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Abstract

France has a very ambitious environmental-policy agenda, aimed chiefly at cutting greenhouse gas (GHG) emissions but also at dealing with local air and water pollution, waste management and the conservation of biodiversity. The laws that followed the Grenelle de l'environnement encompass policy measures in energy generation, manufacturing, transport, waste management, construction and agriculture to encourage a transition towards a low-carbon economy. The government is committed to an ambitious GHG reduction objective of 75% to be achieved by 2050. This paper evaluates its policies in terms of cost effectiveness, with a special emphasis on: how to impose a unique carbon price in the aftermath of the rejection of the carbon tax by the Constitutional Council; the challenges relating to renewable and nuclear electricity generation; the ways to reduce carbon intensity in the residential and transport sectors; how to improve waste management; and whether external costs related to the use of fertilisers and pesticides are properly accounted for in water management. Whereas considerable progress has been made to "green" the economy, an important challenge that remains is to internalise global and local externalities in all sectors of the economy so as to increase the cost-effectiveness of environmental policies.

JEL-Code: Q410, Q420, Q480, Q520, Q530, Q540, Q580, H230.

Keywords: GHG emissions, global warming, carbon price, abatement cost, renewables, nuclear power, negative externalities, environmental policies, water pollution, waste management.

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Contributing to global climate change mitigation

France's commitments and achievements

The European Union is taking the lead in the global efforts to contain global warming. The EU's action plan sets a 2020 target of cutting emissions by 20% from 1990 levels and 30% if other large non-EU GHG emitters commit to significant cuts. For France, the EU-wide 20% goal is translated into a binding national target of a 14% decline by 2020 compared to 2005, the base year for sectors that are not part of the EU-ETS, primarily the residential, transport and agriculture sectors.[2] To date, in managing to cut its total GHG emissions by roughly 6% between 1990 and 2008, France has gone well beyond its Kyoto commitment to hold GHG emissions at 1990 levels for the period 2008-12 (Figure 4.1). This was one of the better performances among high-income OECD countries.

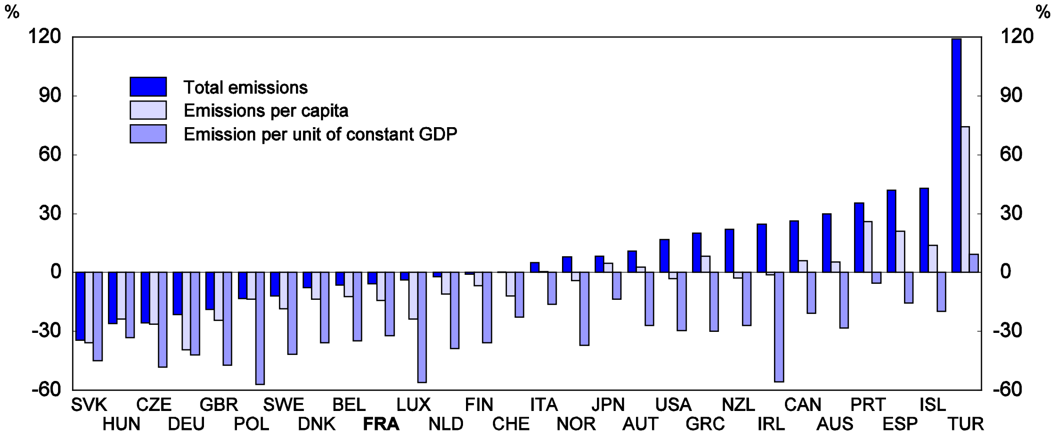
The French government's strong commitment to reduce GHG emissions substantially is also reflected in its long-term objective of a 75% cut from 1990 levels to be achieved by 2050. A climate plan launched in 2004 that has gained momentum since 2008 in the frame of the *Grenelle de l'environnement* (resulting in the first and second Grenelle Laws) encompasses policy measures in energy generation, manufacturing, transport, waste management, construction and agriculture to encourage a transition to a low-carbon economy. According to simulations by the French government, measures taken since 2008 should reduce GHG emissions to 22.8% below 1990 levels by 2020. The simulations also suggest that GHG emissions would decrease by a mere 2.2% in the absence of measures taken since 2008 and that they would rise by 26.6% if no measures had been taken since 1990 (MEEDDM, 2009b).

The potential for further reduction in GHG emissions

GHG reduction targets should be aligned with marginal abatement costs and thus possibly with the absolute level of emissions, given a worldwide target. The government's plans to reduce GHG emissions by 2020 and 2050 are very ambitious, because France has been so far a top performer in terms of the absolute level of GHG emissions. In 2007 and 2008, France emitted less GHGs than its G-7 peers in absolute terms but also when measured on a per capita or per GDP unit basis; in the OECD area, only Sweden and Switzerland did better (Figure 4.2). The main reason for France's outstanding position is that a large proportion of electricity generation uses low-carbon nuclear and hydroelectric technologies. Not considering electricity, France performs much less well (Figure 4.2).

[2]. The target of minus 14% by 2020 compared to the base year of 2005 corresponds to a 12.75% reduction against the benchmark year of 1990.

Figure 4.1. **Changes in % GHG emissions (excluding LULUFC), 1990-2008**[1]



1. LULUFC means land use, land-use change and forestry change.

Source: OECD, *National Accounts* and *Demography and Population Databases*; OECD calculations based on absolute emissions data drawn from UNFCC and Eurostat.

Figure 4.2. **GHG emissions per capita and per unit of GDP, 2008**

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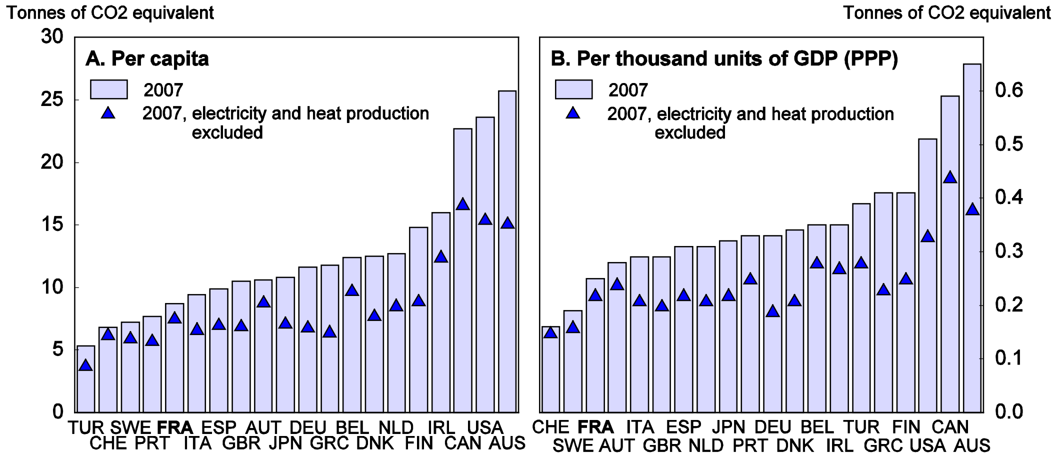

Source: OECD staff calculations based on absolute emissions data drawn from UNFCC; OECD, Economic Outlook 88 database.

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Reducing GHG emissions further will require increasing the carbon efficiency of output. Because some other OECD countries and large emerging economies like China, India and Russia emit up to 13 times more greenhouse gases per unit of GDP than France,[3] cutting GHG emissions in France is unlikely to be the most cost-efficient global solution (Prud'homme, 2009a). But it can be justified on the grounds of equity: if all countries, rich and poor, were allowed to have similar per capita GHG emissions, after reducing global GHG emissions by 50% by 2050, France still would need to lower per capita emissions (Prévot, 2007). Yet the size of the reduction would be smaller than the official objective.

A cross-country comparison of sectoral GHG emissions

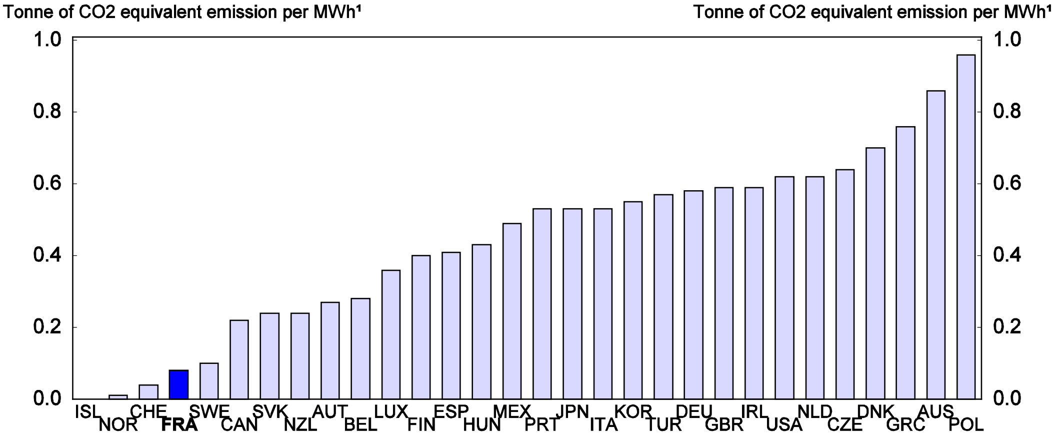
Against this backdrop, cutting GHG emissions by 75% will be much more costly in France than in other major European countries. In 2007 per capita GHG emissions in public electricity and heat production were as low as 0.8 tonne per person in France, while the corresponding statistic ranges from 2.0 tonnes in Italy to 4.2 tonnes in Germany (Table 4.1). Consequently, most of the cuts in France will have to come from other sectors of the economy. A comparison of per capita emissions in other sectors reveals no major differences, with one exception: agriculture, although this reflects the relatively large size of the sector in France, rather than unusually high emissions intensity.

Looking at the sources of lower GHG emissions in Switzerland and Sweden, Europe's two most carbon-efficient economies, may yield additional insights. The main reason why Sweden produces less GHGs than France is because its buildings generate 1 tonne lower emissions per person. This was achieved by a spectacular cut of roughly 70% in the sector thanks to the replacement of heating oil by district heating based on biomass, triggered by an increase in energy and CO_2 taxes (OECD, 2011). By contrast, the key difference in overall carbon intensity of the French and Swiss economies resides in manufacturing, and public electricity and heat production. Lower carbon emissions in the manufacturing sector can be explained by carbon-efficient technologies. Per capita emissions in public electricity and heat generation are 2.5 times lower in Switzerland (0.3 tonne per person) than in France. The two other countries that emit even less GHGs per capita for this purpose in a year are Iceland and Norway with 0.1 tonne per person. But these differences are attributable less to lower per capita electricity consumption than to the lower carbon content of unitary electricity production, as clearly shown in Figure 4.3.

Looking at changes over time, GHG emissions turned out to have been lower in 2007 compared to the benchmark year of 1990 in most sectors of the French economy, with the notable exception of transport where emissions were on a clear rise. While emissions increased in civil aviation, navigation and other transportation, the main driver of this development is road transportation, where GHG emissions increased by around 15% over the period, especially between 1990 and 2001 whereas they remained stable after 2002. Road transport accounted for 93% of total emissions in the transport sector, and 26% of France's global GHG emissions in 2007. The large and rising share of the transport sector in overall GHG emissions is also a prominent feature of other large European countries (with the exception of Germany), and of Switzerland and Sweden.

3. The ratio of 13 is obtained by dividing global GHG emissions compared to nominal GDP in euros for China by the same ratio for France. The sources are the IEA for GHG emissions and the OECD for nominal GDP.

Figure 4.3. **CO_2 emissions per unit of gross electricity production in OECD countries, 2008**



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 wave 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 based on data drawn from IEA and OECD.

Internalising the external costs of GHG emissions

Carbon pricing

The marginal damage of carbon dioxide, also called the social cost of carbon, can be calculated as the net present value of the additional damage caused by the emission of one extra tonne of carbon dioxide (Tol, 2009).[4] Existing estimates show that the mean of the social cost of carbon ranges between EUR 25 and 56[5] (Tol, 2009; Kuik *et al.*, 2009) and that the degree of uncertainty around the mean is huge. For France, the Boiteux report (Boiteux, 2001) proposed a carbon price that was meant to be used for cost-benefit analysis of future infrastructure projects. The report recommended a price of about EUR 32 per tonne expressed in 2009 prices[6] for the period 2000-10 and an annual increase of 3% starting in 2011. Almost a decade later, the Quinet report (Quinet, 2008) commissioned by the French government revisited both the carbon price to be used in the policy debate and decisions with regard to public policies, including public investment. The report used three models and a scenario that reflects the European and French commitments for GHG reductions for calculating the carbon price for 2020 and 2050. On that basis, the following per tonne carbon prices expressed in 2008 prices were put forward: EUR 56 in 2020, EUR 100 in 2030 and EUR 200 in 2050. The government can impose a carbon price to fully internalise the external

4. The social cost of carbon can be measured per tonne of carbon or per tonne of carbon dioxide. One tonne of carbon corresponds to 3.66 tonnes of carbon dioxide (CAS, 2008; Prévot, 2007). This paper uses the social cost of carbon measured on a per tonne of carbon dioxide basis.

5. Tol (2009) reports figures in 1995 USD terms. These figures were adjusted for the cumulated US inflation rate between 1995 and 2009 and converted to euros using the average USD/EUR exchange rate for 2009.

6. The carbon price proposed in the report was EUR 27.3. Accounting for cumulated inflation between 2000 and 2009 gives a carbon price of EUR 31.8 in 2009.

