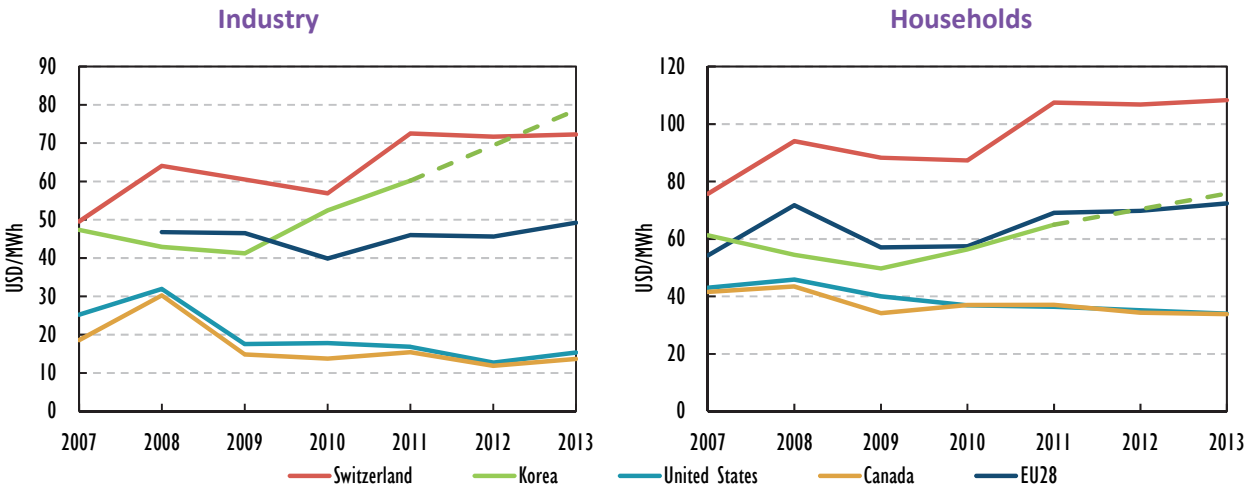
**Figure 7.18** Gas retail prices in the European Union and in selected IEA member countries, 2007-13




Note: Data are not available for EU industry price for 2007. Data are not available for Korea for 2012.

Sources: IEA (2014f), *Energy Prices and Taxes*, OECD/IEA, Paris; Eurostat (2014), *Electricity and Natural Gas Price Statistics*, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/electricity_and_natural_gas_price_statistics (accessed on 1 August 2014).

## SECURITY OF GAS SUPPLY

With respect to gas emergency response capabilities, the IEA has received a mandate from the 2009 IEA Ministerial Meeting to monitor progress in gas markets and gas security policies, and to advise member governments on the development of a gas strategy, and of plans for long-term security of supply and emergency preparedness, including conducting regular emergency reviews and exercises. The IEA can play a role to co-ordinate member countries' actions, where appropriate, in case of an emergency. Within the context of in-depth reviews, the IEA analyses the security of gas supply and emergency policies in place.

In 2014, the geopolitical crisis between Russia and Ukraine renewed concerns over domestic gas imports by Ukraine and the security of transit gas supplies to Europe via Ukraine. At their March 2014 European Council, heads of state and government requested the Commission to deliver a comprehensive plan to reduce energy import dependence. In May 2014, the European Commission presented the EU Energy Security Strategy (EC, 2014f), which assessed the energy supply dependence and resilience of the European Union (with regard to oil, gas, electricity and other imports) and identifies options to reduce such dependence in the medium and long term. These included stress tests of the 28 EU member states and Energy Community countries, measures aimed at increasing gas stocks, developing emergency infrastructure such as reverse flows, reducing short-term energy demand and switching to alternative fuels.

In May 2014, the G7 Energy Ministerial Meeting mandated the IEA to identify options for individual and collective action of the G7 in the field of gas security, notably with a view to short-, medium- and long-term measures to achieve the diversification of gas supplies (see Box 7.2) in co-operation with the European Commission. At the Brussels June 2014 G7 summit, the initiative on energy security was adopted by the heads of state and government.

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**Box 7.2** G7 Initiative for Energy Security (June 2014)

The use of energy supplies as a means of political coercion or as a threat to security is unacceptable. The crisis in Ukraine makes plain that energy security must be at the centre of our collective agenda and requires a step change to our approach to diversifying energy supplies and modernising our energy infrastructure.

Under the Rome G7 Energy Initiative, we will identify and implement concrete domestic policies by each of our governments separately and together, to build a more competitive, diversified, resilient and low-carbon energy system. This work will be based on the core principles agreed by our Ministers of Energy on May 5-6 2014, in Rome:

- development of flexible, transparent and competitive energy markets, including gas markets
- diversification of energy fuels, sources and routes, and encouragement of indigenous sources of energy supply
- reducing our greenhouse gas emissions, and accelerating the transition to a low-carbon economy as a key contribution to sustainable energy security
- enhancing energy efficiency in demand and supply, and demand response management
- promoting deployment of clean and sustainable energy technologies and continued investment in research and innovation
- improving energy systems resilience by promoting infrastructure modernisation and supply and demand policies that help withstand systemic shocks
- putting in place emergency response systems, including reserves and fuel substitution for importing countries, in case of major energy disruptions

Based on these principles we will take the following immediate actions:

- We will complement the efforts of the European Commission to develop emergency energy plans for winter 2014-15 at a regional level.
- Working with international organisations such as the International Energy Agency (IEA), the International Renewable Energy Agency, and the international financial institutions, we will supply technical assistance, including leveraging the private sector, and facilitate exchanges with Ukraine and other European countries seeking to develop indigenous hydrocarbon resources and renewable energies, as well as to improve energy efficiency.
- We will conduct assessments of our energy security resilience and enhance our joint efforts, including on critical infrastructure, transit routes, supply chains and transport.
- We will ask the IEA, in close co-operation with the European Commission, to present by the end of 2014 options for individual and collective actions of the G7 in the field of gas security.

We will also:

- Promote the use of low-carbon technologies (renewable energies, nuclear in the countries which opt to use it, and carbon capture and storage) including those which work as a base-load energy source.



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**Box 7.2** G7 Initiative for Energy Security (June 2014) (continued)

- Promote a more integrated LNG market, including through new supplies, the development of transport infrastructures, storage capabilities, and LNG terminals, and further promotion of flexible gas markets, including relaxation of destination clauses and producer-consumer dialogue.

We ask our Energy Ministers to take forward this Rome G7 Energy Initiative and report back to us in 2015.

Source: Brussels G7 Summit 4-5 June 2014, Declaration, excerpt on energy.

## EU GAS EMERGENCY POLICIES

Since the 2006 and 2009 gas crises, many measures have been implemented to reinforce the European Union's resilience against gas supply disruptions and improve the diversification of sources and supplies, notably through the increase in gas infrastructure capacity. However, instability of North Africa and Middle East supplies, a faster decline in indigenous production and globalising LNG markets have led to an increase in the dependence of the European Union on Russian gas supplies. Despite strong efforts to strengthen EU external energy relations with Ukraine and Russia, current EU external relations and gas market trends call for the need to re-evaluate the security of gas supply of the European Union.

This chapter therefore examines the emergency policies in place at the EU level and options to enhance the security of gas supply: 1) in the short term through flexibility from gas storages, production, LNG and reverse flows, and 2) in the medium term, how to tap into the potential of indigenous gas production, secure new gas supplies and infrastructure investment to Europe. This chapter does not cover the longer-term diversification, with measures to reduce the European Union's dependence on imported gas through energy efficiency and renewable energies, as this is provided in the Chapter 4, "Energy Efficiency" and Chapter 9, "Renewable Energy" of this report.

### EU gas security of supply regulation

Since the first IEA in-depth review in 2008, notably in the aftermath of the 2009 gas crisis between Russia and Ukraine, the European Union has strengthened its emergency preparedness by driving investment in new gas infrastructure, transparency on gas data, common EU-wide network plans and adopting a new gas security policy (EU Regulation 994/2010).

The new rules require EU member states to set security of supply standards, to carry out risk assessments and to adopt preventive action plans and emergency plans and to co-operate at regional and EU levels. Since 2009 the Gas Coordination Group has been reinforced as the most important platform for EU member states to discuss gas security, to co-ordinate emergency responses and to act in a more collective manner. However, few countries have started to discuss common risks, test the resilience or co-ordinate measures on security of gas supply at regional level. To a large extent, security of gas supply is seen as a matter of national security.

The Regulation contains a set of market-based measures with two main gas security standards. First, the supply standards oblige gas undertakings to ensure supplies to a group of defined protected customers, mainly households and important industries, under severe climatic conditions, high gas demand or supply disruptions. In practice, member states decided on a conservative approach to the scope of protected customers. To evaluate the adequate

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scope, it is important to review whether gas supplies will be ensured in the event of a real crisis situation. The testing of the emergency measures should be carried out.

Second, the regulation requires, by the end of 2014, that in case of a disruption of the single largest gas infrastructure, the capacity of the remaining infrastructure be able to satisfy the total exceptionally high gas demand in a member state (N-1 standard). By October 2014, 20 member states were able to fulfil the N-1 standard. Bulgaria, Greece, and Lithuania are working towards compliance by the end of 2014. Three countries have been granted exceptions under the Regulation; they are Sweden, Luxembourg and Slovenia. Three countries should be able to increase their resilience in the coming years. In Lithuania, the Klaipeida LNG terminal started operations in 2014, which ensures the country's greater independence in gas supply security. Greece is set to benefit from possible additional supplies of LNG, and the Southern Gas Corridor (after 2019). Bulgaria is to see enhanced interconnection to Greece and to Romania, but projects face substantial delays.

TSOs are required to enable physical reverse flows on the interconnections, where the benefits for security of supply outweigh the cost of investment. The Regulation requires member states to run a cost-benefit assessment and market test. Progress has been slow as NRAs have decided to provide for an exemption from reverse flows and not to enforce the bi-directional gas flows in most cases. Volumes remain small and not sufficient to ensure the security of gas supply in the event of a supply disruption (see below next section on gas infrastructure investment).

Reverse flows enhance security of supply, foster access to LNG terminals for landlocked countries, and increase market liquidity and price arbitration between gas hubs. Next to high contractual congestion on major interconnections, the lack of reverse flow capacity hampers the flexible emergency response and the gas market functioning.

The Regulation relies on the EU internal gas market to signal demand/supply needs through the price mechanism. There are no mandated non-market-based measures, like strategic gas stocks or demand-restraint programmes, but member states are free to decide on adequate emergency measures needed in their emergency plans, based on the risk assessments and preventive action plans (see overview in Box 7.3).

The European Commission reviewed the implementation of the Regulation in October 2014 (EC, 2014f) and drew conclusions in relation to the evaluation of the results of the stress tests (EC, 2014g), which were carried out in August 2014 in EU member states and the countries of the Energy Community.

In October 2014, the European Commission presented the results of the stress tests, evaluating the disruption of Russian gas supplies throughout six months in winter 2014/15 (EC, 2014h). A sustained gas supply disruption would have a substantial impact on the European Union, notably on Eastern EU countries and countries of the Energy Community. The EC also identified short-term measures can help ensure secure supplies and a better functioning internal energy market, including a market-based approach, short-term behavioural changes to boost energy efficiency and lower demand, increased co-ordination on energy policies among the countries, notably with regard to the maximise the use of interconnector capacity and remove restrictions to cross-border energy trade, developing a more shared responsibility between public authorities and industry through the implementation of the European Union's Security of Gas Regulation while monitoring and jointly examining the gas security situation through the work of the European Union's Gas Coordination Group.



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**Box 7.3** Emergency measures

On the supply side, EU Regulation 994/2010 includes in Annex I several options of measures which member states can take on the basis of their risk assessment as part of their national preventive action plans and emergency plans on the supply side:

- increased production flexibility
- increased import flexibility
- facilitating the integration of gas from renewable energy sources (RES) into the gas network infrastructure
- commercial gas storage withdrawal capacity and volume of gas in storage
- LNG terminal capacity and maximal send-out capacity
- diversification of gas supplies and gas routes
- reverse flows
- co-ordinated dispatching by TSOs
- use of long-term and short-term contracts
- investments in infrastructure, including bi-directional capacity
- contractual arrangements to ensure security of gas supply.

On the demand-side, the Regulation includes the following market-based measures:

- use of interruptible contracts
- fuel switch possibilities including use of alternative back-up fuels in industrial and power generation plants
- voluntary firm load shedding
- increased efficiency
- increased use of RES.

In case of an emergency several measures can be taken on the supply side:

- use of strategic gas storage
- enforced use of stocks of alternative fuels (e.g. in accordance with Council Directive 2009/119/EC of 14 September 2009 imposing an obligation on member states to maintain minimum stocks of crude oil and/or petroleum products)
- enforced use of electricity generated from sources other than gas, enforced increase of gas production levels
- enforced storage withdrawal.

Finally, demand-side non-market emergency measures include demand reduction by:

- enforced fuel switching
- enforced utilisation of interruptible contracts, where not fully utilised as part of market measures
- enforced firm load shedding.

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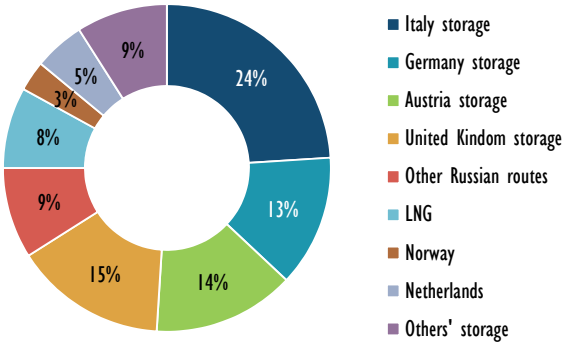
### The Russia-Ukraine gas crisis of 2009

Following disputes between Russia and Ukraine over gas prices for domestic consumption and transit in 2005-06, in January 2009 the dispute escalated into a large European gas disruption and is perceived as a major disruption, despite the fact that the disruption of gas supplies from Libya via Green Stream in 2011 was higher in volumes. Russian exports to Ukraine were cut off on 1 January and exports to 16 EU member states and Moldova were cut off between 7 and 20 January 2009.

The disruption left parts of the Balkans in a humanitarian emergency and caused significant economic damage with industry production being shut down in Hungary (EUR 70 million), Slovakia (EUR 1 billion) and Bulgaria (EUR 255 million). The harsh winter and the dependence of Eastern Europe on one single supplier and supply route worsened the impact of the gas disruption. The missing volumes of 5 bcm in the European Union (and 2 bcm of supply for Ukraine) could be replaced by gas supplies in the EU gas market, notably from gas storage in Austria, Germany, and Italy. Gas was transported east thanks to the establishment of reverse flows to Eastern Europe, e.g. from the Czech Republic to the Slovak Republic and on the last day from Greece to Bulgaria (see Figure 7.19). The crisis has shown the benefits of reverse flow which require relatively little investment in comparison to the investment cost of new gas pipelines.

The insufficient co-ordination of emergency measures within the European Union and the lack of infrastructure, notably the lack of west-east transmission capacity, storage and access to LNG terminals in Eastern Europe were identified among the key shortcomings. In addition, the crisis tested the emergency procedures in place in EU member states. The lack of transparency on gas data, including gas flows and storage levels, was another lesson learnt. During the crisis, member states also limited cross-border trade; for instance, Italy relied on import maximisation.

**Figure 7.19** How Europe replaced 5 bcm in January 2009




Source: IEA (2014c), *Medium-Term Gas Market Report*, OECD/IEA, Paris.

### Resilience to gas supply disruptions

Ukraine remains the most important transit route for gas to Europe. Around 15% of European gas supplies arrive via the Brotherhood pipeline (around 83 bcm in 2013). In autumn 2014, the IEA assessed, Europe's resilience to manage a disruption of Russian gas supplies via Ukraine in the winter 2014/15.



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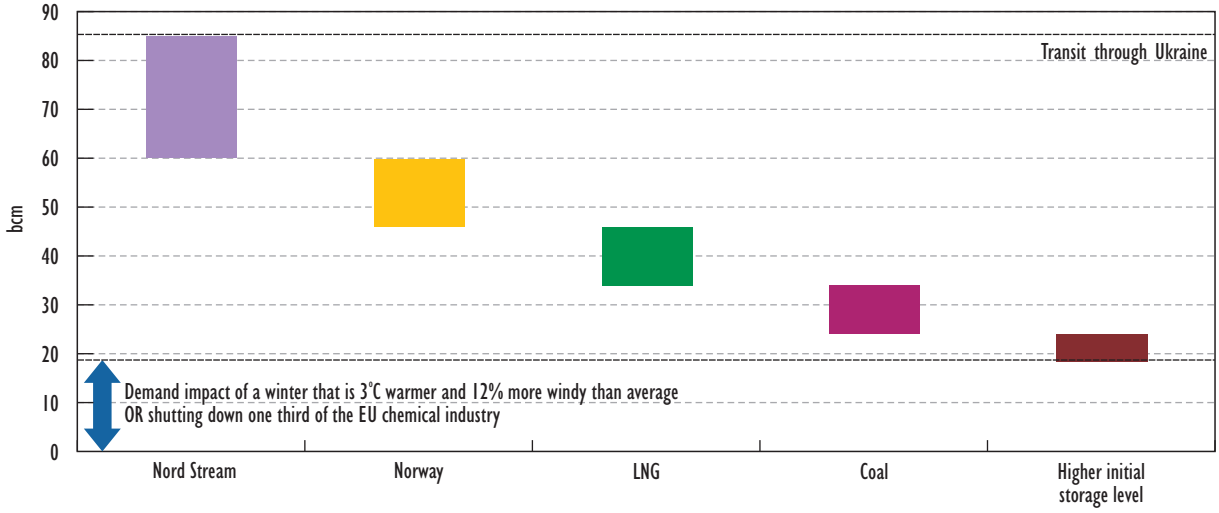
**Figure 7.20** Europe's resilience to manage a disruption of Russian gas supplies via Ukraine in winter 2014/15




Any possible disruption of Russian gas transit through Ukraine in winter 2014/15 would need to be mitigated by demand reduction in industry, by full Nord Stream supplies, increased Norwegian supplies, LNG, fuel switching to coal-fired power plants and larger storage levels (see Figure 7.20).

Nord Stream is the only alternative route with excess capacity (in total 55 bcm per year), in its current operation at 27.5 bcm it could only replace a third of the Ukrainian flows.

The IEA expects that Norway could provide some additional volumes, but this is limited to the pipeline capacity to North West Europe of around 120 bcm per year. The Norwegian Ministry of Petroleum and Energy (the Norwegian Petroleum Directorate) expects gas sales to reach a level between 105 and 130 bcm in 2020, and between 80 and 120 bcm in 2025 (Ministry of Petroleum and Energy of Norway, 2014). So, there is some flexibility but additional capacity is limited.

Europe's resilience to a crisis is much better than in 2009, thanks to the large-scale storage fill that took place. In September 2014, storage levels were at 90% more than in 2013 at the same time. LNG supplies are coming to Europe and substantial free capacity is available to accommodate LNG from the spot market, where the price is attractive and spot market cargoes or swing production are available. Production flexibility within the European Union is limited, as the Netherlands' Groningen gas field has a production cap in the coming three years.

However, there are a number of unknowns with regard to the actual availability of these options because of political constraints or international energy market developments. The following section examines these measures in more detail.

## SUPPLY-SIDE FLEXIBILITY

### Gas infrastructure investment

Since 2008, gas markets have benefited from infrastructure investment, the creation of gas hubs and a more integrated cross-border trade in Western Europe. The gas network in Central

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Europe has become more flexible to transport gas from the west to the east. However, bottlenecks remain which prevent the gas market to respond to a crisis in an effective way, notably in Central East and South East Europe, the Iberian Peninsula and the Baltic region.

In the aftermaths of the 2009 gas crisis, EU support to investment in new gas infrastructure was prioritised and supported by EU funds from the European Energy Programme for Recovery (EEPR) and the Trans-European Networks for Energy (TEN-E) as well as its successor policy framework for PCI under the Energy Infrastructure Package. The European Union has been supporting the development of the Southern Gas Corridor, a new route for gas supplies from Azerbaijan, new interconnections in the north-south direction in the west and in the central-east of Europe as well as gas storage facilities and new LNG terminals.

Between 2010 and 2014 (August), EEPR supported the completion of 31 gas infrastructure projects and allocated EUR 1.3 billion to the projects: by end of 2014, EUR 897.9 million was paid. It has co-financed a number of reverse flow projects, gas storage facilities, LNG terminals and new interconnections. For instance, the EEPR contributed to increasing the interconnection on the Spain–France corridor (Larrau). With the support from EU funding, two gas interconnections connecting Hungary to both Croatia and Romania were completed in 2012. By the end of 2013, 15 projects were completed; 13 were progressing. However, the funding of four gas projects was cancelled by the Commission, as there is no final investment decision for ITGI Poseidon, Nabucco, Galsi (Algeria-Italy) and the reverse flow project in Romania. Seven reverse flow projects were supported (four in Austria, two in the Slovak Republic, and one in the Czech Republic) and now provide better access to the Austrian storage facilities in Baumgarten for neighbouring countries. In 2014, reverse flows are available between Germany and Poland (Yamal), between Germany and Austria, between Germany and the Czech Republic, between Poland and Czech Republic and at the Czech-Slovak border, serving mainly the Slovak Republic, Austria and Hungary.

The EU Energy Security Strategy of May 2014 (European Commission 2014e) identifies 27 projects in gas which are essential to Europe's security of supply. These projects include new LNG terminals in Poland and Lithuania, Croatia and Greece as well as the Baltic LNG; reverse flows and a number of gas interconnectors between Poland-Lithuania, Poland-Slovak Republic, Poland-Czech Republic, Greece-Bulgaria, Bulgaria-Serbia, Bulgaria-Hungary, Finland-Estonia, France-Spain, as well as the projects in the Southern Gas Corridor, including the Trans-Anatolian-Natural Gas Pipeline (TANAP), the TAP and the connecting Balkan gas ring projects.

The Southern Gas Corridor proves the attractiveness of the EU gas market and will secure diversified supplies to Europe after 2019. It also has the potential to be scaled up in the future to tap into the vast gas reserves in the Middle East and Central Asia.

Private investors may not see a business case for new commercial infrastructure projects in Europe at this point. There is over-capacity and low gas demand. LNG imports were at a record low in 2013 with very low utilisation rates. In theory, there could be an interest in new LNG terminals in countries, where there is large-scale gas infrastructure which was originally built for exports but faces declining production (the Netherlands, the United Kingdom) or in countries that import high shares of Russian gas and have sufficient infrastructure (Italy, Germany). Such investment would only happen with regulatory intervention to secure additional capacity in the event of a supply disruption. Markets will not invest in resilience capacity at that scale.



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## Gas storage

Efforts to increase transparency on gas storage in the European Union have resulted in greater availability of detailed data per country and on a daily rate.[17] However, not all storage facilities are subject to transparency rules and data are scarce on storages in Central Eastern Europe.

Since 2009, EU gas markets experienced an over-supply of gas for some time, which resulted in a price gap between gas, priced under take-or-pay long-term contracts, and gas under lower spot market prices. The traditional investment cycle for storage relied on the summer-winter seasonal price spread. During 2009 and 2013, this spread was at historical lows which discouraged users from contracting longer-term storage volumes. In Europe, gas storage is competing with other flexibility products in an increasingly short-term market, amid falling prices at EU gas hubs. As well as hub-related products, other flexibility sources are available: swing gas production, import contracts, line pack, swaps, interruptible contracts, and LNG.

There is plenty of gas in the market if the EU member countries want to consider raising emergency stockpiles. While governments may be tempted to ensure their gas storage capacity for emergency situations in their territory, such a possibility may not be appealing for several reasons relating to cost, administration, availability and market distortion.

Gas needs to be stored in either high pressure or liquid form. Physical stocks for an emergency are removed from the market and are held by the government or by industry, under a public service obligation. In EU countries, there are several storage obligations or alternative-fuel obligations, including a government stockholding agency in Hungary, gas stock holding obligations in Denmark, Italy, Poland, Portugal, the Slovak Republic, and Spain. In addition, France has initiated a consultation to strengthen the regulatory framework with regard to keeping gas in storage at appropriate levels.

The contribution of gas storage facilities to security of supply and emergency situations, however, varies greatly depending on their characteristics (depleted gas field, aquifer or salt cavern) and on withdrawal rates.

Investment into new gas storage facilities is also expensive, particularly compared to oil stocks (IEA, 2014g). Any call for public emergency stock piling would have a direct impact on commercial storage and may deter commercial storage investment.

- An underground gas storage facility costs five to seven times more than underground oil storage, also because of higher capital cost of “cushion gas” (depending on the type of storage it can be up to 80% for aquifers, 50% for depleted fields or 25% of the capital cost for salt caverns).
- An LNG storage facility can be even more expensive, up to ten times of the cost of stocks in oil tanks and 50 times the costs of underground oil storage. LNG has also the so-called boil-off problem, which means that some LNG evaporates in the tanks at low utilisation rates. It can require a terminal to be shut down.
- Variable costs of maintaining gas in storage are estimated to be around 10% to 20% of the capital cost per year per facility.

**17.** Information on storage levels and investment is available on the Aggregated Gas Storage Inventory, an online transparency platform of Gas Storage Europe and Gas Infrastructure Europe (GSE/GIE).

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- Besides the cost, other non-commercial barriers exist. Gas storage requires time for permitting, financing and construction, unless the country has a field nearing depletion. Not all countries have geological conditions suitable for underground gas storages and thus would rely on LNG tanks, where available.

Markets can respond to supply disruptions. In the 2009 gas crisis, however, storages played a key role in ensuring short-term gas supplies. Given the European Union's large storage capacity of up to 20% of its domestic demand, the efficient use of the existing infrastructure for security of supply should be fostered. Depending on the scale and duration of any gas supply disruption and amid repeated disruptions of EU gas imports, there is a need to analyse the market-based measures to ensure an adequate filling of gas storages for security of supply.

Two elements are important to ensure that storages can better compete with other short-term products: 1) effective and transparent third-party access to storage capacity across the borders, and 2) transmission tariffs at the entry and exit should reflect actual cost. The FG on tariff structures should reflect those elements (CEER, 2013). This can also significantly increase the contribution of storages. Rather than developing new gas storage capacity, the creation of emergency stocks may be an option of last resort for the countries, most exposed to supply risks. The regional integration of the storage markets in the European Union through capacity booking and a revised tariff setting of storage, should provide greater flexibility and security.

## Short-term flexibility from LNG markets

The utilisation of the LNG terminals in Europe is low; the average is 23.5%, with more than 70% spare capacity (or 137 bcm). LNG is a very important source of diversified supplies in Europe, despite its low share. Given the turmoil in North Africa and Iraq, LNG is the most credible diversification option. Some of the LNG is locked in, in Spain and Portugal because of the lack of interconnection capacity and in France (odorisation). It is no surprise that these countries are the ones to re-export their LNG, as a contractual response.

Where the markets are interconnected, LNG has been a very good tool to increase diversification. There is significant LNG import capacity in the well-interconnected northwest regions. In the current market circumstances, there is limited potential for additional imports of LNG (LNG spot or diverted LNG cargoes) or increased LNG liquefaction under the existing long-term contracts to Europe. However, LNG markets are reacting fast to price differentials and Europe could become attractive, if pipeline exports are under constraint because of political crises in producer countries or transit disruptions. Qatar for instance has large flexibility to serve different markets (in Asia or in Europe, depending on the price differentials).

Diverting LNG cargoes would effectively mean a swap of cargoes between the spot market and the long-term market. A global LNG response could be possible if one region, unaffected by the supply disruption, could either reduce LNG demand or increase production and divert cargoes to the disrupted region. Regional price changes, however, impact global LNG trade and conversely, regional supply-demand changes affect prices quickly. Such a collective reaction would rely on the possibility of some LNG producers or consumers to provide swing capacity. However, only a European premium on top of the Asian average LNG import price or the narrowing of the price gap with Asia would direct LNG to Europe on the basis of the globalised LNG trade. Much depends on the importance of Asian domestic demand, for instance in Japan and in South Korea and the



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outlook for nuclear energy in that region. Traditionally, these energy islands have strong security of supply requirements themselves and LNG prices are likely to increase following reduced LNG supplies in their markets.

### Demand-side flexibility

On the demand side, there are several short-term emergency measures, ranging from demand restraint (rationing of supplies by the TSO to ensure supplies to the protected customers), to obligations for fuel switching to oil/oil products and interruptible contracts. However, in practise, the scope of these measures is rather limited. Alternative fuel obligations already exist in Estonia, Finland, Greece, Ireland, Portugal, and the United Kingdom.

Oil-fired capacity is on the decline and it cannot be taken for granted that separate oil fuel stocks are held and are available to substitute natural gas use. In order to ensure the actual availability of fuel switching in a crisis, governments could resort to mandating dual-fuel capabilities and to monitoring fuel switching availabilities. There are few data publically available on fuel-switching capabilities, notably for the industrial sector. Although network operators are bound to transparency of gas capacity data, however, there are limited data on interruptible contracts or fuel-switching possibilities of power plants. Switching to diesel generation can be possible in many countries, however, it comes at higher environmental and fuel cost. In countries where gas plays a strong role in power generation, any gas disruption has an impact on the electricity supply situation. Simultaneous gas and electricity peak demand can occur, notably in Northern Europe in the heating season. The heating demand in Europe is seasonal and stable. And gas plays a large role with around 40% in the heat sector. The opportunities for the short- to medium-term reduction of gas demand in heating are constrained by the availability of electric heating and other boilers.

Since current electricity markets are dispatching coal rather than gas, coal-fired plants are already running at their highest capacity in most EU countries. In winter 2014-15, further fuel switching from gas to coal in the power sector is limited. Keeping older coal plants in a cold reserve could be a temporary measure to ensure swift fuel switching in the power sector during a winter system stress.

## MEDIUM-TERM MEASURES ON THE SUPPLY AND DEMAND SIDES

### Indigenous gas production

In the North Sea, there are still substantial indigenous reserves, in the Netherlands and the United Kingdom as well as in Norway. Risk-sharing arrangements, tax breaks and enhanced oil recovery have stimulated exploration and production (E&P) in Norway and also in the United Kingdom, while the increase in Dutch gas production remains under safety review. However, North Sea gas production levels are unlikely to reach levels that can halt the decline in the coming decade, but new production could delay the decline over time.

Different from conventional natural gas, the European Union has still undiscovered unconventional reserves. Within the European Union, technically recoverable resources (TRR) of the Netherlands are estimated at 26 trillion cubic feet (tcf), similar to the TRR of the United Kingdom (26 tcf), but considerably less than in Denmark (32 tcf), Romania (51 tcf), Poland (148 tcf) and France (137 tcf). By comparison, countries such as Germany (17 tcf), Bulgaria (17 tcf), Sweden (10 tcf) and Spain (8 tcf) have few resources (EIA, 2013).

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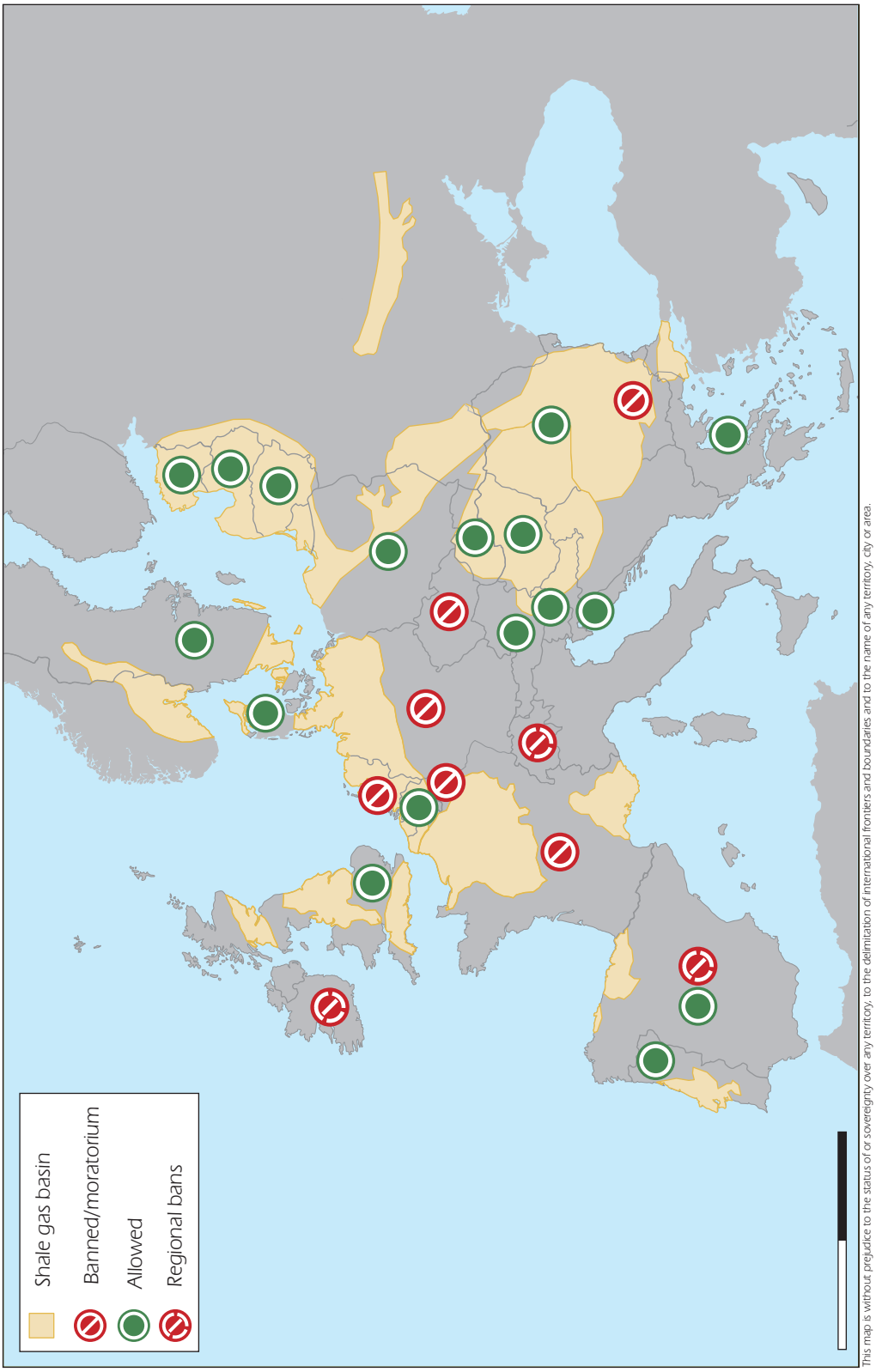
**Figure 7.21** Position of European countries on shale gas exploration




Source: IEA (2014c), *Medium-Term Gas Market Report*, OECD/IEA, Paris.



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However, in comparison to the global resources, Europe has only a very small volume of TRR (470 tcf out of 1 685 tcf in North America or total global of 7 201 tcf). Pending exploratory drillings in most countries, the actual amount of economically recoverable resources or proven reserves remains uncertain. Europe is thus unlikely to become self-sufficient or a net exporter of shale gas. Shale gas production today and until the end of the decade comes from modest production of tight gas in the Netherlands, Poland and the United Kingdom, from some coal-bed methane production in Germany and Poland as well as from shale gas in Germany, Italy, Poland and the United Kingdom. Production of shale gas could potentially slow down the decline of conventional resources and mitigate further increases in import dependence in some of those EU countries, which are highly dependent on gas imports from single suppliers.

