



OECD Economics Department Working Papers No. 982

Climate Change Policies
in Germany: Make Ambition
Pay

Caroline Klein

<https://dx.doi.org/10.1787/5k92sn0f8dbt-en>

Unclassified

ECO/WKP(2012)59

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

12-Sep-2012

English - Or. English

ECONOMICS DEPARTMENT

ECO/WKP(2012)59
Unclassified

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By Caroline Klein

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JT03326151

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ABSTRACT/RÉSUMÉ

Climate change policies in Germany: make ambition pay

Germany reduced greenhouse gas emissions substantially but remains an important emitter. Ambitious targets for climate change mitigation have been fixed and a broad range of environmental measures are being implemented. The efficiency of these measures, as well as their coordination, should be improved though, as reaching the targets risks being costly. In particular, the early phase-out of nuclear power and the development of renewable energy sources will require high levels of investment and public financial support. Establishing a clear carbon price in all sectors of the economy and phasing out environmentally harmful subsidies would contribute to reducing the CO₂ abatement cost. The generosity of feed-in tariffs also needs to be carefully monitored and adjusted tightly in line with market developments to avoid deadweight losses and excessive increases in electricity prices. In addition, in order to maintain the German leadership in green sectors and preserve future sources of growth, competition in the energy sectors should be increased and eco-innovation further developed.

This Working Paper relates to the *2012 Economic Survey of Germany*, www.oecd.org/eco/surveys/germany.

JEL classification: H23 ; O44 ; Q58

Keywords: Germany ; green growth ; climate change ; innovation

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Politiques en matière de changement climatique en Allemagne : tirer profit d'objectifs ambitieux

L'Allemagne a sensiblement réduit ses émissions de gaz à effet de serre, mais elle reste un émetteur important. Ses objectifs d'atténuation du changement climatique sont ambitieux, et elle met actuellement en œuvre un large éventail de mesures de protection de l'environnement. Il faudrait toutefois améliorer l'efficacité de ces mesures, ainsi que leur coordination, car atteindre les objectifs visés risque d'être coûteux. En particulier, l'abandon anticipé de l'énergie nucléaire et le développement des sources d'énergie renouvelables nécessiteront des volumes considérables d'investissement et de soutien financier public. Un prix du carbone clairement défini dans tous les secteurs de l'économie et l'élimination progressive des subventions dommageables pour l'environnement contribueraient à réduire le coût de la réduction des émissions de CO₂. Le système de tarifs de rachat doit également être strictement contrôlé et adapté aux évolutions du marché, pour éviter les pertes d'efficacité et des hausses excessives des prix de l'électricité. De plus, afin que l'Allemagne reste à l'avant-garde dans les secteurs verts et préserve ses futures sources de croissance, il importe d'intensifier la concurrence dans le secteur de l'énergie et de développer davantage l'éco-innovation.

Ce document de travail se rapporte à l'*Étude économique de l'OCDE sur l'Allemagne 2012* (www.oecd.org/eco/etudes/allemande).

Classification JEL: H23 ; O44 ; Q58

Mots clés: Allemagne; croissance verte ; changement climatique ; innovation

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Climate change policies: make ambition pay

By Caroline Klein¹

Despite significant reductions in greenhouse gas (GHG) emissions over the past two decades, Germany remains one of the largest GHG emitters in the OECD, partly due to an emission-intensive energy mix. Germany has committed itself to become one of the most energy-efficient economies in the world and fixed ambitious targets for GHG abatement going beyond the EU requirements regarding climate change mitigation. On the one hand, achieving these objectives may stimulate economic growth, notably by reducing the vulnerability of the economy to energy price volatility and by fostering innovation. In particular, ambitious environmental policies may contribute to increasing the comparative advantage of the industry in green sectors, as was the case in the past. On the other hand, reaching the targets can be costly, not least with the early phase out of nuclear power which will deprive the electricity sector of carbonless generation capacities. Thus, implementing cost-efficient climate change policies and supporting competitiveness in green sectors will be crucial for Germany in order to reap the benefits from climate change mitigation.

This paper analyses the climate change policy framework in Germany, focusing on its cost-efficiency and on the measures which will maximize the economic gains to be drawn from meeting its environmental objectives. The first section details the past performance as well as the challenges Germany is facing. The second section analyses German climate change policies and presents options for improving their cost-efficiency. The last section discusses reforms which would help Germany to further exploit environmentally friendly sources of growth.

Germany has committed itself to challenging reductions in greenhouse gas emissions

Germany substantially reduced GHG emissions but remains an important emitter

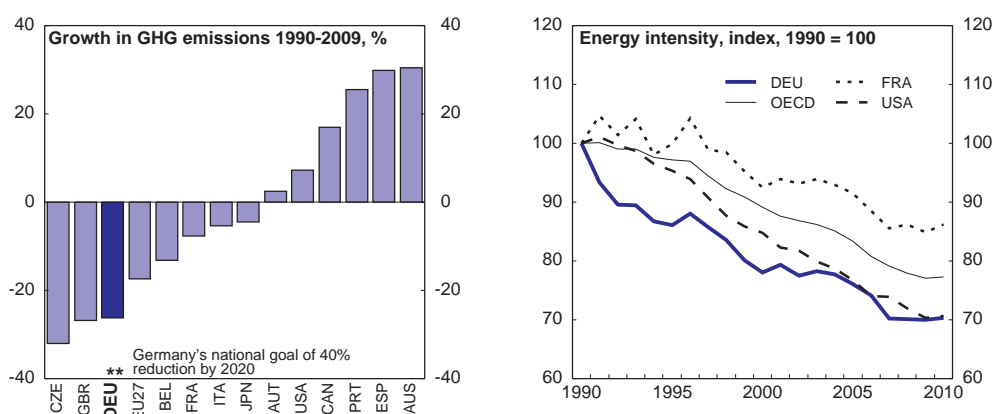
Germany is on track to achieve its Kyoto commitment...

Germany is on track to achieve its Kyoto commitment for 2012 (a 21% GHG reduction from the 1990 level) as GHG emissions were 26% below the 1990 baseline already in 2009 (Figure 1, left panel). This is one of the best performances among high-income OECD countries and, overall, less than half of OECD countries have achieved a comparable result. The largest reductions occurred in manufacturing and in the construction sector with a decrease in emissions of more than 40%, one third higher than the average decline in the EU15. In addition, contrary to many other OECD countries, emissions were reduced in the transport sector, notably in road transportation. Mitigation was less pronounced for electricity and heat production but still slightly higher than the EU15 average and contributing strongly to the GHG abatement, given its large share of total emissions.

1. This paper is drawn from the OECD Economic Survey of Germany published in February 2012. The author is economist on the Germany/Slovakia desk in the OECD Economics Department. She would like to thank Ivana Capozza, Brendan Gillespie, Nils-Axel Braathen, Felix Hufner, Andreas Wörgötter, Robert Ford, Andrew Dean, Karsten Neuhoff and German government officials for their valuable comments on previous drafts but retains full responsibility for any errors and omissions. The author is also thankful to Thorsten Ehinger, Elie Chachoua and Joseph Curtin for their excellent consultancy work, Margaret Morgan for research assistance and Josiane Gutierrez for technical preparation.

Germany has also decoupled energy consumption from economic growth. Despite significant GDP growth since 1990, primary energy use has been reduced by 6% and energy intensity has decreased on average by 1.7% per annum (Figure 1, right panel). The restructuring of the economy after reunification contributed to the decline in energy use, notably the collapse of inefficient firms in east Germany after 1990 (OECD, 2001). Carbon emissions were reduced by the switch from petrol to diesel cars and from heating oil to natural gas, which are less carbon intensive (Destatis, 2011). Higher energy prices as well as European and national environmental policies, such as the implementation of the eco tax and energy standards in the automotive sector, also played a role by creating incentives for energy savings (OECD, 2011a).

Figure 1. Change in greenhouse gas emissions and energy intensity



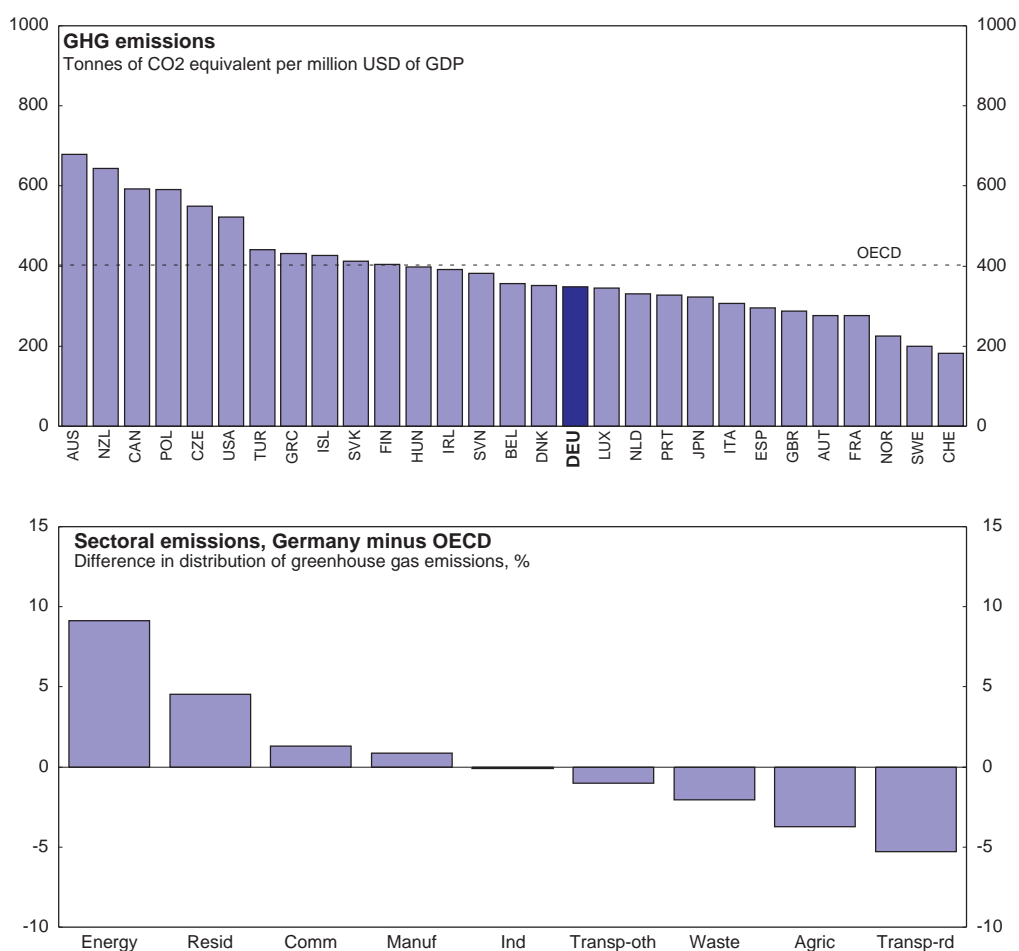
Note: Energy intensity is measured as total primary energy supply/GDP (toe per thousand USD at 2000 PPP).

Source: United Nations Framework Convention on Climate Change (UNFCCC); Bundesregierung (2010), "Energy Concept, For an Environmentally Sound, Reliable and Affordable Energy Supply"; IEA, *Energy Balances of OECD Countries*, 2011 edition.

... but remains one of the main GHG emitters in the OECD...

Germany produced roughly 20% of total EU27 CO₂ emissions in 2009 (with around 920 Mt CO₂ equivalent) making it the largest national emitter in the European Union and the third largest in the OECD after the United States and Japan. In terms of emissions per capita or relative to the GDP level, Germany is below the OECD average but above the EU27 average (Figure 2, upper panel and Table 1). GHG emissions are particularly concentrated in the energy sector: electricity and heat production accounted for 37% of total emissions in 2009, one third higher than the OECD average (Figure 2, lower panel), with around 4 tonnes CO₂ equivalent emitted per capita compared to 3 tonnes on average in the OECD. When excluding emissions from electricity and heat production, Germany is the third lowest emitter in the OECD on a per GDP unit basis.

Figure 2. Greenhouse gas emissions: international comparison and sectoral distribution, 2009



Note: GDP used is in 2005 constant prices at purchasing power parity. OECD is the average of countries in the top panel. Sectors in the second panel are: Energy, Resid: Residential; Comm: Commercial/Institutional; Manuf: Manufacturing/Construction; Ind: Industrial Processes; Transp-rd: Road Transportation; Transp-oth: Other transports; Waste: Waste; Agric: Agriculture.

Source: United Nations Framework Convention on Climate Change (UNFCCC); OECD, *National Accounts database*.

