OECD Economics Department Working Papers No. 953

Climate Change Policies in Poland: Minimising Abatement Costs

Balázs Égert

https://dx.doi.org/10.1787/5k9b7bz18m0x-en

OECD

Unclassified **ECO/WKP(2012)30**

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

24-Apr-2012

English - Or. English

ECONOMICS DEPARTMENT

ECO/WKP(2012)30
Unclassified

CLIMATE CHANGE POLICIES IN POLAND – MINIMISING ABATEMENT COSTS

ECONOMICS DEPARTMENT WORKING PAPER No. 953

By
Balázs Égert

All OECD Economics Department Working Papers are available on the OECD Intranet website at: www.oecd.org/eco/workingpapers

JT03320430

English - Or. English

ABSTRACT/RÉSUMÉ

Climate change policies in Poland – minimising abatement costs

Poland is on track to meet its international greenhouse-gas emissions commitments. However, it will need to cut emissions significantly in the future, if the European Commission's proposal on the Low Carbon Roadmap is adopted. Policies should ensure that the country's substantial reduction potential, mainly linked to the energy sector's high emissions intensity, and implying overall abatement costs above the EU-average, is realised in a least-cost fashion by imposing an economy-wide single carbon price. This stands in contrast with current explicit and implicit carbon prices, which vary widely across different sectors of the economy. Crucial to least-cost abatement is also a high responsiveness to the EU-ETS carbon price signal. While Poland has made good progress in complying with EU regulations related to the energy sector, the large share of public ownership and the lack of effective separation between electricity producers and distributors may blur the price signal for investment decisions in generation capacity. The isolation of the Polish electricity market implies a need for more investment in low-emission technologies in Poland to achieve a given emissions-reduction target, whereas a deeper integration with neighbouring electricity markets would spread the burden more efficiently across countries. The cost-efficiency advantage of uniform support to renewables via green certificates should be retained to minimise abatement costs. Government policies aimed at a higher share of nuclear power and natural gas from shale formations need to take fully into account tail risks and the short- and long-term environmental costs of the use of the former and fully consider environmental risks related to extraction of the latter. Energy efficiency policies can help to address market failure but should not be allowed to distort relative carbon prices. This Working Paper relates to the 2012 *OECD Economic Review of Poland* (www.oecd.org/eco/surveys/Poland).

JEL classification codes: Q41, Q42, Q48, Q52, Q53, Q54, Q58, H23
Keywords: GHG emissions, global warming, carbon price, abatement cost, renewables, nuclear power, negative externalities, environmental policies

****

Politiques liées au changement climatique en Pologne – minimiser les coûts de réduction des émissions

La Pologne est en voie de tenir ses engagements internationaux en matière d'émissions de gaz à effet de serre. Elle devra toutefois réduire sensiblement ses émissions à l'avenir si la proposition de la Commission européenne concernant la Feuille de route pour une économie sobre en carbone est adoptée. Les politiques mises en œuvre devraient s'attacher à exploiter au moindre coût l'important potentiel de réduction des émissions du pays, principalement lié à la forte intensité d'émissions du secteur de l'énergie et qui implique des coûts globaux de réduction supérieurs à la moyenne de l'UE, en imposant un prix unique du carbone pour toute l'économie. Cet objectif contraste avec les prix explicites et implicites actuels du carbone, qui sont très variables selon les secteurs. Une forte sensibilité aux signaux de prix du carbone fournis par le SCEQE est également essentielle à la réduction des émissions au moindre coût. En dépit des progrès significatifs accomplis par la Pologne pour se conformer aux réglementations de l'UE dans le secteur énergétique, l'importance de l'actionnariat public et l'absence de séparation effective entre les producteurs et les distributeurs d'électricité peuvent brouiller le signal de prix pour les décisions d'investissement dans les capacités de production. L'isolement du marché polonais de l'électricité implique qu'il faudra procéder à de plus lourds investissements dans les technologies sobres en émissions pour atteindre un objectif donné de réduction des émissions, alors qu'une intégration plus poussée avec les marchés de l'électricité des pays voisins permettrait un partage plus efficient des coûts entre les différents pays. Il faudrait maintenir l'avantage coût-efficacité du système de soutien uniforme aux énergies renouvelables sous forme de certificats verts en vue de minimiser les coûts de réduction des émissions. Les politiques publiques destinées à accroître la part de l'énergie nucléaire et du gaz naturel à partir des gisements de schiste doivent tenir pleinement compte des risques d'événements extrêmes et des coûts environnementaux à court et long termes de l'utilisation du nucléaire, et intégrer pleinement les risques environnementaux potentiels induits par l'extraction des schistes bitumineux. Les politiques axées sur l'efficacité énergétique peuvent contribuer à remédier aux défaillances du marché, mais elles ne devraient pas aller jusqu'à fausser les prix relatifs du carbone. Ce Document de travail se rapporte à l'*Étude économique de l'OCDE de la Pologne 2012* (www.oecd.org/eco/etudes/Pologne).

Classification JEL : Q41, Q42, Q48, Q52, Q53, Q54, Q58, H23
Mots-clés : émissions de GES, réchauffement climatique, coût d'abattement, énergies renouvelables, énergie nucléaire, externalités négatives, politiques environnementales

Table of contents

Climate change policies in Poland – minimising abatement costs ... 5

A large GHG-emissions reduction due to economic transformation followed by relative stability ... 5
Poland's large emissions-reduction potential should be realised at least cost via a single carbon price ... 6
But explicit and implicit carbon prices vary widely in Poland ... 8
Raising the responsiveness to the EU-ETS carbon price signal in order to minimise abatement costs ... 11
A cost-efficient support scheme for renewables in electricity generation is desirable in the long run ... 15
Electricity mix within the EU-ETS and the scope for direct government intervention ... 20
The role of renewable sources outside electricity production ... 25
Improving energy-efficiency policies ... 28
Towards a more efficient organisation of the transport sector ... 31

Bibliography ... 36

Appendix ... 40

Boxes

1. The impact of the EU-ETS on Poland's competitiveness ... 14
2. Recommendations pertaining to climate-change policies ... 35

Tables

1. Per capita GHG emissions and their decomposition, 2009 ... 7
2. GHG emissions – sectoral indicators, 1990-2009 ... 8
3. Countries with a direct carbon tax in 2011 ... 9
4. Implicit carbon prices based on excise taxes ... 10
5. The power sector, 2008 ... 12
6. GHG abatement costs implied by indirect support schemes (feed-in tariffs, green certificates), 2011 ... 16
7. Overview of measures used to promote renewable energy ... 18
8. Country-specific abatement costs ... 22
9. Poland's renewable energy targets by sectors ... 26
10. White certificate systems in Europe ... 30
11. CO_2-based car taxes in Europe, 2010 ... 34

Figures

1. Changes in GHG emissions, 1990-2009 ... 6
2. Percentage change in non-EU-ETS GHG emissions relative to the 2020 country-specific target ... 6

3. Changes in Poland's GHG emissions implied by the European Commission's proposal on the *Low Carbon Roadmap 2050* and by government projections 8
4. The implied carbon price in automotive excise taxes accounting for local negative externalities. 10
5. Electricity openness as an indicator of electricity market integration and interconnections 13
6. Pre-tax electricity prices for industrial users in the EU 14
7. The share of renewables in gross electricity production, 2009 15
8. Administrative and grid-access lead times for wind energy in Europe, 2008 19
9. Primary energy demand and net electricity generation in 2006 and 2030, by type of energy........ 20
10. Carbon intensity of electricity production, 2008 21
11. Comparison of district heating (DH) systems in Europe, 2009 27
12. Losses in the power sector, 2009 30
13. Passenger cars per 1 000 inhabitants, 1991-2009 32
14. Average CO_2 emissions per km travelled from new passenger cars in Europe 32

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Climate change policies in Poland – minimising abatement costs

By

Balázs Égert[1]

A large GHG-emissions reduction due to economic transformation followed by relative stability

Poland has reduced its greenhouse-gas (GHG) emissions substantially since its economic transformation started in 1990 and is on track to meet its international and European commitments. As elsewhere in Central and Eastern Europe, the economic collapse of the former Soviet bloc resulted in a considerable drop in domestic and foreign demand for the country's very energy- and carbon-intensive products. As a result of the structural shift towards less energy-intensive sectors, the country's overall GHG emissions fell by around 20% between 1988, the Kyoto base year, and 1994. Despite the economic catch-up that has subsequently taken place, a further decrease of more than 10% had occurred by 1999, reflecting mainly investment in more energy-efficient technologies. Since the early 2000s, annual GHG emissions have remained broadly stable, abstracting from cyclical movements. To date, in managing to cut its total GHG emissions by more than 30% between 1988 and 2009, Poland looks set to go well beyond its Kyoto commitment of a 6% reduction between 1988 and the average of 2008-12 (Figure 1). It is also on track to meet the EU 2020 target for the sectors not included in the European Union's Emissions Trading System (EU-ETS), primarily the residential, transport and agriculture sectors. The EU-wide goal of cutting emissions by 20% from 1990 levels by 2020 translates into a national target for Poland's non-EU-ETS sectors of a 14% increase by 2020 compared to 2005, whereas emissions actually declined slightly between 2005 and 2009 (Figure 2). Given the country's 8% share in total EU27 GHG emissions, Poland's compliance with the 2020 non-ETS target is an important factor of the EU's ability to meet that objective.

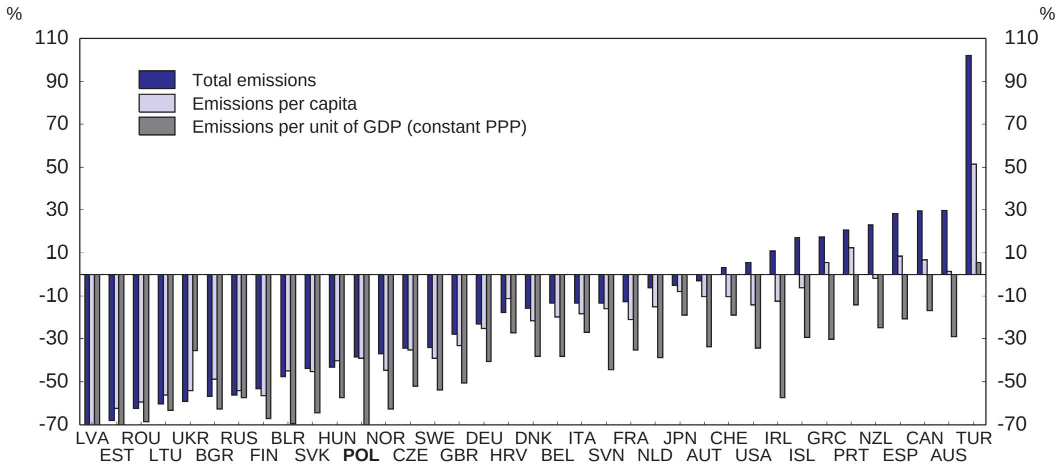
Poland does not have any direct climate-change policy. The country's energy policy strategy, outlined in *Energy Policy of Poland until 2030* (Ministry of Economy, 2009), is mostly focused on improving energy security, efficiency and competitiveness, and implies a small reduction in overall GHG emissions by 2020 and then a 4% increase between 2020 and 2030. Poland will have to develop an explicit climate-change policy to contribute more substantially to the overall long-term EU effort. Indeed, the government is in the process of formulating a national plan for reducing GHG emissions, the National Programme for a Low-Emission Economy, which it expects to finalise and adopt in 2013. The European Council, that is EU member countries, decided in early 2011 on a 80-95% GHG emissions reduction objective by 2050 (European Council, 2011). The European Commission's proposal on the *Low Carbon Roadmap 2050* is currently being discussed by EU Member States (European Commission, 2011a). The EU-wide GHG emissions reduction of 80-95% by 2050 would facilitate the worldwide 50% GHG reduction that would help keep global warming below 2 degrees Celsius. Evidently, the EU's ambitious

---

1. OECD Economics Department, email: balazs.egert@oecd.org. This paper was produced for the OECD *Economic Survey of Poland* published in March 2012 under the authority of the Economic and Development Review Committee. The author thanks Hervé Boulhol, Nils-Axel Braathen, Andrew Dean, Jane Ellis, Robert Ford, Jens Hoj, Tomasz, Koźluk, Peter Jarrett, Artur Radziwiłł, Douglas Sutherland, Stefaan Vergote, Georg Zachmann and Polish government officials for their constructive/critical comments on earlier versions of this paper. The author also thank Patrizio Sicari and Mee-Lan Frank for research assistance and excellent technical preparation.

target only makes sense if other large emitters join the world-wide effort, given the global nature of the negative externalities of GHG emissions.

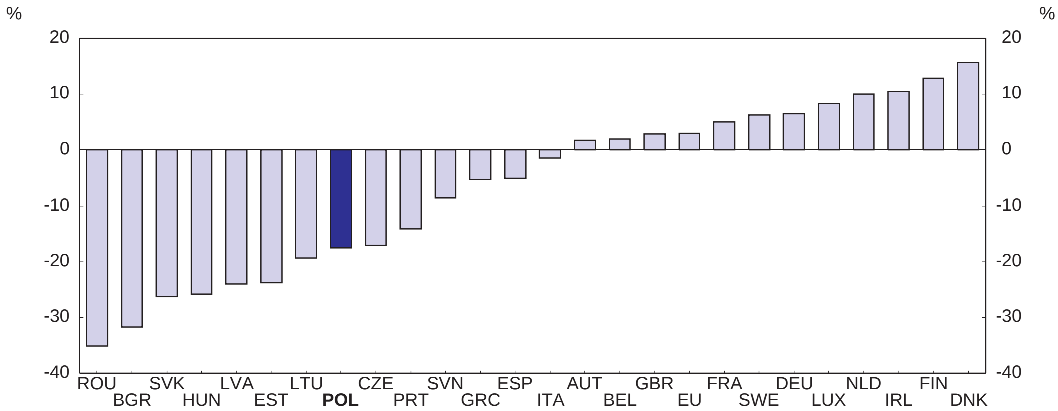
Figure 1. **Changes in GHG emissions, 1990-2009**



Source: OECD calculations based on data from UNFCCC.

Figure 2. **Percentage change in non-EU-ETS GHG emissions relative to the 2020 country-specific target**

Outcome minus target, between 2005 and 2009



Source: OECD calculations based on data from the European Commission (http://ec.europa.eu/europe2020/pdf/overview_of_member_states_national_targets.pdf).

Poland's large emissions-reduction potential should be realised at least cost via a single carbon price

The usual justification for allowing developing countries to cut GHG emissions less than their mature industrialised counterparts is based on equity considerations: they tend to emit less GHGs on a per capita basis and, as real convergence progresses, they should be allowed to move towards the per capita emissions levels of their more affluent counterparts. Within the EU, however, this argument does not seem to hold for Poland, as its per capita emissions are higher than in 11 other EU member countries with higher per capita income. Per capita energy-related emissions can be decomposed into: *i*) the carbon intensity of energy production; *ii*) the energy intensity of a unit of GDP; and *iii*) per capita GDP (Table 1):

$$GHG^{EN}/CAP = GHG^{EN}/EN*EN/GDP*GDP/CAP$$

Poland's high per capita emissions are due to the predominance of fossil fuel combustion, in particular in electricity and heat production. In 2009, only Finland, Greece, the Czech Republic and Estonia recorded higher per capita emissions in heat production.

Table 1. **Per capita GHG emissions and their decomposition, 2009**

	GHG (tCO^2-eq) per capita for specific sectors				Energy sector		Electricity and heat prod (E&H)		GDP
	Total	Non-energy	Energy	E&H	GHG/Energy production	Energy prod/GDP	GHG/E&H production	E&H prod/GDP	Per capita GDP (1 000 EUR)
Sweden	6.4	1.7	4.8	0.9	1 545	0.10	509	0.05	32
Hungary	6.7	1.7	5.0	1.5	4 646	0.06	3 412	0.03	17
Slovakia	8.0	2.7	5.3	1.2	4 880	0.06	1 886	0.03	19
Italy	8.2	1.4	6.8	1.6	15 759	0.02	3 395	0.02	27
France	8.3	2.5	5.8	0.7	2 831	0.07	893	0.03	30
United Kingdom	9.2	1.4	7.8	2.5	3 037	0.08	4 579	0.02	32
Japan	9.5	0.9	8.6	2.8	11 776	0.02	3 970	0.02	30
Poland	**9.9**	**1.8**	**8.1**	**4.2**	**4 600**	**0.10**	**7 842**	**0.03**	**17**
Germany	11.2	1.9	9.3	3.8	5 926	0.05	4 957	0.02	32
Germany	11.2	1.9	9.3	3.8	5 926	0.05	4 957	0.02	32
Estonia	12.6	1.8	10.7	7.7	3 412	0.20	6 829	0.07	16
Czech Rep.	12.7	2.2	10.5	5.5	3 487	0.14	5 763	0.04	22
Canada	20.5	3.7	16.8	2.9	1 478	0.33	1 802	0.05	35
United States	21.5	2.8	18.7	7.1	3 405	0.13	5 843	0.03	42

Note: The energy production-to-GDP ratio is multiplied by 1 000 to fit in the table. E&H denotes Electricity and Heating. See Appendix for a more extensive country coverage.

