Environmental Consumer Subsidies and Potential Reductions of CO_2 Emissions

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1. Introduction

In the environmental debate, global problems clearly gained importance. Successful international conventions could reduce the threats posed by acid rain, ozone depletion and hazardous wastes. Next to end-of-pipe solutions (like placing scrubbers) and cleaner inputs (like low-sulphur coal), cleaner products or retrofit processes (replacing CFCs by HCFCs and HFCs) were available in due course.

Acid rain and ozone depletion are problems caused by specific industrial activities, processes or products, whereas global warming and the resulting climate change are the consequence of a multitude of factors, most of them related to energy use. This limits the possibility of solving the problem with just one set of substituting technologies. It will be necessary to work out a concerted strategy that exploits all potential efficiency gains in all layers of society. We will need to modify whole structures, institutions and behaviours. Therefore we can use economic instruments like taxes, subsidies and tradable permits. In this paper, we will try to estimate the potential of environmental subsidies in terms of reductions of energy use and CO_2 emissions. In the next sections, we will comment on the Kyoto Protocol and the projected CO_2 emissions in the European Union. Starting from data on sectoral energy efficiency, we will indicate policy priorities and will present a short overview of instruments. In the final sections, we work out three types of consumer subsidies and estimate their potential in terms of reducing CO_2 emissions in the EU. We will conclude that these subsidies - basic but attractive instruments for politicians - can be an important step in achieving the Kyoto targets.

2. The Kyoto Protocol

In December 1997, developed countries agreed in Kyoto to reduce significantly emissions of greenhouse gases (GHG) resulting from human activities by the commitment period 2008 to 2012. Each developed country will have to demonstrate significant progress by 2005

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CEEM is the Centre for Environmental Economics and Environmental Management

(UNFCCC, 1997). For the European Union, the agreed reduction will be 8% of the emissions in 1990. Compared to the initial European proposal to reduce emissions of greenhouse gases by 15% - a realistic reduction according to the EC-, the in Kyoto agreed reduction target should not pose serious problems. As a result of the important reductions of greenhouse gases in Germany and the UK, actual emissions in the EU only slightly exceed the 1990-level. This means that all the needed reductions will have to take place without delay. Furthermore, CO_2 and other emissions in Germany will not continue to decrease. This is a crucial element since the relative weight of German emissions in the total emissions in the EU amounts to almost 30%. For the period 1995 to 2005, German emissions are expected to increase by 10% if no measures are taken. In the scenario ‘with measures’, the German emissions could be reduced by an additional 3% (Federal Ministry for the Environment, 1997).

The initial EU proposal contained very generous provisions for Portugal (+40%), Greece (+30%), Spain (+17%), Ireland (+15%) and even Sweden [1](+5%). Not surprisingly, this differentiation[2] was strongly criticised by developing countries that were asked at the Kyoto Conference to engage in significant reductions of greenhouse gases.

For the US, the agreed reduction is 7%, Canada has to reduce emissions by 6% and for Japan the target is -5%. Countries like Australia, Iceland and Norway are allowed to further increase their emissions of greenhouse gases, by respectively 8%, 10% and 1% (UNFCCC, 1997). These increases of GHG emissions have been criticised but in its Climate Change Report (1997), Australia states that its population is expected to grow by almost 33 % for the period 1990-2020. This increased population will consume and produce so the national energy needs will increase much stronger than in regions with lower population growth like Europe - with an expected population growth of +1.7% for the same period - and Japan.

In this perspective, the engagements of the US and Canada are remarkable because their expected population growth is just below the Australian figure.

If we link estimated population growth to the national engagements in Kyoto, the real efforts in terms of reducing emissions strongly differ, as shown in Table I. We should emphasize that Table I does not include other aspects of economic growth like more transport or more tourism. In our calculation, we assumed that the Kyoto targets should be achieved over the

[1] In 1990, emissions in Sweden were at a ‘historical minimum’ with the completion of a nuclear building programme, industrial biomass utilization and energy conservation programmes in virtually all sectors.

[2] According to Michel Raquet (EU, DG XI), it was clear from the beginning that the final distribution of the European reduction would be in line with the differentiation in the first proposal of the European Union.

period 1990-2020 so we could link reductions to the same period of population growth.

Table I - GHG reduction targets and estimated population growth, 1990-2020

Country :	Unit.States	Eur.Union	Canada	Australia.	Norway
Kyoto target (1990=100)	93	92	94	108	101
Population growth (1990=100)	126	101.7	128	133	109
Real needed reduction	- 26.2 %	- 9.5 %	- 26.6 %	- 18.8 %	- 7.4 %

Source for the population data : Australia's Climate Change Report 1997, p.15

The calculated 9.5% reduction for the EU is facilitated by the German unification. Over the period from 1990 to 1995, the closing down of old and inefficient installations reduced total German GHG emissions by 11.7% (Climate Protection in Germany, 1997, p.13). This means that, for the same period, total European GHG emissions were reduced by some 3 to 3.5%.