Table 1. Decomposition of GHG emission levels in 2009

	GHG/Population	GHG/GDP	GHG/Energy	Energy/GDP
Sweden	6.5	0.20	1.9	0.11
Spain	8.3	0.30	4.0	0.07
Italy	8.3	0.31	3.9	0.08
France	8.4	0.28	3.3	0.08
United Kingdom	9.2	0.29	4.3	0.07
European Union 27	9.3	0.34	4.0	0.09
Japan	9.5	0.32	3.9	0.08
Austria	9.6	0.28	3.0	0.09
Norway	10.8	0.23	2.6	0.09
Greece	10.9	0.43	6.0	0.07
Germany	11.1	0.35	4.1	0.08
Denmark	11.4	0.35	4.4	0.08
Finland	12.5	0.40	2.7	0.15
OECD total	13.4	0.42	4.3	0.10
Ireland	14.5	0.39	5.5	0.07
Canada	20.7	0.59	3.6	0.17
United States	21.5	0.52	4.5	0.12

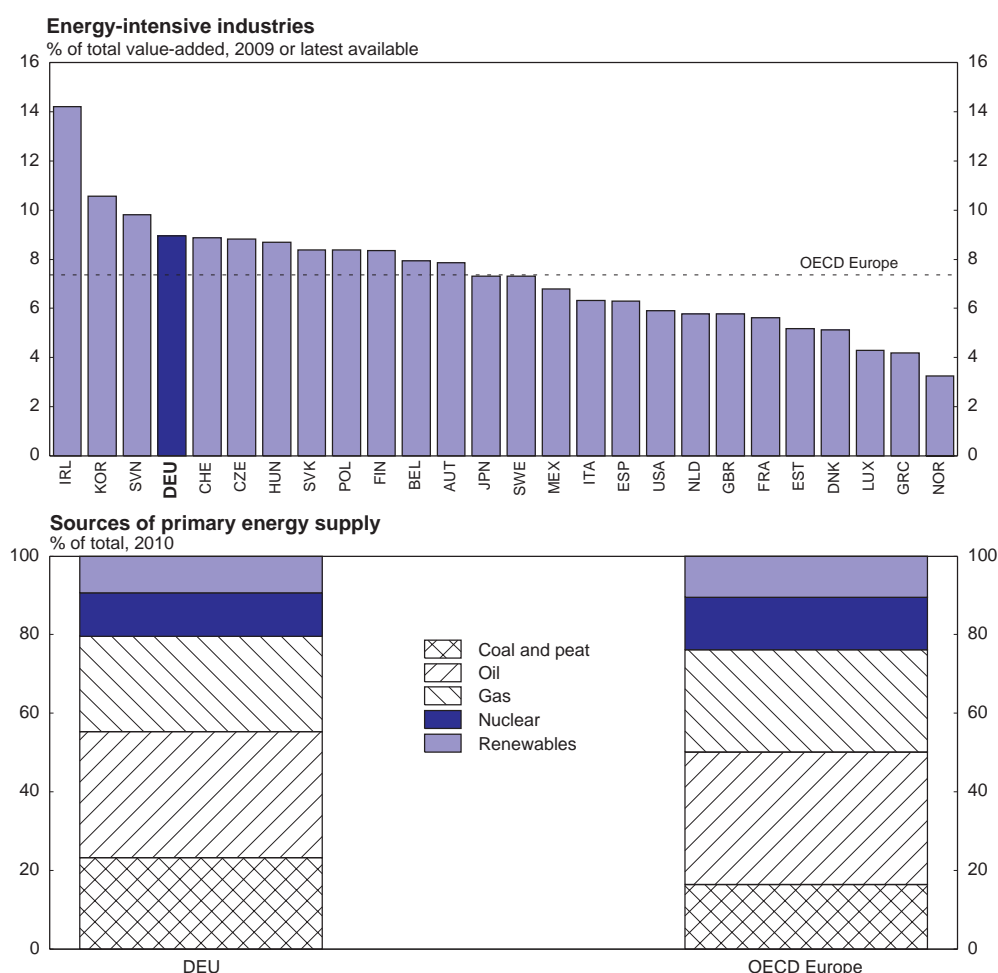
Note: OECD total refers to the OECD countries except Chile, Israel, Korea, and Mexico. GHG refers to GHG emissions in tonnes of CO₂ equivalent, GDP refers to GDP in thousand USD using PPP exchange rates for the year 2005, and energy refers to total final energy consumption in ktoe.

Source: UNFCCC; IEA, *Energy Balances of OECD Countries*, 2011 edition; OECD, *Population Statistics and National Accounts database*.

... not least due to an emission-intensive energy mix

The relatively high emission intensity of the German economy is not due to a high level of energy consumption but rather to a carbon intensive energy mix. Despite a relatively high share of energy-intensive industries (Figure 2.3, upper panel), energy intensity is not particularly high in Germany by international comparison (Table 1). However, GHG emissions per unit of energy consumption stand slightly above the EU27 average (Table 1). In particular, the CO₂ content of electricity production is quite high by international standards: with 0.6 CO₂ tonnes per MWh produced, electricity production in Germany is over six times more carbon intensive than in France and two times more than in Belgium (Egert, 2011). This is due to a relatively high share of fossil fuels, and in particular coal, in the energy mix (Figure 2.3, lower panel). Around 23% of the energy supply is composed of coal and peat, seven percentage points more than in the European OECD countries.² In addition, while the share of renewable energy sources increased significantly since 2000, thereby contributing to the reduction of CO₂ emissions in the energy sector, the share of hard coal in primary energy supply decreased only slightly (from 25% in 2000 to 23% in 2010). This suggests Germany has room to reduce emissions in the energy sector at a relatively low marginal abatement cost, notably by replacing polluting coal-fired power plants with low-carbon electricity generation.

2. While considered as the most climate-unfriendly energy source, coal is still extensively used for electricity generation. Coal and peat account for 44% of the electricity production in Germany, almost double the OECD average in Europe (23%).

Figure 3. A carbon intensive energy mix and an energy intensive industry

Note: Energy-intensive activities refer to pulp/paper, chemicals, minerals and metals (ISIC Revision 3 codes 21 to 28). Data refers to 2008 for France, Germany and Switzerland and 2007 for Poland and the United Kingdom. Renewables are hydro, geothermal, solar/wind/other and combustible renewables and waste. Total excludes electricity and heat. Data for 2010 are estimates.

Source: IEA, *Energy Balances of OECD countries*, 2011 edition; OECD, *STAN database*.

Germany has fixed ambitious targets for 2020

Germany has committed itself to significantly reduce GHG emissions by 2020...

Germany has set itself ambitious targets for GHG emissions, energy efficiency, and renewable energy sources, confirming its leadership role in promoting ambitious climate policy (Weidner and Mez, 2008). In the framework of the EU effort-sharing under the Kyoto Protocol, Germany has committed itself to cutting its emissions of climate-damaging gases by a total of 21% in the period 2008 to 2012 compared with 1990, taking a large share of the total 8% target of emission reductions set by the EU. More recently, the two main programmes defining the climate change and energy strategies - the Integrated Energy and Climate Program (2007) and the Energy Concept (Bundesregierung, 2010) - set national targets going even beyond the EU requirements to reduce GHG:

- The EU commitment for Germany is a 14% reduction by 2020 compared to 2005 levels in the sectors not covered by the EU Emissions Trading Scheme (EU ETS). The EU also set a 21% reduction of emissions in the sectors covered by the EU ETS compared to 2005 at the EU level. Germany has pledged to reduce its overall domestic GHG emissions by 40% by 2020 compared with 1990 and by 80% in 2050.
- The EU also set a 2020 target of reducing primary energy use by 20% compared to 2007. Germany goes further by committing itself to reduce primary energy consumption by 20% by 2020 and by 50% by 2050 compared with 2008.
- The share of renewable energy sources (RES) in final energy consumption should increase to 20% in 2020 at the EU level. For Germany, the EU commitment is 18% of final energy consumption from RES by 2020 (from 5.8% in 2005). The government fixed a 35% target for electricity consumption by 2020 (50% by 2030 and 80% by 2050) and a 30% target for final energy consumption by 2030 (60% by 2050).

The targets may create inefficiencies at the EU level...

Defining national targets for GHG abatement that go beyond EU requirements may create some inefficiency: they may not contribute to higher climate change mitigation at the EU level but instead risk increasing its cost. Trying to over-achieve the targets fixed by EU commitments is inefficient if it requires reducing emissions in those sectors that are already covered by the EU ETS on top of the abatement induced by the ETS allowance price (OECD, 2011b). As emissions are capped under the scheme, such a policy would not have any impact on total GHG emissions at the EU level, as lower German emissions create room under the cap for higher emissions elsewhere. The overall CO₂ abatement cost in the EU could rise as the cost of cutting emissions in Germany rose above those in other European countries. To achieve more GHG emission reductions under the EU ETS, options for Germany would be to buy permits with a strong commitment not to use them or to push for a tighter cap at the EU level. For the moment, these options are not considered by the government and it is not clear in which sectors emissions will be reduced.

In addition, having both a target for renewable energy sources and for GHG emissions puts constraints on the way emissions are reduced and increases the abatement cost in consequence. In particular, support for the expansion of renewable energy sources will reduce emissions in the EU ETS sectors beyond the CO₂ price effect, damping the net efficiency of the scheme (Traber and Kemfert, 2009, estimate that the feed-in tariffs supporting the development of RES in Germany reduce the EU ETS allowance price by 15%). The ETS and the renewable energy support policies are, however, complementing each other somewhat as the price mechanism of the ETS is favouring least-cost options of CO₂ abatement while renewable energy policies are pushing new low carbon technologies that are essential for cost effective abatement in the long term.

... but are supported by national objectives

Such an overlap in targets and in instruments may also be justifiable as the objective of climate mitigation policies (including energy policy) goes beyond GHG abatement. For instance, the aim of the strategy set by the government in its Energy Concept is to make Germany “one of the most energy-efficient and greenest economies in the world while enjoying competitive energy prices and a high level of prosperity” (Bundesregierung, 2010). This includes providing a reliable, secure and affordable energy supply, maintaining Germany’s competitiveness in energy technologies and developing new comparative advantages through innovation as well as signalling the political will of the government and providing certainty to producers and consumers on future environmental policies. Such an objective also

reflects national preferences for the level of emissions and pollution more broadly as well as a political choice regarding the energy mix.

The implementation of ambitious climate change mitigation policies is strongly supported by public opinion. According to a recent survey on environmental awareness in the German population, Germans consider climate change as the third most important policy area, after labour market and fiscal policy, and are convinced that more action against climate change is needed (UBA, 2010a). In particular, around 75% of the population expect the government to implement more stringent laws and the withdrawal of environmentally harmful subsidies. In addition, according to Gallup, almost 60% of Germans support efforts to preserve the environment, compared to an OECD average of 50%. One factor behind the high public support may be knowledge of the costs of non-action, which DIW (2008) estimates to reach around EUR 800 billion by 2050 (more than 30% of GDP). The conviction that climate change policies generate new sources of growth also plays a major role in public acceptance.

The target is ambitious given the slowdown in GHG emissions reduction

Achieving the targets will be challenging as Germany may not benefit further from one-off reductions as in the past. While climate change mitigation policies contributed to reducing GHG emissions, a significant share of past abatement was due to specific events and structural changes. During the 1990s, 50% of the reduction of CO₂ emissions occurred thanks to the restructuring of the East German economy following reunification (Eichhammer *et al.*, 2001; Weidner and Mez, 2008). Inefficient heavy industries located in the new *Länder* collapsed, inducing a reduction by 44% of CO₂ emissions in that region (OECD, 2001). Outsourcing of manufacturing industries to eastern European countries as well as an increasing import penetration probably also contributed. As a result, emissions were already reduced by 16% in 1999 with a significant drop of 8% between 1990 and 1992. Over the past decade, the main reduction occurred during the recession in 2008-09, with a 9% decline between 2007 and 2009. Between 2000 and 2007, emissions were only reduced by 6% as they stabilized in many sectors or even increased in a few others (for instance in the chemicals industry).

Given the importance of these special factors, Germany may not be able to meet its commitments without an acceleration of GHG abatement in the coming years. Reducing emissions by 40% by 2020 would require increasing the annual pace of reduction to 2% (from 1.5% per year between 1990 and 2009). Furthermore, with the economic recovery and in the absence of additional policy actions, emissions have increased. According to current estimates, while remaining below their 2008 level, CO₂ emissions in Germany rose in 2010. In addition, the package of measures defined in the Integrated Energy and Climate Programme and in the Energy Concept may not be sufficient to reach the targets.³ Finally, the recent decision of an accelerated phase-out of nuclear power will add in a constraint on GHG abatement.