The *World Energy Outlook* Special Report *Golden Rules for a Golden Age of Gas* (IEA, 2012) considered that Europe could potentially develop 77 bcm of unconventional gas by 2035 under the conditions of a supportive regulatory and political framework and sufficient public confidence. Such a production volume would however only partly compensate for the decline in conventional gas production, which is expected to almost halve by 2035. Taken into account all barriers and obstacles to shale gas in Europe, the *World Energy Outlook 2014* (IEA, 2014h) projection for EU unconventional gas production is for around 17 bcm by 2040.

On the basis of *Golden Rules for a Golden Age of Gas* (IEA, 2012), the IEA set out the principles needed to earn and maintain a "social license" to produce unconventional gas. These principles include full transparency, measuring and monitoring environmental impacts and engagement with local communities; careful choice of drilling sites and measures to prevent any leaks from wells into nearby aquifers; rigorous assessment and monitoring of water requirements and of waste water; measures to target zero-venting and minimal flaring of gas; and improved project planning and regulatory control. In 2013, following up on the support by governments, notably the G8, the IEA decided to create the Unconventional Gas Forum which contributes to sharing experience and exchanging best practices among IEA member countries.

Potential for sustainable extraction and use of conventional and unconventional gas has yet to be assessed, as most EU member states have developed a restrictive approach to the exploration of the potential reserves with an explicit moratorium on shale gas drilling and hydraulic fracturing imposed in several member states in Western Europe (see Figure 7.21). Environmental integrity, notably water use, and safety (seismic activity) of unconventional hydrocarbons extraction have become a concern in Europe, with some member states issuing bans on shale gas extraction because of public opposition (Bulgaria, the Czech Republic, France, the Netherlands, and some regions of Germany and Spain). Conversely, the Baltic States, Poland, Romania and the United Kingdom are interested in attracting investors to develop their shale gas reserves.

Legislative uncertainty and growing public concerns have the potential to delay the E&P of shale gas in the European Union. At EU level, today, there are common safety standards for offshore oil and gas platforms under the Offshore Safety Directive 2013/30/EU.

The EC decided not to propose legislation with regard to unconventional gas, at this point in time but is open to review this in the light of the experience gained in the member states over time. In January 2014, the European Commission therefore presented non-legislative and non-binding recommendations (EC, 2014), including public consultations and environmental impact assessments for the use of hydraulic fracturing. Since the EU environmental legislation was developed at a time when high-volume hydraulic fracturing was not used in Europe, certain environmental aspects associated

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with the E&P of fossil fuels involving this practice are not comprehensively addressed in current EU legislation. This in particular concerns issues such as strategic environmental assessment and planning, underground risk assessment, well integrity, integrated and consistent requirements in terms of baseline and operational monitoring, capture of methane emissions and disclosure of fracturing fluid composition on a well by well basis.

The recommendations provide minimum principles as guidance to member states, when applying or adapting their legislation applicable to hydrocarbons exploration or production using high-volume hydraulic fracturing. These are as follows:

- plan ahead of developments and evaluate possible cumulative effects before granting licences
- carefully assess environmental impacts and risks
- ensure that the integrity of the well is up to best practice standards
- check the quality of the local water, air, soil before operations start, in order to monitor any changes and deal with emerging risks
- control air emissions, including GHG emissions, by capturing the gases
- inform the public about chemicals used in individual wells
- ensure that operators apply best practices throughout the project.

In July 2014, the European Commission set up a European Science and Technology Network on unconventional hydrocarbon extraction, bringing together the industry, research, academia as well as civil society.

## New gas supplies to the European Union

In the medium term, it is important that the European Union gain access to diversified supplies in order to deal with rising import dependence on one single supplier. The following section provides an overview on possible gas supply diversification for the European Union in the outlook to 2019.

Gas upstream development is carried out on the basis of estimated imports and future demand. Since Europe competes at a global scale with major consumer regions, notably with Asia, the longer-term demand outlook plays an important factor. At the same time, additional gas from traditional gas suppliers in the Middle East and North Africa is impacted by the political situation and growing internal gas demand in these countries.

The fact that many European gas supply contracts expire between 2025 and 2035 could be an opportunity for the diversification of imports. The role of gas in the EU energy mix will depend on the long-term outlook for natural gas within the future 2030 Climate and Energy Policy Framework (see Chapter 2, “General Energy Policy”) and the electricity market design (see Chapter 5, “Electricity”).

Europe benefits from an essential tool for diversified supplies, this is LNG. New LNG supplies from Australia and the United States will become available in the medium term; they have been largely contracted, including by European companies. Given remaining destination clauses and high demand in Asia, the need for Asian LNG re-exports is low. At the same time, LNG re-export from Europe is not likely to remain a long-term phenomenon after the expiry of existing long-term contracts. The future renewal of LNG contracts and the access of EU players to the LNG spot market will determine how Europe can make use of its large-scale regasification facilities.



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While Europe has only some limited leverage on the basis of current gas demand or gas prices to substantially change the trade flows, there are still some factors in the Asian market development to provide flexibility. By 2020, China is set to overtake Japan as importer of natural gas in the region. Its imports can act as a swing for other markets, as it has also contracted pipeline supplies from Central Asia (especially Turkmenistan) and Russia (the "Power of Siberia" pipeline is expected to come on stream around 2018) in the medium-term outlook, thus easing Asian LNG demand.

As of 2019, the Southern Gas Corridor is to deliver 10 bcm of gas per year from Azerbaijan through Turkey to Greece, Albania and Italy along the TAP. This equals 0.02% of the annual demand of the European Union in 2012. An interesting opportunity is therefore the scaling-up to gas supplies from other countries in the region, where possible, as the transport route through Turkey, the Trans-Anatolian Pipeline (TANAP) is being expanded to transport up to 25 bcm per year. In the long term, the availability of such incremental supplies from the Caspian region and Middle East, including Iran or Iraq, depend on the growing scale of domestic demand, the Turkish domestic gas demand and the political situation in the region. In addition, the South Caucasus Pipeline has spare capacity and could bring additional gas supplies from Azerbaijan.

Concluding on the above, unless the political situation changes dramatically, Norwegian and Russian pipeline gas supplies and LNG are likely to remain key import sources for the European Union in the medium term.

### Demand-side flexibility

In the medium-term perspective, coal and nuclear plants are ageing in the European Union (see Chapter 5, "Electricity"). The European Union is set to lose substantial coal-fired capacities in the coming years, notably as a result of the Large Combustion Plant Directive. In the medium term, this may lock Europe even further into gas imports, preventing supply-side fuel switching. Stimulating investment in base-load capacity, including new nuclear or new coal-fired plants with CCS, is important, but large-scale investment is unlikely to come forward in the medium term before 2020. These will not provide a source of flexibility.

## ASSESSMENT

Since the first IEA in-depth review in 2008, there have been marked changes in the functioning of the European gas market as well as in the regional and global gas market context. The European Union has been liberalising its gas markets, while global gas markets changed dramatically, with a major impact on the European Union. A determined policy push following the adoption of the Third Package has coincided with the economic downturn, surplus take-or-pay obligations under long-term gas import contracts and the temporary availability of LNG at competitive prices, no longer required in North America. The over-supply of gas has allowed gas market opening to flourish in the European Union, supporting larger volumes being traded, higher liquidity and cross-border trade.

As gas prices in long-term contracts are often pegged to oil prices resulting in higher gas prices than those prevailing on European spot markets in 2009-10, European companies tried to renegotiate their long-term contracts by including a spot price indexation in order to lower the gas prices of the long-term contracts. Most of the long-term contracts have therefore been renegotiated, sometimes by going through arbitration.

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Over the same period, European gas demand has nonetheless declined substantially, bringing the region's gas demand back to levels seen in the early 2000s. As described in the section on the internal electricity market, the main arena for this decline has been the power sector, where weak demand, rapid growth in renewables-based capacity and strong competition from coal-fired generation (aided by rock-bottom $CO_2$ prices) have squeezed the space available for natural gas.

Despite good progress on market opening, there is scope to enhance the functioning of the European gas market, in line with the aim of the European Union to complete the internal energy market. Key elements of this are full implementation of the Third Package, the adoption and implementation of harmonised rules for the operation of the gas market and efficient utilisation of its gas infrastructure, the implementation of reverse flows and connections between markets, notably the creation of competitive gas markets in Central Eastern and South East Europe.

Infrastructure development is currently not supported by the gas market outlook, notably for security of supply investments, like new LNG terminals or reverse flow investments. The economic and financial crisis has also left the industry and operators with limited access to public/private financing. This may be mitigated by EU support, in the form of a larger EU guarantee in the framework of financial instruments or other funds. The European Investment Bank (EIB) is well placed to support PCI under the CEF, where necessary, and should foster the necessary investment in markets that are not served by commercial banks and investors.

The European Union should continue to reduce contractual congestion of gas interconnectors and ensure gas tariff structures which encourage the efficient use of existing infrastructure in short-term markets and the secure supply in the longer term markets, and promote the emergence of cross-border entry-exit zones to enhance competition and market access for gas suppliers and consumers.

Links between gas and electricity markets mean that the ability of gas to respond flexibly to the variability of wind and solar output is becoming a defining feature of European gas use. Market rules and gas infrastructure need to evolve with this in mind.

Completion of a more interconnected and competitive gas market, with cross-border flows and the construction of new infrastructure driven by transparent market signals is central to Europe's security of gas supply. Europe's capacity to respond effectively to supply disruptions will also be improved under the new Regulation that encourages harmonised and co-ordinated emergency responses. In terms of external supplies, Europe as a whole has a balanced and increasingly diversified portfolio of pipeline and LNG imports, but this should not disguise the fact that some countries in Central and Eastern Europe retain strong reliance on gas from a single source and route from Russia.

The trajectory of future EU gas demand is an uncertainty for investment in new upstream and infrastructure projects supplying or connecting the European market. The recent decisions on phase II of Azerbaijan's Shah Deniz field and the TAP pipeline indicate that a competitive European market can motivate multi-billion-Euro projects. However, the possibility remains that intensified policy efforts on decarbonisation may decrease utilisation rates for gas-fired generation and infrastructure assets, and, thus, the chance of triggering market-based investment in the sector.

How gas consumption translates into a requirement for imported gas will be partly contingent on what European countries choose to do with their indigenous gas



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resources. Conventional gas output is expected to continue a steady decline, but this trend could be mitigated by investment in European unconventional resources, mainly shale gas, if they can be developed profitably and in a socially and environmentally acceptable manner. The technologies and know-how exist to address the social and environmental concerns and this is reflected in the recommendations adopted by the Commission in January 2014 (2014/70/EU, EC, 2014i) which invites member states to follow a set of minimum principles in their legislation covering E&P of unconventional gas, alongside existing EU environmental legislation. Until the end of the decade, unconventional gas production in the European Union will come from modest production of tight gas in the Netherlands, Poland and the United Kingdom, from coal-bed methane in Germany and Poland and from shale gas in Germany, Italy, Poland and the United Kingdom.

European gas developments take place in a broader global context that is evolving rapidly. With an efficient gas market, the development of indigenous resources and a continued shift towards hub-based indices, Europe can remain an attractive market place. There are structural divergences in price levels between Europe and North America and they are likely to persist in the medium term, despite seasonal fluctuations. In mid-2014, European Union gas prices were at USD 7 per MBtu as of mid-2014, while US gas prices stood at around USD 4-4.5 per MBtu and Asian spot prices dropped to less than USD 11 per MBtu.

Europe is set to compete for available LNG supplies with consumers in the Asia-Pacific region, where imports are increasing fast and are dominated by rigid, oil-indexed contracts that produce a much higher price level. Even if global energy commodity prices are on a downward trend by end of 2014, Europe has an important stake in securing competitive gas markets and upstream investment in producer countries and new LNG supplies. In this context, the EU should facilitate an active trade policy and diversification investment in the medium to longer term, outside the EU territory, through the EIB and the European Bank for Reconstruction and Development (EBRD).

Action is needed to pursue a gas diversification policy. Actions to revert current market trends however will come at a higher price. Reversing dependence trends will require policy action to invigorate competitive gas markets across the European Union, phasing out regulated prices, to re-evaluate the natural gas production in the European Union, and to foster production from indigenous resources, including renewable energies and shale gas, as well as to play an active role in international co-operation to pursue the dialogue with new producer and consumer regions. Importantly, reduced gas demand in the power sector has been taken up by renewable energies and their role in the heat sector is set to grow. In order to control the rising import dependence in the longer term, the security benefits from using renewable energies and energy efficiency are high and can be evaluated and quantified.

## *RECOMMENDATIONS*

*The European Union should:*

- *Pursue urgently the completion of the internal gas market, through full implementation of the Third Package and the adoption of harmonised market rules to ensure effective use of existing infrastructure.*
- *Work with national regulators to ensure a supportive environment for infrastructure investment, including reverse flows, accompanied by a strategic and focused use of*

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*EU financing instruments. Assess the implications for infrastructure of the changing profile of gas demand in complementing output from variable renewable sources.*

- *Ensure effective gas market functioning and the adoption of short-term emergency measures, notably in the countries that rely on one single supplier and route.*
- *Continue to seek a balanced approach to unconventional gas development, recognising the potential for exploration and development of this resource to contribute to Europe's policy objectives while maintaining a rigorous, science-based approach to the hazards and the measures required to address them.*
- *Pursue a well-functioning European gas market and a continued shift towards transparent hub-based pricing, alongside an enhanced dialogue on efficient, flexible gas markets with major gas suppliers, LNG importers and exporters.*
- *Ensure a well-diversified gas import portfolio and competition at retail levels by phasing out price regulation and supporting new entrants in larger gas market areas.*

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# 8. COAL

**Key data (2012)**

**Production (2013)*:** 113.7 Mt of hard coal and 407.5 Mt of brown coal

**Net imports (2013)*:** 216 Mt of hard coal

**Share of coal:** 17.5% of TPES and 28.1% of electricity generation

**Consumption by sector:** power generation 77.4%, other transformations 9.5%, industry 9.2%, residential 3.1%, commercial 0.8%

* Source: Euracoal, 2014.

## OVERVIEW

In the European Union (EU), coal is the main energy source for electricity and the third primary energy source. But the European Union does not have a specific coal policy, even though its policy decisions affect coal use, including the European Union Emissions Trading Scheme (EU-ETS), air pollution directives and renewable energy targets. There is still substantial competitive indigenous coal production in the European Union and well diversified, secure international coal supplies at low (hard) coal prices; this fuel has clear energy security benefits. A continued contribution from coal in a low-carbon economy is however compromised by its high $CO_2$ intensity. Considerable improvements in power plant efficiency and the use of carbon capture and storage (CCS) technologies will therefore be required.

## SUPPLY AND DEMAND

### SUPPLY

Coal supply in the European Union amounted to 287.5 million tonnes of oil-equivalent (Mtoe) in 2012, or 17.5% of total primary energy supply (TPES). Coal has the third-highest share in European Union's TPES, after oil and natural gas.

Over the past decade, coal supply has been declining. From 2002 to 2012, the decline averaged 0.9% per year. Since 2009, demand has returned to growth and total supply has increased by 9.6% from 2009 to 2012. Table 8.1 provides an overview on the coal supply to the European Union in 2012 and 2013.

Hard coal supply consists of domestic and imported coal. In 2013, imports from outside the European Union accounted for 65% of the total. Intra-EU coal trade is limited, only 16 million tonnes (Mt) in 2012. Domestic hard coal production has decreased as uncompetitive mines have been closed, mainly in Germany and Spain. Brown coal, in turn, is locally produced and consumed, owing to its low-energy content. EU coal production in energy terms accounted for around 4% of the world total in 2012.

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**Table 8.1** EU coal supply, 2012 and 2013

| | 2013 (Mt) | 2012 (Mt) |
|---|---|---|
| Hard coal production | 113.7 | 128.5 |
| Hard coal imports | 216.0 | 213.5 |
| Brown coal production | 407.5 | 433.8 |
| **Total** | **737.2** | **775.8** |

Source: Euracoal (2014), *EURACOAL Market Report 1/2014*, Brussels.

## Imports

EU hard coal imports amounted to 216 Mt in 2013. Hard coal imports to the European Union come mainly from Russia (26% of the total in 2012), Colombia (24%) and the United States (23%). Smaller, but still significant volumes are imported from Australia (7%), South Africa (5%) and Indonesia (5%).

In recent years, steam coal imports from the United States have increased (up from 31 Mt in 2010 to 50 Mt in 2012), as shale gas has replaced coal in power generation and made more coal available for exports from the United States. At the same time, large coal mines have become operational in Indonesia and Australia, adding low-cost supply to the international coal market and helping coal to become increasingly competitive against natural gas in power generation.

By country, the largest importers in the European Union are Germany (50 Mt in 2013), the United Kingdom (49 Mt) and Italy (23 Mt). These three countries accounted for 56% of total EU coal imports in 2013. Indeed, these countries were among the ten largest importers in the world.

**Table 8.2** Hard coal production in the European Union by country, 2012 and 2013

| Country | 2013 (Mt) | 2012 (Mt) |
|---|---|---|
| Bulgaria | 2.1 | 2.3 |
| Czech Republic | 8.6 | 11.4 |
| Germany | 7.5 | 10.8 |
| Poland | 76.5 | 79.2 |
| Romania | 1.8 | 1.9 |
| Spain | 4.4 | 6.1 |
| United Kingdom | 12.8 | 16.8 |
| **Total** | **113.7** | **128.5** |

Source: Euracoal (2014), *EURACOAL Market Report 1/2014*, Brussels.



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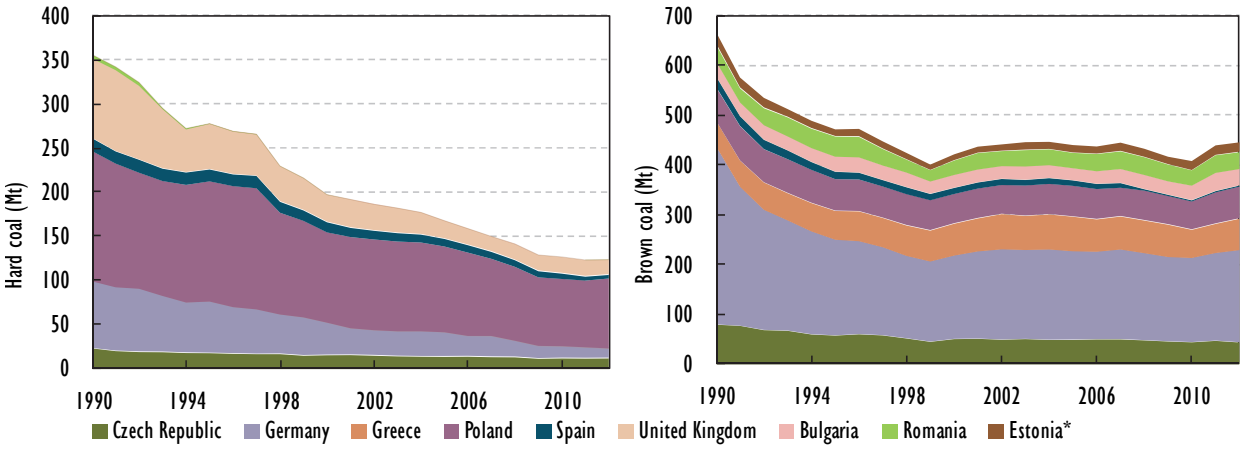
## Reserves and resources

The European Union has extensive coal reserves and resources,[1] and these are several times larger than those of oil and natural gas. Most of the hard coal resources are, however, uncompetitive at the current world market prices.

The European Union is estimated to hold 18.5 billion tonnes (Gt) of hard coal reserves in 2012 and 468.9 Gt of hard coal resources. These correspond to 2.4% of the global hard coal reserves and 2.7% of the global hard coal resources (Andruleit et al., 2013).

Brown coal, (or lignite), reserves in the European Union are estimated at 56.3 Gt in 2012 and brown coal resources at 287.3 Gt. The EU reserves represent 20% of the world total and the resources around 7% of the world total. The majority of the lignite reserves in the European Union are in Germany, around 40 Gt. However, nearly 80% of the resources are in Poland (Andruleit et al., 2013).

**Figure 8.1** Coal production in major EU countries, 1990-2012




* Data for Estonia is for oil shale.

Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

## Production of brown coal

Brown coal production amounted to 407.5 Mt in 2013, according to Euracoal (see Table 8.3). Germany, the world's largest lignite producer, accounted for 45% of the total, followed by Poland (16%), Greece (13%) and the Czech Republic (10%), as shown in see Figure 8.2.

Unlike hard coal production, brown coal production has remained relatively consistent since declining in the 1990s. Production in Germany has varied little over the past decade, while output in Poland, Bulgaria and Romania has increased since the start of the century. In contrast, production in Greece and the Czech Republic has declined by around 10% from 2002 to 2012.

**1.** Resources refer to all potentially valuable mineral resources which are available for eventual economic extraction. Reserves are the resources which are legally, economically and technically feasible to extract.

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**Table 8.3** Brown coal production in the European Union by country, 2012 and 2013

| Country | 2013 (Mt) | 2012 (Mt) |
|---|---|---|
| Bulgaria | 25.4 | 30.4 |
| Czech Republic | 40.5 | 43.5 |
| Germany | 182.7 | 185.4 |
| Greece | 53.8 | 62.2 |
| Hungary | 9.5 | 9.3 |
| Poland | 65.5 | 64.3 |
| Romania | 22.9 | 32.1 |
| Slovak Republic | 2.3 | 2.3 |
| Slovenia | 3.9 | 4.3 |
| **Total** | **405.5** | **433.8** |

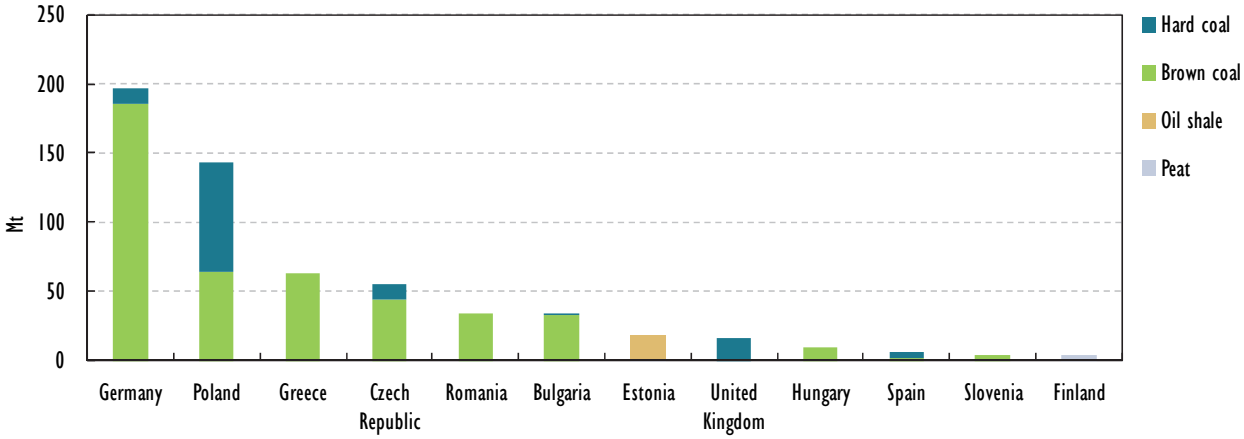
Source: Euracoal (2014), *EURACOAL Market Report 1/2014*, Brussels.

## Production of peat and oil shale

Compared to hard coal and lignite production, peat production is marginal in the European Union. In 2012, it amounted to 6.2 Mt, with 66% from Finland, 23% from Ireland, 8% from Sweden and 3% from Estonia and Lithuania. Peat production may vary widely from year to year, as rainy weather complicates harvesting. From 2002 to 2012, production averaged around 11.8 Mt per year and peaked in 2006 at 17.9 Mt.

Oil shale, which like peat is classified under coal in international energy statistics, is produced in Estonia. In 2012, production totalled 18.8 Mt. From 2002 to 2012, production grew on average by 4.2% per year.

**Figure 8.2** Hard coal, brown coal, peat and oil shale production in major EU producing countries, 2012




Sources: IEA (2014a), *Energy Balances of OECD Countries*, OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries*, OECD/IEA, Paris.



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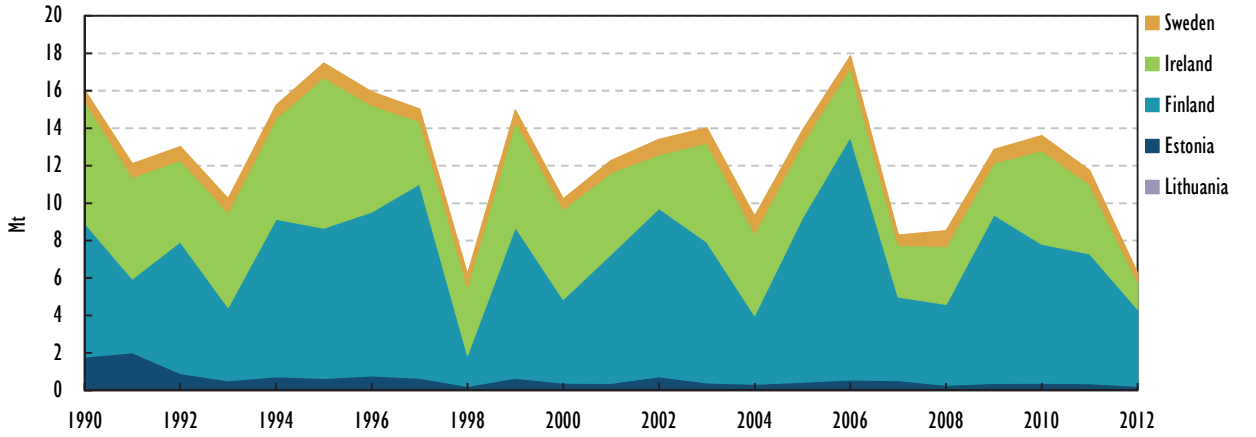
**Figure 8.3** Peat production in major EU producing countries, 1990-2012

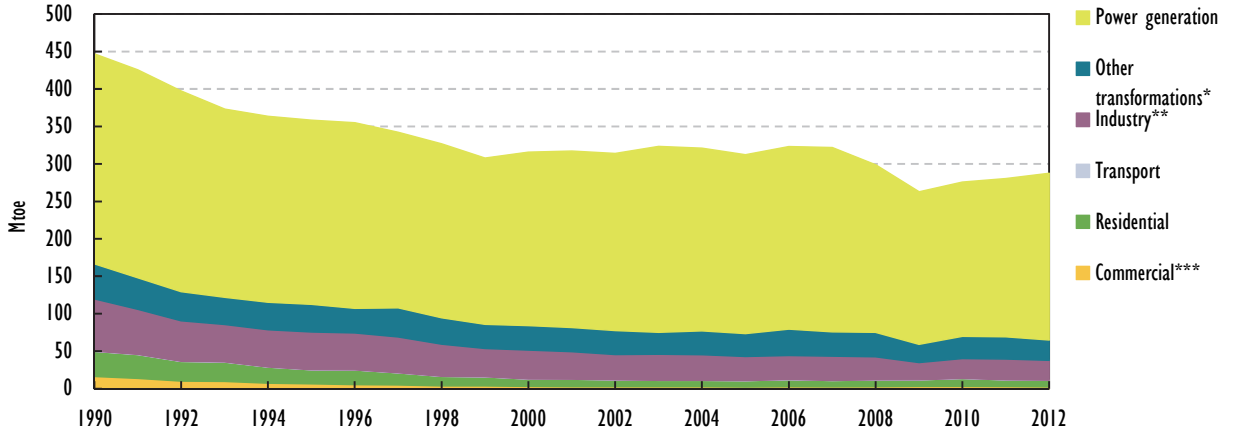



Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

## DEMAND

The power and heat sector dominates coal demand, accounting for 77% of total EU coal demand in 2012. Another 10% was used in blast furnaces and coke ovens for iron and steel production. Other industry, such as cement, accounts for 9% of coal use, the residential sector for 3% and commercial and other services for 1%. Coal demand has been declining slowly for decades, with a slight resurgence since 2009. Coal demand in industry has declined the fastest between 2007 and 2012, on average by 4.1% per year. Demand has also declined in power and heat generation by 0.2% per year, while iron and steel production has seen consumption decline by 3.5% per year during the same period. Demand in the residential sector has increased by 1.2% per year in that period.

**Figure 8.4** Coal consumption in the European Union by sector, 1990-2012




Notes: TPES by consuming sector. Includes oil shale.

* *Other transformations* includes energy own use.

** *Industry* includes non-energy use.

*** Commercial includes commercial and public services, agriculture/fishing and forestry (negligible).

Sources: IEA (2014a), *Energy Balances of OECD Countries,* OECD/IEA, Paris; IEA (2014b), *Energy Statistics of Non-OECD Countries,* OECD/IEA, Paris.

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## POLICIES AND MEASURES

### State aid rules

The hard coal industry has received subsidies both for production and for mine closure. All subsidies are regulated under EU state aid rules. In 2010, the subsidies amounted to EUR 2.9 billion for the production of 27 Mt of coal, mostly in Germany and Spain. In that same year, EU member states decided to phase out gradually the remaining subsidies by the end of 2018 (Council Decision 2010/787/EU). Until then, state aid may be granted for production in uncompetitive mines to help with their closure. Competitive hard coal production is set to continue.

Lignite production is not subsidised in the European Union.

### Environmental rules

Coal-fired power generation emits more $CO_2$ per kWh than other power plants, such as the combined-cycle gas turbines (CCGTs). One way to address this high carbon intensity is to increase plant efficiency. The European Union's coal-fired power plants are on average 36% efficient, while the most efficient plants, ultra-super critical power plants in Germany, reach an efficiency of 45%.

**Box 8.1** The Directives on Large Combustion Plants and Industrial Emissions

EU air pollution legislation is affecting the current and future prospects of coal-fired power generation.

The **LCPD** (2001/80/EC) is aimed at reducing acidification, ground level ozone and particulates by controlling the emissions of sulphur dioxide, oxides of nitrogen and dust from large combustion plants. All combustion plants built after 1987 must comply with the LCPD emission limits. Those power stations in operation before 1987 have three options for complying: 1) by installing emission abatement equipment, e.g. flue- gas desulphurisation; 2) by operating within a "National Plan" setting a national annual mass of emissions calculated by applying the emission limit value (ELV) approach to existing plants, on the basis of those plants' average actual operating hours, fuel used and thermal input, over the five years to 2000; or 3) by opting out of the directive. An existing plant that chooses to opt out is restricted to 20 000 total hours of operation after 2007 and must close by the end of 2015.

The LCPD is expected to lead to retiring 8 GW of coal-fired power capacity in the United Kingdom. In other EU countries, reductions are expected to be much lower, totalling around 10 GW. All in all, the shutdowns would affect around 2% of EU total generating capacity.

In 2011, the **Industrial Emissions Directive (IED, 2010/75/EU)** came into force, updating and merging seven pieces of existing legislation, including the LCPD. For power plants, the update tightens ELVs for sulphur dioxide (from 400 mg/Nm$^3$ to 200 mg/Nm$^3$). Operators will have to install selective catalytic reduction from 2016 to meet the nitrogen oxides (NOx) ELV. Peaking plants (<1 500 annual operating hours) can run indefinitely, a Transitional National Plan to mid-2020 allows trading in most pollutant categories to achieve emissions reductions equivalent to the directive's ELVs, and a derogation allows operators to run their plants for just 17 500 hours after 1 January 2016 before closure, which must be before the end of 2023.



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One indirect driver for increasing the efficiency ratio is air pollution legislation in the European Union which requires upgrade and the closures of old, polluting and inefficient coal-fired power plants by the end of 2015 (see Box 8.1.).

The impact of this Large Combustion Plants Directive (LCPD) will be felt mostly in the United Kingdom, while in other member countries capacity reductions will be smaller. Indeed, as new plants are taken into use in Germany and the Netherlands, total coal-fired power generating capacity will be rather unchanged in the short term. Poland faces the largest investment challenge for the modernisation of its coal-power plant fleet.

The greenhouse gas (GHG) regime and clear incentives for investment after 2020 are critical for the continued use of coal in the European Union. The United Kingdom is currently introducing a capacity market into its electricity system arrangements, which will also cover coal-fired power generation.

However, little progress has been achieved on demonstrating coal-fired power generation equipped with CCS. Current efforts are ongoing on demonstrating clean coal technologies in the European Union, notably in the Netherlands and the United Kingdom. The outlook for clean coal in the future will depend on the future progress of the European Union on the capture and storage of $CO_2$.

## GAS TO COAL COMPETITION IN POWER GENERATION

In 2012, coal was the largest source of electricity in the European Union, accounting for 28% of total supply. Coal competes against natural gas in power generation, and the relative fuel economics are largely explained by price differences, plus $CO_2$ allowance prices and other environmental regulation. These two elements have had a strong interplay in Europe.

The global coal market is currently oversupplied. Demand growth in Asia has been lower than expected, but many new large mining capacities, that were committed during the boom years 2008 to 2011, are coming online in 2012 to 2014. There has been strong production growth in Australia and Indonesia (companies trying to lower their unit cost by increasing scale of output) and reduced US coal imports from Colombia that freed-up Colombian coal for the Atlantic market. Increasing US exports are a result of the domestic shale gas boom. This all led to the global coal market being faced with over-supply.

Coal import prices plummeted from EUR 130 per tonne (t) in March 2008 to below EUR 60 per t in May 2014 at the EU import reference price. Figure 8.5 illustrates this growing price difference between gas and coal. The natural gas spot prices at the Dutch gas hub, the Title Transfer Facility TTF, and the UK National Balancing Point are portrayed against the European coal import prices expressed in cost, insurance, freight at Amsterdam-Rotterdam-Antwerp area (CIF ARA) and the US East Coast coal price, expressed as free-on-board (FOB) price.

Further, due to the combination of collapsing EU energy demand amid the economic crisis, high renewable deployment and energy efficiency measures delivering the emissions reductions required, additional action required from EU-ETS entities was lower than expected. The EU-ETS allowance prices collapsed from over EUR 30 per $tCO_2$ in 2008 to EUR 6 per $tCO_2$ in 2014. Low coal prices, supported by a low $CO_2$ price, led to a significant gas-to-coal switch in Europe, mainly in the United Kingdom, Spain and Germany, but also in the Netherlands. In fact, in relative terms, gas prices increased much more than coal prices decreased in the last couple of years.

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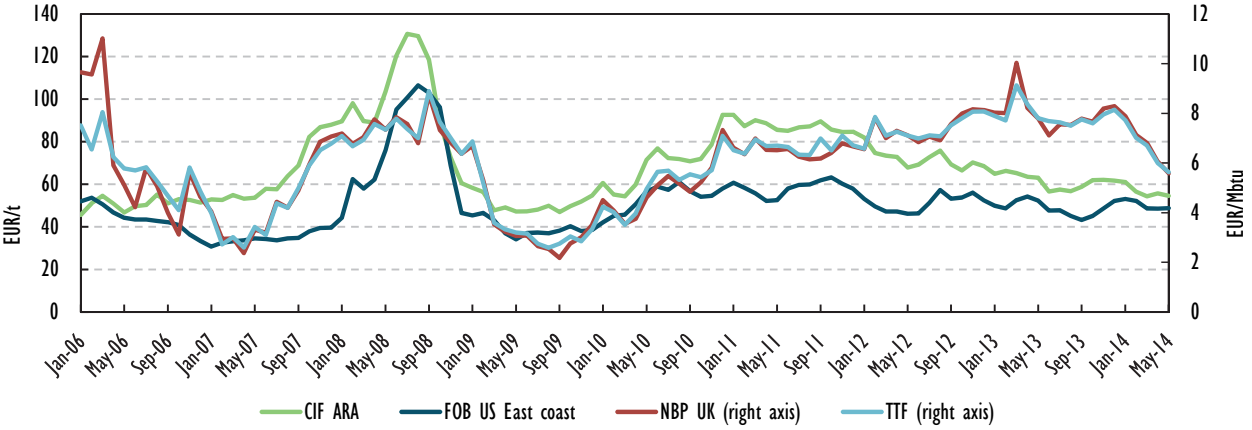
As a result of the widening gap between coal and gas prices and low carbon prices under the EU-ETS, coal has been much more competitive as a fuel for power generation. In 2014, in energy value terms, gas wholesale prices were three times higher than coal prices on average in Europe. Adjusting for the different efficiencies of coal and gas-fired power plants, the cost of gas-fired generation is about 70% more expensive.