Source: OECD calculations based on data obtained from UNFCCC.

It is also interesting to compare Poland with its Central and Eastern European peers with similar GHG emissions levels (the Czech Republic and Estonia) and with lower emissions (Hungary and Latvia) and with one of the more developed countries at the cutting edge (Sweden). Poland's per capita emissions are especially high in the residential sector, three to four times higher than in Estonia and Latvia and nine times higher than in Sweden (Table 2). The reason for these differences is a radical shift in Sweden from heating oil to district heating based on biomass, triggered by an increase in energy and CO_2 taxes (OECD, 2011a) and the heavy reliance on biomass in Estonia and Latvia. Per capita fugitive emissions from fuels and industrial processes in Poland are also above the levels observed in most other countries. This is mostly related to coal mining and the transportation and handling of oil and natural gas. By contrast, per capita emissions due to the commercial sector and agriculture are comparable in Poland to levels seen elsewhere. Emissions from waste and transportation are particularly low. Offsets from land use, land use change and forestry (LULUCF) are important, one tonne per habitant, even though well below levels recorded in the Baltic countries and Sweden.

Calculations carried out by McKinsey (2009) and the World Bank (2011) show that an emissions reduction of 40% by 2030 compared to the 1990 level can be achieved in Poland. Such a cut would be consistent with the path of the European Commission's *Low Carbon Roadmap 2050* (Figure 3). The average unitary abatement cost consistent with a 40% GHG emissions reduction is roughly EUR 10 (in 2005 prices) for each tonne of CO_2 avoided and the marginal abatements costs to go beyond a cut of 50% is estimated at about EUR 70 per tonne. Historical CO_2 prices of about EUR 10 to 20 in the EU-ETS would need to rise above EUR 70 (in constant prices) if Poland wanted to further cut emissions efficiently in the non-ETS sectors. At the same time, according to World Bank (2011) estimates, the overall abatement costs of an emissions reduction of about 40% by 2030 would peak in 2020, when the level of real GDP would be 1.8 to 3.1 percentage points below that of the baseline scenario. But the cost would decrease to about 0.7 percentage point by 2030. Overall abatement costs are found to be about two to three times higher for Poland than for the EU average. The World Bank report also shows that off-shoring GHG emissions reduction outside the EU, based on a very flexible clean development mechanism (CDM), would cut costs by a factor of four both for Poland and the EU as a whole.

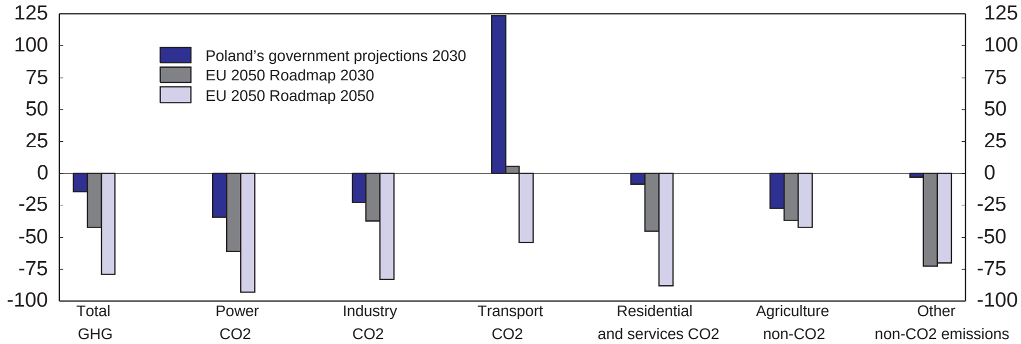
Table 2. **GHG emissions – sectoral indicators, 1990-2009**

	Shares, 2009						Per cent changes, 1990-2009						GHG (tCO_2-eq) per capita, 2009					
	POL	HUN	CZE	EST	LAT	SWE	**POL**	HUN	CZE	EST	LAT	SWE	**POL**	HUN	CZE	EST	LAT	SWE
1. Energy eq.	**82**	75	83	86	67	74	**-17**	-28	-30	-60	-62	-16	**8.1**	5.0	10.5	10.7	3.2	4.8
Energy	**44**	24	44	64	18	17	**-27**	-26	2	-62	-70	5	**4.4**	1.6	5.6	8.0	0.8	1.1
Manufacturing	**8**	8	12	4	8	15	**-30**	-62	-66	-73	-76	-29	**0.8**	0.5	1.5	0.5	0.4	0.9
Transport sector	**12**	19	14	13	26	34	**76**	55	140	-13	-7	7	**1.2**	1.3	1.8	1.6	1.2	2.2
Commercial sector	**2**	6	2	0.5	5	1	**-29**	-6	-67	69	-82	-74	**0.2**	0.4	0.3	0.1	0.2	0.1
Residential sector	**9**	13	6	1	6	2	**-2**	-45	-66	-84	-51	-80	**0.9**	0.9	0.7	0.2	0.3	0.1
Agriculture sector	**2**	2	0.2	1	3	3	**37**	-67	-91	-61	-78	10	**0.2**	0.1	0.0	0.2	0.2	0.2
Fugitive emissions from fuels	**3**	3	4	2	1	2	**-27**	-8	-45	-58	-62	186	**0.3**	0.2	0.4	0.3	0.0	0.1
2. Industrial processes	**6**	6	8	3	3	8	**4**	-53	-43	-57	-40	-20	**0.6**	0.4	1.1	0.3	0.2	0.5
3. Solvents	**0.2**	1	0.4	0.1	0.3	0.5	**18**	50	-34	-17	-46	-11	**0.0**	0.0	0.0	0.0	0.0	0.0
4 .Agriculture	**9**	12	6	8	21	14	**-29**	-43	-51	-57	-62	-11	**0.9**	0.8	0.8	1.0	1.0	0.9
5. LULUCF	**-10**	-5	-5	-42	-191	-69	**85**	55	89	-32	35	-7	**-1.0**	-0.3	-0.7	-5.2	-9.1	-4.5
6. Waste	**2**	6	3	4	8	3	**-8**	13	31	-16	0	-43	**0.2**	0.4	0.3	0.5	0.4	0.2

Source: OECD calculations based on data obtained from UNFCCC.

Figure 3. **Changes in Poland's emissions implied by the European Commission's proposal on the *Low Carbon Roadmap 2050* and by government projections[1]**

Percentage changes compared to 1990



1. Government projections show outcomes based on current and new policies.

Source: Polish Government (2011), "Projections of greenhouse gas emissions and removals up to 2030"; European Commission (2011), A roadmap for moving to a competitive low carbon economy in 2050, Brussels, 8.3.2011, COM(2011) 112 final; UNFCCC.

Governments can impose a single carbon price to fully internalise the external costs of GHG emissions either by imposing a tax or setting up a permit trading system. Ideally, to minimise the total abatement cost, a single carbon price should be applied across all countries and sectors to reduce GHG emissions where it is the cheapest to do so, especially if marginal abatement costs are different in some countries or sectors (OECD, 2006). If the carbon price were to differ across sectors, the same amount of emissions reduction would be achieved only at a higher cost, because some high-cost abatement measures will substitute for minimum-cost options.

But explicit and implicit carbon prices vary widely in Poland

A carbon price is already imposed in Poland via multiple channels. First, the Polish power and heavy energy-using industries are covered by the EU-ETS. Second, Poland is one of the few countries to have an explicit carbon tax, even though it is only symbolic at EUR 0.065/tonne of CO_2 for industrial sectors outside the EU-ETS (Table 3). Finally, a range of excise taxes are levied on fossil energy products. However, natural gas used as a heating fuel, liquefied natural gas (LNG), heavy industrial oil for agricultural use and for electricity and heat generation are not taxed. In 2012, Poland introduced a tax on coal used outside the EU-ETS. Yet it is very limited in both size and coverage, because it applies only to companies' own heat production but not to household heating. The exemption for electricity and heat generation is justified by the inclusion of this sector in the EU-ETS. Table 4 shows the carbon prices implied by the excise tax, which vary significantly across different fossil-energy products. For example, the implicit carbon price derived from the excise tax in 2010 amounted to EUR 187 for petrol and to EUR 120 for automotive diesel, but the distortions are even larger between automotive fuel and other fossil energy products. Imposing a single carbon price may eventually increase the price of many fossil fuels. A well targeted direct lump-sum (cash) compensation, financed by a higher effective carbon price, would be needed to offset the adverse effects of higher energy prices on poor households.

Table 3. **Countries with a direct carbon tax in 2011**

Country	Name	Year of introduction/ year of last revision	EUR/tonne CO_2	Coverage
Canada (British Columbia)	Carbon tax	2008/2009	CAD 15 (≈ EUR 11)	Exemptions are: bio-fuels, ethanol and fuel for civil aviation
Denmark	Duty on CO_2	1998/2010	≈ EUR 30	
Finland	CO_2 tax	1990	EUR 10 – 35	
Finland	Charge on exceeding GHG emission limits	2004	EUR 100 000	
Poland	**Tax on air pollutants, tax base for CO_2**	**1990/2001**	**EUR 0.065**	**Industries not covered by the EU-ETS**
Slovenia	CO_2 tax	1997/2011	EUR 10-20	Automobile fuels exempted
Sweden	Energy and CO_2 tax on petrol	2010	EUR 250	This is a straight excise tax
Switzerland	CO_2 levy on heating and process fuel	2008/2010	CHF 36 (≈ EUR 30)	

Source: OECD/European Environment Agency, Economic Instruments Database, http://www2.oecd.org/ecoinst/queries/index.htm

The carbon prices for automobile fuels shown in Table 4 are biased upward, since part of the taxes can be ascribed to negative local externalities, which are not taken into account in the calculations.[2] When considering the costs of local negative externalities, the implied carbon price for automotive fuels decreases significantly, and the relative distortion in favour of diesel increases as the local external costs of burning diesel are higher than for petrol.[3] Accounting for differences in local input prices and the valuation of human life, which are important parts of the costs of local pollution, results in a higher implicit carbon price for diesel in Poland than in other more developed OECD countries, although still much lower than that for petrol (Figure 4).

2. Burning fossil energy releases particulate matter, nitrogen oxides, sulphur dioxide, ozone and volatile organic compounds into the atmosphere, damaging human health, degrading buildings and resulting in agricultural crop losses and harm to biodiversity and ecosystems through soil and water pollution. Further negative externalities include noise pollution, accidents not covered by private insurance and bottleneck and flow congestions resulting from the use of vehicles. Nevertheless, excise taxes might not be the most efficient way to deal with congestion, which could be taken care of more efficiently by road/congestion pricing. The total costs of local negative externalities vary a great deal depending on population density and time of day but also on the type of fuel used (diesel *versus* petrol) and the vehicle emission standard applied (Euro 1 *versus* Euro 5).

3. Environmental taxes are mainly aimed at correcting negative externalities. Using them beyond the level that would correct those externalities to raise tax revenues creates more distortion than an increase in a broad-based VAT.

Table 4. **Implicit carbon prices based on excise taxes**

EUR/tonne, 2010:q4

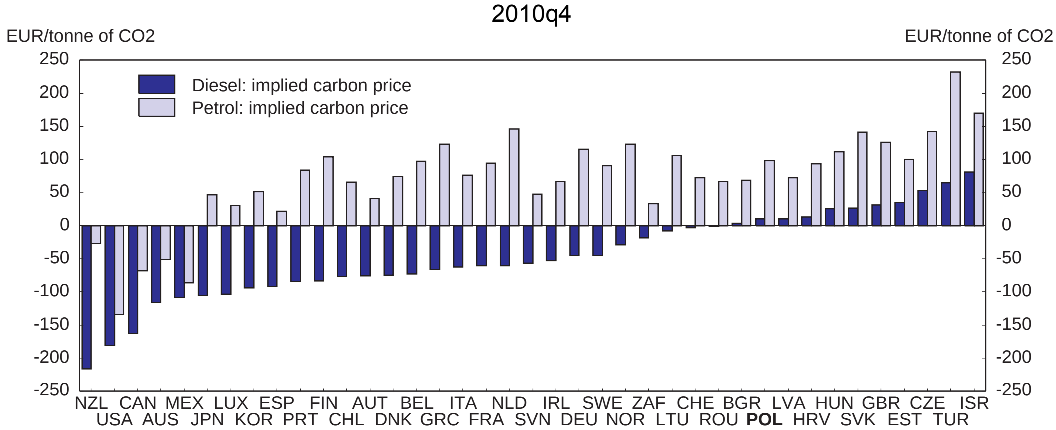
	Petrol	Diesel	Diesel/ Petrol	LPG	Natural gas		Electricity		Light fuel oil		Coal
					HH	IND	HH	IND	HH	IND	
United Kingdom	302	251	0.83		0	2	0	6	48	48	2
Germany	292	174	0.60	54	-	-	133	-	23	23	0
France	271	159	0.59	35	6	8	156	100	21	21	0
Sweden	267	174	0.65		130	39	1937	36	153	25	-
Italy	252	157	0.62	74	-	-	72	98	149	149	0
Czech Republic	231	164	0.71	51	0	7	2	2	10	10	2
Slovak Republic	230	136	0.59	0	0	7	0	0	-	0	-
Japan	223	113	0.51	51	-	0	8	8	7	7	2
Hungary	200	135	0.68	55	0	5	0	3	-	-	0
Estonia	189	146	0.77	41	12	9	14	13	41	41	-
Poland	**187**	**120**	**0.64**	**68**	**0**	**0**	**6**	**6**	**22**	**22**	**0**
Canada	106	55	0.52	-	0	0	-	-	13	8	-
United States	40	37	0.92		-	-	-	-	-	-	0
Mexico	0	0	-		0	0	0	0	0	0	0

Note: The implied carbon price is computed as the amount of the tax levied per litre times the amount (litres) of fuel that needs to be burnt to reach a CO_2 emission of one tonne of CO_2eq. One litre of diesel (light fuel oil for households and industry), petrol and LPG (liquefied petroleum gas) is assumed to produce respectively 2.7, 2.24 and 1.7 kg of CO_2. It is assumed that 4 535 269 kcal of natural gas generates 1 tonne of CO_2 and that burning 1 kg of coal generates 2.93 kg of CO_2. HH and IND refer to households and industry, respectively. See Appendix for a more extensive country coverage.

Source: OECD calculations based on data obtained from International Energy Agency (2011), *Energy Prices and Taxes*, Paris.

Figure 4**. The implied carbon price in automotive excise taxes accounting for local negative externalities**[1]

2010q4



1. The implicit carbon tax is obtained by using the same methodology as in Table 4; the basis of the calculation is the excise tax from which two sets of the external costs of negative local externalities are subtracted.

Source: OECD calculations.

Overall, Poland, as with most OECD countries, is a far cry from having a unique carbon price. Low carbon prices for any fossil energy products are tantamount to direct subsidies that result in overconsumption of those sources of energy (Metcalf, 2009). The differences in implied carbon prices should be gradually decreased by eliminating existing tax exemptions, by increasing the implied carbon price on underpriced products and the near-zero carbon tax to the carbon price prevailing in the EU-ETS, which is exogenous for Poland, and by correcting the distorted relative price of diesel versus petrol. When adjusting relative carbon prices policymakers should of course consider the external costs of local pollution. A uniform carbon tax levied on top of existing taxes would not satisfy this goal as tax adjustments should explicitly account for local negative externalities. A simulation exercise (details of which are available upon request), using a very simple model calibrated to reflect the features of the Polish economy, shows that, abstracting from investment decisions and labour-market outcomes, a single carbon price would achieve GHG-emissions reduction of between 10 and 20% at a cost that is 0.2 to 0.7 percentage points of GDP lower than various alternative scenarios involving heterogeneous carbon prices. With a more ambitious reduction objective the savings might even be more than proportionally larger.

Raising the responsiveness to the EU-ETS carbon price signal in order to minimise abatement costs

The EU-ETS is the backbone of the European GHG emissions–reduction programme. The Europe-wide 20% decrease by 2020 requires a cut of 21% between 2005 and 2020 and the European Commission's proposal on the *Low Carbon Roadmap 2050*, which aims at a 80 to 95% reduction by 2050, implies almost zero emissions in the industries currently covered by the European cap-and-trade system. Such a system makes it possible to target directly (multi-annual) GHG emissions, the total amount of which corresponds to the desired quantitative emissions target at the relevant horizon. Firms can then buy or sell permits depending on whether their actual GHG emissions are higher or lower than the emissions limit given by their permits. This ensures that companies that can cut emissions at a lower cost than the permit price will sell their emissions permits to companies facing marginal abatement costs that exceed the price.

While the EU-ETS would ideally take care of changes in the electricity mix to generate required cuts in GHG emissions, in practice a number of practical barriers exist preventing the electricity mix from being endogenously determined in an optimal fashion, thereby increasing abatement costs. They include preponderant state ownership and the lack of competition in electricity generation, an underdeveloped organised wholesale electricity market (power exchange) and the vertical integration of electricity producers and distributors. In Poland, it is all the more important to increase responsiveness of investment decisions in generation capacity to the carbon price signal, since nearly half of base-load coal-fired generation capacity will have to be retired by 2030 by tranches of about 10% every five years, and another 10% of installed capacity will have to undergo deep modernisation between 2011 and 2015 (Ministry of Economy, 2009).