Table 4.1. **GHG emissions – sectoral indicators, 1990-2007**

	Per capita GHG emissions, 2007 (tCO_2eq/capita)						**Percentage changes in total GHG emissions, 1990-2007**						**Share in total GHG emissions, 2007 (%)**					
	FRA	DEU	ITA	UK	SWE	CHE	**FRA**	DEU	ITA	UK	SWE	CHE	**FRA**	DEU	ITA	UK	SWE	CHE
Total excluding LULUCF	**8.3**	11.6	9.3	10.4	7.2	6.8	**-5.3**	-21.3	7.1	-17.3	-9.1	-2.7	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Total including LULUCF	**7.2**	11.4	8.1	10.4	4.9	6.7	**-11.8**	-20.8	7.4	-17.8	12.7	0.5	**..**	..	..	..	..	..
1 - Energy equivalent	**6.0**	9.4	7.7	8.9	5.3	5.6	**0.3**	-21.7	9.5	-10.8	-9.5	-0.3	**72.4**	80.9	83.0	85.3	73.7	81.9
1.A.1 - Energy Industries equivalent	**1.1**	4.7	2.7	3.5	1.2	0.5	**1.5**	-7.1	17.6	-11.3	5.7	36.0	**12.7**	40.8	28.7	33.2	16.5	6.8
1.AA.1.A - Public electricity and heat production equivalent	**0.8**	4.2	2.0	2.9	0.9	0.3	**0.8**	2.9	12.7	-13.3	5.9	18.3	**9.1**	36.6	21.9	28.0	13.0	5.0
1.AA.1.B - Petroleum refining equivalent	**0.2**	0.3	0.4	0.2	0.2	0.1	**14.6**	9.6	58.1	-17.8	8.0	138.3	**2.9**	2.3	4.7	2.4	3.0	1.7
1.AA.1.C - Manufacture of solid fuels	**0.1**	0.2	0.2	0.3	0.0	0.0	**-26.0**	-69.7	4.5	26.4	-9.0	..	**0.7**	1.9	2.0	2.8	0.5	..
1.A.2 - Manufacturing industries and construction equivalent	**1.2**	1.1	1.4	1.3	1.2	0.8	**-10.7**	-42.3	-11.1	-19.9	-9.1	-2.6	**14.9**	9.4	14.6	12.6	16.3	11.4
1.A.3 - Transport – Classification: Total for category	**2.2**	1.9	2.2	2.2	2.3	2.2	**15.4**	-6.9	25.1	11.9	12.1	10.7	**25.8**	16.0	23.4	20.9	31.9	31.9
1.AA.3.A - Civil aviation	**0.1**	0.0	0.0	0.0	0.1	0.0	**8.7**	-22.4	50.5	71.7	-10.7	-45.2	**0.9**	0.2	0.4	0.3	0.9	0.3
1.AA.3.B - Road transportation	**2.0**	1.8	2.0	2.0	2.1	2.1	**15.1**	-4.5	26.6	10.4	14.4	12.4	**24.1**	15.2	21.8	19.3	29.8	31.1
1.AA.3.C - Railways	**0.0**	0.0	0.0	0.0	0.0	0.0	**-46.5**	-55.6	-25.6	32.0	-33.9	27.2	**0.1**	0.1	0.1	0.4	0.1	0.1
1.AA.3.D - Navigation	**0.1**	0.0	0.1	0.1	0.0	0.0	**70.1**	-74.1	-8.3	19.9	-17.6	3.3	**0.6**	0.1	0.9	0.8	0.7	0.2
1.AA.3.E - Other transportation	**0.0**	0.0	0.0	0.0	0.0	0.0	**164.5**	-15.7	88.1	70.7	5.7	-42.5	**0.1**	0.4	0.1	0.1	0.3	0.2
1.A.4 - Other sectors	**1.5**	1.6	1.4	1.7	0.5	2.1	**-3.0**	-38.2	4.8	-8.6	-58.9	-13.3	**17.9**	13.4	14.9	16.0	6.8	30.1
1.AA.4.A - Commercial/Institutional	**0.4**	0.4	0.4	0.3	0.1	0.6	**-1.4**	-44.9	39.3	-19.3	-66.5	-13.3	**5.2**	3.8	4.1	3.2	1.3	9.1
1.AA.4.B - Residential	**0.9**	1.1	0.9	1.3	0.2	1.4	**-1.2**	-34.0	-4.2	-4.4	-72.9	-13.6	**11.1**	9.1	9.2	12.0	2.7	19.9
1.AA.4.C - Agriculture/Forestry/Fisheries	**0.1**	0.1	0.1	0.1	0.2	0.1	**-17.3**	-48.0	-4.7	-19.7	8.5	-6.4	**1.7**	0.6	1.6	0.7	2.8	1.1
1.B - Fugitive emissions from fuels	**0.1**	0.1	0.1	0.2	0.1	0.0	**-51.2**	-60.9	-32.7	-62.1	12.6	-46.9	**1.1**	1.1	1.3	2.1	1.9	0.5
2 - Industrial processes	**0.6**	1.4	0.6	0.5	0.7	0.4	**-28.4**	-3.1	-0.5	-48.3	12.8	-6.1	**7.5**	12.1	6.6	4.4	10.0	6.0
3 - Solvent and other product use	**0.0**	0.0	0.0	..	0.0	0.0	**-33.9**	-38.5	-10.9	..	-11.5	-50.7	**0.3**	0.3	0.4	..	0.4	0.5
4 - Agriculture	**1.5**	0.6	0.6	0.7	0.9	0.7	**-11.0**	-16.5	-8.3	-20.9	-10.1	-9.4	**18.0**	5.4	6.7	6.8	12.9	10.4
5 - LULUCF	**-1.1**	-0.2	-1.2	0.0	-2.2	-0.1	**-80.6**	42.9	-5.1	266.0	36.2	72.3	**-13.5**	-1.7	-12.8	-0.3	-31.3	-1.3
6 - Waste – Classification	**0.2**	0.1	0.3	0.4	0.2	0.1	**-16.7**	-71.5	2.9	-56.8	-38.4	-33.3	**1.9**	1.2	3.3	3.6	2.9	1.3

Note: LULUCF means land use, and land-use and forestry change.

Source: OECD calculations based on data drawn from the UNFCCC, Eurostat and OECD.

costs of GHG emissions. If this price covers the costs of the marginal uncompensated environmental damage, it maximises social welfare and is usually referred to as a Pigouvian tax. Such a tax can be imposed either via a straight tax levied on carbon-intensive goods and services or via a cap-and-trade system.The carbon tax in France

France attempted to introduce a carbon tax in 2009. Yet in December 2009, the Constitutional Council (*Conseil constitutionnel*) rejected the carbon tax that was adopted by parliament in the 2010 budget as inconsistent with the constitution. The carbon tax, initially set at EUR 17 per tonne of CO_2, was intended to put a price, starting in 2010, on the externalities caused by CO_2 emissions of households and firms (except for those covered by the EU-ETS). In its decision, the Council stressed the constitutional principle that protecting the environment is everybody's duty and that exemptions should be aligned with the final goal of the carbon tax, namely the reduction of CO_2 emissions in France. The Council recognised that exemptions can be allowed if justified by the public interest, such as preserving competitiveness, or if a sector is subject to other regulatory measures with a similar objective such as the EU-ETS. The Council pointed out that the tax covered less than half of total CO_2 emissions, mainly due to burning fuel and heating oil, and that 97% of industrial CO_2 emissions were not covered. The participation of selected industries in the EU-ETS does not change the overall picture, given that emissions quotas were allocated for free. The planned exemptions, the Council argued, were clearly inconsistent with the overall objective of cutting CO_2 emissions and with the principle of equal burden sharing to achieve this objective.

Following the failure of the carbon tax in France, there are several options for how to impose an explicit carbon price on sectors not covered by the EU-ETS. One possibility to extend coverage is to introduce a cap-and-trade system for households' fuel consumption (Raux, 2007). Nonetheless, a cap-and-trade system at the household level has potentially high operational costs. Another low-cost option would be to expand the EU-ETS to the final products of actors in the fossil fuel wholesale market, namely to oil refineries or fuel wholesalers (Delpla, 2009). As a result, not only road transportation, but also GHG emissions due to heating of residential and commercial properties would be included, increasing the coverage of the emissions trading system from 30% to roughly 75% of France's total GHG emissions. Finally, a straight carbon tax would probably pass muster with the Constitutional Council if emissions permits were auctioned for French firms in the EU-ETS (in fact they are expected to be in 2013).

The importance of a single carbon price

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. Marginal abatement costs may be higher or lower in some countries or sectors than others. Specifically, the carbon price should not differ across sectors on the basis of the existence of low-carbon alternative technologies or because of different demand elasticities to the price of carbon-intensive products. Instead of granting exemptions and reductions to the carbon tax or emissions permits, direct transfers and compensation should be used to maintain cost-effectiveness (OECD, 2006). Revenues from a carbon tax or permit auctioning could be used to compensate poor households or to decrease distortionary taxes such as taxes on labour and capital to counteract the negative effects of a carbon tax or existing distortionary tax policies on employment and investment (called revenue recycling or the "double dividend"). Moreover, tax revenues could be used to finance increased R&D in carbon-abatement technologies.

Climate change mitigation policies in France: the Grenelle de l'environnement

The wide range of implied carbon prices

A number of excise taxes (*Taxes intérieures sur la consommation*, TIC) are levied on fossil energy products in France; the most prominent is the excise tax on fuels (*Taxe intérieure sur les produits* *pétroliers* – TIPP), which generates the bulk of environmental tax revenues (1.3% of GDP in 2008) (Callonnec, 2009). Others are the excise tax on natural gas (*Taxe intérieure sur la consommation de gaz naturel*, TICGN) and coal (*Taxe intérieure de consommation sur les houilles, lignites et cokes*, TICC). Unfortunately, the carbon price implied by these various excise taxes varies considerably across different fossil energy products (Table 4.2). For example, the implicit carbon price derived from the excise tax in 2009 amounted to EUR 271 for petrol and to EUR 159 for automotive diesel, both well above the OECD average. These figures suggest that diesel is favoured unduly compared to petrol, as in all other OECD countries. The distortion between automotive fuels and other fossil energy products is much larger as the latter are taxed at extremely low rates, implying carbon prices at least 90% lower than for automotive fuels. The most extreme cases are natural gas for households and coal used for electricity production and household heating, which are not taxed at all (Table 4.2). Nevertheless, electricity production-related GHG emissions are covered by the EU-ETS.

Table 4.2. **Implicit carbon price based on excise tax content, 2009:q3**

	Petrol	Diesel	Ratio of diesel over petrol	LPG	Natural gas		Light fuel oil		Coal	Electricity	
					HH	IND	HH	IND		HH	IND
Netherlands	317	156	0.5	42	85	46	94	94	..	4	..
Turkey	312	162	0.5	155	0	5	132	..	0	13	6
Germany	292	174	0.6	54	..	..	23	23	0	0	..
United Kingdom	281	233	0.8	..	0	3	45	45	0	0	5
Finland	280	135	0.5	..	10	10	32	32	0	19	6
Belgium	274	131	0.5	0	..	..	7	7	0	..	..
Norway	271	173	0.6	..	..	..	61	61	..	1707	0
France	271	159	0.6	35	0	6	21	21	0	139	87
Portugal	260	135	0.5	32	0	0	65	..	0	0	0
Italy	252	157	0.6	74	..	..	149	149	0	57	78
Denmark	251	142	0.6	..	135	135	108	11	19	128	9
Sweden	237	154	0.7	..	..	..	135	22	..	..	..
Slovak Republic	230	178	0.8	0	0	8	0	0	..	0	0
Ireland	227	152	0.7	..	0	0	18	18	0	0	0
Switzerland	220	189	0.9	..	10	10	9	9	7	73	73
Austria	217	143	0.7	..	31	..	40	40	0	76	65
Czech Republic	207	144	0.7	50	0	6	10	10	2	2	2
Luxembourg	206	112	0.5	32	..	3	4	8	0	26	..
Spain	195	126	0.6	19	0	0	32	32	..	14	9
Korea	188	109	0.6	74	19	19	22	22	..	..	..
Japan	186	94	0.5	43	..	0	6	6	2	5	5
Hungary	184	127	0.7	..	0	5	..	..	0	0	2
Greece	183	112	0.6	..	0	0	112	112	..	..	..
Poland	176	101	0.6	64	0	0	21	21	0	5	5
New Zealand	112	1	0.0	..	4	4	..	0	..	0	0
Australia	99	82	0.8	0	..	..	..	..	..	..	..
Canada	80	48	0.6	..	..	..	6	6	..	..	..
United States	38	35	0.9	..	..	..	..	..	0	..	..
Mexico	0	0	..	..	0	0	0	0	0	0	0
Average	208	126	0.6	45	16	13	46	31	2	103	19

Note: Average refers to the unweighted average. 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. 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.

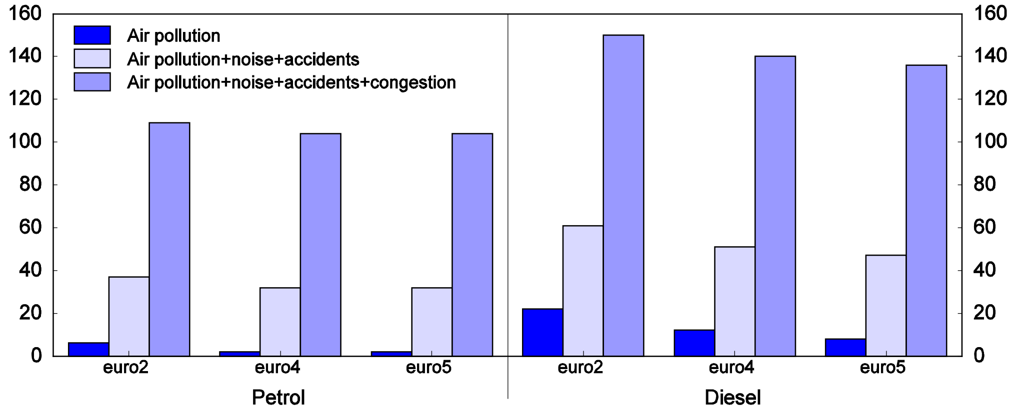
Source: OECD calculations based on data obtained from International Energy Agency.

