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Taxing energy – why and how?

The present policies across western countries

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Abstract

A range of motives underlie energy related taxes. Typical reasons are collection of the ground/scarcity rent in resource extraction, taxation of monopoly profit and to collect public revenues. Energy taxes may also serve as pricing of infrastructure use and to adjust for imperfections in markets exploiting non-renewable energy resources. Most energy production and energy use bring along negative externalities, and taxes, tradable permits, green and white certificates are used to internalise such effects. However, policy is not straightforward because of the influence on cost and competition and concerns for regional employment, economic activity within certain industries, and any distributional effects. Tax discrimination, subsidies and regulations then undermine the efficiency of energy instruments. Hence, the taxes may deviate from theory. This report illuminates to what extent the energy related taxes may vary between western countries, and whether this variation can be explained by economic theory. We find that taxation varies tremendously among countries, and this variation indicates divergence between theory on efficient means and energy related policy.

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1. Introduction

Generally, the prices on energy goods in competitive markets reflect operating costs, shadow costs on capacity constraints, and the costs of capacity expansion. Taxes in energy markets are launched for several reasons, like out of revenue concerns and to correct for market failures and negative externalities.

Since taxation in markets with no externalities normally influences on volumes, the society suffers an efficiency loss which should be compared to the need for funding of for instance governmental services. According to the novel article by Ramsey (1927), such taxes should be put on the least elastic commodity to minimize the efficiency losses.

Some primary energy sources, as for instance crude oil, gas and coal, are scarce and exhaustible. Other primary energy sources, such as hydro, face decreasing returns to scale. Both resources then enjoy resource and scarcity rents. This is a perfect tax base for the government (Hotelling 1931, Karp and Newberry 1991). A tax on the scarcity rent does not cause any inefficiency since is has no impact on supplied volumes, and hence, does not correct for any externalities in production.

In many of the primary energy markets, producer concentration is high, and abuse of market power reduces volumes and increases prices. In practice it is hard to separate monopoly profits and resource/ground rents. Then taxing of monopoly profits is a favourable option to many countries.

Some energy uses are close information carriers for the use of infrastructure, such as roads and transmission networks for electricity transportation. In transmission networks, the pricing is direct via transmission tariffs, while for transport the payment for using the facilities is indirect and inaccurate through fuel prices (cf. that the energy use per kilometre varies between by the weight of the vehicle).

Most energy production and use bring about negative externalities. These can include emissions of greenhouse gases (fossil fuels), emissions of sulphur and particulate matter (fossil and bio fuels), aesthetics and noise (wind power), destruction of nature (hydropower), and radiation (nuclear power). Producers and consumers do not normally consider such costs. Correction of negative externalities is then an important argument for taxing energy extraction/production and consumption (Pigou 1920, Sandmo 1975). A system of tradable emission permitted under a cap is a cost efficient alternative to externality taxes, given that the permit price equals the tax under the same externality cap.[1] In a cost efficient approach, the environmental costs are exposed to all sources according to the stress they cause. Energy-related emissions will then fall through substitution between primary energy sources, the development and utilization of improved technologies in the conversion from primary to secondary energy, substitution between energy carriers, and more efficient technologies in energy consumption. However, correction of externalities may be complex, cf. the additivity problem of capturing complex negative externalities by taxation in Sandmo (1975). Substituting taxes on factor inputs (labour, capital) by taxes on externalities may also increase overall efficiency (the double dividend, Sandmo 1975, Goulder 1995b). In the economics literature, first-best cost efficient instruments in the presence of negative externalities have been extensively discussed (Diamond and Mirrles 1971, Sandmo 1975, Ballard and Fullerton 1992). In the presence of positive external effects, e.g. from research and development, subsidies should be used to correct market failure.

In the presence of imperfect information, taxes and subsidies may also be optimal instruments to correct such market failures. Further, what may seem as an optimal

[1] Some of the literature highlights the differences between these instruments. See, for example, Bovenberg and de Mooij (1994). We do not go into these details here. Rather, we start out with the equality presumption as our focus is on other aspects of the implementation of these instruments.

domestic tax system can induce non-optimal solutions in a global context. If domestic taxation on emissions contributes to leakages and higher emissions abroad, exemptions could be made from what is an optimal solution for a closed economy. However, this is not straightforward since information on the relative elasticities for different sectors is needed to form the optimal discrimination schedule.

Since taxes imply increasing costs, technology adjustments and structural changes, competition, local employment, and income distribution may be affected (Hoel 1995). To circumvent these effects, policymakers introduce exceptions from and countermeasures to the first-best instruments (see examples for taxes in Norway; Bye, Hagem and Kverndokk 2007, and Bruvoll and Bye 2003). Tax exemptions for specific groups and energy end users, free allowances of emission permits and discrimination with respect to both taxation and responsibility under a cap-and-trade system, reduced carbon tax rates and subsidized electricity contracts are all examples of divergence from the first-best solutions. A range of additional instruments are also introduced. These include renewable share requirements in energy production—so-called *green certificates* (Bye 2003, Menanteau et al. 2003), requirements for demand side energy saving—referred to as *white certificates* (Bertoldi et al. 2006, Quiron 2006), cap-and-trade for greenhouse gas emissions (Hoel and Karp 2001) — also known as *brown certificates*, subsidies for renewable energy and standards for energy consuming appliances.

In the literature, the partial effects of the introduction of different instruments are intensively discussed. The literature concludes that the partial effects of each instrument depend upon the elasticities of both demand and supply and the strength of the instrument. Some studies include the combination of taxes and subsidies (Goulder et al. 1999) while others discuss which instrument is best (Quiron 2006). Fischer and Newell (2008) assess different policies for reducing carbon dioxide emissions in the electricity sector and conclude that a portfolio mix of instruments may be optimal because of knowledge spillover. Bye and Bruvoll (2008) show that all of these instruments work as combinations of taxes and subsidies through market effects. In addition, since the effects of the instruments depend on the demand and supply side elasticities, any instrument changes the technological composition. This implies that the instruments' effects depend on the sequence of introduction; they are path dependent.

The extent of motives, instruments and possible exceptions from first-best-instruments, opens for a jungle of political tools. The relationship between the theoretical basis and the (variation in) instruments is more difficult to detect the more instruments are launched to reach the same, or overlapping, goals. As referred above, there is a wide literature on partial effects and to some degree the effects of the combination of two instruments. But in practice, empirical analyses of the deviation of total instrument portfolio from theory are very difficult or impossible to conduct. As an indication of variation in the deviation between theory and practise, this report aims to illuminate to what degree instruments may vary between countries. The review shows that instruments vary significantly between countries and economic activities. This indicates divergence between theory on efficient means and energy related policy. The benefits from coordinating and simplifying the policies with the aim to approach the efficiency principle of one instrument per objective should be subject to further investigation.

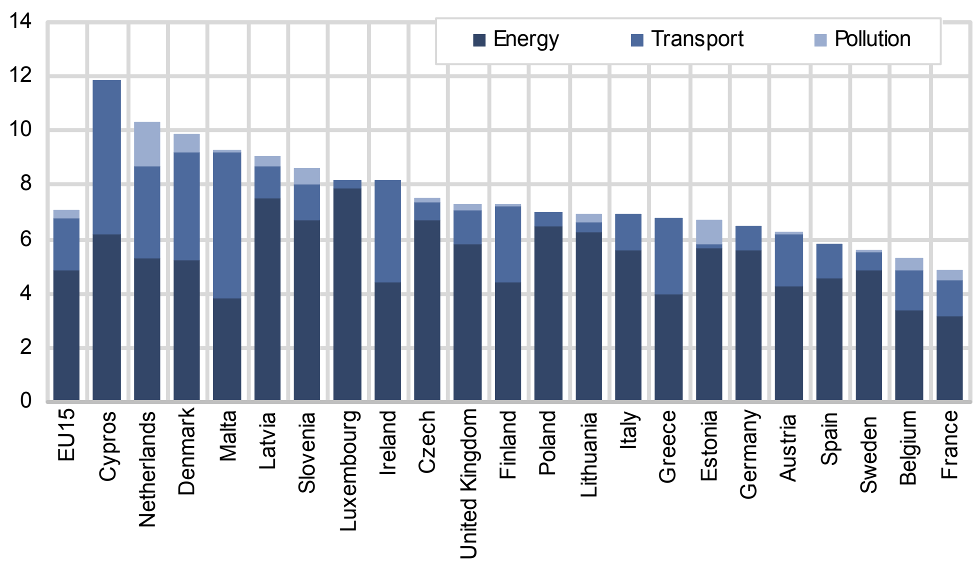
2. The variation in tax levels

During the 1960s and 1970s, taxes on energy were launched to capture governmental revenue. As energy price elasticities are generally low, these taxes may be characterized as Ramsey pricing. During the 1970s, OPEC I in 1973 and OPEC II in 1978, crude oil prices doubled twice, and the awareness of a possible scarcity of oil increased. The fall in crude oil prices in mid 1980s eased the introduction of taxes on petroleum products. At the same time, local pollution became an increasing concern, and oil products with heavy sulphur content were banned or heavily taxed. Pollution taxes met opposition, and earlier energy taxes were partly reduced to compensate. Hence, the apparent strengthening of environmental policy was partly a redefinition of energy taxes, and the total effect on the energy markets was considerably lower than the pure environmental policy promised.

Figure 1 depicts and overview over the energy and environment tax revenues in European countries. Environmental taxes dominate in most countries, followed by transport taxes. The environmental taxes constituted the smallest revenues. Energy and environmental taxes amounted to 526 billion Euros in 2004, i.e. 7 percent of total tax revenues.

Taxes vary significantly between countries and economic activities. The variation in transport taxes can be substantiated in differing infrastructure standards. Transport and infrastructure is also crucial policy variables to support regional settlement. Further, high density means high efficiency in public transports, while scattered population demands high roads cost per person kilometre. On the other hand, densely populated areas demand high standard roads, and land prices in central areas are high, see Chapter 4 for a further discussion of taxes on transport energy. Pollution taxes as share of total taxes vary between zero and 1 per cent, and the variation is relatively high among countries, see also Chapter 5.

Figure 1. Revenues from energy and environmental taxes in percent of total revenues from taxes and social contributions. 2004.