The *World Energy Outlook* (IEA, 2014c) considers that for the cost of gas-fired generation to fall to that of coal-fired generation, the gas price would need to fall by around 40%, to USD 5.9 per MBtu. Alternatively, the price of $CO_2$ in the ETS would need to rise almost five-fold form its current level of USD 7.6 per tonne to almost USD 35.1 per tonne for a typical CCGT (57% efficiency) to break-even with a typical coal plant (37% efficiency). Or in euro values: the price of $CO_2$ in the ETS would need to rise from its current level of EUR 6 per tonne to almost EUR 27.7 per tonne for a typical CCGT (57% efficiency) to break-even with a typical coal plant (37% efficiency). Environmental regulation and the strengthening of the EU-ETS regime are needed to support effective signals for coal and gas use in power generation (see Chapter 3, "Climate Change").

Total gross power generation in the United Kingdom decreased by 5 terawatt hours (TWh) from 2011 to 2012, coal-fired generation increased by 34 TWh, but gas-fired generation decreased by 47 TWh. In Germany, coal-fired generation grew by 15 TWh, partly driven by power exports to neighbouring countries, such as the Netherlands. In Spain, coal-fired generation grew by 11 TWh, to make up for lower hydro and gas-fired generation.

**Figure 8.5** Wholesale gas prices of major hubs in the European Union and coal import prices, January 2006 to May 2014




Source: IEA (2014d), *Coal Information*, OECD/IEA, Paris., IEA (2014e), *Natural Gas Information*, OECD/IEA, Paris.

## ASSESSMENT

Since the 2008 IEA in-depth review of the European Union, coal use has increased and experienced a large renaissance in the European Union. As international coal price dynamics changed, EU carbon prices experienced a major decline but gas prices were on the rise. As a result, hard coal imports and domestic lignite production have been rising and new coal-fired power plants are being added.

Since 2011, the European Union has witnessed a dash for coal, as natural gas in several countries and nuclear power in Germany have been replaced by existing coal-power plants and new ones are coming online. Current price trends in coal, natural gas and $CO_2$ allowances are favourable to coal.



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Coal provides more than a quarter of electricity supply in the European Union and is a necessary process input in iron and steel and cement production. Power generation is the main use for coal in the European Union, accounting for almost four-fifths of total coal use. Today, many coal-fired power plants are competitive, as manifested by the 28% share of coal in power generation in the European Union.

Since 2008, new EU legislation on air pollution and the EU-ETS limit emissions from coal-fired power plants and coal use in industry. These limits will become gradually stricter over time, notably through the adoption of the new Industrial Emission Directive 2010/75/EU, calling for the closure of old inefficient coal plants. At the same time, the European Union was successful in phasing out subsidies. Inefficient hard coal mines will be closed by 2018 and state aid will need to be phased out.

The IEA considers the increase in coal use over the past few years to be of a temporary nature, caused by the relative competitiveness of cheap coal compared with expensive oil-indexed gas, as illustrated above. The IEA expects coal use in the European Union to decline towards 2020, as a result of sluggish economic growth, increasing renewable generation and efficiency gains (including from replacing old coal plants with new plants).

Coal improves the European Union´s security of supply as most of the coal used in the European Union is of domestic of origin. Europe has very large lignite coal resources, which can be profitably mined. Apart from Poland, the remaining reserves of hard coal are small and not competitive with global hard coal prices. The European Union is likely to continue to use lignite coal, as the local production remains profitable and does not compete with international markets. The use of such indigenous resources should be enabled with the promotion of efficient technologies.

The European Union's long-term decarbonisation target, however, implies that the viability of coal use in power generation will depend on its $CO_2$ intensity. Coal-fired power generation needs to become more efficient with inefficient old plants being phased out and replaced by new ones equipped with CCS. This can be complemented by tighter emission performance standards for combustion plants. Developing CCS should receive stronger attention from the European Union, as there are large lignite reserves available in the European Union which can be exploited at commercially competitive scale. The IEA encourages the European Union to continue efforts for developing CCS into a commercially viable low-carbon technology (see Chapter 3, "Climate Change"), including for clean coal applications.

As countries seek to reduce their exposure to external gas supply risks and dependence on gas imports, existing coal-fired power plants can play an important role as back-up for a gas emergency in power generation. As a temporary measure, the European Union should support the use of older plants as reserve capacity in these countries, as security benefits outweigh the limited impact from air pollution during the few hours of operation.

## *RECOMMENDATIONS*

*The European Union should:*

- *Ensure the smooth transition of the EU coal sector towards a low-carbon energy system through RD&D support, including more efficient plants, CCS, and environmental performance standards.*

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- *Continue to enhance internationally competitive and sustainable indigenous coal production and efficient coal use, while ensuring the phase-out of subsidies to fossil fuel production and consumption.*

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# 9. RENEWABLE ENERGY

**Key data (2012)**

**Share of renewable energy:** 14.1% in gross final consumption,[1] 12.1% of TPES and 24.1% of electricity generation (IEA median: 9.7% of TPES and 19.4% of electricity generation)

**Renewables in final consumption:** electricity: 23.5%; heat: 15.6%; transport: 5.1%

Source: Eurostat (2014a), *News Release, Renewable energy in the EU28*, http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/8-10032014-AP/EN/8-10032014-AP-EN.PDF, (accessed on 10 March 2014).

## OVERVIEW

Renewables already play an important role in the European Union's (EU) energy mix, accounting for 14.1% of total final energy consumption in 2012. Increasing this share is a critical step towards an energy economy that is secure and environmentally sustainable.

The Energy Roadmap 2050 of 2011, which evaluates energy scenarios to achieve a low-carbon economy by 2050, envisaged a strong growth in renewables (EC, 2011).[2] The share of renewable energy (RE) rises substantially in all the scenarios considered by the European Commission, achieving at least 55% in gross final energy consumption in 2050. The share of renewable energy in electricity consumption reaches 64% in a high energy efficiency scenario and 97% in a high renewables scenario.

This important role of renewables is also echoed in IEA analysis. For example, in the 450 Scenario[3] within the *World Energy Outlook 2013* (IEA, 2013a), renewables provide 46% of electricity globally and 58% within the European Union by 2035. In fact, this analysis indicates that renewables will play an increasingly important role in all the scenarios considered, and in all three sectors: electricity, heat and transport. Achieving a growing share of RE is therefore an essential step in developing a sustainable energy system.

The European Union has established a 2020 target of 20% of RE as a proportion of gross final consumption, and EU leaders agreed to at least 27% of RE for 2030. Reasonably good progress is being made towards the 2020 target. However, as the share of RE rises, the Union faces new challenges – particularly in integrating higher shares of variable renewable electricity from wind and solar photovoltaics (PV) and in developing

**1.** Gross final consumption of energy is defined in Directive 2009/28/EC on renewable sources as energy commodities delivered for energy purposes to final consumers (industry, transport, households, services, agriculture, forestry and fisheries), including the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission. The gross final consumption of energy from renewable sources is calculated as the sum of: (a) gross final consumption of electricity from renewable energy sources; (b) gross final consumption of energy from renewable sources for heating and cooling; and (c) final consumption of energy from renewable sources in transport.

**2.** See www.roadmap2050.eu.

**3.** A scenario presented in the IEA *World Energy Outlook 2013* that sets out an energy pathway to 2035 consistent with the goal of limiting the global increase in temperature to 2°C by limiting concentration of greenhouse gases in the atmosphere to around 450 parts per million of $CO_2$.

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sustainable biofuels. There are signs that policy uncertainty may threaten the achievement of the 2020 goals. Further steps are needed to provide the long-term policy stability needed to maintain momentum in the sector.

## INSTITUTIONS

Within the European Commission, the Directorate-General for Energy is the lead organisation as far as policy issues relating to the regulatory framework for RE is concerned.

Many other Directorate-Generals (DGs) have an interest in RE issues and design policies, and administer EU funding programmes, including the DGs for Agriculture and Rural Development, Climate, Competition, Environment, Mobility and Transport as well as Research and Innovation.

Several EU agencies support RE projects on the ground and contribute to the administration of European Union funding under cohesion and research policies and programmes such as Horizon 2020 (see Chapter 11, "Energy Research, Development and Demonstration").

## POLICIES AND SUPPORT MEASURES

### LEGAL FRAMEWORK AND TARGETS

Since the last in-depth review of the European Union in 2008, the EU Renewable Energy Directive (RED) (2009/28/EC Promotion of the use of energy from RES) was introduced and adopted in 2009. This Directive establishes a common framework for the use of energy from RES in order to limit greenhouse gas (GHG) emissions and to promote cleaner transport.

Under the provisions of the Directive, each member state has a target calculated for the share of energy from RES in its gross final consumption for 2020. When aggregated, these targets are consistent with the overall goal of achieving a 20% contribution of renewables by 2020 and in line with the overall "20-20-20" goal. These targets, which reflect member states' different starting points and potential for increasing renewables production, range from 10% in Malta to 49% in Sweden. In addition, the share of energy from RES in transport must amount to at least 10% of final energy consumption in the sector in each member state by 2020.

Each member state is required to establish a national RE action plan (NREAP) that shows how it expects to achieve that the target. These action plans show the anticipated levels of energy from RES consumed in electricity, heating and transport in 2020, taking into account the effects of energy efficiency measures on final energy consumption. These plans must also establish the policy and other measures to be established to deliver the targets, such as support schemes, procedures for the reform of planning and pricing schemes, access to electricity networks, and the promotion of energy from RES. The Directive set interim targets for each member state for 2011/12, and there is also an indicative annual trajectory towards the 2020 target for the electricity, heat and transport sectors. The NREAPs will be reviewed and, if necessary, revised in 2015 in the light of progress and the need for "course correction" to ensure that the binding national targets will be achieved.

The Directive provides for member states to "exchange" an amount of energy from RES using a statistical transfer or to set up joint projects concerning the production of electricity and heating from RES. It is also possible to establish co-operation with third countries if certain conditions are met.



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The Directive also requires member states to build the necessary infrastructure for energy from RES by ensuring that operators guarantee the transport and distribution of electricity from RES and provide for priority access for this type of energy.

The Directive takes into account the importance of the overall sustainability of biofuels for transport. It sets a requirement that biofuels should provide a reduction of at least 35% of GHG emissions compared to the fossil fuels they replace. This reduction needs to increase to 50% from 1 January 2017. In order to comply with sustainability criteria, biofuels must not be produced on land with high biodiversity value or with high carbon stock.

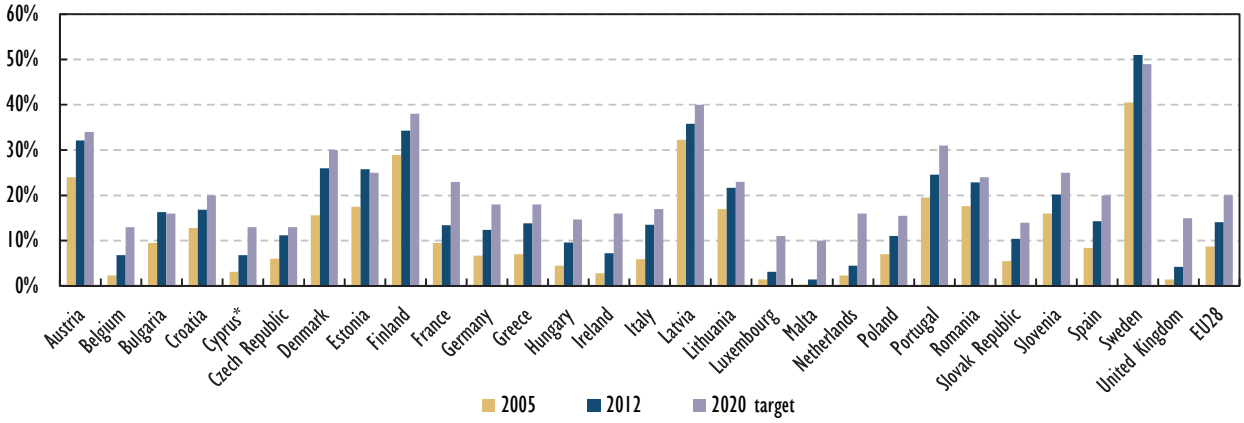
## RENEWABLE ENERGY IN FINAL CONSUMPTION

The share of gross final energy consumption from renewable sources in the European Union increased from 8.7% in 2005 to 12.5% in 2010, and to 14.1% in 2012. The progress made by each country is shown in Figure 9.1 and in Table 9.1 (which also includes the indicative minimum target for 2011-12 contained in the NREAPs together with the interim 2011-12 and 2020 targets, as cited in the RED).

There have been significant increases in the proportion of RE in each country. Three countries (Bulgaria, Estonia and Sweden) already have renewable shares above their 2020 targets. In 2012, only two countries (Malta and the Netherlands) were below the indicative minimum target established for 2011-12 in the NREAPs, so overall progress towards the goal is promising.

The following sections of this chapter look in more detail at the trends in RE production in the European Union in electricity, heat and transport. The sections compare these trends with global developments over the same period and look at the prospects for achieving the targets for 2020, using the forecast data contained in the IEA *Medium-Term Renewable Energy Market Report 2014* (*MTRMR 2014*) (IEA, 2014a).

**Figure 9.1** Share of renewables in gross final energy consumption in 2005, 2012 and 2020 target




* Two footnotes: 1. **Footnote by Turkey:** The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue". 2. **Footnote by all the European Union Member States of the OECD and the European Union:** The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

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**Table 9.1** Share of renewable energies in gross final energy consumption in 2005, 2010 and 2011/12, along with the 2011/12 NREAP targets and 2020 targets

| | 2005 | 2010 | 2011/2012 Average | Interim Target for 2011/2012 | 2020 Target |
|---|---|---|---|---|---|
| Austria | 24.0 | 30.8 | 32.1 | 26.3 | 34 |
| Belgium | 2.3 | 5.0 | 6.8 | 4.36 | 13 |
| Bulgaria | 9.5 | 14.4 | 16.3 | 10.72 | 16 |
| Croatia | 12.8 | 14.3 | 16.8 | | 20 |
| Cyprus | 3.1 | 6.0 | 6.8 | 4.92 | 13 |
| Czech Republic | 6.0 | 9.3 | 11.2 | 7.48 | 13 |
| Denmark | 15.6 | 22.6 | 26.0 | 19.6 | 30 |
| Estonia | 17.5 | 24.6 | 25.8 | 19.4 | 25 |
| Finland | 28.9 | 32.4 | 34.3 | 30.4 | 38 |
| France | 9.5 | 12.7 | 13.4 | 12.2 | 23 |
| Germany | 6.7 | 10.7 | 12.4 | 8.24 | 18 |
| Greece | 7.0 | 9.8 | 13.8 | 9.12 | 18 |
| Hungary | 4.5 | 8.6 | 9.6 | 6.04 | 14.65 |
| Ireland | 2.8 | 5.6 | 7.2 | 5.68 | 16 |
| Italy | 5.9 | 10.6 | 13.5 | 7.56 | 17 |
| Latvia | 32.3 | 32.5 | 35.8 | 34.08 | 40 |
| Lithuania | 17.0 | 19.8 | 21.7 | 16.6 | 23 |
| Luxembourg | 1.4 | 2.9 | 3.1 | 2.92 | 11 |
| Malta | 0.3 | 0.4 | 1.4 | 2 | 10 |
| Netherlands | 2.3 | 3.7 | 4.5 | 4.72 | 16 |
| Poland | 7.0 | 9.3 | 11.0 | 8.76 | 15.48 |
| Portugal | 19.5 | 24.2 | 24.6 | 22 | 31 |
| Romania | 17.6 | 23.2 | 22.9 | 19.04 | 24 |
| Slovak Republic | 5.5 | 9.0 | 10.4 | 8.16 | 14 |
| Slovenia | 16.0 | 19.2 | 20.2 | 17.8 | 25 |
| Spain | 8.4 | 13.8 | 14.3 | 10.96 | 20 |
| Sweden | 40.5 | 47.2 | 51.0 | 41.64 | 49 |
| United Kingdom | 1.4 | 3.3 | 4.2 | 4.04 | 15 |
| **European Union 28** | **8.7** | **12.5** | **14.1** | | **20** |

Source: Directive 2009/28/EC and national renewable energy action plans and Eurostat (2014a), *News Release, Renewable Energy in the EU28*, http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/8-10032014-AP/EN/8-10032014-AP-EN.PDF, (accessed on 10 March 2014).



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## RENEWABLE ELECTRICITY

### Global trends in renewable electricity generation

Globally renewables power generation increased by 43% between 2005 and 2012 with the overall share in electricity demand rising from 18.4% to 21.8% despite a strong overall growth in global electricity demand (21%). Globally, generation from hydro grew strongly during that same period (by 24%), particularly in China and other rapidly developing economies in Africa, Asia and South America. (This is in contrast to the European Union, where growth in hydro-generation has been modest). Non-hydro renewables have grown by a factor of three over the same period, increasing from 2% to 5% of total global electricity generation, with strong growth in wind and, in recent years, in solar PV.

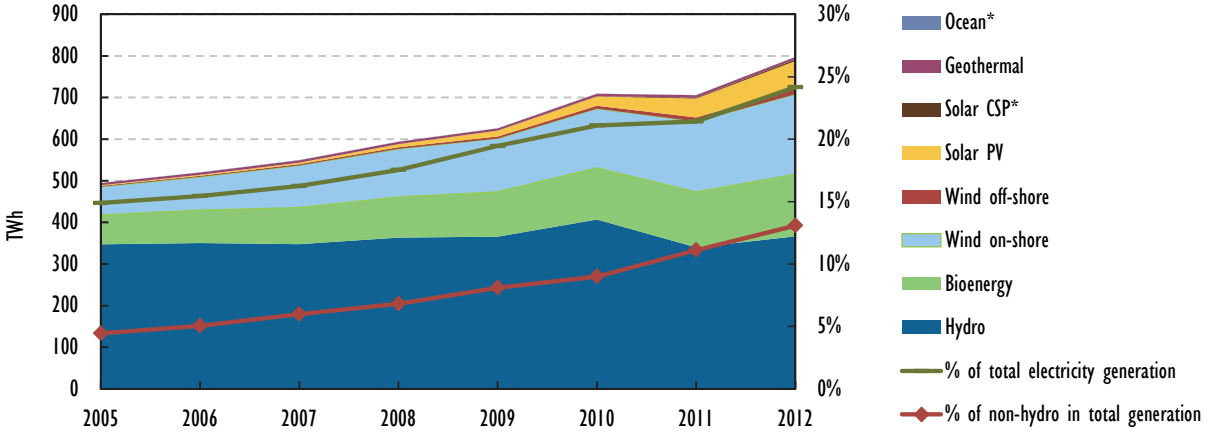
### EU trends in renewable electricity generation

Renewables generation in the European Union has consistently shown strong growth since non-hydro renewables first entered the market and, between 2005 and 2012, they increased threefold. Figure 9.2 shows the trends in renewables electricity generation in the European Union between 2005 and 2012. Growth has been particularly strong in wind, which is now the second most significant hydro technology, and in PV, where generation has increased by a factor of 56 since 2005.

Figure 9.2 also shows that between 2005 and 2013 the percentage of electricity in the EU mix has grown from 14.9% to 26.1%. This growth is due almost exclusively to the increase in non-hydro renewables, which grew from 4.4% to 14.5% of total generation.

In 2012 there was a wide variation in the shares of renewables in the electricity generation of each country, as illustrated in Figure 9.3. Seventeen countries already receive more than 20% of electricity from renewables. Six countries receive over 50% of their electricity from renewables, mostly countries with good, well-developed hydro resources. However, a number of countries are now reaching high shares of non-hydro renewables. Denmark generated over 48% of its electricity from non-hydro renewables in 2012, and seven other countries had shares of 15% or more.

**Figure 9.2** Trends in EU renewable electricity generation by technology 2005-12




* Negligible.

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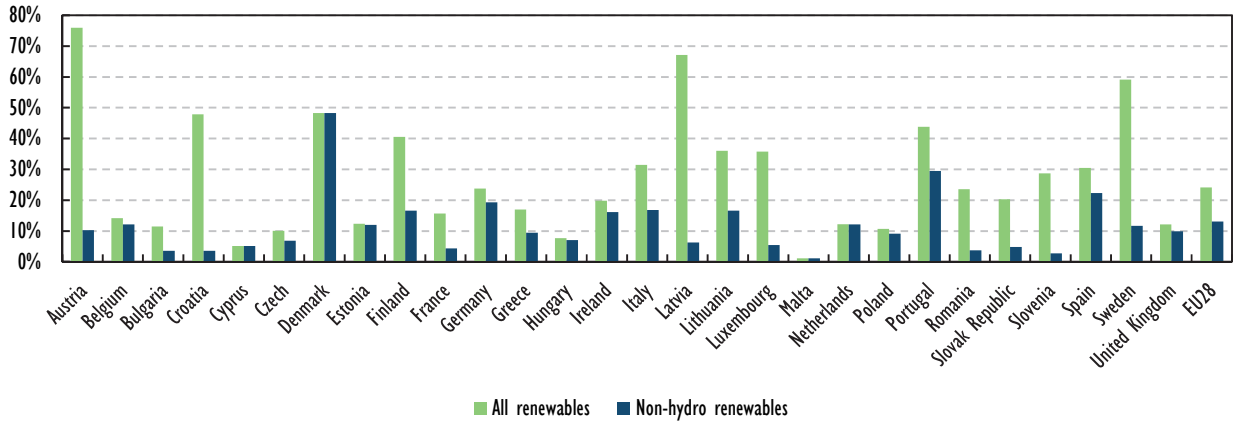
**Figure 9.3** Shares of renewable electricity generation by EU member state, 2012



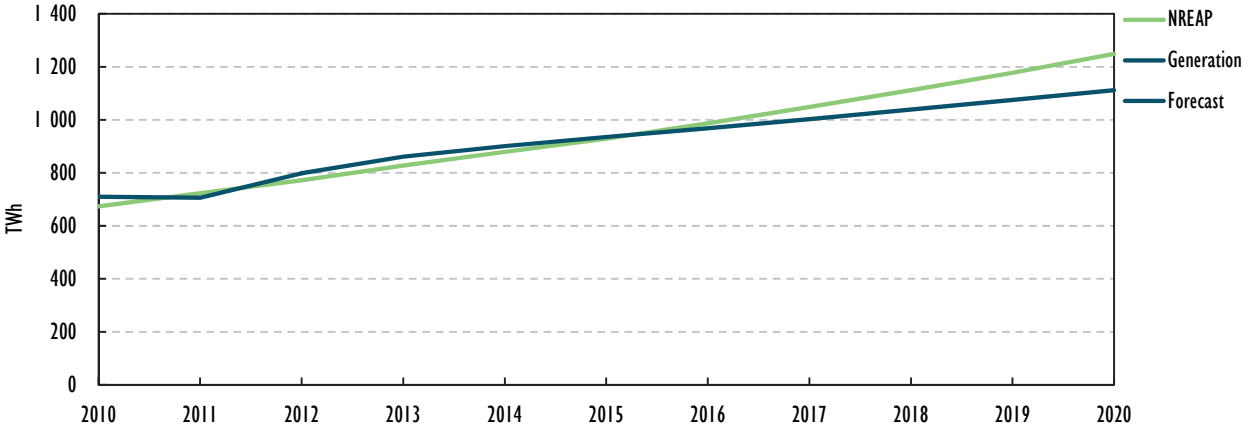

Source: Eurostat (2014b), *Renewable Energy Statistics*, Database of Eurostat (nrg_105a) and (tsdcc330), (accessed on 14 November 2014).

## Comparison with the national action plans

The NREAPs, prepared by each country, show indicative levels for renewable electricity generation for 2020 consistent with the binding targets for renewables as a share of gross final energy consumption along with indicative "paths" that provide annual milestones towards reaching that goal.

In 2012, overall renewables generation in the European Union was ahead of the trajectory in the plans, as shown in Figure 9.4. This figure also compares the indicative NREAP figures to 2020 with the projections that are included in the MTRMR 2014 (IEA, 2014a). These projections are based on a detailed market analysis for the major renewables markets. Trends to 2020 will lead to a continuing growth in renewables generation, but there may be a shortfall of around 105 TWh (or 9% of the NREAP total for 2020) unless policy initiatives are taken to stimulate the market in some countries.

**Figure 9.4** Comparison of actual and IEA forecast electricity generation of renewables with NREAPs




A more detailed look at the figures indicates important differences in performance and projections for the different countries and technologies. Figure 9.5 compares the EU generation in 2012 for each technology with the indicative NREAP trajectory. The results shown indicate that hydro and offshore wind are behind target, but this is made up for



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by extra generation from bioenergy and, particularly, from PV, where generation is twice the level foreseen in the NREAPs. Figure 9.5 also looks forward to 2020 and compares the IEA forecast generation with the NREAP targets. Generation from solar PV is anticipated to remain ahead of the original target, producing some 50 TWh more than the sum of the original NREAPS. Other technologies – notably off-shore wind – are expected to underperform.

**Figure 9.5** Difference between 2012 generation and 2020 NREAP target, by technology

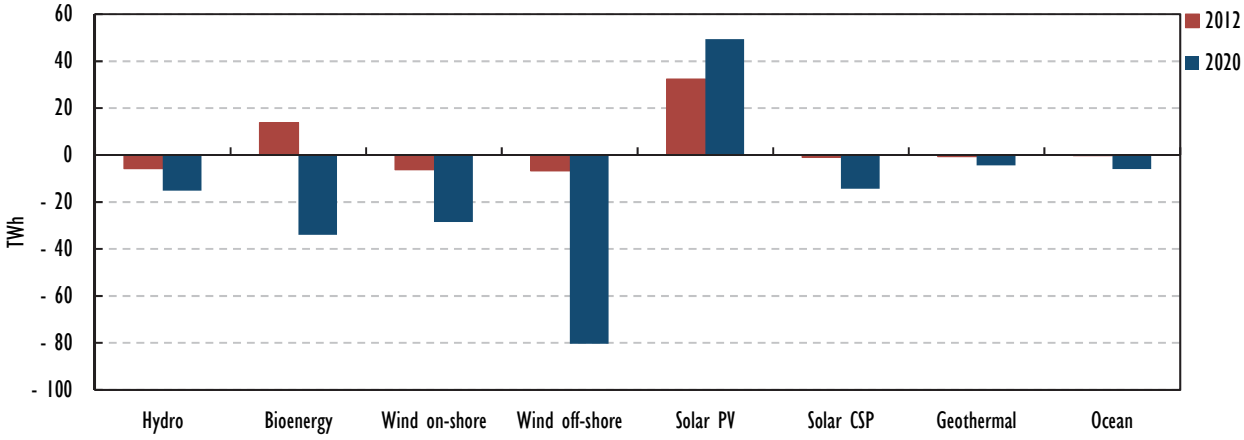
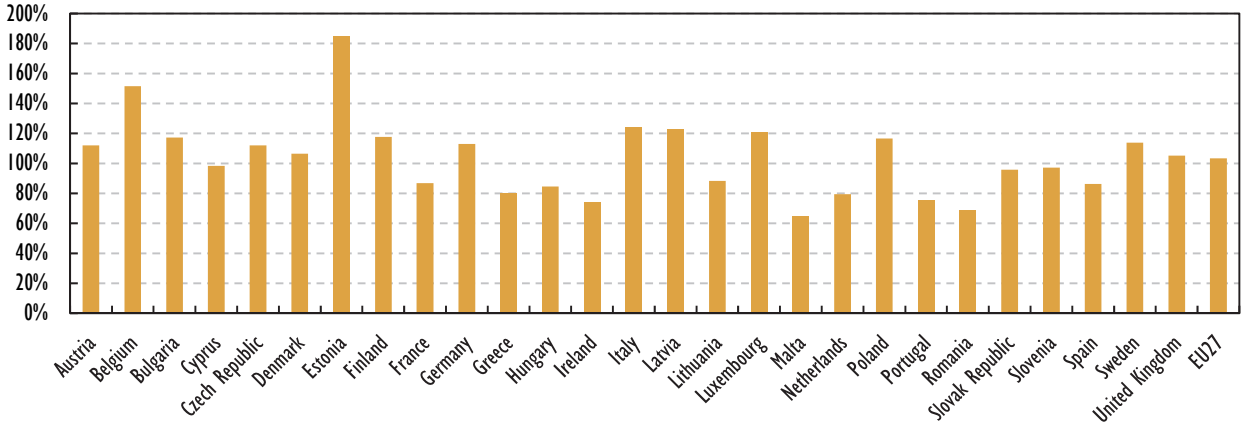



**Figure 9.6** Percentage of renewables electricity target achieved by each EU member state, 2012




In terms of country performance, four countries exceeded their target expectations in 2012 by more than 20% (Estonia, Italy, Latvia and Luxembourg), while six are also currently undershooting by a similar margin (Greece, Ireland, Malta, the Netherlands, Portugal and Romania) (Figure 9.6). However, in absolute terms, France is most significantly undershooting the 2012 target, while Italy and Germany are furthest ahead of target, with most of the extra generation provided by PV.

Comparison between the IEA forecasts at country level and the NREAP targets for 2020 (Figure 9.7) suggests that Denmark, Estonia, Italy and the United Kingdom may significantly over-achieve the electricity targets, whereas nine countries will undershoot their targets by more than 20% (Cyprus, France, Greece, Hungary, Malta, the Netherlands, Romania, the Slovak Republic and Spain).

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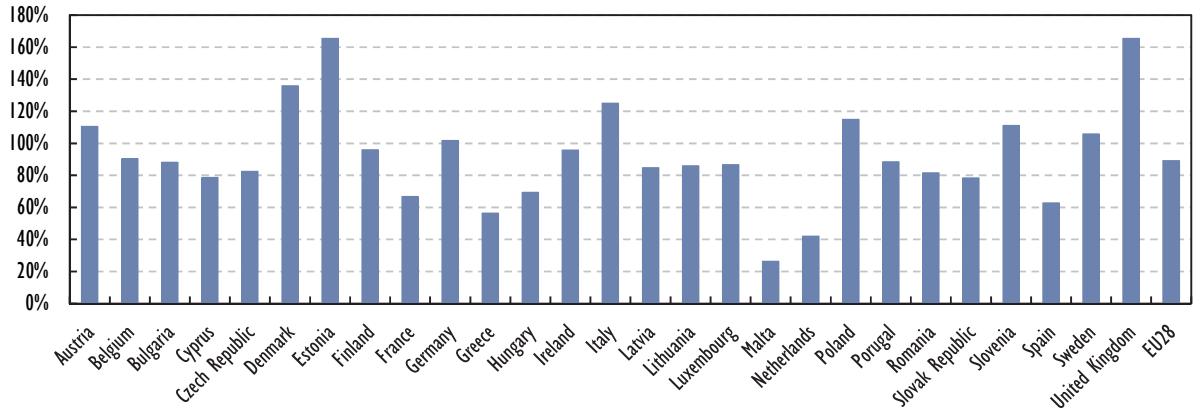
**Figure 9.7** Forecast percentage by 2020 achieved by each EU member state




It should be noted that, due to economic downturn in many countries, electricity demand has grown less in recent years than projected when the NREAPs were first developed. So while it currently appears that the European Union as a whole – and several countries in particular – may undershoot their NREAP trajectories in terms of TWh generated, in fact, the contribution as a share of electricity demand and final energy demand may still be on track. The revision of the NREAPs in 2015 will provide an opportunity to re-calibrate ambitions, plans and policies that will provide course corrections.

## Deployment

As the analysis above shows, RED has a robust framework with ambitious targets, which has led countries to put support measures for renewables in place and stimulated deployment of additional renewable electricity capacity and generation. Since 2005, the level of renewable generation in the electricity mix has risen from 15% to 23.5%, and the level of non-hydro renewables has risen from 4.4% to 14.8%. Most countries are close to their indicated levels of deployment in 2013. However, the analysis also suggests that, while deployment will continue to grow to 2020, some significant shortfalls compared to national plans may occur unless policy measures are taken to stimulate further deployment.

Along with other global developments, these growing markets have stimulated significant cost reductions, particularly in onshore wind and solar. In favourable cases, the technologies can now compete with new-build fossil fuel generation when the full costs (including capital, operating and fuel costs) are compared – although competition with existing generation assets is tougher). These cost reductions mean that future deployment in the European Union will not depend so heavily on financial incentives.

## EU market share

EU deployment has made up the dominant share of new capacity in wind and PV, thus serving as the main driver of global cost reductions. The EU share of global PV generation rose from 36% to 70% between 2005 and 2012 before falling back to 59% in 2013. The European Union was responsible for 67% of onshore wind generation in 2005, although this level has fallen to 36% in 2013 as wind markets have accelerated in China, the United States and many other markets. Offshore wind deployment has been based almost exclusively in EU markets. Looking forward, however, IEA forecasts suggest that these markets shares will reduce as the technologies are more widely adopted.



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Early deployment of these new technologies in EU member states has played a key role in pushing these technologies along the "learning curve" and facilitating cost reduction. The increased technical and commercial maturity, as well as lower costs, has enabled renewables deployment in a much wider range of emerging and developing countries which are now deploying renewables as a competitive component of an expanding electricity system.

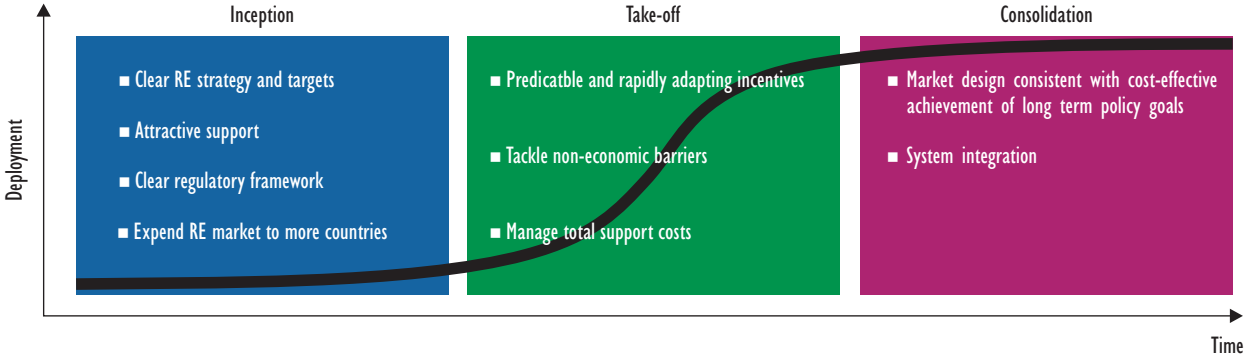
## Policy implementation and effectiveness

Previous IEA analysis (IEA, 2011; see Figure 9.8) has noted that three different phases in renewables deployment can be identified, with the most significant issues and required policy measures changing as deployment levels grow. In the first phase, *inception*, a climate allowing investment in early projects is created; next, in the *take-off* phase, managing support policy costs becomes critical. Finally, in the *consolidation* phase integration issues come to dominate. At this point, renewables can no longer be considered in isolation since they have impacts across the whole electricity system, which needs to evolve to accommodate them. In the electricity sector the RED has played an important role in enabling the progress of EU markets through the first two phases.