Hence, the carbon prices discussed above cannot be viewed as effective prices because a number of exemptions and reductions exist and the costs of other negative externalities are not accounted for. According to Callonnec (2009), the effective carbon price that accounts for the exemptions and reductions is EUR 155 per tonne of CO_2 for fuel and EUR 7 for non-fuel fossil energy products. The major excise tax exemptions concern: *i*) fuel used for aircraft and for maritime navigation and fishing (excluding private jets and private boat use); *ii*) fossil energy products for electricity generation excluding cogeneration; *iii*) natural gas and coal for private consumption of households (including collective heating); and *iv*) fossil energy products used in energy-intensive industries such as metallurgy and chemistry. Callonnec (2009) points out that exemptions for coal cover around 92% of France's coal consumption, but most of the industries exempted from the tax are covered by the EU-ETS, justifying those exemptions. The major tax reductions include: *i*) a partial reimbursement of 3.6 cents per litre of fuel for trucks, agricultural vehicles of over 7.5 tonnes and buses; and *ii*) a partial reimbursement of 12 cents for diesel and 24 cents for petrol for taxi drivers. An additional excise tax reduction for bio-fuels, first introduced in 1992, was 21 cents per litre for bio-petrol and bio-diesel in 2009 but fell to 14 cents in 2011. This implies an upward carbon price adjustment for bio-fuels, with the relative price of biodiesel to that of bio-petrol moving closer to that for conventional fuels.

The carbon prices shown in Table 4.2 are substantially upward biased since part of the taxes can be ascribed to negative local externalities, which are not taken into account for the calculations. As a matter of fact, burning fossil energy sources releases into the atmosphere particulate matter, nitrogen oxides, sulphur dioxide, ozone and volatile organic compounds that damage human health, degrade buildings, result in agricultural crop losses and impact on biodiversity and ecosystems by polluting soil and water. Further negative externalities include noise pollution, accidents not covered by private insurance and bottleneck and flow congestions resulting from the use of vehicles. 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), the vehicle emission standard applied (Euro I, II, III, IV) and the type of externalities considered (Figure 4.4). When considering the costs of local negative externalities, the implied carbon price for automotive fuels decreases significantly in absolute terms, and the relative distortion in favour of diesel rises as the local external costs of burning diesel are higher than petrol. If only air, soil and water pollution and damage to the landscape are considered, the carbon price of diesel drops by EUR 50/tonne, while it does not change much for petrol. Adding noise and accidents to air pollution results in a negative carbon price for diesel and in a carbon price of around EUR 100/tonne for petrol (Figure 4.5). Considering negative local externalities relating to congestion on top of noise, accident and air pollution yields massively negative carbon prices both for petrol and diesel. Nevertheless, excise taxes might not be the most efficient way to deal with some externalities. For example, the external costs of accidents, including time losses, could be covered by private insurance, while those related to congestion could be taken care of by road/congestion pricing.[7]

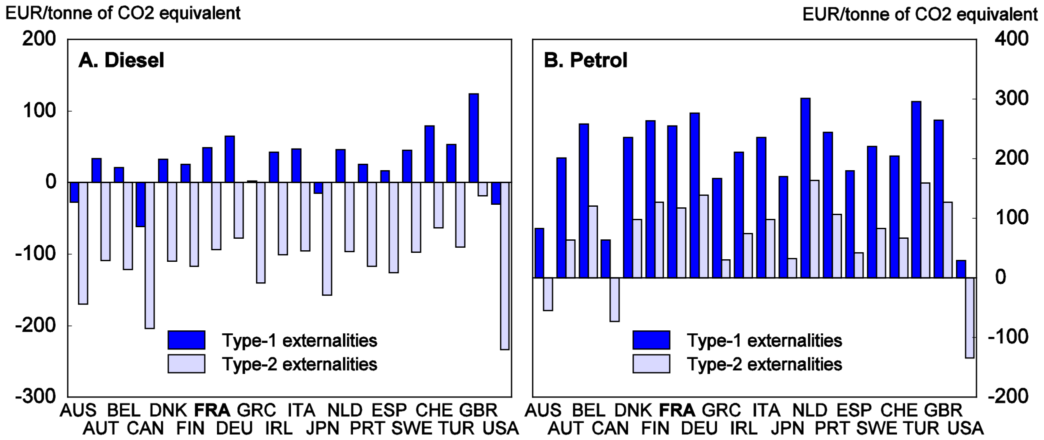
[7]. Environmental taxes are mainly aimed at correcting negative externalities. Using them beyond the level that would correct those externalities to raise tax revenues creates more distortion that an increase in VAT.

Figure 4.4. **Estimated external costs of petrol and diesel cars (EUR cents/litre), 2009**



Source: The external costs of noise pollution, accidents and congestion are taken from Persson and Song (2010, The land transport sector: policy and performance, *OECD Economics Department Working Paper*, No. 817, Table 5.9). The cost of air pollution for Germany published in CE DELFT (2008, *Handbook on estimation of external costs in the transport sector)* is used for all countries. In this figure, air pollution also contains soil and water pollution and damage to the landscape. The original figures refer to 2000 prices and are converted to 2009 prices by using the cumulated inflation rate of the EU25. Euro2, 4 and 5 refer to vehicle emission standards.

Figure 4.5. **The implied carbon price in automotive excise taxes if the costs of local negative externalities are taken into consideration**[1]



1. The implicit carbon tax is obtained by using the same methodology as in Table 4.2; the basis of the calculation is the excise tax from which two sets of external costs are reduced: 1) the external cost of air pollution (type-1 externalities); 2) the external cost of air pollution, noise and accidents (type-2 externalities).

Source: OECD calculations.

France is a far cry from having a unique carbon price. The differences in existing implied carbon prices should be decreased gradually by phasing out current tax reductions and exemptions, by increasing the carbon price of underpriced products such as coal and natural gas and by correcting the distorted relative price of diesel and petrol. A uniform carbon tax levied on top of existing taxes would not allow this goal to be achieved. This is all the more important because non-existent or very low carbon prices for several fossil energy products are tantamount to direct subsidies that result in overconsumption of those sources of energy (Metcalf, 2009). When adjusting relative carbon prices policymakers should of course consider the external costs of local pollution.[8]

The "Grenelle de l'environnement"

Official estimates suggest that existing and new measures would allow emissions in sectors outside the EU-ETS to be reduced by 18.3% between 2005 and 2020, compared to a -14% target for France within the EU's burden-sharing plan in these sectors (MEEDDM, 2009a). The government expects the new measures taken to impact almost exclusively on energy use in electricity generation, manufacturing, transport, the tertiary sector and agriculture, with a cut of 29% in GHG emissions compared to the scenario of no additional measures taken, whereas GHG emissions not related to energy use in industrial processes, agriculture and waste management would either remain unchanged or fall only marginally (MEEDDM, 2009b). Another objective is to increase the share of renewable energy to 23% in total final energy consumption by 2020. In fact, the French government's climate change mitigation policy can be viewed as a transposition of the EU's triple 20 plan according to which a 20% reduction in GHG emissions by 2020 compared to 2005 should be achieved by cutting energy consumption by 20% and increasing the share of renewable energy to 20% in total energy consumption.

Smoothing peak demand

Given that roughly 90% of France's electricity production is virtually carbon free thanks to its stock of nuclear and hydroelectric power plants, a further decarbonisation should target the remaining 10%, which mainly relates to semi-base and peak electricity production. Coal-fired power plants should be replaced by fast-reaction natural gas-fired plants, and peak demand should be smoothed to decrease the demand for high-carbon electricity produced by fossil fuel-fired plants. Nonetheless, the *Grenelle de l'environnement* aims at a considerable increase in the share of renewable energies in total electricity production. Against this background, a careful analysis should determine the least-cost options.

Electricity generation in France is characterised by an excess base-load capacity reflected in electricity exports, and an increased peak demand that can be covered only by electricity imports during some 60 hours per year (Rapport Poignant-Sido, 2010). Serving electricity demand during peak periods requires rapid-response capacities as demand and supply need to be balanced continuously in the electricity grid. Quick-response generation capacity usually relies on high-carbon content technology, mostly oil in France's case. As a result, smoothing peak demand can contribute to lower GHG emissions. Peak demand has daily, weekly and annual patterns, the latter being mostly associated with the heating season and cold waves since a considerable number of French households use direct electric heating or have switched recently from fossil fuel to alternative heating technologies such as heat pumps that use electricity as an input. The seasonal pattern in electricity demand can be smoothed in two complementary ways: smoothing demand and lowering the carbon content of semi-base and peak supply.

Demand can be smoothed to lower the reliance on high-carbon power stations serving peak demand.

- Off-peak and peak electricity tariffs can help smooth intraday demand, especially if the price of electricity is calibrated to change consumer behaviour. Special tariff (so-called peak day withdrawal or PDW) packages had been introduced to help smooth demand over longer time periods by offering electricity at a very high price on pre-announced days for which high demand is forecast. At present, the PDW tariff is no longer available to new customers. Although interesting in principle, this tariff was poorly designed and did not allow full cost recovery. The

8. Existing exemptions could be reassessed on the basis of all global and local externalities.

Poignant-Sido report (2010) suggests a progressive but comprehensive transition from flat to time-varying tariffs.

- The French electricity distributor (Electricité réseau distribution France, ERDF) is currently trialling a new generation of communicating electric meters called "Linky" that will provide a precise indication of users' load curves as well as two-way communication from and to users. It will serve as a platform for new services, which will allow users greater control over their consumption, especially during peak hours. A recent study by the consulting company Accenture 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). The "smart grid" opens new perspective thanks to remote control services that enable the network operator to switch off high electricity consumption devices such as electric radiators, air conditioners, hot water tanks or heat pumps for a limited period of time during peak demand without causing major disruption for the consumer. The Poignant-Sido report recommends that all new electric heating and air-conditioning appliances should be equipped with devices which allow the network operator to transmit a signal to switch them off for a predetermined period of time. Indeed, the French company Voltalis already offers to French households the 'Bluepod' box, which switches off the aforementioned devices if necessary. If demand exceeds electricity production, the transmission network operator (Réseau de transport d'électricité, RTE) contacts Voltalis, which can withdraw demand in real time by modulating electricity consumption in many households via the 'Bluepod'.[9] Furthermore, seasonal consumption could be also reduced by modernising France's public street lighting and by an information campaign promoting lower recommended heating and higher air-conditioning target temperatures (Rapport Poignant-Sido, 2010).

On the supply side, electricity produced during periods of low demand relying on low-carbon technology such as nuclear or renewable energies should be stored and then used when demand is high. Currently, the only technology available on an industrial scale is electricity stored in the form of water behind dams. Yet, there are strong geographical and ecological constraints on a significant expansion of hydropower capacity in France. New technologies, including electricity storage with air compression, may change the *status quo*. In addition, the electricity sector's multi-year investment plan recognises the scope to cut the carbon content of the semi-base-load by investing in gas-fired power plants to replace coal-fired plants but nevertheless emphasises the need to maintain oil-fired plants to meet peak demand (MEEDDAT, 2008a).

Maintaining and modernising the nuclear stock and dealing with its waste

Crucial to maintaining a low-carbon electricity generation capacity is to keep France's ageing nuclear stock operational. Its 58 reactors in the 19 nuclear power stations were built between 1979 and 2000 and had an average age of 23 years in 2009 (IEA, 2010). The first reactors will reach the end of their planned lifetime of 40 years[10] towards 2020, but EDF, the national electricity supplier that operates all the reactors,

9. From a legal standpoint, the question of who has to pay for electricity that is produced but is not delivered by suppliers in the event of a major withdrawal of demand has not been settled. Even though the CRE ruled in favour of EDF that Voltalis – which is paid by the RTE like the suppliers – should compensate EDF for the electricity generated and supplied to the network but not consumed, the dispute will be settled in the *Conseil d'Etat*.