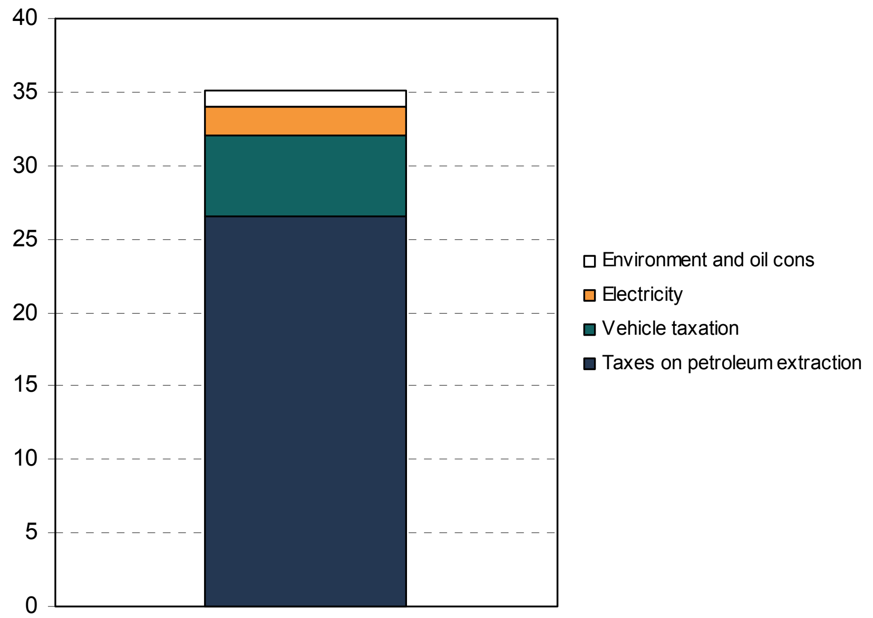
Source: Eurostat (2008a).

In countries rich on primary energy sources, for instance Norway, UK and the Netherlands, taxes on the resource and monopoly rent may override any other taxes on energy, whether taxes are based on the Ramsey principle[2] or on externalities.

[2] Ramsey pricing (Ramsey 1927) advocates taxes correlated to relative price elasticities, i.e. a high tax on commodities/input factors with low elasticity produces relatively high income and less product/factor distortions.

Norway is an obvious example of the importance of such taxes, see Figure 2. In 2006, taxes on petroleum extraction constituted 76 percent of total energy related taxes in Norway. Taxes on electricity and road transport together constituted 21 per cent. Energy related taxes constituted 28 per cent of total taxes to the government, 5 times the share in any other European country. This obviously reduces the need for extensive Ramsey taxation of energy commodities. In 2005, the oil and gas sector contributed to 35 percent of public revenues.

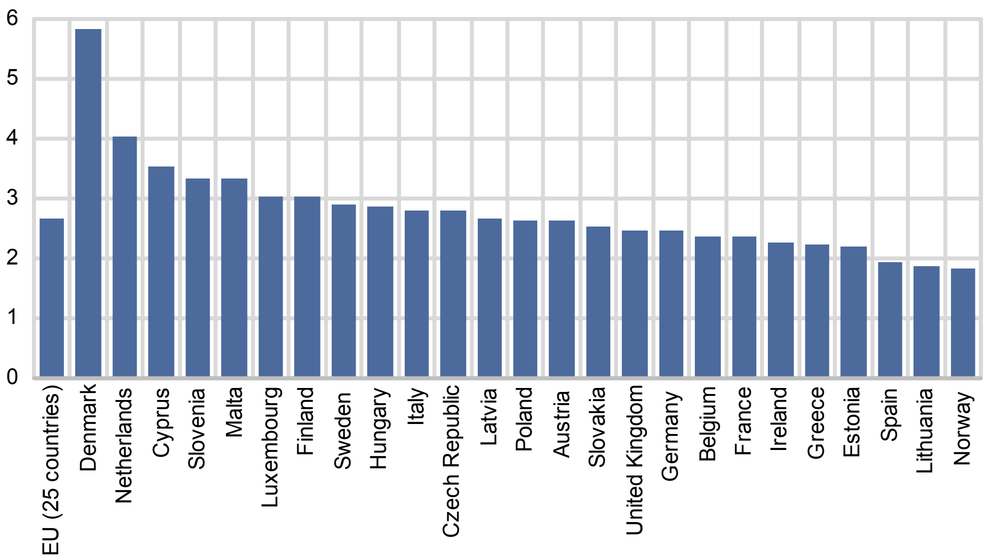
Figure 2. Revenues from energy related taxes in Norway, 2006. Billion Euro



Source: Statistics Norway.

Figure 3 depicts the environmental taxes compared to GDP, including taxes from all activities with negative impact on the environment (taxes on transport, energy, pollution and resources). With the exception of Denmark, taxes vary between 2 and 4 percent of GDP. Hence, despite the significant emphasis on environmental and energy regulations in terms of instruments, the importance to the overall economy may be limited.

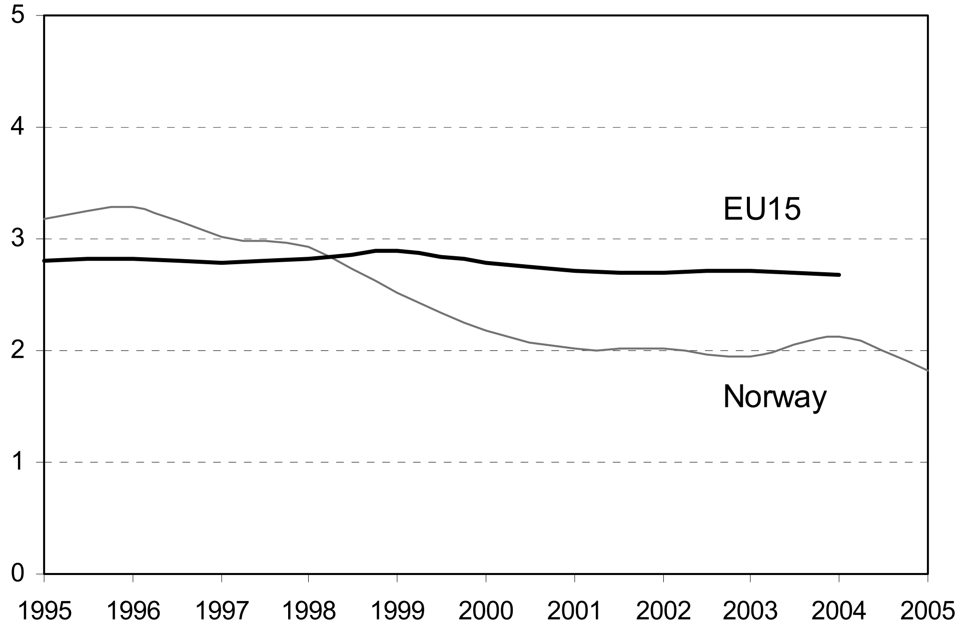
Figure 3. Total energy and environmental taxes as share of GDP. Percent. 2005 (2004 for EU25)



Source: Eurostat (2008b).

One may expect that increasing environmental awareness may increase the environmental taxes relative to GDP, cf. the EKC literature.[3] When looking at the share of taxes over time, these have been fairly constant for the EU (15) countries, see Figure 4.

Figure 4. Total environmental taxes as share of GDP. Percent



Source: Eurostat (2008b).

I.e, taxes have increased nominally, and about at the pace of GDP growth. In Norway, the share has decreased significantly over the period. The reason for the reduced tax/GDP share is the extremely high growth of the Norwegian petroleum sector. The revenues from the taxes have remained fairly constant also for Norway.

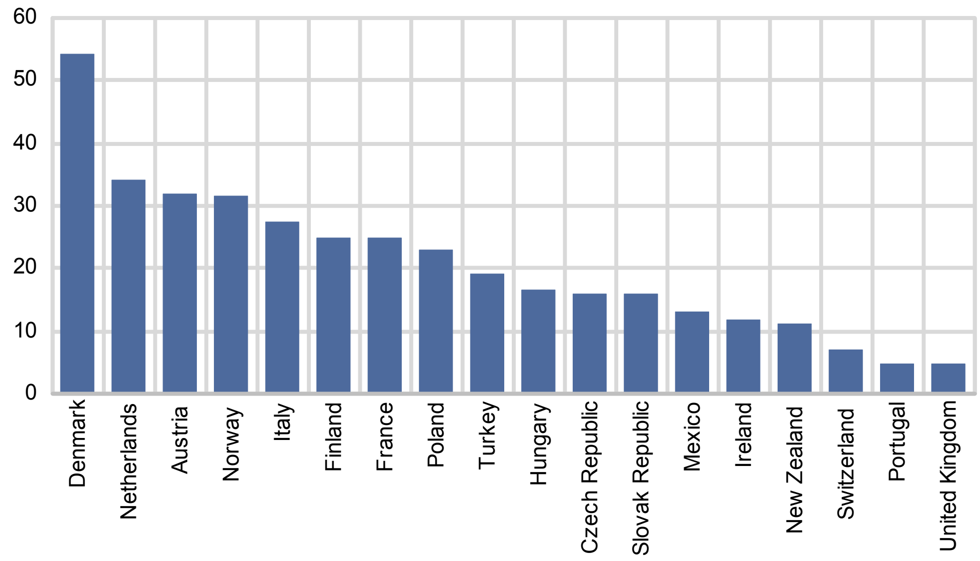
[3] The Environmental Kuznets Curve literature, hypothesizes that pollution first rise, then fall by increasing income. One of the reasons for the bending curve, is increasing environmental awareness and political acceptance for environmental regulations when income increases, see e.g. Stern (2004).

3. Ramsey taxes

Electricity is a much used tax base in Europe. Some relevant theoretical arguments may apply; The total electricity bill should cover both power and infrastructure costs for transporting electricity. The tax could pay for the infrastructure. But most countries separate the payment of power and transports through the network. A second argument for a tax on electricity may be the need for revenue. Then the Ramsey principle advocates taxing the least elastic commodity. Electricity may be such a commodity.   Some argue that we should launch an electricity tax to capture negative externalities. The production of electricity may cause several environmental problems, but use of electricity does not (if we disregard any radiation). I.e. any taxes on the use of electricity must be regarded as Ramsey taxes.

The electricity taxes vary significantly between countries, see Figure 5. For households the tax share of the price varies between 5-55 per cent. Denmark tops the electricity tax list, followed by Netherlands, Austria and Norway. On the low tax side we find United Kingdom, Portugal and Switzerland. One reason to the variation may be comparable differences in elasticities and the need for governmental income and priority of public funding. However, there is no reason to think that elasticities vary that much across countries. The tax base could also differ between countries, cfr for instance the Norwegian, UK and Dutch large revenue from the petroleum sector that reduces the need for supplementary taxes.