Reducing public ownership while ensuring competition in electricity generation

State-owned firms dominate electricity generation in many countries. In such cases investment decisions as to generation capacity are probably especially heavily influenced by political considerations. In Poland, the Treasury has a controlling stake in three major electricity producers covering roughly 50% of Poland's electricity production and a minority stake in a fourth company accounting for another 15%. The State's political role in investment decisions should be minimised and special care taken to ensure a high degree of competition, which is crucial for the long-term efficiency and stability of the system. The market for generation capacity and electricity production is among the least concentrated in Europe, measured by the Herfindahl-Hirschmann index (HHI), with only Great Britain, Norway and the Netherlands having lower HHIs in 2009 (European Commission, 2011). However, concentration relative to other competitive industries is nonetheless high (Energy Regulatory Office, 2011a). Increasing competition would render the sector more responsive to the carbon price signal.

Ownership of electricity generation should be unbundled from distribution

Poland has gone a long way in legally unbundling vertically integrated companies in the energy sector, as required by the EU (Table 5). But legal separation is not sufficient, the bulk of the bilateral contracts having been concluded within holding companies. In 2010, bilateral contracts between electricity producers and distributors belonging to the same holding company absorbed more than 70% of electricity, and another 20% was sold on the OTC market between groups (Energy Regulatory Office, 2011a). Even if investment decisions in generation capacity are private, they are limited by the size of the distribution grid (for small-scale plants). With electricity generation and distribution belonging to the same owner, distributors may tend to favour their own electricity production over that of independent producers. Separating the ownership of electricity production from distribution is a straightforward way to cut short not only any such potential bias but also incentives for within-company bilateral contracts and to shift sales to the spot market.

Table 5. **The power sector, 2008**

	Power exchange	Unbundling					
		Distribution system operators			Transmission system operators		
	Spot traded volume[1]	Total number	Ownership unbundled	Legally unbundled	Total number	Ownership unbundled	% of public ownership
Austria	7.8	129	0	11	3	0	76.5
Belgium	12.1	26	11	26	1	0	35.6
Czech Republic	3.8	3	0	3	1	1	100.0
Denmark	91.1	84	0	84	1	1	100.0
Estonia	n.a.	38	n.a.	1	1	0	100.0
Finland	54.3	88	1	50	1	1	12.0
France	10.8	148	0	5	1	0	84.8
Germany	25.2	866	0	171	4	2	0.0
Great Britain	3.3	19	10	9	1	1	0.0
Greece	106.9	1	0	0	1	0	51.0
Hungary	n.a.	6	0	6	1	0	0.0
Ireland	128.9	1	0	1	1	1	100.0
Italy	66.5	144	121	11	9	1	30.0
Netherlands	24.8	8	6	8	1	1	100.0
Norway	230.6	152	7	38	1	1	100.0
Poland[2]	**15.0**	**22**	**0**	**7**	**1**	**1**	**100.0**
Portugal	81.3	13	10	11	3	1	51.0
Slovakia	5.1	3	0	3	1	1	100.0
Slovenia	n.a.	1	0	1	1	1	100.0
Spain	88.7	351	0	351	1	1	20.0
Sweden	80.0	170	0	170	1	1	100.0

1. As a share of electricity consumption.
2. 2011, preliminary rough estimate for spot traded volume.

Source: European Commission (2011b); Energy Regulatory Office (2011a).

But ownership separation becomes somewhat artificial if both the producer and distributor companies remain under the supervision of the state. Consequently, ownership separation for electricity generation and distribution also requires the privatisation of at least one of the companies. But the privatisation of both companies is necessary if a similar approach is applied to the ownership separation of the transmission network from generation and distribution. In Poland, the Treasury is a 100% owner of the transmission system operator.

The role of the organised wholesale electricity market (power exchange) should be enhanced

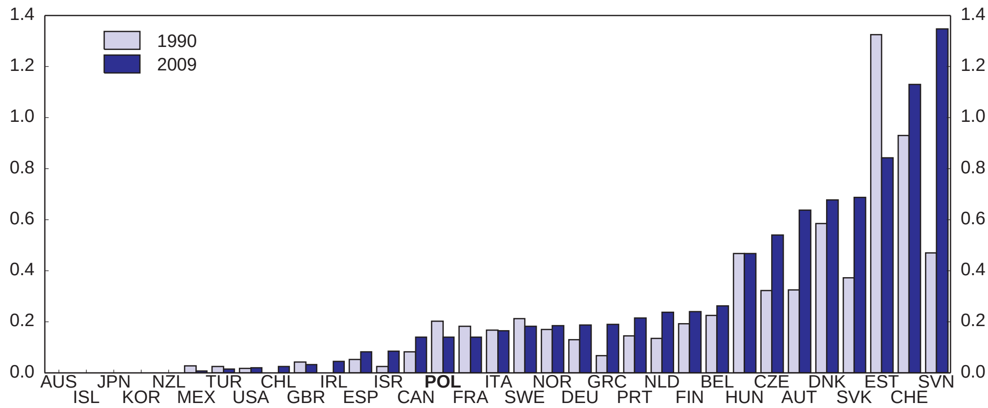
Well designed privatisation and effective vertical separation of electricity producers will result in an increased role of the power exchange. In fact, the volume of electricity traded on the power exchange as a share of domestic electricity consumption is small. In 2010, only about 5% of electricity production transited through the power exchange (Energy Regulatory Office, 2011a). As a result of the Energy Law of 2010, which imposed the obligation on electricity producers to sell at least 15% of their production on the power exchange, the spot traded volume started to increase in 2011. Preliminary estimates suggest that spot traded volumes as a percentage of production reached about 15% in 2011. In many European countries including Denmark, Greece, Ireland, Portugal, Spain and Sweden, spot traded volumes were close to 100% of domestic electricity consumption (Table 5).

The Polish electricity market should be better integrated with neighbouring markets

If European energy markets were to be fully liberalised and integrated, in the short run the spot wholesale price of electricity (excluding transmission and distribution costs) would correspond to the cost of the marginal unit, the highest price in the market, *i.e.* close to today's price of electricity produced in Poland. In such a case, all over Europe the high profit rates would incentivise the deployment of generation capacities that would produce electricity at lower costs because of their lower carbon content. These new technologies would in turn crowd out old and carbon-intensive coal-fired power plants and eventually decrease the market price.

Nevertheless, the Polish market is rather isolated and electricity trade with its neighbours is asymmetric due to interconnection bottlenecks (Figure 5). For instance, in 2009, Poland imported 4% and 1% of its electricity production from Germany and Sweden, respectively, while electricity exports to these countries were close to zero. At the same time, exports to the Slovak and Czech Republics amounted to 2% and 5% of output, respectively, with no reverse flows. But even if the country's electricity openness were greater, the impact on the wholesale market would be modest because of the limited role of the Polish power exchange, as mentioned above. Consequently, auctioning emissions permits to Polish energy producers will increase electricity prices only in Poland, and the price signal will allow low-cost abatement only in Poland and not in Europe more broadly. From a general cost-effectiveness point of view, this is a good approach because emissions will be reduced where it is the cheapest to do so, that is in Poland (with its highly emissions-intensive generation). But the overall implications of a closed Polish electricity market are that initial EU-wide GHG reductions will occur in Poland and that this will cost Poland more in investment as a share of GDP than other countries. At the same time, changes in energy prices may penalise the Polish economy compared to its European competitors (Box 1).

Figure 5. **Electricity openness as an indicator of electricity market integration and interconnections**[1]



1. Electricity openness is calculated as the ratio of electricity imports plus exports over electricity consumption.

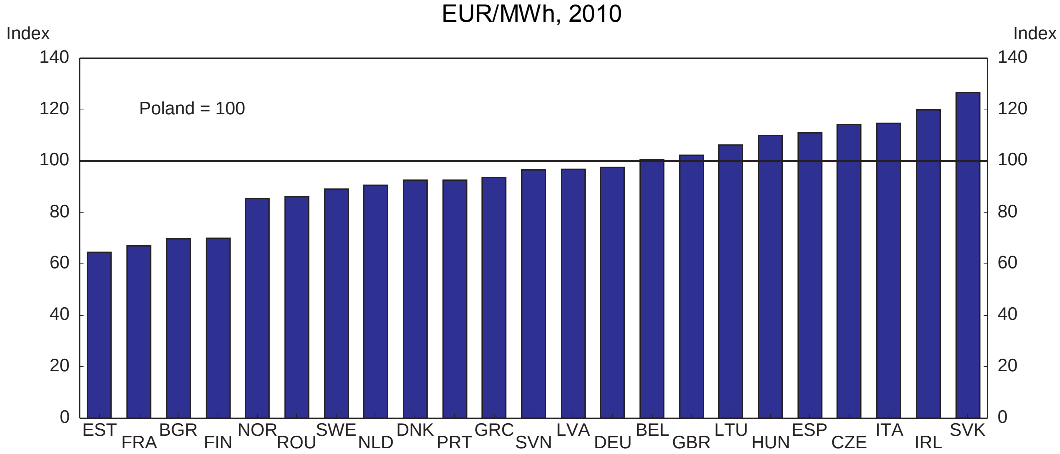
Source: OECD calculations based on IEA data.

Box 1. **The impact of the EU-ETS on Poland's competitiveness**

The Polish government fears that the third phase of the EU-ETS, which will last from 2013 to 2020 and during which the number of permits will be decreased by 1.75% per year, will penalise Poland's competitiveness via higher energy and electricity prices. The main change in the third phase is that 50% of emissions permits will no longer be given away for free but will be sold at auction to the power and heating sectors and other participating industries. The European Commission proposed the establishment of emissions benchmarks: permits will be allocated for free corresponding to the emissions of the benchmark technology, and permits to cover emissions in excess of the benchmark will have to be purchased. The fact that natural gas is being proposed as the technological benchmark for power generation implies that Poland will pay for the largest share of the permits, since electricity produced in Poland is the most carbon-intensive in the EU-27. This would be translated into a greater rise in Polish energy prices than elsewhere. A carbon price of 40 euros/tonne is estimated to generate a price increase of 35-50% (3 to 4 euro cents/kWh) for coal-fired plants (Mott MacDonald, 2010; Polish News Bulletin, 2011g). But these concerns may be exaggerated: Figure 6 below shows that the final price of electricity for industrial users is 10% to 25% higher in Poland's main CEE competitors (Czech and Slovak Republics, Hungary). Holding transmission and distribution costs constant, the estimated increase in the price of electricity will not increase electricity prices above those countries' price levels, as coal plays an equally important role in their electricity mix.

Figure 6. **Pre-tax electricity prices for industrial users in the EU**

EUR/MWh, 2010



Source: OECD calculations based on data from Eurostat.

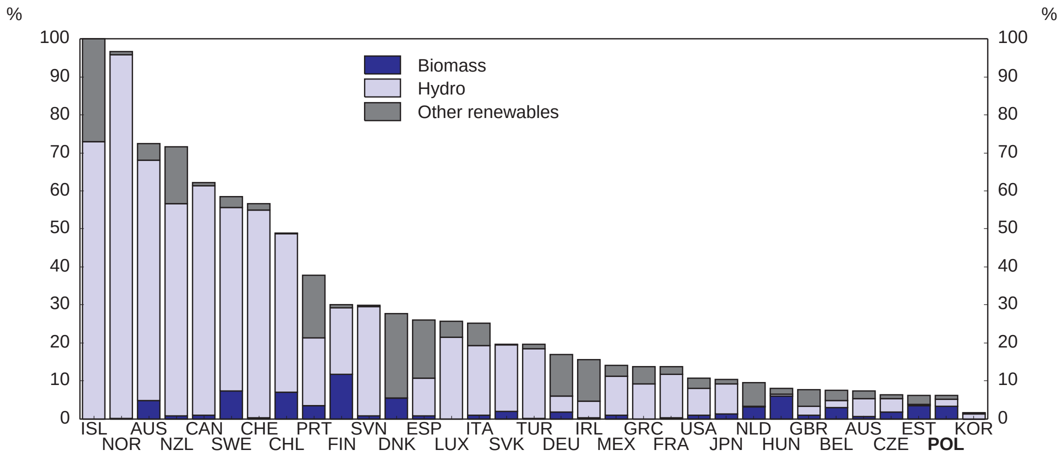
Energy Policy of Poland until 2030 sets the objective of extending cross-border connections to increase electricity trade to 15%, 20% and 25% of electricity consumption, respectively, by 2015, 2020 and 2030. For instance, there are plans to construct a cross-border transmission line interconnecting the Polish and Lithuanian transmission grids by 2018. This line, supported financially by the EU Cohesion Fund, will be part of the Baltic Ring, which, if completed, will connect the Baltic and Nordic countries, Poland and Russia, creating a huge integrated electricity market (Ministry of Economy, 2009 and 2010). Further plans include interconnections with the Ukraine and Belarus and the construction of a third interconnector to Germany (Ministry of Economy, 2010). While this is a step forward, even greater electricity openness would certainly lower the burden of abatement on the Polish economy.

A cost-efficient support scheme for renewables in electricity generation is desirable in the long run

Maintaining equal abatement costs for different technologies is crucial to minimise total abatement costs

Renewables accounted for only a small proportion of Poland's gross electricity production in 2009 (Figure 7). While support schemes targeted at renewables overlap with price signals provided by the EU-ETS, and are therefore costly, actively supporting renewable in electricity generation is required if Poland wishes to comply with renewables targets determined at the EU level. Supporting renewables could be also justified on the grounds of positive externalities including learning by doing and scale effects or on the basis of infant-industry arguments. But in any event, if the government wishes to maintain support for renewables, it should do so in a cost-efficient and technology-neutral way: that is each technology should be awarded the same amount of support per tonne of CO_2 avoided. Since 2004 the Polish government's main instrument to promote renewable energy in electricity generation has been a quota system combined with tradable green certificates. At the heart of the system is the obligation for electricity distributors to prove that the electricity mix they sell to end users contains the amount of renewable sources required by the regulator. This quota is set to 10.4% in 2011 and 2012 and will increase by 0.5 percentage point each year to reach 14.4% in 2020. This seems to be out of line with the objective of 19.12% in gross final electricity consumption specified in the National Renewable Energy Action Plan (Ministry of Economy, 2010; RE-Shaping, 2011). To meet their quota obligations, the distributors can either buy the green certificates, initially issued for the producers of renewable energies and traded on the commodities exchange, or they can pay a substitution fee to the regulator (Energy Regulatory Office, 2011b; RE-Shaping, 2011). That fee represents a *de facto* price ceiling, because if the market price were to exceed the fee, all producers would choose to pay the fee, rather than buying the certificates in the market. Given that the quotas fixed for 2010 and 2011 were higher than the observed amount of electricity produced from renewables, the market price of the certificates has equalled the substitution fee.

Figure 7. **The share of renewables in gross electricity production, 2009**



Source: OECD calculations based on IEA data.

The subsidy implied by the certificates is technology-neutral, as it is the same for all forms of renewable energy. This, in principle, ensures that those with the lowest abatement costs are chosen. Using the most carbon-intensive technology, namely coal-fired power plants and the country's actual electricity mix as carbon-intensity benchmarks yields implied abatement costs of EUR 67 to EUR 71 per tonne of CO_2 (Table 6). By contrast, in other European countries (except the Netherlands) indirect subsidies, mostly in the form of feed-in tariffs, are differentiated across technologies to reflect the actual costs of investment

Table 6. **GHG abatement costs implied by indirect support schemes (feed-in tariffs, green certificates), 2011**

	Solar	Wind	Biogas	Biomass	Geothermal	Hydro	Tidal wave
	Abatement cost, benchmark=coal-fired power plants (EUR/tonne of CO_2 equivalent)						
Austria	(-50)-280	47	135		25		
Belgium	150-250	50	50	50		50	50
China	90-456	16-28	44				
Czech Republic	254	41	-50	136		72	
Denmark	21	0					
Finland		30	24-74				
France	70-410	(-20)-80	(-30)-40	30-90	150-230	10-35	100
Germany	45-240	42-80	26-133	26-123	55-146	(-16)-77	
Greece	328-479	179	129-149	9-129	28-79	17	
Ireland		15-635	25	25		25	
Italy	177-335	153	113-213	153	133		273
Japan	332	138					
Netherlands	47	47		47		47	
Poland	**65**	**65**	**65**	**65**	**65**	**65**	
Portugal	208-421	25	66	70	121-221	46	211
Slovakia	332	31	76	63		11	
Spain	81-232	231	21-92	79-123	25	34	24.6
Switzerland	303-673	158-194	164-292	(-7)-213	227-439	42-268	
Turkey	29	-40	29	29	8	-16	
United Kingdom	37-436	(-6)-355	3	(-31)-43		(-6)-179	
	Abatement cost, benchmark=country-specific electricity mix (EUR/tonne of CO_2 equivalent)						
Austria	(-180)-1 007	169	485		90		
Belgium	530-883	177	177	177		177	177
China	112-570	20-35	55				
Czech Republic	383	62	-75	205		108	
Denmark	29	115					
Finland		64	51-159				
France	803-4 701	(-229)-917	(-344)-459	344-1 032	1 720-2 637	115-401	1 147
Germany	75-402	70-134	44-223	44-206	92-244	(-26)-128	
Greece	420-614	229	165-191	12-165	36-101	22	
Ireland		25-1 050	41	41		41	
Italy	319-603	275	203-384	275	239		492
Japan	610	253					
Netherlands	74	74		74		74	
Poland	**67**	**67**	**67**	**67**	**67**	**67**	
Portugal	393-795	47	125	132	229-418	87	399
Slovakia	1 310	122	300	249		43	
Spain	176-506	503	46-200	172-268	54	75	54
Switzerland	7 488-16 632	3 905-4 794	4 053-7 216	(-173)-5 264	5 610-10 849	1 038-6 623	
Turkey	52	-72	52	52	14	-29	
United Kingdom	63-741	(-10)-603	5	-53-73		-(10)-304	

Note: Abatement costs are computed using the lower- and upper-bound feed-in tariffs in excess of wholesale electricity prices and the amount of avoided CO_2-equivalent emissions.