The binding targets and the need to produce NREAPs have triggered the development and implementation of a range of national policy measures aimed at stimulating deployment. The RED did not provide specific guidance on the types of policies that could be used to stimulate deployment, leaving this to each member state. This led to different types of financial support schemes in different countries – in particular, to feed-in tariffs (FiT) and certificate schemes.

IEA and other assessments of policy effectiveness have indicated that while both types of schemes can be effective in stimulating deployment, FiTs have been more cost-effective since they provide a greater security around income flows to investors, thus reducing financing costs. Certificate schemes provide less certainty about income and involve significant transaction costs so that not all the certificate value is received by projects. There has been a general trend towards FiT and, more recently, feed-in premium schemes as the way to support renewables through the *inception* and *take-off* phases (see Figure 9.9).

**Figure 9.8** Changing priorities in renewable energy policies




Source: IEA (2011), *Deploying Renewables*, OECD/IEA, Paris.

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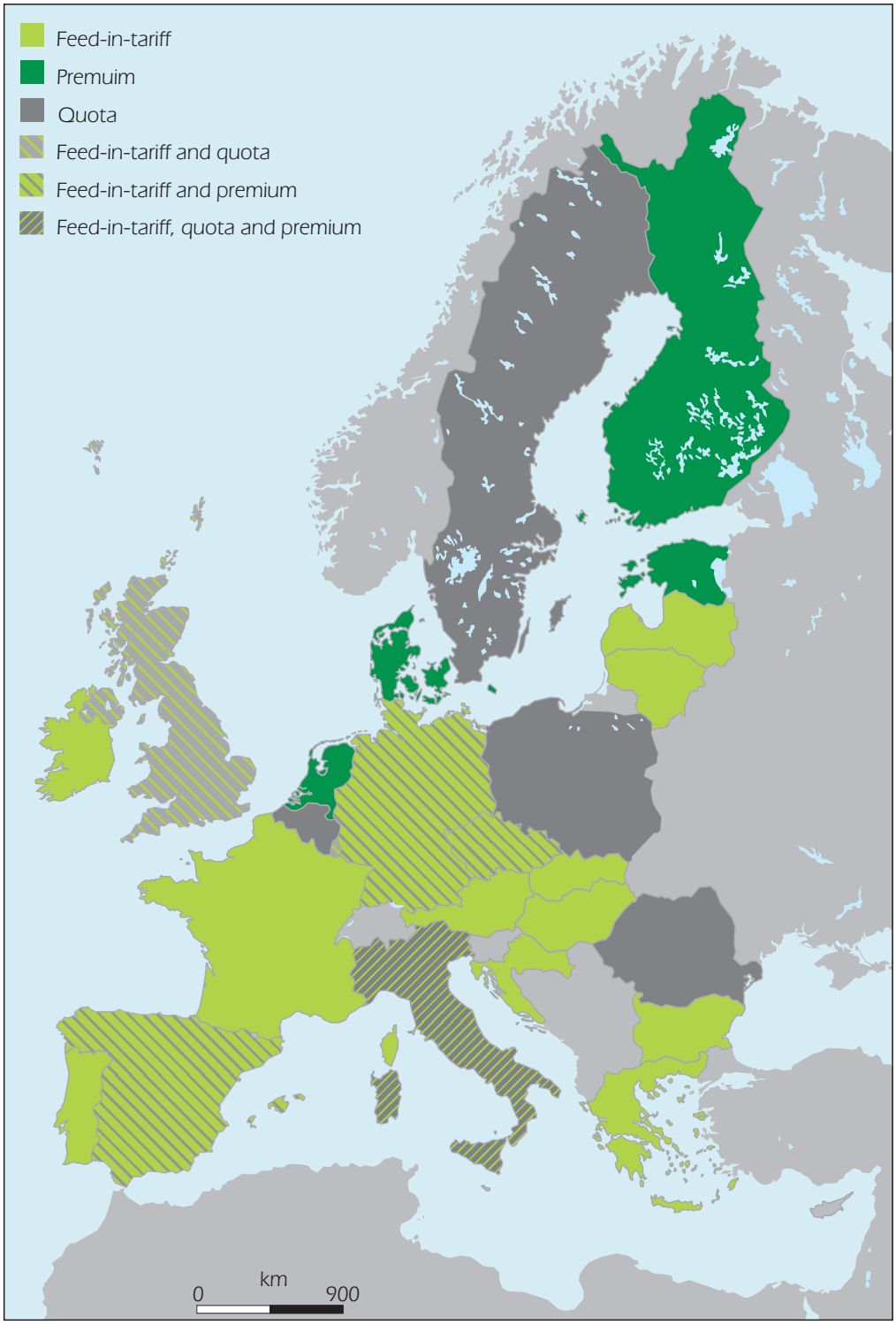
**Figure 9.9** Renewable support schemes, 2013




This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.



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A range of different types of support mechanisms have been used, which in general have stimulated deployment at rates and costs in line with expectations. The exception to this is solar PV. In a number of countries, including the Czech Republic, Italy and Spain, deployment levels have been much higher than envisaged in the NREAPs.

Since PV had been among the highest cost technologies (before recent price reductions), this extra reliance on PV to meet targets has pushed renewables support costs above envisaged levels. This was usually the case where generous FiTs for PV were in place and where the volumes of deployment were not controlled or capped, and support mechanisms were not sufficiently responsive to rapidly falling costs. This meant that PV developers could earn very high rates of return on their capital and led to overheated markets and rapid rises in support costs.

These trends have placed policy makers in difficult positions. They have often reacted by dramatically reducing tariffs and/or introducing retrospective measures aimed at recouping some of the costs (in Spain, for example). These measures have had a very detrimental impact on investor confidence by undermining confidence in the governments' commitment, which will be difficult to repair. This has often had an impact on other renewable technologies in the same country.

The policy lessons are clear – FiT and other support mechanisms should have a built-in control on deployment volumes and include sufficient flexibility to allow tariffs to be adjusted through a transparent process as deployment levels rise and costs fall. Retroactive measures have a long-lasting and very detrimental impact on investor confidence and should be avoided wherever possible.

In other countries, support mechanisms and levels of financial support have been reviewed and adjusted in a managed way in light of experience, decreasing technology costs and the need for support, with tariff level reductions linked to deployment levels.

While significant levels of financial support have been needed for the early stages of deployment (particularly for PV), the level of support required for the additional deployment required to meet the 2020 target, as well as for future renewable electricity deployment, will be much lower given current and anticipated cost reductions.

In some markets, where early deployment has been more rapid and costly than anticipated, support schemes have been drastically cut back or moratoriums on future deployment instigated. These measures, however, are leading to a loss of momentum that threatens achievement of the planned levels of renewables electricity deployment. This would be unfortunate given that costs of further deployment will be much lower and that the "heavy lifting" necessary to work down the learning curve has already been done. In order to ensure that the targets are achieved, a number of countries will have to review or re-institute favourable policy measures in order to stimulate the necessary investment and deployment

Understandably, member states will want to achieve their targets at the lowest possible cost. Policy analysis indicates that policy choices have a distinct impact on the costs of delivered renewable electricity. The overall determining factor is providing a stable investment climate which boosts investor confidence. Since the costs of renewables are virtually all associated with investment rather than operating costs, the cost of electricity is radically affected by the costs at which capital can be provided; this in turn depends on the perceived risks. Policy-associated risks are seen by investors as those they are least able to control.

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Even where renewables are financially attractive (with or without financial policy support), there are a range of other non-economic barriers that may increase project risks and costs, and so either dissuade investors or increase the price at which they are prepared to invest. Complex and costly permitting processes are a good example. While several countries have made good progress in improving such issues – for example, by clarifying or providing a one-stop-shop for approval processes, overall progress on this front has been disappointing.

The European Commission has developed guidance on good practices for effective and efficient policy, which takes into account the capital-intensive nature of the technologies and the cost of capital on energy prices, while moving away from FiT systems. There is further scope for quantifying and evaluating the effectiveness and costs of the range of policies in order to develop an evidence-based approach to what constitutes best practice.

## Entering the *consolidation* phase

In several member states, the level of electricity generation from variable renewable sources has now risen to a level above 20%, and the market is, therefore, now reaching the *consolidation*, the third phase of development. In this phase, renewables generation can no longer be thought of as a minor addition to the system but starts to have impacts on the electricity system as a whole – in particular, requiring greater levels of flexibility from other generators and impacting electricity wholesale prices, market operations and the business models of large-scale utilities. In this last phase of market deployment, so far, policy experience is limited, and best practice models have yet to evolve.

The most advanced European renewable electricity markets are now seeing the overall system impacts of higher shares of variable renewables in the system. While some systems have been able to adapt successfully (notably, Denmark and Ireland), in other markets the impacts have been more obvious. For example, in Germany renewables flows from north to south have put significant pressure on grid capacity. Large volumes of electricity from solar PV have radically altered the net demand profile and had an impact on wholesale prices and the business models of incumbent generators.

At a time when European power demand has not been growing, the growing volumes of renewables generation have had the inevitable effect of reducing generation from other sources and impacting the business models and profitability of the large incumbent generators. However, these impacts result from the combination of a number of factors, not just renewables, including: low power demand and over-capacity as a result of the economic downturn and crisis, high gas and low coal prices, and a very low carbon price. Clearly, it is more difficult to increase renewable generation in a market where power demand is essentially stable than in a market where demand is growing dynamically (as is the case in many emerging and developing economies, where renewables are playing an important role in meeting growing demand). In a stable market, renewables have to compete with the marginal costs of existing generation.

The IEA has recently published a comprehensive review and evaluation of the challenges of integrating high levels of variable renewables into the electricity system: *The Power of Transformation, Wind, Sun and the Economics of Flexible Power Systems* (IEA, 2014b). The study shows that integrating high shares of wind and solar PV in power systems can come at little additional cost in the long term. However, costs depend on how flexible the system is currently and what strategy is adopted to develop system flexibility over the long term. The report says that for any country, integrating the first 5-10% of



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variable renewable energy (VRE) generation poses no technical or economic challenges at all provided that three conditions are met: uncontrolled local "hot spots" of VRE deployment must be avoided; VRE must contribute to stabilising the grid when needed; and VRE forecasts must be used effectively. These lower levels of integration are possible within existing systems because the same flexible resources that power systems already use to cope with variability of demand can be put to work to help integrate variability from wind and solar. Such resources can be found in the form of flexible power plants, grid infrastructure, storage, and demand-side response. This reflects European experience.

The report notes, however, that going to higher levels, i.e. beyond 30% of variable renewable generation, will require a transformation of the system. This transformation has three main requirements: deploying variable renewables in a system-friendly way using state-of-the art technology; improving the day-to-day operation of power systems and markets; and, finally, investing in additional flexible resources.

The challenges of such transformation depend on whether a power system is (a) "stable," meaning no significant investments are needed to meet demand in the short term, or (b) "dynamic", meaning it requires significant short-term investments to meet growing power demand or to replace old assets.

In stable systems, such as those in Europe, the existing asset base can help to provide sufficient flexibility to increase VRE generation further. In the absence of demand growth, however, increasing VRE generation in stable systems is inevitably detrimental to incumbent generators thus putting the system as a whole under economic stress. The transformation challenge in stable systems such as Europe is, therefore, twofold: scaling up a new, flexible system while scaling down the inflexible part of the old.

## EU-wide synergies

There are, in principle, cost advantages that could be achieved by optimising renewable generation in areas with the best resources – for example, solar PV in southern Europe or wind in northern regions such as Scotland. The RED takes account of this through allowing national targets to be met by allowing the use of flexibility mechanisms including statistical transfers and joint projects.

Some member state NREAPs acknowledged the need to make use of such mechanisms to meet the binding national targets, and the development of some projects has been actively considered (for example, between Ireland and the United Kingdom). There have, however, been no examples so far of these co-operation mechanisms being put into practice (except for the common green certificate scheme between Sweden and Norway). The Commission has recently issued helpful new guidance on how such mechanisms could be used.

It should be noted, however, that the situation is more complicated and that it is not just a question of minimising production costs. The value of the electricity produced – which depends on the location and on the time of production – must also be considered. Huge quantities of additional wind power in northern Europe would necessitate very considerable investment in transmission lines to take the power to where it is needed. Similarly, large additional volumes of solar PV in the southern regions would increase the need for investments in grid infrastructure and produce a peak in electricity production, which might not be well matched to demand patterns, and may occur at times when power prices would be low. Therefore, a well-distributed pattern of renewables generation throughout Europe is likely to provide a more valuable contribution to overall system operation.

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A further complicating factor is that the costs of renewable generation are very strongly influenced by the costs of financing. The underlying interest rates and availability of capital vary widely across Europe. This means that production costs are influenced as much by the financial environment as by the renewable resource level. Until there is greater financial convergence across Europe, or ways are found to make lower cost capital uniformly available, the playing fields will remain uneven.

The ability of Europe to use a diverse portfolio of renewables in terms of the range of technologies as well as the place and timing of generation is a major potential advantage. However, realising the advantages of such diversity requires a much better integrated system – both physically in terms of interconnections, and in terms of market integration. This would facilitate the optimum use of generation and also allow the best use to be made of the range of flexibility options needed to integrate high shares of renewables. The success of Denmark in achieving very high shares of wind in their electricity mix depends largely on the high level of interconnectivity with their neighbouring countries.

Improving the level of interconnection across Europe is probably the most significant step that could be taken to facilitate the development of a more effective pan-European renewable system. Facilitating such investment should be a priority within EU structural funding and in the activities of the European Investment Bank (EIB).

## HEAT

### Global trends in renewable heat production

A major proportion of energy is used globally to provide heat for use in buildings and industry; 40% of gas and 20% of both coal and oil are used to produce heat, with major consequences for energy security, and with environmental impacts from fossil fuel use. In addition, there is a rapid growth in energy used for cooling. There is a well-developed suite of technologies for providing heat from biomass, solar and geothermal sources, and, in the right circumstances, these technologies can be cost-competitive.

The IEA believes that more attention needs to be given to renewable heat. A comprehensive review of market, technology and policy developments has recently been published in *Heating without Global Warming* (IEA, 2013b). The *MTRMR 2014* (IEA, 2014a) includes a detailed market analysis and forecast for renewable heating. Renewable heat (excluding traditional biomass use) currently provides around 8% of global demand in the heat sector, and this is forecast to rise to around 10% by 2020.

### EU deployment trends

The use of renewable heat grew within the European Union by 63% between 2005 and 2012. A further increase of 57% on the 2012 generation would be needed to meet the 2020 target figure in the NREAPs.

Figure 9.10 shows how the various heat technologies are expected to contribute to these increases. Bioenergy is expected to remain the most significant technology, but with significant increases seen also in the deployment of heat pumps and solar thermal technologies.

Figure 9.11 compares the achieved share of renewables in gross final consumption in the heat sector in 2012 based on the indicative figures within the NREAPs for each country between 2012 and 2020. All but four countries are achieving or exceeding the planned



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trajectory for 2012, and in ten countries the contribution already exceeds that planned for 2020. While continued efforts will be required to spur the deployment of renewable heat, the signs indicate that in most cases this element of the renewable action plans will be achieved.

**Figure 9.10** Heat technologies and their development as planned under the NREAPs towards 2020

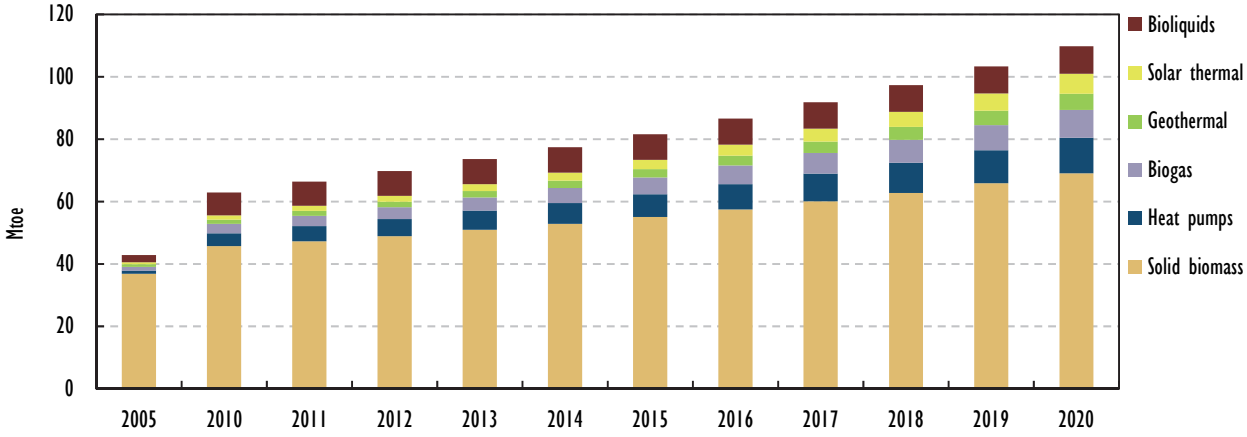
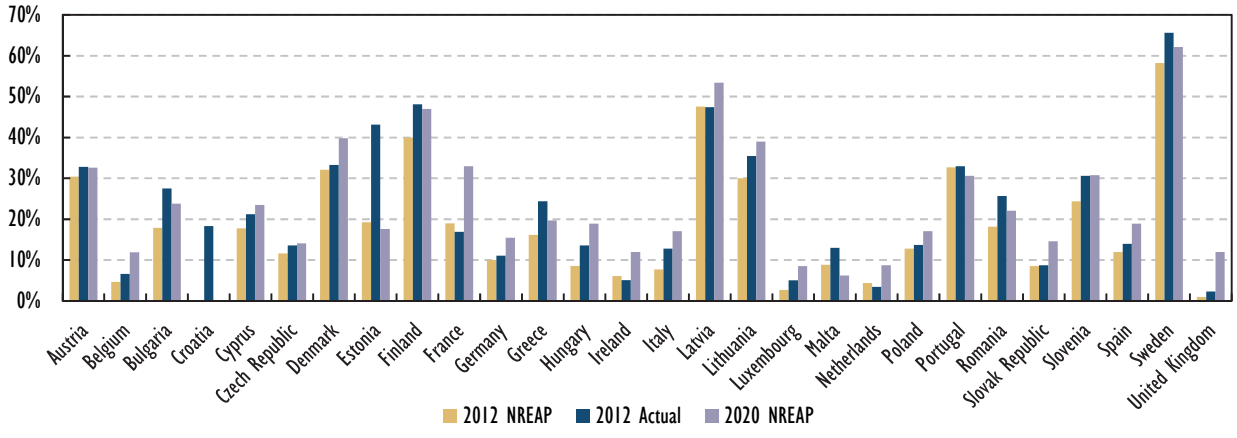



**Figure 9.11** Comparison of the share of heat in gross total final consumption with the NREAP projections in 2012




## Policy developments and discussion

The binding national renewable energy targets under the Renewable Directive were formulated as a proportion of gross final energy consumption. Renewable heat can make an important and cost-effective contribution to meeting the overall target. This requirement has stimulated member states to implement policies designed to bring forward additional contributions from these technologies and to set ambitious plans for renewable heat within the NREAPs. In fact, the European Union is now a focal point in terms of renewable heat policy development: each of the 28 countries has put some measures in place; this is a large share of the 50 countries worldwide that have supportive policies for renewable heat. Progress towards the heat targets within the NREAPs looks promising, and there is a good chance that these targets will be met.

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Many EU member states have encouraged the use of renewable heat by providing capital grants for installations based either on a percentage of costs or a fixed grant. (Austria, Bulgaria, Czech Republic, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Luxembourg, Malta, Poland, Portugal, Slovak Republic, Slovenia and the United Kingdom). The United Kingdom introduced a version of a FiT for heat for non-domestic users in 2011, which has recently been extended to domestic customers. The Netherlands has also introduced a similar scheme. Obligations to use renewables (or specifically solar) for heating have been introduced in Belgium, the Czech Republic, Denmark, Germany, Greece, Ireland, Italy, Portugal, Slovenia and Spain. These financial mechanisms are often backed up with other measures designed to tackle non-economic barriers to the deployment of renewable heating systems. For example, several countries have introduced quality assurance certification schemes as a prerequisite for receiving financial support in a drive to ensure the reliability of systems and their proper installation.

There are some good examples of situations where a competitive supply chain for renewable heat installations has been created. For example, support polices including a carbon tax on fossil fuels in Denmark have been an important driver for the development of solar heating to provide part of the energy needed for Denmark's already extensive district heating network. In a competitive market situation between local suppliers, the system costs of Danish large-scale solar thermal installations are now in the range of USD 350/kilowatt thermal capacity ($kW_{th}$) to USD 400/$kW_{th}$, whereas in other European countries, costs are up to USD 1 040/$kW_{th}$ (IEA, 2014a). While specific circumstances in Denmark have contributed to this cost reduction, the example shows how competition within a sizeable market can lead to rapid cost reduction.

Despite an encouraging increase in market growth and some good examples of falling costs, currently the costs of heat from renewable systems differ markedly between markets. These differences can be only partly explained by differences in the available renewable resource. The capital costs of similar systems vary widely among countries and do not always represent the state of market development. Prices in some countries with well-established markets can be higher than in those with less mature markets. Charges for installation and the "soft costs" associated with marketing and customer acquisition play an important role in these differences.

There is also some evidence that vendors do not recognise the need to reduce costs to open up more larger-scale markets since small-scale local markets are seen as relatively price-insensitive. In such circumstances financial incentives can discourage further cost reductions in technology. A UK study, for instance, found that financial incentives in combination with relatively high fossil fuel prices made biomass heating systems economically attractive for some consumers and thus led to stable demand for installers. As a result, there was little pressure on the installer side to achieve further cost reductions (Carbon Trust, 2012).

A more consistent effort to collect and analyse information about system costs in different markets would help in the design of renewable heat policies and would also facilitate comparison of the effectiveness of different policy portfolios.

An additional push is also needed to identify and encourage the use of renewable heat in industrial applications, which in the long term may be the most significant role for these technologies in a low-carbon energy system. Future efficient and low-carbon urban environments will be based on a more integrated approach to the production and use of energy for electricity, heat and transport (IEA, 2013c). Further work is needed to define how renewable heat sources can best play a useful role in such an integrated system.



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## TRANSPORT

Transport is one of the most rapidly growing end-use sectors. A range of measures can be employed to reduce fossil fuel use by improving fuel-use efficiency, using electricity, and improving the access to and the performance of public transport.

IEA analysis, however, indicates that in order to reduce transport sector emissions to the low levels required under a low-carbon scenario, biofuels are needed in particular as a way of reducing emissions from long-haul transport by air, sea and road. In the IEA *World Energy Outlook 2013* 450 scenario,[1] biofuels will provide some 14% of road transport energy demand in 2035. In the *Energy Technology Perspectives* (*ETP*) (IEA, 2014c) 2DS Scenario, biofuels provide 27% of transport energy by 2050.[4]

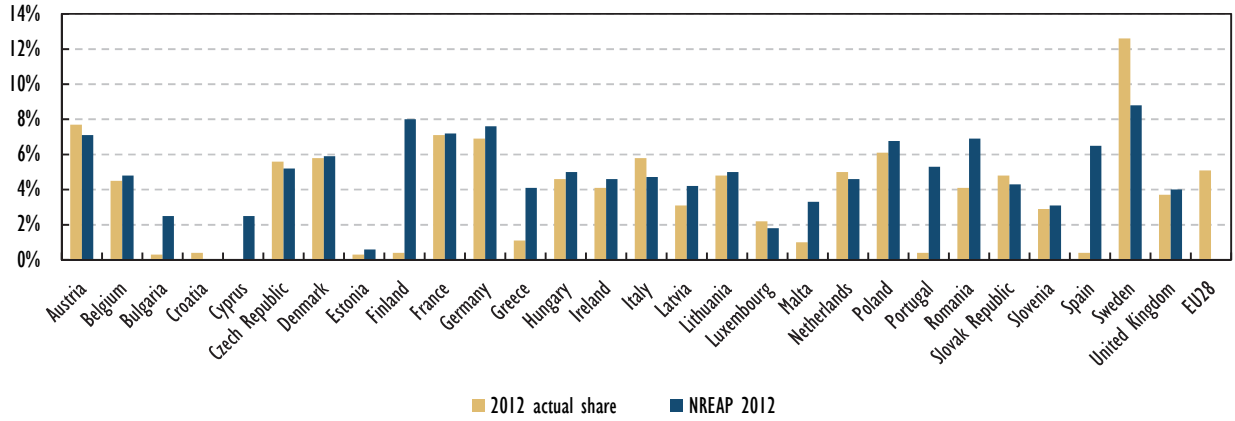
Between 2005 and 2010 there was rapid growth in global biofuels production, particularly in Brazil, the European Union and the United States. Since 2010, growth has slowed in these three main markets. In 2012, biofuels provided some 3.5% of global road transport energy requirements.

### EU deployment trends

Under the EU RED, a requirement is in place for each member state to reach a target share of 10% of renewable energy in their transport energy mix by 2020. As electric vehicles are only gaining momentum slowly, most of the 10% target for renewable energy will likely be achieved through the use of biofuels.

The overall proportions of renewable energy in the transport mix for the European Union in 2012 was 5.2%. Figure 9.12, based on Eurostat data, shows the proportion for each of the EU member states. Only one country – Sweden – is already reaching the 10% figure. The figure also shows that only eight countries are ahead of the target within the NREAP for 2012 with many countries well behind the anticipated trajectory – seven countries have yet to achieve 30% of the 2012 target figure. In some countries, delay in the transposition of the RED sustainability criteria into member state legislation has contributed to this slow progress.

**Figure 9.12** Share of renewable energy in transport in 2012 and comparison with NREAP




Source: Eurostat (2014c), *Renewable Energy Statistics*, database of Eurostat (tsdcc340) (accessed on 14 November 2014).

**4.** A scenario presented in *Energy Technology Perspectives 2014* (IEA, 2014c) that sets out an energy pathway to 2050 consistent with the goal of limiting the global increase in temperature to 2°C.

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## Policy developments and discussion

The slow progress towards the transport component for the renewables target can be partially ascribed to policy uncertainty. While the final provisions for the RED were being put in place, but after the 10% target had been agreed, a strong debate took off about the life-cycle GHG balance associated with production of biofuels and with other sustainability issues, including the "food versus fuel" issue. This debate has continued with particular emphasis on the issues associated with emissions from land use change – both direct and indirect (ILUC) – with the latter proving difficult to tackle convincingly given the complexity of the potential interactions between the energy and agricultural sectors. Initially, some amendments were made to the Directive: e.g. the exclusion of the use of biofuels from sensitive or carbon-rich land and the introduction of a threshold of 35% for the $CO_2$ savings ratio for the biofuels compared to fossil fuels being replaced. There is also provision under the Directive to reward biofuels based on wastes and non-food feed-stocks by allowing them to count twice towards the 10% target.

Based on scientific evidence that ILUC is a real issue, the Commission proposed further measures to reduce the risk of ILUC in 2013. The main element is to limit the proportion of the 10% target that can legitimately be met through the use of "food-based" biofuels (made from oils, sugars and cereals), thus creating strong incentives for other renewable energy options such as advanced biofuels and electricity. The legislative procedure on ILUC is ongoing.

The EU biofuels industry has been active in the development and demonstration of advanced biofuels, with support from both national and EU technology development programmes. However, while there have been a number of pilot and small-scale commercial projects, so far there are only small volumes of such fuels available to European markets, mirroring the international position. Moving to full-scale commercial plants has been slow – partly because of perceived technical risks and the difficult overall investment climate following the economic crisis, but largely because of uncertainties about the policy framework over the long term in which such plants would have to operate.

This ongoing debate and regulatory uncertainty led to concerns in member states under pressure from non-governmental organisations and others concerning the wisdom of encouraging additional biofuel use, and accounts for the poor progress towards the 2010 targets illustrated above. It also provided a difficult business climate for the European biofuels producers, who, at the same time, were suffering intense (and sometimes unfair) competition from overseas suppliers. Currently around 50% of EU biofuels production capacity is unused.

Amendments to the state aid guidelines prohibit investment aid for conventional biofuels production facilities. They do allow investment aid for the conversion of plants to advanced biofuels and for the construction of new advanced plants where such support is necessary to make the plants economically competitive.

Such measures, when enacted, should go some way towards clarifying the policy framework for biofuels and provide additional motivation for developing and deploying advanced biofuels. However, at present there is no provision for an EU biofuels target in the EC proposals for a Policy Framework for Climate and Energy in the period from 2020 to 2030. It is, therefore, very unlikely that these measures go sufficiently far to encourage the necessary large-scale investments in advanced biofuel production capacity, given the long-term investment horizon that such plants need, which stretch well beyond 2020.



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## ASSESSMENT

### ELECTRICITY

The decarbonisation objectives for the EU electricity system are challenging. In achieving this objective, renewables, and particularly variable renewables such as wind and solar PV will play critical roles. In the *ETP 2014* (IEA, 2014c) 2DS scenario, by 2050, 70% of electricity generation in the European Union will come from renewable sources and 44% from variable renewables. Such a change would require a major transformation of the system. In the most developed EU markets, the specific challenges associated with this *consolidation* phase are now coming to the fore, with integration and other system-wide impacts on markets forcing a reconsideration of the way electricity systems are operated physically and commercially.

The RED and the policies and measures it has stimulated in member states have played an important role in the recent global evolution of renewable electricity generation, particularly from wind and solar PV. Large-scale deployment has stimulated cost reduction and opened the way to deployment not only in the European Union but also in many other markets worldwide by enabling progress along the learning curve. This progress has required significant investment, which has been concentrated in a few leading EU markets and, in some cases, exacerbated by poor policy designs that allowed growth in PV deployment at a much faster rate than expected with higher associated than anticipated costs.

Some of the lessons learnt in the EU markets are apparent. FiT mechanisms need to have capacity or financial caps to avoid excessive levels and the potential to adjust in line with declining system prices. The European Commission has developed guidance on good practice for effective and efficient policy that takes into account the capital-intensive nature of the technologies and the effect of the cost of capital on energy prices, while moving away from FiT systems. There is further scope for quantifying and evaluating the effectiveness and costs of the range of policies so as to develop an evidence-based approach to what constitutes best practice. These analyses will require the development of better, comparative data on the impact and costs of policy.

The deployment of PV at rates that exceeded those anticipated within the NREAPs has been one factor putting pressure on consumer prices in these markets. At a time of severe financial and economic crisis in several EU member states, support cost increases and price hikes became a real concern. This led to abrupt policy changes and some retroactive measures aimed at recovering and redistributing these costs. The loss of investor confidence triggered by retroactive measures as well as a loss of momentum in some of these markets now threaten the achievement of the 2020 targets and future goals.

While the issue of how to allocate invested costs among consumers is a real one, governments need to distinguish clearly between the past, the present and the future. Given recent cost trends, future deployment of renewables now hinges less on high levels of financial support. With the right policy frameworks in place, deployment can be achieved at much lower costs than in the past. It would be unfortunate to scale back deployment plans now after the “heavy lifting” associated with bringing down costs has been done.

Policy makers faced with this market design challenge need to balance seemingly competing requirements. On the one hand, there is a need to integrate renewables into the electricity market; to remove some of the market protection that renewables have

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enjoyed through the use of FiTs and priority dispatch; to increase competition; to reward generation based on the value of the electricity depending on the time and place of production; and to engage renewable generators in the challenges of integrating large shares of variable renewables.

On the other hand, it is necessary to recognise the different characteristics associated with renewables (and other low carbon) generation systems – high upfront capital costs and nearly zero fuel and operating costs. The principal costs and commercial risks of generation shift from those associated with fuel prices to those associated with financing. For these technologies, the costs of the power produced depend critically on financing costs. In turn, these financing costs are not only dependent on the general local investment environment but also critically on the policy environment since business finds it hard to manage risks that are related to political and policy uncertainty.

So what kind of market design can deliver a high share of renewables at optimum cost? Such a design must recognise the need not just to stimulate investment in renewables generation but in the whole range of components needed for secure electricity supply, including other forms of complementary generation capacity and other flexibility resources (demand-side integration, storage and investment in the necessary transmission and distribution assets). It must also recognise that the future system will engage not just large-scale operators and investors but a much wider range of stakeholders including, for example, those from municipalities and industrial and commercial and household consumers.

This is a relatively new challenge for policy makers and experience, and best practice is still evolving in markets facing these new consolidation challenges, such as in the European Union. But some key principles are emerging.

The IEA believes that providing investment signals through putting a price on carbon emissions is a useful but insufficient step towards creating the investment climate needed for this transition. A carbon price sends market signals that can encourage a switch to lower carbon options, particularly when choices between using different existing assets are possible (and often provide windfall profits to existing players rather than encouraging new investors). However, there is little evidence that such a carbon price alone will be effective in sending signals to encourage investment in low-carbon generation since it is subject to both political and policy risks. Hence, it does little to provide a long-term stable context for investment. Complementary policies that support specific technologies are needed to provide the necessary stability and to help overcome non-economic barriers. Additional measures are also needed to assist the development and commercial deployment of the suite of technologies necessary for the achievement of decarbonisation objectives in the longer term.

For larger scale renewables projects, a framework that provides a long-term predictable stream of revenue is necessary to reduce policy and market risk. Market competition (over the long, rather than the short term) can be introduced via competition for long-term supply contracts. Such systems are now being introduced in a number of EU markets such as the United Kingdom.

In order to encourage investment in distributed generation at smaller scale, different mechanisms will be required since the transaction costs associated with tendering for long-term power purchase agreements would be prohibitive for such investors (including householders, for example). For such distributed systems, an income stream that reflects the value of produced electricity to the system is likely to prove most effective and equitable. Methodologies for the calculation of the appropriate values should allow for



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the recovery of the costs of the distribution and transmission system even at high levels of penetration, while also factoring in reductions in investment and operating costs. Such analysis is currently an area of intense policy work.

Other complementary measures are needed to facilitate the integration of large shares of variable renewables within the system, including placing responsibility for balancing charges on renewable generators. This would encourage better use of modern wind and solar forecasting techniques. Experience indicates that there is scope to improve market operation by moving to a shorter market trading interval (which, for example, in the Texas ERCOT market is now five minutes), by providing locational price signals, and by improving the markets for flexibility services.

Integration of renewable electricity into the overall system is a key issue. IEA analysis shows that such integration is possible at low levels given attention to network codes, operational practice and avoidance of high concentrations of generation in areas where the network is weak. At higher levels of generation, flexibility options – flexible generation, grid infrastructure, demand-side integration and energy storage – are critical. In particular, demand-side options can play a significant and cost-effective role, and further measures to encourage demand-side response are necessary. At higher levels of supply from variable renewables, there is a need to take a whole system view rather than just seeing the variable RE generation as a perturbation. Such a view can significantly reduce the overall system costs.

## HEAT

Policies to encourage the use of RE for heat have gained attention through the development of the NREAPs, and the European Union is now the leading region as far as experience of renewable heating and associated policies is concerned. These policies are tackling the economic and institutional barriers, but experience of policy best practice is limited, and the markets are rather undeveloped. Further effort is merited in this area. This needs to be fully integrated with energy efficiency measures and to take into account likely long-term developments in the heat sector, such as a decline in heat demand in buildings as efficiency rises.

Renewable heat is not mentioned specifically in the Commission's proposals for a policy framework for climate and energy in the period from 2020 to 2030, despite its importance, and so its future deployment will depend on national actions. The Commission could assist these and avoid a loss of momentum by helping to identify and promote best practice policies for renewable heat that stimulate better cost-effectiveness and tackle non-economic barriers. The Commission could also co-ordinate work to obtain better country-level renewable heat cost data and to understand the current significant differences.

Encouraging investment (via EU structural funds, the EIB and other investment bodies) in district heating networks, which can play an important role in facilitating more integrated renewable and low-carbon heating solutions, would help catalyse further cost-effective deployment of renewable heating.