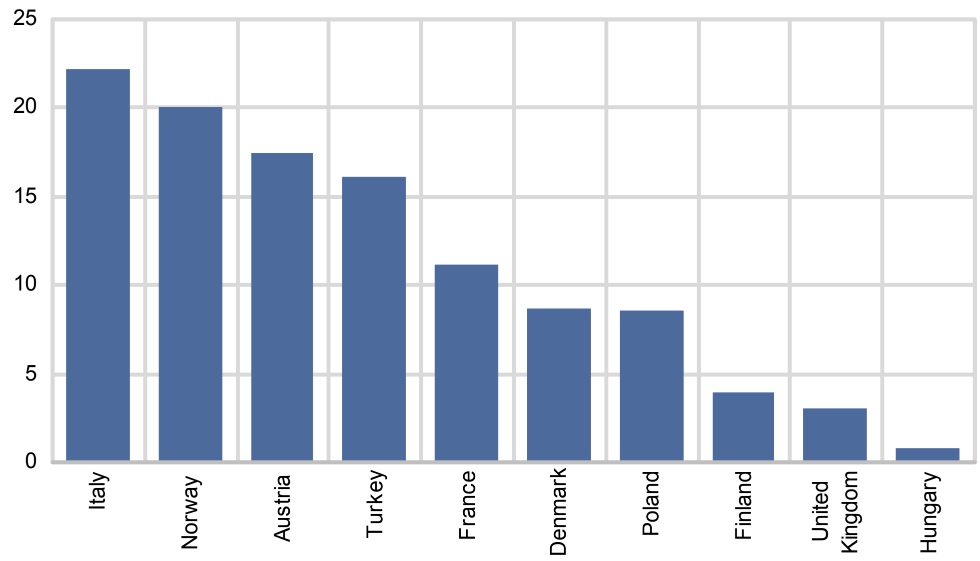
Figure 5. Taxes on electricity in households. Percent of price. 2007



Source: OECD/IEA (2007).

For industries, the taxes are generally lower, see Figure 6, varying from 2-22 per cent, lowest in Hungary and United Kingdom and highest in Belgium and Italy. Many manufacturing industries are fully exempt from electricity taxes. Unless this difference is substantiated in significantly higher demand elasticities than for households, this reveals an implicit relative subsidization of industries. The argument for this discrimination is often comparative advantages for industries. cfr Krugman (1996) for the relevance of this argument.

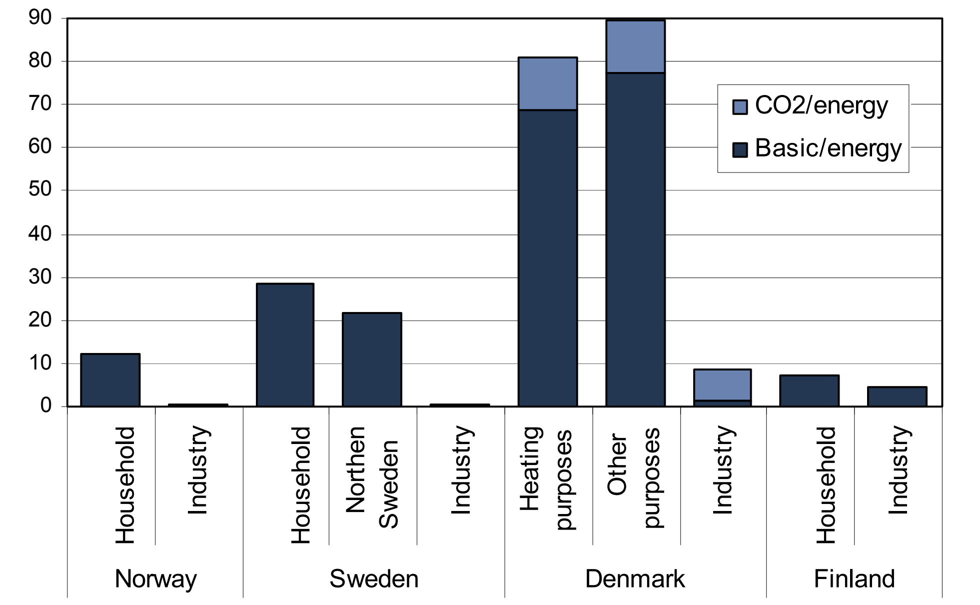
Figure 6. Taxes on electricity in industry. Percent of price. 2007 (2004 for Denmark)



Source: OECD/IEA (2007).

The Nordic countries are more similar when it comes to public sector and welfare levels than European countries in general. Then one may also expect rather similar Ramsey taxes across countries. Electricity taxes are levied in all Nordic countries, with the exception of Iceland, see Figure 7.

Figure 7. Taxes on electricity in Nordic countries. Euro/MWh. 2005



Source: Nordic Council of Ministers (2006).

The rates vary greatly not only between the Nordic countries but also between different user groups within the same country. All countries have introduced special provisions for the industry, out of competitiveness concerns.

In Denmark, the total average tax for all end uses is three times higher than in Sweden and six times higher than in Norway. Most production of electricity is thermal (coal based) and heavily polluting. This substantiates an argument that this is not a simple Ramsey tax but also contain a substantial CO_2-tax element.

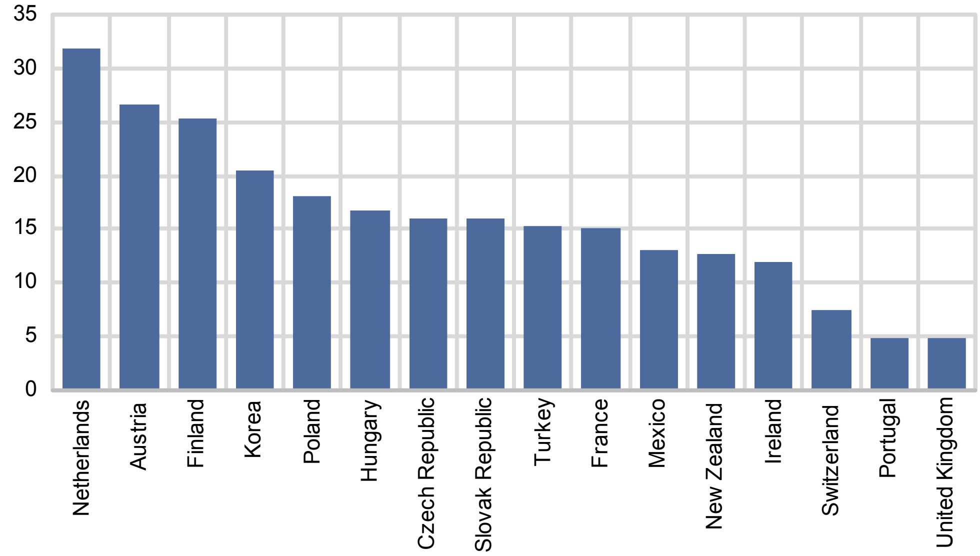
The tax also depends on the specific energy use differentiated on processes, and the industries face reduced rates if committing to increase energy efficiency. Hence, also here the basic tax includes a compensating CO_2-element. The industry as a whole is completely exempted from the basic energy tax.

Likewise, Swedish industry, agriculture, forestry and fisheries are not subject to the basic energy tax and receive major support in terms of reduced CO_2 tax levels. Manufacturing industry faces low rates. Finland has lower energy taxes and does not grant energy and CO_2 tax reduction programs on the same scale as the other countries.

In Norway, a very low tax on industry reflects that power intensive industries, which constitute a large share of the industrial electricity end use, are totally exempted from electricity taxes. These exemptions apply for several production processes, such as electricity used for chemical reduction, electrolytic, metallurgical and mineralogical processes, that benefit the metal and cement industry, and the production of basic chemicals. Renewable projects and smaller power production sites are exempt from the electricity tax.

For households' natural gas taxes we find the same pattern for the distribution of taxes among countries in Europe, see Figure 8. Netherlands and Austria face the highest taxes, while United Kingdom, Portugal and Switzerland tax the least. It is not straightforward to see if there is any link between theoretical arguments and the great variation in taxes on natural gas.

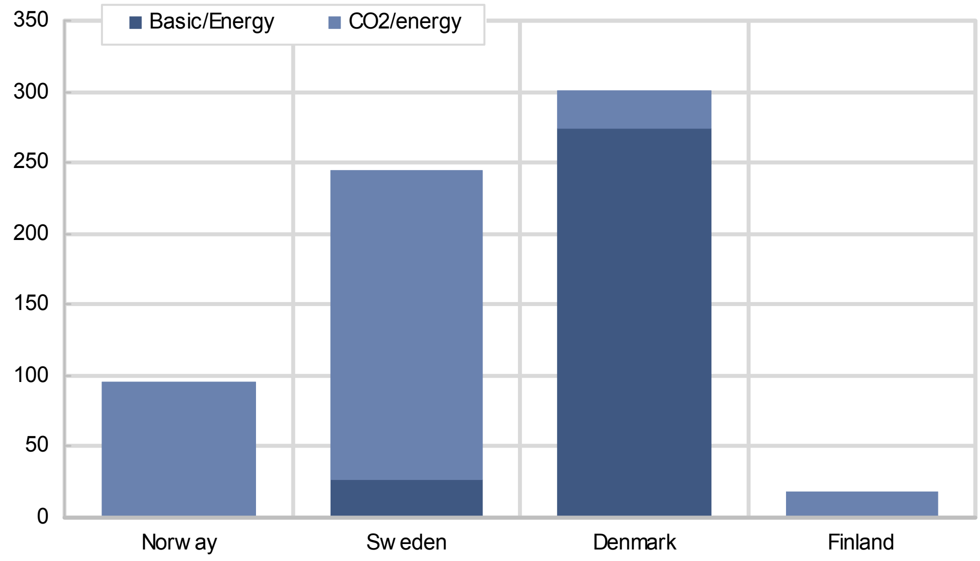
Figure 8. Taxes on natural gas in households. Percent of price. 2007



Source: OECD/IEA (2007).

A closer look at the Nordic countries reveals that Norway, Sweden and Finland almost exclusively tax natural gas out of environmental reasons, see Figure 9, while almost 95 per cent of the Danish tax is a Ramsey tax, only 5 per cent a carbon tax.

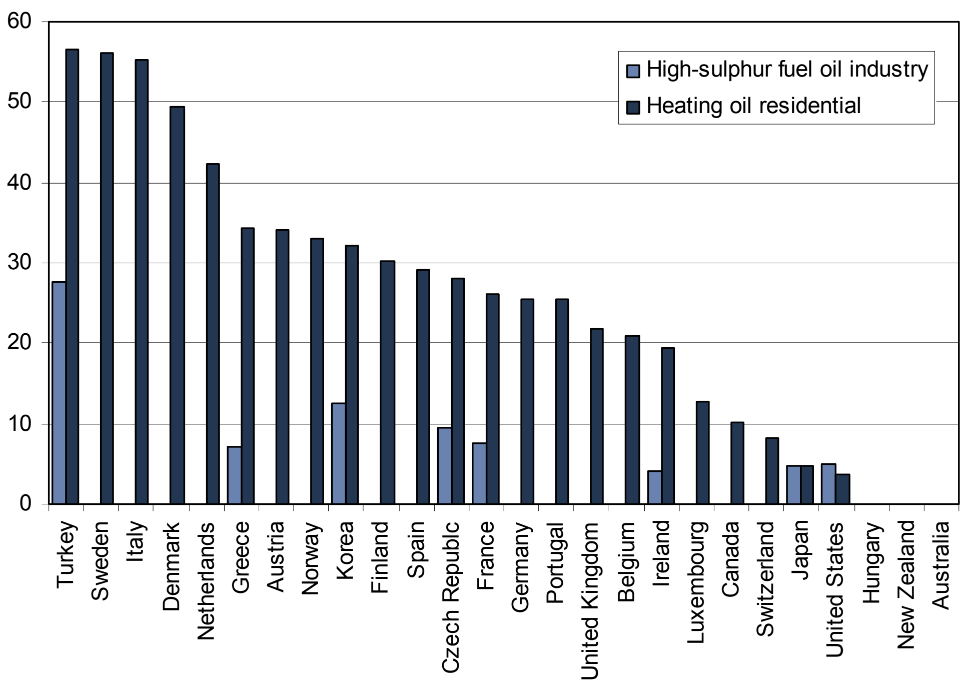
Figure 9. Taxes on natural gas. Euro/Sm³



Source: Nordic Council of Ministers (2006).