Source: OECD calculations.

in renewable energies, leading to utilisation of a wide range of technologies, but also a wide range of abatement costs for various abatement options. The Polish government's plan to modify the existing quota system by introducing support that accounts for technology-specific investment costs will lead to an outcome that is more diversified across alternative green technologies at the expense of considerably higher total abatement costs.

The timeframe of the support scheme should be expanded

The current system encouraged the development of co-firing, a practice consisting of adding biomass to coal in existing power plants, a way to lower CO_2 emissions without much investment. In 2009, more than half of gross electricity produced on the basis of renewable sources was related to biomass, accounting for a little more than 3% of total gross electricity production. The government's renewable energy strategy projects a further threefold increase in absolute terms by 2020 (Ministry of Economy, 2010).

But the current system has some flaws. Co-firing crowded out new investments in power generation using renewable energies because the green certificates represented windfall revenues for energy producers, and no new investment could compete in terms of profitability. Poland will achieve its 15% renewables target (in gross final consumption of energy) by 2020 thanks to co-firing. But this achievement will be very short-lived, as old coal plants, which provide the bulk of co-firing, will have to retire after 2020 as a result of EU regulation. The sudden drop could be taken up either by other renewables generation capacity, nuclear power or new fossil fuel-fired plants, but this will be difficult to achieve, given the long lead times of plant construction. Second, the certificate system does not ensure that investment in renewables capacity will break even, as the system is currently slated to last only until 2017, and, even if it will probably be extended until 2020, this period is clearly too short for new investment with a lifetime of 20 years and more. In this respect the system also favours existing power plants and incumbents over new investments and independent producers. Changes currently planned by the government aim to expand the time horizon of the system and to encourage new investment in renewable technologies.

Measures on top of the quota system should be kept consistent with least-cost abatement

On top of the quota system, the government supports renewable energies via: *i*) a 50% reduction of the costs of the grid access for small renewable plants (less than 5MW) and for small co-generation plants (smaller than 1MW); *ii*) an exemption from the stamp duty for issuing green certificates and for the issuance of the operating licence and the annual licence for energy production from renewable sources; and *iii*) an exemption from the excise tax of PLN 20/MWh applying to electricity generated from renewable sources. Furthermore, investment subsidies and preferential loans are provided by the National Fund for Environmental Protection and Water Management, EU funds and the Norwegian government. In compliance with the EU's Renewable Energy Directive, administrative measures comprise preferential treatment of wind energy for commercial balancing and a priority transfer of electricity produced from renewable sources by the transmission and distribution network operators (Ministry of Finance, 2010; RE-Shaping, 2011) (Table 7). The government should make sure that those measures are consistent with the objective of least-cost abatement.

The sustainability criteria for biomass firing needs to be strengthened

The production of biomass may increase overall GHG emissions via direct and indirect land-use change (NL Agency, 2010). The European Commission (2010) suggests member states apply sustainability criteria when using biomass for electricity and heat production (in line with the sustainability criteria for bio-fuels): *i*) the use of biomass from land converted from forest and from areas with high carbon storage and high biodiversity should be banned; *ii*) the use of biomass should reduce GHG emissions by at least 35% (and by 50% in 2017 and 60% in 2018 for new plants) relative to the EU's existing fossil energy mix; *iii*) combined heat and power (CHP) plants with high energy efficiency should be promoted; and *iv*) the origin of biomass should be monitored. Therefore, Poland's heavy reliance on an ever increasing use of biomass in order to meet the government's medium-term objectives needs to go hand in hand with a careful monitoring according to the sustainability criteria proposed by the European Commission.

Table 7. **Overview of measures used to promote renewable energy**

	POL	AUT	BEL	BLG	CZE	DEU	DNK	EST	ESP	FIN	FRA	GRC	HUN	IRL	ITA	LIT	LVA	NLD	PRT	ROM	SWE	SVN	SVK	GBR
Electricity																								
Feed-in-tariffs		X	X	X	X	X		X	X		X	X	X	X	X	X	X		X			X	X	X
Premium					X		X	X	X									X				X		
Quotas	**X**		X												X					X	X			X
Investment grants			X		X					X		X	X			X	X							
Tax exemptions	**X**		X						X	X		X					X	X			X		X	X
Fiscal incentives	**X**			X		X		X										X				X		
Heating																								
Investment grants	**X**	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X		X	X	X	X
Tax exemptions		X	X				X				X	X				X		X			X			X
Fiscal incentives				X		X		X			X								X					
Bio-fuels																								
Quotas	**X**	X		X	X	X	X		X	X	X			X	X	X	X	X	X	X		X	X	X
Tax exemptions		X	X		X	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X

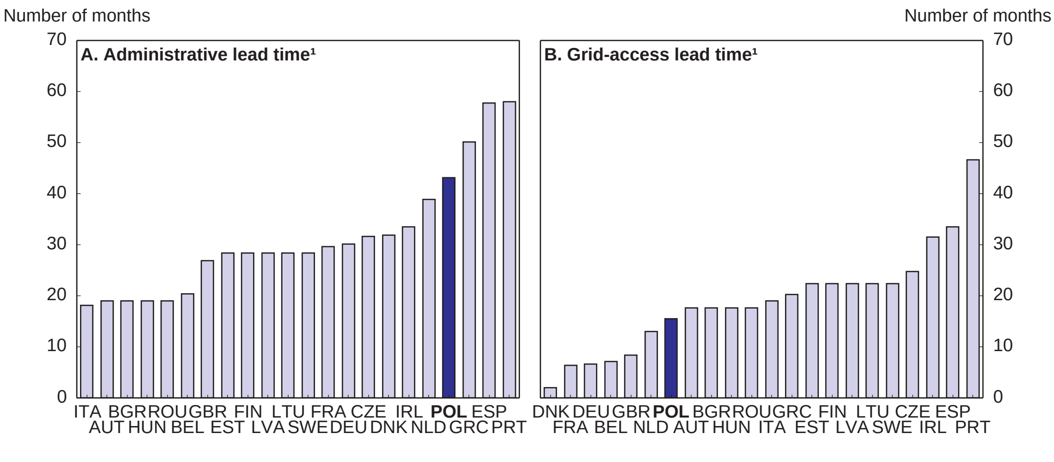
Source: European Commission (2011), "Renewable Energy: Progressing towards the 2020 target", Communication from the Commission to the European Parliament and the Council,"COM(2011) 31 Final, Brussels, 31 January.

Administrative barriers for wind energy should be reduced

Wind energy harbours an important potential for electricity production, given the excellent wind conditions in most of the country and on its shores (Kolvits, 2008). Nevertheless, wind contributed to only 1% of electricity production in 2010, and the government expects it will provide only 3% of power generation by 2020 and afterwards. The wind industry is more optimistic: the European Wind Energy Association (EWEA) and the Polish Wind Energy Association predict that the share of wind will reach 14% of total electricity production by 2020 (PNB, 2011b). According to the Institute for Renewable Energy, 35 GW of gross electricity production capacity could be potentially installed in offshore wind farms (PNB, 2011c), which could satisfy over 40% of electricity consumption by 2030.

The under-use of wind energy in Poland is a result of administrative and grid-access barriers. One major obstacle is the long time needed to obtain a building permit: for onshore wind farms it was 43 months in 2008, more than the double the European average, with only Portugal, Spain and Greece having longer administrative lead times (Figure 8). The absence of clear requirements with regard to the scope of the environmental impact analysis is a major cause. In addition, developers have to deal with eight authorities to get the necessary paperwork done (EWEA, 2010). Another major obstacle relates to connecting new wind farms to the grid. While average grid-access lead time is low in a European comparison, 60% of respondents to a recent survey mentioned insufficient grid capacity as the second most important reason for postponing projects. In fact, the grid infrastructure is underdeveloped in Northern and Western Poland, precisely where wind conditions are best (Kolvits, 2008). Not only does building high-voltage lines take a long time (five years for permissions and two for construction), but the unpredictability of the regulated tariffs that network operators can charge for the use of the grid is also not conducive for long-term investment in the grid. This is related to the lack of a national master strategy for grid improvement and extension (EWEA, 2010). Also, long queues for grid connection hamper new wind projects. A recent change in the Energy Law aims to shorten delays by filtering out “virtual” projects: since March 2010 only projects with a development plan approved by local governments can apply for connection. The introduction in the same year of a high deposit fee for reserving wind-farm grid access goes in the same direction (RE-Shaping, 2011).

Figure 8. **Administrative and grid-access lead times for wind energy in Europe, 2008**



1. Administrative lead time refers to the period needed to obtain official permits and authorisations to start construction. Grid-access lead time indicates the time period needed to connect a new plant to the grid.

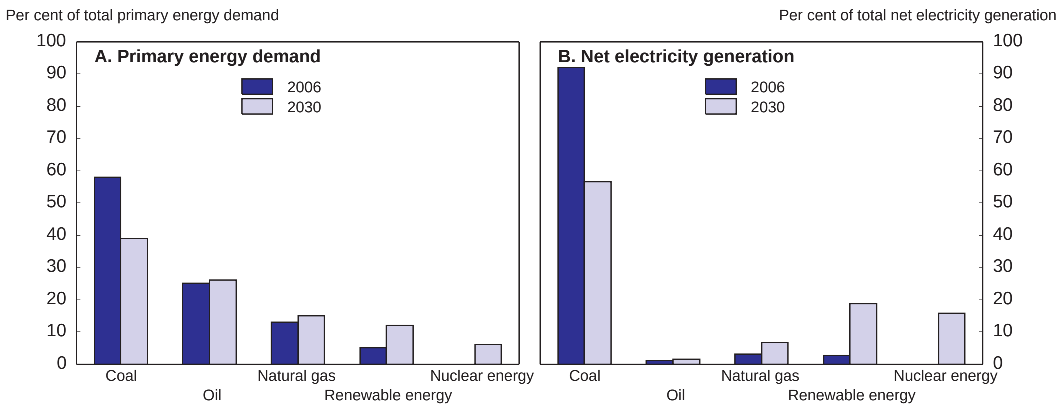
Source: European Wind Energy Association (2010).

The survey conducted by EWEA (2010) shows that, notwithstanding long administrative lead times, administrative costs as a share of total investment costs are in line with the European average, and that connection costs are comparatively low. This latter finding is somewhat in contrast with the experience of the Polish Wind Energy Association, according to which high connection costs are a barrier, given the lack of nationwide cost standards for grid connection. The vertical integration of the big utility companies, which own electricity production capacity and the distribution system, may imply that new wind projects by independent producers may potentially be disadvantaged.

Electricity mix within the EU-ETS and the scope for direct government intervention

Coal accounts for about 90% of fuel used for Polish electricity production (Figure 9). Poland seeks to use coal as long as possible (Ministry of Economy, 2009) because the country's important coal reserves can guarantee energy security and the coal-mining industry employs over 100 000 workers (Suwala, 2010). But coal production has been on a rapid decline, with exports shrinking sharply: in 2010, domestic coal consumption was barely covered by domestic coal production, and the country's coal reserves will last only 43 years at current production levels (BP, 2011). With a single carbon price, which should rise significantly in the future to meet the ambitious GHG emissions-reduction objectives (and if local externalities related to burning coal were internalised properly), the economic appeal of coal-fired power generation would decline. While the transition to a low-coal economy will raise energy imports in the immediate future, the depletion of the country's coal reserves will increase coal imports in any case and thus lower the country's energy independence in the longer run. If the government sticks to its current energy strategy of keeping coal as a primary energy source as long as possible, the burden on the economy of achieving any given overall GHG emissions reduction target will be considerably higher, chiefly because of the reliance on more expensive abatement options.

Figure 9. **Primary energy demand and net electricity generation in 2006 and 2030, by type of energy**

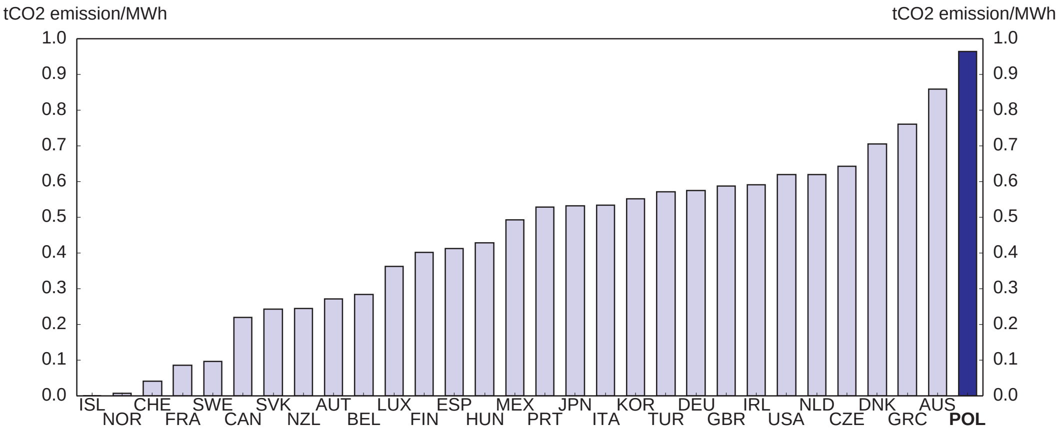


Source: Ministry of Economy (2009), "Projection of demand for fuels and energy until 2030", Appendix 2 to Energy Policy of Poland until 2030, November.

Abatement scenarios

The electricity mix will depend on government policies and the responsiveness to the carbon price signal. The government's energy strategy implies a drop in the carbon-intensity of electricity production from 0.95 tonne of CO_2/MWh in 2008 to slightly above 0.6 tonne/MWh by 2030. This figure is still well above the current OECD and European averages of 0.5 and 0.4 tonne, respectively (Figure 10). Substituting natural gas for all coal and oil while keeping the share of renewables and nuclear power at levels predicted by the government's strategy would lower carbon intensity to 0.33 tonne of CO_2 per MWh. Increasing the shares of nuclear and renewable energy to 25% each in the electricity mix by replacing natural gas would result in a further drop to 0.25 tonne of CO_2 per MWh. Alternatively, retrofitting old and equipping new coal and gas-fired plants with carbon capture and storage (CCS) facilities, a technology not yet proven on an industrial scale, but which could eventually become economically and technically feasible, could reduce carbon content to 0.17 tonne of CO_2/MWh, through sticking to government objectives. Even a virtually full decarbonisation is possible: a combination of the two scenarios, that is nuclear power and renewable energy together accounting for 50% of the electricity mix, coupled with the other 50% from gas-fired plants with CCS, would result in a carbon content of 0.07 tonne of CO_2/MWh.

Figure 10. **Carbon intensity of electricity production, 2008[1]**



1. The share of various energy sources in total gross electricity production of each country is multiplied by the per MWh CO_2 equivalent emissions. For nuclear, hydroelectric, geothermal, solar, tidal and wind, the values of 0 tCO_2 equivalent/MWh, for natural gas 0.5 tCO_2 equivalent/MWh and for non-gas combustibles 1 tCO_2 equivalent/MWh are used.

Source: OECD calculations.

The question to be answered in this context is how high the abatement costs are of moving from a carbon content of 0.95 to 0.07 tonne of CO_2/MWh. To put it differently, how does the electricity price implied by low-carbon generation technologies compare to the price given by investment, operations and maintenance and fuel costs related to coal- and gas-fired power generation? The estimated costs of electricity production indicate that nuclear power and, to a lesser extent, wind, hydroelectricity, biogas, biomass and geothermal energy are very cost competitive with coal- and natural gas-fired power plants. Photovoltaic stands out as currently the least cost-competitive technology (Table 8). The results are sensitive to: *i*) the discount rate used as (a higher rate penalises capital-intensive, low-carbon technologies and reduces the appeal of nuclear energy and wind power; *ii*) the evolution of fossil fuel prices, as lower future prices reduce the production costs of coal and natural gas-based plants relative to nuclear and renewable technologies; and *iii*) the relative costs of different technologies, which hinges crucially on national or even regional factors, including geographical endowments, meteorological conditions, the costs of local inputs and the regulatory environment. For instance, nuclear power is estimated to be cheaper than coal in Slovakia, Germany and France but more expensive in Hungary. However, the cost estimates for nuclear power do not reflect the need for higher security standards in the aftermath of the 2011 Fukushima accident. Electricity produced in onshore wind-power installations costs almost the same in the United States as electricity generated in coal-based power plants. Finally, a unit of electricity from photovoltaics is much more expensive in the Netherlands than in China (Table 8). According to the US Energy Information Administration (2011), the discounted production costs of the same technology vary significantly across US states, implying strong regional differences in the relative cost-competitiveness position of a given electricity production technology.