3. Projected CO_2 emissions in the European Union

As a consequence of the Rio Conference in 1992, the European Union elaborated several measures of which the controversial CO_2 tax received most attention. This CO_2 tax was first re-proposed in a very weakened and modified form and then 'declared dead' in March 1996 (Howes, 1997). The tax was replaced in 1997 by a new proposal ; the Energy Product Tax (COM(97)30). This new tax will introduce higher minimum tax rates for all energy products. The proposed minimum tax rates are at least 33% higher than existing minimum rates on hydrocarbon oils and they will be increased by more than 10% automatically in the year 2000. Subject to adoption of the proposal by the Council, the Energy Product Tax should come into effect in 1998 (COM(97)30 - Information Note). But since industry will probably fight also this tax and the argument of international competitiveness will remain on top of the European agenda, the chances of the Energy Product Tax are limited. Furthermore, a survey by Klassen and Jansen (1997) on the impact of this EU energy tax proposal, indicated that in the year 2005, CO_2 emissions in the EU will be only 0.5 to 1.6% lower - depending on the model used (HERMES, GEM-E3 or E3ME) - than in the scenario without the tax. If economic growth in the EU accelerates, the environmental impact of the Energy Product Tax will be even more modest. As a result, other instruments like subsidies certainly deserve consideration.

If we reduce global warming to a problem of reducing CO_2 emissions - the most important greenhouse gas next to methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexofluoride (SF_6) - , our starting point should be the projected CO_2 emission in the EU for 2010 if no new measures are taken.

Table II presents the projected distribution of CO_2 emissions in the EU for 2010. Without new measures, total emissions will increase by 8%. We added some sectoral target values leading to a reduction that complies to the Kyoto obligations for the EU. The transport sector - including air transport - is responsible for the bulk of the projected increase. Another conclusion is that in 2010 residential, tertiary and institutional emissions will almost exceed total emissions by industry.

Table II - Sectoral emissions of carbon dioxide (CO_2) in the EU (mill.tons)

Sector/year	1990	2010	change	*Target for 2010*
Transport (incl.intern. air transport.)	743	1032	+ 39 %	*775 (+4%)*
Industry : combustion	626	532	- 15 %	*500 (-20%)*
Industry : industrial processes	141	158	+ 12 %	*120 (-15%)*
Residential/Commercial/Institutional	658	680	+ 4 %	*592 (-10%)*
Energy and transformation	1036	1057	+ 2 %	*930 (-5%)*
Total emissions	3200	3459	+ 8 %	- *9 %*

Source : COM(97)481 + *own additions*

The foreseen reductions of CO_2 by industry are probably an underestimate. It is for instance illustrative that the potentials of Co-generation or Combined Heat and Power (CHP) installations are continuously upgraded. In the Netherlands, voluntary agreements with some 30 industrial sectors include the target of an improved energy efficiency by 10 to 25% for the year 2000 relative to 1989 (Second Netherlands' National Communication on Climate Change Policies, 1997). From the first results and from experiences of global corporations like Hoechst (Hoechst, 1997) the targets will be met in most cases. For the remaining ten year, further reductions should be possible.

Less energy used means less carbon dioxide emitted. Since many industrial processes, like in the sectors of iron and steel, are still strongly depending on the burning of coal, potential reductions of CO_2 are still very great. Similar remarks can be made for emissions by fossil fuel power plants. According to the EU, the overall thermal efficiency of existing fossil fuel power plants in the EU was 38% around 1994 compared with new power plants that typically offer efficiencies of around or even above 50% (COM(97)481). Next to measures of thermal efficiency, there are still important extraction, transportation and tranformation losses.

4. Sectoral energy use efficiency

From a pragmatic view, greenhouse policies should focus on improving energy efficiency. Table III contains a balance of final energy consumption by sector and by energy service for Germany in 1992 (old Federal Länder). This final energy consumption of 7751 PJ was possible after the primary energy consumption of some 11000 PJ. The transformation losses and non-energy-related consumption of primary energy consumption still account for 35% of primary energy consumption in 1995.

In the transport sector, almost all consumed energy is converted into mechanical energy. The efficiency loss of this transformation processes is however very high. Only some 18% of the consumed energy is used in an efficient way. Also in other sectors, significant opportunities to improve efficiency remain.

If we link the projected increase of transport CO_2 emissions to the low efficiency of actual mechanical energy use in this sector, it is clear that technological improvements are urgently needed. Another conclusion is that the continuous improvement in industrial energy use should be enforced by efforts in the residential and tertiary sector.