With respect to heating oil, high sulphur oils in industries are usually taxed low or not at all. Only 8 out of 26 countries tax such oils, see Figure 10. This may reflect that heavy fuel oil use is banned or regulated in other ways. Governments may also be reluctant to tax industries for competitive reasons, and consumer taxes seem to be more political acceptable when taxing pollution. The tax rates also vary much between countries. Differences in tax rates may be founded in the variation in local pollution, which is the main externality argument for taxing heavy fuel oils. Light fuel oils in the residential sector is taxed in most countries and much more than the heavy fuel oils. Some may argue that taxing the residential sector is consistent with the Diamond and Mirrlees argument[4] about VAT, but since the reason for taxing fuel oil is the externality, this does not apply.

Figure 10. Tax as share of oil product prices. Percent of oil product prices

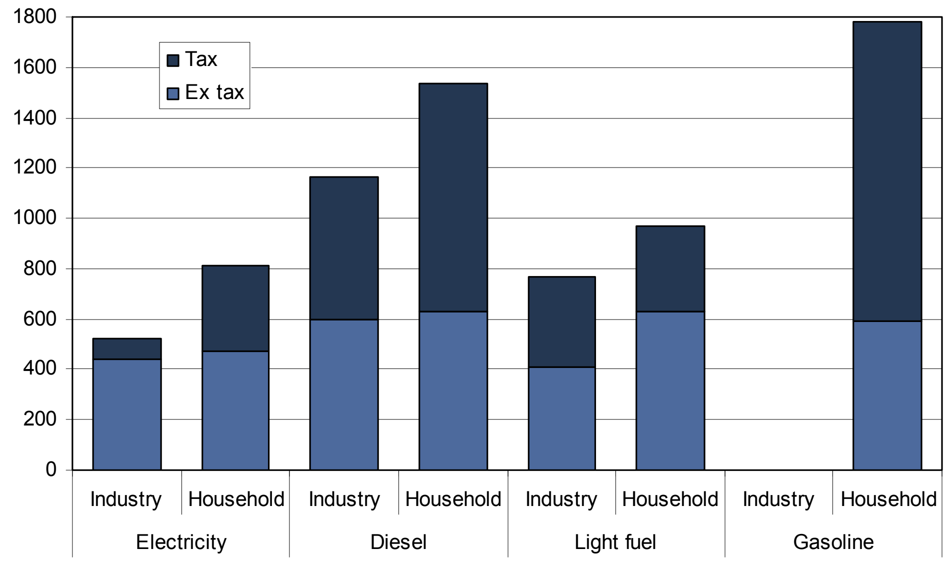


Source: OECD/IEA (2006a).

[4] Diamond and Mirrlees (1971) advocate that distortions should be confined to final consumption, leaving production undistorted, i.e. all taxes should be VAT only.

The Norwegian taxes, see Figure 11, illustrate an important aspect of taxation policy in most European countries. The relative taxes on light fuel and electricity are almost equal. The theoretical argument for electricity taxes may be the Ramsey principle, while taxes on fuel oils could be based both on a Ramsey argument and a correction of externalities. Gasoline and the diesel are more heavily taxed. Since light fuel oil creates both local and global externalities this seem odd. The reason may be that the price elasticity for transport fuels are lower than for heating oils, cf. the Ramsey argument, and a price on the use of road infrastructure.

Figure 11. Fuel prices in Norway. USD/toe



Source: OECD/IEA (2005b).

The electricity tax is much higher in the residential than in the industry sector. This may reflect that electricity has a much higher cost share than the other fuels in the industries. I.e., from a competition point of view, electricity taxes are kept low in industries.

To summarize, this overview has shown significant differences in the, presumably, Ramsey motivated taxes across countries and sectors. Differences in taxes could theoretically be substantiated in varying elasticities and different need for public funding. Important reasons for the great variance could also be the impact of particular pressure groups, regional concerns, mixed incomprehensible and unsuccessful environmental measures, etc. Note that such concerns should, according to theory, be subject to specifically defined instruments.

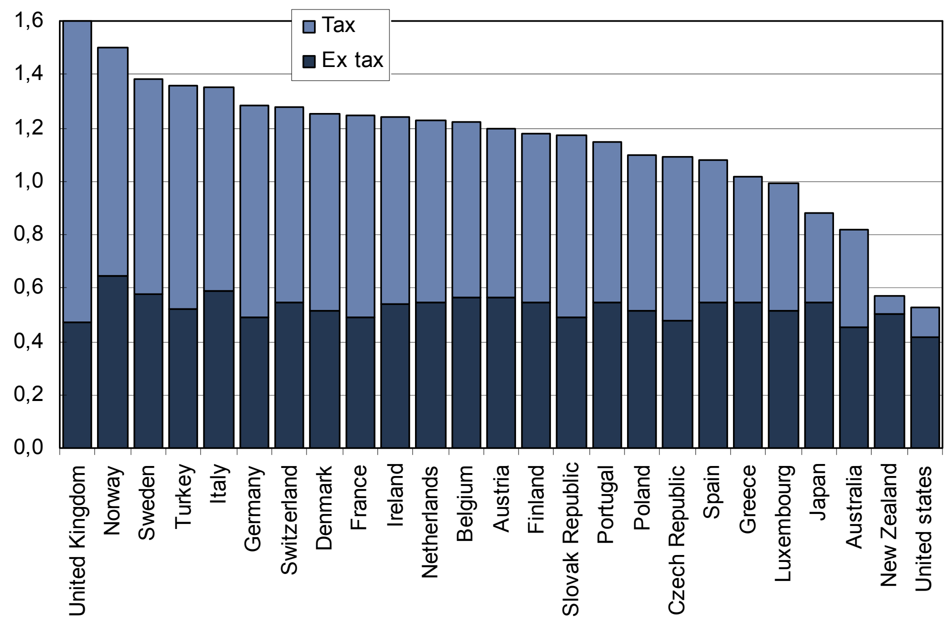
4. Transport related taxes

OECD (2004) claims that policies to reduce emissions from road transport appear to have little effect and entail relatively high costs. Nevertheless, most countries levy very high taxes on transport fuels. One obvious reason is that the tax serves as a price for the use of the transport infrastructure; another is that low price elasticities on transport fuels serve as a perfect revenue tax. According to Newberry (1982, 1988, 1990, 1998, 2004), the tax for road use in the purchaser price for gasoline or diesel often reflects the marginal cost of the infrastructure cost and may be well above the average cost of such use. Some countries use direct road pricing (turnpike roads), which works as a marginal cost of use, and some pay a standard annual fee for the use of roads (work as a funding fee when facing decreasing marginal cost of use). In many countries the earlier Ramsey tax on petrol and diesel are renamed to externality taxes. This implies that what appears to be a strengthening of environmental policy actually is just a conceptual redefinition.

Generally, taxes in Europe are higher than in other OECD countries (e.g. US, Canada, New Zealand, and Australia), see Figure 12 and 13. One reason may be more expensive road infrastructure, another that higher income levels make it easier to handle high tax burdens, and a third reason is different emphasis on climate gas abatement; i.e. the CO_2 tax element.

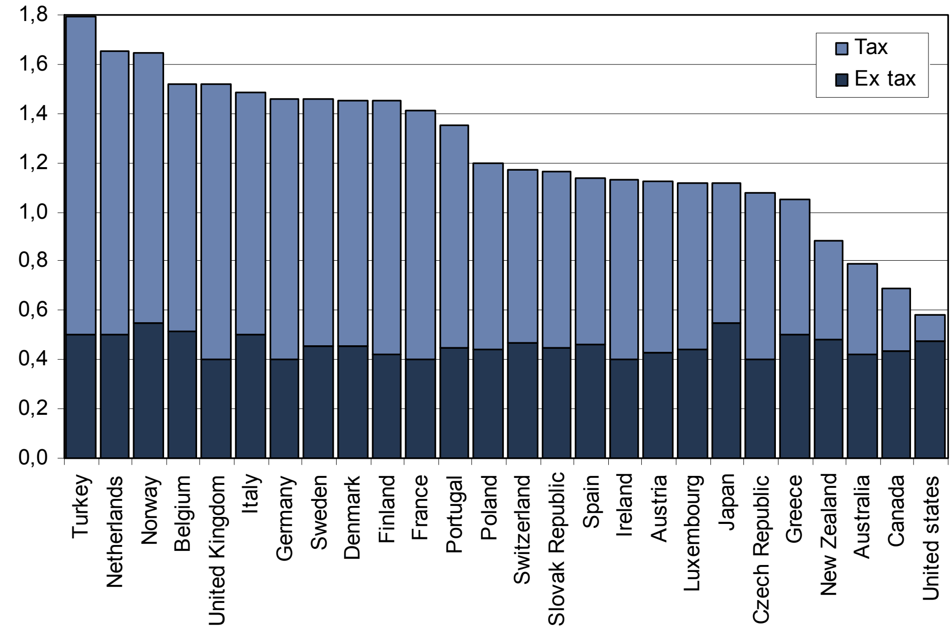
The gasoline taxes are relatively higher than the taxes on diesel. The un-weighed European average is 62 percent for gasoline taxes, compared to 46 percent for diesel. One reason is that gasoline releases more CO_2 than diesel. But still the tax measured per tonne of CO_2 is higher for gasoline. Diesel, on the other hand, releases significant amounts of other pollutants, especially particulate matter.

Figure 12. OECD automotive diesel prices and taxes, USD/litre, 2005



Source: OECD/IEA (2005b).