Table 8. **Country-specific abatement costs**

Abatement cost	Nuclear	Gas	Gas with ccs	Coal with ccs	Wind onshore	Wind offshore	Solar	Hydro	Biogas	Biomass	Geo-ther-mal
Power generation with a carbon price of EUR 40/tonne of CO_2											
Austria		-40						-47			
Belgium	-38	-15			-12	56					
Czech Rep.	-33	-7	-9	-11	24		207	31			38
France	-41	-25			-16	24	130		-24		
Germany	-46	-15		-15	-4	19	142				
Hungary	-24										
Italy		-13			25		221				
Netherlands	-31	-12			-14	18	270			19	
Slovakia	-62										
Switzerland	-40	-1			38			0			
Industry-low	-28	-3		-17	-18	26	37				-34
Industry-high	-33	-3		-17	7	24	104				
EC1 low	-60	-40	-18	-26	-50	-40	165	-50	-50	-20	
EC1 high	-45	-60	-29	-11	-35	-10	335	35	75	75	
EC2 low	-65	10	16	-19	-65	-55	150	-65	-70	-30	
EC2 high	-60	-30	-7	-19	-60	-35	310	10	50	65	
Canada					-1	27	93				
Japan	-50	4									
Korea	-51	15									
Mexico		-9									
United States	-39	-18	-4	-21	-39	0	84		-39	-35	-50
Brazil	-39	-10			-50						
China	-40	-31			-16		29				
Russia	-44	-28		-1							

Note: Abatement costs are calculated on the basis of country-specific costs of specific technologies and compared to the cost of coal-fired plants (converted from USD to EUR at 1.35 USD/EUR). A negative abatement cost implies that the abatement option is cost-effective, considering the carbon price, and its implementation would be less costly than the savings it would produce. For Austria, Canada, France, Italy and Switzerland, data on the cost of coal-fired plants are unavailable. For these countries, German data are used. For Hungary, Czech data are used. Abatement cost estimates assume the following CO_2 emissions reductions: 100% for nuclear energy and renewable energies, 50% for gas-fired plants, 90% for gas-fired plants with CCS, and 70% for coal-fired plants with carbon capture and storage (CCS). Empty cells imply the lack of country-specific data. Industry-low and industry-high indicate general cost estimates by the electricity industry. EC1 and EC2 refer to data obtained from EC (2008) using a low and high-fuel price scenarios, respectively. EC low and EC high indicate lower- and upper-bound costs estimates.

Source: OECD calculations based on data obtained from IEA (2010) and EC (2008).

The absolute difference in production costs can be translated into abatement costs (the costs of reducing one tonne of CO_2, using technology-specific CO_2 emissions per unit of electricity produced). Keeping in mind the sensitivity of the cost estimates to some of the underlying parameters, if a carbon price of EUR 40 per tonne were added to the production costs, abatement costs (relative to coal) would tend to be negative, except for photovoltaic. A negative abatement cost implies that the abatement option is cost-effective, considering the carbon price, and its implementation would be less costly than the savings it would produce, making it a worthwhile undertaking.

Poland's promising shale gas potential needs to be carefully developed to avoid local pollution

The recent discovery of potentially large reserves of natural gas from shale formations raises the possibility of significantly reducing Poland's natural gas supply dependence on Russia and opens up new possibilities for the use of gas in the country's electricity mix. Preliminary estimates quantify Poland's shale gas deposits, the biggest of their kind in Europe, at up to one fifth of proven shale gas reserves of the United States: 1.4 trillion to 5.3 trillion cubic metres, which would cover the current level of gas consumption for more than 200 years (IEA, 2011a; US EIA, 2011). The state-owned Polish Oil and Gas Company (PGNiG) estimates that small-scale (test production) shale-gas extraction could start within two years in 2014 (PNB, 2011d), whereas IEA (2011a) suggests that shale-gas production at an industrial scale could not begin earlier than 2020.

Natural gas from shale formations has been extracted at an industrial scale in the United States for many years, and such production is being considered in parts of Europe and elsewhere. However, there is increasing public scepticism with regard to the environmental impact of shale-gas mining, which relies on hydraulic fracturing or "fracking" (creating fractures in rock formations deep under the earth using pressurised water) in order to set free gas trapped in shale reservoirs. A serious concern relates to pollution of the underground water supply. Water pollution can occur directly through chemicals pumped into the rocks as part of the pressurised water to liberate shale gas, or indirectly, as injected water gets contaminated by radioactive materials and heavy metals from the rock (IEA, 2011b). Fracking also requires large amounts of water: 7 500 to 20 000 cubic metres of water injected per well, and can potentially cause seismic effects. Concerns relating to pollution of underground water supply have prompted a ban on shale gas mining in France. The potential seismic effects that drilling can trigger led to the suspension of drilling operations in the United Kingdom (The Guardian, 2011). In late 2010 and 2011, a temporary moratorium was placed on hydraulic fracturing in Québec and the US states of New York and Maryland, and the South African government also ordered a permanent ban in parts of the country (IEA, 2011b). The US Environment Protection Agency has recently launched an in-depth environmental impact analysis of shale-gas extraction in five US states, with first results to be published in 2012 (Reuters, 2011).

There are concerns regarding the over-the-lifecycle GHG balance of shale gas but also of conventional natural gas. Methane, which has a global greenhouse gas impact much greater than that of CO_2 and which escapes during the extraction phase, may wipe out the benefits of the decreased emissions when shale gas is used to replace coal. Based on data from the United States, Howarth *et al.* (2011) estimated that 4 to 8% of the methane from shale-gas production is released into the atmosphere via leaking and venting. As a result, the over-the-lifecycle GHG emissions from shale gas are estimated to be at least 30% higher than those for conventional gas or oil, and 20% greater than coal. But Cathles *et al.* (2012) argue that Howarth *et al.* (2011) substantially over-estimate life-cycle emissions because of some of their assumptions that are difficult to justify. Using more plausible assumptions results in life-cycle emissions, which are 30% lower for shale gas than for coal. In a similar vein, a special report by the International Energy Agency (2011b) finds that extra GHG emissions from shale-gas extraction are only 12% higher than for conventional natural gas and merely 4% if venting is avoided.

The existing legal system in Poland poses certain limits to shale-gas exploitation, including environmental protection, geology and water use, and property law. For instance, mining is prohibited in some areas, while other areas are protected by the EU Natura 2000 Programme (PNB, 2011e). Environmental barriers should be changed only if the changes would pass an independent environmental impact analysis. More generally, before entering the stage of full-scale exploitation, the government should commission an independent environmental impact analysis of Polish shale-gas mining. Potential sources of environmental pollution should be tackled by appropriate regulation enforced by a politically arms-length watchdog. Short- and long-term environmental risks (including excessive water use and underground water pollution) should be monitored continuously, and if potential damage is large and irreversible, a ban should be placed on the extraction technologies used.

Special attention is warranted for nuclear waste management

The Polish government's energy plan includes the construction of four to six third-generation nuclear reactors (depending on the technology chosen and investment plans). The first reactor is planned to start operations in 2020. By 2030, all reactors are expected to be fully operational. Nuclear power is an appealing alternative to carbon-intensive technologies, given the large amount of carbon-free base-load. But constructing nuclear power plants may be cumbersome because of the significant upfront investment costs and the many years needed for commissioning and construction. Also, the 40-to-60-year-long lifespan of the plants implies a very long lock-in to a specific technology. A permanent disposal of very long lived radioactive waste remains a largely unresolved issue. Whereas the idea of permanent deep geological disposal has been mooted for some time, no country has yet implemented this solution, because of the difficulty of finding suitable storage sites. Cost estimates for permanent storage are extremely uncertain, given the very long periods involved. As a result, the Swedish Radiation Safety Authority recently increased the nuclear waste fee paid by the industry to the Nuclear Waste Fund by 300% (Kokkvoll Tveit, 2011).

For the Polish nuclear programme to cover long-term costs, the final price of electricity should cover the full costs of long-term waste management and decommissioning. Strict safety and environmental standards should be set and implemented to minimise tail risks. An independent body composed of domestic and international experts should approve cost estimates, and money should be set aside in dedicated special reserve funds, untouchable by the nuclear industry and also by any future government tempted to use them to fix short-term budgetary problems. The legal framework, which entered into force in 2011, is well in line with those requirements. Nuclear energy producers are required to provision for the estimated future costs of decommissioning and long-term waste disposal. Based on expert assessment, the president of the nuclear energy agency proposes the amount of provisions to be set aside per unit of electricity production. The government (Council of Ministers) then evaluates and decides on the final amount for a multi-year period.

The current framework could be improved in two aspects. First, to ensure full transparency, the government's approval should be a purely administrative step that formal requirements of the cost estimation procedure were respected, rather than involving any judgement. Second, the independence of the regulator should be strengthened. The president of the nuclear energy agency is nominated by the prime minister for an indeterminate period of time and can be dismissed by the prime minister. Such an arrangement makes his/her removal relatively easy. Instead, he or she should be appointed for a period, extending beyond political cycles, for instance six or eight years, during which he or she cannot be fired. In principle, the price of nuclear energy should incorporate an insurance premium covering tail risks. But no private insurer would be ready to provide coverage at a reasonable price, as risks cannot be diversified sufficiently within Poland (for the small number of planned reactors). Such tail risks could, however, be meaningfully diversified at the global level. In any case, the low probability of an accident means that an explicit government insurance scheme would collect funds, which are very small compared to the total costs of a nuclear disaster. Nevertheless, in the absence of such an insurance scheme, nuclear energy would be under-priced, thus leading to its over-production. Therefore, imposing an insurance premium or a tax relating to tail risk is desirable in principle, even though estimating the probability and the costs of an extreme event is a very complicated task.

Smoothing peak electricity demand

Smoothing daily, weekly and annual peak demand is generally very helpful in lowering GHG emissions related to electricity production and consumption. Semi-base and peak electricity production usually relies on fast-reaction power plants using gas, coal or oil. If base-load electricity production relies on low-carbon technologies like nuclear or hydroelectric power, smoothing peak load will decrease the demand for high-carbon electricity produced by fossil-fuel-fired plants. Currently, smoothing peak demand in Poland would have a different benefit, given that both base and peak-load depend heavily on coal and other carbon-intensive fossil fuels. While flattening peak demand would do little to reduce GHG emissions, it would instead lower the costs of electricity production by increasing the utilisation rate of power plants and thus lowering the need to build new capacity used only to meet peak demand. The climate impacts of flattening peak demand could be partly offset by some increase in demand in response to the lower electricity prices that would ensue.

But in the longer run, a significant decarbonisation of base-load is expected to occur as a result of *Energy Policy of Poland until 2030* and, if adopted, the European Commission's *Low Carbon Roadmap 2050*. Once in place, smoothing peak demand served by high-carbon power stations will decrease overall GHG emissions. An effective way of doing so is to introduce time-varying tariffs. At present, Polish households can choose between a flat rate and day/night tariffs (Barth, 2008). While day/night tariffs can smooth peak demand moderately, truly time-varying prices are more effective in encouraging people to modulate their electricity consumption in line with the price. A pre-condition of time-varying tariffs is a well functioning wholesale electricity market, which Poland still does not have. A second condition is that time-varying wholesale prices are passed through to end-user prices. Intelligent meters providing real-time information on electricity prices and the precise shape of users' load curves could encourage a proactive application of energy-efficiency measures (IEA, 2010). A recent study estimated that peak demand could be cut by 7% in Europe if 50% of households and small businesses were equipped with smart meters (Ollagnier, 2010).

In addition, smart or intelligent grids open new perspectives to network operators to modulate electricity demand during peak periods via demand withdrawal. The roll-out of smart meters can take as long as seven years from initial tender to operation and the deployment of a smart grid 20 years (Shargal, 2010). Poland's action plan relating to its energy strategy included a gradual roll-out of electronic meters, starting in 2011. Yet, little progress has been made thus far. Hence, Poland should start thinking about the development and implementation of a strategy aimed at deploying smart meters and a comprehensive smart grid. As part of the EU effort to improve energy efficiency by 20% by 2020, many member countries have developed strategies to deploy smart meters and roll out a smart grid. Italy and Sweden are front runners, but Denmark, Finland, France and the Netherlands are also making efforts to increase the penetration rate of smart meters. In those countries, the regulatory environment was conducive to their roll-out (Shargal, 2010). Yet, the Polish energy regulator has not set smart metering requirements nor any roll-out date. A recent position paper by the energy regulator, which sets minimum technical requirements for grid operators wishing to deploy smart meters and distribution tariffs incorporating investment costs, is an encouraging, but still insufficient step forward (Energy Regulatory Office, 2011c).

The role of renewable sources outside electricity production

The EU target set by the Directive on renewable energy to increase the share of renewable sources to 20% in gross final consumption of energy by 2020 and to 10% in the transport sector is translated into binding national targets of 15% for Poland, which is among the least ambitious: only the Benelux countries and a number of other new EU members have smaller targeted shares. The National Renewable Energy Action Plan (NREAP) foresees a modest increase to 16% by 2030 (Ministry of Economy, 2010). The overall objective of 15% is broken down into three sector-specific targets for electricity, heating and transport (bio-fuels). In 2010, almost 72% of all renewable fuel sources was used in heating, and only 28% went to electricity production and transport (Table 9).

Releasing the potential of renewables in heat production and individual heating

The use of renewable energy is concentrated in individual heating, for which solid biomass dominates other renewable energy sources by a wide margin and accounts for almost all renewables in this sector (Ministry of Economy, 2010). About half of solid biomass, mostly woodchip, is currently used in the residential sector for heating purposes. This raises a number of concerns. First, individual heating devices, especially old ones, have low energy conversion rates and are an important source of local atmospheric pollution via fine-particulate-matter emissions. Therefore, the traditional use of solid biomass is not considered by IEA (2011a) as a sustainable renewable energy use. Second, as in the case of biomass used for electricity production, the sustainability criteria suggested by the European Commission for the use of biomass should be respected.

Table 9. **Poland's renewable energy targets by sectors**

	Share of sector-specific renewable use in gross final energy use			Share of sector-specific renewable use in total renewable use		
	2010	2020	2030	2010	2020	2030
Electricity	1.3%	3.9%	4.2%	14%	26%	26%
Heating	6.8%	9.0%	9.5%	72%	60%	59%
Transport (bio-fuels)	1.3%	2.1%	2.3%	14%	14%	15%

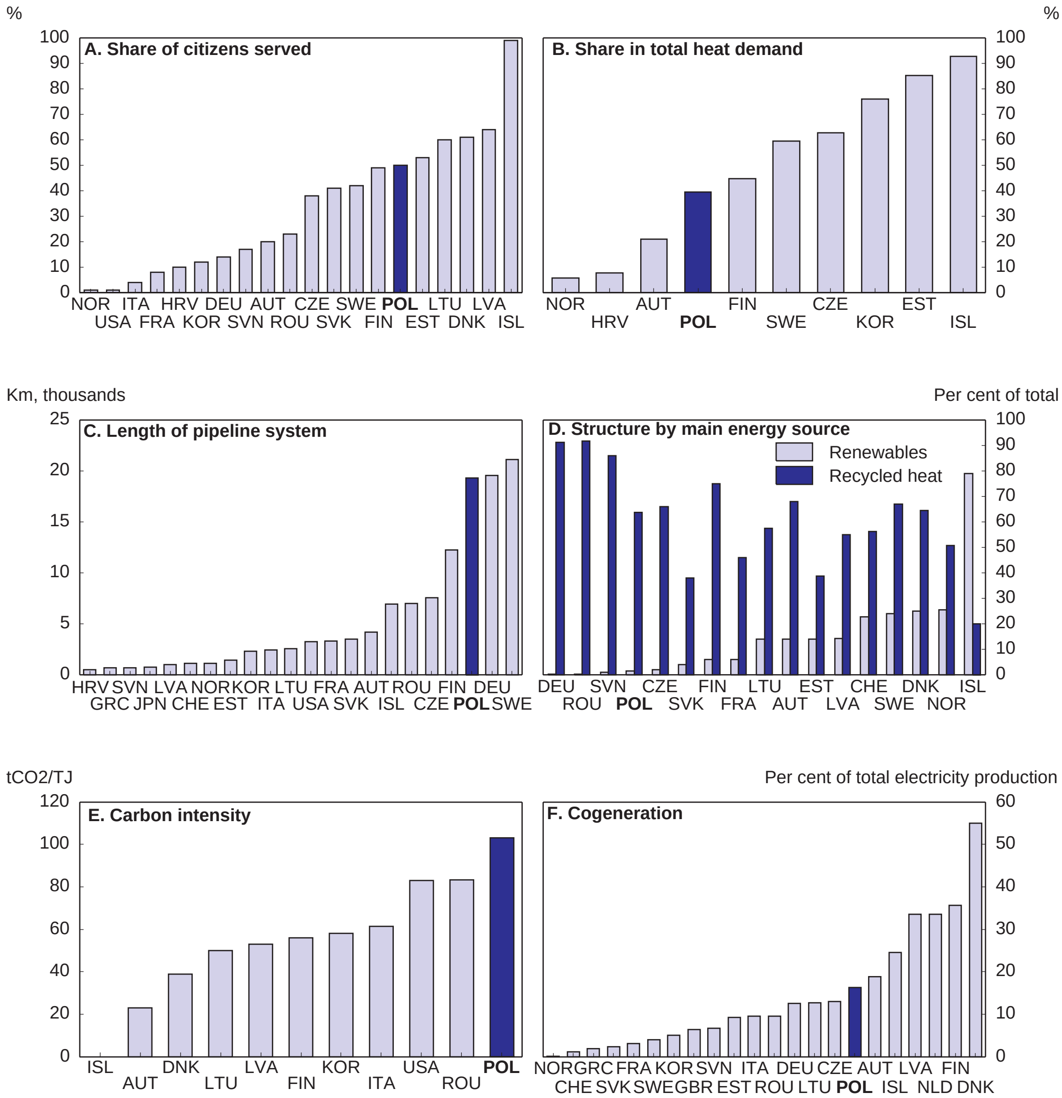
Source: Ministry of Economy (2010), updated for 2010.