... and the early phase-out of nuclear power

After the Japanese nuclear catastrophe in March 2011, the government decided to accelerate the phase-out of nuclear power, reversing its 2010 decision to increase the lifespan of nuclear power plants. This plan is broadly in line with the initial one decided ten years earlier (Box 1). The definitive closure of seven old reactors, accounting for around 8% of power generation capacities, created some tensions in European electricity networks, as German electricity imports increased significantly to compensate for the losses in generation capacities. Therefore, the nuclear phase-out will make the management of European electricity networks more challenging, especially in the coming winters when demand will peak, and thus

3. A recent study from the Federal Environment Agency indicates that the measures defined in the Integrated Energy and Climate Program in 2007 will only result in an emissions reduction of 30-33% compared to 1990 (UBA, 2011a).

weigh on electricity prices. In the longer term, the impact on prices is quite uncertain but should be limited. Studies suggest the increases in electricity prices will be weak as imported electricity is less expensive than domestic electricity and as wholesale prices account for only a low share in consumer prices (Samadi *et al.*, 2011). According to DIW estimates, the consumer price should increase only by 1.5% in 2011 and by 5% with the complete phase out of nuclear power (DIW, 2011). The main uncertainty comes from the cost of the investment needed to ensure a secure energy supply, which is difficult to assess.

Overall, the phase-out of nuclear power means that Germany will have to adjust its energy policies to compensate for the loss of a low carbon energy source and ensure a reliable energy supply. The government plans to accelerate the expansion of RES and to foster energy efficiency gains. The accelerated development of RES requires anticipating investments in infrastructure, in particular for the adaptation and the extension of the electrical grid. On the one hand, this will encourage innovation and the development of more advanced technologies in particular because the government will reinforce support to energy research, and thus this may create a “first mover” advantage for Germany. On the other hand, as the technological progress may take time to appear and to adapt to specific needs, anticipating investment also risks deterring the use of more advanced and more efficient technologies (IEA, 2007). This may also force the use of still costly energy sources. In particular, investments in additional fossil fuel power plants will be needed to complement the intermittent energy production from RES. These investments will have to be supported as they may not be profitable in the long run. Contrary to RES, fossil fuel power plants do not have priority access to the electricity grid and would only sell their production at the margin when RES will not be sufficient to satisfy demand. This is creating uncertainty about the production level and about the benefits in investing in these activities. As a result, Germany is envisaging supporting the construction of highly efficient fossil fuel fired power plants which will add to the cost of GHG mitigation.

The early phase-out of nuclear power may increase GHG emissions in Germany, thus raising the gap to reach the 40% emission reduction target by 2020. In the short run, GHG emissions are expected to increase between 9% and 13% in the electricity sector (DIW, 2011; CDC, 2011) as the closure of eight reactors requires increased use of fossil fuel fired power plants, at least temporarily. Also over the longer run, accelerating the phase out of nuclear may increase GHG emissions. By 2020, and in absence of a fundamental technological break-through, doubling of the electricity production from RES and reducing electricity consumption by 10% will not be sufficient to compensate the loss of nuclear capacities, thus additional fossil fuel fired power plants will be required. In addition, balancing and reserve capacities will be needed to complement intermittent and unpredictable renewable energy supply. Furthermore, sufficient energy efficiency gains - which will be essential to limit the recourse to carbon-intensive energy sources - may not be feasible (ZEW, 2011). Indeed, electricity consumption per GDP unit has decreased less than energy intensity and even increased per capita over the past two decades. In addition, technologies used to reduce GHG emissions will increase electricity demand (*e.g.* electric cars, heat pumps, use of IT). According to CDC estimates (2011), the phase out of nuclear may increase emissions in the electricity sector from 4% to 13% in 2020 compared to 2010 depending on the technologies replacing the lost capacities (gas, coal) and assuming that the most efficient technologies available on the market are used (*i.e.* assuming no technological improvement by 2020) (CDC, 2011).

Box 1. Germany and nuclear power: strong public opposition and a political seesaw

The decision to phase out nuclear power in Germany dates back to the red-green coalition government in 1999. An agreement in 2000 between the German government and energy utilities (*Atomkonsens*) as well as resulting amendments to the Nuclear Power Act in 2002 set out the terms of this phase out. These included time limits for commercial electricity generation for each existing power station based on an average 32-year lifetime (BMU, 2000). The first nuclear power station was shut down already in 2003 and the last one would have been most likely out of service by 2021 (BMU, 2008a). In October 2010, however, the conservative-liberal government altered the plans of the nuclear phase-out by extending the time limits by an average of twelve years. As a result of the Fukushima nuclear power plant accident in Japan, the nuclear law was changed again. After a

three months moratorium in March 2011, including an immediate shutdown of eight nuclear power plants and a security check of each nuclear power plant, the German parliament enacted in July 2011 a definitive nuclear phase out by 2022. This plan is broadly in line with the initial one decided ten years earlier.

Public opposition to nuclear power was always pronounced in Germany, with origins dating back to the student protests of 1968. Public protests against the building of new nuclear power plants date back to the 1970s, culminating in protests with tens of thousands participants at the Wyl plant in 1975, at Brokdorf in 1976, and especially after the nuclear accident in Three Miles Island in the United States in 1979 (Kriehner, 2011). In the 1980s, these protests continued with efforts focused on preventing the construction of reprocessing plants in Wackersdorf and Gorleben. With the foundation of the Green Party in 1980, the anti-nuclear movement had a political platform and public opposition was boosted by the Chernobyl accident in 1986 (Kriehner, 2011). In the 1990s, protests continued with demonstrations against the transportation of nuclear waste to Gorleben (so called *Castor-Transporte*). With the decision in 2002 by the government of the nuclear phase out, the movement seemed to have achieved its targets. However, protests increased rapidly after the government's decision to prolong the reliance on nuclear power in 2010 and especially in the aftermath of the Fukushima accident in 2011.

Climate change policies need to become more cost-efficient

Achieving the targets may be costly for Germany

Achieving the targets for climate change mitigation and RES development may induce substantive costs in the absence of substantial technological progress in particular because marginal abatement costs rise quickly once the cheapest options are exploited. Theoretical analyses and international experience suggest that despite strong policy commitment, moving away from fossil fuels without nuclear power is costly, not least because other available low carbon technologies are not yet competitive (OECD, 2009). The public investment needed to reach the targets is estimated at around 1% of GDP per year (KfW, 2011). When assessing CO₂ abatement cost in Germany, evaluations differ significantly. Reducing emissions by 35% by 2020 is estimated to cost on average from EUR -38/t CO₂ to more than EUR 80/t CO₂ (BMU, 2008b; McKinsey, 2007). The differences in estimates are mainly due to assumptions about the technological changes to be expected by 2020 which determine the cost of investment in low-carbon technologies and their performance in energy savings. These results point to the need for implementing cost-efficient policies leading to a reduction of emissions in sectors where marginal abatement costs are the lowest.

Improving the framework of climate change policies

Limiting overlaps in instruments

German policymakers have used a vast panel of instruments to prevent climate change, ranging from industrial agreements to environmental taxes. This accumulation of instruments risks creating inefficiencies. For instance, as mentioned earlier, instruments may overlap as it is the case for the EU ETS and the support for the RES development which are both reducing emissions in the energy sector. Complementing instruments may be justified as some instruments are not dedicated to only one objective, such as the RES policy which also aims at technology promotion. Overlaps may, however, also reflect that policy objectives are not clearly defined, reducing the efficiency of the respective instruments. In addition, instruments do not cover all sectors of the economy. Some sectors do not have any incentives in reducing emissions, despite a large abatement potential (e.g. some export-oriented sectors in agriculture and manufacturing) (OECD, 2011a). Germany should consider further simplifying its climate change policy by first listing instruments used, identifying the externalities they are targeting, assessing whether they are cost-effective in addressing those externalities and identifying potential overlaps and loopholes. When designing the policy, the cost and benefits of the measures envisaged against the objectives they are supposed to serve should be carefully assessed. Particular attention should be given to the interaction with the EU ETS to limit overlaps.

Improving the decision making and evaluation process

The evaluation and decision making process of climate change policies could be made more transparent and pragmatic (OECD, 2011a). For example, the criteria used to select the abatement measures could be made clearer, as evaluations show that options which are cheaper than those considered in the Integrated Energy and Climate Programme exist (such as the replacement of three to four low efficiency lignite fired-power plants) (BMU, 2008b). Decisions should rely more on analysis, including the calculation of CO₂ abatement costs, to identify the least costly options for mitigation and to target measures accordingly. In addition, evaluations of different programmes were initially not designed to strongly influence decisions on environmental policies as the monitoring process did not rely on interim targets and indicators which would facilitate continued assessment of the impact of policies. Thus, the recent decision to evaluate the implementation of the Energy Concept every year, based on selected indicators in order to make rapid adjustments to the policies possible is a step in the right direction.

Putting a price on GHG emissions

Putting a single clear price on GHG emissions is a cost-efficient way to encourage emission reductions, as it prices negative externalities related to GHG emissions, encourages polluters to search and adopt less costly abatement options and generates public revenues (de Serres *et al.*, 2010). While Germany uses some market-based instruments for reducing emissions, a clear carbon price is still lacking. The carbon price set by the EU ETS may be too low to encourage abatement in the sectors covered by the scheme. In the other sectors, the Integrated Energy and Climate Programme and the Energy Concept include only few measures aiming at pricing carbon. In addition, Germany still has environmentally harmful policies which blur the price signal. As a result, existing cheap options for CO₂ abatement have not yet been exploited to a sufficient extent.

Industrial self regulation was inefficient

Germany has used industrial self regulation which had not been successful in reducing GHG emissions but later facilitated the introduction of market-oriented instruments in climate change policy. In the 1990s, the government negotiated agreements with industrial federations on carbon emission and cogeneration development (combined heat and power installations). Industry formally agreed to reduce CO₂ emissions by 8% by 2005 and 35% by 2012 if no carbon tax was introduced (OECD, 2001; Weidner and Mez, 2008). However, industry did not comply with these commitments, thus supporting international evidence that such voluntary approaches are less effective than other instruments (OECD, 2003). Nevertheless, these agreements facilitated negotiations on EU ETS implementation, partly because they underlined the necessity of carbon pricing.

Improving the impact of the EU ETS

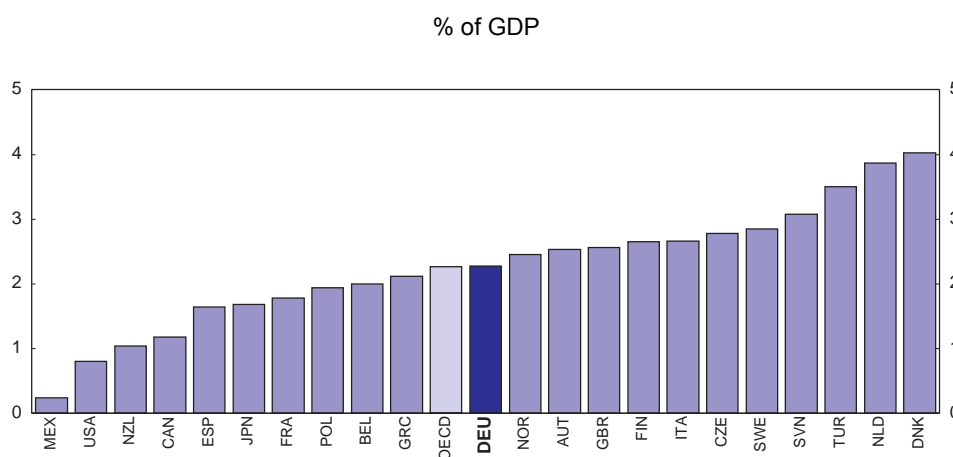
Germany has participated in the EU ETS since its beginning in 2005, but this instrument barely contributed to GHG mitigation. Partly due to the over-allocation of allowances, the implicit carbon price was too low to encourage a significant reduction in emissions during the first phases of the scheme. The price of allowances has also been highly volatile (in particular during the economic crisis when prices fell by 70% between July 2008 and February 2009). In the third phase of the EU ETS (2013-20), the scheme should become more efficient as the cap for emissions will be defined at the EU level and progressively reduced. In addition, an increasing share of allowances will be auctioned. However, despite these improvements, there is a risk that the carbon price remains too volatile to provide sufficient incentives for long term investment in low carbon technologies (HM Treasury, 2010). Indeed, in cap-and-trade schemes, volatility is usually high as quotas are fixed and thus shifts in demand translate into prices (Metcalf, 2009). In addition, the timing, the amount and the method of tightening of the EU cap remain unclear, thus

providing uncertainty about the future carbon price and about the profitability of risky and long-term abatement options (OECD, 2011a). Consideration should be given to implement measures to increase the stability of the carbon price in the sectors covered by the EU ETS at the EU level.⁴ Germany should thus contribute to discussions about possible measures to maintain an effective carbon price signal in the EU ETS in line with overall medium and long-term EU emission reduction targets.

Creating a clear carbon price signal in the sectors not covered by the EU ETS

Reduction of GHG emissions in the sectors not covered by the EU ETS, such as transports, households and services, have been encouraged by the introduction of environment-related taxes. Most of these taxes are based on energy consumption: 73% of tax revenues come from an oil duty, 15% from the motor vehicle tax and 11% from the electricity tax. With the sharp decline in energy intensity since 1990 and the increase in energy prices, environmental taxes declined as a share of GDP and are now standing close to the OECD average (Figure 4). In 2009, environmental tax revenues accounted for 2.3% of GDP and 6% of total tax revenues.