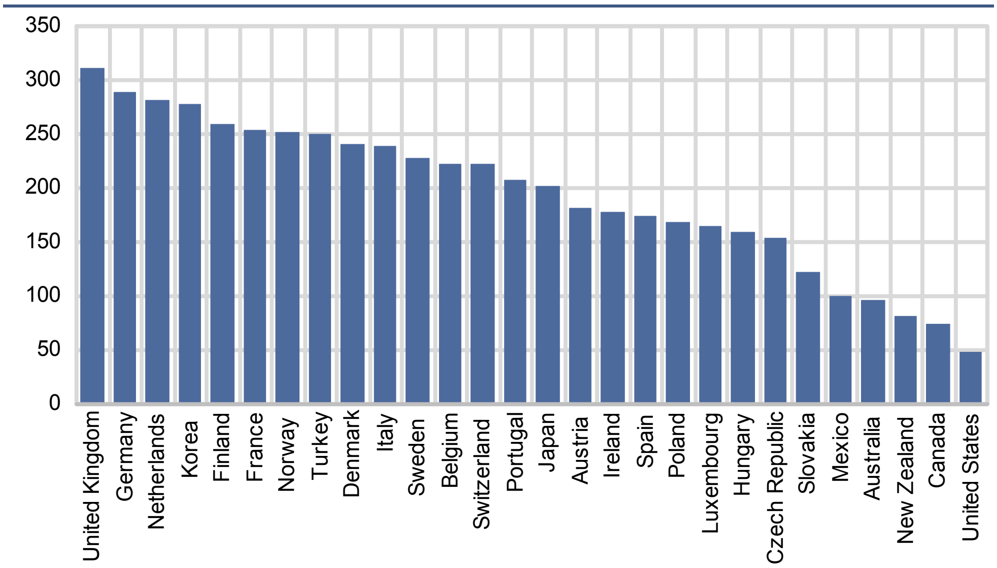
Figure 13. OECD unleaded gasoline prices and taxes, USD/litre, 2005



Source: OECD/IEA (2005b).

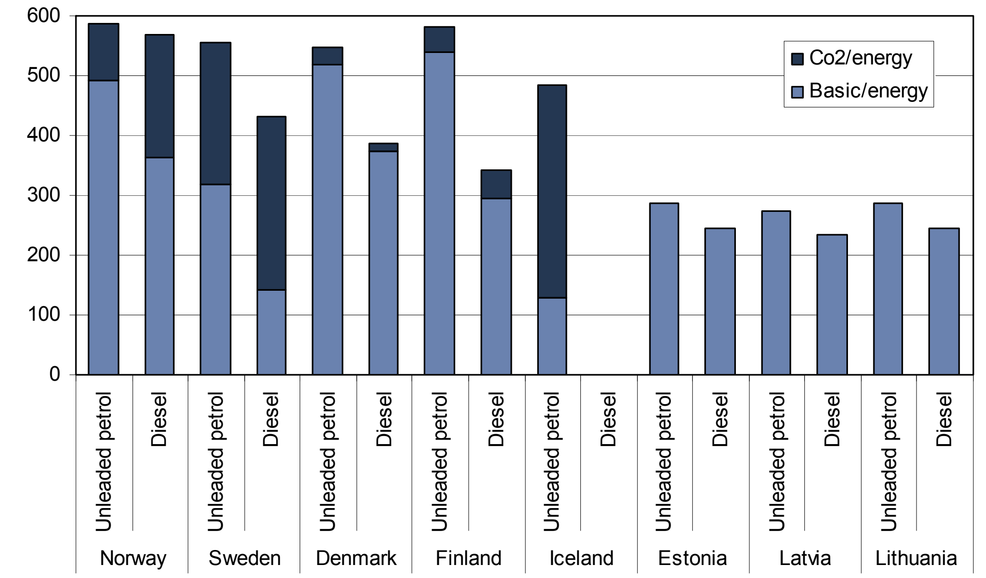
Different CO_2 policy explains some of the variation in transport fuel taxes, see Figure 14. Typically, European countries implement the highest taxes, while the lowest tax is in the US. Although the marginal cost of a unit emission is equal, different governments evaluate global warming differently. Different evaluation contributes to varying taxes.

Figure 14. CO_2 taxes on petrol. Euro/tonne of CO_2



Source: OECD (2004).

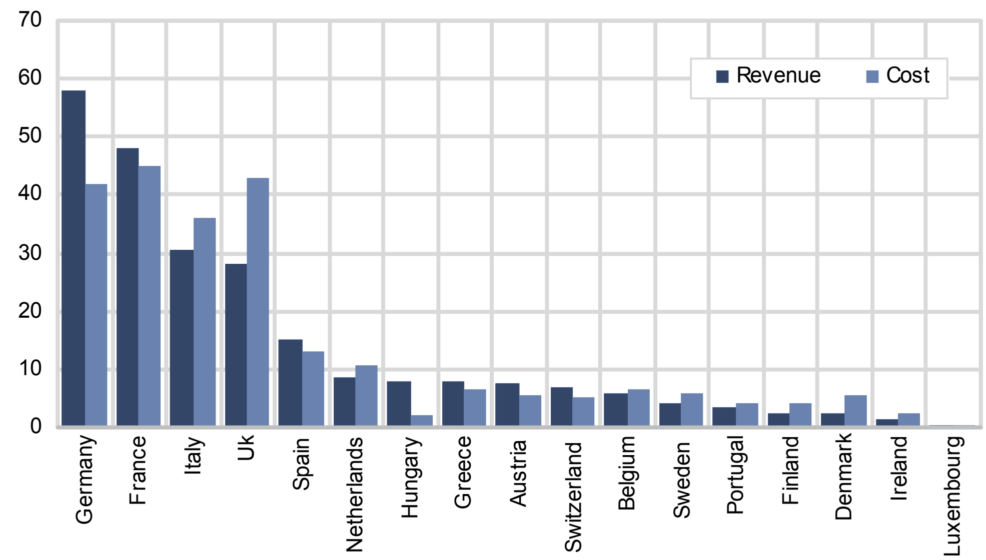
Figure 15. Taxes on diesel and petrol. Euro/1000 l.



Source: Nordic Council of Ministers (2006).

Figure 15 shows the taxes subdivided into the basic energy taxes and CO_2 taxes in northern Europe. Generally, the externality element is much lower than the revenue element. Again the taxes vary tremendously. It is not obvious whether revenue taxes reflect Ramsey taxation, or road pricing. Nash et al. (2002) compares costs and revenues associated with road transport, see Figure 16.

Figure 16. Road transport. Total costs and revenues*. Mill Euro. 1998



*: Costs: Infrastructure, air pollution, noise, global warming costs and external costs of accidents Revenues: Charges for infrastructure use, vehicle and fuel taxes.

Source: OECD (2005), Nash et al. (2002).

The social costs vary due to country specific characteristics, such as population density and traffic volumes. The figure shows that the social costs are comparable to the total revenue in most countries. This indicates that taxes are approximately right. On the other hand, increasing traffic incurs increasing marginal costs, by expanding the infrastructure, increasing congestion (the shadow price of capacity constraint) etc. Optimal taxation implies prices according to the marginal cost. Then average prices are too low to secure optimal investments in new capacity.

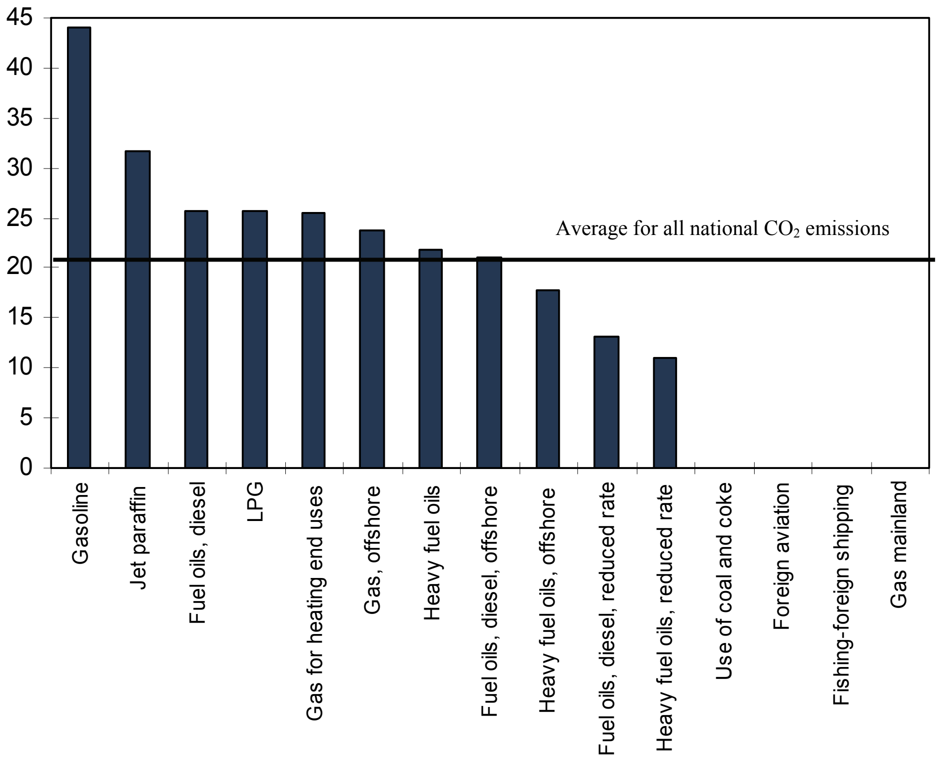
Regulation of emission intensities is one of the main instruments to control emissions from transport. Also, the chemical composition of motor fuels has been changed. E.g., the sulphur content of fuels is being reduced everywhere in the OECD area (OECD 2004).

In addition to taxes on transport fuels, most countries implement additional measures, such as taxing car purchases, subsidizing railways, waterways, bio-fuels and fuel cells.

5. Taxes on externalities

Many countries have changed their taxes to place costs on emissions rather than on the energy source. When comes to CO_2 taxes, they should principally be equal across sectors and countries, as the marginal damage is independent on the location of the emission source. In practise, CO_2 taxes vary between countries, and within each country they vary across fuels and sectors. Particularly, large emission-intensive sectors have obtained reduced rates or tax breaks (OECD 2004). A few countries apply specific carbon taxes, as part of the tax rate on petrol, recall Figure 14.
Norway was a pioneer in introducing a CO_2 tax system already in 1991, and the rates are among the highest in the OECD. However, the Norwegian system is an example of impaired taxation, see Figure 17.