## TRANSPORT

The deployment of renewables in the transport sector has proven to be the most difficult part of the RED ambitions for 2020, as increased awareness of issues with the

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GHG balances and other sustainability issues for conventional biofuels coincided with the establishment of the 10% target. Progress towards the target is poor given the policy uncertainty and the inevitably difficult investment climate. The measures announced recently go some way towards providing a greater degree of certainty, but the remaining issues (such as the approach to ILUC) need to be urgently resolved in a definitive way that provides for policy predictability.

The recently announced measures also do little to provide a context in which the necessary long-term investment in advanced biofuels projects is likely within the European Union. This is unfortunate since there are a number of successful European Union technology companies that will have to compete for markets in Asia and the United States without the benefit of a home market.

If momentum is not to be lost in the development of these advanced biofuels technologies, which will be critical to the decarbonisation of some long-haul transport sectors, then a strategy for completing the commercialisation of these processes must be given priority. Technology development and demonstration alone will not be sufficient to stimulate the necessary investment. A stable policy framework is also needed to justify the large-scale investments required for a series of plants to make the transition to full commercial-scale operation and to allow the technology learning needed to drive costs down.

## BIOENERGY

A holistic and consistent approach to the sustainable use of bioenergy in the electricity, heating and transport sectors is needed. Sustainability criteria have been introduced for biofuels and for bio-liquids used for heating. There are no sustainability criteria for biomass use in other sectors. This represents a future policy risk that can be avoided by giving serious consideration to developing a consistent set of criteria covering all sectors, perhaps using existing certification schemes such as those of the Forest Stewardship Council (FSC) and Pan-European Forest Council (PEFC) in order to avoid imposing an unmanageable bureaucratic burden.

## TOWARDS THE 2030 CLIMATE AND ENERGY POLICY FRAMEWORK

The 2030 Climate and Energy Policy Framework as adopted by EU leaders at their European October 2014 Council includes an EU-wide renewables target, but does not propose setting binding national renewables targets. This raises questions about the responsibility for the delivery of the EU-wide target. The governance framework to be developed is therefore crucial.

Member states will be expected to prepare national action plans covering their overall GHG reduction targets for 2030 and including commitments to renewable energy. Once countries have volunteered commitments to renewables within their carbon action plans, and these have been scrutinised by the European Commission with regard to ability to be aggregated towards the overall target, these targets should become binding on member states and sanctions imposed if the targets are not achieved. For the policy to be effective, it is paramount that a similar level of policy confidence is created with the national plans and supporting framework as has been provided by nationally binding targets.

A core element of the 2030 Climate and Energy Framework is the need for EU member states to enhance their policies to facilitate the transformation of the energy system



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with more cross-border interconnections, storage potential and smart grids to manage demand. This aims to ensure a secure energy supply in a system with higher shares of variable renewable energy. The IEA strongly supports this recommendation as a key step in delivering the potential synergies of working at a European level. The European Union should consider a focused plan using structural funds along with the available mechanisms of the EIB in order to deploy the identified key grid reinforcement projects as soon as possible.

Unfortunately, the 2030 Climate and Energy Framework does not specifically highlight the role of renewable heat despite the opportunities it provides for low-cost renewables generation without significant integration problems and its potential to make a significant contribution to energy security by reducing gas and oil demand.

The Commission does not think it is appropriate to establish a separate target for renewable energy in the transport sector after 2020. Given the issues surrounding conventional biofuels discussed in this chapter, this is understandable to some extent. However, further urgent work is needed to resolve some remaining issues (such as the approach to ILUC) in a definitive way that provides clear guidelines to promote investment. In particular, the further development and deployment of advanced biofuels is at risk. A stable policy framework is vital to justify the large-scale investments required to make the transition to full commercial scale.

The calls for a comprehensive review of all biomass-using sectors, including the paper and pulp industries, and biochemical and energy production, are welcome and should be extended to include the food and other bio-based industries, with the aim of identifying synergies between primary production and co-production of energy.

## *RECOMMENDATIONS*

*The European Union should:*

- *Develop a market framework by 2020 which supports the system transformation needed to accommodate large shares of renewable electricity. Ensure long-term stability to stimulate investment in capital-intensive technologies, system flexibility and reward production depending on the value, time and location of the generation.*
- *Continue to develop evidence-based guidelines for cost-effective renewables policies, derived through the assessment of comparable information. To facilitate such analysis it will be necessary to develop and enforce reporting standards on the cost of support given to renewable energy.*
- *Enhance efforts to develop cost-effective strategies to encourage renewable heat generation, consistent with heat demand patterns, to complement energy efficiency efforts.*
- *Develop a holistic EU approach on bioenergy; develop and apply sustainability criteria to all sectors; and take measures to support the development and deployment of the advanced biofuels solutions required for decarbonisation of the transport sector.*
- *Encourage the use of structural funds, the activities of the EIB and other European and member state financial organisations to facilitate, under favourable financing terms, the investment needed to secure the necessary capacity and other infrastructure required to provide electricity, heat and advanced transport fuels from renewable sources.*

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# 10. NUCLEAR ENERGY

**Key data (2012)**

**Number of plants in operation:** 131 reactors at 56 sites in 14 countries

**Installed capacity:** 116 GW (net)

**Electricity generation:** 880 TWh (27% of total power generation)

## OVERVIEW

Nuclear energy plays an important role as source of low-carbon electricity in the European Union (EU), providing 27% of the total electricity generated in the European Union. There are 56 nuclear power plants (NPPs) and 131 operating nuclear reactors in 14 member states. Five of the six countries in the European Union with the lowest $CO_2$ emissions per kWh have nuclear capacity shares of at least one-third: Belgium, Finland, France, Slovenia, and Sweden (the sixth country is Latvia with half hydro and half fossil). The current dominant reactor technologies are the Pressurised Light Water Reactor (PWR) and the Boiling Light Water Reactor (BWR). Tables 10.1, 10.2 and 10.3 provide an overview by country.

Many NPPs in the EU are reaching the end of their "design" lifetimes. Eighty-eight commercial units have been retired and will need to be decommissioned in the foreseeable future. As new builds, there are two European Pressurised Water Reactors (EPRs) under construction (one in Finland and another in France) and two Russian-designed units in the Slovak Republic; and plans for new plants are being discussed in Bulgaria, the Czech Republic, Finland, Hungary, Lithuania, Poland, Romania, Sweden, and the United Kingdom. Long-term market uncertainty is, however, inhibiting investment in new plants. Instead, the EU runs life extensions, upgrades and uprates.

Safety and decommissioning have become important issues with varied responses by member states to the accident in Japan at Fukushima Daiichi in March 2011. Germany has already shut down some of its plants and is committed to closing the remainder by the early 2020s. All countries have completed "stress tests" of their operating plants and are investing in safety upgrades; some have also already done capacity uprates, and "lifetime extension". To further its safety objectives, the EU adopted an amendment to the nuclear safety directive in 2014 to re-define EU nuclear safety objectives.

Regarding decommissioning, the European Commission published recommendations in 2006 on the transparent management of financial resources to ensure safe decommissioning of nuclear installations and the related management of waste and used nuclear fuel. Since 2004, the European Commission has been regularly tracking the accumulation of decommissioning funds, the estimation of future decommissioning liabilities, and best decommissioning practices. Through the Euratom Treaty, there are three main directions of the nuclear policy at the EU level, which are supply security, safety and safeguards as well as spent fuel and radioactive waste management.

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**Table 10.1** NPPs in the European Union as of mid-2013 with reactors in operation (with net MWe)

| Country | Reactors in operation |
|---|---|
| Belgium | 7 reactors (2 NPPs with 5 355 MW) |
| Bulgaria | 2 reactors (1 NPP with 1 840 MW) |
| Czech Republic | 6 reactors (2 NPPs with 3 488 MW) |
| Finland | 4 reactors (2 NPPs with 2 195 MW) |
| France | 58 reactors (19 NPPs with 62 420 MW) |
| Germany | 9 reactors (8 NPPs with 12 068 MW) |
| Hungary | 4 reactors (1 NPP with 1 322 MW) |
| Netherlands | 1 reactor (1 NPP with 447 MW) |
| Romania | 2 reactors (1 NPP with 1 295 MW) |
| Slovak Republic | 4 reactors (2 NPPs with 1 628 MW) |
| Slovenia | 1 reactor (1 NPP with 666 MW) |
| Spain | 7 reactors (5 NPPs with 6 495 MW) (does not include Garoña) |
| Sweden | 10 reactors (3 NPPs with 8 324 MW) |
| United Kingdom | 16 reactors (8 NPPs with 9 439 MW) |
| **Total** | **131 reactors (56 NPPs)** |

Source: EC (2013), *Nuclear Power Plants in the EU,* Brussels, http://ec.europa.eu/energy/nuclear/doc/nuclear_power_plants.pdf and International Atomic Energy Agency (IAEA) (2013), *Nuclear Power Reactors in the World, 2013 Edition, Reference Data Series 2*, Vienna, www-pub.iaea.org/books/IAEABooks/10593/Nuclear-Power-Reactors-in-the-World-2013-Edition.

**Table 10.2** Reactors permanently shut down and/or being decommissioned (with net MWe)

| Country | Shut down reactors out of which being decommissioned |
|---|---|
| Belgium | 1 reactor (10 MW) out of which 1 reactor being decommissioned |
| Bulgaria | 4 reactors (1 632 MW) out of which 4 reactors being decommissioned |
| France | 12 reactors (2 694 MW) out of which 10 reactors being decommissioned |
| Germany | 27 reactors (14 300 MW) out of which 19 reactors being decommissioned |
| Italy | 4 reactors (1 423 MW) out of which 4 reactors being decommissioned |
| Lithuania | 2 reactors (2 370 MW) out of which 2 reactors being decommissioned |
| Netherlands | 1 reactor (55 MW) out of which1 reactor being decommissioned |
| Slovak Republic | 3 reactors (909 MW) out of which 3 reactors being decommissioned |
| Spain | 3 reactors (1 067 MW) out of which 2 reactors being decommissioned |
| Sweden | 3 reactors (1 210 MW) out of which 3 reactors being decommissioned |
| United Kingdom | 29 reactors (2 458 MW) out of which 26 reactors being decommissioned |

Sources: EC (2013), *Nuclear Power Plants in the EU,* Brussels, http://ec.europa.eu/energy/nuclear/doc/nuclear_power_plants.pdf and International Atomic Energy Agency (IAEA) (2013), *Nuclear Power Reactors in the World, 2013 Edition, Reference Data Series 2*, Vienna, /www-pub.iaea.org/books/IAEABooks/10593/Nuclear-Power-Reactors-in-the-World-2013-Edition.



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**Table 10.3** Reactors under construction (with net MWe)

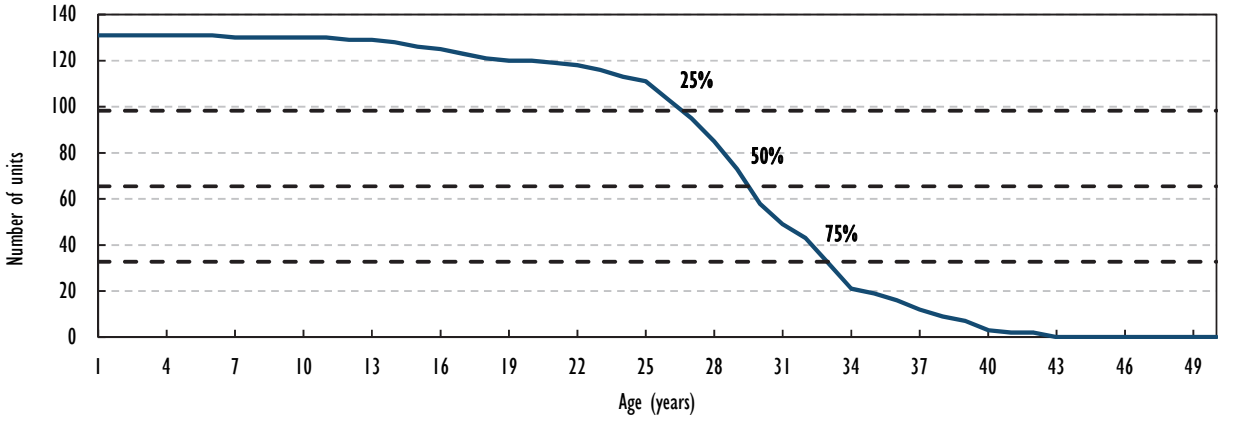
| Country | Reactors under construction |
|---|---|
| Finland | 1 (Olkiluoto-3, European Pressurised Reactor, 1 600 MW) |
| France | 1 (Flamanville-3, European Pressurised Reactor, 1,630 MW) |
| Slovak Republic | 2 (Mochovce 3 & 4, VVER V-213-updated, 880 MW) |

Sources: EC (2013), *Nuclear Power Plants in the EU,* Brussels, http://ec.europa.eu/energy/nuclear/doc/nuclear_power_plants.pdf and International Atomic Energy Agency (IAEA) (2013), *Nuclear Power Reactors in the World, 2013 Edition, Reference Data Series 2*, Vienna, www-pub.iaea.org/books/IAEABooks/10593/Nuclear-Power-Reactors-in-the-World-2013-Edition.

The history shows the diversity across the European Union in NPP types and the diversity of manufacturers within the same type. Of the 131 reactors presently operating, 75% have been operating more than 27 years, half the units have been operating more than 29 years, and 25% of the units have been operating 33 years or longer (see Figure 10.1).

The ageing of the EU reactor fleet requires country-level and owner/operator-level decisions in the short term regarding plant safety regulations, plant upgrades, plant uprates, plant lifetime extension and licence renewal, plant retirements, plant decommissioning, spent nuclear fuel and radioactive waste management, and new plant construction. These issues are discussed in the following sections.

**Figure 10.1** European operating NPP age distribution (2013)




Source: International Atomic Energy Agency (IAEA) (2013), *Nuclear Power Reactors in the World, 2013 Edition, Reference Data Series 2*, Vienna, www-pub.iaea.org/books/IAEABooks/10593/Nuclear-Power-Reactors-in-the-World-2013-Edition.

## HISTORY

When reviewing the history of nuclear power development in the EU member states, the diversity of nuclear power technologies, the age of the nuclear power programmes, and the complexity of regulating different technologies becomes apparent.

Because of the strategic nature of nuclear technologies, each country developed its nuclear power programme independently. Four developed indigenous nuclear power technologies: France, Germany, Sweden, and the United Kingdom. All other "nuclear" countries imported reactors from these developers and from the United States (US) or the Soviet Union.

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From the 1950s through the 1980s, the United Kingdom developed and deployed a gas-cooled graphite reactor (GCR, all of which have been retired) and the Advanced Gas-cooled Reactor (AGR). A PWR (imported from Westinghouse) was completed in 1995. Also, without early access to enriched uranium, France developed and deployed GCRs, but switched to PWR technology and has built 59 PWRs since the 1970s, most of which are being uprated and upgraded (see below). (West) Germany developed several reactor types, but began building BWRs and PWRs in the mid-1960s, nine of which are still operating, but are scheduled to be retired by 2022. In 1964 Sweden's Asea began supplying BWR technology, starting its first BWR in 1966 and finishing nine units in Sweden and Finland by 1985. Westinghouse also built three PWRs in Sweden, finishing in 1983. In 2010 the Swedish Parliament passed legislation to allow the construction of new units to replace retiring units.

Seven other Western European countries have imported NPPs. Belgium imported its PWRs from Westinghouse (US) (a first small unit starting in 1962 and four units starting in 1975 and beyond) and Framatome (France) (two units starting in 1982). Finland imported two VVER-440s from the Soviet Union in the early 1970s (upgraded with Western control systems and containment) and two BWRs from Sweden in the mid−1970s. Italy imported BWRs from General Electric (GE) (USA) (two units starting in 1959), a GCR from the United Kingdom in 1958, and a PWR from Westinghouse in 1961; all units were retired by 1990. The Netherlands imported a BWR from GE in 1965 (retired in 1997) and a PWR from Germany in 1969. Slovenia imported a 700-MW Westinghouse PWR in 1975. Spain imported BWRs from GE (two units starting in 1966), a GCR from France in 1968 (retired in 1990), and PWRs from Westinghouse (six units starting in 1964) and from Germany's KWU (one unit in 1979).

The Soviet Union deployed two reactor types within its territory and in Eastern Europe: a Light Water Graphite-Moderated Reactor (RBMK as at Chernobyl) with two 1 200 MW units in Lithuania (now retired), and the VVER (a PWR with several models). In a first generation, two VVER prototypes (210 MW and 365 MW) were built in Russia, providing experience for a standardised VVER-440/V-230 (440 MW), deployed starting in 1967. Such plants were built in Bulgaria (four units), Slovakia (two units) and (East) Germany (four units). A second-generation VVER-440/V-213 with enhanced safety features was deployed starting in 1970 in Finland (two units), Hungary (four units), (East) Germany (one unit), and Czech Republic (four units) and Slovak Republic (two units, and two more are currently being finished). A third generation VVER-1000 (1 000 MW) was deployed starting in 1974, and built in Bulgaria and in the Czech Republic. All NPPs in Eastern Europe have undergone safety upgrades since 1990. However, safety concerns led to the European Union to require that particular units be retired as part of EU accession negotiations. As a result, eight reactors were permanently retired between 2002 and 2009: six VVER-440s/V-230 in Bulgaria and Slovak Republic (the VVER plants in the eastern part of Germany had been retired at the time of the German reunification), and two Chernobyl-like reactors in Lithuania.

## INSTITUTIONAL FRAMEWORK

The **European Atomic Energy Community (Euratom)**, established by treaty in 1957, plays a fundamental role in civilian nuclear activities within the European Union. No major changes have been made to the treaty since it was adopted. Despite the entry into force of the TFEU, Euratom maintains is separate legal status and has evolved little since its creation.



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As outlined in the Euratom Treaty, its specific tasks are:

- promote research and disseminate technical information
- establish uniform safety standards to protect industry employee health and the public
- facilitate investment in the establishment of the basic installations necessary for the development of nuclear energy in the European Union
- ensure that all member states with operating NPPs receive an equitable supply of uranium and nuclear fuel
- ensure that civil nuclear materials are not diverted to other (e.g. military) purposes
- establish relations with third countries and international organisations.

Euratom primary law, however, does not provide rules for decommissioning or waste management. But secondary law has been adopted on the basis of the Euratom Treaty.

Euratom is Party to International Conventions under the umbrella of the International Atomic Energy Agency (IAEA): Convention on the Physical Protection of Nuclear Materials (CPPNM), Convention on Nuclear Safety (CNS), Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (Joint Convention), Convention on Early Notification of a Nuclear Accident and Convention on Assistance in the case of a Nuclear Accident or Radiological Emergency. The review of the CNS will provide an opportunity for the Euratom Community to influence the reshaping of the international legal framework with the ambitious nuclear safety objective introduced by the amended Nuclear Safety Directive. The Radioactive Waste Directive will impact on the international level through the review process of the Joint Convention.

The Euratom Community has concluded nuclear co-operation agreements to create a stable legal framework with third countries, ensuring a corresponding level of safety and security, facilitating nuclear trade and also ensuring diversification of the European Union's supply of nuclear fuel. Agreements have been concluded with the United States, Canada, Australia, Kazakhstan, Argentina, Ukraine, Uzbekistan and Japan. A broad Euratom agreement with South Africa was signed in 2013, but has not entered into force. Several other agreements are at different stages of preparation.

One of the fundamental objectives of the Euratom Treaty is to ensure that all users in the European Union enjoy a regular and equitable supply of ores and nuclear fuels (source materials and special fissile materials). To this end, the Euratom Treaty created **the Euratom Supply Agency**. The Agency has the competence, as exclusive right, to conclude contracts with respect to the supply of nuclear materials coming from inside or outside of the European Union. In practice, this right is applied softly as markets are matching supply and demand with no major risk of disruption of supply.

Relations between Euratom and the IAEA have been considerably reinforced over the past decade. The most recent example was the signing of a Memorandum of Understanding on Nuclear Safety in September 2013. In the area of nuclear safeguards, the Commission performs joint inspections with the IAEA.

The **European Nuclear Safety Regulators' Group** (ENSREG) was formed in 2007 and is made up of officials of the member state regulatory bodies for nuclear safety, radioactive waste, and radiation protection and representatives of the European Commission. In addition, the **Western European Nuclear Regulators' Association (WENRA**, formed in 1999) involves regulators of all EU countries with operating and closed NPPs plus Switzerland; other EU member states and Former Soviet Union countries (Armenia, Russia, and Ukraine) are observers.

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To strengthen EU research and assessment in nuclear safety and radiation protection, and provide technical support to the Regulators, three member state safety organisations (Bel V for Belgium, IRSN for France and GRS for Germany) formed, in 2006, the **European Technical Safety Organisation Network.** In 2010, this became a legal entity and extended to Finland (VTT), the Czech Rep (UJV) and Lithuania (LEI). As of now more members have joined (making a total of ten member states represented) and Japanese, Russian and Ukrainian organisations are associated members. Closely linked to ETSON, the **European Nuclear Safety Training and Tutoring Institute (ENSTTI)** was created in 2011: Belgium's Bel V (of the Federal Agency for Nuclear Control); France's Institut de Radioprotection et de Sûreté Nucléaire (IRSN, Institute for Radiological Protection and Nuclear Safety); Germany's Gesellschaft für Anlagen- und Reaktorsicherheit (GRS); and the Lithuanian Energy Institute (LEI). Since 2011, ENSTTI has been joined by four contributors (including one from the Ukraine) and eight collaborators (including three from Japan, Russia, and Switzerland).

Nuclear Fission and Fusion Research and Innovation are guided by recommendations of the **Scientific and Technical Committee (STC).** It was created by the Euratom Treaty and is made up of experts which are nominated by the EU member states. Overall co-ordination of Fission research at wide EU level is performed by the European Technology Platforms (SNE-TP for Sustainable Nuclear Energy TP and IGD-TP for Implementing Geological Disposal TP, created, with the support of the European Commission, in 2007 and 2010 respectively). Within SNE-TP, a legal entity NUGENIA has been created in 2011 focusing on the safety and technology of generation II and III plants.

Originally formed in 1991 to aid Former Soviet Union and Eastern European countries, the **European Bank for Reconstruction and Development (EBRD)** administers three funds for nuclear safety on behalf of the European Union and G24 countries:[1] (1) the Nuclear Safety Account (NSA) for safety and waste management projects in Bulgaria, Lithuania, Russia, and the Ukraine; (2) the International Decommissioning Support Funds (IDSFs) for decommissioning in Bulgaria, Lithuania, and Slovak Republic; and (3) the Chernobyl Shelter Fund (CSF) in the Ukraine.

## NUCLEAR ENERGY POLICY IN THE EUROPEAN UNION: SAFETY, SAFEGUARDS AND SECURITY

In 2009, the nuclear safety directive[2] provided the first Community framework for the nuclear safety of nuclear installations, making the major international nuclear safety principles legally binding in all member states. It requires member states to establish and maintain a national legislative, regulatory and organisational framework governing the safety of nuclear installations and recognises the prime responsibility of licence holders for nuclear safety, under the supervision of the competent authorities. The implementation of this directive is supported by the ENSREG.

Following the accident at Fukushima Daiichi NPP Units 1-4 in March 2011, the European Council of 24-25 March, 2011, requested the safety of all EU nuclear plants to be reviewed on the basis of a comprehensive and transparent risk and safety assessment

**1.** The G24 Nuclear Safety Coordination was set up in 1992 as an intergovernmental co-operation mechanism between the European Union Western countries, the countries of Central and Eastern Europe, the NEA and the IAEA, presided by the European Union (two vice-rotating presidencies of a western country and an Eastern European country), with the European Commission as secretariat.

**2.** Council Directive 2009/71/EURATOM of 25 June 2009 establishing a Community framework for the nuclear safety of nuclear installations.



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("stress tests"). These “stress tests” were further defined as targeted reassessments of the safety margins of NPPs, developed by ENSREG, including the European Commission. The ENSREG, with the co-operation of the WENRA, was tasked to oversee the safety and risk assessments, “stress tests,” of operating NPPs and spent fuel storage facilities. The stress tests focused on applying lessons learnt from the Fukushima Daiichi accident to three areas: (1) natural initiating events, including earthquakes, floods, and extreme weather events; (2) the loss of safety systems and the loss of electrical power (including a station black-out); and (3) severe accident management, including methods to avoid and to manage (a) the loss of reactor core and spent fuel storage pool cooling, and (b) containment integrity.

The stress tests were conducted in a three step process: (1) All the operators of NPPs in the European Union had to review the response of their nuclear plants to those extreme situations and make proposals for safety improvements. (2) The national nuclear regulators conducted independent reviews of the operators’ assessments and issued requirements and summary national reports. (3) The final national reports were reviewed by peer review teams, set up by ENSREG.

The final ENSREG report concluded that four main areas should be improved at the EU level: the lack of consistency in the assessment of natural hazards; the need for regular assessments of the implementation of safety measures; as well as an improvement of prevention measures, including the protection of mobile equipment and emergency response centres against extreme natural hazards and contamination, and the availability of rescue teams and equipment to support local operators.

The results of the stress tests were announced on 4 October 2012. All EU countries with NPPs, as well as Switzerland and Ukraine, conducted stress tests and participated in peer reviews. The peer reviews concluded that all countries had taken significant steps to improve the safety of their plants. Recommendations were also made to strengthen safety at many operating reactors, including: installing (or improving) on-site seismic instrumentation and filtered containment venting systems; storing equipment for accidents in secure, easily accessible locations; and installing a back-up emergency control room.

On 8 July 2014, the Council adopted an amendment to the nuclear safety directive that provided and re-prioritised detailed EU nuclear safety objectives and developed peer review mechanisms. The amended Nuclear Safety Directive enhances the nuclear safety framework of the European Union, building on the lessons learnt from Fukushima Daiichi and the nuclear stress tests as well as the safety requirements of the WENRA and the IAEA. The amended directive strengthens the requirements imposed on members states for the power and independence of national regulatory authorities, introduces a high-level EU-wide safety objective to prevent accidents and avoid radioactive releases, sets up a European system of peer reviews on specific safety issues every six years, increases transparency on nuclear safety matters by informing and involving the public and promotes an effective nuclear safety culture.

The European Commission presented in May 2014 the European Energy Security Strategy (EC, 2014a), together with an evaluation of security of supply in the European Union and raised concerns about the foreign supply of fuel (EC, 2014b). At the same time, it concluded nuclear fuel cycle facilities in member states (conversion, enrichment, and fuel fabrication) provide sufficient capacity for the production of nuclear fuel to assure nuclear fuel supplies for all but the Russian-designed reactors. It proposes actions in five primary areas, including increasing EU electricity capacity, while diversifying energy supply with nuclear capacity in those member states, where safe nuclear power

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is an electricity generating option. To increase electricity reliability in the European Union 1) in the short and medium term (before 2030), NPP lifetimes could be extended with upgrades and uprates, as discussed below, and 2) in the medium and long term (after 2020), new advanced NPPs could be constructed.

To support this possibility, in addition to the EU Nuclear Safety Directive already mentioned above, in 2011, the EU nuclear waste management policy was strengthened with the adoption of Directive 2011/70/Euratom, establishing an EU framework for the safe management of spent nuclear fuel and radioactive waste, based on advice from the ENSREG and expert groups of the Euratom Scientific Technical Committee. The directive is based on the "polluter pays principle," that ensures that future generations will not be burdened by current waste streams, placing the responsibility on member states to manage and dispose of these wastes. All EU member states were to bring their laws and regulations into compliance with the directive by August 2013. Member states' reports on the implementation of the directive are to be submitted to the European Commission by August 2015.

Further, the directive affirms: (1) the primary responsibility of managing the waste lies with the producer of the waste under license from a national regulatory authority; (2) the safety of managing this waste is under the appropriate national regulatory authority; and (3) public participation in decision making. While it is possible under the directive to temporarily store radioactive waste, disposal of all waste must be accomplished in a timely manner. Member states are obliged to establish and implement national programmes for management of spent fuel and/or radioactive waste from generation to disposal. Member states are obliged to notify to the Commission their national programmes by August 2015 and any subsequent significant changes.

Member states are in various stages of implementing their national programmes. EU member states have low and medium level radioactive waste disposals; however; there is not yet a single final repository for high-level radioactive waste produced in the European Union. Some member states (Finland, France and Sweden) plan repositories to be opened between 2020 and 2025. However, due to economies of scale, regional waste disposal sites could be less costly than national waste disposal sites, in particular for countries with small nuclear programmes, as informally discussed in the European Nuclear Energy Forum (ENEF). But, this will have to overcome the hurdle of import/export of nuclear waste.

The revised Basic Safety Standards Directive Council Directive 2013/59/Euratom, adopted by the Council at the end of 2013, provides for uniform safety standards for the protection of the health of individuals subject to occupational, medical and public exposures against the dangers arising from ionising radiation. It set out a framework for improved national measures and plans in case of a radiological emergency.

Finally, nuclear safeguards policies at EU level aim to ensure nuclear materials are not diverted to purposes other than those for which they were originally declared. They oblige users of nuclear material to keep a system of records and to make declarations about the nuclear material they hold and process to the European Commission. The European Commission has the mandate to verify these declarations with regard to their correctness and completeness in order to assure citizens, supplier states and the international community that the nuclear material remains in use only for peaceful purposes.



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**Box 10.1** Nuclear phase-out in Germany

Following the Fukushima Daiichi nuclear accident in March 2011, the federal government began to reconsider the long-term role of nuclear power.

Analyses prepared by the Reactor Safety Commission (RSK) and the Ethics Commission supported the decision, that by means of an incremental process to be completed by the end of 2022 at the very latest, Germany will abandon the generation of electricity from nuclear power stations. While the RSK found that Germany's nuclear power stations are highly robust facilities, the Ethics Commission concluded that a major nuclear accident could prove unmanageable. Following consideration of the findings of the two Commissions, the federal government decided to phase out the use of nuclear power for commercial electricity generation at the earliest possible time – on a staggered schedule. To that end, on 30 June 2011, the Bundestag (parliament) passed the Thirteenth Act amending the Atomic Energy Act (*Dreizehntes Gesetz zur Änderung des Atomgesetzes*). The act entered into force on 6 August 2011.

Eight nuclear power reactors older than 30 years were shut down in August 2011. These units were Biblis (a two-unit PWR), Brunsbuettel (a single-unit BWR), Isar-1 (a BWR of a two-unit plant), Kruemmel (a single-unit BWR), Neckarwestheim Unit 1 (a PWR of a two-unit plant), Philippsburg Unit 1 (a BWR of a two-unit plant), Unterweser (a single-unit PWR), with a total capacity of 8422 MW. Applications to decommission Neckarwestheim Unit 1 and Phillipsburg Unit 1 were submitted in May 2013.

In order to phase out nuclear power more quickly, however, the process of reorganising Germany's energy supply at a fundamental level – a process which had already begun with the Energy Concept of 2010 – needed to be substantially accelerated (the *Energiewende* or energy shift). To this end, the Federal Cabinet, the Bundestag and the Bundesrat adopted a comprehensive package of legislation ("Energy Package") in June and July 2011. The Energy Package consists of seven acts and one ordinance, e.g. on expanding renewables, on expanding the grid, on energy efficiency and on the funding of the reforms. The Energy Package marked a second significant step by the federal government towards the restructuring of the energy supply. An important aim of the legislative package was to ensure that the nuclear phase-out could proceed as fast as possible and in an irreversible and orderly manner, with the eight oldest NPPs not being reconnected to the grid. Compensation costs are to be borne by the federal government. Should back-up capacity be needed, it will be provided by conventional power plants. Shortly afterwards, the Federal Council followed the Bundestag's vote and approved the energy legislation.

Source: IEA (2013), *Energy Policies of IEA Countries: Germany 2013*, OECD/IEA, Paris.

## PLANT UPGRADING, PLANT LIFE MANAGEMENT, AND LIFETIME EXTENSIONS

The ageing of the EU reactor fleet requires country-level and owner/operator-level decisions regarding plant upgrading (e.g. upgrading safety systems, Instrumentation and Control (I&C) systems, replacing ageing or outdated equipment); uprating (i.e. increasing the productive capacity of the reactor by replacing steam generators, turbine generators, I&C systems, etc.); long-term operation (LTO); and lifetime extension and/or licence renewal.

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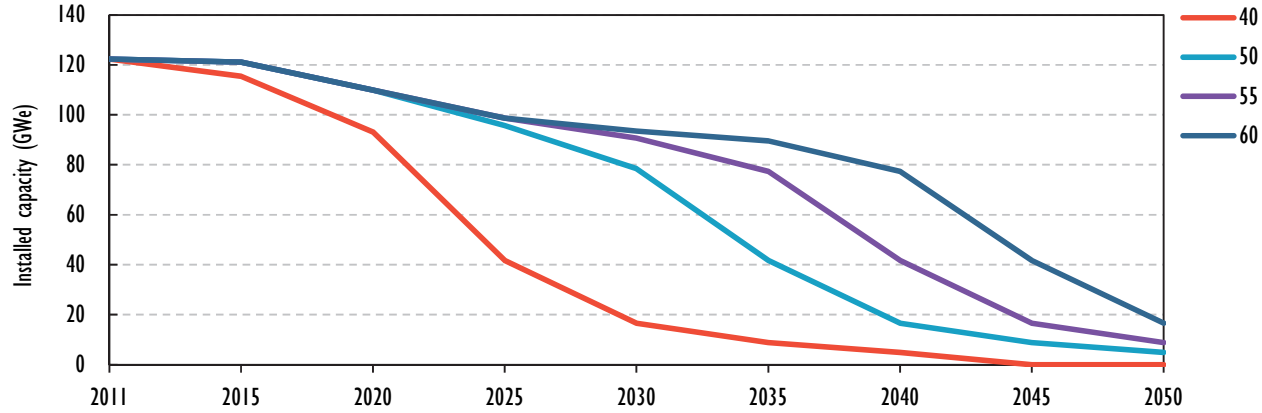
The cost of the upgrading and uprating can vary by project from some EUR tens of millions to upgrade a turbine generator to EUR hundreds of millions (up to EUR one billion) to upgrade a plant for an extra ten to 20 years of operation. Figures on the order of EUR 1 000/kW for all fleet investments through 2025 have been announced by EDF's president; this includes refurbishment, safety upgrades, and capacity uprates (see also figures in [NEA, 2012]). Upgrading and uprating existing NPPs appear to be one of the cheapest ways of producing carbon-free electricity in the European Union through 2030. Without LTO, nuclear capacity in the European Union could fall by a factor of six by 2030, making it more difficult to achieve EU 2030 targets.

The decline in nuclear capacity if all plant lifetimes were either 40, 50, 55, or 60 years (i.e. with life extensions to 40, 50, 55, or 60 years) is shown in Figure 10.2. For example, comparing with Figure 10.1, if all plant lifetimes were 40 years, 25% of the nuclear units now in operation in the European Union would be closed by 2020, 50% would be closed by 2024, and 75% would be closed by 2026. Note that some licensed lifetimes are 30 years and some member states are retiring plants at 30 years or sooner; this shifts the lines in Figure 10.2 downward, creating more stress on EU electricity capacity than can be seen in the figure.

**Figure 10.2** Evolution of installed capacity for different LTO periods (includes reduction in Swiss nuclear capacity)




Source: OECD/NEA (2012), *The Economics of Long-term Operation of Nuclear Power Plants*, OECD Publishing, Paris.