10. There is no legal limit in France on the operating life of nuclear reactors, even through the licences to create nuclear reactors issued by the French administration are tacitly based on a lifetime of 40 years. However, all nuclear reactors must be granted an operating licence validated by the Nuclear Safety Authority (ASN) every ten years. Consequently, extending the lifetime of a number of reactors from 30 to 40 years will depend on the opinion of the ASN (ASN, 2010).

is seeking to extend their lifespan to 60 years, as suggested by the Roussely report (Roussely, 2010), subject to the approval of the Nuclear Safety Authority (*Autorité de sûreté nucléaire*, ASN). In the meantime, in 2007 EDF started the construction of a "third-generation" European Pressurised Water Reactor (EPR) and plans a second one; they offer a higher level of safety. But the new reactors will produce electricity at a higher cost than existing nuclear capacity for which investment costs are largely written off. The New Law on the Organisation of the Electricity Market of 7 December 2010 (*Nouvelle loi du marché de l'électricité*, NOME) opened 25% of EDF's historical nuclear power generation to alternative suppliers who will be able to buy electricity from EDF for their domestic needs at a price which will be determined by the government until 2015, and by the energy regulator (*Commission de regulation de l'énergie*, CRE) thereafter, and which will have to reflect the economic conditions of the historical installed nuclear capacity. In the spirit of the Champsaur report (Champsaur, 2009), the NOME recommends that the access price for historical nuclear power should be based on the future costs of maintaining the historical installed nuclear capacity in operational condition and extending its lifetime, in addition to historical costs of past investments that have not yet been amortised and operating costs. Taking a step forward, the Roussely report suggested that investment costs related to the renewal of the nuclear stock should also be reflected in the access and retail prices. This would imply a major but progressive increase in the regulated price of electricity.[11]

France has the second largest stock of nuclear waste in the developed world, chiefly as a result of its large civilian nuclear programme (Figure 4.6). The stock of very low, low- and intermediate-level radioactive waste amounted to over 1 million cubic metres at the end of 2007. At that time, approximately three quarters of that waste was stored in final depositories, while the stock of high-level radioactive waste was 2 300 cubic metres, all in intermediary storages. According to the Nuclear Safety Agency (Autorité de sûreté nucléaire, 2010), the stock of very low, low- and intermediate-level waste will double by 2030. The urgency of constructing long-term depository sites for all levels of radioactive waste, addressed in the Law on Sustainable Management of Radioactive Materials and Waste (Loi no. 2006-739 du 28 juin 2006) became evident after a recent inquiry by ASN that revealed major weaknesses at a temporary storage site of the company AREVA in La Hague (Le Monde, 2010). The National Agency for Radioactive Waste Management (*Agence national pour la gestion des déchets radioactifs*, ANDRA) is in charge of taking the lead in finding appropriate sites for near-surface disposals for long-life, low-level waste and for deep disposals for intermediate- and high-level waste (IEA, 2010). The Roussely report urges ANDRA to join forces with EDF and other actors in the French nuclear industry to meet the deadline of 2015 for applying for a construction licence for a deep geological storage facility.

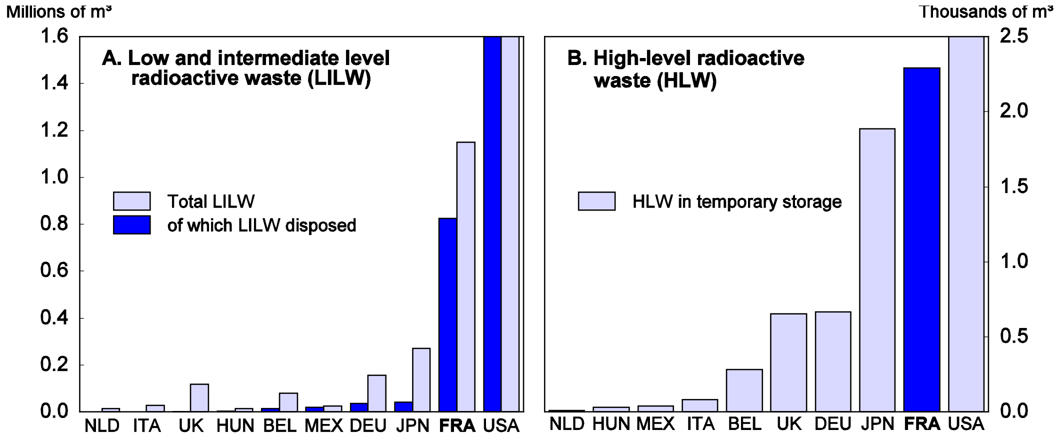
According to the law, the costs of waste disposal and decommissioning have to be covered by the nuclear industry (EDF and AREVA), and provisions must be made for this purpose. In the case of waste storage, an estimate drawn up by ANDRA (National Agency for Radioactive Waste Management) is used as a basis for assessing the size of the provisions the operator needs to make. These costs were estimated to amount to around 1% of production costs in 2002 and between EUR 21 and 26 billion in 2009 (National Assembly, 2011). According to the Court of Audit, deep geological storage would cost between 13.5 and EUR 16.5 billion (Cour des Comptes, 2006). By contrast, provisions for decommissioning are estimated by EDF. But they have to be validated by EDF's Nuclear Commitments Monitoring Committee, of which the Director of Energy and Climate from the Ministry of Energy is a member. A national evaluation committee, whose mandate was renewed on 10 August 2010, is tasked with checking that these provisions are properly funded. By way of example, by 2010, EDF had set aside EUR 12.4 billion of financial assets to finance these provisions. At the same time, all future costs of decommissioning and nuclear waste

11. Regulated prices will be phased out after 2015 for large and medium-sized businesses but will be maintained for households for an indefinite period of time.

management are estimated at around EUR 30 billion in present value at end of 2010.[12] EDF has to constitute a portfolio of financial assets covering those costs by 2016 (rather than 2011 as initially planned).

Figure 4.6. **Radioactive waste stocks, 2007**

m3, low- and intermediate-level radioactive waste LILW (left) and high-level radioactive waste HLW (right)



Source: IAEA (http://nucleus.iaea.org/sso/NUCLEUS.html?exturl=http://newmdb.iaea.org/) and Autorité de sûreté nucléaire (2010, *Annual Report 2009*) for France.

Encouraging other forms of renewable energy

The French government uses two main instruments to promote renewable energy. First, the tax system includes a tax credit for the purchase of equipment, and a reduced VAT rate of 5.5% is applied to equipment used for investment in small solar energy plants (<3kWe). Second, mandatory feed-in tariffs imposed on EDF or local distribution firms and set by ordinance above the market price of electricity for terms of up to 20 years have been introduced to ensure that electricity producers can at least break even on investment. In addition, feed-in tariffs are often used to support infant industries or innovative activities, although broader and less targeted support, including access to venture capital and an innovation policy that encourages basic and applied research, would seem to be more effective. Feed-in tariffs were first introduced in 2001-02 for electricity generation technologies that make use of solar, wind, tidal wave, geothermal and hydro energy, biomass and biogas. They were revised upwards for solar, geothermal and hydro energy and biogas but were rregressive for wind. There is a large dispersion in feed-in tariffs across renewable energies. But there is also substantial variation for a given source of energy. Feed-in tariffs may depend on installed electricity generation capacity, the specific technology used (offshore *versus* onshore wind, rooftop or ground-based solar panels), the geographic location (metropolitan France *versus* Corsica and overseas departments for solar and geothermal energy, geographical situation on a North/South

12 . The legislation also requires operators to submit a report to the Ministry of Energy every three years in which they describe the evaluation of charges, the methods used to calculate provisions and the choices made in terms of the composition and management of assets assigned to covering provisions, whose management procedures are set out in government Decrees. The Nuclear Safety Authority issues an opinion on the three-yearly reports by operators in the area that falls within its jurisdiction (strategy towards decommissioning and the management of spent fuel and radioactive waste). The government also relies on expert advice provided by the Insurance inspection unit (*Corps de contrôle des assurances*) and the French Treasury Agency (Agence France Trésor). Finally, in July 2010, the Ministry of the Environment commissioned a report on the transparency of the nuclear fuel cycle which usefully supplemented the three-yearly report.

gradient in metropolitan France), energy efficiency (biogas and biomass) and the season of the year (winter *versus* summer for hydroelectric power plants). Two important issues with regard to feed-in tariffs are: the implicit subsidies to producers due to what is for a set period of time an above-market selling price; and the cost of an avoided tonne of CO_2 equivalent GHG emission due to the specific technology supported by feed-in tariffs.

In early 2010, this difference between feed-in tariffs and market prices was particularly high for solar energy, reaching 27 to 54 cents per kWh with a wholesale market price of around 6 euro cents per kWh. In fact, guaranteed feed-in tariffs for photovoltaic energy were 7 to 14 times higher than the market price of electricity (Table 4.3a). In September 2010, the feed-in tariff was lowered by 12% for large-scale installations, and as of 2011 the budget bill lowered the tax credit granted to small installations from 50% to 25%. The ratio ranges from 3 to 4 for biomass, geothermal and tidal power, while it is below 3 for wind, hydroelectricity and biogas. Feed-in tariffs for solar energy in France were among the highest in the OECD (only Portugal provides more generous subsidies), while those for biogas were and remain the lowest (Table 4.3b).

While on the rise, the share of specific renewable energies in France's gross electricity production were below the OECD average in 2008. For instance, whereas wind accounted for more than 10% of electricity production in Germany, Denmark and Spain, its share in France was a mere 1%. Similar conclusions can be drawn for solar and geothermal energy and combustible renewables. By contrast, the share of electricity produced using tidal power is the highest in France, though it is quantitatively not very important, accounting for only 0.1% of gross electricity production. It should be recognised, however, that renewable energies such as wind and solar energy cannot replace base load and semi-base load on a large scale due to intermittence unless technological progress is made to store electricity, for instance using compressed air. This is being deployed in a demonstration power plant of the German electricity supplier RWE (RWE, 2010).

Overall, subsidies implied by feed-in tariffs received by French electricity producers using renewable energy (except for hydropower)[13] are estimated to be EUR 0.5 to 1 billion per annum, which corresponds to 0.02%-0.05% of GDP.[14] A large share goes to wind and biomass. At the same time, subsidies directed at solar energy were low in 2009, due to the fact that, despite extremely high feed-in tariffs, the installed solar capacity remained low.[15] When compared to other OECD countries, the overall amount of subsidies in 2009 therefore seems moderate: direct subsidies to renewable electricity producers in particular in Germany but also in Italy and Spain are estimated to be higher by a factor of 5 to 10, as a percentage of GDP, than in France.

The design of feed-in tariffs in France is rather simple: they are fixed separately in absolute monetary values that are revised only occasionally. Feed-in tariffs are not reviewed systematically to respond to trend declines in the cost of renewable-energy-based power and can therefore generate high rents for electricity producers. Following Germany's example, degressivity has been recently introduced in France with two decreases in 2010 in the feed-in tariff for solar energy and a scheduled regular decrease for wind energy of -2% per year (since 2008), which will eventually make feed-in tariffs converge to market prices.

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13. Table 4.3b contains estimates for hydroelectric power generation, but these figures probably overestimate subsidies because hydroelectric plants built a long time ago do not benefit from the high feed-in tariffs, and a large proportion of such power comes from older plants.

14. These estimates are lower-bound estimates for the overall level of subsidies because they do not account for favourable tax treatment and the external costs of electricity generation that are not reflected in taxes.

15. This is due to the technical constraints faced by the network operator in connecting massive numbers of facilities to the grid. A significant improvement in the situation was expected in 2010.

In addition, the Decree of 9 December 2010 suspended the requirement to purchase solar energy produced by certain installations for a period of three months in order to introduce a new regulatory framework for the sector which in particular would include annual volume targets (in terms of installed capacity) (Chauveau, 2010).

Table 4.3. **Feed-in tariffs and implied producer subsidies in Europe**

	Panel A. Feed-in tariffs, 2009-10						
	The ratio of feed-in tariffs to average market price of electricity production						
	Solar	Wind	Biogas	Biomass	Geothermal	Hydro	Tidal wave
Austria	7.7-11.8	1.9	4.4		1.9		
Belgium	3.6-10.8	1.6-2.2		1.6-2.2			
Czech Republic	12.8	2.1	2.6	2.6	4.1	2.1	
Denmark		1.1-2.6					
Finland		1.8	1.6-2.7				
France	**7.3-13.5**	**1.9-3.0**	**1.0-2.0**	**2.9-4.1**	**2.8-3.5**	**1.5-2.4**	**3.5**
Germany	8.5-11.1	2.4-3.3	2.0-3.0	2.0-3.0	2.7-6.3	2.0-3.3	
Greece	5.6-7.7	1.2-1.0					
Ireland		3.5-1.4	1.8-4.7	3.0-3.5		1.8	
Italy	4.9-6.6	4.2	2.5-4.2	3.1	2.8		4.8
Netherlands	2.3	2.3		2.3		2.3	
Portugal	8.9-16.5	0.7-1.3				1.1	3.7
Slovakia	10.9	2.1	3.2	2.9			
Spain	8.1-8.6	2	2.2-3.5	1.5-4.3	1.8-1.9	1.9-2.1	1.8-1.9
Switzerland	6.0-11.1	3	2.6-4.2	0.4	3.4-6.0	1.1-3.9	
United Kingdom	8.8-12.4	1.3-10.3	1.6	0.7-2.7		1.4-6.0	

	Panel B. Direct producer subsidies implied by feed-in tariffs, 2009							
	EUR million							**% of GDP**
	Solar	Wind	Biogas	Biomass	Geothermal	Hydro	Tidal wave	**Total, excl. hydro**
Austria	6-9	90	75		0.1			**0.05-0.06**
Belgium	18-67	23-47		62-129				**0.03-0.07**
Czech Rep.	40.7	14	21	92	0	129		**0.12**
Denmark		20-538						**0.01-0.24**
Finland		11	3-8					**0.01-0.01**
France	**44-88**	**302-674**	**1-31**	**120-193**	**0**	**1 397-3 662**	**53**	**0.02-0.05**
Germany	1 805-2 426	2 009-3 446	487-972	506-1 009	1-4	885-2 065		**0.20-0.33**
Greece	2	4-27						**0.00-0.01**
Ireland		51-296	4-17	5-6		40		**0.04-0.19**
Italy	206-299	1 394	168-352	421	690			**0.19-0.21**
Netherlands	3	253		199		5		**0.08**
Portugal	50-98	0-96				24		**0.03-0.12**
Slovakia	0	0	1	33				**0.05**
Spain	1 724-1 846	1 422	29-62	36-263	0	1 277-10 367		**0.31-0.34**
Switzerland	8-16	2	14-28	0	0	224-5 205		**0.01-0.01**
United Kingdom	5-8	119-3 175	159	216		126-1 765		**0.02-0.23**

Source: Panel A: OECD calculations based on data on feed-in tariffs obtained from official sources and market prices of electricity exchanges. The ranges refer to the lowest and highest feed-in tariffs for a given energy source. Panel B: OECD calculations. The amount of subsidy is calculated as the lower and upper-bound feed-in tariffs in excess of the market prices multiplied by electricity production from a given energy source in 2009.