Figure 4. Environmental tax revenues, 2009



Note: OECD is the arithmetic average of ratios of member countries. Environmentally related taxes include taxes on energy products (for transport and stationary purposes including electricity, petrol, diesel and fossil fuels), motor vehicles and transport (one-off import or sales taxes, recurrent taxes on registration or road use, other transport taxes), waste management (final disposal, packaging, other waste-related product taxes), ozone-depleting substances and other environmentally related taxes.

Source: OECD/EEA, *database on Instruments for Environmental Policies*.

While no tax is really dedicated to reducing CO₂ emissions in Germany, some apply to emission-intensive products. For example, an eco tax was implemented in 1999, taxing electricity consumption and increasing the energy tax on fossil fuels with tax rates varying across fuels, although not based on their CO₂ content. Estimates suggest that it decreased CO₂ emissions by 2-3% between 2003 and 2010 in Germany and contributed to improving the market penetration of green technologies without major adverse effects on economic growth (Knigge and Görlach, 2005). The tax revenues are earmarked for reducing social contributions and to a lesser extent for funding RES development, thus contributing to increasing growth and employment and not significantly weighing on the energy intensive sectors (Andersen *et al.*, 2007). In the transport sector, the eco tax is complemented by other measures, such as an environmental road toll for heavy duty vehicles based on the driving distance, number of vehicle axles, and

4. One option would be to extend the energy tax in the sectors covered by the EU ETS at a flexible rate, thereby ensuring a certain level for the carbon price as proposed in the UK (OECD, 2011c).

emission category; it was amended in 2009 to make it more dependent on the actual emission level and investment in less polluting trucks increased consequently (BMVBS, 2011). The motor vehicle tax (tax on vehicle ownership) has also been reformed in 2009 to include CO₂ components in the tax base (e.g. cars emitting less than 120 g/km are exempted). Finally, a tax on air traffic has been introduced in 2011.

While these measures create incentives to reduce energy consumption, they are not providing a clear carbon price signal. In particular, the eco tax is not based on the CO₂ content of the tax bases and thus does not target the most carbon-intensive sources. In addition, these taxes address several externalities related to fuel consumption and transportation activities (e.g. air pollution, accident costs, road wear, noise and congestion) but are not designed to do so which makes their signal unclear and measuring outcomes difficult. One tax could be dedicated to different objectives but in this case the transparency of the tax rates should be increased so as to clearly signal what externality it addresses. One part of the rate should depend on the pollution content of the tax base as it was done for instance for the motor vehicle tax. As suggested in the Energy Concept, eco tax rates should rely more on the CO₂ content of the taxed fuel. Germany should also support the European Commission initiative regarding the EU Directive on energy taxation, which recommends splitting energy taxes into two components so as to make the CO₂ tax explicit and introducing a minimum CO₂ tax rate. However, as taxing fuel would not be enough to encourage a sufficient change in consumption behaviour at least in the short run (OECD, 2011d) and is not addressing all externalities related to fuel consumption, other instruments should be used, as, for instance, the motor vehicle tax to encourage the adoption of energy efficient cars. A road toll could be used to finance road infrastructures, as road wear related costs directly depend on the use of roads. It could also address congestion issues by extending it to congested roads or making it dependent on traffic volumes. In addition, to avoid distortions in the transport sector, extending the toll to all vehicles as planned in the Netherlands, or at least to all trucks should be considered.

Revising environmentally harmful policies

Despite strong environmental commitments, Germany still spends large amounts on environmentally harmful support measures. The Federal Environment Agency estimates that in 2008 around EUR 48 billion (1.9% of GDP) in subsidies could be considered as environmentally harmful (UBA, 2011b). According to OECD estimates, support to fossil fuels, *i.e.* any measure encouraging fossil fuel consumption, amounted to around EUR 7.5 billion in 2010 (0.3% of GDP) (OECD, 2011e). A large share of this support is targeted to energy-intensive sectors, with around 65% allocated to coal, the most polluting energy source. Such measures encourage energy consumption and exempt polluting sources from paying for negative externalities they generate. In particular, they reduce incentives for energy-intensive firms to reduce GHG emissions and delay the adoption of energy efficient technologies. In line with G20 commitments, Germany should eliminate the support measures to fossil fuels and if needed replace them by environment-neutral measures.

Around 65% of the support to fossil fuels consists of tax expenditures, mainly exemptions from the eco tax, which amounted to 0.2% of GDP in 2010 (OECD, 2011e). Within the fuel consumption tax structure, tax rates vary according to fuels, users and purposes, suggesting taxation is not systematically related to the level of negative externalities. For instance, tax rates are reduced for heating fuels and are quasi null for coal. Despite a higher CO₂ content, diesel is less taxed than petrol, contributing to a lower diesel price in Germany compared to other OECD countries. Also, many exemptions are targeted to energy intensive sectors and sectors exposed to international competition. For example, the eco tax is not applied to energy intensive industries and is refunded to export manufacturing firms under a peak equalization scheme which guarantees a refund of 90% of eco tax payments exceeding the relief on social contributions. Such tax exemptions aim at limiting the negative impact of the tax on firms' competitiveness. While concerns about international competitiveness are legitimate, the risk of competitiveness losses in some exempted enterprises is likely to be overstated (OECD, 2011f; Thöne *et al.*, 2010). Also, competitiveness

concerns need to be addressed in a way so that the incentives for emission reduction are maintained (such as through a lump-sum refund, not related to the level of energy consumption). By contrast, exemptions or reduced tax rates should only be implemented to avoid a double taxation. For instance in the sectors covered by the EU ETS, carbon emissions are already priced through the scheme and thus should not be eligible for the carbon tax. However, sectors covered by the EU ETS should not be totally exempted from the eco tax which covers other externalities than those related to CO₂ emissions. Some tax exemptions have recently been made less generous and relief for energy intensive firms will be conditioned on energy savings from 2013 onwards following European Commission requirements.⁵ Nevertheless, exemptions and reduced tax rates should be further phased out except when they are implemented to avoid a double taxation. If needed, they could be replaced by better targeted public support, ideally conditioned to energy savings.

The production of coal is supported through direct subsidies covering the difference between production costs and the world market price of coal exports (IEEP *et al.*, 2007). Following the 1997 decision to gradually phase out this support until 2018 and in accordance with the EU regulation, subsidies have been significantly reduced and in 2010 they amounted to EUR 1.7 billion (0.1% of GDP) (OECD, 2011e). Nevertheless, the coal mining industry continues to be a major receiver of direct financial subsidies from the government. Germany should consider accelerating the phasing out of coal subsidies. Coal subsidies have negative environmental consequences in terms of GHG emissions, but also air pollution, soil degradation, toxic waste and water pollution. In addition, maintaining subsidies cannot solve the structural problem facing the German coal mining industry, namely its low cost competitiveness. While subsidies should be eliminated, active labour market policies should be used to facilitate labour mobility and promote employment in the regions affected by the waning mining sector.

Other environmentally harmful expenditures include the tax treatment of personal road transports, which fosters the use of cars over public transportation. For example, company cars used for private purposes are taxed at a flat and low rate (1%), encouraging employers to pay their employees partly in a form of a car. As a result, 30% of cars registered in Germany are company cars. This tax treatment should be made less advantageous. Distance-based income tax deductions for commuters also promote use of cars and encourage workers to live further away from their place of work. They are estimated to cost around 0.2% of GDP and to account for 2 million tonnes of CO₂ emissions by 2015 (UBA, 2011b). Consequently, they should be rethought in light of their environmental impact.

Fostering energy savings and renewable energy sources

In some cases, pricing carbon is not sufficient to reduce emissions and change consumption behaviour. For instance, in the residential sector, split incentives, lack of information or weak access to finance hamper the implementation of energy savings and emission abatement. The development of RES also necessitates public support as barriers, such as network effects or limited access to credit undermine investment in these technologies. Such market failures thus require the implementation of non market based measures. Germany implements several of those, but they could be made more cost-efficient.

5. The German fiscal consolidation package from 2011 to 2014 includes the removal of some eco tax and energy tax exemptions. From 2011, the tax reduction for industry and agriculture has been limited from 40% to 25%, the minimum tax payments raised from around EUR 500 to EUR 1 000 and the peak equalization scheme reduced from 95% of the tax payment exceeding the relief of social contributions to 90%.

Measures to raise energy efficiency should be better targeted

The residential sector has a significant potential to reduce GHG emissions in Germany. Many measures improving energy efficiency in the building sector have a negative CO₂ abatement cost, meaning that their implementation is profitable even in the absence of a carbon price (McKinsey, 2007). For instance, energy efficient renovations may lead to energy savings exceeding the initial investment cost. However, a lack of information on the profitability of investments, split incentives between landlords and tenants, a too long payback period or credit constraints may hamper investment in this area. In Germany, the building stock is already relatively energy efficient, not least due to relatively strict building norms (IEA, 2007). In addition, energy efficiency gains have been substantial over the past decade: energy consumption for heating per square meter was reduced by 25% between 2000 and 2009. However, there is still room for improvement. The share of total energy used in the residential sector is 1.5 times higher than in the average OECD country. Emissions in the residential sector are also quite high by international comparisons, with 1.3 tonne per capita *vs.* 0.8 tonne on average in the OECD. Energy performance could be further improved by increasing the rate of renovation of the building stock and indeed the government plans to encourage further energy-efficient building refurbishments (IEA, 2009).

A vast range of measures have been implemented to stimulate energy savings in the residential sector. These measures are welcome as they could usefully complement the price signal of a carbon tax.

- Germany advertises potential energy savings and available technologies, for instance by providing audits on energy efficiency options.
- Strict standards for the energy performance of new buildings and existing buildings that undergo major renovation are set at the national level. The 2002/2007 Energy Saving Ordinance has been amended to introduce stricter norms in 2009 (energy performance increased by 30%) and made energy certification of buildings compulsory when they are constructed, sold, leased or rented out (in line with the EU Energy Performance of Buildings Directive).
- The Building Rehabilitation Programme and the Energy Efficient Construction Programme offer low-interest loans and grants for energy performance improvements in the residential sector. These subsidies are provided on a first-come-first-serve principle, suggesting high deadweight losses. Given that available resources are limited, such subsidies, in particular grants, should be targeted to low income households and credit constrained firms, which otherwise may not have the capacity to finance profitable energy-efficient investment. To avoid that this measure leads to low cost investments which induce low energy savings, the provision of the grants could also be conditioned to energy efficiency gains.

Nevertheless, these measures may not be sufficient to induce high renovation rates in the rental housing sector as split incentives between landlords and tenants may hamper renovation activity (de Serres *et al.*, 2010). The payback period is usually too long for a tenant to invest in renovations and owners do not have adequate incentives to improve the performance of their building. Landlords are not benefiting from the induced energy savings as German tenancy law limits increases in rents following an improvement in the energy performance of the dwellings.⁶ This is particularly problematic in view of the high share of rental housing in Germany. The government is considering allocating tax incentives for energy efficient renovations. If implemented, this subsidy should depend on the income level of eligible households and should not overlap with the allocation of grants in the Building Rehabilitation Programme and the Energy

6. Following energy efficient renovation, the landlords can increase the rent by 11% annually until the costs have been compensated. However, the rent cannot increase above a certain percentage of the local comparative rent, which might not take into account energy efficiency aspects.

Efficient Construction Programme. The priority is to revise rental market legislation as considered in the Energy Concept. Rents should also be made more flexible to ensure landlords can benefit from renovation investments; one option would be the introduction of an energy-efficiency rental index. Amendments of rent regulation aiming at better distributing the cost of renovations between the landlord and the tenant are currently discussed. Proposed changes in rent regulation which can further remove obstacles to energy savings investments in rental housing should be swiftly implemented.

RES development needs to become more cost-efficient

RES development will be necessary to reduce GHG emissions to the level targeted in the Energy Concept. To reach the government's objective in terms of RES expansion, financial support beyond the incentives generated by carbon pricing will be required as some technologies are not competitive compared to conventional energy sources even with a carbon price. This may be due to the low performance of certain technologies, lack of energy sources (such as sun and water in Germany) but also to market imperfections. For instance, learning and demonstration effects as well as access to finance are hampering the penetration of RES. In particular, there is evidence of risk premium and thus additional financial cost for RES relative to conventional energy projects limiting the profitability of investment in these technologies (Kalamova *et al.*, 2011).