Figure 17. Norwegian CO_2-taxes by sector (line, 2008), and average for all national emissions (bars, 2006), Euro/ tonne CO_2



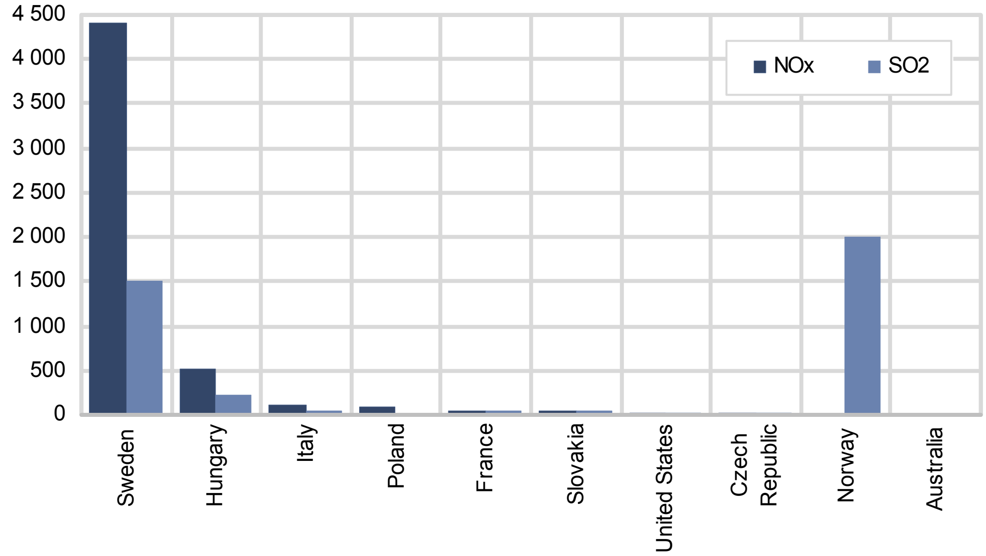
Source: Statistics Norway.

Exemptions are given to the sectors where carbon taxes would have caused restructuring and downscaling of the activity, while sectors in which the taxes have small effects, face high rates (Bruvoll and Larsen 2006). The exemptions are given out of competitiveness concerns, such as energy-intensive process industries, international aviation, gas consumption in refineries on land, the fishing fleet and coastal traffic. Other face reduced rates, such as pulp and paper and fishmeal industry.

Also the non-CO_2 greenhouse gases should face the same marginal emission costs as CO_2. Norway and Denmark have recently introduced such taxes, Norway in 2003 (PFCs, HFCs) and Denmark in 2001 (PFCs). Non-CO_2 greenhouse gas emissions are regulated by voluntary agreements, taxation and direct regulations.

The use and level of SO_2, NO_x and VOC taxes also show a wide variation in levels, see Figure 18. Varying marginal damage of local pollution is a theoretical argument for differing taxes. However, the high taxes in Sweden and Norway relative to other countries indicate that other concerns dominate the tax levels.

Figure 18. Taxes on SO_2 and NO_x. Euro/tonne



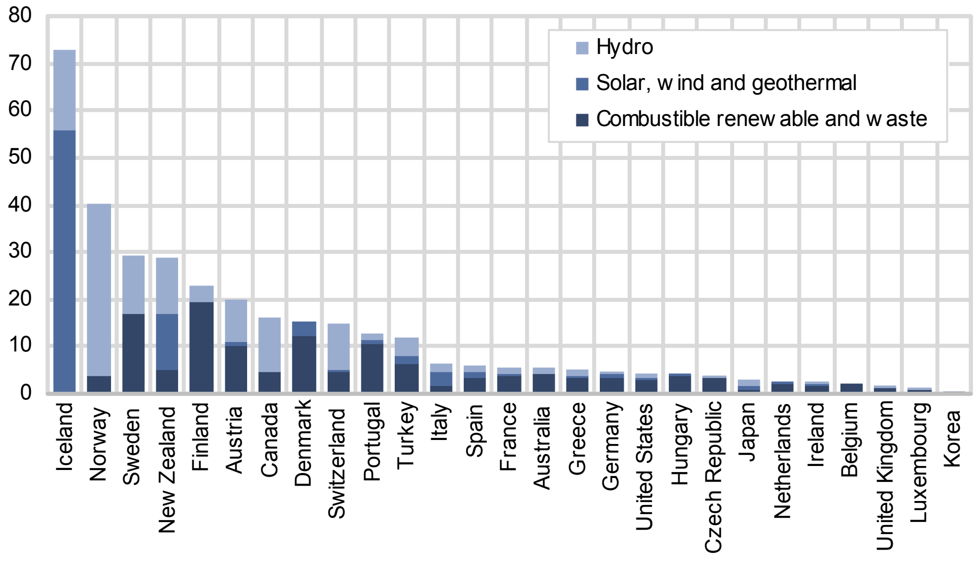
Source: OECD (2004).

6. Subsidies

6.1. Renewable energy shares

In most countries, stimulation of renewable energy sources plays a part of environmental policy, as alternative to policies directed at reducing the emissions from fossil energy. When looking into the spread and multitude of pollution related taxes, it is useful to bear in mind that the share of renewable energy of total energy production varies between countries, see Figure 19. In general, the share is less than 5 percent of total energy supply. The highest shares are found in Iceland, Norway, Sweden and New Zealand - all relatively small countries both with respect to population and energy use, and with respect to natural energy resources. Iceland is exceptional in its access to geothermal energy resources. Norway differs from other IEA countries in the domination of hydropower, as it contributes to 99 percent of the electricity production. Thus, energy demand in stationary use is also relatively clean, while like for other countries of course energy use for transportation is mostly fossil fuel. New Zealand and Canada are examples of hydropower intensive countries outside Europe. Hence, the externality element in the overall environment and energy taxes should vary accordingly between countries.

Figure 19. Renewable Energy as percentage of total supply, 2005

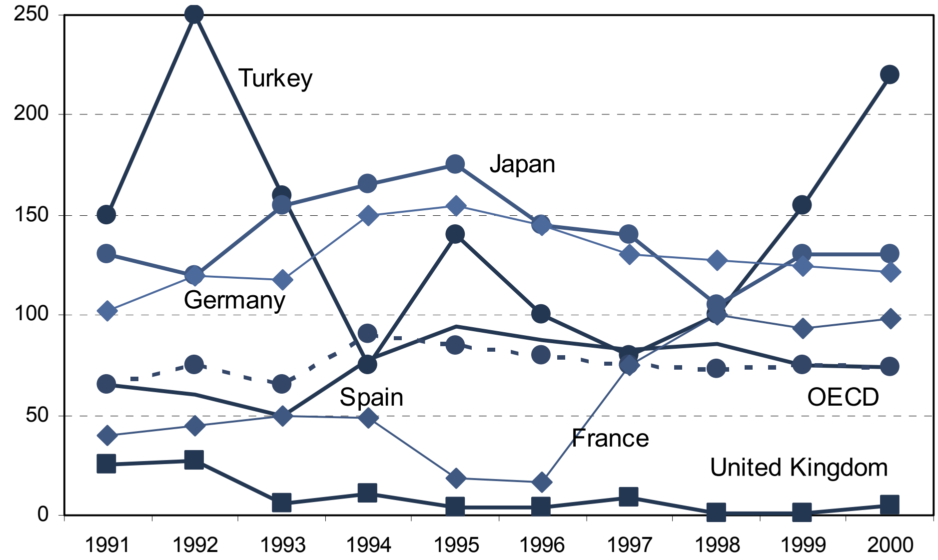


Source: OECD/IEA (2007).

6.2. Direct subsidies

The OECD measures subsidies in terms of grants or soft loans to producers or consumers of energy, market price support, differential tax rates on different fuels and publicly funded research and development programs (OECD 2005). Subsidies to energy producers usually take the form of grants, loans and tax exemptions. Over 40 percent of US subsidies go to tax exemptions that lower the cost of energy production. A review of harmful subsidies in OECD concludes that there have been no systematic efforts to assess the environmental impacts of manufacturing subsidies (OECD 2005). The existing estimates of support to both energy production and consumption are thus incomplete and approximate.

Figure 20. Support per tonne of coal production in selected OECD countries. USD/toe



Source: OECD (2005).

About a third of the producer energy subsidies support coal production (OECD 2005), for which there are relatively good estimates. The coal support in some selected OECD countries was nearly halved from 1990 to 2000. This was mainly due to reduced production, hence subsidies per tonne of coal production remained rather stable, see Figure 20. The subsidization of the coal industry is a notable self-contradiction to the theoretical foundation for Ramsey taxation and correction of externalities. For the coal industry, the well-organized labour force in the coal industry is an important explanation.

OECD concludes that the more environmentally damaging sectors are, the greater recipients of government support than the cleaner sectors, and the most damaging sectors are the old and declining sectors of the economy. Table 1 provides estimates from OECD on the level of support, measured by the effective rate of protection (the ratio of the difference between the assisted and unassisted value added over the unassisted value) in the two most (leather and metal production) and least (electronic and transport equipment) pollution intensive industries as rated by the World Bank (OECD 2005).

Table 1. The level of support in the two most pollution-intensive and the two least pollution-intensive industries as classified by the World Bank (2000).

Effective rate of protection	Aus	NZ	Can	USA	GBR	Deu	Dnk	Swe	Fin	REU	Average
Transport equip (clean)	0.04	-0.08	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.02	0.007
Electronic equip (clean)	0.08	0.06	0.00	0.02	0.05	0.06	0.02	0.02	0.04	0.05	0.040
Leather prds (polluting)	0.85	0.24	0.30	0.21	0.07	0.06	0.06	0.03	0.04	0.05	0.191
Metals (polluting)	0.41	0.14	0.06	0.06	0.04	0.05	0.05	0.02	0.02	0.02	0.086

Source: OECD (2005).

The subsidies of polluting industries increase the need for countermeasures against externalities. Instead of reducing the harmful subsidies, new subsidies are given to renewables to increase competitiveness of non-polluting energy production, relative to e.g. the coal industry. The costs of such abatement policies seem to be higher than direct regulation, and indirect subsidies are inconsistent with theory. Subsidies are optimal only if the use and development of the subsidized technologies have positive side-effects in themselves, i.e. in terms of learning by doing. As shown in Bye and Bruvoll (2008) both green and white certificates (see Chapter 8 and 9) include subsidy elements.

OECD (2004) claims that the strategies to stimulate renewable sources of energy have involved abatement costs that are far higher than alternative programs to reduce CO_2 emissions. This is illustrated in Table 2, that shows a great variation in the costs per tonne of CO_2 depending upon type of renewable energy. The costs per tonne of CO_2 far overreach the CO_2 taxes and the prices in the permit markets of about 20 Euro, see Chapter 7.

Table 2. Abatement costs of measures promoting renewable sources of energy, Euro per tonne of CO_2

	Biomass	Photovoltaic	Dams	Geothermic	Wind
Austria	341	1454		114	134
Belgium – Wallonia	63		125		125
Belgium – Flanders	79	79	79		79
Czech Republic	64	153			
Denmark	149				91
Finland	20				52
France	86	328	155		154
Germany	195	1217	118	163	167
Greece					60
Hungary					147
Ireland	62		74		32
Italy	200	200	200	200	200
Luxembourg	63	1265	63		63
Netherlands	87	87	87		87
Portugal	58	938	83		112
Spain	84	910	75		65
Sweden	25	25	25		73
United Kingdom	117	117	117	117	117
United States	39				39

Source: OECD (2004), different years; based on country surveys.

The Nordic countries make widespread use of support schemes for renewable energy sources, including green certificates, investment aid, tax exemptions/reductions/refunds and direct support mechanisms.