The costs implied by the feed-in tariffs of abating one tonne of CO_2 equivalent GHG emissions depend crucially on two parameters: the excess of the feed-in tariff over the market price and, very importantly, the carbon-intensity of the power generation technology that is displaced by the subsidised technology.[16] Previous OECD work (OECD, 2004a) computed the abatement costs of measures promoting renewable sources of energy by assuming that investment in electricity production based on renewable energies will replace natural gas-fired combined-cycle turbines as the benchmark technology that would be a natural choice for increasing capacity. We take a different view and argue that two different benchmarks should be used. It should be stressed that the abatement costs calculated here are lower-bound estimates, given that investment subsidies are not taken into account.

The first benchmark is the most carbon-intensive technology, namely coal-fired power plants. This choice permits the comparison of the least-cost abatement options in each country.[17] As reported in the upper panel of Table 4.4, the abatement costs are a linear function of the feed-in tariffs in excess of the market price of electricity (as carbon intensity for the displaced technology is held constant across countries): abating GHG emissions in the French electricity sector appears to be the most expensive if photovoltaic is the replacement technology (EUR 270-540 per tonne of CO_2 avoided) and costs the least for biomass (EUR 2-44 per tonne of CO_2 abated). These abatement costs are, respectively, among the highest and lowest in the OECD. Abatement costs for other sources of renewable energy are closer to the OECD average.

The second and perhaps more appropriate benchmark is the country's actual electricity mix if a significant rise in the share of renewable energies crowds out all existing technologies. For France, the 23% objective for renewable energy in the global energy mix coupled with a current share of 75-80% of nuclear energy in electricity production would mean that low-carbon renewables would replace an existing low-carbon technology, obviously at a very high cost.[18] The lower the carbon intensity of a country's electricity mix, the higher the abatement cost associated with a given low-carbon technology. This is shown in Table 4.4: reducing GHG emissions is extremely expensive in France and Switzerland, while it is much cheaper in countries with a higher share of coal-fired power plants, such as Germany, Denmark and Poland.

Ideally, the abatement costs implied by feed-in tariffs should be aligned with the carbon price projected by the government to achieve GHG emissions goals. These costs should be set equal for all sources of renewable energy to insure that those with the lowest actual abatement costs are chosen and to avoid favouring particular technologies. However, it should be noted that the large number of externalities to be taken into account, including local air pollution, pollution of land, air and damage to the countryside, does not necessarily mean that a strict equalisation of feed-in tariffs would be optimal. Yet, in most OECD countries, including France, abatement costs for solar energy and other renewables are well above any realistic carbon price and vary a great deal across different energy sources, mainly because feed-in tariffs reflect, besides considerations of energy security and industrial policy, the actual costs of investment in renewable energies.[19] The only exception is the Netherlands, where feed-in tariffs are uniform and imply abatement cost of EUR 55 and 87 per tonne of CO_2 using, respectively, coal-fired capacity and the observed electricity mix as benchmarks.

16. In a given multi-year phase of the EU-ETS, a decrease in one country's emissions will allow more emissions elsewhere. Nevertheless, emissions decreases may be constraining in the longer term if the overall emissions ceiling is adjusted for reduced emissions between two multi-year phases of the EU-ETS.

17. The abatement cost is minimised if the most carbon-intensive technology is displaced.

18. A more general problem of solar and wind energy is that they depend on weather conditions and therefore have to be backed up by more reliable energy sources both for base and peak-load electricity generation. But technological progress in storing electricity other than pumped hydro would attenuate this problem.

19. Breaking even on investment requires more time and/or higher prices for solar and wind energy in countries with a lower number of sunny or windy days per year.

Table 4.4. **GHG abatement costs implied by feed-in tariffs Europe, 2009-10**

	Solar	Wind	Biogas	Biomass	Geothermal	Hydro	Wave
Abatement cost, benchmark=coal-fired power plants (EUR/tonne of CO_2 equivalent)							
Austria	261-421	37	131		34		
Belgium	108-408	23-48		23-48			
Czech Rep.	457	47	62	64	119	43	
Denmark		0-80					
Finland		39	29-83				
France	**271-537**	**39-87**	**2-44**	**82-132**	**77-107**	**23-59**	**107**
Germany	291-391	53-91	39-78	39-78	66-205	38-88	
Greece	329-479	2-14					
Ireland		17-100	30-149	80-100		32	
Italy	275-399	229	109-229	149	129		269
Netherlands	55	55		55		55	
Portugal	311-611	(–13) –12				3	106
Slovakia	386	42	87	74			
Spain	281-301	39	46-100	18-130	30-34	36-44	30-34
Switzerland	241-482	96	78-153	-26	115-239	6-139	
United Kingdom	311-454	14-373	26	(–10) –68		14-198	
Abatement cost, benchmark=country-specific electricity mix (EUR/tonne of CO_2 equivalent)							
Austria	939-1 515	132	472		123		
Belgium	382-1 442	82-170		82-170			
Czech Rep.	689	71	94	96	179	65	
Denmark		4-111					
Finland		85	63-179				
France	**3 107-6 157**	**447-997**	**23-507**	**940-1 513**	**883-1 227**	**260-682**	**1 227**
Germany	487-655	89-153	65-130	65-130	111-343	63-147	
Greece	422-614	3-17					
Ireland		28-165	50-246	132-165		53	
Italy	495-718	412	196-412	268	232		484
Netherlands	87	87		87		87	
Portugal	587-1 154	(–25) –24				5	200
Slovakia	1 524	166	344	293			
Spain	612-655	85	100-218	39-284	66-75	78-96	66-75
Switzerland	5 952-11 916	2 367	1 922-3 786	-652	2 844-5 916	148-3 430	
United Kingdom	528-772	24-634	44	(–16)–115		24-337	

Source: OECD calculations. Abatement costs are computed using the lower- and upper-bound feed-in tariffs in excess of market prices and the amount of avoided CO_2 equivalent emissions.

The residential, commercial and government sectors have reasonably low abatement costs

The government hopes to achieve lower GHG emissions in the residential, commercial and government sectors by reducing the consumption of primary energy sources by 38% by 2020 and by engineering a switch from fossil to renewable sources for heating purposes. For residential housing, which represents about three-quarters of total heated space, the current annual average energy consumption of 240 kWh per square metre is expected to be reduced to 150 kWh by two main channels. First, stringent norms will impose very low energy consumption of 50 kWh for new residential buildings from 2012 onwards and “energy-plus” buildings, designed to produce energy to cover their own energy needs, starting in 2020. The second is through energy efficiency improvement of existing buildings. The renovation of the current stock and the modernisation of heating systems are supported by a tax credit for sustainable development (crédit d’impot développement durable), an environmental zero interest loan (éco-prêt à taux zero), a low-interest credit assigned for eco-friendly social housing, and the reduced VAT of 5.5% for a variety of equipment. The conditions for access to the tax credit and the reduced VAT were tightened in 2010. Even though MEEDDAT (2008b) presents abatement costs for the energy consumption of new buildings and the thermal renovation of public and private buildings, it would be desirable to introduce a systematic analysis of specific measures in terms of abatement costs both to determine the cost of public subsidies and to improve the cost efficiency of the measures. Estimated abatement costs of selected investments in low-carbon and energy-efficient equipment shown in Table 4.5 exhibit a substantial variation depending on the existing heating system and the type of housing considered (single family houses *versus* multi-unit buildings). Abatement costs are the lowest for replacing carbon-intensive heating systems, while they are very high for replacing electric heating and heat pumps. They are particularly low for multi-unit buildings. It should be noted that these figures represent gross costs in that they do not take account of energy savings and should therefore be interpreted as the abatement costs of the measures taken by the government and not as total abatement costs.

Table 4.5. **Estimated abatement costs of measures aiming at better thermal insulation and upgrading heating systems**

EUR/tonne of CO_2 equivalent

Type of original heating	Coal	Heating oil		Natural gas		Electricity		Heat pump	
Type of dwelling	Family house	Family house	Multi-unit building	Family house	Multi-unit building	Family house	Multi-unit building	Air-source Family house	Ground source Family house
Type of thermal insulation									
Windows	256-341	278-370	37-43	773-1 031	103-120	1 522-2 029	152-178	4 167-5 556	5 556-7 407
Walls	319	346	170	962	473	1 894	698	5 185	6 914
Roof	107	116	39	322	107	634	159	1 736	2 315
Type of new heating system									
Natural gas (condensation)	67	74	41	516	286				
Electric heating	31	34	4	157	27				
Heat pump									
Air source	64-136	69-149		222-475		560-1 199			
Ground source	88-179	97-195		299-599		699-1 398			

Note: The figures shown in the table are gross abatement costs because they exclude energy saving.

Source: OECD calculations.

Additional measures include relief on property tax for the renovation of buildings built before 1989, special public funds provided for renovations meeting strict energy-performance standards. To increase public awareness of energy efficiency, and to comply with the EU Directive of 2002 on the energy performance of buildings, a commercial or residential property sale or rental contract has to be accompanied by an energy-performance certificate (*diagnostic de performance énergétique*) that classifies the property in terms of energy efficiency and CO_2 emissions in seven major dimensions. Real estate advertisements have to be accompanied by energy-performance certificates starting in 2011.

Since 2006, energy providers (electricity, gas, heating fuel and district heating, of which nearly 80% is supplied by EDF and GDF Suez) are required to secure energy savings. A similar system was put in place in 2002 in the United Kingdom and in 2005 in Italy. Energy providers have the obligation to reduce the energy sold with the help of increased energy efficiency of their final customers. If they miss the reduction target, they have to pay 2 cents for each kWh by which they fail to meet the target. Certified energy reductions are rewarded by so-called white or energy-saving certificates that can be used for a provider's own target compliance or can be sold to other providers that cannot meet their targets. As in any other cap-and-trade system, the incentives ensure that cuts are done where they are the cheapest. According to DGEC (2009), in 2009 92% of white certificates were concerned with residential and commercial buildings, of which improvements to heating systems and thermal isolation represented the major chunk, and the price of exchanged certificates remained below 1 cent per kWh. Energy savings during the first phase (1 July 2006-30 June 2009) amounted to 60 TWh (compared to a goal of 54 TWh), *i.e.* 15% of the annual energy consumption of the housing sector in France. The system is now entering into its second phase from 1 January 2011 to 31 December 2013 with a target of 345 TWh, *i.e.* more than six times the goal for the first period (MEEDDM, 2009e).

The transport sector: reducing GHG emissions at a very high price?

The transport sector, which accounted for around one quarter of France's total GHG emissions in 2007 emitted 15.4% more GHGs in 2007 than in 1990. The main goal of French environmental policies targeted at the transport sector is to reduce GHG emissions by 20% between now and 2020 in order to reduce them to 1990 levels by that date. Because road transportation is responsible for the lion's share of sectoral emissions, the measures taken aim to divert transport away from roads, especially from the use of cars to alternatives including public transport, railways and inland water and sea transport and to increase the energy efficiency of road transportation.

Three distinct measures are being used to encourage the shift from roads to alternative means of transportation. The first aims to reduce the role of individual transport in long-distance travel by adding an extra 2 000 km to the 1 875 km of existing high-speed rail network (lignes à grande vitesse, LGV) by 2020, a EUR 16 billion investment, and possibly another 2 500 km later on. Second, the expansion of the existing 326 km of public transport lanes (tramways, buses, etc.) to 1 800 km in major provincial French cities, and the building of a circular automatic train linking the outskirts around Paris are meant to reduce the use of passenger cars in peri-urban areas. Third, an investment programme of EUR 7 billion launched in 2009 seeks to reduce long-distance road freight transportation by increasing the share of rail in total freight to 25% by 2022 from 14% in 2003 (Loi Grenelle I). Pivotal to the programme are the so-called rail motorways, of which there are two in experimental form linking Perpignan to Luxembourg and Lyon to Turin, and a third connecting south-west France and the northern part of the country via the Ile-de-France region is expected to be launched in the near future. In addition, measures are being taken to increase the speed and length of freight trains, to reduce congestion in the Montpellier-Nîmes area and around Lyon and to improve railway and inland water connections to major sea ports (MEEDDM, 2010c). Furthermore, the government hopes to remove 5 to 10% of lorry traffic by creating sea motorways along the French coastlines and by developing inland water traffic. For instance, the modernisation of the canal route Seine-Northern Europe is expected to reduce 250 000 tonnes of GHG emissions annually at a cost of EUR 4 billion in investment.