The CO₂ abatement cost related to RES is on average lower in Germany than in many other OECD countries but is still relatively high for certain energy sources. As the energy mix is emission-intensive in Germany, notably because of the nuclear phase-out, abatement costs in the energy sector are low by international comparison (Egert, 2011). Developing RES is thus relatively less costly than for countries like France for instance, which would need to replace low carbon electricity production by RES. However, the abatement cost related to non-mature or low-performing technologies may still remain high. For instance, abatement costs implied by feed-in tariffs for biomass and wind power were around EUR 40 to 90 t CO₂, while abatement cost for photovoltaic largely exceeded EUR 200/t CO₂ in 2009-10 (Egert, 2011).

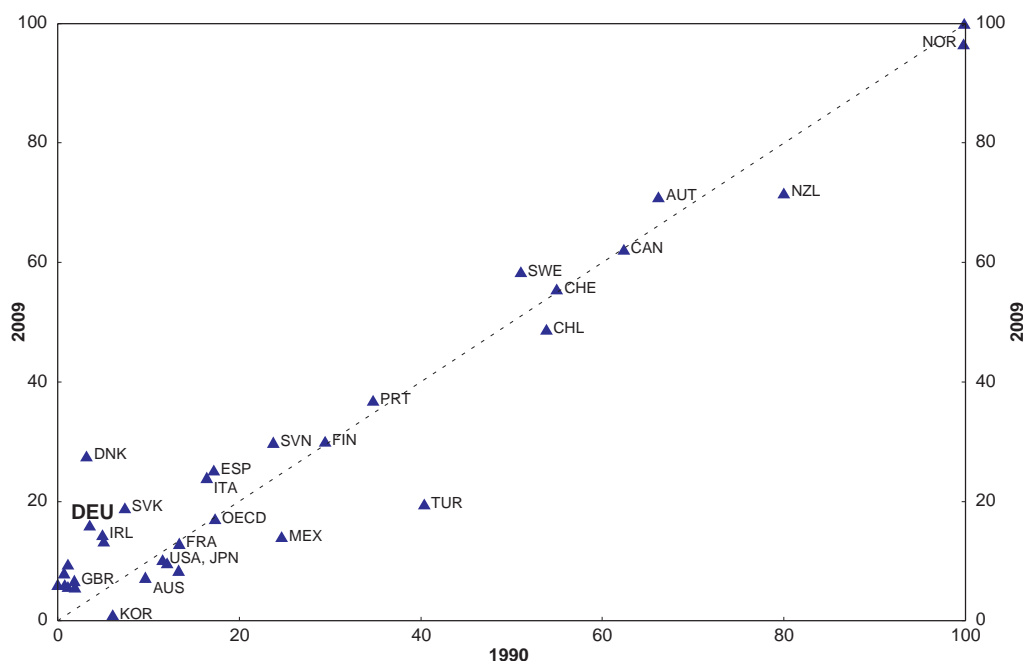
A vast range of measures has been implemented to encourage RES development. The main measure was the introduction of feed-in tariffs guaranteeing the sale price of electricity produced from RES, jointly with a preferential access to the grid. RES production rose after the implementation of the feed-in tariffs scheme in 1991 and even more so after 2000 with the passing of the RES Act (*Erneuerbare Energien Gesetz, EEG*) and its following amendments in 2004, 2008, 2010 and 2011. In particular, the RES Act introduced cost-based tariffs, which significantly increased the level of remuneration, and imposed the obligation to purchase renewable energy electricity to grid operators and energy suppliers (IEA, 2004). These measures have been complemented by investment support through capital grants and low interest loans, provided by the state-owned KfW bank. In particular, capital costs were reduced for firms investing in wind and solar energy. Reduced tax rates for electricity and heat produced from RES, support to biofuels (tax exemptions and quotas), and financial incentives for heating installations and renovation of buildings have also contributed to RES development. In 2009, the Act on the Promotion of Renewable Energies in the Heat Sector increases the compulsory share of RES in final energy consumption for heating and air conditioning in new buildings (from 6% in 2009 to 14% by 2020). Finally, to limit competition coming from nuclear power and to internalize decommissioning costs of nuclear power plants, a nuclear fuel tax was introduced in 2010. The revenues were earmarked to support RES development.

As a result, RES developed at a strong pace. Since 1990, renewable energy consumption increased more than two fold and accounted for 11% of total energy consumption in 2010. RES have been the fastest growing source of electricity in Germany. Between 1990 and 2010, RES electricity production growth was ten times higher than in the OECD and the share of RES in electricity production almost reached the OECD average (Figure 5). Even though 17% of electricity consumption was from RES in 2010 (and has

increased further in 2011), this share is still low compared to some other OECD countries (Figure 5). This is partly explained by the availability of renewable energy sources which is high for instance in Nordic countries, benefiting from large hydroelectric capacities. In Germany, wind and biomass account for two thirds of the RES electricity production, while hydropower and solar remain limited (20% and 7%).

Figure 5. Renewable energy sources in the electricity sector

Share of renewable energy sources in electricity production, %



Source: IEA, *Energy Balances of OECD countries*, 2011 edition.

The high predictability of the German policy in terms of RES development, and the implementation of feed-in tariffs in particular, contributed significantly to reducing the barriers to RES expansion. Uncertainty regarding environmental policies hampered the development of RES in other OECD countries (OECD, 2011a). Some studies also show that feed-in tariffs were more efficient than other policies in increasing RES penetration. Butler and Neuhoff (2008) and Mitchell *et al.* (2006) find that Germany's feed-in tariffs scheme was more likely to foster investment in RES and less costly compared to the UK Renewables Obligation. Overall, German feed-in tariffs are better designed than in most OECD countries implementing such a system. They broadly respect the conditions for an effective policy aiming at increasing the penetration of RES on the electricity market (IEA, 2008).

- The support is predictable and transparent enough to encourage long term investment. As returns depend on the policy implemented (in particular the internalisation of negative externalities), improving transparency, predictability and longevity of government programmes is necessary to reduce financing costs for firms investing in RES (or even give them access to finance). In Germany, feed-in tariffs are guaranteed for 20 years and revised every four years (except for photovoltaics, see below), which ensure a high stability for investors.
- RES have priority access to the grid and to the electricity market, ensuring a certain rate of return to investors (as they can sell their entire production at a guaranteed price).

- Feed-in tariffs are designed to ensure the diversity in the technologies used. In Germany, the feed-in tariffs vary with the technology used and the capacity generation, to foster the development of non-mature but promising technologies (Table 2). Tariffs are fixed to equalize the cost for producers and ensure that no specific technology is privileged. This strategy, while not being the most cost efficient, ensures that complementary energy sources develop. Given the intermittence and the unpredictability of the energy supply from RES, it is worth having a diversified RES energy mix. In addition, due to learning cost effects, promising technologies could be excluded from the market. Nevertheless, differentiating between technologies also has drawbacks. First, it requires picking winners at some stage and the accuracy of the administration to choose the most promising technologies may be questionable. Second, due to asymmetric information, determining the adequate level of feed-in tariffs is difficult. Regular evaluations and adjustments help to overcome these challenges.
- Feed-in tariffs are reduced each year according to a predetermined rate of depreciation to encourage innovation and efficiency gains (except for photovoltaics, see below). While encouraging investors to choose more efficient technologies, this prevents excessive rents of RES producers as the cost of equipment declines with the adoption of technologies at a large scale.

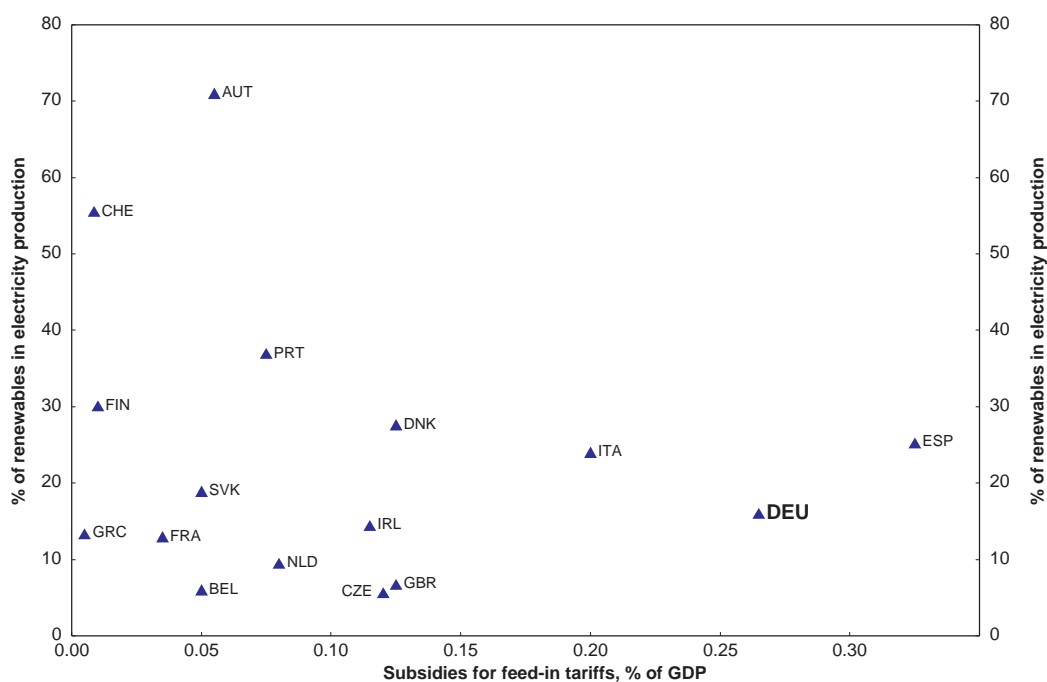
Table 2. Feed-in tariffs in Germany

Range of rates offered in EUR cents per kWh

Energy source	2009	2012
Biomass	7.79-11.67	6-14.3
Solar	31.94-43.01	21.11-28.74
Geothermal	10.5-16	25
Biogas	6.16-11.67	6-8.6
Offshore wind	3.5-13	3.5-19
Onshore wind	5.02-9.2	4.87-8.93
Hydro	3.5-12.67	3.4-12.7

Source: Federal Ministry for the Environment, *Nature Conservation and Nuclear Safety, RES Legal*. The figures refer to basic tariffs without bonuses.

While the feed-in tariffs system is broadly well designed, it is nevertheless relatively costly. Subsidies to RES, measured as the difference between the feed-in tariffs and the electricity market price multiplied by the level of RES production as a share of GDP, are among the highest among OECD countries with similar programmes (Figure 6). Between 2000 and 2010, the total support of the RES Act amounted to EUR 61.7 billion, far exceeding prior government expectations and increasing sharply over the past few years. In 2010, feed-in tariffs amounted to around EUR 13.2 billion (0.5% of GDP). This is notably due to the strong development of photovoltaics, boosted by generous feed-in tariffs and a sharp decline in costs. Indeed, feed-in tariffs in photovoltaics induced negative private abatement costs, thus explaining the huge increase in solar energy installations (McKinsey, 2007).

Figure 6. Renewable energy sources and feed-in tariffs, 2009

Note: Renewables in electricity production are hydro, geothermal, solar/wind/sea, biofuels and waste are excluded. Subsidies are calculated by Egert (2011) as the lower and upper-bound feed-in tariffs in excess of the market prices multiplied by electricity production from a given energy source in 2009. The graph shows the midpoint where a range of tariffs exists.

Source: IEA, *Energy Balances of OECD countries*, 2011 edition; Egert, B. (2011), "France's Environmental Policies: Internalising Global and Local Externalities", *OECD Economics Department Working Papers*, No. 859.

While, as mentioned earlier, support for RES has a limited impact on emissions at the EU level, estimates found that RES may have avoided 72 million tonnes of CO₂ emissions in 2009 in the German electricity sector (BMU, 2010). Thus the absolute CO₂ abatement cost of RES was around EUR 74/t CO₂ in 2009, more than six times the carbon price in the EU ETS. Feed-in-tariffs are financed by a fee included in the electricity price (the "EEG surcharge") and this fee nearly trebled between 2009 and 2011 (from 1.2 cents per kWh to 3.5 cents). The EEG surcharge accounted for 9.6% of the electricity price in 2010. By increasing electricity prices feed-in tariffs encourage energy savings and thus emission abatement in Germany.

Going forward, pursuing the feed-in tariffs policy may be not sustainable considering the scale and the timeframe of RES expansion by 2020. According to the government, the EEG surcharge should remain unchanged at around 3.5 cent per kWh: the expected decline in investment costs and increase in energy prices should improve the profitability of RES and reduce the need for subsidies to ensure their developments. However, these developments are uncertain and other evaluations project significant increases in prices. The Germany Energy Agency (Dena) estimates that the expansion of renewable energies would lead to electricity prices going up by around EUR 2 Ct/kWh, increasing the electricity bill of households by around 10% (Dena, 2011). These estimates do not include the cost induced by the necessary extension of the grid to ensure the integration of the RES on the electricity network.⁷ In addition,

7. Dena (2011) estimates the total cost of the German energy policy at around EUR 4-5 Ct/kWh. This evaluation includes the cost of grid extension that would have occurred even without the RES development.

the recent revision of the Renewable Energy Act to be implemented from January 2012 increases feed-in tariffs for some technologies, thus raising the cost related to the feed-in tariffs system. As the revision of tariffs is not retroactive, the overall cost of the RES policy may increase sharply in the coming years. The German economy is more electricity intensive than the OECD average and thus may be more vulnerable to an increase in electricity prices. Energy intensive firms are exempted from the EEG surcharge thus are protected from the increasing cost of electricity. However, these exemptions increase the weight of the RES support on private consumers and other sectors of the economy, thus creating distortions. In Germany, a 10% increase in energy prices over three years is estimated to reduce GDP by 0.4%, more than in most of the euro area members, mainly due to a higher impact of energy price increases on private consumption (ECB, 2010).