In Denmark, several subsidy schemes have been used to support renewable energy sources; biogas plants, solar heat installations, heat pumps and bio fuel boilers receive investment support. Windmills no longer receive investment subsidies. The subsidy constituted up to 30 percent of the construction costs (in 2002, Nordic Council of Ministers 2006). The production subsidy is now an extra charge paid by the consumers and is no longer financed over the public budget. Windmills receive minimum prices, combined heat and power plants using natural gas are granted price supplements, and biogas, natural gas and waste are granted production subsidies.

The Swedish goal is to increase new renewable energy by 17 TWh by 2016 (Ministry of Sustainable Development 2006). The energy tax legislation excludes biofuels from all energy related taxes. In addition, investment subsidies are granted for renewable energy sources, windmills included. Combined heat and power plants are exempted from energy taxes, and partially exempted from the CO_2 tax. The green certificate system was introduced in 2003. This is a production subsidy system for renewable energy. Energy intensive industries are not obliged to participate in the system.

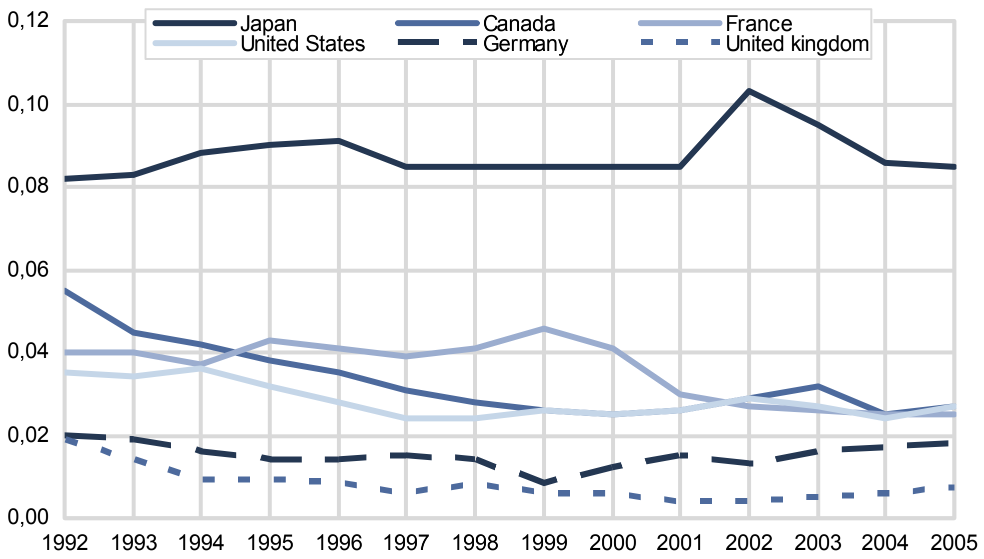
In Finland, electricity production from green fuels and green energy technologies is granted CO_2 tax refunds, and subsidies are given to investment in green technologies. The highest support is given to wind power and electricity produced from forest chips. Investment subsidies are also provided.
The Norwegian support scheme for renewables has since 2001 been managed by the government agency Enova SF. The main goal is an increase of 30 TWh in renewable energy sources and energy saving in 2016 compared to 2001 (Ministry

of Environment 2007). Enova grants subsidies to wind energy projects, other renewable energy projects and energy savings projects to organizations applying for such projects. Enova's activities are funded by a dedicated levy on the transmission tariff for electricity and from the state budget. Wind power has received most funding, then heat distribution and development bioenergy. Further support is coming through research support from NVE. Other technologies, such as solar and water heating and new hydropower projects, have also been supported. Funds are also granted for research and development concerning energy and oil production and consumption.

6.3. Subsidies for research and development

The government budgets for energy R&D vary considerably between countries, see Figure 21. The reason may be the varying shares of different energy sources within the economies. About 40 percent of the R&D budget in the IEA countries is devoted to nuclear technologies, and 11 percent to fossil fuels. Public R&D in renewable technologies and energy efficiency amounts to 12 percent each.

Figure 21. Nominal R&D budget as a percentage of nominal GDP, percent



Source: OECD/IEA (2006a).

In Norway, several gas-fired power stations are licensed. These will increase CO_2 emissions, and increased efforts to develop technologies for CO_2 capture have become important in Norwegian energy policy. The governmental agency Gassnova SF was established in 2008, to promote the development of technological solutions for CCS.

7. The permission market

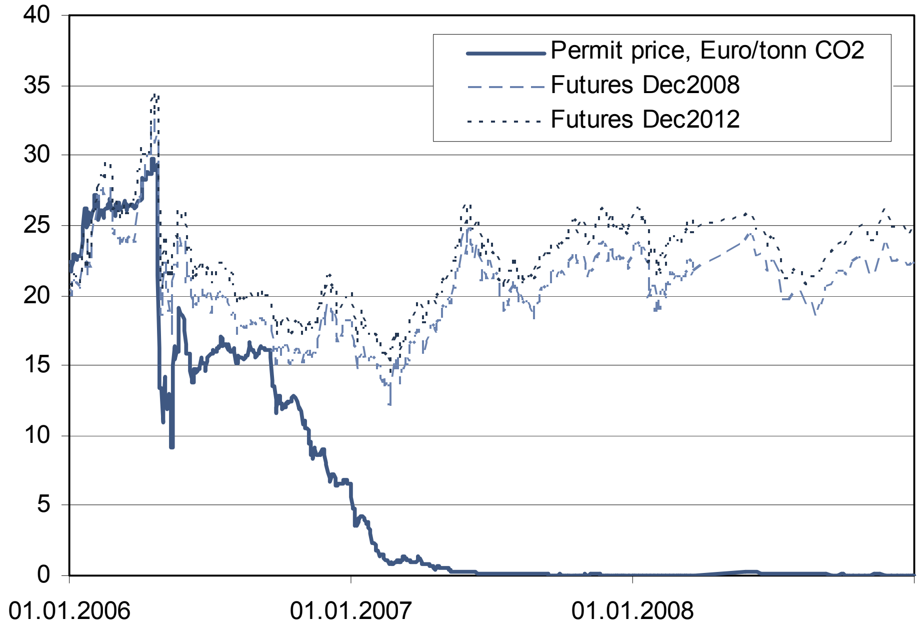
Carbon trading gains in scope in many countries, this comprises both single-country systems and international harmonized markets. A cap and trade system for greenhouse gases is comparable in distribution of costs to a tax system. Since the cap introduces a shadow price on the restriction it serves as a tax. The more countries joining the markets, the more cost efficient is compliance at given emission caps. A well functioning trading market secures equal marginal abatement costs for those participating in the system.

In the first phase (2005-2007) the European Emission Trading (EU ETS) scheme only covered 38 per cent of total greenhouse gases – and 45 per cent of CO_2 emissions within EU countries. In the second phase (2008-2012) the market has increased to include approximately 50 per cent of greenhouse gases. EU ETS represents a multi-country scheme for climate gas emissions. Still, the market only covers large manufacturing industries and the power sector, i.e. cost efficiency is not secured. There is no link to other international permit markets and the link to Clean Development Mechanisms (CDM) with developing countries and Joint Implementation (JI) mechanisms (with Annex I countries) are limited. In the first phase existing emitters got approximately 95 per cent free allowances and in the second phase they get 90 per cent for free. These allowances are “restricted”, as they are not free tradable goods without consequences for the future allocation of free allowances (updated grandfathering). This allocation scheme then influences the efficiency - the benefit of reducing capacity or introducing new energy saving technology should include the discounted future loss of the reduced free allowances. Given free trade of allowances, grandfathering may produce efficient second hand allocations (Böhringer and Lange 2005, Böhringer and Rosendahl 2007). New installations also get free allowances based on benchmarking, and closure of firms implies no allocation the next year.

The Norwegian permit system is linked to the EU ETS system. However, in some respects the Norwegian system differs, as i) more emitters are included, ii) the amount of auction based permits is larger, iii) free allowances will be phased out, iv) all emitters not included in the permit system are taxed on emissions, v) emitters that are taxed may opt-in to the permit system, and vi) gas power plants receive allowances but are committed to CCS in the future.

At first (2006), the EU ETS produced a high price, see Figure 22. The market seemed to assume that the system put a real restriction on the total emissions. The allocation of permits was based upon firms’ own projections of necessary emission permits and the number of allowances was reduced by five percent compared to the projections. This was expected to push prices upwards. It also turned out that the energy intensive industry actually withheld their excess allowances, pushing prices further upwards. As both projections and allowances turned ot to be all too high, market prices plunged to almost one half in 2006. At the end of 2006, the market became even more aware of the excess amount of permits, the industry started to sell some of the withheld permits, and the market almost collapsed.

Figure 22. The permit price on the EU ETS. Euro/ton CO_2



Source: NordPool Exchange and EEX.

In the second phase, the commission reduced the number of free allowances. This was supposed to tighten the market and increase the price. As the graph shows this has not happened so far. However, the NordPool exchange and EEX notify also futures and forwards for in the EU ETS market. For December 2008 the price is expected to rise to 23 Euro/EUA (European Allowance). In the longer future – up to 2012 - the price drops again to approximately 17 Euro/EUA. I.e. the price seems to stabilise at a level close to the early 2006 level (between 15-23 Euro/EUA).

8. The green certificate market

During the past years, interest in the green certificate system has increased, and markets have been established in the UK, Italy, Belgium and Sweden. Several countries plan to implement the system. In 2001, EU introduced the aim to attain a share of renewable energy consumption of 20 percent by 2020, and the introduction of green certificates is one means to reach this goal. Norway has considered joining the Swedish green certificate market, but has turned this down out of cost concerns.

A green certificate is a proof of the green origin of an amount of energy produced, see Bye and Bruvoll (2008)[5]. For each unit of secondary energy produced by a renewable primary energy carrier the government issues a green certificate to the producer. The consumer has to purchase a number of certificates proportional to energy consumption (i.e. the face a tax on their energy use). This creates a market for the green energy certificates. The producers of green energy harvest a certificate price in the certificate market additional to the energy price in the energy market, which increases the profitability of producing energy from green technologies (i.e. the harvest a subsidy which is a negative tax). An advantage of such an instrument over a simple lump sum subsidy is that the certificate market will realize a cost efficient investment for capacity expansion under the green energy production share constraint. This may be comparable to an auction based subsidy system. The subsidy element may be founded in the positive externality related to learning by doing (see also Bye, Greaker and Rosendahl 2002).