In terms of NPP refurbishment, upgrading, uprating, and life extension, EU member states can be grouped into three categories: (1) those with new plants, such as Romania, where it is premature to discuss life extension; (2) those who have determined that they are no longer interested in having operating NPPs after the mid-2020s, such as Belgium (although in January 2014 Electrabel and EDF agreed to invest over EUR half a billion to extend the life of Tihange 1 to 2025) and Germany; and (3) those with NPP operators who are actively upgrading their plants. Operators upgrading their plants include the following:

*Bulgaria*: Kozloduy NPP PLC is working with Rosenergatom and EDF to extend the life of Kozloduy Units 5 and 6 beyond their current 30-year licensed lifetimes (to 2017 and 2019) to 50 years, as well as to uprate the Unit 6 turbine generator to 1 100 MW.

*Czech Republic*: The CEZ Group has started its LTO project to extend the lives of the Dukovany reactors by 10 years, which consists of over 200 sub-projects costing more than half a billion Euros between 2009 and 2015; and extension to 60 years is under consideration.



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*Finland*: TVO uprated the nearly twin units at Olkiluoto 1 and 2 from 658 MW (net) to 885 MW and 880 MW (net), by the end of 2011 and in 2012 Fortum announced that Loviisa would be upgraded and uprated between 2014 and 2017 by Skoda. All licences were extended to 50 years in 2007, and since then, licences have been extended to 60 years, subject to safety reviews.

*France:* EDF is considering extending the lives of all operating units to 60 years, requiring the replacement of all steam generators, to be completed by 2025. The license extension has not been granted per se, as each nuclear plant is reviewed every ten years by the Nuclear Safety Authority, whose approval is needed to continue the operation of the plant for ten more years. The Nuclear Safety Authority should give its first generic opinion on the extension of the operation of the French nuclear plants to 50 years by 2018 or 2019.

*Hungary*: Regarding the four-unit Paks NPP, in November 2005, the Hungarian Parliament passed a 20-year life extension project for Paks. In December 2012, the Hungarian Atomic Energy Authority approved a 20-year licence extension for Paks Unit 1 to the end of 2032 and anticipates extending the lives of the other three units as their current licenses expire.

*Netherlands*: in February 2014 Borssele was granted an irrevocable licence to operate to 2034 (60 years).

*Slovak Republic*: From 2005 to 2008, owners of the Mochovce NPP conducted a major modernisation programme on the two operating Bohunice units to improve (1) seismic resistance, (2) cooling systems, and (3) I&C systems, extending operational life to 40 years (i.e. to 2025).

*Slovenia*: In June 2012 the Slovenian Nuclear Safety Administration approved the viability of life extending upgrades for the single-unit Westinghouse PWR, Krsko (following the regulatory requirements of the US Nuclear Regulatory Commission, which has been involved in extending the licensed lifetimes of dozens of Westinghouse reactors). The original operating life was 40-years and a 20-year life extension is waiting for final approval after the Periodic Safety Review in 2023.

*Spain*: In 2011 the Spanish Nuclear Safety Council recommended licence extensions of ten years for the Almaraz units (with 70 MW uprates for both units) and for Vandellós 2. In 2011 it recommended ten-year licence extensions for Cofrentes and for the Asco units.

*Sweden*: The Swedish units have been uprated to replace the power from retiring a two-unit plant (Barsebäck) and most are being considered for life extensions to 60 years.

*United Kingdom*: EDF Energy (owner-operator of the UK operating units) will determine whether to upgrade each unit on a case-by-case basis as a function of the findings and requirements of the ten-year safety reviews conducted by the Office for Nuclear Regulation. EDF Energy plans on retiring all AGRs by 2023.

## NUCLEAR POWER PLANT CONSTRUCTION

There are several reactor designs under consideration for construction in Europe. Few NPPs are, however, being built in the European Union, because of the many uncertainties in future demand growth; future electricity prices; future regulations and tax policy; total construction costs; terms of finance; and EU competition regulation.

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Citing market failures that prevent new nuclear build from supporting European goals for energy security, sustainability, and competitive prices, Jan Mládek, Czech Republic Minister of Industry and Trade, addressed his concerns and those of ministers in nine other EU members states, to outgoing EU energy Commissioner Oettinger in July 2014.[3]

Half a dozen industrial consortia are now competing in the EU NPP vendor market. A summary is provided below by type of construction design. For some cases the situation might further evolve rapidly in different directions.

(1) *EPR*: EDF and AREVA have four EPRs under construction a) one in Finland (in September 2014 the expected commercial operation date of Olkiluoto 3 was extended to 2018; this has led to a delay of up to five years in the start of construction of Olkiluoto 4); b) one in France (by the end of 2012 EDF estimated that the total capital construction cost would be more than EUR 8 billion for Flamanville 3 and the expected commercial operation date would not be before 2016) and c) two in China with Chinese participation. EDF and AREVA also have proposals to build up to four EPRs in the United Kingdom with UK loan guarantees and contracts-for-difference, supplemented with Chinese equity (see below).

(2) *VVER (Water-Moderated, Water-Cooled Power Reactor):* Rosatom is working with various local partners. (a) It is finishing twin VVER-440s in Slovak Republic; (b) in June 2014 a Skoda-Russian consortium formed to consider the financing and building of Temelin 3 and 4 (twin VVER-1200s) in the Czech Republic; (c) in December 2013 Fennovoima signed an Engineering Procurement and Construction contract with the Russian supplier to build a VVER-1200 with a minimum 34% Russian equity share (originally held by E.ON); and (d) in January 2014 the Hungarian government signed an agreement with Rosatom to build two VVER-1200s with the first unit to be operating around 2023, and in February 2014, Russia agreed to finance all of the EUR 10 billion out of the estimated cost of EUR 10 to 12 billion.

(3) *PHWR (Pressurised Heavy Water Reactor):* China General Nuclear Power Group. In July 2014 a subsidiary of the China General Nuclear Power Group signed a co-operation agreement with the Romanian state-owned nuclear power operator and Candu Energy Inc. to construct the next two PHWRs (Candu-6s) units in Romania.

(4) *AP1000 (Advanced Passive):* Westinghouse (–Toshiba). (a) On 30 July 2014 the Bulgarian Council of Ministers approved an agreement between the Bulgarian utilities with Westinghouse (–Toshiba) to seek financing to build an AP1000; and (b) Westinghouse (–Toshiba) has proposed three AP1000s in the United Kingdom (see below).

(5) *ABWR (Advanced BWR):* GE–Hitachi. (a) in 2012 Lithuania initialled an agreement with GE–Hitachi to build a single ABWR and plans are under consideration for Estonia, Latvia and Poland to join this regional project, (b) GE–Hitachi has proposed to build up to four ABWRs in the United Kingdom with financial support (see below).

(6) *APR-1400 (Advanced Pressurised Reactor):* Poland and Slovak Republic are considering all non-Russian and non-Chinese vendors, including the Korean Hydro and Nuclear Power APR-1400, for up to four units by 2040.

**3.** Letter of 4 July 2014: "On behalf of the Ministers of Bulgaria, France, Hungary, Lithuania, Poland, Romania, Slovak Republic, Slovenia and the United Kingdom responsible for energy policy … We call on the Commission to reflect on … market failures and the need to hedge against investment risks … to create the necessary market conditions for investment in new nuclear build projects in Europe."



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**Box 10.2** Investment in new nuclear in the United Kingdom

The United Kingdom has been active in encouraging the private development of new nuclear power since 2006 through (1) reforming the licensing process by implementing a Generic Design Assessment (GDA) to license standardised designs, and (2) providing government financial support similar to the support that is given to some other low-carbon generating alternatives.

There are three active design assessments underway by the Office of Nuclear Regulation (ONR): the UK EPR submitted by AREVA and EDF (approval given in December 2013); the AP1000 submitted by Westinghouse (–Toshiba); and the ABWR submitted by GE–Hitachi. (Rosatom has announced that it will submit the VVER-1200 for GDA in association with Rolls-Royce and Fortum). Plans have been proposed (1) by EDF Energy to build twin EPRs at Hinkley Point C-1 and C-2 and at Sizewell C-1 and C-2; (2) by Horizon, a wholly-owned subsidiary of Hitachi Ltd., to build twin ABWRs at Wylfa Newydd 1 and 2 and at Oldbury B-1 and B-2; and (3) by NuGeneration, a joint venture of Toshiba (with a 60% ownership share) and GDF Suez (with a 40% share) to build three AP1000s at Moorside Units 1, 2 and 3. By end 2014, only the EPR design by EDF Energy for Hinkley Point C has been certified.

To help ensure the profitability of these projects, (1) the UK government agreed in June 2013 to guarantee loans for the construction of Hinkley Point C and in December 2013 agreed to consider a similar arrangement for Wylfa Newydd, and (2) provide a contract-for-difference[4] for power produced at Hinkley Point C at a strike price agreed between the government and the operator, depending on the construction of one or two units. These measures were subject to the approval of the DG Competition of the European Commission. On 8 October 2014, the European Commission approved the measures with some modifications. It required the increase of the guarantee fee to be paid by the operator to the public entity in line with the risk profile of the project. The modification also includes a gain-share mechanism for the entire lifetime of the project of 60 years. It requires the sharing of any profits above the originally established thresholds with UK consumers by a decrease in the price paid by the public entity to the operator (the so-called "strike price").

Further, in October 2013, to secure financing for Hinkley Point C, EDF Energy announced the formation of an investment company in which EDF would hold 45%-50% equity, China General Nuclear Power Group (CGN) and China National Nuclear Corporation (CNNC) would hold 30%-40%, AREVA would hold 10%, and other parties would hold up to 15%.

In June 2014, a memorandum of understanding was signed between the UK government, the Nuclear Decommissioning Authority (which owns the NPPs undergoing decommissioning in the United Kingdom, see below), the CNNC, and the China Atomic Energy Authority to build Chinese-designed reactors (e.g. the CAP-1400, a Chinese version of the AP1000 available through the State Nuclear Power Technology Corporation) in the United Kingdom, subject to certification through the GDA process.

**4.** Under a Contracts-for-Difference (CFD) in the UK electricity market, the government pays the generator the difference between the UK electricity market price and the strike price if the strike price is higher than the electricity market price and the generator pays the government if the market price is higher than the strike price. CFDs are being used to support renewables and new nuclear.

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## SECURITY OF NUCLEAR TECHNOLOGY AND FUEL SUPPLY CONCERNS

The European Union is one of the most open nuclear market in the world, with no formal restrictions on foreign investment and an open electricity market. Moreover, state aid to European companies requires EU approval. Unless appropriate market mechanisms can be effectively implemented, as for example in the United Kingdom, it is likely that vendors who may benefit from the direct (financial) support of their national authorities will get an advantage that might be considered as a bias to a regular competitive process, or at least not allow the proper functioning of the nuclear technology market.

EU-wide nuclear design approval processes, combined with appropriate market mechanisms facilitating the investment decision in a competitive environment will help reduce this risk.

Electricity produced from NPPs constitutes a reliable base-load electricity supply of emission free power and plays an important role in energy security. The relative value of the nuclear fuel is marginal in relation to the total production cost of electricity (10%-20%) compared to gas or coal-fired plants, and uranium is about half of the total cost of the nuclear fuel. The worldwide uranium supply market is stable and well diversified but the European Union is nonetheless completely dependent on external supplies. There are only a few entities in the world that are able to transform uranium into fuel for the nuclear reactors, but European Union industry has technological leadership in the whole chain, including enrichment, fuel fabrication, and reprocessing.

Particular attention should be paid to investments in new NPPs to be built in the European Union using non-EU technology to ensure that these plants are not bound only to one supplier for nuclear fuel: the possibility of fuel supply diversification should be a condition for any new investment, to be ensured by the Euratom Supply Agency, contributing to the overall diversified portfolio of fuel supply in the interest of all EU plant operators.

## NUCLEAR POWER PLANT AND FUEL CYCLE FACILITY DECOMMISSIONING

Regarding decommissioning of NPPs and fuel cycle facilities, EU nuclear policy efforts focus on the adequacy, availability, and transparent management of decommissioning funding. The Commission addresses these issues with the support of the Decommissioning Funding Group (DFG).

As outlined above, in July 2011 the European Council adopted Council Directive 2011/70/Euratom providing a framework for the management of spent nuclear fuel and radioactive waste.

The location of NPPs in the European Union, both in operation and under decommissioning, is provided in Figure 10.3. While this figure is from 2007, it continues to provide a fairly accurate picture of the current situation; only one plant has entered service since 2007 (a PHWR in Romania in October 2007, which would increase the size of that country's circle in Figure 10.3); much of the proportions of units in operation, under (active) decommissioning, dismantled (decommissioning completed), and safe enclosure (decommissioning delayed) have changed little in all but Germany (with eight units retired since 2011), Lithuania (with a unit retired in 2009), and Romania.

Because of the diversity of the early nuclear power programmes in EU member states, the current EU decontamination and dismantlement programmes for commercial NPPs



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are mostly "first-of-a-kind" projects. As these earlier plants are decommissioned (PWRs in Germany) experience will be gained and applied to the more standardised units (PWRs in France). Unfortunately, decommissioning the gas-graphite reactors involves managing large quantities of contaminated graphite (in the United Kingdom and to a lesser extent France, Lithuania and Spain), increasing the cost of waste disposal.

Given the higher needs for decommissioning in the European Union in the coming decade, there would be justification for public EU R&D funds (see Chapter 11, "Energy Research, Development and Demonstration") to be used to incorporate lessons learnt into the next phase of decontamination and dismantlement (D&D) activities.

Many learning opportunities could be fostered among member states in terms of the various reactor technologies:

*PWR*s: Belgium is participating with EDF in decommissioning the Franco-Belgian Chooz A in France, which should be completed by 2020. Chooz A is the only PWR currently being decommissioned in France. Despite some specific characteristics of this reactor (e.g. a smaller size than that of the reactors in the current French fleet), EDF considers Chooz A as featuring all the technical issues that will be typically encountered when dismantling other PWRs. Germany will be decommissioning 13 PWRs (including six VVER-440s at Greifswald, currently underway). In Spain ENRESA (Empresa Nacional de Residuos Radiactivos SA) began decommissioning Jose Cabrera ("Zorita," a 142 MWe PWR) in 2010 at an estimated cost of EURO 135 million over six years through 2016.

*BWR*s: Much of the experience with PWRs can be applied to the Light Water Reactor BWRs, which are being decommissioned: in Germany with nine units; in Italy with two units (to be decommissioned by 2025); in the Netherlands with one unit (to be monitored until 2045 at which time it will be decontaminated and dismantled); and in Sweden (Barsebäck Units 1 and 2, twin 600-MW BWRs, which have been de-fuelled).

*GCR*s: More problematic is the decommissioning of the Gas-Cooled Graphite Reactors because of the need to dispose of radioactive graphite. There are eight in France, including Bugey 1 that is not scheduled for complete decommissioning until 2040; the others are in "safe storage." In Italy at Latina (a 153 MW GCR (Magnox), retired in 1967) the turbine building has been dismantled and the remainder of the D&D should be completed by 2025. In Spain ENRESA finished the primary decontamination and dismantling of Vandellos 1 (a 480 MWe GCR) in 2003 for EUR 93 million over 63 months. However, the reactor has not yet been decommissioned and is in "safe storage" for 30 years, or until a disposal path for the contaminated graphite is secured. In the United Kingdom 29 GCRs (Magnox) have retired and are at various stages of decommissioning. The Nuclear Decommissioning Authority (NDA) owns these nuclear sites and the associated civil nuclear liabilities and assets of the public sector, and is responsible for their decommissioning.

*One-of-a-kind units*: There are also several one-of-a-kind units that have been retired: two fast reactors in France and one in Germany, two High Temperature Gas Reactors in Germany, two Heavy Water (moderated) Gas-Cooled Reactors (HWGCR) (one in France and one in Germany), and a 10-MW PHWR in Sweden, Agesta (now in extended storage after some decontamination).

To reinforce national programmes, the EBRD established the IDSF in 2001 for Bulgaria (four PWRs), Lithuania (two Light Water-moderated Graphite Reactors, LWGRs), and the Slovak Republic (two PWRs). At the end of 2013, more EU funds were pledged with an

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assurance of continuing support through 2020. In addition to the IDSF there is a Bulgarian decommissioning fund to support decommissioning activities at Kozloduy Units 1-4 which could cost around EUR 1.11 billion to complete (Lithuania and the Slovak Republic have also additional decommissioning funds in place). Lithuania is decommissioning Ignalina RBMK (a LWGR) Units 1 and 2. Both units have been de-fuelled and the fuel has been moved to an interim storage facility. The D&D of Unit 2 started in mid-2014. The total estimated cost of the Ignalina decommissioning project is over EUR 2.8 billion, with EUR 1.58 billion from the European Union. In the Slovak Republic, the Bohunice IDSF supports the decommissioning of the Bohunice V1 plant (two VVER-440s/V-230s). In 2012, the Slovak Republic started decommissioning the Bohunice V1 reactors and it is estimated that the decommissioning will be completed by 2025 at a total cost of approximately EUR 1.14 billion.

## ASSESSMENT

Nuclear energy is the second-largest source of low-carbon electricity in the European Union, providing 27% of the total electricity generated in the European Union. There are 131 nuclear reactors operating in 14 member states. Five of the six countries in the European Union with the lowest $CO_2$ emissions per kWh have nuclear capacities of at least one-third. There is still sensitivity surrounding nuclear power among the European public opinion and the decision on the share of nuclear energy in the mix, rests with the member states.

The Euratom Treaty continues to remain the legal framework for nuclear energy policy within the European Union, also after the entry into force of the TFEU. The framework was reinforced during the past five years with new legislation adopted, notably with regard to nuclear safety objectives and nuclear waste management and radiation protection.

Since the first in-depth review in 2008, the Euratom Community and its member states have taken a proactive response to safety, safeguards and security concerns, by adopting a Community framework for nuclear safety in 2009, which was amended and strengthened in 2014, notably in the aftermath of the Fukushima Daiichi accident and the results of the stress tests carried out by operators, national regulators and peer reviews by ENSREG. Commendably, the Euratom Community and its member states have also become proactive in the area of spent fuel and radioactive waste management, with the adoption of the radioactive waste and spent fuel management Directive in 2011, which among other issues also aims to secure adequate funding is available for the management of spent fuel and radioactive waste. In 2013, the Council adopted the Basic Safety Standards Directive.

The European Union faces major challenges linked to ageing NPPs in the coming decade. Indeed, out of the 131 reactors presently operating, 75% have been operating more than 27 years, half the units have been operating more than 29 years, and 25% of the units have been operating 33 years or longer. The ageing of the EU reactor fleet requires country-level and owner/operator-level decisions in the short term regarding plant safety regulations, plant upgrades, plant uprates, plant lifetime extensions and license renewals, plant retirements, plant decommissioning, spent nuclear fuel and radioactive waste management, and new plant construction.



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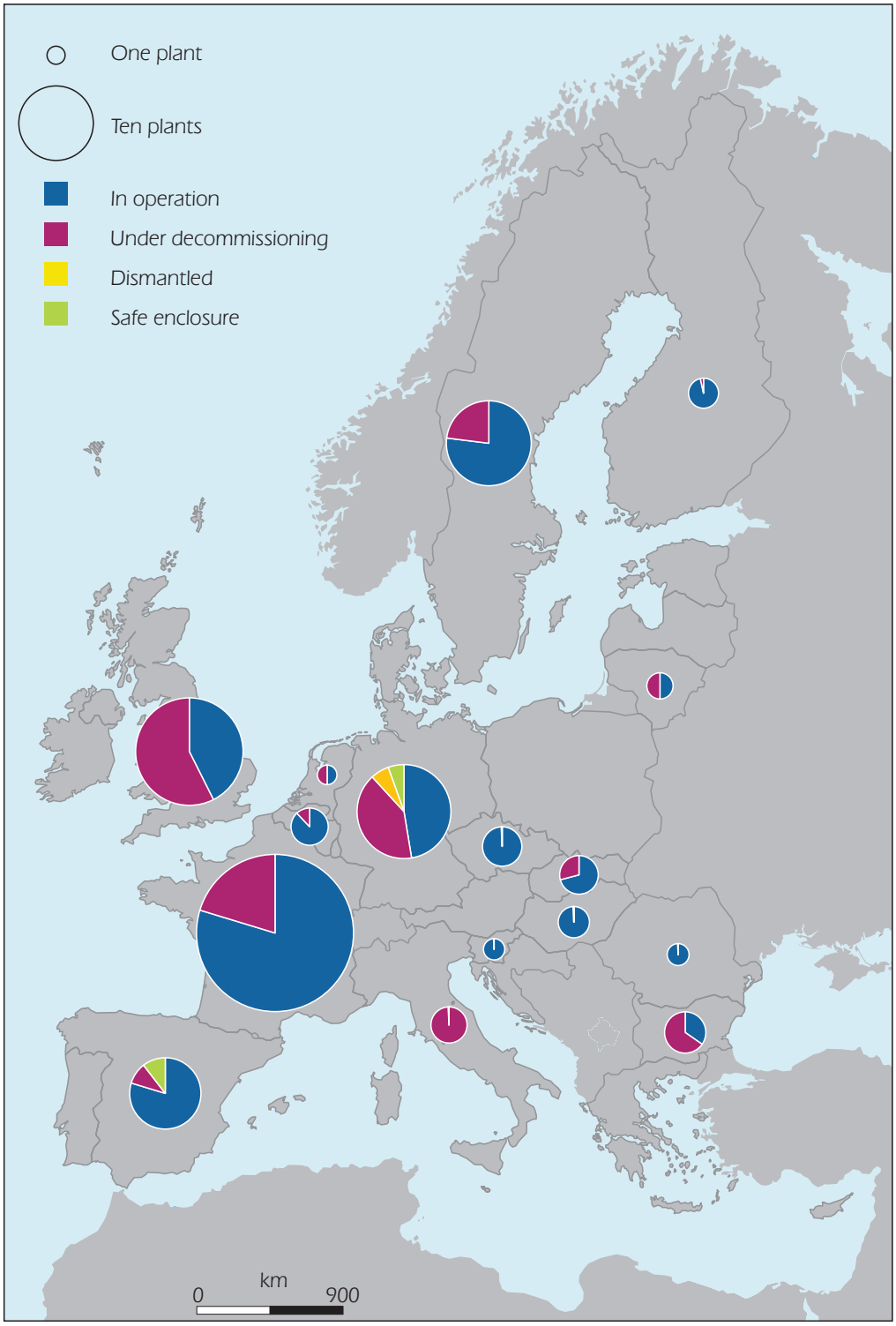
**Figure 10.3** Location of NPPs in operation and under decommissioning (June 2007)




This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: Based on data from EC (2007), *EU Decommissioning Funding Data, Commission Staff Working Document, Document accompanying the Communication from the Commission, Second Report on the use of financial resources earmarked for the decommissioning of nuclear installations, spent fuel and radioactive waste*, SEC(2007) 1654 final/2.

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A European framework for co-operation and co-ordination among member states, in support of those important decisions is important for several reasons.

(a) Nuclear electricity ensures reliable low-carbon base-load capacity within the European electricity markets. Retiring nuclear plants prematurely risks reducing the diversity of the European Union's electricity supplies, and as a result, could be reducing its energy security and adequacy.

(b) As member states retain the sovereignty over their fuel mix, some countries have developed nuclear power as an indigenous basis of their energy security and others have not. Ambitious nuclear phase-out policies, such as Germany has taken forward in 2011 or decisions to close NPPs in Belgium, can have important impacts on neighbouring countries' security and should be co-ordinated in an EU-wide generation adequacy assessment, as suggested in Chapter 5, "Electricity".

(c) Because of differences in the perception of costs, benefits, and risks, each member state closely guards its sovereignty over its nuclear power industry. Each member state licenses NPP technologies: there is no EU-wide licensing of NPP designs. NPP vendors are required to license their designs in each country. An EU-wide NPP design approval and certification process would be desirable. In combination with appropriate market mechanisms, facilitating the investment decision in a competitive environment it would help the security of the European Union, both from the nuclear technology and the reliability of electricity supply perspectives.

(d) Most of the EU NPPs are amortised. Therefore, the cost of upgrading the ageing NPP fleet to continue to produce clean energy is far less than building new capacity. An EU framework to ensure the safety of EU NPPs for the extended lifetime would be a very important requirement in the coming years.

Recently, the European Union has revised its rules with regard to public support to energy investments by member states in the July 2014 Environmental and Energy State Aid Guidelines (EEAG) which are now applicable to the energy sector. The guidelines do not cover rules on aid to nuclear energy. If member states decide to fund projects in this area, they need to notify the Commission of the aid, so that it can be assessed on a case-by-case basis under the general Treaty state aid provisions and the Euratom Treaty requirements. When assessing state aid to nuclear, the European Commission should aim to ensure a level playing field for all low-carbon energy technologies.

The European Union reinforces the sovereignty of member states by following the "polluter pays" principle. However, because of scale economies, it is unlikely that having each country manage its own high-level radioactive waste is economically efficient, in particular for countries with small programmes (a few NPPs). As the nuclear power plant capacity in the European Union is ageing, the EC should encourage member states to work together to manage their high-level radioactive waste, including through regional repositories.

## *RECOMMENDATIONS*

*The European Union should:*

- *Enhance EU-wide co-operation and co-ordination on uprates, safety upgrades, and extensions of the lifetimes of European Union's existing NPPs to ensure highest safety standards and regulatory stability for investment into the nuclear fleet in the transition to a low-carbon economy. Discuss investments with investors and operators, policy makers, regulators, and electricity consumers.*



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- *Support the harmonisation of NPP design approval and certification across member states, to foster fair competition between nuclear power technology options and vendors and increase the technology options available.*
- *Ensure appropriate incentives to encourage new nuclear power plant investment can be used in those member states who wish to maintain the nuclear option as part of their energy supply diversity and security (using the same market rules as for supporting other low-carbon generating technologies).*
- *Ensure co-ordination among member states regarding all forms of radioactive waste, particularly regarding high-level waste, including through the creation of regional repositories. With regard to nuclear plant decommissioning, ensure that adequate funding is available for the decommissioning and the related management of all forms of radioactive waste. Take a proactive role in encouraging the sharing of lessons learnt in decommissioning and waste management.*

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# PART III
# ENERGY TECHNOLOGY

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# 11. ENERGY RESEARCH, DEVELOPMENT AND DEMONSTRATION

**Key data (2011)**

**Government energy RD&D spending* in the EU:** EUR 4 billion

**Share of GDP (nominal):** 0.03%

**Largest spending by country:** France EUR 1.1 billion, Germany EUR 714 million, United Kingdom EUR 404 million, Italy EUR 390 million, and Finland EUR 254 million

**EU level funding for 2007-13:** EUR 10.5 billion[1]

* Data for 19 member states for which information is available; includes the largest economies.

## OVERVIEW

The European Union's (EU) research, development and demonstration (RD&D) policy is aimed at strengthening the European Union's scientific and technological base, and plays an important role in supporting its competitiveness. The EU RD&D policy complements member states' activities by focusing on cutting-edge technology activities with EU-level added value on the basis of Articles 173 and 179-190 of the Treaty on the Functioning of the European Union (TFEU).

European energy RD&D funding aims to integrate RD&D efforts across borders by building long-term partnerships and increasing effective exchange of RD&D results at EU level. Over a seven-year period, the EU support programmes run in parallel with national support programmes but have become an important source of funding for R&D institutions in the European Union. Since its launch in 2008, the Strategy Energy Technology Plan (SET Plan) and its technology initiatives and public-private partnerships have evolved. In 2014, a new period of the multi-annual framework programme started, with an improved structure, an increase in the energy funding and a new approach.

With the focus on creating a competitive low-carbon economy in Europe, energy RD&D has also become a key element in the work to meet the targets of the 2020 Climate and Energy Package, emphasising the need for sustained investment in research and development and an active market take-up of new technologies in energy. Action at the EU level has therefore been shifting from supporting the development of individual energy technology solutions under basic research to demonstration and deployment.

The European Union is focusing on energy systems under the new Horizon 2020 framework programme. The European Union will also need to develop the priorities, policies and programmes to implement the targets of the 2030 Climate and Energy Policy Framework.

**1.** Includes FP7 funding within the energy theme of EUR 2.35 billion, EUR 0.730 billion for Intelligent Energy Europe, nuclear-related research of EUR 1.152 billion for fission and EUR 4.149 billion for fusion (including ITER) as well as the NER300 of EUR 2.1 billion.

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## EU ENERGY RD&D POLICIES

Under the Europe 2020 Strategy, two flagship initiatives, the Resource Efficiency and the Innovation Union are of particular relevance to EU energy R&D policies. The European Union aims to increase the overall share of R&D to 3% of GDP from less than 2% in 2010.

The main elements of the EU-level policy on research and innovation (RDI) are set out in the Multi-annual Framework Programme (FP) for Research and Innovation (formerly FP for Research and Technology Development). The FP includes the general and sector-specific objectives of the EU-level RDI activities, details the amount of spending per sector, including energy, and sets out the spending rules.

The FP is a joint effort by the European Commission, the Council and the European Parliament. The FP is prepared for seven years at a time, to coincide with the European Union's seven-year budget cycle. Following the EU budget review in 2010, at the end of 2013, the new EU multi-annual financial framework, or budget, for the period 2014-20 was adopted and with it a new RDI FP, Horizon 2020, which runs from 2014 to 2020.

### THE STRATEGIC ENERGY TECHNOLOGY PLAN (SET PLAN)

The Strategic Energy Technology Plan (SET Plan) is the research and innovation pillar of EU energy policy. Launched in 2008, the SET Plan lists six technology areas as the most relevant for both the European Union's targets for 2020 and 2050 (see Chapter 2, "General Energy Policy"): wind; solar (photovoltaics and concentrated solar power); bioenergy, with the focus on second-generation biofuels; carbon capture and storage (CCS); electricity grids, and nuclear fission. In these six areas, European Industrial Initiatives (EIIs) were established.

In 2009, the European Commission estimated that implementing the SET Plan in full would require investments in R&D of EUR 8 billion per year from 2010 to 2020, according to the European Commission's estimates of 2009. The Plan did not include any specific funding for its implementation. The objective was to raise the funding via joint and co-ordinated activities at EU and member state level. The SET plan has become central for the prioritisation and co-ordination of EU and member states' action.

Since the launch of the SET Plan in 2008, the energy sector has undergone major technology changes. In May 2013, the European Commission therefore proposed suggestions for a new strategy for energy technology development by 2020 and beyond. Its objective was to take an energy system approach and encompass the whole innovation chain of the different technology solutions. New technology development in the energy sector is expected to reduce the cost of low-carbon technologies, unlock the potential of energy efficiency and increase the flexibility and security of the European energy system.

#### The EU FP Horizon 2020 and work beyond 2020

Horizon 2020, the EU FP for Research and Innovation 2014–2020 is the funding programme to implement the Europe 2020 Strategy's flagship initiatives, the Innovation Union, and the Resource Efficiency Initiative, in the pursuit of a smart, sustainable and inclusive growth. The European Union's stated goal for 2020, as it was for 2010, is to increase total (public and private sector) spending on research and development to 3% of gross domestic product (GDP) from less than 2% in 2010.



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Energy is part of the Horizon 2020 programme, as explained below in the sections on funding priorities and levels and features prominently in the societal challenges to be addressed:

- health, demographic change and well-being
- food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy
- secure, clean and efficient energy
- smart, green and integrated transport
- climate action, environment, resource efficiency and raw materials
- Europe in a changing world – inclusive, innovative and reflective societies
- secure societies – protecting freedom and security of Europe and its citizens.

Priorities are based on the SET Plan up to 2020 and will need to be re-defined to keep track with technology development after 2020.

The European Commission's proposals include:

- determining priorities for technology developments on the basis of both energy system requirements and the needs of particular technologies, not just the latter
- strengthening the link between technology development and market uptake
- reinforcing the development of industrial supply chains in Europe
- making better use of existing financial resources, at the same time opening possibilities for the development of innovative financial instruments
- while keeping the options open for new technologies.

In order to achieve these objectives, the European Commission is to develop, together with stakeholders:

- An **Integrated Roadmap** by the end of 2014. The objective is to propose key research and innovation actions for the period 2014–2020, bearing in mind also the objectives up to 2030. These actions should be the basis for EU, national and multi-member state activities and can also serve as a focus for private-sector investment in energy research and innovation. The draft will be prepared by a co-ordination group which is chaired by the Commission and attended by member state representatives and experts from all low-carbon energy technology fields. The co-ordination group is assisted by a working group which gathers all relevant stakeholders.
- An **Action Plan** by mid-2015. The Action Plan should describe how member states and the Union intend to support financially the Integrated Roadmap. This fosters aligning priorities and leveraging other EU funding.
- A robust **reporting system**, improving the current Strategic Energy Technologies Information System (SETIS), for monitoring the implementation of the Integrated Roadmap and the Action Plan.
- Periodic **conferences on EU Energy Research and Innovation Policy** (at least once every 18 months), providing the opportunity for projects in the same area to compare progress and for national / EU policy makers to exchange experience.

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## FUNDING

### FUNDING PRIORITIES

Horizon 2020 covers energy-related RD&D. As outlined in Regulation 1290/2013, Horizon 2020 includes the following broad lines of the activities for non-nuclear energy RD&D:

- (a) *Reducing energy consumption and carbon footprint by smart and sustainable use.* Activities shall focus on research and full-scale testing of new concepts, non-technological solutions, more efficient, socially acceptable and affordable technology components and systems with in-built intelligence, to allow real-time energy management for new and existing near-zero-emission, near-zero-energy and positive energy buildings, retrofitted buildings, cities and districts, renewable heating and cooling, highly efficient industries and mass take-up of energy efficiency and energy saving solutions and services by companies, individuals, communities and cities.
- (b) *Low-cost, low-carbon electricity supply.* Activities shall focus on research, development and full-scale demonstration of innovative renewables, efficient, flexible and low-carbon emission fossil power plants and CCS, or $CO_2$ re-use technologies, offering larger scale, lower cost, environmentally safe technologies with higher conversion efficiency and higher availability for different market and operating environments.
- (c) *Alternative fuels and mobile energy sources.* Activities shall focus on research, development and full-scale demonstration of technologies and value chains to make bioenergy and other alternative fuels more competitive and sustainable for power and heat and for surface, maritime and air transport, with potential for more efficient energy conversion, to reduce time to market for hydrogen and fuel cells and to bring new options showing long-term potential to maturity.
- (d) *A single, smart European electricity grid.* Activities shall focus on research, development and full-scale demonstration of new smart energy grid technologies, back-up and balancing technologies enabling higher flexibility and efficiency, including conventional power plants, flexible energy storage, systems and market designs to plan, monitor, control and safely operate interoperable networks, including standardisation issues, in an open, decarbonised, environmentally sustainable, climate-resilient and competitive market, under normal and emergency conditions.
- (e) *New knowledge and technologies.* Activities shall focus on multi-disciplinary research for clean, safe and sustainable energy technologies (including visionary actions) and joint implementation of pan-European research programmes and world-class facilities.
- (f) *Robust decision-making and public engagement.* Activities shall focus on the development of tools, methods, models and forward-looking and perspective scenarios for a robust and transparent policy support, including activities on public engagement, user involvement, environmental impact and sustainability assessment improving the understanding of energy-related socio-economic trends and prospects.
- (g) *Market uptake of energy innovation – building on Intelligent Energy Europe.* Activities shall build upon and further enhance those undertaken within the Intelligent Energy Europe (IEE) programme. They shall focus on applied innovation and promotion of standards to facilitate the market uptake of energy technologies and services, to address non-technological barriers and to accelerate the cost-effective implementation of the Union's energy policies. Attention will also be given to innovation for the smart and sustainable use of existing technologies.



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The Horizon 2020 regulation (1290/2013) does not allocate a budget to these activity areas, but only specifies that 85% of the budget for energy should be allocated to renewable energy, end-user energy efficiency, smart grids and energy storage, i.e. non-nuclear and non-fossil low-carbon energy technologies.