A revision of the feed-in tariffs system would contribute to damping the increasing cost of the RES expansion. First, tariffs should be lowered as carbon prices on the EU ETS should increase creating additional incentives on the energy market to develop low carbon power sources. Second, some flaws should be corrected to maintain abatement costs related to feed-in tariffs at reasonable levels:

- The CO₂ abatement cost for certain technologies reached extraordinary levels in the past and are still high despite recent revisions of the feed-in tariffs system. In Germany, the feed-in tariff for photovoltaics was eight to ten times higher than the electricity price and more than three times the feed-in tariff paid to wind in 2009. Significant reductions have been implemented over the past two years but tariffs remain two to three times higher for solar compared to wind or hydro power. Very high abatement costs may reflect that technologies are not yet competitive because of their low performance and not because of market failures, in which case their exploitation is inefficient. Other technologies, such as offshore wind, require the development of specific infrastructure on the electricity network, adding to the cost of feed-in tariffs in the wind sector. When determining the level of feed-in tariffs, higher subsidies should be restricted to promising technologies. To assess the profitability of a technology, cost benefit analysis should be implemented, including the total cost of its integration into the energy system and taking interactions with the EU ETS cap into account (OECD, 2011b).
- Feed-in tariffs are not flexible enough to adapt to market developments. In Germany, the tariffs and the degression rates are usually revised every four years but some additional adjustments are possible and have been recently used for photovoltaics. In response to the increasingly rapid deployment of solar power, the government introduced a volume responsive degression system in 2009 for photovoltaics.⁸ The system was revised in 2010 and in 2011 as solar generation capacities continue to expand at a high pace. These adjustments have been insufficient to control the development of photovoltaics and the government is revising again the support measures. Feed-in tariffs should be cut further and the degression system could be made more efficient by basing it on an analysis of price elasticities. More broadly, all feed-in tariffs could be made dependent on market developments to better control the increase in cost. This would limit the recourse to unpredictable adjustments undermining the stability and the transparency of the system which may deter investment. Besides, as suggested in the Energy Concept, other forms of incentives could be considered for large scale projects, such as offshore wind power capacity expansion: feed-in tariffs could be determined by issuing tenders, granting licenses to those producers who propose the lowest tariffs for a certain amount of electricity production. In addition, the introduction of a "market premium" for renewable producers who opt to sell

8. In 2009, Germany was the largest world market for solar equipment with 53% of newly installed capacities (OECD, 2011a). Feed-in tariffs decline as a function of the amount of capacity installed. Each GW installed in excess of the baseline would result in an additional 1% degression (up to 13%) in 2011 and 3% in 2012 (up to 21%). Since 2011, the degression rates are revised twice a year to smooth adjustments.

electricity at the market price and thus do not benefit from feed-in tariffs should be carefully designed so that it effectively reduces the cost of the RES development. Finally, Germany should continue monitoring the generosity of the feed-in tariffs and ensure they are removed when technologies become profitable.

Continuing the green growth success story

In the past, Germany was successful in turning environmental challenges into a source of growth. Benefiting from its first mover position and from high innovative capacities, it is now a leader in green technologies. To keep the lead and create new sources of growth from the challenging targets it set on climate change mitigation, Germany should ensure an adequate investment level in the energy sector and in eco-innovation. Doing so will require policy adjustments.

Germany is a leader in green technologies...

Germany benefited from being a leader in environmental policy making, as policies implemented to reduce air pollution, save energy and develop RES created new markets for the domestic industry and fostered innovation. By increasing the price of pollution and energy, environmental policies fostered demand for green products and technologies. As a result, Germany is one of the largest markets for environmental goods. For example, Germany had the largest installed solar photovoltaic capacity and the second largest installed wind capacity in the world in 2008 (OECD, 2011a). The net impact of environmental policies on growth is ambiguous, though. On the negative side, strong environmental constraints impose costs on production and in the case of climate change policies induce carbon leakage (outsourcing of carbon-intensive activities). In addition, the demand for green products and technologies created could be addressed by foreign suppliers, increasing dependency on imports and limiting the positive impact of environmental policies on the domestic economy. On the positive side, by developing incentives to innovate and increasing energy efficiency, these policies may create competitive advantages. The net impact will thus strongly depend on the cost-efficiency of the measures implemented and their impact on firms' competitiveness. For instance, the positive impact of the RES policy on the economy has been limited not least because of the increase in electricity prices it induced (Box 2). However, Germany benefited from being a first mover and managed to develop an innovative industry. Overall, green technologies accounted for 8% of GDP in 2007, a share that could increase to 14% by 2020 (BMU, 2009). According to some estimates, environmental protection employs 1.8 million workers (around 4% of total employment) and emission-reducing investment amounts to 5% of GDP (BMU, 2008b). In addition, a relatively high share of the value added in the green sectors is produced in Germany, suggesting these sectors are more employment-intensive than on average in the economy.⁹

Green sectors boomed over the past few years (Occampo, 2010). This trend is likely to continue with global markets for solar thermal energy, photovoltaic and wind power projected to grow by 20% per year until 2020 (BMU, 2009). Being among the largest producers of environmental goods and services, with the second largest market share in global trade of climate protection related products after China amounting to more than 12%, Germany benefits substantially from this development (BMU, 2012). Germany is a leader in the wind and the photovoltaic sectors with respectively two and three firms among the ten main producers of wind turbines and solar panels worldwide

However, competition is developing quickly on the environmental good and services market. With an export share of RES equipment of around 80%, Germany is highly exposed to this competition and firms have difficulty preserving their markets. For instance, the export market share of Germany in photovoltaics

9. 65% of the value added in green sectors is produced domestically; this compares with 22% in the automotive sector.

decreased from 77% in 2004 to 31% in 2009 (PRTM Management Consulting, 2010). In 2009, more than 70% of photovoltaic equipment was imported from Japan, China and Spain. The situation is less dramatic for wind where three quarters of equipment bought in Germany is produced by German manufacturers.

Box 2. Evaluation of the impact of RES policy on employment and growth

Evaluations generally conclude that the development of RES in Germany had a positive impact on growth and employment, even though estimates vary significantly. For instance, DIW found that increasing the share of RES to 30% of the total energy consumption by 2030 could lead to an increase in the level of GDP varying between 1% and 3% by 2030 and create between 15 000 and 166 000 jobs depending on the assumptions used in the evaluation (DIW, 2010). Overall, the total impact on the economy is assessed to be weak in absence of productivity gains in the RES sector and of improved competitiveness on the world markets.

The support to RES stimulates the economy by boosting investment spending and creating demand for green technologies. In particular, in the electricity sector, it induces the production of new power generation and storage capacities but also the development of network infrastructure. In 2010, investment in renewable facilities accounted for EUR 26.6 billion (0.1% of GDP), 2.6 higher than in 2005 (a 21% annual increase). Employment in RES sectors has also increased sharply over the past two decades, with more than 370 000 persons employed in 2010, three times more than in 2002 (BMU, 2011).

In addition, increasing the share of RES contributes to reducing Germany's energy dependency which is high by international comparison. In 2009, German produced only 40% of its total energy supply - less than half the OECD average. RES expansion is estimated to reduce energy imports by 20% until 2020 and 60% by 2050 (BMU, 2011). By developing non fossil fuel domestic energy sources, Germany reduced the vulnerability of its economy to energy price volatility. Besides, RES exert downward pressure on electricity prices on the spot market due to the "merit order effect" (BMU, 2010). During peak demand, feed-in tariffs may be below the market price and as they have priority dispatch, RES may substitute inefficient fossil fuel-fired generation with higher marginal costs (like diesel generators).

However, the cost of RES development and its impact on other sectors of the economy may limit its positive effects on growth. Indeed, it induces losses in conventional energy sectors and may hamper investment in other activities, notably by increasing competition for credit. The financing of the RES policy is also weighing on activity. By increasing electricity prices, the feed-in tariffs system weighs on households' disposal income and dampens domestic consumption. While some energy intensive firms are exempted from the EEG surcharge, it also raises the production costs of non energy intensive firms and may deteriorate their price competitiveness. Most studies assume the cost of RES support will decrease significantly, due to increasing productivity and technological learning effects in the RES sector. By contrast, Frondel *et al.* (2010) conclude that the impact on growth should be weak when only taking into account the negative impact of increasing electricity prices on the economy. This suggests that in absence of technological progress and productivity gains, RES may not be a new source of growth for Germany because of its cost. The final impact on growth will also depend on the price developments in the energy sectors as well as on the net effect of the "merit order effect" and of the EEG surcharge on electricity prices.

The performance of German firms on green markets will also be decisive. With growing demand of foreign markets for RES technologies, maintaining a first-mover advantage and a technology leadership would ensure Germany will reap the benefits of its investment in RES. The Ministry of Environment estimates the worldwide investment in RES should be multiplied by five from EUR 122 billion in 2005 to EUR 590 billion in 2030. Depending on the assumptions made on German export market shares, the estimated impact on GDP of the RES policy varied by 20% and the impact on employment by one third (BMU, 2011).

... and this competitive advantage should be maintained

Maintaining the competitive advantage in an ever more competitive environment will require reducing the costs related to climate change policies and creating or exploiting new markets in environmental areas. Implementing cost-efficient climate change policies will not be sufficient to maintain the leadership on green markets. Ensuring adequate development of infrastructure, improving competition

in energy sectors, and investing further in eco-innovation would help Germany to further exploit environment friendly sources of growth.

Investing in adequate infrastructure

Investment in infrastructure is an important factor when changing the energy mix as envisaged in the Energy Concept. Integration of RES into the electricity system requires the expansion of the electricity transmission and distribution network as the national grid is not suited to transport electricity from decentralized sources which are not located close to demand (*e.g.* offshore wind). In addition, the network needs to be adapted to intermittent energy supply. Overall, up to 0.2% of GDP will need to be invested annually by 2020 to adapt the network infrastructure to RES development (Dena, 2010). The government identified the expansion and improvement of the networks as a key priority, by developing a strategic plan for grid extension and – in line with the recent revision of the Energy Act - is establishing ten-year-plans for grid extension which are coordinated amongst operators on a national basis. This initiative is welcome as it ensures the coordination of the projects and may create synergies, increases transparency and enhances participation of all relevant stakeholders. Also while it will not reduce the need for grid expansion, smartening the grid could help managing unpredictable energy sources and generating efficiency gains as it improves demand side management. Smart metering systems, *i.e.* systems which provide information on the energy consumption and its cost in real time and allow the introduction of peak-load pricing, could contribute to reducing peaks in demand. Overall, while ensuring the adequate development of infrastructures, Germany should ensure that the most efficient technologies are used on the electricity network.

However, despite the urgency of further development, investment in grid extension is stagnating and many of the projects planned are experiencing delays (Bundesnetzagentur, 2010). In 2009, less than 40% of the investment in grid extension initially planned materialized. According to the Federal Network Agency, the reasons behind these delays relate to public opposition at the local level (*e.g.* with respect to overhead power lines), fractured responsibilities for site approval and in some cases changing procedures. To address *inter alia* the lack of public acceptance, discussion platforms bringing together the main stakeholders involved in grid expansion were established in February 2011 to generate an active follow up and engagement of the different stakeholders. In addition, the “Grid Development Act” of 2009 facilitates the planning and authorisation process for 24 strategic grid expansion projects. More recently the “Grid Expansion Acceleration Act” of 2011 is assigning part of the consenting approval process at the federal level. Decisions on the construction of some high voltage lines are now taken by the Federal Network Agency, which is a first step towards harmonized approval procedures for infrastructure planning.¹⁰ The new “Energy Act” and the new “Grid Expansion Acceleration Act” also further improve the transparency and public involvement in the decision process to ensure the completion of the planned projects. These measures would be usefully complemented by additional improvements of the investment framework. In particular, procedures for authorisation could be further harmonized and streamlined and a point of single contact for all investment projects could be established.