Promoting district heating via an economy-wide single carbon price

Poland has one of the most extensive district heating (DH) systems in Europe. In 2009, DH served half of the country's citizens, had a 40% penetration rate in total heating demand, and the length of the heating grid was just a little shorter than those in Germany and Sweden (Figure 11). Indeed, DH systems have a number of advantages over individual heating applications. First, the energy conversion factor is higher, especially if heat is obtained from cogeneration (CHP plants). Modern cogeneration plants can reach fuel efficiency levels above 90%. Cogeneration can meet peak demand both for electricity and heat, given that low-grade heat generated during peak electricity production can be stored easily for up to two days. Second, DH systems can accommodate a variety of energy sources and production types such as CHP, geothermal heat, surplus heat from industry and a vast range of renewable sources, which are difficult to use in individual heating systems (unrefined biomass, wood waste, municipal solid waste and sewage sludge), as well as coal and gas (Euroheat & Power, 2011). High energy efficiency coupled with an extensive use of renewable fuels make cogeneration-based district heating a very powerful tool in the fight against GHG emissions. Finally, and importantly, compared to individual heating devices, DH systems have a limited number of emission points, which can be fitted more easily with modern filters to radically reduce air pollution and global warming: one tonne of black-carbon/soot particulate matter has a global warming potential 600 times higher than CO_2 over 100 years (Grieshop *et al.*, 2009). For instance, in 2008, 40% of Poland's total particulates emissions came from individual residential heating devices, whereas public electricity and heat production, including DH, was responsible for only 6%.

Yet, the average carbon intensity of one MWh produced in the Polish DH system is the highest in Europe (Figure 11). In addition to increasing the share of renewables in the fuel mix of the DH system (and cogeneration), the share of cogeneration, currently 60%, could be increased to cover most DH needs by the construction of new small- and micro-scale CHP plants or the modernisation and replacement of old turbines. COGENchallenge (2007) estimates that Poland's cogeneration capacity could be doubled to reach 40% of gross electricity production. Clearly, an economy-wide carbon price (applied also to individual heating and including the EU-ETS) would help investment in the construction and modernisation of CHP plants using renewable energies. Given that more DH coupled with CHP would mean a move away from individual heating, the government could consider providing loans for credit-constrained households to join the DH grid. At the same time, given the monopolistic nature of district heating pipelines, incentive regulation based on benchmarking could help simulate market competition and improve efficiency.

Figure 11. **Comparison of district heating (DH) systems in Europe, 2009**



Source: Euroheat&Power, http://www.euroheat.org/Statistics-69.aspx

Achieving transport bio-fuel targets by focusing on the carbon content

The government's ambitions with regard to the development of bio-fuels have been in line with EU targets, but the measures taken to achieve them are not cost-efficient. Bio-fuels' share in the total energy consumption (in calorific values) in road transport was set to reach 5.75% in 2010 in accordance with the European objective and the 10% binding minimum European target for 2020. In 2009, bio-fuels accounted for just 4.6% of total fuel consumption (Ministry of Economy, 2010). The underlying justification for the use of bio-fuels is that related GHG emissions are lower than for conventional fuels. The life-cycle GHG outcomes of first- and second-generation bio-fuels are subject to significant controversy, however, mainly because the intermediate stages of the production cycle, including crop production and the transformation of crops into bio-fuels, can be very energy intensive (Steenblik, 2007; International Transport Forum, 2008), and direct and indirect land-use change can reduce, or even negate, overall GHG savings. Bio-fuels can directly increase life-cycle GHG emissions if crops are grown in areas that previously absorbed more CO_2 from the atmosphere such as forest cover. An indirect effect causing unfavourable GHG balances occurs if diverting crops in one country and making up for them elsewhere causes deforestation, for instance. In both cases, the reliance on bio-fuels may have a negative impact on biodiversity, and the indirect effect can trigger food shortages for the poor.

Realising the problem with the life-cycle GHG balances, the European Union's Renewable Energy Directive set new sustainability criteria for bio-fuels, which are similar to those proposed for biomass, and which have to be considered for the fulfilment of the 10% target. By 2016, GHG emissions stemming from the use of bio-fuels should be at least 35% lower compared to conventional fuels. GHG-emissions reductions should go further to 50% by 2017 and to 60% by 2018. Bio-fuels produced from crops grown on land converted from forest, from areas with high carbon storage and high biodiversity will not be counted toward the objective. The tightening of the life-cycle sustainability of bio-fuels will require a shift from first- to second-generation bio-fuels: the government's renewables action plan foresees that the share of second-generation bio-fuels in total bio-fuel use will rise above 20% by 2020 and to 40% by 2030 (Ministry of Economy, 2010). But achieving these goals will be challenging, given that Poland's bio-fuels industry produces almost exclusively first-generation bio-fuels.

The two major measures that help to achieve these bio-fuels goals are very similar to those applied in other European countries. First, a heavy penalty of more than PLN 15 (3 euros) per litre of bio-fuels not introduced is levied on fuel distributors that do not respect the annual targets. Second, a set of financial incentives are meant to encourage the production and consumption of bio-fuels, including exemption from the excise duty and the fuel charge and a tax reduction for bio-fuels producers. In addition, grants and low-interest loans from various funds are available for investment in bio-fuels production (Ministry of Economy, 2010; RE-Shaping, 2011). These instruments will help achieve the quantitative targets, but at a high cost. It would be more cost-efficient to target and/or tax the carbon content of fuels, rather than imposing volumetric production targets for bio-fuels because different bio-fuels have different GHG balances (International Transport Forum, 2008).

Improving energy-efficiency policies

Reflecting the EU's target of a 20% improvement in energy efficiency, *Energy Policy of Poland until 2030* sets two targets: *i*) a constant-energy-use economic growth path, which implies that energy-efficiency improvements would fully offset increased primary energy demand stemming from economic growth;[3] and *ii*) bringing Poland's energy intensity to the current EU-15 level. Generally speaking, a single carbon price will enhance energy efficiency as a side effect of GHG emissions reduction. Therefore, energy-efficiency measures are best suited to compliment carbon prices if responsiveness to the carbon-price signal is considerably reduced in the presence of market failures such as credit-constrained households or asymmetric information. As such, they should be directly connected with CO_2 reduction. It is not fully clear how the energy-efficiency objectives are targeted at low-response sectors. More specifically, showing a business-as-usual scenario and the contribution of specific energy-efficiency measures to achieve the policy objectives would increase the credibility of the programme. A direct link to how efficiency measures would affect overall and sectoral GHG emissions would be very beneficial to clarify Poland's stance on climate-change-mitigation policies.

A number of ministries and agencies with diverging interests are in charge of the country's energy-efficiency strategy and its practical implementation, thereby posing challenges for coordination. While the overall national strategy is developed by the Ministry of Economy, the transport and tertiary (building) sectors are the purview of the Ministry of Infrastructure and regional and local governments, and the strategy's implications for climate change and municipal and industrial waste are dealt with by the

3. EU regulation requires a 9% improvement in energy efficiency of the Polish economy by 2016.

Ministry of Environment. The Polish National Energy Conservation Agency (KAPE) is also involved in the strategy-making and implementation process. Financial support is provided by the National Fund for Environmental Protection and Water Management and regional funds (IEA, 2011a). A good example of the coordination problem is the different energy-performance criteria used for issuing energy certificates and for receiving financial support. This multi-layered institutional framework needs to be consolidated and coordinated or supervised by a single institution or ministry.

Energy-efficiency targets and white certificates

Poland is about to introduce a system of tradable white certificates. This is an important cross-cutting measure, which is expected by the government to have a major impact on improving energy efficiency in the economy. As in any other cap-and-trade system, the incentives ensure that cuts are carried out where they are the cheapest. According to the Energy Efficiency Law, voted in April 2011, energy (electricity, gas and heat) suppliers will have to improve efficiency via reducing losses in production, distribution, transmission and in the end-use sector. The law requires that claimed efficiency gains be subject to energy-savings audits, for which firms will be rewarded with white certificates, or, if they miss their targets, they will have to purchase white certificates or pay a substitution fee, much like the green-certificate system for renewables described above. The government has yet to announce details of the scheme, such as the total energy savings to be targeted, the amount of the substitution fee and how white certificates can be redeemed at the Energy Regulatory Office.

White certificates can be seen as a reasonable alternative to a carbon tax for "diffuse" energy consumption of households and small businesses, for which setting up a GHG emissions-trading system is too costly. The United Kingdom has used CO_2-weighted energy savings in the past, and CO_2-emissions reductions have been targeted there explicitly since 2008 (World Energy Council, 2010). Lessons from the experience of the five European countries – Belgium (Flanders), Denmark, France, Italy and the United Kingdom – operating white-certificate systems might prove useful for the design and operation of the Polish system (Table 10). First, energy savings need to be defined carefully. According to best practice, they should be accredited only for the installation of appliances with energy-efficiency levels in excess of the market average and only for the fraction representing energy savings above the market average and that was not supported by public funds. Second, to encourage innovation, apart from measures accredited independently for energy savings, energy suppliers should have the option to claim energy savings from innovative technologies, approved by public authorities on the basis of a small-scale demonstration, for example. Third, the regulatory set-up should decouple the energy distributors' revenues from the quantity of energy sold, because white certificates, aimed at reducing distributed energy, would create perverse incentives for energy distributors. Fourth, the ability to bank the certificates is essential for long-term investment. In addition, experience shows that energy-savings targets have been met easily, suggesting that objectives have not been ambitious enough or that the savings potential is substantial.

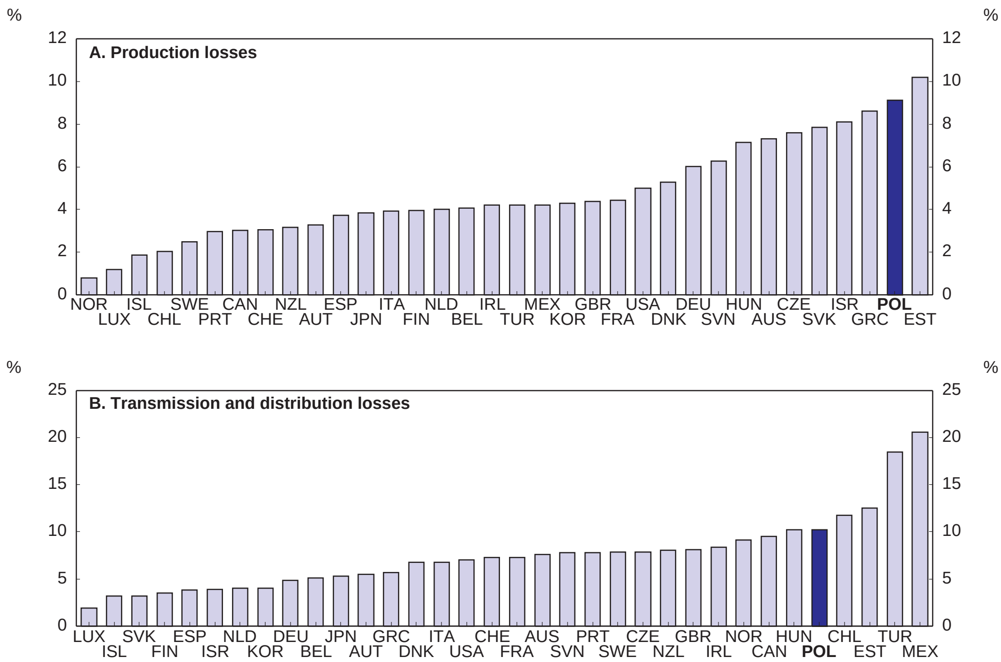
Electricity production in Poland is among the least efficient in the OECD in terms of energy losses (Figure 12). Production losses, defined as the difference between gross electricity production and the electricity fed into the national grid (that is, the power plants' own needs) are the second highest in OECD after Estonia. Losses suffered in the transmission and distribution grid are also substantial. The government's objective to cut grid losses is commendable. It could be achieved via the modernisation of the existing transmission and distribution network and by encouraging small-scale power generation that could be linked directly to the distribution grid (Ministry of Economy, 2009). The government and the energy regulator have yet to propose tariff schemes to encourage investment in the national grid.

Table 10. **White certificate systems in Europe**

	Period	Sectors covered		Obligated companies	Nature of saving targets	Trading	Gross abatement cost (M EUR/TWh)
		Residential	Commercial				
Belgium(Flanders)	2008	58%	42%	Electricity distributors	Annual final energy	No	44
Denmark	2008	42%	50%	Heat, electricity, gas and oil distributors	Annual final energy	Between distributors	30
Italy	2005-08	83%	0%	Electricity and gas distributors	Cumulative	Yes	8
France	2006-09	86.7%	4.2%	All energy suppliers	Lifetime final energy	Yes	3
United Kingdom	2005-08	100%	0%	Electricity and gas distributors	Lifetime final energy	Between suppliers	

Source: World Energy Council (2010) and OECD calculations.

Figure 12. **Losses in the power sector, 2009[1]**



1. Production losses as a share of gross electricity production. Transmission and distribution losses as a share of electricity consumption.

Source: OECD calculations based on data obtained from the IEA.

Transposing the mandatory labelling of energy efficiency of consumer products into Polish law, as required by the 2010 EU Directive on Energy Efficiency Labelling, will increase consumers' awareness and exploit the large potential for efficiency gains in consumer products. The Polish government could go one step further by requiring obligatory display of the over-the-lifetime environmental impact (including the carbon equivalent footprint) of consumer products, the production, distribution and waste management of which account for a large proportion of households' CO_2 emissions. This labelling could cover all products, imported and domestically produced. France's initiatives in this area may provide useful insights for practical implementation.

Energy efficiency in the residential, commercial and government sectors

Residential and commercial buildings cause 11% of Poland's global GHG emissions, which is higher than in most CEE countries. In addition, GHG emissions in this sector declined less between 1990 and 2009 than in the other countries (Table 3 above). This outcome is the result of a continuing use of coal for heating and hot water, coupled with low energy efficiency due to high heat losses because of poor thermal insulation and low efficiency of individual boilers (IEA, 2011a). Poland's energy strategy aims at cutting energy intensity by improving efficiency, which is expected to yield modest cuts in GHG emissions. These efforts are necessary to comply with the EU's Directive on the Energy Performance of Buildings, fully transposed to Polish Law in 2008. An important part of the directive is the minimum energy-performance standard required for new buildings and existing buildings undergoing major renovation. The existing ceiling of 90 to 120 kWh/m^2 annual primary energy consumption, in place since 1998, is not only high in comparison with French or Swedish energy standards (50 and 30-60 kWh/m^2, respectively), it is also not fully enforced by the authorities (IEA, 2011a). The revamp of the Directive in 2010 requires that all new buildings be nearly zero-energy structures by 2020 (and by 2018 for government-owned and -occupied new buildings), by designing them to produce sufficient energy to cover almost all their energy needs. Intermediate targets shall be set up by 2015 to secure the achievement of the 2020 target. Reducing new buildings' primary energy consumption to almost zero will be very challenging.

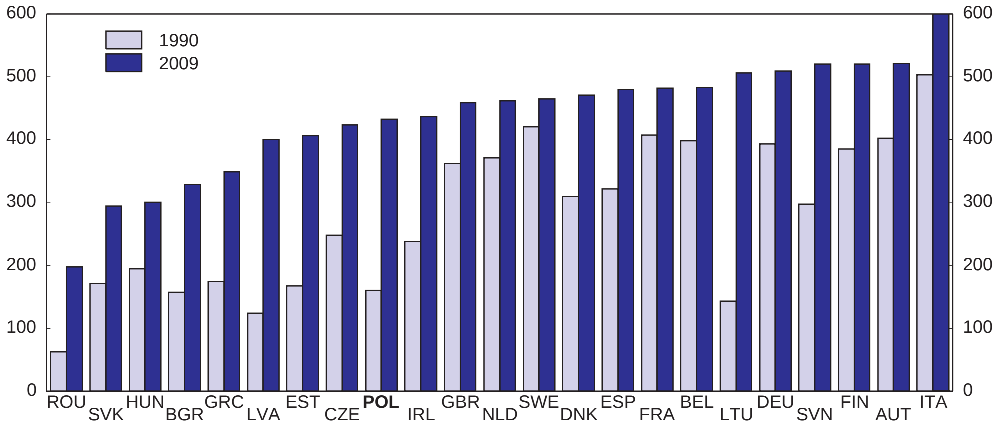
A second important measure attributable to the Directive is the system of energy-performance certificates for new and old private buildings that are sold or rented, and for all public buildings (in which the certificates have to be displayed prominently). The current system is not perfect. First, energy performance is shown on a continuous scale rather than showing energy classes, which would facilitate public understanding. And the certificates indicate only the share of renewable energy sources used by the buildings, not the overall standardised CO_2 emission levels. Finally, setting up a national register of energy certificates for buildings would be useful (Sowa, 2011).