## FUNDING RULES

Project-specific funding from the FP is allocated through annual calls for proposals. These are set out in biennial work programmes providing details about the topics, timings and implementation. In most cases, the calls for proposals are developed with the help of the various European Technology Platforms that bring together public and private-sector researchers, industry, regulators and financial institutions, and that also contribute to the work programmes.

Under Horizon 2020, for any standard RD&D project, the participation of at least three different entities from three different countries is required. Horizon 2020 includes several changes to the rules for participation and funding that were applied to its predecessor, the Seventh Framework Programme on Research and Technology 2007-2013 (FP7).

The new rules under Horizon 2020 are intended to reduce the administrative burden on the participants in comparison with FP7, through:

- fewer rules for grants (e.g. one funding rate within a project, fewer evaluation criteria) and fewer and more targeted controls and audits
- a target reduction to eight months of the time between the call deadline and the grant signature
- clearer rules on intellectual property
- new forms of funding aimed at innovation, such as an instrument specifically for small and medium enterprises (SMEs) and pre-commercialisation procurement
- undergoing a mid-term review in 2017 which enables reviewing and revising these rules
- less prescriptive work programmes than those of FP7, with the result that consortia have greater freedom to propose work that is within the scope of the topics. This will increase competition for funding – also an aim of the Commission. However, the downside of this approach is that at least for the energy calls of Horizon 2020 that have already closed, there has been very substantial oversubscription.

## FUNDING LEVELS

### Framework Programme 2007-13 and Horizon 2020

Horizon 2020 is the EU main funding mechanism to support research and innovation. Around EUR 79 billion is available for 2014-20. Out of this total, EUR 5.6 billion is allocated to non-nuclear energy RD&D. The Horizon 2020 has more than twice the budget of the previous 2007-13 FPs (FP7 and the related Euratom programme).

However, other EU sources of demonstration and deployment funding were available in the timeframe 2007-13 outside the framework of FP7, such as IEE, the European Energy Programme for Recovery (EEPR) and New Entrants Reserve (NER300), which together

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provided significant resources for the demonstration of innovative renewable energy, energy efficiency and CCS projects. The IEE programme has been merged under Horizon 2020, while the EEPR was a one-off initiative; the NER300 is set to continue. The European Council of October 2014 called for the continuation of the new Entrants Reserve and the creation of a new NER400 after 2020.

Energy efficiency features prominently also in the Horizon 2020 work programme for the first two years (2014-15), in which energy efficiency-related projects account for 32% (FP7: 29%), whereas renewable-related projects represent 23% of the European Union's energy-related RD&D (FP7: 50%). However, since this work programme for the first two years allocates only part of the overall budget, it is too early to draw any conclusions on funding by technology area in Horizon 2020. Dividing the overall budget in annual work programmes provides the European Union with some flexibility to react on developments, e.g. upcoming findings from the Integrated Roadmap can be considered in later work programmes of Horizon 2020.

Horizon 2020 was preceded by the FP7 that had a budget of EUR 2.35 billion for non-nuclear energy for 2007-13. According to the European Commission evaluation by 1 January 2014, only EUR 1.9 billion, or 81%, out of EUR 2.35 billion was actually spent on projects (including other energy-related funding activities it was estimated to be EUR 2.238 billion on 1 January 2014). Not spending the whole budget is largely a result of the lengthy procedures for applying for funding and participating in activities under FP7. Horizon 2020 contains some measures aimed at improving these processes.

The FP7 funding for 2007-13 by country and technology is shown in Figure 11.1. Slightly more than half of the non-energy RD&D went to the five largest economies in the European Union (France, Germany, Italy, Spain and the United Kingdom). This, however, is not surprising, since these countries accounted for 70% of the contributions to the overall EU budget in 2007-13.

For comparison, government spending on energy RD&D for 2011 by EU member state is shown in Figure 11.2.

Combining national and EU public RD&D (including nuclear), annual public energy-related RD&D accounted in 2011 for 0.03% of the European Union's GDP. This share is similar to the United States, but much lower compared to Japan (0.09%) or Norway (0.1%). Cyprus,[2] Slovenia, Slovak Republic and Czech Republic have the lower RDD spending under FP7.

By technology area, renewable energy accounted for around 50% of the FP7-funded projects (including IEE projects) for 2007-13, followed by energy efficiency (smart cities and communities, energy efficiency in buildings and industry) with a share of 29% (Figure 11.3). Larger variations can be observed for technology shares in national public RD&D spending. In Hungary, 95% of public energy-related RD&D (excluding nuclear) was allocated to energy efficiency in 2007-11, whereas the Slovak Republic spent only 7% in this technology area. Still energy efficiency and also renewables have been central

**2.** Two footnotes: 1. **Footnote by Turkey**: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of United Nations, Turkey shall preserve its position concerning the "Cyprus issue". 2. **Footnote by all the European Union Member States of the OECD and the European Union**: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.



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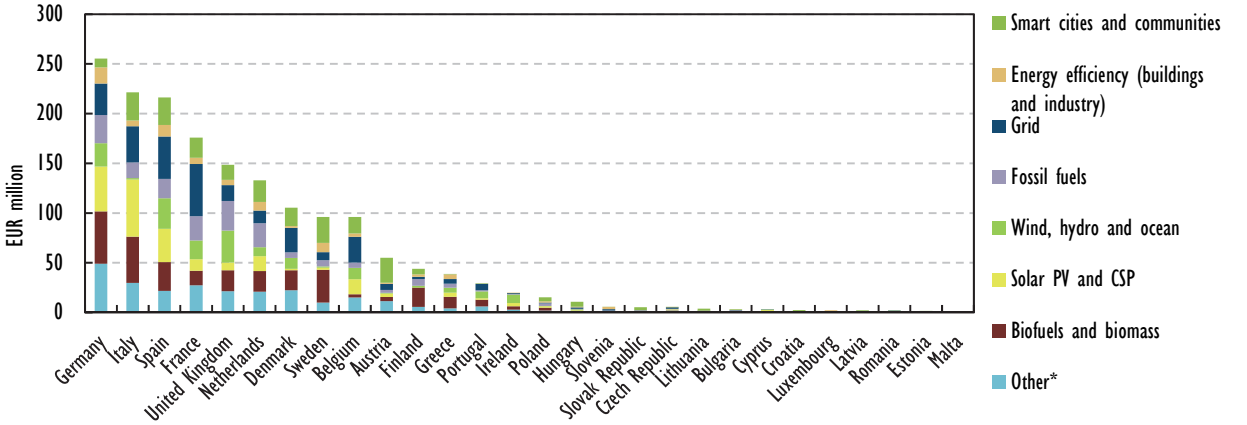
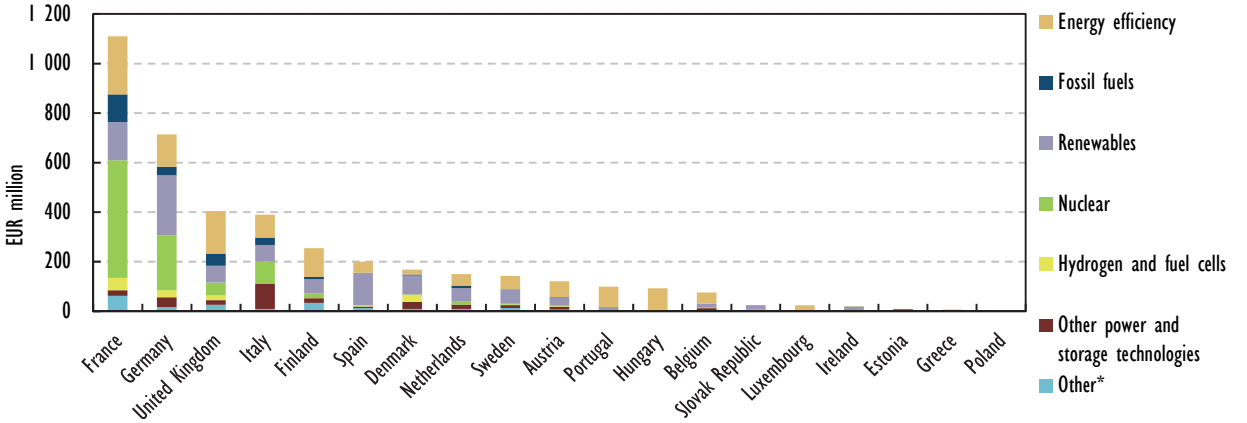
elements of public RD&D in many EU member states in the period 2007-11: 12 out of 19 countries spent at least one-quarter of their public energy RD&D on energy efficiency or renewables. On average, energy efficiency accounted for 35% of national, public RD&D compared to 32% for renewables.

**Figure 11.1** Energy RD&D funding under FP7 (2007-13) by country of recipient




* *Other* includes fuel cells/hydrogen, FET/materials, geothermal, cross-cutting issues, renewables for heating and cooling and policy issues.

**Figure 11.2** Government spending on energy RD&D in selected EU member states, 2011




Notes: data not available for Bulgaria, Croatia, Cyprus, the Czech Republic, Latvia, Lithuania, Malta, Slovenia and Romania.

**Other* includes fuel cells/hydrogen, FET/materials, geothermal, cross-cutting issues, renewables for heating and cooling and policy issues

The spending on energy-related RD&D under the energy theme of FP7 or the energy challenge of Horizon 2020 gives only a partial picture on the entire energy RD&D spending under FP7 or Horizon 2020, since energy-related aspects are also included in some of the other research themes, e.g. in Horizon 2020 the Energy-efficient Buildings (EeB) and Sustainable Process Industry (SPIRE) public-private partnerships in the Challenge Leadership in Enabling and Industrial Technologies (LEIT). Information on the additional spending on energy-related RD&D outside the central energy theme/challenge in FP7/Horizon 2020 would be desirable for better tracking and assessing the overall energy RD&D by the European Union, but this data is so far not centrally collected within the European Commission.

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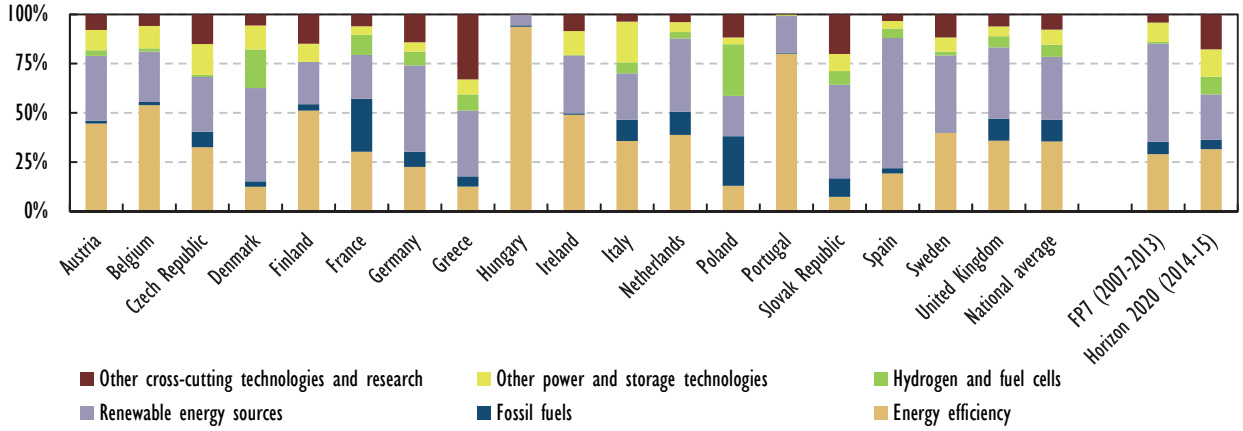
**Figure 11.3** Public spending on non-nuclear energy RD&D by technology area in selected EU member states (2007-11), FP7 and Horizon 2020




Note: FP7 includes spending under the Intelligent Energy – Europe programme.

## Nuclear energy research and development

The budget for nuclear RD&D for 2007-13 was EUR 1.15 billion for fission under the Euratom Research Programme and EUR 4.15 billion for nuclear fusion research for energy activities, including the International Thermonuclear Experimental Reactor (ITER) project.

Regarding nuclear RD&D, EU and national public funding complemented each other: EU funding focused on higher-risk fusion-related activities, while the member states spent three-quarters of their total nuclear RD&D budget on fission-related projects (see Figure 11.2).

In the coming funding period, nuclear energy is funded under the sub-programme, the Euratom Research and Training Programme 2014–2018 (Regulation 1314/2013) which focuses on both fission and fusion (ITER) energy and nuclear safety, including reactor and fuel safety and waste management with a total nuclear energy RD&D budget of EUR 1.603 billion. The budget for the Euratom Research and Training Programme (2014-18), adopted in December 2013, is allocated as set out in Table 11.1.

**Table 11.1** Euratom Fusion and Fission R&D Funding (2014-18)

| Type | Funding (EUR million) | Share |
|---|---|---|
| Fusion indirect actions | 728 | 45% |
| Fission indirect actions | 316 | 20% |
| JRC direct actions | 560 | 35% |
| **Total Euratom R&D Budget** | **1 603** | **100%** |

Notes: *Indirect actions* fund fusion or fission R&D projects set up by consortia of EU organisations. *Indirect fusion actions* fund fusion technologies other than ITER. *Direct actions* fund R&D performed by the EC JRCs (Joint Research Centres).

Source: Euratom Research and Training Programme, 2014.

Adding the fission indirect actions plus the JRC direct actions, the budget for activities related to nuclear electric power amounts to EUR 175 million per year for the years 2014 through 2018. These EUR 175 million are allocated equally to radiation protection and



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medical applications, waste management, and power reactor and fuel cycle technologies, i.e., about EUR 60 million are spent on research each year associated with new NPP design, NPP safety, NPP upgrades, NPP life extension, and NPP decommissioning.

In addition, the European Union has allocated EUR 2.9 billion for the ITER fusion project under a separate supplementary programme for 2014-20.

Despite the different timeframes, it can be compared to EUR 5 931 million (for seven years) or EUR 850 million per year for "secure, clean and efficient energy", under Horizon 2020, outside of nuclear energy RD&D.

## Funding outside of the research FPs

The European Union is also supporting energy RD&D outside its research FP through various other instruments, such as the European Energy Programme for Recovery, Structural Funds or the NER300 programme. Table 11.2 provides an overview of this additional financing by the European Union of the energy sector, in the areas of transmission networks, sustainable energy (excluding nuclear) and nuclear energy. These instruments aim to reduce the financing risks associated with the capital-intensive step of demonstrating new technologies on an industrial scale and crossing the so-called "valley of death" in technology development.

The **Risk Sharing Financing Facility (RSFF)** is a financing instrument to provide loan financing for RD&D and innovation. From 2007 to 2013, the European Union (through FP7) and the European Investment Bank (EIB) each contributed EUR 1 billion to this instrument. Through the leverage effect, this contribution guarantees loans by the EIB of EUR 10 billion in the period 2007-13. Within this loan portfolio, energy-related projects accounted for 16% (or EUR 4.8 billion) of the RSFF supported loans in 2007-12 (EIB, 2013). In Horizon 2020, so far, around EUR 200 million have been allocated for 2014-15 to the RSFF instrument (Rouillon 2014).

**Intelligent Energy – Europe (IEE).** FP7 only supported pre-commercial research, while market uptake activities for renewable technologies and energy efficiency were supported through the IEE programme with a budget of EUR 730 million for 2007-13, which has mobilised through its financial instruments an estimated additional funding of EUR 11 billion from third parties, assuming a leverage factor of 15 (CEPS 2014). The IEE activities were integrated in Horizon 2020, which addresses the entire technology development process from basic research to commercial applications.

**European Structural and Investment Funds (ESIF).** The EU cohesion policy provides through its Structural Funds additional support for low-carbon energy technologies. In the budget period 2007-13, the European Regional Development Fund (ERDF) and the Cohesion Fund invested EUR 18.5 billion in low-carbon themes, such as renewable energy, energy efficiency, clean urban transport and cycle paths. For the period 2014-20, the ERDF support for the transition to a low-carbon economy has been increased by earmarking a minimum of EUR 23 billion to this area, four times more than the budget for energy in Horizon 2020. These ERDF resources are targeted towards a range of activities, but the role of RD&D is stressed in the new ERDF regulation through the condition that at least 50%-80% (depending on the economic development status) of the national ERDF resources should be spent on the four areas of RD&D, information, communication and technology (ICT), competitiveness of SMEs or the low-carbon economy. Because innovation in energy technology meets two ESIF policy objectives simultaneously, there is great potential in the period 2014-20 to use ESIF instruments to support energy innovation.

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The **EEPR** provides financial support to selected highly strategic projects with a total EU commitment of EUR 4 billion. Among the objectives of EEPR are to make energy supplies more reliable, to reduce greenhouse gas emissions, and to boost Europe's economic recovery. By August 2014, out of the total volume of EUR 4 billion, EUR 2 268 billion had been committed to gas and electricity interconnectors (40% or EUR 897 million has been disbursed), to CCS projects (EUR 347 million), to offshore wind (EUR 226 million) and to the European Energy Efficiency Fund (EUR 88 million). While several interconnection projects are completed, technology complexity of large-scale projects, regulatory obstacles and lack of public acceptance made progress of the offshore wind projects slow and sobering for CCS. In the absence of sufficient additional support from either member states or the EU-ETS, none of the six CCS projects that initially were included under the EEPR has taken a final investment decision. By April 2014, four are no longer proceeding (Spanish project completed the operational pilot plants) and two are ongoing (ROAD project in the Netherlands, Don Valley project in the United Kingdom).

The **NER300 (New Entrants' Reserve) programme** is potentially a large source of funding for the SET Plan. The programme is conceived to support CCS and innovative renewable energy projects that are not yet commercially viable at a commercial scale. It was established under article 10a(8) of the EU-Emissions Trading Directive and is funded from the sale of 300 million emission allowances from the New Entrants' Reserve (NER) set up for the third phase of the ETS. The monetisation of these allowances has been made available to co-financing up to half the costs of demonstration projects. The NER300 is considered a critical part of EU innovation policy as it aimed to bridge the gap between R&D (for example, projects funded under FP7) and commercial viability – the so-called "valley of death". The results from the first round are therefore eagerly awaited.

In the first call in December 2012, a total funding of EUR 1.1 billion was provided for 20 projects, leveraging additional private funding of EUR 2 billion. For the second call in spring 2013, 19 projects were awarded a total of EUR 1 billion. Despite the stated intention to support CCS, only one CCS project was awarded funding. In total, EUR 2.1 billion have been spent under the NER300. The NER300 award is only paid out once plants have successfully started to operate and, while member states can opt to take on the risk of allocating funding upfront, this may have hampered the scheme's ability to support the riskiest projects (see Table 11.2).

As an indication of the inherent risks associated with demonstration projects, five renewable energy projects awarded funding from the first call have been cancelled since December 2012, reducing the amount awarded to ongoing projects from EUR 1.1 billion to less than EUR 0.8 billion. Member states are interested to continue with a new entrants reserve for 400 million allowances (NER400) in the 2030 Climate and Energy Policy Framework. These unavoidable risk factors for demonstration-stage technologies therefore need to be addressed and the governance of the funding enhanced.

## INSTITUTIONAL FRAMEWORK

EU energy RD&D policy involves numerous stakeholders, initiatives and operating frameworks (see Figure 11.4). The European Union aims to develop a favourable environment for research and development activities by establishing a European Research Area (ERA). Through this, the goal is to remove obstacles to cross-border co-operation and increase the effectiveness of activities. To facilitate the voluntary co-ordination among national research funding agencies, several trans-national instruments have been established and supported through the past FPs:



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- **ERA-NET and ERA-NET Plus** aim at co-ordinating national research projects with the main research funding provided by national programmes, supplemented by EU budget for co-ordination costs. In the case of ERA-NET Plus, also additional top-up funding is provided by the European Union.
- **"Article 185" Initiatives** refer to Article 185 of the TFEU, which provides a legal basis for the European Union to participate in research and development programmes of the member states in order to help the co-ordination of RD&D and support a more coherent use of resources. The "Article 185" Initiatives are more ambitious and have a wider scope than ERA-NET activities: their agenda definition is brought from the national to the European level.
- **Joint Programming Initiatives (JPIs)** do not define their objectives or scope according to a scientific field, but aim to address societal challenges and therefore, in contrast to ERA-NETs and "Article 185" Initiatives, take a multi-disciplinary approach. The Joint Programming process, launched in July 2008, is a structured and strategic process in which member states agree, voluntarily and with a variable geometry in terms of participation, on common Strategic Research Agendas (SRA). A High-Level Group on Joint Programming consisting of representatives of member states and of the European Commission, and assisted by the Council Secretariat, has been set up to implement the Joint Programming Process by identifying themes. So far, ten JPIs have been launched.
- **Joint Undertakings** (under Article 187 TFEU) can be set up by the Union for the efficient execution of EU research, technological development and demonstration programmes. To date, the European Union has set up several Joint Technology Initiatives (JTIs).
- **Knowledge and Innovation Communities (KIC) – Climate, InnoEnergy, Urban Mobility–** bring together stakeholders from higher education, research and business in the energy RD&D area. Set up in 2010 by the European Institute of Innovation and Technology (EIT), the KIC Climate has partners with 47% from business, 32% from academia, and 21% public bodies. Created in 2009, KIC InnoEnergy brings together eight companies, seven research institutes and 13 universities and business schools covering the sustainability across the whole energy mix. Six regionally bundled centres form this consortium.

These different instruments provide flexibility for supporting the creation of the ERA, but also increase the complexity on the implementation and management level. In Horizon 2020, ERA-NET activities have been streamlined by merging the ERA-NET and ERA-NET Plus instruments into a single ERA-NET instrument, under which it will be compulsory to organise joint calls for proposals that will receive top-up funding from the European Union.

Under the SET Plan, the EIIs bring together industry, research entities, member states and the European Commission in risk-sharing partnerships that aim at rapidly developing the technologies. In addition, the SET Plan incorporates the Fuel Cells and Hydrogen Joint Undertaking which had been set up already before the SET Plan was adopted. The European Innovation Partnership Smart Cities and Communities (EIP-SCC) builds upon the earlier SET Plan SCC Initiative on scaling-up efforts on urban energy efficiency.

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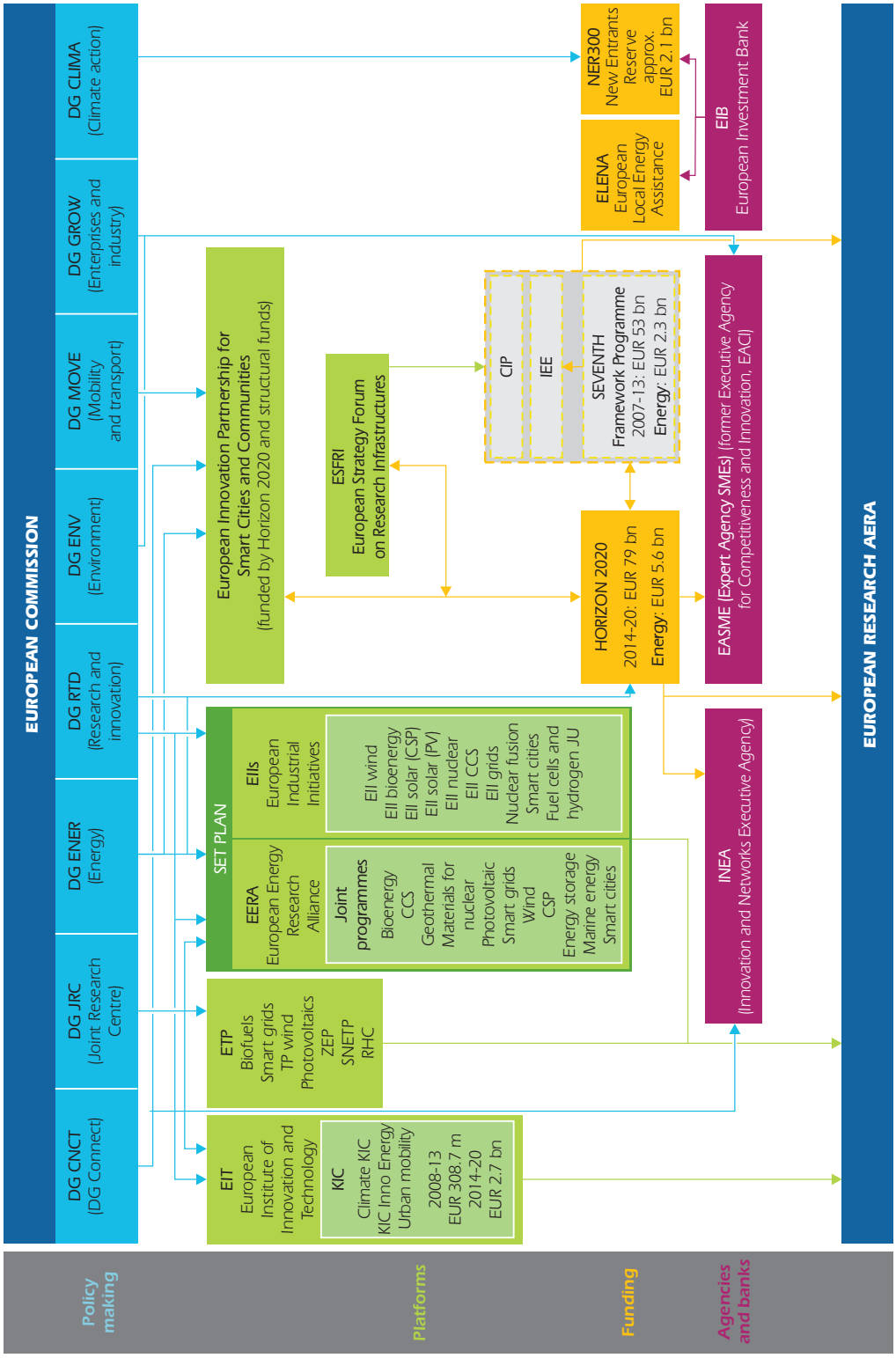
**Figure 11.4** EU energy research community




Source: Adapted from David McAuley, Sustainable Energy Authority of Ireland (SEAI), http://www.seai.ie/Renewables/Energy_Research_Portal/EU_Research/EU-Progs-JPEG.jpg



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**Table 11.2** EU financing in the energy sector, March 2014

| EU programme | Support | Budget (EUR million) | | Comment |
|---|---|---|---|---|
| | | 2007-13 | 2014-20 | |
| **Transmission networks** | | | | |
| TEN-E Programme | G | 145 | 0 | Replaced by CEF |
| Project Bond Initiative (PBI) Pilot | F | 10 | Under CEF | |
| EEPR | G | 4 | 0 | EUR 1.5 billion paid by end 2013 |
| Connecting Europe Facility (CEF) | G/F | 0 | 5 850 | |
| Marguerite (2020 European Fund for Energy, Climate Change and Infrastructure) | F | 80 (transport TEN-T budget) | Possibly under CEF | |
| Structural funds | G | 1 607 | Not yet available | |
| RTD (FP7) | G | 150 | Not yet available | |
| **Sustainable energy excluding nuclear** | | | | |
| RTD (FP7.Co-operation. Energy theme->H2020- Energy Challenge) | G | 2 350 | 5 600 | |
| RSFF according to EIB 2013 | F | 4 800 | Not yet available | Leveraged amount of EIB loans in energy sector |
| Marguerite (2020 European Fund for Energy, Climate Change and Infrastructure see above) | F | 214 | 0 | |
| IEE programme (within Competitiveness and Innovation Programme) | G/F | 730 | Integrated in Horizon 2020 | |
| EEPR | G | 565 (Offshore wind) + 1 000 (CCS) | Not yet available | |
| European Energy Efficiency Fund (EEEF) (spin-off from EEPR) | F | 265 | 0 | |
| NER300 | | 2 100 | | NER300 funds were committed during 2011-14 but will be paid out in 2014-20. |
| Structural/cohesion funds | G/F | 10 100 | min. 23 000 | |
| **Nuclear*** | | | | |
| Decommissioning fund | G | 1 786 | 969 | |
| Nuclear Euratom Fission | G | 1 152 *(incl. 747 for JRC)* | 874 *(incl. 315 for JRC)* | |
| Nuclear Euratom Fusion | G | 4 149 (*including ITER)* | 3 643 *(including ITER 2 915)* | |

Notes: G = grant; F= financial instrument.

* Euroatom funding so far has been adopted for the period 2014-18. An extension from 2018 to 2020 will need to be agreed by member states at a later stage. The table includes under the 2014-20 funding levels the EC proposed funding under Euratom, not the approved funding. The funding on nuclear energy in the period 2007-13 and 2014-18 can therefore not be directly compared.

Source: European Commission, European Investment Bank.

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The SET Plan also includes the European Energy Research Alliance (EERA) which aims to improve the co-ordination of energy technology research at a pre-commercial scale between leading European research organisations and institutes. The EERA is governed by a General Assembly composed of representatives of all its members and by an executive committee of 15 European research institutes. They have set up 15 Joint Programmes to accelerate the development of new energy technologies and to integrate activities and resources, combining national and Community sources of funding. More than 3 500 researchers from more than 250 public research centres and universities are actively collaborating today in the EERA Joint Programmes, identifying and bringing together national centres of excellence in the energy research sector, and highlighting common needs, objectives and research interests for the 2013-20 programming period.

## MONITORING AND EVALUATION

Following the mid-term review of the EU budget in 2010, the European Commission evaluated the previous 7th Framework Programme and the energy-related RD&D activities. This evaluation was the basis for the preparation of Horizon 2020.

The European Commission is responsible for monitoring annually the implementation of Horizon 2020 and the Euratom Research and Training Programme. The monitoring results are to be made publicly available. The Commission is also required to evaluate the full results of the FP7 by December 2015 and the 2012-13 Euratom Framework Programme by May 2015. It will also need to conduct a mid-term review of Horizon 2020 by December 2017 and of the Euratom programme by May 2017.

Finally, the European Commission is obliged to carry out an ex-post evaluation of Horizon 2020 by December 2023 and of the Euratom programme by the end of 2022. In all evaluations, the Commission is to be assisted by transparently selected independent external experts.

Evaluation criteria in the Horizon 2020 regulation are general and do not include any energy-specific dimensions. More specific evaluations will be carried out on individual programmes and projects under Horizon 2020.

A similar approach applies to the evaluation of the Euratom programme and its subprogrammes. The performance criteria to be used are laid out in Annex II of the Euratom programme regulation (1314/2013).

## INTERNATIONAL COLLABORATION

The European Union has bilateral and multilateral agreements on co-operation on energy RD&D with several countries. These countries include Australia, Azerbaijan, Brazil, China, India, Iraq, Japan, Kazakhstan, South Africa, Russia, Turkey, Turkmenistan, Ukraine, the United States, Uzbekistan and countries in the Euro-Mediterranean energy co-operation.

EU non-member states could become associated to FP7, thus paying their share of the FP7 budget in exchange for a status similar to that of member states. Around 10% of the FP7 energy budget has been spent in EU non-member states, with the majority of this share going to so-called associated countries (in FP7: Albania, Bosnia and Herzegovina, Faroe Islands, Former Yugoslav Republic of Macedonia, Iceland, Israel, Liechtenstein, Moldova, Montenegro, Norway, Serbia, Switzerland and Turkey).



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FP7 Energy was open to the participation of entities from nearly all countries of the world, and those entities could receive funding provided that they were not based in high-income countries. Out of the EUR 28 million received by third countries (excluding associated countries), participants from BRICS (Brazil, Russia, India, China and South Africa) received EUR 11 million over the period 2007-13. In addition, international co-operation took place through co-ordinated calls with third countries funding agencies, mostly targeted at BRICS, with EUR 13 million.

The European Commission participates in 20 IEA Implementing Agreements (IAs), mostly on renewable energy and nuclear fusion. Typically, the Commission is represented either by DG ENER or DG RTD. In recent years the European Commission has collaborated with the IEA on low-carbon energy technology, including through the activities of the IEA International Low-Carbon Technology Platform.

## ASSESSMENT

Innovation is at the heart of the Europe 2020 Strategy for smart, sustainable and inclusive growth. Under the Europe 2020 Strategy, the European Union aims to increase the overall share of R&D to 3% of GDP from less than 2% in 2010. Energy technology research, development and innovation is considered as a major long-term driver for secure, competitive and environmentally sustainability energy supply.

The European Union has significantly increased funding for energy RD&D, a positive development since the previous in-depth review in 2008. Horizon 2020 will provide EUR 5.6 billion for the period of 2014-20 dedicated to energy efficiency, competitive low-carbon energy, and smart cities and communities. This is a laudable increase from the previous seventh framework programme (FP7): non-nuclear energy research more than doubled in nominal terms and its relative share in the total RD&D budget of the European Union increased from 4.7% in FP7 to 7.7% in Horizon 2020. Since the first IEA in-depth review in 2008, the European Union has also increased its demonstration and market uptake funding with the launch of new programmes, such as the EEPR, NER300, TEN-E and CEF funding, in co-operation with the EIB.

These increases however may not be as substantial as they seem at first sight, as changes in other sources of funding energy-related RD&D partially offset their effect. With the IEE activities being integrated in Horizon 2020, and in the absence of any follow-ups to EEPR or clear signals on NER300-type instruments for 2014-20, it seems that EU funding to non-nuclear energy research has increased in real terms by only 17%. On average, this is less than the funding increase for other Horizon 2020 themes.[3]

On the positive side, with its stronger emphasis on energy efficiency and smart cities, Horizon 2020 improves the funding balance between supply and demand sides compared to FP7. This is in line with an important recommendation from the IEA 2008 in-depth review.

The Strategic Energy Technology Plan (SET Plan) has helped increase RD&D investment in eight key low-carbon energy technologies (wind, solar, bioenergy, CCS, electricity grids, nuclear, fuel cells and hydrogen, energy efficiency) across the European Union from EUR 3.2 billion to EUR 5.4 billion per year, including funding from industry and member states.

**3.** Data from the European University Association and the European Renewable Energy Research Centres Association.

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Furthermore, from 2014 to 2020, more funding for low-carbon technology development and deployment is available for the EU member states from EU sources, such as the ERDF and Cohesion Fund, which allocate at least EUR 23 billion for 2014-20 for low-carbon technology. The European Union also closely co-operates with the EIB to continue and further develop financial instruments including financing RSFFs to support long-term energy RD&D.

The structure of Horizon 2020 features a number of welcome changes. Instead of prescribing technology options, it focuses on solutions to energy challenges. By introducing technology readiness levels in the funding criteria, it better addresses the different support needs along the technology development pathway from basic research to large-scale demonstration. Moreover, Horizon 2020 facilitates access to finance for SMEs. On the administrative side, Horizon 2020 has simpler participation rules compared to previous FPs. The IEA welcomes these changes as making the programme more flexible and less burdensome on participants.

## Monitoring, evaluation and prioritisation

An essential part of RD&D policy is systematic monitoring of progress and effective programme evaluation. More attention to these areas would be desirable.

While monitoring the progress of EU RD&D efforts includes economy-wide innovation indicators – complementing the set of economy-wide indicators tracked in the Innovation Union Scoreboard reports, similar indicators to track energy-related RD&D results at EU and member state levels have, however, not so far been developed.

Evaluations of past FPs and the guidelines of Horizon 2020 make no attempt to track the research spending on EU and national levels against the guiding principle of EU-level RD&D: to complement the national RD&D efforts of the member states. At least under the SET Plan, estimates of public and corporate RD&D spending on EU and member state level have been provided every two years for six technology areas for which EIIs exist (wind, solar, bioenergy, carbon capture and storage, electricity grids, and nuclear fission).