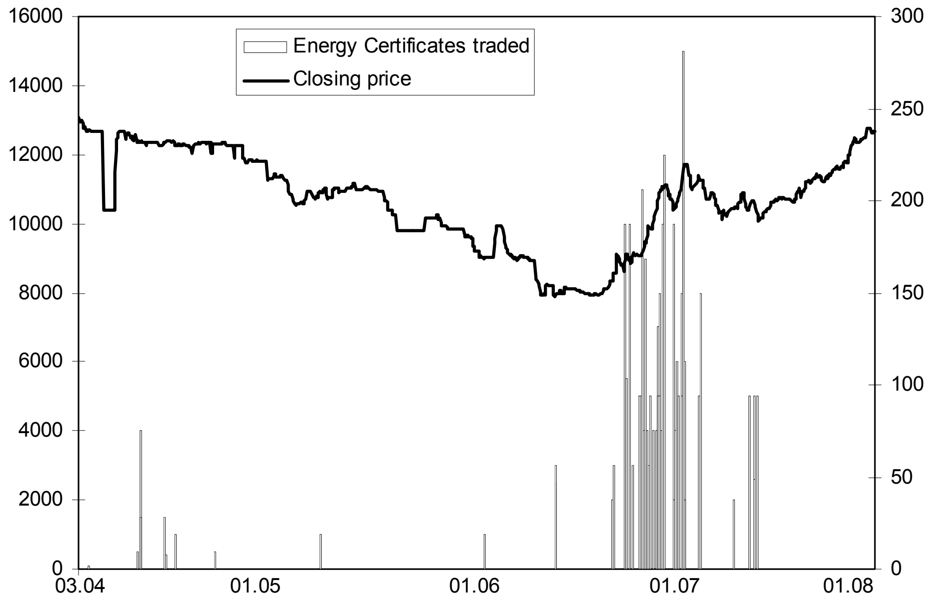
The designs and experiences vary between the markets. The system requires a definition of the relevant technology space. The green commitment share and the definition of relevant green technologies is a governmental issue. In the European countries that have introduced green certificate systems, definitions and scope of technologies differ tremendously.

The Dutch market was the first one to introduce green certificates, but later substituted this with other systems. Italian certificates are issued only for new production. The UK market puts large credit risks on investors and plant developers, resulting in problems in financing. In both UK and Italy, wind power is expected to deliver most of the certificates the coming years (2005), solid waste and hydro power in Italy and biomass in Sweden.

Sweden implemented an electricity certificate system in 2003, see Figure 23. The Swedish system had some start-up problems, as large amounts of certificates were in store. Later the market increased for some months but now face very small volumes again. The certificate price started at 250 SEK/ ECS decreased to 150 SEK/ECS when volume rised and the increased again to 250 SEK/ECS and volumes dropped. Until now, the system is believed to have increased the production of new renewable energy by 5 TWh (Ministry of Sustainable Development 2007). The ambitions are to increase new renewable technologies with 12 TWh over the period 2007-2016.

[5] Different kinds of renewable energy sources are classified as green; see COM (2000), Voogt et al. (2000), Voogt et al. (2006), Amundsen and Mortensen (2001), and Jensen and Skytte (2002). Brekke and Bye (2003) discuss whether we can characterize any energy source as green.

Figure 23. Price (right axis) and volumes (left axis) in the Swedish certificate system. March 2003- december 2007



Source: NordPool.

9. The white certificate market

While green certificates deal with the supply side, white certificates concern energy savings on the demand side. A white certificate system may impose a restriction on total allowable energy consumption for separate consumer groups, which introduces a shadow price on the restriction, i.e. a tax. In practice, the restrictions are imposed on distribution companies or the energy suppliers; see Bye and Bruvoll (2008). These invest in energy efficiency measures on behalf of their consumers, and consumers eventually pay through additions to energy tariffs.

Several European countries have implemented white certificate schemes or seriously consider doing so. Italy opened their market in 2004. The Italian scheme has a target expressed in primary energy. The aim was to save 7 TWh, which is considered a small portion of total consumption. The aim is to increase the scope of the system over time. France opened a white certificate system a year later, in 2006. The goal is to reduce energy use by a total of 54 TWh over three years (cf. a total yearly consumption of 270 TWh). A penalty for not complying (0.02 Euro in France) implicitly defines the maximal price and "abatement cost". United Kingdom has combined its obligation system for energy savings with the possibility to trade obligations and savings. All electricity and gas suppliers must achieve a saving by assisting their customers to take energy-efficiency measures in their homes. The aim is partly to benefit low-income households. Suppliers with at least 50.000 domestic customers are eligible for an obligation. The Energy Efficiency Commitment 1 (2002-2005) program required that all electricity and gas suppliers with 15.000 or more domestic customers must achieve a combined energy saving of 62 TWh by 2005 by assisting their customers to take energy-efficiency measures in their homes: suppliers must achieve at least half of their energy savings in households on income-related benefits and tax credits. In the current (2005-2008) EEC 2, energy saving targets were raised to 130 TWh suppliers, and here suppliers with at least 50.000 domestic customers (including affiliated licenses) are eligible for an obligation. Denmark and the Netherlands are seriously considering introduction of a white certificate scheme in the near future.

Generally, attempts to improvements of energy efficiency have proven to increase efficiency and reduce emissions in countries with low energy efficiency ex ante, such as countries in transition, while regulatory measures and subsidies targeting specific means to save energy in countries with high energy efficiency to begin with have proved costly (OECD 2004).

10. Other regulations

Command and control regulation is the main instrument to reduce local/regional energy related pollutants (such as SO_2, NO_x, VOC) from large sources in most OECD countries (introduces a shadow price on the restriction – i.e. a tax). Given that the marginal costs differ between sources and localities, the marginal abatement costs also differ, i.e. a uniform regulation introduces differences in shadow prices (comparable to differences in taxes). In practice, the polluters have significant say in designing regulations and hence attain exemptions for existing sources (OECD 2004). Such political pressure proves to distort efficient taxation that would secure equal marginal abatement costs per unit pollutants over different sources, local damage variation disregarded. Consequently, the marginal abatement costs differ significantly between sources.

This may be illustrated by the varying marginal abatement costs under the US Clean Air Act 1979-1985, see Table 3. A volume regulation on these emission sources would generally not coincide with a uniform marginal cost regulation (for instant a uniform tax). A volume regulation would most probably imply a tremendous variation in the implicit tax among emission sources.

Table 3. Marginal abatement costs under the US Clean Air Act, USD/tonne

	Partuculate matter	Sulphur dioxide	Nitrogen dioxide
Beverages	92	250	14300
Paper	65	400	1500
Pulp	30	175	800
Coal	22	2300	150
Rubber	57	1150	400
Machinery	143	850	600
Ships	51	870	2700

Source: OECD (2004).

11. Voluntary agreements

Compared to Pigovian taxes, voluntary agreements are preferable the polluters. Under a voluntary agreement, the polluters only carry the abatement costs, while they do not pay for the remaining emissions. Generally, these have been found to be costly or ineffective (OECD 2004). In a review of OECD countries, OECD (2004, p. 93) specifically recommended several countries, among them Norway, to end voluntary agreements.

In Norway, voluntary commitments are used for parts of the process industry that is not covered by the trading system or CO_2 taxes, particularly for other climate gases than CO_2. The government has expressed that emission trading is preferred to voluntary agreements as long-term instruments.

12. Summary and conclusions

The reason for levying energy related taxes are public revenue concerns, harvesting of resource and ground rents and capturing some of the monopoly profits (Bye, 2007), indirect pricing of highly correlated commodities (for instance the use of transport infrastructure which correlates to petrol fuel use), corrections of negative externalities, i.e. climate change and local air pollution, and energy security,

This review shows that taxes vary significantly between countries and economic activities. Average taxes on energy and environment constituted approximately 7 per cent of total tax revenue in EU15 in 2004, varying from 5 to 12 per cent. Of these, the pure energy taxes constituted 5 per cent, the payment for traffic infrastructure use 2 per cent and taxes on pollution 0.3 per cent. As a share of GDP, total environmental taxes were 2.7 per cent in 2004. The non-EU member Norway is an outlier. Total energy taxes constitute 28 per cent of total tax revenues, due to an extraordinary tax on the resource rent on petroleum extraction and hydro power production.

Also the specific taxes on electricity, natural gas and heating oils vary much between the countries. The electricity tax works as a Ramsey tax – the price elasticity for electricity in households is low and revenue collection consequently high. This then seems as a lost opportunity for revenue collection for many countries. The average electricity taxes are generally much lower in industries than for households. This may be consistent with the Diamond and Mirrlees (1971) principle, advocating that distortions should be confined to final consumption, leaving production undistorted. Taxes on natural gas and heating fuels follow the same pattern. While electricity taxes may be characterized as Ramsey taxes, taxes on natural gas may be used both of Ramsey and environmental concerns. Industries are favoured due to competitive arguments.

Taxes on transport fuels are 2-4 times the commodity price. The arguments may be threefold; the tax serves as a price of the use of road infrastructure, the environmental element is large (greenhouse gases), and the price elasticity on road transport is relatively low, i.e. this is a well suited commodity to tax for revenue purposes (Ramsey tax). Studies indicate that the tax on transport fuels covers average cost in most countries, i.e. the fuels are probably not taxed sufficiently to cover increasing marginal costs.

The ETS market for emission allowances in Europe adds to the general tax systems in the pricing of greenhouse gases. However, so far the market has not been restricted enough to really price these emissions. The futures market for the allowances, however, price these emissions high compared to average taxes on greenhouse gases in the EU countries. Discrimination with respect to allocation of free allowances and indirect restriction on tradability cause market inefficiencies. Hence, a combination of taxes and tradable permits do not necessarily secure efficiency in the greenhouse emissions reductions.

Lately, both green and white certificates have been introduced in several European countries. Green certificates put a restriction on the supply side and white certificates put a restriction on the demand side of the energy market. They both then introduce a shadow price on the restriction, which serves just as a tax in the market (through market effects they also introduce a subsidy element). So far these markets cover just smaller parts of the European energy market.

Different energy production patterns, the general production structure and the political emphasis on distributional effects bring along extensive variation in energy taxation policies across countries. Further, conflicting interests, income distribution and environmental concerns cause exemptions, tax discounts and subsidies to particular groups, and form the background for the development of a portfolio of instruments to solve a limited set of problems. The desire to preserve employment, particularly in energy-intensive industries, and regional concerns, are the main reasons behind reduced rates and exemptions of carbon taxes in industry (OECD 2004). There is also a great variation between industries. The free allocation of allowances in the emission trading schemes reflects industry competition concerns and regional and social policy objectives. Subsidies, green certificates and white certificates in combination of discriminatory regimes all bring along complex combinations of implicit taxes and subsidies in the energy sector. Just as tax regimes vary among the European countries, the introduction of and the scope of new instruments also do.

Bye and Bruvoll (2008) show that the portfolio of economic instruments are in principle simple combinations of taxes and subsidies, and pose the question whether it is time to launch an energy instrument reform. This review of the practical implementation of energy related policies across countries supports this, as it indicates divergence between theory on efficient means and energy policy. The benefits from coordinating and simplifying the policies with the aim to approach the efficiency principle of one instrument per objective should be subject to further investigation.

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