The government provides financial support to energy-efficiency improvements in the building sector. The Thermo-Modernisation Fund, established in 1998, and transformed into the Thermo-Modernisation and Repair Fund in 2009, can cover up to 20% of a bank loan for investment in thermal renovation, but cannot exceed 16% of the total costs of investment. The support can be awarded to investment projects that reduce annual energy consumption by at least 10% if the heating system is modernised or by at least 25% in other cases (thermal insulation). Yet, the way the energy performance of the thermal investment projects is measured is different from the methodology used for the energy certificates. The two systems should be harmonised to ensure full transparency (Sowa, 2011). Furthermore, it would be preferable to support investment projects of credit-constrained households depending directly on their GHG emissions reduction.

Towards a more efficient organisation of the transport sector

GHG emissions in the transport sector almost doubled between 1990 and 2009, as the number of passenger cars per capita rose threefold (Figure 13). A further catch-up in the stock of cars and their heavier use, in line with rises in per capita income, is likely to result in a further increase in transport-related GHG emissions over the coming decades. Considering that per capita GHG emissions in transport are about half the level seen in more industrialised countries, they could potentially double over time. The government's strategy seeks to promote a shift towards sustainable transport systems. But the supporting policies are either too general (such as the preparation of urban plans for sustainable transport and the promotion of alternatives to road transport) and not backed by specific actions, or, while useful, are likely to have only a marginal impact. This includes the promotion of "eco driving", car-pooling, the checking of tyre pressure and lifestyle changes to rely less on cars (IEA, 2011a).

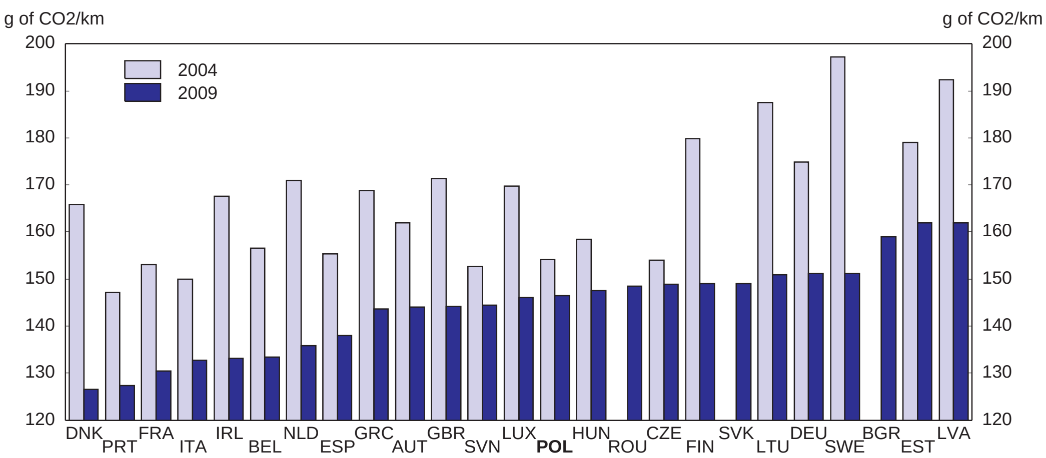
Figure 13. **Passenger cars per 1 000 inhabitants, 1991-2009**



Source: Eurostat.

Cutting GHG emissions in the transport sector is especially challenging, given that the demand for travel is very unlikely to decline in the future. Increasing the fuel efficiency of currently available engine technologies could smooth the transition period before a massive deployment of alternative low-carbon technologies. To date, it seems probable that cars fuelled by electricity stored in batteries or in other ways (wind-produced liquid hydrogen or other renewable energies) and capable of travelling considerable distances will pave the way to a low-carbon transport sector. If implicit or explicit carbon taxes give the right price signals, rational and fully informed consumers would opt for carbon-efficient cars. In the case of market failure, when myopic behaviour and asymmetric information prevent consumers from fully perceiving the lifecycle carbon savings, carbon emissions standards can be a useful tool to achieve higher fuel and carbon efficiency. In 2009, the European Union set emissions-performance standards with a view to reducing the average CO_2 emissions of the new car fleet to 130 grammes per km by 2015 and to 95 grammes per km by 2020. Some European countries have managed to cut the emissions of new cars substantially over the last decade, and Denmark, Portugal and France were in compliance with the 2015 target already in 2010. Poland, starting from a comparatively low average emissions level upon EU entry, has achieved little progress, like its Central and Eastern European peers, and was in the middle of the field in 2010 (Figure 14).

Figure 14. **Average CO_2 emissions per km travelled from new passenger cars in Europe**



Source: Eurostat.

The virtual explosion of the number of cars per inhabitant came at a cost of the expansion of an ever ageing, polluting and fuel-consuming car fleet. The average age of Polish passenger cars is around14 years (against eight years in Western Europe), and almost 70% of cars are older than 10 years. In the aftermath of Poland's EU accession, the number of second-hand cars imported from the EU, mainly from Germany, skyrocketed from close to zero to almost a million per year, as the abolition of the import duty lowered the price of imported cars by 20 to 30%. Today, three-quarters of newly registered cars are imported used vehicles. In 2006 the government wanted to replace the existing one-off registration tax by one calculated on the basis of engine size and EU emissions standards, aimed at reducing emissions other than CO_2. While such a tax would have certainly halted the flood of imported second-hand cars, it was not implemented. Yet, in 2009 the registration fee of 3.1%, applied regardless of the car's age and engine size, was raised to 18.6% for cars with engines bigger than two litres.

The European Commission (2005) argues that annual vehicle taxes should incorporate an element linked to CO_2 emissions and that car registration taxes should be phased out, as they can lead to double taxation for second-hand cars and thus impede the free movement of goods within the EU. Such a solution may be second best compared to taxes proportional to use. Polish passenger-car taxation, which comprises moderately high one-off registration taxes and fees applied to newly registered cars but no annual vehicle taxes, would certainly benefit from an overhaul, along the lines of the Commission proposal. The huge stock of ageing cars cannot be contained any more by a one-off registration tax, especially if not set based on the level of environmental externalities. Instead, a well designed annual vehicle tax could provide powerful incentives for the renewal of the car fleet. Elsewhere in Europe annual vehicle taxes based on CO_2 emissions, in some cases coupled with similar upfront fees and taxes, not rare in Europe, have led to a rapid decline in the average emissions of the overall car fleet, as large, old and heavily polluting vehicles were replaced by small, new and carbon-efficient cars (Table 11). To date, in Poland, taxes related to the purchase, registration, ownership and usage of passenger cars are not linked to carbon efficiency.

If Poland decides to introduce annual car taxes, they should, in addition to a CO_2 component, also have a penalty for local air pollution. Most Polish cars meet only Euro 1 and 2 fuel standards, which are much more lenient than Euro 4 or 5 with regard to air pollutants. For instance, a modern diesel car emits 14 times less particulate matter than older models meeting only Euro 1, CO and NO_X emissions are also considerably lower. A penalty on CO_2 and other air pollutants, increasing over time, preferably in line with the actual social costs of the related negative externalities (climate change, health, and water and soil pollution) could engineer a shift towards newer, cleaner and more energy-efficient vehicles. It is crucial that diesel cars are not treated more favourably than petrol cars, as happens in many countries. Even if diesel cars account for only 20% of the Polish passenger car fleet, diesel represents about 70% of total fuel consumption, reflecting its extensive use in trucks, buses and agriculture.

Company cars represent nearly half of new passenger cars in Poland, midway between Greece's 24% and 60% in Sweden and Germany. If the tax system encourages the private use of company cars over private cars, private-sector employees will drive bigger and more expensive cars than what they otherwise would be willing to buy, and they will add more mileage than they would do if they had to pay privately. The fact that personal income tax for company car use is based on the leasing cost of a comparable car and fuel costs for private use paid by the company are not subject to an explicit benefits tax results in an over-use of company cars for private purposes in Poland.[4] Car taxes should be changed to remove this distortion. In addition, the companies themselves should also be encouraged to rationalise the use of passenger cars by the introduction of environmental taxes similar to those to be applied for private cars.

4. See OECD (2011b) for the case of Israel.

Table 11. **CO_2-based car taxes in Europe, 2010**

	Upfront	% of car net price (2008)	Bonus-penalty	Annual	Annual company car tax
Austria	Fuel efficiency	10%	<120g CO_2/km, +EUR 300 >160g CO_2/km, -EUR 25/g		
Belgium	Tax incentives for cars <115g CO_2/km	4%	<125gCO_2/km, +EUR 1 000 >155gCO_2/km, -EUR 1 500	Discount of -15% for cars <150gCO_2/km	CO_2-based
Denmark	Fuel efficiency (P/D)	170%		Fuel efficiency (petrol/diesel)	
Germany		0%		Base tax based on engine power + CO_2 part EUR 2 per gCO_2/km cars <120g/km exempted (<110g/km in 2012-13; 95g/km after 2014)	
Finland	Linear CO_2-based 12.2% <60g/km 48.8% >360g/km	42%		CO_2-based starting in 2011 EUR 20 to EUR 605	
France		3.4%	<110gCO_2/km >150gCO_2/km		CO_2-based
Ireland	Linear CO_2-based 14% <120g/km 36% >225g/km	36%		CO_2-based EUR 104 to EUR 2 100	
Latvia	CO_2-based LVL 0.3 per g/km <120g/km LVL 5 per g/km >350g/km	2%			
Luxembourg		0%		CO_2-based, exponentially increasing	
Netherlands	CO_2-based (P/D)	36%			
Portugal	Engine size and CO_2-based	37%			
Romania	Based on CO_2, cylinder capacity and Euro emission standards	3.5%			
Spain	CO_2-based 0% <120g/km 14.75% >200g/km	9.75%			
Sweden		0%		CO_2-based + supplement for diesel cars	
United Kingdom	CO_2-based extra fee >165g/km	0%		CO_2-based GBP 0 to GBP 405	

Source: ACEA (2010), http://www.acea.be/images/uploads/files/20100420_CO2_tax_overview.pdf ; Copenhagen Economics (2010).

Some of the new motorways under construction will be run by private companies. Investment costs will be recouped by tolls. At the same time, an electronic collection system for trucks (with a weight of over 3.5 tonnes) was launched in July 2011 on public motorways and major routes, replacing the existing vignette system for heavy-duty trucks (over 12.5 tonnes). The toll is a function of the distance travelled, and the vehicle's weight and Euro emissions standards. Light trucks pay 20% less than heavy trucks and the same as buses, and vehicles meeting Euro 5 standards are charged 50% less than those on Euro 2 (viaTOLL, 2011). While the principle of differentiating according to environmental performance is commendable, properly monetising external costs relating to air pollution would yield much wider differences. The electronic toll system, which lets vehicles pass through the gates without stopping, thus limiting emissions, is initially being run on about 1 600 kilometres of motorways, expressways and selected sections of national roads, but coverage will eventually be extended to 8 000 kilometres of roads under the supervision of national road administration.

The government has recently adopted a railway investment programme until 2013, possibly to be extended until 2015 (Ministry of Infrastructure, 2011). The programme foresees the modernisation of existing railroads aimed at the reduction of travel time and the improvement of passenger safety.

Nevertheless, the government's desire to encourage railroads as part of a sustainable transport mix may be inconsistent with the ongoing expansion of the country's motorway network. Helped massively by EU funds to double its length between 2004 and 2011, the country's 1 000 km long motorway network remains smaller than that of geographically much smaller countries like the Czech Republic or Hungary. The plan is to build a network by 2015 around three major axes, two connecting east and west Poland and the third running from the north to the Czech border. Facing fiscal constraints, the government decided to slow down the expansion of the road network for 2014-20. At the same time, because of savings from lower than expected contract prices and the slow absorption of EU funds in the railway sector, Poland asked the European Commission for permission to relocate funds from railroad projects to motorway construction. This could amplify under-investment in new railroad infrastructure. Part of the railroad network's problem is inefficient management. The pricing system allowing for operating- and possibly also capital-cost recovery, coupled with a truly independent sector regulator, and perhaps with more private sector involvement, is key to seeing railways as a real alternative to roads, both for passenger and freight transport. Indeed, the modal split is strongly biased in favour of roads: rail passenger transport accounts for only 6% of total inland passenger transport, and just 20% of freight is transported by rail.

Box 2. **Recommendations pertaining to climate-change policies**

Carbon tax

- Implicit and explicit carbon taxes should be equalised for sectors outside the EU-ETS and aligned to the EU-ETS prices with a view to achieving a unique carbon price for the whole economy, first by progressively eliminating exemptions from the excise duty for coal and gas for household use. Lump-sum cash compensation for the poor should be provided. Taxes on petrol and diesel should be adjusted to internalise negative global and local externalities.

Electricity production and distribution

- The responsiveness to the price signal for investment in generation capacity should be reinforced by deepening the organised wholesale electricity market (power exchange), improving cross-border interconnections and potentially by privatising electricity generation capacity.
- A long-term national plan for grid development is needed to keep up with demand and allow new installed capacity to be connected. Price regulation should encourage private-sector investment in grid development. Increasing cross-border interconnection capacity should be a priority to spread the burden of EU-ETS over a larger region.
- Investment choices in new power-generation capacity should be backed by transparent cost-benefit analysis. Negative externalities should be accounted for in the tariffs. For nuclear energy, the approval of the estimation of costs of future decommissioning and long-term waste disposal should be insulated from political influence and the independence of the president of the nuclear energy agency should be strengthened by a fixed-term nomination going beyond political cycles and during which he or she cannot be removed. Strict safety and environmental standards should be imposed and enforced to minimise the tail risks of nuclear energy. For natural gas from shale formations, environmental risks should be continuously and effectively monitored, especially with respect to water pollution and methane leakage. For wind, the time needed to obtain a construction permit should be considerably reduced and a one-stop shop opened for contacts with public administration.

- Special attention should be paid to the lifecycle GHG balance of renewable resources, especially of biomass and bio-fuels. Binding sustainability criteria for the use of biomass, including energy crops and woodchip, should be set following the European Commission's proposal. The cost-efficiency advantage of uniform support to renewables via green certificates should be retained. Uncertainty for new investment should be mitigated by extending the time horizon of the scheme.
- A regulatory framework for smart grid deployment should be developed, which, combined with a deeper power exchange, will help implement real-time tariffs for end-users.

Energy efficiency

- The white-certificate scheme should be directly aimed at CO_2 reduction rather than energy savings. It should be targeted at sectors with low responsiveness to the carbon price signal.
- The systems of energy-performance certificates for buildings should be extended to cover CO_2 emissions and other environmental impacts. Certificates should be made more transparent by setting CO_2 classes. Financial support provided for energy-efficiency projects should depend on CO_2 performance. Stricter energy performance standards for new buildings should be properly enforced.

Transport sector

- Incentives in the railway sector for investment in network infrastructure need to be strengthened by private-sector involvement, a truly independent sector regulator and price regulation ensuring efficiency gains and cost recovery.
- An annual vehicle tax, calibrated to vehicles' environmental performance, should be introduced. Taxes should be extended to company cars.

Bibliography

Barth, V. (2008), "ALICE Electricity Sector Country Study: Poland", Carl von Ossietzky University, mimeo.

BP (2011), BP Statistical Review of World Energy June 2011, http://www.bp.com/statisticalreview

Cathles, L.M., L. Brown, M. Taam and A. Hhunter (2012), A commentary on "The greenhouse-gas footprint of national gas in shale formations" by R.W. Howearth, R. Santoro and Anthony Ingraffea, *Climate Change* (forthcoming) http://drydensec.org/sites/default/files/rebuttal%20of%20Howarth%20fulltext.pdf

COGENchallenge (2007), "Small-scale CHP, Factsheet Poland", December.

Committee on Climate Change (2008), "Building a low-carbon economy – the UK's contribution to tackling climate change", The First Report of the Committee on Climate Change, December.

Copenhagen Economics (2010), "Company Car Taxation", Working Paper No. 22/2010.

Energy Regulatory Office (2011a), *National Report to the European Commission, 2011*, July, Warsaw.

Energy Regulatory Office (2011b), *Polish support schemes for renewable and cogeneration sources*, Warsaw, mimeo.

Energy Regulatory Office (2011c), "Position of the President of Energy Regulatory Office on necessary requirements with respect to smart metering systems implemented by DSO E taking into consideration the function of the objective and proposed support mechanism in context of the proposed market model", Warsaw, 31 May, mimeo.

Euroheat & Power (2011), *District Heating in Buildings*, Brussels.

European Commission (2005), "Proposal for a Council Directive of 5 July 2005 on passenger car related taxes", 2005/261, Brussels.

European Commission (2008),"An EU Energy Security and Solidarity Action Plan: Energy Sources, Production Costs and Performance of Technologies for Power Generation, Heating and Transport", Commission Staff working document accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 13 November, Brussels.