Yet this impressive investment agenda implies a very high public GHG abatement cost: EUR 530 to EUR 2500 per tonne of CO_2 equivalent avoided (Prud'homme, 2009b). In 2008, the railway system and local public transport received EUR 13 and EUR 18 billion in implicit subsidies, respectively, while public revenues related to road transportation exceeded the running and capital costs of the road network by a large margin (EUR 16 billion[20]). High-speed trains (TGVs) cover around 90% of total costs, but the share is only 50% for nationwide passenger trains, 30% for regional trains and freight rail transport and 25% for urban public transport (Prud'homme, 2009b). Doubling the share of rail in total transport will add at least another EUR 10 billion in public subsidies, abstracting from those to staff pensions. A similar scaling up of public transport would result in extra public subsidies of EUR 18 to EUR 31 billion. All in all, doubling rail's share would increase the general government deficit by about 0.5 to 0.9 percentage point of GDP a year, all other things being equal. This taken together with a similar increase in public transportation would lead to an annual rise in the public deficit of 1.5 to 2.5 percentage points of GDP. Prud'homme (2009b) points out that public subsidies in the current regulatory environment do not incentivise either the network operator (RFF) or the service provider (SNCF) to improve performance. Allowing inter- (coaches *versus* trains) and intra-modal (alternative passenger train service providers) competition or introducing a variant of incentive regulation would foster cost efficiency. Combined with an independent regulator, it would also

20 . Taking the EUR 35 billion in road-related revenues into account road transport was taxed by EUR 19 billion.

be bound to spur investment, as shown for instance in Égert (2009) for network industries. The creation of an independent railway regulator (*Autorité de régulation des activités ferroviaires*) in December 2010 is an important step in this direction.

Considering that rail and road transport accounted, for, respectively, 11% and 87% of total transport services, a doubling of the rail share and a corresponding decline in road transport would give net GHG emission savings of 14.15 Mtonnes per year. Dividing the annual costs of EUR 10 to EUR 17 billion by avoided emissions yields an abatement cost of EUR 526 to EUR 894 per tonne of CO_2 avoided.[21] Kageson (2009) points out that high-speed trains are unlikely to contribute significantly to reducing GHG emissions because building the new infrastructure and equipment generates GHG emissions that counterbalance the gains from diverting traffic from road vehicles and airplanes but also because their high energy needs are likely to be covered by gas- or coal-fired capacity in the short run. Looking more specifically at abatement costs in rail freight, a simple calculation including both the costs of investment and public subsidies gives a range of EUR 618 to EUR 1 007 per tonne, depending on the size of previous public subsidies.

Policies aimed at reducing GHG emissions in road transportation rely on advertising campaigns, standards and market-based instruments. Two major campaigns launched in 2006 have sought to increase public awareness regarding private cars' carbon emissions. First, new cars are now categorised and labelled according to their CO_2 emission levels, as with the energy efficiency labelling of household appliances and residential buildings. Second, questions relating to efficient driving are included in driving theory tests, and more generally companies are encouraged to promote such "green" driving. This may in turn encourage innovation.[22]

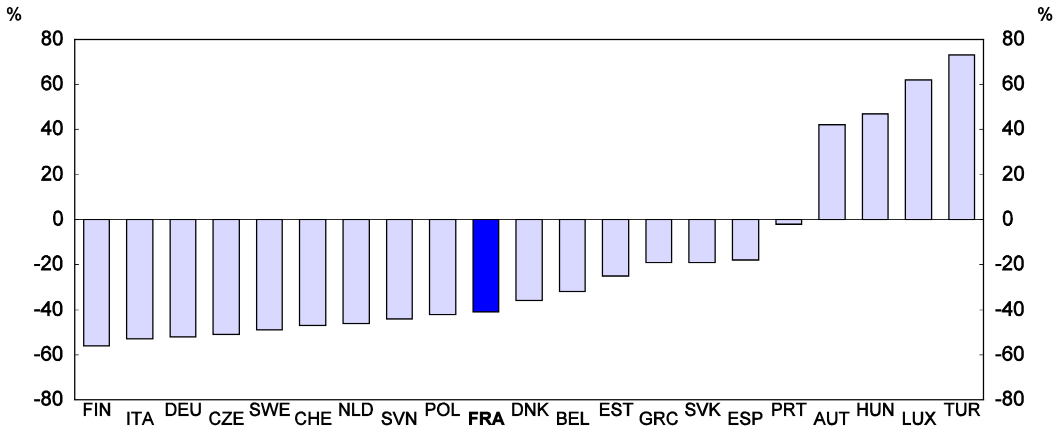
The government has set a goal of lowering the average 176 grams/km of CO_2 emitted by the French passenger car fleet to 120 grams by 2020. That would cut GHG emissions by a third if higher fuel efficiency does not translate into more car use (the so-called rebound effect). A similar reduction is being sought for heavy vehicles and motorcycles. In line with EU objectives, average emissions of all newly registered passenger cars of each manufacturer should not be higher than 130 grams/km of CO_2 by 2015 and 95 grams/km by 2020. Non-compliance will trigger progressive penalty payments for each gram in excess of the standard. In addition, stringent EU standards with a view to reducing local pollution have been gradually implemented on new cars since 1992. Euro V, just implemented, and Euro VI to be introduced in 2015 impose drastic reductions of local pollutants compared to Euro I. For instance, vehicle emission standards imposed a cut by a factor of five for the share of particulate matters in exhaust fumes of diesel passenger cars between 1992 (Euro I) and 2006 (Euro IV). The achieved cut of 40% over the same period in France is large but lags behind the change in vehicle emission standards for several reasons (Figure 4.7). First, the norms for heavy trucks, which are less strict, are being applied with considerable delay. Second, the share of diesel passenger cars in the ever expanding car fleet almost doubled to 54% in 2008 from 31% in 1997, largely due to public policies favouring diesel over petrol engines. Third, overall mileage on the French road network has increased over time. Fourth, it takes years for the new norms to be transmitted to the entire car fleet. In 2007, 95% of the French car fleet was consistent with

21. It should be noted that these figures are only approximate because they do not consider: *i*) initial investment costs needed to expand the railway network; *ii*) negative local externalities, though not much reduced, given that the external costs of road transportation outside of cities are not very high and because rail also generates some negative local externalities; and *iii*) positive network externalities.

22. For instance, an alarm system has been recently developed by the company Viveris Technologies that first blinks and then beeps if the engine rotation speed deviates from optimum. This new gadget ordered by a regional transport company costs EUR 750 and saves 1 litre per 100 km for buses (Berkovicius, 2010). The abatement cost of this new gadget is around EUR 130 per tonne under the assumption of an average annual mileage of 35 000 km over a six-year lifetime.

Euro I, while only 35% met Euro IV norms. A simple calculation that uses the observed annual increase of 2% in the total number of passenger cars (after scrapping), a total car fleet of 30.85 million cars and 2.05 million new cars in 2008, suggests that 22 years will be needed for a complete renewal of the fleet.

Figure 4.7. **Change in total emissions of particulate matter due to road transportation, 1992-2006**



Source: OECD calculations based on data obtained from Eurostat.

Promoting bio-fuels has been high on the government's agenda as it has fixed more ambitious targets than those recommended by the European Union: their share in total energy consumption (in calorific values) of road transport was set to reach 7% by the end of 2010 instead of the European objective of 5.75%, and the 10% objective should be reached by 2015 rather than by 2020. The underlying justification of 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 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). A recent study commissioned by the French government argues that, in France, first-generation bio-fuels have had a favourable GHG emission balance compared to fossil fuels (Bio Intelligence Service, 2010). Yet the study does not account for indirect land-use change: a positive life-cycle GHG balance can become negative if diverting crops in one country and making up for them elsewhere causes deforestation, for instance. While it is highly questionable whether bio-fuels help reduce GHG emissions, using bio-fuels in vehicles significantly reduces local pollution due to sulphur oxides (SO_X), carbon monoxide (CO) and particulates.

The first measure that helps achieve these bio-fuels goals is a penalty incorporated since 2005 in the general tax on polluting activities (TGAP) on fuel sold by distributors that does not respect a specified target. The minimum share of bio-fuels in total fuel sales was 1.75% in 2006 and was progressively increased to 7% in 2010. The second measure is a partial exemption from excise tax for bio-diesel and bio-ethanol and tax relief on vegetable oils used by farmers and fishermen as fuel. The partial tax exemption has been extended to 2013.[23] Furthermore, the 10% objective is well reflected in the launch in 2009 of a fuel composed of 90% of 95-octane petroleum petrol and 10% of ethanol that can be used by 60% of the French petrol car fleet and that is supposed to ultimately replace the conventional 95- and 98-octane petrol. However, in order to reduce GHG emissions, it is more efficient to target and/or tax the carbon content of fuels, rather than imposing volumetric production targets for bio-fuels because various

23. The tax reduction on bio-diesel (bio-fuel added to petrol) was 0.22 (0.27) euros/l in 2008, 0.15 (0.21) euros/l in 2009, 0.11 (0.18) euros/l in 2010 and 0.08 (0.14) euros/l in 2011.

bio-fuels have different GHG balances (International Transport Forum, 2008). Of course this holds only if bio-fuels have a favourable GHG balance, which remains highly uncertain.

The bonus-penalty system that has been in place since 2008 helps the shift towards low-carbon and less polluting cars by offering a monetary award to those purchasing a new car with an emission level of below 130g of CO_2/km and by penalising the purchase of cars that emit more than 160g of CO_2/km. Until end-2010 this system, which replaced the surtax introduced in 2004 on cars with emission levels above 200g of CO_2/km, was coupled with a car-scrapping scheme as from December 2008, which was ended on 1 January 2011 and which had aimed at reducing the average emissions of the overall French fleet by replacing old polluting cars. Even though this system has speeded up the reduction in emissions from new vehicles, it has further strengthened the decade-long trend increase in the share of diesel cars in the total stock by focusing only on CO_2 emissions and has failed to take account of the higher contribution of diesel fuelled cars to local air pollution. Indeed, the main instrument for reducing emissions other than CO_2 is the Euro standard. Until the Euro V standard entered into force on 1 January 2011 for new cars, the standards tended to be less stringent for diesel cars than for petrol cars. But Euro V closes the gap between the permitted emissions ceilings for petrol and diesel cars. In 2011, the bonuses were lowered and the emission grids for the bonuses and penalties tightened; as of 1 January 2011, the only vehicles eligible for a bonus are those whose CO_2 emissions are less than 110g/km and a penalty is applied to vehicles whose CO_2 emissions exceed 150g/km. As from 1 January 2012, these values will be lowered to 105g/km for the bonus and 140g/km for the penalty. This is an important further step, which should be pursued until the bonuses are reduced to zero because the bonus-penalty system financially rewards a negative global and local externality since even very low-emission cars cause a negative externality. In any case, the thresholds in the bonus-penalty system and the car labelling scheme are not fully aligned with each other, reducing transparency and increasing compliance costs for manufacturers. The two schemes should be harmonised in the future.

Personal and business car owners have to pay, in addition to the VAT, a one-off tax related to the power of the engine instead of CO_2 emissions at the time of the purchase of the car. Passenger cars owned by companies are subject to a special annual tax (*Taxe sur les véhicules des sociétés*) that is calculated on the basis of a car's CO_2 emissions and the annual mileage for cars that were registered after 2004 (on the basis of the car's horsepower for those purchased before 2004). Nevertheless, a two-year break applies to electric cars and those run on natural gas or super-ethanol (E85), while taxis, rented cars, cars used in driving schools or for racing are fully exempted. Company utility vehicles are not subject to any tax of this kind. Indeed, the implementation in late 2009 of the European Directive 2007/46/EC made it possible for companies to register large cars like Audi Q7, BMW X5, Porsche Cayenne, Volkswagen Touran, Renault Espace and Grand Scenic, Citroën C4 and C5 as utility vehicles that escape from the taxes applying to other company-owned passenger cars (Fainsilber, 2010). This loophole was closed by article 24 of the 2011 budget bill adopted on 29 December 2010.

Another component of French transport policies is road pricing. The toll levied on users of French motorways depends on the mileage and the type of vehicle (motorcycles, passenger cars, light utility vehicles, bus and trucks) and aims principally to finance the costs of investment, maintenance and operation, rather than monetising explicitly external costs relating to local pollution, accidents and congestion. A first step in dealing with extra pollution caused by the many toll gates on French motorways was the introduction of the system called "Liber-T" that allows vehicles to pass the gates quicker and to make traffic more fluid. Furthermore, toll gates will be installed for passage without stopping and by making the toll vary according to the time of day, the occupancy ratio and the energy efficiency of the cars. At present, time-varying tolls are applied on two motorway sections in the Paris region: the tunnel "Duplex" linking the northern and southern part of the A86 around the west of Paris and the A14 linking Orgeval to La Défense. Motorway schemes relying on variable but enforceable speed limits, successfully trialled by French motorway operators, may also help reduce congestion and thus reduce GHG emissions.

An environmental road toll for heavy vehicles on the national road network was voted in the 2009 budget, in accordance with the European Directive 2006/38/EC, but will be implemented at the national level only in 2012 due to technical problems with the toll collection system and following an experimental period in Alsace where traffic grew significantly due to a similar tax in Germany (MEEDDM, 2010d and 2010e). Not only will the toll, calculated on the basis of actual mileage, reflect vehicle characteristics and the costs of the wear and tear of the road network, but it is also supposed to cover the external costs caused by heavy trucks with the hope of diverting goods transportation from road to rail and inland waterways. The "Grenelle 2" law allows for cities with more than 300 000 inhabitants to experiment with congestion charges. Nevertheless, care should be taken when designing urban road tolls so that they produce net social benefits. International experience shows that whether urban tolls produce net benefits depends largely on the calculation of time gains due to reduced congestion (Raux, 2005).[24] Global and local environmental gains are less important. A number of conditions are needed for benefits to exceed costs: *i*) a high level of road congestion; *ii*) keeping operational costs low; and *iii*) a low level of congestion in public transportation (Kopp and Prud'homme, 2010; Raux, 2005).