In addition, the risk of underinvestment in the electricity transmission sector remains. The transmission and distribution market is monopolistic by nature and the lack of competition among transmission systems operators (TSO) and distribution system operators (DSO) could lead to restriction of capacities. As a consequence, the network markets are highly regulated to ensure TSOs and DSOs provide reliable services to electricity producers and consumers. Prices for access to the grid as well as investments in grid extension are regulated by the Federal Network Agency. Since 2009, incentive-based regulation has

10. The Federal Network Agency is responsible for the two first steps of consenting process, the justification of each project and the geographical route, for trans-national and trans-regional high voltage lines and for new projects above or equal to 110 kV. Local authorities are still in charge of the final site approval.

been implemented. While maintaining security of supply, the regulation aims at cost-efficiency via benchmarking, and cost reduction by setting a cap on TSO and DSO revenues. Regarding investments in most grid expansion or restructuring projects, the TSOs and in some cases DSOs, submit investment budgets to the regulator for approval. Projects are evaluated according to a cost-benefit assessment, encouraging the use of the most efficient technologies. The “Smart grid initiative” recently launched by the government should lead to a change in these regulatory practices. Incentives for choosing the most efficient technologies and integrating smart technologies in the market should be implemented on a cost and benefit basis.

Improving the competition framework in the energy sectors

In many ways, a high level of competition in energy markets would contribute to reducing the cost of climate change mitigation in Germany. In particular, at the generation level, it would limit the cost induced by the intermittent nature of the RES. For instance, by lowering the price of gas, more competition in the gas market could support the development of energy efficient peak-load gas power plants able to supplement renewable energy supply and could thus facilitate the replacement of polluting coal power plants. In addition, increased liquidity on the spot markets would reduce the rise in electricity prices during peaks in demand and ease adjustments to fluctuations (IEA, 2011). Finally, developing connections with external energy markets could extend storage capacities (in particular, by using foreign pumped storage plants).

Despite some progress over the past few years, the competition level in energy sectors in Germany remains low (Box 3). Markets are concentrated at the regional level and a large share of energy is traded under long-term contracts. In addition, while Germany stands above the 10% target for interconnection capacity set at the EU level, integration with the European energy market is limited, in particular given the needs for interconnected networks created by the RES development (European Commission, 2011). In Denmark, where wind represents 20% of annual electricity production, interconnection capacity is equivalent to 80% of total peak demand and has a major role in providing flexibility to the electricity system (IEA, 2011). By comparison, interconnection capacity in Germany was around 23% of 2009 peak demand.

Recent initiatives to increase liquidity and transparency on the spot market and to improve access to the gas network should contribute to raising the competition level (Box 3). The implementation of the third EU Energy Package - a set of measures promoting increased competition in EU gas and electricity markets - was also a step in the right direction. Unbundling rules will be tightened and the rights of consumers will be strengthened by increasing transparency of energy bills and creating a special body for out-of-court dispute settlement. However, additional measures should be considered to speed-up competition developments. The establishment of a new market monitoring body in charge of guaranteeing market transparency in the wholesale trade of gas and electricity as planned in the Energy Concept is welcome. Integration with the European energy market should also be accelerated.

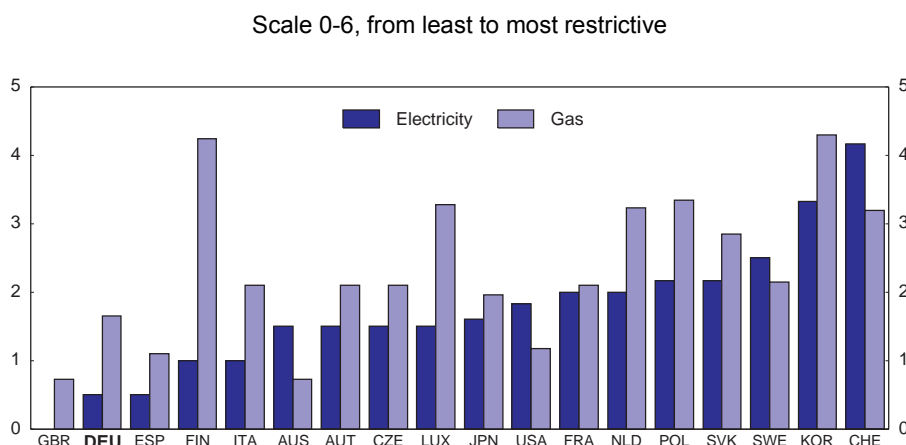
Competition could also stimulate efficiency gains and eco-innovation as firms on contestable markets are encouraged to exploit new technologies to gain market share and as most radical innovations are performed by new firms (de Serres *et al.*, 2010). In particular, empirical evidence suggests that eco-innovation is fostered by a higher probability of customer switching electricity suppliers (Jamashb and Pollitt, 2008). In this regard, it is unfortunate that consumer switching is low in Germany, thus making it difficult for new entrants to gain customers (Box 3). Providing information about switching possibilities, which is now an obligation defined in the third EU package, contributes to a proper development of competition at the distributional level. Initiatives from the Federal Network Agency to encourage consumers to find out about switching suppliers should be thus continued.

Box 3. Competition in the German energy sectors

While the regulatory environment in the energy sectors improved significantly in Germany during the last decades with product market regulation now lower than in most other OECD countries (Figure 7), the level of competition remains weak in both electricity and gas markets (European Commission, 2010; Monopolkommission, 2011).

The electricity market at the generation level is still concentrated. In 2010, four companies accounted for a market share of nearly 80% and most of the electricity is traded under long-term contracts (Bundesnetzagentur, 2010). Nevertheless, there has been some improvement over the past years. Since 2007, the unbundling process and the appointment of an independent regulator (*Bundesnetzagentur*) contributed to a fall in the market share of the big four from 85% to 79%. In addition, integration with the EU energy market progressed. Germany now participates in four of a total of seven regional initiatives for the integration of European power markets. Since May 2010, market coupling between the German and the Nordic electricity markets has developed. Germany is also part of the Central Western European Market and signed a “Memorandum of Understanding regarding the Central Eastern European Forum for Electricity Market Integration” as well as another “Memorandum of Understanding on the Baltic Energy Market Interconnection Plan”. At the retail level, while the number of electricity providers increased significantly, competition is still limited (Frontier Economics, 2010). The switching rate of consumer is low by international comparison (4.75% in 2008 while it is around 11% in Sweden and 9% in Netherlands), in particular for SMEs and households (4.7% vs. 17.4% in large industry). Even though consumers can achieve substantial savings by switching suppliers (EUR 160 per year), most of them do not make use of this possibility (Bundesnetzagentur, 2010). In addition, around half of consumers switching supplier went to one of the big four.

Figure 7. Regulation in the electricity and gas sectors, 2007



Source: OECD, *Product market regulation indicators database*.

Competition is also underdeveloped in the natural gas market. The market is quite concentrated as gas is supplied by four principal market entities (E.ON Ruhrgas, Verbundnetz Gas, Wingas and RWE) and Germany is still divided in six markets areas. The natural gas market also lacks liquidity due to long-term supply contracts. Competition has improved as the number of suppliers has increased over the past few years. The number of market areas with only 1 to 5 suppliers was five times lower in 2009 compared to 2008. Furthermore, the system of long-term capacity booking was reformed in 2010 with an amendment of the Gas Network Access Ordinance. Under the former system, capacities were booked for two years according to a first come, first serve basis. The booked capacities were generally not used while not being available to other market entities (in three-quarters of the cases by distributors affiliated with the network operator) thus excluding small market entities from the market and permitting the network affiliates to maintain a dominant position in their traditional supply areas (Bundesnetzagentur, 2010). Now capacities are auctioned, thus removing barriers to grid access and simplifying the booking process. However, as on the electricity market, a majority of consumers are not benefiting from savings they could get from provider switching (Bundesnetzagentur, 2010).

Investing further in eco-innovation

Eco-innovation - defined as the implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organisational structures and institutional arrangements which leads to environmental improvements compared to relevant alternatives - is needed to reach the 2020 targets and would reduce significantly the cost of their achievement. In addition, eco-innovation could also generate additional growth, thereby offsetting some of the adverse effects of emission reduction policies (OECD, 2011f).

Despite strong technological development over the past few decades, technologies and processes needed to significantly reduce emissions (“backstop” technologies) are still lacking (OECD, 2010b; Aghion *et al.*, 2009). In addition, the potential impact of technological development on CO₂ abatement cost is huge: OECD simulations show that the cost of climate change mitigation could be halved (from 4% of world GDP to 2% in 2050) if renewable technologies would be made competitive in the electricity and non-electricity sectors (OECD, 2011f). Given the ambitious targets both in terms of emission reduction and RES deployment and their associated costs, eco-innovation is required in many areas in Germany (Box 4). In particular, technological development and increased efficiency of the grid management can both play a central role in the adaptation to higher RES supply. It will determine at which cost and under what conditions investments will be done, which will be crucial not least from a cost-efficiency point of view, but also for public acceptance.

Box 4. Options for eco-innovation

Eco-innovation could facilitate the achievement of the Energy Concept targets by addressing central challenges such as dealing with the intermittent nature of RES, for instance:

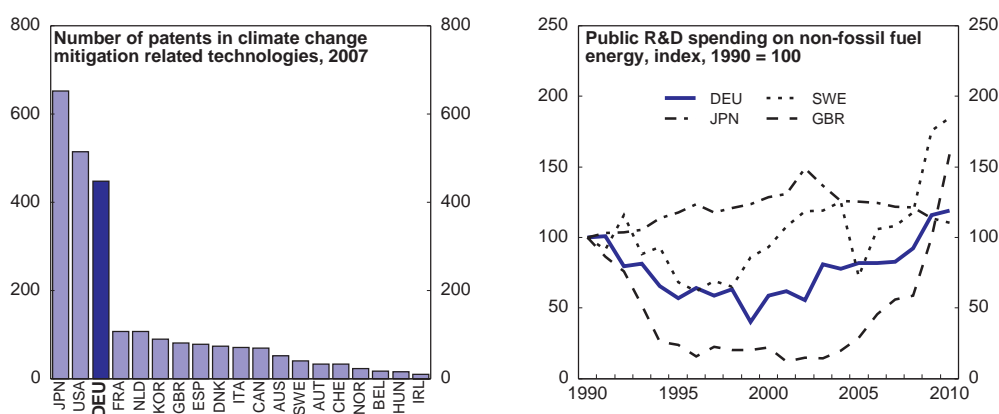
- Storage capacities for electricity are needed to deal with the variability of the RES supply. Available pumped-hydro capacities are limited in Germany and other technologies such as compressed air and hydrogen storage are not yet mature enough for industrial use. The use of smart charging stations for electrical cars is an example of innovative storage options that is now experimented within Berlin.
- Limiting peaks in energy consumption could facilitate the management of energy production. Demand side management technologies could limit the peak load requirement from fossil fuel fired power plants and reduce the cost of power generation by 0.02% of GDP by 2020 (Dena, 2010). For instance, smart electric meters - allowing consumers to get information on his/her energy consumption and its related cost and allowing suppliers to implementing peak load pricing - would contribute to reducing and smoothing energy consumption.
- Innovation will also be needed to improve the environmental performance of conventional power plants, as they will be necessary to complement the intermittent RES. The efficiency and the emission-intensity of fossil fuel power plants should be improved, for example by developing efficient cogeneration of heat and power stations.
- Carbon capture and storage technologies, whereby CO₂ is liquefied and pumped into underground cavities, should also be explored. A law allowing tests with an opt-out clause for those *Länder* where opposition to this technology is too high is currently discussed.

With strong innovative capacities and a broad industrial base, Germany has a long experience of policy-induced environmental innovation (OECD, 2011a). For example, regulation of air pollution in the 1970s and on waste in the 1980s triggered innovation in these sectors (Popp, 2004). New standards in the automotive sector and increasing fuel prices also led to a sharp increase in innovative solutions for

limiting motor vehicle emissions (OECD, 2011a). Patenting activities in RES also accelerated after the introduction of feed-in tariffs, in particular in solar technologies after the implementation of the EEG Act in 2000. Overall, environmental policies were one of the main drivers of innovation in green technologies as they created a need for abatement solutions and market opportunities for innovative firms. Also the diffusion and adoption of these technologies benefitted from the implemented policies, in particular for RES (Johnstone *et al.*, 2010; Popp *et al.*, 2011).

Germany's innovation performance is in the upper range of OECD countries (OECD, 2010a), in particular in environmental technologies. Patenting activity in general environmental management activities constantly increased since 1980. In 2007, Germany was the third main producer of triadic patents in RES (OECD, 2011h). It also ranks third regarding the number of patent applications in technologies related to climate change mitigation (Figure 8, left panel). Regarding the number of patent applications per capita, Germany remains in third place after Denmark and the Netherlands.

Figure 8. R&D spending and innovation in environmental areas



Note: R&D spending on non fossil fuel energy refers to spending in the following areas: energy efficiency, renewable energy source, nuclear, hydrogen and fuel cells, other power and storage technologies and other cross-cutting techs/research. Patents in climate change mitigation related technologies refer to patent applications filed under the Patent Co-operation Treaty (PCT), by priority date and inventor's country of residence in renewable energy, electric and hybrid vehicles and energy-efficient buildings and lighting.