European Commission (2010), "Commission adopts biomass sustainability report", IP/10/192, 25 February, Brussels.

European Commission (2011a), A roadmap for moving to a competitive low carbon economy in 2050, Brussels, 8.3.2011, COM(2011)112 final.

European Commission (2011b), "2009-2010 Report on Progress in Creating the Internal Gas and Electricity Market, Technical Annex", *Commission staff working paper*, 9 June, Brussels.

European Council (2011a), 4 February 2011 conclusions, Brussels, 8 March. http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/119175.pdf

EWEA (2010), "*Wind Barriers: Administrative and grid access barriers to wind power*", July.

The Guardian (2011),"Influential MEP calls for shale gas regulation", 30 June.

Grieshop, A.P., C.C.O. Reynolds, M. Kandlikar and H. Dowlatabadi (2009), "A black-carbon mitigation wedge", *Nature Geoscience*, 2 August.

Howarth, R.W., R. Santoro and A. Ingraffea (2011), "Methane and greenhouse-gas footprint of natural gas from shale formations: A letter", *Climatic Change* (forthcoming), http://www.sustainablefuture.cornell.edu/news/attachments/Howarth-EtAl-2011.pdf

International Energy Agency (2010), *Energy Technology Perspectives 2010: Scenarios & Strategies until 2050*, Paris.

International Energy Agency (2011a), "Poland 2011 Review", *Energy Policies of IEA countries*, Paris.

International Energy Agency (2011b), "Are We Entering a Golden Age of Gas? Special Report", *World Energy Outlook 2011*, Paris.

International Transport Forum (2008), "Bio-fuels: Linking support to performance", *Joint Transport Research Centre*, *Discussion Paper*, No. 2008-7, Paris.

Kokkvoll Tveit, A. (2011), "Swedish example shows that nuclear waste storage could be far more expensive than expected", Bellona, 16 August, http://www.bellona.org/articles/articles_2011/waste_costs_sweden.

Kolvits, K. (2008), "Wind Energy in Poland – Potential, Prospects and Pitfalls", joint seminar by demosEuropa and the Danish Embassy, 19 November, Warsaw.

McKinsey (2009), *Assessment of Greenhouse Gas Emissions Abatement Potential in Poland by 2030*, Warsaw.

Metcalf, G.E. (2009), "Tax policies for low-carbon technologies", *NBER Working Paper*, No. 15054.

Ministry of Economy (2009), *Energy Policy of Poland until 2030*, November, Warsaw.

Ministry of Economy (2010), *National Renewable Energy Action Plan*, Warsaw.

Ministry of Infrastructure (2011), *Multi-annual investment programme in the railway sector until 2013 (and 2015)*, Warsaw, http://bip.transport.gov.pl/pl/bip/px_wpik_do_roku_2013_z_perspektywa_2015___po_konsultacjach_spolecznych.pdf

Mott MacDonald (2010), *UK Electricity Generation Costs Update*, Brighton.

NL Agency (2010), "Indirect effects: Macro monitoring and land use planning", Ministry of Economic Affairs, Agriculture and Innovation, November, Utrecht.

OECD (2006), *The political economy of environmentally related taxes*, OECD Publishing, Paris.

OECD (2011a), *Economic Survey of Sweden*, OECD Publishing, Paris.

OECD (2011b), *Economic Survey of Israel*, OECD Publishing, Paris.

Ollagnier, J.-M. (2010), "Réduire le coût de la transition vers une économie décarbonée", *Les Echos*, 17 August.

Perkins, S. (2011), "Green Growth and Transport", *International Transport Forum, Discussion Paper,* No. 2011-02, February.

Polish News Bulletin (2011a), "Renewable Energy Industry Calls for Changes in System", 24 August.

Polish News Bulletin (2011b), "EWEA Optimistic About Development of Wind Energy in Poland", 12 July.

Polish News Bulletin (2011c), "Environmentalists Promoting Wind Farms", 14 July.

Polish News Bulletin (2011d), "Shale Gas from Poland in Two Years?", 10 June.

Polish News Bulletin (2011e), "Shale Gas Exploration Requires Legal Changes", 7 July.

Polish News Bulletin (2011f), "Electronic Tolls will be Launched on Time", 15 June.

Polish News Bulletin (2011g), "EC more restrictive about CO_2", 1 August.

Reuters (2011), "EPA to study natgas fracking in five U.S. states", 23 June.

RE-Shaping (2011), "Renewable Energy Policy Country Profiles", Intelligent Energy Europe, www.reshaping-res-policy.eu.

Shargal, M. (2010), *From Policy to Implementation: The Status of Europe's Smart Metering Market*, Capgemini, http://ddata.over-blog.com/xxxyyy/1/15/80/34/Energie/capgemini-smart-metering.pdf

Sowa, J. (2011), "Implementation of the EPBD in Poland: Status in November 2010", Concerted Action, Energy Performance of Buildings.

Steenblik, R. (2007), "Subsidies: The distorted economics of bio-fuels", *International Transport Forum, Joint Transport Research Centre, Discussion Paper*, No. 2007-3.

Suwala, W. (2010), "Lessons learned from the restructuring of Poland's coal mining industry", Global Subsidies Initiative (GSI) of the International Institute for Sustainable Development (IISD), Geneva.

U.S. Energy Information Administration (2011), "*World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States*", April, Washington.

viaTOLL (2011), "Toll rates", http://www.viatoll.pl/en/heavy-vehicles/viatoll-system

World Bank (2011), *Transition to a low-emissions economy in Poland*, February, www.worldbank.org/pl/lowemissionseconomy.

World Energy Council (2010), *Energy Efficiency: A Recipe for success*, London.

Appendix

Table A1. **Per capita GHG emissions and their decomposition, 2009**

	GHG (tCO^2-eq) per capita for specific sectors				Energy sector		Electricity and heat prod		GDP
	Total	Non-energy	Energy	E&H	GHG/Energy production	Energy prod/GDP	GHG/E&H production	E&H prod/GDP	Per capita GDP (1 000 EUR)
Latvia	4.8	1.6	3.2	0.8	4 020	0.06	1 693	0.04	13
Turkey	4.9	1.2	3.7	1.3	9 994	0.03	5 478	0.02	11
Romania	6.1	2.0	4.0	1.8	3 020	0.12	4 917	0.03	11
Sweden	6.4	1.7	4.8	0.9	1 545	0.10	509	0.05	32
Lithuania	6.5	2.9	3.6	1.0	3 085	0.08	1 387	0.05	15
Croatia	6.5	1.7	4.8	1.0	5 433	0.05	3 202	0.02	16
Hungary	6.7	1.7	5.0	1.5	4 646	0.06	3 412	0.03	17
Switzerland	6.7	1.3	5.5	0.3	3 319	0.04	415	0.02	37
Portugal	7.0	2.0	5.0	1.6	10 612	0.02	3 723	0.02	21
Bulgaria	7.8	1.9	5.9	3.8	4 402	0.12	5 375	0.06	11
Spain	8.0	1.8	6.2	1.6	9 465	0.02	2 992	0.02	27
Slovakia	8.0	2.7	5.3	1.2	4 880	0.06	1 886	0.03	19
Ukraine	8.1	2.5	5.6	1.9	3 146	0.31	3 011	0.11	6
Italy	8.2	1.4	6.8	1.6	15 759	0.02	3 395	0.02	27
France	8.3	2.5	5.8	0.7	2 831	0.07	893	0.03	30
Belarus	9.1	3.4	5.7	3.1	13 606	0.04	3 294	0.08	12
United Kingdom	9.2	1.4	7.8	2.5	3 037	0.08	4 579	0.02	32
Slovenia	9.5	1.7	7.8	3.0	4 329	0.07	3 721	0.03	25
Japan	9.5	0.9	8.6	2.8	11 776	0.02	3 970	0.02	30
Austria	9.6	2.3	7.3	1.1	5 396	0.04	1 243	0.03	35
Poland	**9.9**	**1.8**	**8.1**	**4.2**	**4 600**	**0.10**	**7 842**	**0.03**	**17**
Norway	10.6	2.6	8.1	0.4	176	0.96	153	0.05	48
Greece	10.9	2.0	8.9	4.5	10 290	0.03	10 480	0.02	26
Germany	11.2	1.9	9.3	3.8	5 926	0.05	4 957	0.02	32
Denmark	11.3	2.3	8.9	3.9	2 066	0.13	3 585	0.03	32
Belgium	11.5	2.1	9.5	2.0	6 575	0.04	2 505	0.02	32
Netherlands	12.0	1.9	10.1	3.2	2 650	0.10	4 148	0.02	36
Finland	12.4	2.5	9.9	4.2	3 229	0.10	2 106	0.06	31
Estonia	12.6	1.8	10.7	7.7	3 412	0.20	6 829	0.07	16
Czech Rep.	12.7	2.2	10.5	5.5	3 487	0.14	5 763	0.04	22
Ireland	14.0	4.7	9.3	2.8	28 601	0.01	5 301	0.01	36
Iceland	14.5	8.1	6.4	0.0	441	0.43	9	0.16	34
Russia	15.2	2.7	12.6	5.6	1 422	0.65	3 465	0.12	14
New Zealand	16.4	9.1	7.3	1.4	2 023	0.15	1 583	0.04	25
Canada	20.5	3.7	16.8	2.9	1 478	0.33	1 802	0.05	35
United States	21.5	2.8	18.7	7.1	3 405	0.13	5 843	0.03	42
Australia	25.0	5.9	19.1	9.5	1 348	0.41	9 762	0.03	34

Note: The energy production-to-GDP ratio is multiplied by 1 000 to fit in the table. E&H denotes Electricity and Heating.

Source: OECD calculations based on data obtained from UNFCCC.

Table A.2. **Implicit carbon prices based on excise taxes**

Euros/tonne, 2010:q4

	Petrol	Diesel	D/Petrol	LPG	Natural gas		Electricity		Light fuel oil		Coal
					HH	IND	HH	IND	HH	IND	
Netherlands	323	159	0.49	51	88	14	10	26	96	96	-
Turkey	322	175	0.55	152	0	6	16	7	143	-	0
United Kingdom	302	251	0.83		0	2	0	6	48	48	2
Norway	300	191	0.64	-	-	-	822	0	68	68	-
Greece	299	153	0.51	-	0	0	18	20	8	8	-
Germany	292	174	0.60	54	-	-	133	-	23	23	0
Finland	280	135	0.48	-	10	10	38	11	32	32	17
Belgium	274	146	0.53	0	12	5	76	46	7	7	0
France	271	159	0.59	35	6	8	156	100	21	21	0
Sweden	267	174	0.65		130	39	1937	36	153	25	-
Portugal	260	135	0.52	33	0	0	0	0	79	-	0
Israel	259	191	0.74	-	-	-	0	0	191	-	1
Italy	252	157	0.62	74	-	-	72	98	149	149	0
Denmark	250	144	0.58	-	152	-	160	13	123	21	19
Switzerland	248	217	0.87		28	28	555	555	28	28	8
Ireland	242	166	0.69	-	15	0	0	0	33	18	0
Czech Republic	231	164	0.71	51	0	7	2	2	10	10	2
Slovak Republic	230	136	0.59	0	0	7	0	0	-	0	-
Korea	227	125	0.55	85	22	22	-	-	25	25	-
Slovenia	223	162	0.73	44	23	23	37	30	45	45	-
Japan	223	113	0.51	51	-	0	8	8	7	7	2
Austria	217	143	0.66	-	31	-	127	109	40	40	17
Luxembourg	206	115	0.56	32	-	-	-	-	4	8	0
Hungary	200	135	0.68	55	0	5	0	3	-	-	0
Spain	197	127	0.65	19	0	0	0	0	32	32	-
Lithuania	194	102	0.52	99	0	0	0	3	8	8	-
Estonia	189	146	0.77	41	12	9	14	13	41	41	-
Poland	**187**	**120**	**0.64**	**68**	**0**	**0**	**6**	**6**	**22**	**22**	**0**
Croatia	182	123	0.68	40	0	0	0	0	28	-	-
Latvia	161	120	0.75	75	-	-	0	0	16	16	-
Bulgaria	157	114	0.73	55	0	0	0	2	114	114	-
Romania	155	108	0.70	40	42	19	0	0	108	108	-
Chile	154	32	0.21	0	0	-	0	0	0	-	-
New Zealand	147	1	0.00	-	5	5	0	0	-	0	-
Australia	124	103	0.83	0	-	-	-	-	-	-	-
South Africa	121	92	0.76	-	-	-	-	-	-	-	-
Canada	106	55	0.52	-	0	0	-	-	13	8	-
United States	40	37	0.92		-	-	-	-	-	-	0
Mexico	0	0	-		0	0	0	0	0	0	0

Note: The implied carbon price is computed as the amount of the tax levied per litre times the amount (litres) of fuel that needs to be burnt to reach a CO_2 emission of one tonne of CO_2eq. One litre of diesel (light fuel oil for households and industry), petrol and LPG (liquefied petroleum gas) is assumed to produce respectively 2.7, 2.24 and 1.7 kg of CO_2. It is assumed that 4 535 269 kcal of natural gas generates 1 tonne of CO_2 and that burning 1 kg of coal generates 2.93 kg of CO_2. HH and IND refer to households and industry, respectively.

Source: OECD calculations based on data obtained from International Energy Agency (2011), *Energy Prices and Taxes*, Paris.

WORKING PAPERS

The full series of Economics Department Working Papers can be consulted at www.oecd.org/eco/workingpapers/

952. *Income inequality in the European Union*
(April 2012) by Kaja Bonesmo Fredriksen

951. *Reducing poverty in Chile: cash transfers and better jobs*
(April 2012) by Nicola Brandt

950. *Tax reform in Norway: A focus on capital taxation*
(April 2012) by Oliver Denk

949. *The short-term effects of structural reforms: an empirical analysis*
(March 2012) by Romain Bouis, Orsetta Causa, Lilas Demmou, Romain Duval and Aleksandra Zdzienicka

948. *Short-term gain or pain? A DSGE model-based analysis of the short-term effects of structural reforms in labour and product markets*
(March 2012) by Matteo Cacciatore, Romain Duval and Giuseppe Fiori

947. *Do house prices impact consumption and interest rate?: Evidence from OECD countries using an agnostic identification procedure*
(March 2012) by Christophe André, Rangan Gupta and Patrick T. Kanda

946. *Assessing the sensitivity of Hungarian debt sustainability to macroeconomic shocks under two fiscal policy reactions*
(March 2012) by Pierre Beynet and Edouard Paviot

945. *Non-Keynesian effects of fiscal consolidation: an analysis with an estimated DSGE Model for the Hungarian economy*
(March 2012) by Szilárd Benk and Zoltán M. Jakab

944. *Work incentives and recent reforms of the tax and benefit system in Hungary*
(March 2012) by Tímea Ladányi and Rafal Kierzenkowski

943. *Building blocks for a better functioning housing market in Chile*
(February 2012) by Aida Caldera Sánchez

942. *The impact of changes in second pension pillars on public finances in Central and Eastern Europe*
(January 2012) by Balász Égert

941. *Improving energy system efficiency in the Czech Republic*
(January 2012) by Artur Radziwill

940. *Structural change and the current account: the case of Germany*
(January 2012) by Fabrizio Coricelli and Andreas Wörgötter

939. *Reforming education in England*
(January 2012) by Henrik Braconier

938. *The nature of financial and real business cycles: The great moderation and banking sector pro-cyclicality*
(January 2012) by Balázs Égert and Douglas Sutherland

937. *Fiscal consolidation*
Part 6. What are the best policy instruments for fiscal consolidation?
(January 2012) by Robert P. Hagemann

936. *Fiscal consolidation*
Part 5. What factors determine the success of consolidation efforts?
(January 2012) by Margit Molnar

935. *Fiscal consolidation*
Part 4. Case studies of large fiscal consolidation episodes
(January 2012) by Hansjörg Blöchliger, Dae-Ho Song and Douglas Sutherland

934. *Fiscal consolidation*
Part 3. Long-run projections and fiscal gap calculations
(January 2012) by Rossana Merola and Douglas Sutherland

933. *Fiscal consolidation*
Part 2. Fiscal multipliers and fiscal consolidations
(*forthcoming*) by Ray Barrell, Dawn Holland and Ian Hurst

932. *Fiscal consolidation*
Part 1. How much is needed and how to reduce debt to a prudent level?
(January 2012) by Douglas Sutherland, Peter Hoeller and Rossana Merola

931. *Less income inequality and more growth – Are they compatible?*
Part 8. The drivers of labour income inequality – A review of the recent literature
(April 2012) by Rafal Kierzenkowski and Isabell Koske

930. *Less income inequality and more growth – Are they compatible?*
Part 7. The drivers of labour earnings inequality – An analysis based on conditional and unconditional quantile regressions
(January 2012) by Jean-Marc Fournier and Isabell Koske

929. *Less income inequality and more growth – Are they compatible?*
Part 6. The distribution of wealth
(January 2012) by Kaja Bonesmo Fredriksen

928. *Less income inequality and more growth – Are they compatible?*
Part 5. Poverty in OECD countries
(January 2012) by Mauro Pisu

927. *Less income inequality and more growth – Are they compatible?*
Part 4. Top incomes
(January 2012) by Peter Hoeller