Mandatory environmental labelling of consumer products

The Grenelle laws set the ambitious goal of requiring an obligatory displaying of the over-the-lifecycle environmental impact (including the carbon equivalent footprint) of consumer products, the production, distribution and waste management of which account for half of the CO_2 emissions of households. The labelling is aimed to cover all products, imported and home produced, across all sectors. A trial period will be launched in July 2011, with a progressive expansion of the product coverage. This is an interesting initiative that the French government intends to promote at the EU level as well.

Waste production and management

Avoiding the production of waste is at the heart of waste management policies in France, which had set an objective of stabilising the amount of municipal waste produced for the period from 2003 to 2008 and a decrease of 7% per capita for 2009-14. The main instrument to achieve these goals is an information campaign targeted at households, firms and local authorities. Nevertheless, municipal waste production has been on a steady rise since 1997, and the stabilisation goal for 2003-08 was not achieved: per capita municipal waste increased by 7% during this period. Rising municipal waste is a general trend in Europe, with only a few exceptions including Germany, the United Kingdom and Spain (Table 4.6). Notwithstanding the observed rise, the level of municipal waste, which reached 543 kg per capita in 2008, is only moderately high by European standards. Yet France fares relatively well in terms of hazardous waste production, with 152 kg per head in 2008, the main chunk of which relates to construction and manufacturing activities.

France has adopted moderately ambitious recycling goals: 35% by 2012 and 45% by 2015 for household waste, and 75% for packaging material and industrial waste excluding construction and agricultural waste, while waste dumped and burnt should decline by 15%. Table 4.7 shows that the goal set for 2012 was almost attained in 2008, with a recycling rate of 33%, up by 13 percentage points compared to 1997. At the same time, half of the remaining waste was landfilled and the rest incinerated. To recycle 75% of packaging waste appears to be a more challenging task, given that only 57% of this type of waste was recycled in 2007 (Table 4.7). Another 10% of packaging waste was burnt to produce electricity or heat. The observed level of recycling and recovery of packaging material, except that for plastics, is in line with the EU Directive 2004/12/EC on packaging and packaging waste that sets a minimum recovery

24. Kopp and Prud'homme (2010) and Prud'homme and Bocajero (2005) show that the social costs of the Stockholm and London urban toll exceed social benefits, while on the other hand Santos (2007) and the International Transport Forum (2010) report opposite results.

rate of 60%, a minimum recycling rate of 55% for overall waste and the following specific minimum recycling rates: 60% for glass and paper, 50% for metal, 22.5% for plastic and 15% for wood. According to MEEDDM (2009d), two-thirds of construction waste was recycled.

When comparing waste management outcomes at the European level, it turns out that some countries have reduced landfill to almost zero (Table 4.6). Low landfill rates, often a result of stringent quantitative goals set by governments or high landfill taxes, were achieved either by increasing recycling rates (Belgium and the Netherlands) or by raising recycling and incineration rates at the same time (Austria, Germany and Sweden). Countries with low landfill rates are also the ones with the highest, sometimes almost complete, recovery rates for packaging waste (Table 4.7). Nevertheless, the high recycling rates observed in some countries may not be cost effective if the unit recycling cost is much higher than the total social costs of landfill or incineration. Recycling may be expensive because of inefficient organisation due to the lack of competition or incentive regulation, or simply because of intrinsic high marginal costs relating to the specificity of each material and population density (OECD, 2004b).

Table 4.6. **Waste production and management in Europe, 1997-2008**

Kg of waste per capita

	Municipal waste			Recycled		Incinerated		Landfilled	
	2008	1997-2008	2003-08	2008	1997-2008 p.p.	2008	1997-2008 p.p.	2008	1997-2008 p.p.
Czech Republic	306	-4%	9%	18%	18%	11%	11%	71%	-29%
Poland	320	2%	23%	28%	25%	1%	1%	71%	-26%
Slovakia	328	19%	10%	15%	-10%	9%	-2%	76%	12%
Turkey	428	-15%	-4%	-1%	-10%	13%	-4%	89%	13%
Greece	453	25%	6%	23%	14%	0%	0%	77%	-14%
Hungary	453	-7%	-2%	18%	5%	9%	2%	74%	-7%
Slovenia	459	-22%	10%	24%	8%	2%	2%	74%	-9%
Portugal	477	18%	7%	17%	-17%	19%	19%	64%	-2%
Norway	490	-21%	22%	44%	-28%	38%	24%	18%	4%
Belgium	493	6%	5%	61%	26%	33%	-4%	5%	-21%
Estonia	515	22%	23%	52%	51%	0%	0%	48%	-52%
Sweden	515	24%	9%	49%	16%	49%	12%	3%	-28%
Finland	522	17%	12%	32%	0%	17%	12%	51%	-12%
France	**543**	**9%**	**7%**	**33%**	**13%**	**32%**	**-3%**	**36%**	**-10%**
Iceland	555	25%	14%	..	..	..	..	..	..
Italy	561	20%	7%	39%	25%	12%	6%	49%	-31%
United Kingdom	565	6%	-5%	36%	28%	10%	4%	55%	-32%
Spain	575	2%	-12%	34%	-3%	9%	3%	57%	0%
Germany	581	-12%	-3%	66%	16%	33%	16%	1%	-32%
Austria	601	13%	-1%	70%	16%	27%	17%	3%	-32%
Netherlands	622	5%	2%	66%	15%	33%	-4%	1%	-11%
Luxembourg	701	15%	2%	46%	19%	35%	-14%	19%	-5%
Ireland	733	34%	0%	37%	18%	3%	3%	60%	-20%
Switzerland	741	22%	11%	50%	-3%	50%	3%	0%	0%
Denmark	802	36%	19%	42%	6%	54%	0%	4%	-7%

Note: The rate of recycling is computed as the share of municipal waste that cannot be accounted for by incineration and landfill.

Source: OECD calculations based on data obtained from Eurostat.

Nevertheless, actual and targeted recycling rates do not appear to be excessive in France. A cost-benefit analysis commissioned by the European Commission concluded that the optimal rate of recycling for French household waste ranges from 46% to 69% (Research Development and Consulting, 2003). The unit cost of recycling of EUR 64 to EUR 80 per tonne in 2009 in France, which is much lower than that observed for instance in Austria, Germany or Japan of around EUR 300 per tonne (OECD, 2004b; MEEDDM, 2009c), is broadly in line with the private costs of landfill and incineration of

EUR 55-80/tonne (MEEDDM, 2009c). If the positive externalities associated with avoided global and local pollution and savings of energy resources are expressed in monetary terms, which in aggregate can reach EUR 300/tonne, recycling becomes a solution largely superior to landfill or incineration. Table 4.8 shows that with a few exceptions, recycling helps save raw material and energy resources and reduces GHG emissions, water use, the amount of waste water treated and solid waste generated for most recycled materials. Furthermore, the overall positive impact was relatively large in 2006, as avoided GHG emissions accounted for about 3.5% of France's total GHG emissions in that year.

Table 4.7. **Recovery and recycling rates of packaging waste, 2007**

	Recovery rate (%)					*of which*: Recycling rate (%)					
	Total	Plastic	Paper	Metals	Wood	Total	Glass	Plastic	Paper	Metals	Wood
Denmark	97	98	100	87	52	57	128	22	61	87	33
Belgium	95	86	97	91	100	80	100	38	92	91	72
Germany	95	95	98	90	97	67	84	43	80	90	30
Luxembourg	92	90	96	80	98	63	92	39	71	80	31
Netherlands	92	92	97	84	94	61	81	26	74	84	32
Austria	90	95	95	67	71	67	86	33	84	67	19
Norway	90	85	93	66	..	68	99	30	82	66	..
Finland	84	43	96	70	90	52	81	18	88	70	10
Sweden	82	78	74	74	100	59	95	42	74	74	17
Czech Republic	71	57	99	56	44	66	65	46	94	56	37
France	**67**	**53**	**97**	**64**	**33**	**57**	**62**	**21**	**89**	**64**	**21**
Slovakia	67	45	97	74	21	61	55	42	86	74	5
Italy	67	59	78	67	61	57	60	28	70	67	54
United Kingdom	64	32	87	52	77	59	55	23	79	52	77
Ireland	64	22	77	68	99	61	76	22	77	68	76
Poland	60	47	75	30	78	48	40	28	69	30	48
Portugal	59	23	84	63	73	57	46	15	82	63	71
Spain	58	38	66	63	67	52	56	23	61	63	61
Bulgaria	55	20	98	0	0	55	71	20	98	0	0
Hungary	55	44	92	65	20	46	21	17	87	65	20
Estonia	52	38	57	18	67	50	62	38	57	18	39
Greece	48	14	80	51	75	48	18	14	80	51	75

Note: Recovery rate is the share of waste production that is recycled or incinerated to generate heat or electricity.

Source: Eurostat.

Table 4.8. **Avoided pollution and resource savings due to recycling in France, 2006**

	Per unit impact (per tonne recycled)					
	Raw material	Fossil energy	GHG	Water	Eutrophication	Non-hazardous waste
Unit	tonne	toe	tCO_2eq	m^3	Kg-eq-PO4	tonne
Iron	-1.40	0.50	-1.60	-1.80	-0.20	-0.97
Aluminium	-2.30	-2.20	-7.10	-9.80	-0.05	-1.50
Copper	-0.85	-0.45	-1.14	-50.10	-0.19	-1.00
Lead	-2.56	-0.07	-0.69	-94.50	-0.09	-1.40
Packaging board		**0.03**	-0.16	-17.80	**0.51**	-0.05
Paper		-0.24	-0.37	-4.65	-0.004	-0.09
Special paper		**0.06**	-0.39	-10.30	-0.003	0.31
Glass	-1.20	-0.12	-0.46	-1.30	-0.01	-1.06
Plastic						
PE	-0.71	-1.06	-2.30	**4.70**	-0.003	-0.28
PET	-0.62	-0.90	-2.70	-0.27	**0.01**	-0.49

Source: ADEME (2009), *Bilan du recyclage 1997-2006, Rapport*, Synthèse générale et analyse par filière.

The costs of negative local externalities due to landfill and incineration are not fully internalised. The external costs of landfill, dominated by GHG (methane) emissions, are evaluated at EUR 10-13 per tonne by Rabl *et al*. (2008) and at EUR 18-25 per tonne by Chèze and Arnold (2005). The negative externalities connected with incineration are mainly related to toxic gas and GHG emissions whose corresponding costs are estimated respectively at EUR 4-21 and EUR 15-22 per tonne.[25] In 2008, the general tax on polluting activities (TGAP) was levied on landfill but not on incineration, and its level of EUR 10.03 per tonne was lower than the estimated external costs. The tax, revised to EUR 15 per tonne in 2009, will increase to EUR 40 by 2015. At the same time, the tax was extended in 2009 to waste burnt in incineration plants with an initial rate of EUR 7 per tonne and a planned increase to EUR 14 per tonne by 2013. A tax reduction is available for landfill sites if energy recovery from biogas exceeds 75% and if waste is transported from the collection points to the final repository site by rail or boat. A complete exemption applies to sites with full energy recovery from biogas. Waste incineration also receives tax reductions based on the degree of energy recovery, the means of transport and the NO_X pollution caused. The increase in TGAP is a very welcome development, because it aligns taxes with external costs and because the pre-announced gradual but strong increase is likely to influence behaviour. One of the explicit goals of the change was to equalise the cost of landfill with that of incineration and to raise costs above the cost of recycling, which has environmental benefits that are far superior. The tax of EUR 40 per tonne for landfill is well above the higher-bound estimate of the external cost. As the external cost estimates are based on a carbon price of EUR 19-20 per tonne, the landfill tax can reflect a higher carbon price in accordance with the path proposed by the Quinet report. At the same time, the tax of EUR 14 for incineration is broadly aligned with the cost estimates of the related negative externalities obtained using a low carbon price (Rabl *et al.*,2008). The taxes should be harmonised according to the costs of global and local externalities, even though some local externalities cannot be readily quantified.

While the composition of waste treatment can be changed if the price of waste collection and treatment incorporates an incentive element, an overall reduction in the volume or weight of municipal waste cannot be taken for granted if households pay a flat fee for final waste disposal. To finance waste management, most local authorities rely on a household waste collection tax (*Taxe d'enlèvement des ordures ménagères*) that is based on the rateable value of residential properties in the official registry,

25. The figures in Chèze and Arnold (2005) are in 2000 prices. The figures reported here are adjusted for cumulated inflation between 2000 and 2009. Other externalities include the damage of leachates and reduced amenity values. It is worth noting that, as of today, all authorised French landfill sites are equipped with liners to prevent leakage to the soil and groundwater.

obviously disconnected from the waste generated by households. Others use general revenues or charge a specific waste-management fee (*Redevance d'enlèvement des ordures ménagères*), usually a lump-sum fee (Glachant, 2003). The setting of the waste-management fee already allows the inclusion of a variable part based on the amount of waste produced. In addition, article 46 of the Planning Act of 3 August 2009 regarding implementation of the *Grenelle de l'environnement* introduced the principle of creating a legislative framework that will allow local authorities to introduce, between now and 2015, incentive-based waste pricing by splitting the waste tax or fee into a fixed part covering fixed costs and a variable part that should vary according to the weight or volume of the waste collected from individual households.[26] Nevertheless, the success of the new policy will hinge critically upon practical design features, including the measurement of individual waste production and the pricing policy. A danger related to incentive waste pricing is that it may result in backyard waste burning or illegal dumping (Glachant, 2004; OECD, 2004b).