Source: IEA database, *Energy Technology R&D Statistics*; OECD, *Patent database*.

Improving the climate change policy framework could further support eco-innovation in Germany. Uncertainty on the carbon market development and about future climate change mitigation policies make private returns of eco-innovation unpredictable. According to a recent Eurobarometer survey on “Attitudes of European entrepreneurs towards eco-innovation”, more than 50% of firms state that uncertainty about the return on investment, a too long payback period, or a too uncertain market demand are the main barriers for innovation. This suggests environmental policies should be highly predictable and credible to foster investment in green technologies. Thus, Germany should make clearer the measures that will be implemented to reach the targets fixed in the Energy Concept. When defining its climate change mitigation policies, the impact of the measure on innovation should be considered. In particular, the establishment of a credible, transparent, predictable carbon price would support the development of greener production processes, product and technologies (OECD, 2011g). Compared to “command and control” measures, pricing pollution provides greater incentive for innovation as it rewards for continual improvements (OECD, 2011h). In addition, while feed-in tariffs could have had a positive impact on innovation during the creation of the RES market, this effect may decline as technologies become profitable under the current scheme. Incentives included in the system (*i.e.* the degression rates which encourage efficient gains) may not be sufficient to foster innovation. Thus, strengthening incentives in the RES sector by conditioning the

feed-in tariffs to the use of the most advanced technologies or to the performance level should be considered.

However, environmental policies alone may be not sufficient to trigger radical innovations which often are too far from the market to be developed by the private sector. A broad R&D support is thus needed to develop breakthrough technologies which require basic research with long-term and uncertain payoffs. In addition, in certain areas, including energy and environment, learning cost and scale effects may constitute entry barriers to new technologies (in particular in network industries such as the energy sector), thus necessitating government support. Germany is providing such a support, by offering a favourable innovation framework as well as targeted measures encouraging technology development in the energy and the environmental fields (in particular, with the recent 6th Energy Research Programme).

In addition to environmental policies, a favourable innovation framework with strong public support of R&D (beyond green sectors) and a good protection of intellectual property rights contributed to developing eco-innovation in Germany.¹¹ The level of total R&D spending is above the OECD average, accounting for around 2.6% of GDP in 2010. Both public and private spending are high by international comparison, with 67% of R&D expenditures funded by industry (versus 64% on average in the OECD) and government spending amounting to 0.76% of GDP (*vs.* 0.65% in the average OECD country). In particular, public R&D spending in the environment and energy sectors was slightly above the OECD average at around 0.06% of GDP in 2010. As in other OECD countries, public spending in non fossil fuel energy increased significantly over the past decade (Figure 8, right panel). The targeted support has progressively switched from nuclear and fossil fuels to RES and other non-fossil technologies (*e.g.* storage), encouraging patenting activities in these technologies (OECD, 2011a). In addition, collaboration between private and public spheres is well developed. Innovation policy involves many public and private actors, notably through the development of innovation alliances to coordinate and support joint research. The share of government expenditure on R&D financed by industry was more than twice the OECD average (9.3% *vs.* 3.8%) and the same holds for higher education expenditure on R&D (15.1% *vs.* 6.4%).

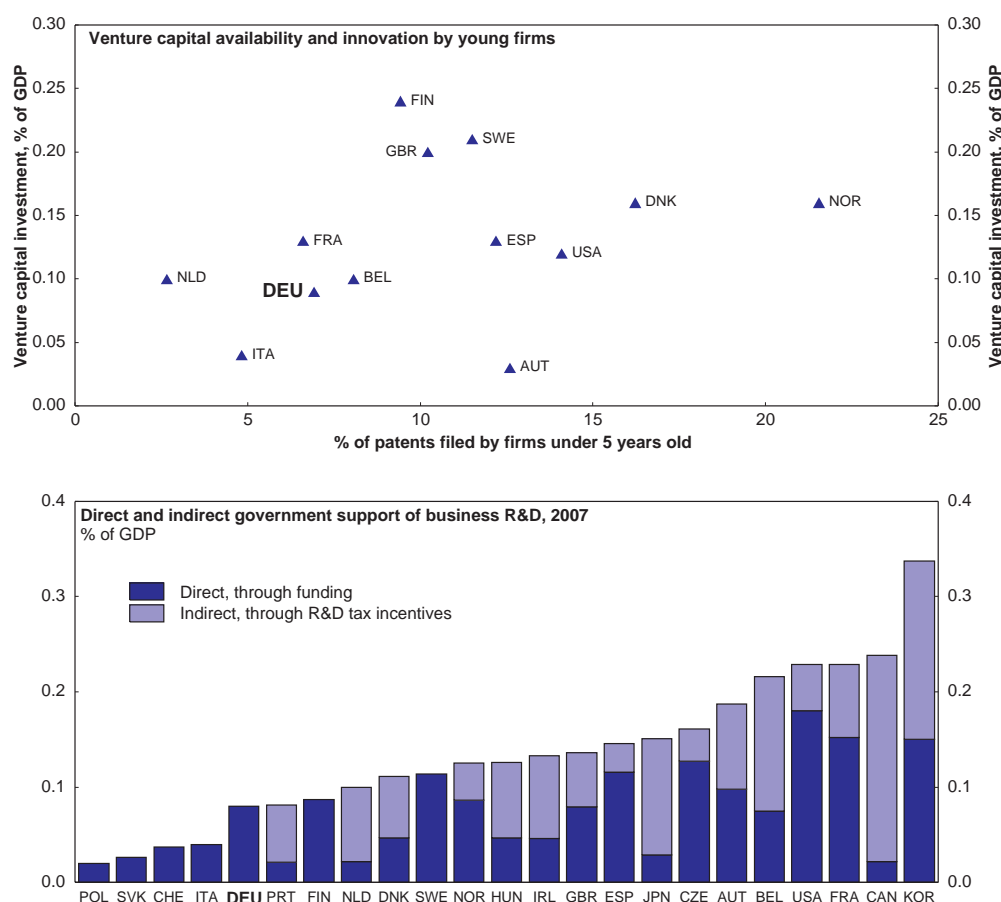
Innovation policy also includes measures to encourage the development, diffusion, and adoption of more mature technologies (*e.g.* zero emission buildings, efficient coal and gas fired power plants). For instance, the German Environmental Innovation Programme supports large scale demonstration projects in the heat and electricity sectors by providing soft loans. To improve the efficiency of these measures, coordination of support to eco-innovation intensified recently. In 2008, Germany established the Master Plan on Environmental Technologies (included in the Hi-Tech Strategy 2020) - a horizontal project aiming at fostering eco-innovation - providing targeted R&D public funding and developing partnerships between the academic and the business spheres in environmental areas. In addition, the government plans to increase its financial support to R&D in the coming years. The Cabinet recently adopted the 6th Energy Research Programme providing EUR 3.5 billion (0.1% of GDP) for energy research on the period 2011-14, a 75% increase compared to 2006-09. Maintaining a high level of public funding in R&D is welcome, not least because direct public support proved being efficient: national grants leads to higher innovation input and better outcomes (Czarnitzki and Lopes Bento, 2011). In addition, foreign competition on eco-innovation is developing, with most of OECD countries increasing their R&D budgets.

However, despite this strong public support to innovation and R&D, indicators for innovation performance show a decline in German's innovative outcomes over the past few years, with a decrease in the number of triadic patents per capita produced and in the share of innovative firms (OECD, 2010a).

11. The protection of intellectual property rights is within the OECD average (Park and Lippoldt, 2008). By ensuring inventors that their invention will not be used without compensation and guaranteeing they will get the full returns on their investment, the protection of property rights is a crucial factor for a high level of patenting activities.

Furthermore, innovation activities are concentrated in incumbents and large firms while SMEs and new firms are lagging behind. The share of patents filed by young firms is quite low compared to other innovative countries: only 7% of patents are filed by firms less than 5 years old, half of the US share and one third of Norway (OECD, 2010b). This is unfortunate as radical innovations are often performed by small firms.

As stressed in OECD (2010a), limited access to finance for start-ups is a major obstacle to innovative activities. As the return to investment in green technologies is highly uncertain, this barrier is likely to be even higher in environmental areas. Young high-tech firms in Germany are mainly financed with cash flows and own resources, as venture-capital financing is underdeveloped, in particular for the start-up phases (Commission of Experts for Research and Innovation, 2011). This is unfortunate as venture capital provides not only funds but also knowledge about the markets, entrepreneurial competences and networks of contacts supporting the creation and the development of start-ups. Cross-country evidence also suggests that the availability of venture capital is positively correlated with the patenting activity of young firms (Figure 9, upper panel). While some measures have been implemented recently, such as the Act on the *Modernization of Framework Conditions for Venture Capital and Equity Investments* (MoRaGK) in 2008 and the establishment of start-up funds (included in the High Tech Strategy), more needs to be done to mobilise venture capital in Germany. The government appropriately plans to improve the framework conditions for venture capital when implementing the EU Directive on Alternative Investment Fund Managers (AIFM) in national legislation. At this occasion, measures should be taken to reduce the strictness of the existing regulation, improve the transparency of the supervision system defined in the MoRaGK and provide venture capitalists with appropriate exit possibilities. In addition, Germany should consider accelerating the implementation of the AIFM Directive which is due until mid-2013.

Figure 9. Financing innovation: venture capital and government support of business R&D

Note: Venture capital investment is defined here as the sum of investments in "seed/start-up stages" and "early development and expansion stages" and refers to 2008. Patents filed refer to patent application filed under the Patent Co-operation Treaty in 2005-07. The R&D tax expenditures estimates do not cover sub-national R&D tax incentives. Austria estimate covers the refundable research premium but excludes other R&D allowances. The United States estimate covers the research tax credit but excludes the expensing of R&D. Data refers to 2008 for several countries

Source: OECD (2010b), *Measuring innovation*.

Access to finance could also be improved by introducing indirect R&D support through the tax system as is the case in many other OECD countries. Government R&D support currently relies on direct government subsidies and does not include tax incentives, contrary to the majority of the OECD countries (Figure 9, lower panel). While the outcome of indirect R&D support depends significantly on its design and on country specificities, empirical studies indicate that tax incentives have a positive and relatively higher impact on private innovation compared with direct funding (OECD, 2010a). Indeed, they may be more efficient than direct government support as they avoid "picking winners" and as there are deadweight losses related to the asymmetry of information on the market value of innovation. Implementing tax credits also tends to stimulate venture capital for young companies (Commission of Experts for Research and Innovation, 2011). It also tends to be more beneficial for smaller companies, as they have fewer resources to deal with the heavy administrative workload often related with applications for direct government support. Finally, tax incentives would make Germany more attractive as a location for research as most of other OECD countries already provide this support (Ernst and Spengel, 2011). Thus, consideration should be given to complementing the direct support with tax incentives. Particular attention should be given to

the design of such instrument to maximise the impact of the policy while minimizing deadweight losses. The features of the tax incentives - including the level, the form (*e.g.* tax deferrals, tax allowances or tax credits), the base (*e.g.* level or increment of R&D expenditures) and the coverage (*e.g.* total or partial with targeted support) - should be carefully determined in function of Germany's specific needs.¹² Only a very small percentage of green technology patents between 2000 and 2007 draw on environmental or energy R&D (OECD, 2011f). Tax incentives should thus not be targeted to environmental outcomes but rather encourage innovation on a broader base. Finally, as tax incentives tend to encourage mainly marketable innovations rather than projects with a high social value, Germany should maintain direct research funding, notably by using public tenders.

Finally, shortages of skilled workers risk undermining eco-innovation in the near future. Ageing combined with a low level of tertiary education attainment will create significant shortages on the labour market limiting the development of new activities while reducing Germany's attractiveness as an investment location (OECD, 2012). In addition, shortages of high-skilled workers reduce the innovative and absorptive capacity of the economy which significantly relies on the quality of human capital formation. Job creation in green technologies could also be limited by labour shortages as the development of green sectors necessitates skilled workers which are already lacking on the German labour market (Michaels and Murphy, 2009). Indeed, a green economy is high-skill-intensive: 30% of employees in green sectors are tertiary graduates compared to 20% in other sectors, suggesting the lack of tertiary graduates could limit the creation and diffusion of green technologies (BMU, 2009). Shortfalls in adequate labour force are already visible: compared to the EU average, German firms more frequently identify the lack of qualified personnel as a barrier to eco-innovation. A study from the Federal Environment Agency also shows that energy efficient renovations in the building sector are already hampered by lack of qualified workers (UBA, 2011c). Thus, in addition to reforms Germany should implement to address labour shortages and to improve the qualification level of the population, it should make sure sufficient training is provided to meet greening labour market needs.

12. An overview of issues to be considered when designing fiscal support for business R&D is available in OECD (2011j).

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