Better monitoring and more detailed evaluation of energy-related RD&D at EU and member state level would help to ensure that EU efforts are complementary and provide additional value to the RD&D pursued by the member states. The European Union should continue efforts to better align European Union and national R&D priorities, policies and international technology co-operation.

The SET Plan has helped to formulate priorities for energy technology development, supporting the 2020 energy and climate package. As the European Union is preparing its 2030 Climate and Energy Policy Framework, the formulation of EU energy technology priorities will need to be reviewed. While current funding programmes target the 2020 horizon, the next decade is likely to bring major shifts in technology development which can be anticipated and supported by EU RDD policies.

Stimulating innovation requires foresight; in the coming years EU policies should place emphasis on integrating technology and innovation foresight[4] into its approach, when setting new priorities for future energy technology innovation.

**4.** Technology foresight is the process for bringing together in partnership scientists, engineers, industrialists, government officials and others to identify areas of strategic research and the emerging technologies likely to yield the greatest economic



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The Integrated Roadmap due by the end of 2014 is expected to provide a tool for this at a strategic level. The related Action Plan to be released by mid-2015 is to indicate how each member state intends to support the implementation of the Integrated Roadmap, including an indication of the resources to be committed. At operational level, EERA is a welcome form of co-operation in the drive for cost-efficiency.

### International co-operation

In addition to creating a truly European energy RD&D community through the ERA, KICs and other fora, the European Union is active in international energy RD&D collaboration with countries such as the United States, China and Russia as well as organisations such as the IEA and IRENA). The European Commission has long participated in the IEA IAs. The EC participates in 20 IAs largely focused on renewable energy sources and (through Euratom) on fusion energy. In 2014 and 2015, the EC will financially support 12 IAs under Horizon 2020. The IEA sees all this work as very fruitful and urges the European Union to continue its active international energy RD&D collaboration.

## *RECOMMENDATIONS*

*The European Union should:*

- *Ensure adequate energy RD&D funding to help meet EU energy policy goals and accelerate the commercial deployment of low-carbon and energy-efficient technologies.*
- *Strengthen co-operation and co-ordination across the European Commission of energy, technology, RD&D and innovation policies. Equally, strengthen the co-ordination of RD&D with member states and industry to maximise the impact of EU funds, notably structural funds and demonstration funds, and leverage private funds.*
- *Regularly monitor and assess outcomes of energy RD&D programmes based on a set of indicators on competitiveness and innovation to evaluate and maximise economic and social benefits of EU funds. Assess technology and innovation foresight and adapt technology roadmaps in line with the 2030 targets.*
- *Continue active international energy RD&D collaboration and share the European Union's energy policy lessons with global energy stakeholders, including through IEA IAs and the IEA International Low-Carbon Energy Technology Platform.*
- *Rebalance EU nuclear R&D programmes with regard to NPP advanced design, safety improvements, generating upgrades, license extensions, decommissioning, and non-electric energy applications, as a contribution to maintaining competitiveness, security of supply, and sustainability.*

and social benefit and which in the long term will sustain industrial competitiveness. In the technology foresight process the participants develop consensus on research priorities, creating a shared vision of the future they would like to achieve. The process is concerned with constructing a desirable but achievable long term future and with identifying the critical strategic decisions which must be taken now to make the achievement of this vision more probable.

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# PART IV
# ANNEXES

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# ANNEX A: ORGANISATION OF THE REVIEW

## REVIEW CRITERIA

The Shared Goals, which were adopted by the IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews (IDRs) conducted by the IEA. The Shared Goals are presented in Annex C.

## REVIEW TEAM

The in-depth review team visited Brussels during 20-27 January 2014. The team met with government officials, energy suppliers, interest groups and various other organisations. This report was drafted on the basis of these meetings, the team's preliminary assessment of the European Union's energy policy, the European Commission response to the IEA energy policy questionnaire and other information. The members of the team were:

*IEA member countries*

Dr. Yonghun Jung, Korea (team leader)

Mr. Rob James (Canada)

Ms Bjorg Borgstrand (Norway)

Dr. Lukas Gutzwiller (Switzerland*)*

Dr. Geoffrey Rothwell (Nuclear Energy Agency [NEA]/OECD)

*International Energy Agency*

Mr. Laszlo Varro

Mr. Tim Gould

Mr. Robert Tromop

Mr. Kijune Kim

Mr. Miika Tommila

Mr. Adam Brown

Ms Sylvia Elisabeth Beyer (desk officer)

The team is grateful for the co-operation and assistance of the many people it met during the visit, their kind hospitality and their willingness to discuss the challenges and opportunities that European Union is currently facing.

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The IEA team wishes to express its gratitude to Mr. Dominique Ristori, Director-General of the Directorate-General for Energy at the European Commission, for his personal engagement in meeting and Mr. Hans van Steen, Head of Unit International Relations DG Energy. The team also wishes to thank Mr Erlendas Grigorovic and Ms Marion Schiller-Probst for their tireless efforts and professionalism in planning and organising the review visit and for supporting the team throughout the review process.

Ms Sylvia Beyer prepared the review and is the author of the chapters on general energy policy, gas, electricity and oil of this report. Mr. Geoffrey Rothwell contributed from the NEA/OCED with a chapter on nuclear energy. Mr. Miika Tommila wrote the chapters on coal and research, development and deployment, with input from Mr. Uwe Remme, Mr. Simon Bennett and Mr. Simone Landolina. Ms Ellina Levina completed the chapter on climate change, supported by Mr. Simon Bennett with regard to CCS. The energy efficiency chapter was prepared by Ms Melanie Slade, Mr. Lorcan Lyons and Ms Sara Pasquier. Mr. Adam Brown was in charge on the chapter on renewable energy.

The report has also received support from Dr Ann Eggington to whom the author wishes to express her special gratitude for the review of the document and provision of expert comment. The author is grateful for the fruitful discussions, the comments and substantive input provided by the review team members cited above and many other IEA and NEA colleagues, including Mr. Antoine Halff, Mr. Martin Young, Mr. Paolo Frankl, Mr. Philippe Benoit, Mr. Samuel Thomas, Mr. Maro Baroni, Mr. Anne Braaksma, Ms Anne-Sophie Corbeau, Ms Toril Bosoni, Mr. Charles Esser, Mr. Manuel Baritaud, Ms Sonja Lekovic, Dr Johannes Trueby and Dr Marc Deffrennes.

A special thanks to the IEA secretariat with regard to the data, publication and editing. Ms Sonja Lekovic and Mr. Bertrand Sadin ensured the preparation of the design of the report with figures, tables and maps. Ms Roberta Quadrelli and Mr Klaus Pedersen provided support on the IEA statistics. Ms Muriel Custodio, Ms Angela Gosmann and Ms Astrid Dumond managed the publication process. Ms Viviane Consoli, Ms Therese Walsh and Ms Rebecca Gaghen ensured the editorial finalisation. Catherine Smith helped in the preparations of the IEA SLT Committee and the logistics of the review visit.

## ORGANISATIONS VISITED

During its visit to Brussels, the review team met with the following organisations:

- Council Secretariat Working Party on Energy
- Hellenic European Union Presidency
- European Commission DG Energy, DG Climate Action, DG Taxud, DG Enterprise, DG Research and Innovation RTD, Joint Research Centre (JRC), DG Environment, DG Competition, DG Health and Consumers (SANCO)
- European Parliament – Committee on Industry, Transport, Research and Energy (ITRE), Committee on Internal Market and Consumer Protection (IMCO), Committee on Environment (ENVI)
- European executive agencies (EACI, TEN-T EA)
- European Network of System Operators – Gas (ENTSO-G)
- European Network of System Operators – Electricity (ENTSO-E)



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- CORESO
- Agency for the Cooperation of Energy Regulators (ACER)
- Council of European Energy Regulators (CEER)
- Eurelectric
- Eurogas
- Gas Infrastructure Europe (GIE)
- International Association of Oil and Gas Producers
- European Federation of Energy Traders (EFET)
- Europex
- BusinessEurope
- Euroheat&Power
- Cembureau
- GEODE
- CECED
- CEFIC
- Eurofer
- Euracoal
- Europia
- CEPS
- Think (Florence School of regulation)
- ifri
- E3G
- European Renewable Energy Council (EREC)
- Zero-Emission Platform (ZEP)
- Carbon market watch
- European Policy Centre

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# ANNEX B:
# ENERGY BALANCES
# AND KEY STATISTICAL DATA

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Unit: Mtoe

| SUPPLY | | 1990 | 2011 | 2012 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|---|---|---|
| **TOTAL PRODUCTION** | | **950.48** | **806.86** | **798.94** | **808.13** | **750.17** | **757.92** | **737.91** |
| Coal | | 361.02 | 160.85 | 162.03 | 139.65 | 88.53 | 74.29 | 69.14 |
| Peat[1] | | 8.77 | 6.74 | 5.50 | .. | .. | .. | .. |
| Oil | | 134.59 | 84.65 | 76.37 | 77.51 | 55.60 | 34.21 | 16.35 |
| Natural gas | | 164.02 | 141.64 | 133.11 | 140.74 | 109.61 | 95.37 | 69.67 |
| Biofuels and waste[2] | | 46.35 | 121.75 | 129.67 | 150.68 | 152.96 | 161.61 | 164.08 |
| Nuclear | | 207.31 | 236.41 | 230.06 | 193.49 | 201.19 | 217.92 | 215.93 |
| Hydro | | 24.89 | 26.77 | 28.82 | 32.18 | 34.09 | 35.70 | 36.57 |
| Wind | | 0.07 | 15.44 | 17.70 | 41.93 | 66.07 | 78.01 | 92.48 |
| Geothermal | | 3.19 | 5.68 | 5.70 | 9.25 | 10.09 | 19.29 | 27.78 |
| Solar/other[3] | | 0.27 | 6.93 | 9.99 | 22.71 | 32.03 | 41.52 | 45.91 |
| **TOTAL NET IMPORTS[4]** | | **691.73** | **854.49** | **838.28** | **856.54** | **861.30** | **853.51** | **892.11** |
| Coal | Exports | 42.42 | 26.00 | 26.69 | .. | .. | .. | .. |
| | Imports | 123.13 | 145.82 | 150.64 | 96.77 | 85.34 | 54.55 | 54.87 |
| | Net imports | 80.71 | 119.83 | 123.94 | 96.77 | 85.34 | 54.55 | 54.87 |
| Oil | Exports | 268.89 | 350.45 | 370.92 | .. | .. | .. | .. |
| | Imports | 799.06 | 900.33 | 907.58 | 528.62 | 521.99 | 528.66 | 544.04 |
| | Int'l marine and aviation bunkers[5] | -59.28 | -93.86 | -89.49 | -54.60 | -57.37 | -58.96 | -62.49 |
| | Net imports | 470.88 | 456.01 | 447.16 | 474.02 | 464.61 | 469.70 | 481.55 |
| Natural Gas | Exports | 28.29 | 84.24 | 90.05 | .. | .. | .. | .. |
| | Imports | 163.87 | 355.16 | 348.57 | 266.44 | 290.11 | 307.78 | 335.47 |
| | Net imports | 135.58 | 270.93 | 258.53 | 265.52 | 287.61 | 302.30 | 326.96 |
| Electricity | Exports | 15.88 | 27.69 | 29.58 | .. | .. | .. | .. |
| | Imports | 19.82 | 28.36 | 31.22 | -1.60 | -1.49 | -1.82 | -2.10 |
| | Net imports | 3.94 | 0.67 | 1.65 | -1.60 | -1.49 | -1.82 | -2.10 |
| **TOTAL STOCK CHANGES** | | **2.45** | **-1.70** | **6.38** | **-** | **-** | **-** | **-** |
| **TOTAL SUPPLY (TPES)[6]** | | **1644.66** | **1659.66** | **1643.59** | **1664.66** | **1611.47** | **1611.43** | **1630.02** |
| Coal | | 446.78 | 280.39 | 287.49 | 236.42 | 173.86 | 128.84 | 124.02 |
| Peat[1] | | 8.78 | 7.19 | 6.53 | .. | .. | .. | .. |
| Oil | | 605.79 | 548.04 | 526.45 | 551.53 | 520.21 | 503.91 | 497.90 |
| Natural gas | | 296.94 | 403.59 | 392.48 | 406.26 | 397.22 | 397.67 | 396.63 |
| Biofuels and waste[2] | | 46.69 | 128.55 | 136.75 | 172.50 | 178.19 | 190.40 | 194.90 |
| Nuclear | | 207.31 | 236.41 | 230.06 | 193.49 | 201.19 | 217.92 | 215.93 |
| Hydro | | 24.89 | 26.77 | 28.82 | 32.18 | 34.09 | 35.70 | 36.57 |
| Wind | | 0.07 | 15.44 | 17.70 | 41.93 | 66.07 | 78.01 | 92.48 |
| Geothermal | | 3.19 | 5.68 | 5.70 | 9.25 | 10.09 | 19.29 | 27.78 |
| Solar/other[3] | | 0.27 | 6.93 | 9.98 | 22.71 | 32.03 | 41.52 | 45.91 |
| Electricity trade[7] | | 3.94 | 0.67 | 1.65 | -1.60 | -1.49 | -1.82 | -2.10 |
| ***Shares in TPES (%)*** | | | | | | | | |
| *Coal* | | *27.2* | *16.9* | *17.5* | *14.2* | *10.8* | *8.0* | *7.6* |
| Peat[1] | | *0.5* | *0.4* | *0.4* | .. | .. | .. | .. |
| *Oil* | | *36.8* | *33.0* | *32.0* | *33.1* | *32.3* | *31.3* | *30.5* |
| *Natural gas* | | *18.1* | *24.3* | *23.9* | *24.4* | *24.6* | *24.7* | *24.3* |
| Biofuels and waste[2] | | *2.8* | *7.7* | *8.3* | *10.4* | *11.1* | *11.8* | *12.0* |
| *Nuclear* | | *12.6* | *14.2* | *14.0* | *11.6* | *12.5* | *13.5* | *13.2* |
| *Hydro* | | *1.5* | *1.6* | *1.8* | *1.9* | *2.1* | *2.2* | *2.2* |
| *Wind* | | *-* | *0.9* | *1.1* | *2.5* | *4.1* | *4.8* | *5.7* |
| *Geothermal* | | *0.2* | *0.3* | *0.3* | *0.6* | *0.6* | *1.2* | *1.7* |
| *Solar/other[3]* | | *0.0* | *0.4* | *0.6* | *1.4* | *2.0* | *2.6* | *2.8* |
| Electricity trade[7] | | *0.2* | *-* | *0.1* | *-0.1* | *-0.1* | *-0.1* | *-0.1* |

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Historical data are obtained as sum of the data for individual countries; forecasts data are based on direct submission from the European Commission.



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Unit: Mtoe

| DEMAND | | | | | | | |
|---|---|---|---|---|---|---|---|
| **FINAL CONSUMPTION** | **1990** | **2011** | **2012** | **2020** | **2030** | **2040** | **2050** |
| **TFC** | **1129.15** | **1146.77** | **1139.24** | **1259.59** | **1247.08** | **1252.39** | **1270.63** |
| Coal | 119.84 | 39.52 | 37.72 | 55.00 | 49.53 | 42.53 | 38.74 |
| Peat[1] | 1.75 | 0.65 | 0.58 | .. | .. | .. | .. |
| Oil | 502.58 | 486.20 | 469.34 | 510.60 | 484.92 | 471.05 | 466.10 |
| Natural gas | 225.63 | 250.88 | 258.52 | 263.10 | 255.37 | 254.69 | 259.45 |
| Biofuels and waste[2] | 38.46 | 79.33 | 81.87 | 106.59 | 109.20 | 109.53 | 106.09 |
| Geothermal | 0.41 | 0.53 | 0.49 | 2.45 | 2.75 | 3.13 | 3.27 |
| Solar/other[3] | 0.14 | 1.70 | 1.83 | 10.09 | 13.80 | 15.31 | 15.84 |
| Electricity | 186.05 | 239.92 | 240.51 | 255.70 | 275.58 | 298.90 | 322.77 |
| Heat | 54.29 | 48.03 | 48.39 | 56.07 | 55.94 | 57.26 | 58.35 |
| ***Shares in TFC (%)*** | | | | | | | |
| *Coal* | *10.6* | *3.4* | *3.3* | *4.4* | *4.0* | *3.4* | *3.0* |
| Peat[1] | *0.2* | *0.1* | *0.1* | .. | .. | .. | .. |
| *Oil* | *44.5* | *42.4* | *41.2* | *40.5* | *38.9* | *37.6* | *36.7* |
| Natural gas | *20.0* | *21.9* | *22.7* | *20.9* | *20.5* | *20.3* | *20.4* |
| Biofuels and waste[2] | *3.4* | *6.9* | *7.2* | *8.5* | *8.8* | *8.7* | *8.3* |
| *Geothermal* | *0.0* | - | - | *0.0* | *0.0* | *0.0* | *0.3* |
| *Solar/other[3]* | - | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *1.2* |
| *Electricity* | *16.5* | *20.9* | *21.1* | *20.3* | *22.1* | *23.9* | *25.4* |
| *Heat* | *4.8* | *4.2* | *4.2* | *4.5* | *4.5* | *4.6* | *4.6* |
| **TOTAL INDUSTRY[8]** | **441.49** | **374.35** | **362.22** | **428.49** | **428.48** | **423.80** | **428.85** |
| Coal | 69.85 | 27.85 | 26.31 | 44.23 | 42.19 | 35.39 | 32.12 |
| Peat[1] | 0.70 | 0.33 | 0.27 | .. | .. | .. | .. |
| Oil | 139.41 | 120.80 | 115.41 | 131.41 | 125.74 | 120.19 | 118.20 |
| Natural gas | 112.88 | 96.80 | 94.81 | 102.92 | 104.63 | 106.31 | 111.71 |
| Biofuels and waste[2] | 13.91 | 24.74 | 23.06 | 34.60 | 41.16 | 45.30 | 43.69 |
| Geothermal | - | 0.01 | 0.00 | 0.02 | 0.02 | 0.01 | - |
| Solar/other[3] | - | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Electricity | 85.44 | 89.20 | 86.53 | 96.19 | 95.48 | 95.61 | 100.42 |
| Heat | 19.31 | 14.62 | 15.82 | 19.12 | 19.24 | 20.99 | 22.70 |
| ***Shares in total industry (%)*** | | | | | | | |
| *Coal* | *15.8* | *7.4* | *7.3* | *10.3* | *9.8* | *8.3* | *7.5* |
| Peat[1] | *0.2* | *0.1* | *0.1* | .. | .. | .. | .. |
| *Oil* | *31.6* | *32.3* | *31.9* | *30.7* | *29.3* | *28.4* | *27.6* |
| *Natural gas* | *25.6* | *25.9* | *26.2* | *24.0* | *24.4* | *25.1* | *26.0* |
| Biofuels and waste[2] | *3.2* | *6.6* | *6.4* | *8.1* | *9.6* | *10.7* | *10.2* |
| *Geothermal* | - | - | - | - | - | - | - |
| *Solar/other[3]* | - | - | - | - | - | - | - |
| *Electricity* | *19.4* | *23.8* | *23.9* | *22.4* | *22.3* | *22.6* | *23.4* |
| *Heat* | *4.4* | *3.9* | *4.4* | *4.5* | *4.5* | *5.0* | *5.3* |
| **TRANSPORT[6]** | **258.85** | **316.14** | **306.90** | **359.01** | **353.93** | **357.75** | **365.73** |
| **OTHER[9]** | **428.81** | **456.28** | **470.12** | **472.09** | **464.68** | **470.84** | **476.06** |
| Coal | 49.78 | 11.66 | 11.40 | 10.76 | 7.34 | 7.15 | 6.63 |
| Peat[1] | 1.05 | 0.33 | 0.30 | .. | .. | .. | .. |
| Oil | 110.35 | 71.45 | 70.07 | 58.25 | 48.79 | 40.79 | 36.22 |
| Natural gas | 112.41 | 151.27 | 160.91 | 156.31 | 145.61 | 141.55 | 138.25 |
| Biofuels and waste[2] | 24.53 | 40.80 | 44.09 | 45.50 | 40.48 | 37.05 | 33.75 |
| Geothermal | 0.41 | 0.52 | 0.48 | 2.43 | 2.73 | 3.12 | 3.27 |
| Solar/other[3] | 0.14 | 1.69 | 1.82 | 10.08 | 13.66 | 14.65 | 14.61 |
| Electricity | 95.16 | 145.15 | 148.47 | 151.80 | 169.37 | 190.25 | 207.69 |
| Heat | 34.99 | 33.41 | 32.58 | 36.95 | 36.70 | 36.27 | 35.65 |
| ***Shares in other (%)*** | | | | | | | |
| *Coal* | *11.6* | *2.6* | *2.4* | *2.3* | *1.6* | *1.5* | *1.4* |
| Peat[1] | *0.2* | *0.1* | *0.1* | .. | .. | .. | .. |
| *Oil* | *25.7* | *15.7* | *14.9* | *12.3* | *10.5* | *8.7* | *7.6* |
| *Natural gas* | *26.2* | *33.2* | *34.2* | *33.1* | *31.3* | *30.1* | *29.0* |
| Biofuels and waste[2] | *5.7* | *8.9* | *9.4* | *9.6* | *8.7* | *7.9* | *7.1* |
| *Geothermal* | *0.1* | *0.1* | *0.1* | *0.0* | *0.0* | *0.0* | *0.7* |
| *Solar/other[3]* | - | *0.4* | *0.4* | *2.1* | *2.9* | *3.1* | *3.1* |
| *Electricity* | *22.2* | *31.8* | *31.6* | *32.2* | *36.4* | *40.4* | *43.6* |
| *Heat* | *8.2* | *7.3* | *6.9* | *7.8* | *7.9* | *7.7* | *7.5* |

Historical data are obtained as sum of the data for individual countries; forecasts data are based on direct submission from the European Commission.

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Unit: Mtoe

| DEMAND | | | | | | | |
|---|---|---|---|---|---|---|---|
| **ENERGY TRANSFORMATION AND LOSSES** | **1990** | **2011** | **2012** | **2020** | **2030** | **2040** | **2050** |
| **ELECTRICITY GENERATION[10]** | | | | | | | |
| Input (Mtoe) | 646.06 | 708.90 | 705.64 | 653.49 | 638.71 | 663.74 | 692.70 |
| Output (Mtoe) | 221.51 | 280.92 | 280.72 | 294.85 | 315.14 | 343.29 | 373.12 |
| Output (TWh) | 2575.73 | 3266.46 | 3264.14 | 3428.49 | 3664.47 | 3991.70 | 4338.64 |
| ***Output Shares (%)*** | | | | | | | |
| *Coal* | *40.0* | *26.5* | *28.1* | *21.3* | *13.6* | *8.8* | *9.3* |
| Peat[1] | *0.8* | *0.6* | *0.5* | .. | .. | .. | .. |
| *Oil* | *8.7* | *2.2* | *2.2* | *0.8* | *0.6* | *0.5* | *0.5* |
| *Natural gas* | *7.5* | *21.4* | *17.8* | *19.9* | *19.5* | *18.9* | *17.3* |
| *Biofuels and waste [2]* | *0.8* | *4.7* | *5.2* | *6.4* | *6.6* | *7.9* | *7.9* |
| *Nuclear* | *30.9* | *27.8* | *27.0* | *21.9* | *21.8* | *22.5* | *21.3* |
| *Hydro* | *11.2* | *9.5* | *10.3* | *10.9* | *10.8* | *10.4* | *9.8* |
| *Wind* | *-* | *5.5* | *6.3* | *14.2* | *21.0* | *22.7* | *24.8* |
| *Geothermal* | *0.1* | *0.2* | *0.2* | *0.2* | *0.2* | *0.5* | *0.7* |
| *Solar/other [3]* | *-* | *1.6* | *2.3* | *4.3* | *5.8* | *7.8* | *8.4* |
| **TOTAL LOSSES** | **504.21** | **508.53** | **504.65** | **404.72** | **364.22** | **359.11** | **359.45** |
| of which: | | | | | | | |
| Electricity and heat generation[11] | 363.09 | 370.03 | 366.56 | 292.28 | 257.67 | 254.00 | 252.51 |
| Other transformation | 33.01 | 25.78 | 26.54 | 8.89 | 8.17 | 7.62 | 7.30 |
| Own use and transmission/distribution losses[12] | 108.11 | 112.72 | 111.54 | 103.54 | 98.38 | 97.49 | 99.63 |
| **Statistical Differences** | **11.30** | **4.36** | **-0.30** | **0.35** | **0.17** | **-0.06** | **-0.07** |
| **INDICATORS** | **1990** | **2011** | **2012** | **2020** | **2030** | **2040** | **2050** |
| GDP (billion 2005 USD) | 10068.21 | 14668.16 | 14614.03 | 16729.92 | 19880.64 | 22489.28 | 25769.52 |
| Population (millions) | 477.60 | 505.70 | 507.40 | 517.00 | 524.90 | 528.20 | 526.50 |
| TPES/GDP (toe/1000 USD)[13] | 0.16 | 0.11 | 0.11 | 0.10 | 0.08 | 0.07 | 0.06 |
| Energy production/TPES | 0.58 | 0.49 | 0.49 | 0.49 | 0.47 | 0.47 | 0.45 |
| Per capita TPES (toe/capita) | 3.44 | 3.28 | 3.24 | 3.22 | 3.07 | 3.05 | 3.10 |
| Oil supply/GDP (toe/1000 USD)[13] | 0.06 | 0.04 | 0.04 | 0.03 | 0.03 | 0.02 | 0.02 |
| TFC/GDP (toe/1000 USD)[13] | 0.11 | 0.08 | 0.08 | 0.08 | 0.06 | 0.06 | 0.05 |
| Per capita TFC (toe/capita) | 2.36 | 2.27 | 2.25 | 2.44 | 2.38 | 2.37 | 2.41 |
| Energy-related $CO_2$ emissions ($MtCO_2$)[14] | 4067.8 | 3547.7 | 3504.9 | 3381.2 | 3030.1 | 2809.9 | 2771.8 |
| $CO_2$ emissions from bunkers ($MtCO_2$)[14] | 182.7 | 288.9 | 275.2 | 173.7 | 182.5 | 187.6 | 198.8 |
| **GROWTH RATES (% per year)** | **90-10** | **10-11** | **11-12** | **12-20** | **20-30** | **30-40** | **40-50** |
| TPES | 0.2 | -3.5 | -1.0 | 0.2 | -0.3 | -0.0 | 0.1 |
| Coal | - | 1.7 | 2.5 | -2.4 | -3.0 | -3.0 | -0.4 |
| Peat[1] | - | -1.9 | -9.2 | .. | .. | .. | .. |
| Oil | - | -3.9 | -3.9 | 0.6 | -0.6 | -0.3 | -0.1 |
| Natural gas | - | -9.7 | -2.8 | 0.4 | -0.2 | 0.0 | -0.0 |
| Biofuels and waste[2] | - | 2.3 | 6.4 | 2.9 | 0.3 | 0.7 | 0.2 |
| Nuclear | - | -1.1 | -2.7 | -2.1 | 0.4 | 0.8 | -0.1 |
| Hydro | - | -17.1 | 7.7 | 1.4 | 0.6 | 0.5 | 0.2 |
| Wind | - | 20.3 | 14.6 | 11.4 | 4.7 | 1.7 | 1.7 |
| Geothermal | - | 4.4 | 0.3 | 6.2 | 0.9 | 6.7 | 3.7 |
| Solar/other[3] | - | 52.5 | 44.1 | 10.8 | 3.5 | 2.6 | 1.0 |
| TFC | 0.3 | -4.7 | -0.7 | 1.3 | -0.1 | 0.0 | 0.1 |
| Electricity consumption | 1.4 | -1.9 | 0.2 | 0.8 | 0.8 | 0.8 | 0.8 |
| Energy production | -0.6 | -3.4 | -1.0 | 0.1 | -0.7 | 0.1 | -0.3 |
| Net oil imports | -0.0 | -3.0 | -1.9 | 0.7 | -0.2 | 0.1 | 0.2 |
| GDP | 1.8 | 1.6 | -0.4 | 1.7 | 1.7 | 1.2 | 1.4 |
| TPES/GDP | -1.6 | -5.1 | -0.5 | -1.5 | -2.0 | -1.2 | -1.2 |
| TFC/GDP | -1.5 | -6.1 | -0.3 | -0.4 | -1.8 | -1.2 | -1.2 |

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Historical data are obtained as sum of the data for individual countries; forecasts data are based on direct submission from the European Commission.



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## Footnotes to energy balances and key statistical data

1. Peat is aggregated with coal for forecast years.
2. Biofuels and waste comprises solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
3. Other includes tide, wave and ambient heat used in heat pumps.
4. In addition to coal, oil, natural gas and electricity, total net imports also include peat, biofuels and waste and trade of heat. Only net imports are available for forecast years.
5. Data on international aviation bunkers are not available for forecast years.
6. Excludes international marine bunkers and international aviation bunkers.
7. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
8. Industry includes non-energy use.
9. Other includes residential, commercial and public services, agriculture/forestry, fishing and other non-specified.
10. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
11. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and solar thermal, 10% for geothermal and 100% for hydro, wind and solar photovoltaic.
12. Data on “losses” for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
13. Toe per thousand USD at 2005 prices and exchange rates.
14. “Energy-related $CO_2$ emissions” have been estimated using the IPCC Tier I Sectoral Approach from the Revised 1996 IPCC Guidelines. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 2012 and applying this factor to forecast energy supply. Future coal emissions are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

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## ANNEX C: INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

**1. Diversity, efficiency and flexibility within the energy sector** are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

**2.** Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

**3. The environmentally sustainable provision and use of energy** are central to the achievement of these shared goals. Decision makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

**4. More environmentally acceptable energy sources** need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

**5. Improved energy efficiency** can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

**6.** Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

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**7. Undistorted energy prices** enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

**8. Free and open trade** and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

**9. Co-operation among all energy market participants** helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.



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## ANNEX D: GLOSSARY AND LIST OF ABBREVIATIONS

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

| | |
|---|---|
| ABWR | advanced boiling water reactor |
| ACER | Agency for the Cooperation of Energy Regulators |
| AGR | advanced gas-cooled reactor |
| APR | advanced pressurised reactor |
| | |
| bcm | billion cubic metres |
| b/d | barrels per day |
| BWR | boiling water reactor |
| | |
| CCS | carbon capture and storage |
| CDM | clean development mechanism (under the Kyoto Protocol) |
| CEER | Council of European Energy Regulators |
| CEF | Connecting Europe Facility |
| CER | certified emissions reduction |
| CHP | combined production of heat and power (or co-generation) |
| CPPNM | Convention on the Physical Protection of Nuclear Materials |
| | |
| DFG | Decommissioning Funding Group |
| DHC | district heating and cooling |
| DSO | distribution system operator |
| | |
| EEA | European Economic Area |
| EEA | European Environment Agency |
| EEEF | European Energy Efficiency Fund |
| EEPR | European Energy Programme for Recovery |
| EIB | European Investment Bank |
| EIIs | European Industrial Initiatives |
| ENEF | European Nuclear Energy Forum |
| EPC | energy performance certificate |
| EPR | European pressurised water reactor |
| ERA | European Research Area |
| ERDF | European Regional Development Fund |
| ESCOs | energy services companies |
| EU-ETS | Emissions Trading Scheme (European Union) |
| ENTSO-E | European Network of Transmission System Operators (Electricity) |
| ENTSO-G | European Network of Transmission System Operators (Gas) |

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| | |
|---|---|
| GCR | gas-cooled graphite reactor |
| GHG | greenhouse gas |
| HDV | heavy-duty vehicle |
| IAs | implementing agreements (IEA projects) |
| IAEA | International Atomic Energy Agency (in Vienna) |
| IDSF | International Decommissioning Support Funds |
| IEE | Intelligent Europe Energy |
| IMO | International Maritime Organisation |
| IPs | interconnection points |
| IPCC | Intergovernmental Panel on Climate Change |
| ITER | international thermonuclear experimental reactor |
| JI | joint implementation (projects under the Kyoto Protocol) |
| JRC | Joint Research Centre |
| KIC | Knowledge and Innovation Communities |
| kb/d | thousand barrels per day |
| kWh | kilowatt hour |
| LNG | liquefied natural gas |
| LPG | liquefied petroleum gas |
| LULUCF | land use, land-use change, and forestry |
| LWGR | light water-moderated graphite reactor |
| mb | million barrels |
| MBtu | million British thermal units |
| mcm | million cubic metres |
| MEPS | minimum energy performance standards |
| MERS | minimum energy performance requirements |
| Mt | million tonnes |
| MtCO2-eq | million tonnes of carbon dioxide-equivalent |
| Mtoe | million tonnes of oil-equivalent |
| MW | megawatt |
| NPP | nuclear power plant |
| NPS | New Policy Scenario |
| NRA | national regulatory authorities |
| NREAP | National Renewable Energy Action Plan |
| NTC | net transfer capacity |
| ONR | Office of Nuclear Regulation |
| OU | ownership unbundling |
| PCI | project of common interest |
| PHWR | pressurised heavy water reactor |
| PPP | purchasing power parity: the rate of currency conversion that equalises the purchasing power of different currencies, i.e. PPP estimates the differences in price levels between countries |



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| | |
|---|---|
| PV | photovoltaics |
| PWR | pressurised water reactor |
| | |
| RE | renewable energy |
| RES | renewable energy sources |
| R&D | research and development |
| ROAD | Rotterdam Capture and Storage Demonstration Project (*Het Rotterdam Opslag en Afvang Demonstratieproject*) |
| RSK | Reactor Safety Commission |
| | |
| SCC | small cities and communities |
| SET (Plan) | Strategic Energy Technology Plan |
| SMEs | small and medium-sized enterprises |
| STC | Scientific and Technical Committee |
| | |
| TEN | Trans-European Networks |
| TFC | total final consumption of energy |
| TFEU | Treaty on the Functioning of the European Union |
| toe | tonne of oil-equivalent |
| TPA | third-party access |
| TPES | total primary energy supply |
| TSO | transmission system operator |
| TTIP | Transatlantic Trade and Investment Partnership |
| TYNDP | Ten-Year Network Development Plan |
| | |
| UNFCCC | United Nations Framework Convention on Climate Change |
| | |
| VRE | variable renewable energy |
| VTP | virtual trading point |
| VVER | water-moderated, water-cooled power reactor |

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Energy Policies of IEA Countries

# European Union

In October 2014, the European Union (EU) set ambitious climate and energy targets for 2030, confirming its global leadership on climate change. But while the targets are in place, the legal framework to implement them is yet to be developed. *Energy Policies of IEA Countries: European Union – 2014* provides recommendations on how the targets can be reached in a cost-effective and integrated way, while fostering the competitiveness and energy security of the European Union. The recommendations build on the lessons learned since the first IEA in-depth review of the European Union in 2008.

Since then, EU energy policy has been driving energy market integration, cross-border trade and the implementation of energy and climate targets by 2020. The European Union is a global leader in transitioning towards a low-carbon economy: Europe's unprecedented renewable energy boom, its action on energy efficiency and the economic downturn have all contributed to a drop in greenhouse gas emissions. However, energy security concerns have increased. Ageing nuclear and coal plants will be shut, and EU energy systems and markets must accommodate growing shares of variable renewable energy. The European Union seeks to foster access to diversified gas and oil supplies to reduce dependence on single suppliers.

Making the most of its diversity, the European Union must strengthen the internal energy market to enhance both its energy security and the competitiveness of its industry. Yet, important interconnections are missing, and, despite the opening of the wholesale market and decreasing prices, concentrated and regulated retail markets do not deliver benefits to consumers. As member states adopt different decarbonisation pathways and energy policy choices, a strong "Energy Union" is needed with effective energy market rules and policies that support the development of low-carbon technologies, within the new energy and climate policy framework for 2030.

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