A useful complimentary policy to reduce waste downstream is to tax waste production upstream. The extended producer responsibility schemes used in France and other EU countries require producers to organise the recycling of waste associated with a number of product groups including household packaging, electrical appliances and electronics, tyres, batteries and accumulators, textile products, motor oil and scrapped vehicles (MEEDDM, 2010a). Producers usually join forces in the form of joint ventures that take charge of recycling. In France, producers pay a unit fee per package/product according to the product's weight and its recycling costs. If producers cannot pass the tax on to the final price, such fees should incentivise them to innovate in order to reduce the weight and/or the recycling costs. Yet fees paid by producers are low and cover only a fraction of recycling costs.

Consequently, fees that have been set too low have helped to increase recycling rates but have not contributed to cutting waste at the source (Glachant, 2003 and 2005). In 2005, almost 80% of out-of-use cars, 89% of accumulators and 74% of tyres, 31% of batteries and 30.5% of motor oil was either re-used or recycled (ADEME, 2006). Against this backdrop, the *Grenelle de l'environnement* proposed to increase cost recovery rates (for example, up to 80% for household packaging, despite not giving a specific deadline).

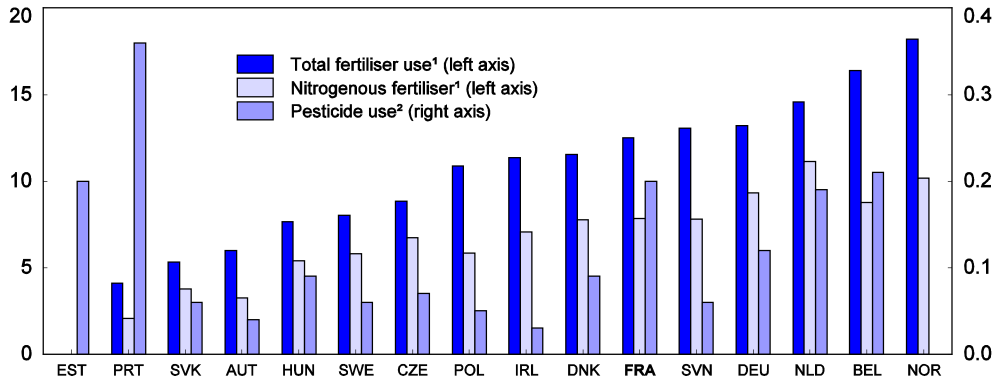
Water pollution and management

Environmental policies governing France's water resources seek to address water pollution and the sustainable use of water resources. As for pollution, achievement of the goal of bringing the total surface and groundwater water body to good condition by 2015 in accordance with the EU Water Framework Directive of 2000 looks likely to be particularly challenging. In 2010, only 45% of surface water bodies were reported to be in good condition (up from 38% in 2007) and 56% of groundwater bodies (90% of groundwater bodies were in good quantitative conditions and 59% in good chemical condition) (Eaufrance, 2010). With its heavy reliance on the use of pesticides and fertilisers, agriculture is a major source of water pollution in France. In 2008 French farmers were among the heaviest users of pesticides in Europe on a per hectare basis (Figure 4.8). In 2007, the presence of pesticides was detected in 91% of river water and 59% of groundwater observation points. The pesticide content of water was higher than allowed by existing environmental standards in 11% and 18% of the respective observation points (CGDD, 2010a). Figure 4.8 also shows the heavy use of nitrogenous fertilisers. When accounting for livestock manure and nature's absorption capacities, France had an excess of about 50 tonnes of nitrogen per hectare of agricultural land, somewhat below the OECD and EU averages (OECD, 2008). Nevertheless, nitrate (NO_3) concentration of groundwater has been on the rise over the last decade: it exceeded the maximum admissible concentration of 50 mg/l (Groundwater Directive of 2006), above which water is considered undrinkable, in 6% of the observation sites in 2007 up from 4% in 1997, and was between 40 and 50 mg/l in 6% of the observation

26. Around 30 French municipalities covering 600 000 inhabitants experimented with incentive-based waste pricing in 2009.

points in 2007 compared to 5% ten years earlier (CGDD, 2010b). Water pollution is especially important in some regions such as Brittany (partly due to livestock manure), where nitrate concentration was above the maximum admissible concentration at 20% of drinking water extraction sites and where around one third of extraction sites delivered water incompatible with existing quality standards already in 2002 (Cour des Comptes, 2002).

Figure 4.8. **Fertiliser and pesticide use in Europe, 2008**



1. Tonne/ha of total agricultural land.
2. Tonne of active ingredient/ha of total agricultural land

Source: OECD calculations based on Eurostat data.

Policy measures to improve surface and groundwater quality include the restoration of the ecological continuity of watercourses, the creation of at least five-meter-wide green buffer zones alongside watercourses, the purchase of 20 000 hectares of wetland, the establishment of marine natural parks to cover 2% of French sea areas by 2020, the protection of the 500 most endangered water extraction sites and the tripling by 2012 of the area covered by organic agriculture in particular close to watercourses and water extraction sites (Bommelaer *et al.*, 2010). Mention should also be made of the extension of winter soil cover in vulnerable areas starting in 2012.

Specifically targeting farmers, the government's Eco-Phyto programme aims to halve pesticide consumption by 2018, mainly based on an awareness and education campaign, the development of a real-time warning system against pests and the banning of a number of substances used in pesticides (MAP, 2009). Since 2000, the general tax on polluting activities (TGAP) has been levied on pesticides with an average tax rate of 2% (Aubertot *et al*., 2005). In 2009, the TGAP on phyto-sanitary products was replaced by a fee on diffuse agricultural pollution (*Redevance pour pollutions agricoles diffuses*), ranging from EUR 0.6 to EUR 3.7/kg in 2009 increased to EUR 0.9 to EUR 5.1/kg in 2011. The main changes are that the tax will not be paid by producers but by distributors and the amount of the tax will be documented on the invoice to increase farmers' awareness. Yet two open issues remain. First, the proceeds of the tax, which will be distributed among the water and waste-treatment-plant operators according to observed pollution levels, is unlikely to cover the costs of removing pesticides from the water. The projected revenues from the fee amount to around EUR 60 million per annum after 2010 (Bommelaer *et al*., 2010), of which only EUR 30 million have been earmarked for water agencies whereas the other half has been assigned to funding the Eco-Phyto plan. However, the annual costs of removing pesticides to produce drinkable water is estimated at EUR 50-100 million (Aubertot *et al*., 2005). Moreover, using pesticides has other important externalities: a negative impact on wildlife and biodiversity (killing honeybees, beneficial predators, fish and birds) and on human health through pesticide poisoning. Just the external costs on human health may be around EUR 2/kg of substance (Tegtmeier and Duffy, 2004). Overall, external costs of pesticide use appear not to be fully internalised. Second, the projected revenues imply an effective tax rate of 6% that seems to be too low to trigger changes in farmers' behaviour. The Danish experience shows that the implied tax rate has to be significantly higher to achieve a strong reduction in pesticide use (Aubertot *et al.*, 2005).

A water pollution fee for non-domestic water pollution is determined for industrial users and farmers that varies as a function of the level of annual water pollution (Environmental Law; article L. 213-10-2). Farmers also have to pay a fee to the water companies on water pollution from livestock (*Redevance pour pollution de l'eau d'origine non domestique des activités d'élevages*). However, the fee applies only to farmers with a large number of animals and only to a fraction of the livestock.

No policy measures are planned to deal specifically with pollution arising from the massive use of fertilisers. Yet, in addition to ground water pollution, the use of synthetic nitrogenous fertilisers entails a number of negative externalities. Fertiliser production generates GHG emissions and causes local atmospheric pollution. When in the soil, nitrates are decomposed by bacteria resulting in N_2O emissions that account for 5% of global GHG emissions. Furthermore, run-off of nitrates and other nutrients from agriculture to surface water causes eutrophication (algal blooms) that blocks sunlight and decreases the water's oxygen content. Blottnitz *et al.* (2006) estimate the external costs at EUR 0.16/kg of nitrogen for fertiliser production and EUR 0.15/kg for fertiliser use based on a carbon price of EUR 19 per tonne. These estimates would increase substantially if the carbon price put forward in the Quinet Report (2009) were to be used. While fertiliser producers are covered by the EU-ETS, the external costs related to the use of the products should be matched by a corresponding tax levied on the products or by imposing fertiliser usage quotas on farmers in the spirit of a tradable permits system. Each system has pros and cons in terms of economic efficiency and practical feasibility. Proposals to this effect had been put forward in the latest laws on water. Therefore, economic agents concerned by the new regulation need to be compensated for example in the form of lump-sum payments.

Water pollution stemming from household wastewater is much better handled. Around 94% of French households are connected to sewage treatment plants (OECD, 2009b). This ratio is somewhat higher in Canada, Germany and the United Kingdom, but is much lower (around 70%) in other OECD countries including Belgium, Ireland, Mexico or Turkey. Most sewage treatment plants in France meet existing European standards that require secondary (biological) treatment and low nitrogen and phosphorus concentration through tertiary treatment. The 146 largest sewage treatment plants identified at the end of 2006 as substandard should be brought up to full compliance by 2015. By March 2010, 104 of those plants had been modernised, and work had started at 36 others (MEEDDM, 2010b), while as of 1 January 2011, 122 had been brought into compliance and work was underway at a further 22. In addition, households pay the water agencies a fee on water pollution (*Redevance pour pollution de l'eau domestique*) that cannot exceed EUR 0.5/m3. Finally, household detergents containing phosphates have been banned since 1 July 2007. In accordance with the Act of August 2009 implementing the *Grenelle de l'environnement*, this ban will be extended to industrial detergents, currently subject to the TGAP, from 2012 onwards.

The second major objective of French water management policies is the sustainable use of water resources. Overall water consumption was slightly above 500 cubic meters per year per person in 2006 and necessitated the use of 17% of long-term fresh water reserves. An important part of water consumption is connected with the cooling needs of nuclear power plants. Nevertheless, even abstracting from that, per capita water consumption of households and agriculture is still among the highest in Europe (Table 4.9). High consumption coupled with drought causes seasonal local water shortages. For instance, on 13 August 2010, restrictions on water use were imposed by the prefects in 52 departments (out of the total 96 in Metropolitan France) (MEEDDM, 2010f). The prices charged for household water in major French cities are close to the European average. At the same time, nationwide water prices are among the highest in the OECD area (Figure 4.9). It would seem that countries with higher prices recorded lower per capita household water consumption. Households are charged proportionately to water use, and prices cover operating and infrastructure maintenance and renewal costs (OECD, 2010). Incentives to save water could also include progressive water tariffs such as increasing block tariffs. Furthermore, rather than the standard VAT rate of 19.6%, it is the reduced rate of 5.5% that is applied to water services in France. Even though European Directive 2006/26/EC permits the use of the reduced rate for water distribution, this reduced rate may induce a relative overconsumption of water relative to other goods and services and thus should be eliminated. At the same time, according to OECD (2010), water prices are below total cost recovery for industry and agriculture. Cutting indirect subsidies on industrial and agricultural water use would efficiently reduce water consumption.

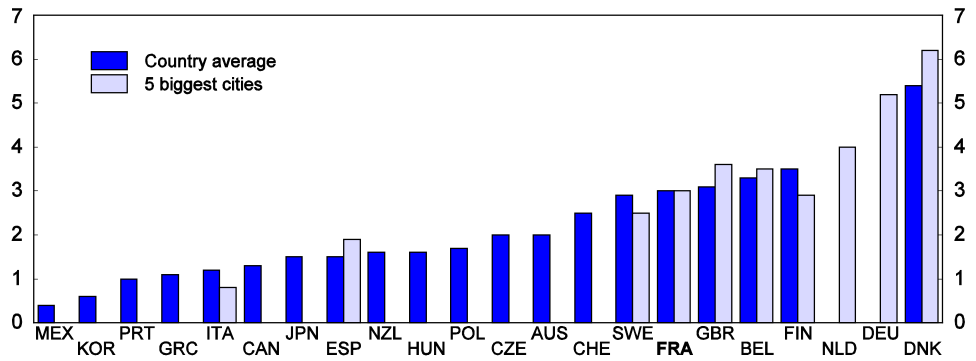
Table 4.9. **Per capita water use, 2006**

	Abstraction/resources Per cent	Total	Public system	Agriculture	Industrial cooling	Manufacturing
			m^3 per capita			
Netherlands	10.9	598.7	36.7	8.5	318.5	161.6
Switzerland	5.0	356.6	47.8	..	225.2	..
Slovakia	0.9	127.5	59.2	4.4	7.0	56.9
Germany	18.9	430.8	65.1	..	272.2	65.6
Czech Republic	12.3	191.4	68.2	2.9	59.0	29.5
Belgium	32.1	611.6	69.7	3.6	398.7	123.5
Greece	13.2	853.8	75.7	757.1	9.0	
Denmark	4.2	126.0	78.2	36.5	0.8	8.3
Slovenia	2.9	465.3	83.3	2.3	351.3	27.3
France	**17.5**	**516.7**	**93.0**	**75.5**	**302.7**	**45.4**
Sweden	1.4	288.6	97.8	11.7	11.3	154.3
Spain	30.4	771.5	130.3	467.4	149.1	21.9
Ireland	1.5	169.3	141.2	..	..	..

Note: Data refer to 2006 or to the latest available year.

Source: OECD calculations based on data obtained from Eurostat.

Figure 4.9. **Unit price of water for households in OECD countries, 2008**[1]



1. 2008 for the 5 biggest cities, and 2007 or latest available year for the OECD country averages

Source: OECD (2010, *Pricing water resources and water and sanitation services*) for country averages and NUS Consulting (2008, *Étude sur le prix de l'eau en Europe en 2008*) for the average price in the 5 biggest cities of a country.

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