Table III - Energy consumption by sector and efficiency of energy use, old Federal Länder, 1992

Sector	*Final energy*		*Usable energy*	
	PJ	Percentage	PJ	Percentage
Transport	**2194**	**100 %**	**396**	**18 %**
-heat	2	0.1	1	70
- mechanical	2189	99.8	394	18
- lights	3	0.1	0	7.5
Residential	**2069**	**100 %**	**1357**	**65.6 %**
- process heat	340	16.4	160	47.0
- indoor heat	1568	75.8	1145	73.0
- mechanical	126	6.1	50	40.0
Industry	**2212**	**100 %**	**1323**	**59.8 %**
- process heat	1521	68.8	882	58.0
- indoor heat	217	9.8	152	70.0
- mechanical	439	19.8	285	65.0
- lights	35	1.6	4	10.0

Source : Federal Ministry for the Environment, 1997, Climate Protection in Germany. Second Report of the Government of the Federal Republic of Germany Pursuant to the United Nations Framework Convention on Climate Change, p.45

(* including the institutional sector in this table would result in a total final energy consumption of 7751 PJ)

5. Policy options and sets of instruments

We presented some indications for giving priority to energy issues in transport and in the residential/tertiary sector. Before discussing some instruments, it is interesting to refer to some estimates of total greenhouse policy costs. In COM(97)481, we read :

"For a 15% reduction in CO_2 emissions compared to 1990, estimates of the direct compliance costs related to energy supply/demand mitigation actions range from around 15 bn Ecu to about 35 bn Ecu annually by 2010. This corresponds to roughly 0.2 and 0.4% of GDP in the year 2010."

Since the European reductions will not be 15 but only 8%, total costs will be lower but still very impressive. Most estimates amount to 0.1% to 0.2% of GDP. Similar findings are presented by the Energy Technology Systems Analysis Programme (ETSAP), a cooperative research agreement among member countries of the International Energy Agency (IEA). Through partnerships, ETSAP uses the expertise of 60 teams in more than 30 countries that work with the MARKAL-MACRO family of energy/economy/environment models. ETSAP estimates that the marginal CO_2 reduction costs in 2010 can amount to $ 150 per ton reduced, depending on the specific country of analysis (ETSAT Kyoto Statement, 1997).

These high estimates of CO_2 abatement costs in the EU are derived from a framework that does not include the potential costs saving from emission permit trading or Joint Implementation that allows countries with high marginal abatement costs to buy or receive credits from countries where abatement costs are much lower. Since many developing countries have very inefficient electricy plants, substantial reductions of emissions are possible on short term and at a low cost.

In a recent communication (COM(98)353), the European Commission elaborates a first comprehensive Kyoto strategy in which flexible instruments will be included. 'The existence of the EU bubble does not prevent the Community from fully participating in international emission trading... An EC-wide approach to emissions trading could facilitate the administrative implementation of the system and prevent new barriers to trade (Press rel. ip-/98/498).'

For the US, the economic costs of implementing CO_2 reduction measures are calculated using the opportunities of international emissions permit trading, Joint Implementation and the Clean Development Mechanism. Dr.Janet Yellen of the President's Council of Economic Advisors indicated in a recently given testimony that the abatement cost for carbon dioxide would be roughly $ 14 - $ 23 per ton. This would correlate to between 3-4 cents per gallon of gasoline, a modest increase (USIS, Embassy of the United States of America, 1997).

National systems of CO_2 permit trading do not yet exist. For reductions of emissions at the national level, other policy options and instruments are available :

1. Taxes on energy

Fiscal instruments are being increasingly used as a step towards implementing the Polluter Pays Principle (PPP). The Commission's communication on environmental taxes and charges in the Single Market provides guidelines for Member States in designing, implementing and evaluating environmental levies and charges (COM(97)9). This communication came one year after the discussions on a European CO_2 tax so its future use will probably be more in the field of ecotaxes on products and packaging wastes.

Taxes on energy are among the most popular environmental instruments. But in many countries energy taxes are already very high. Additional taxes will result in 'cigarette prices': prices of which 75 to 90% consists of taxes. The health implications of smoking cigarettes are however more obvious for smokers than the negative consequences for the environment of burning fuels. High taxes on cigarettes are therefore an application of the *Killer Pays Principle*.

In related debates, energy taxes are presented versus labour taxes as 'taxing the bad versus taxing the good'. The problem here is that we rather have to differentiate according to the efficient or inefficient use of energy. If we take a central heating burner of 1970 - of which many millions are still used in Europe - and compare this burner to the best types of 1998, the two installations have extreme differences in energy efficiency. For old burners the efficiency is around 50-60% while this percentage will be around 95% for the newest types. The best types reach an efficiency of 97-98%.

If an energy tax would be installed because 'using energy is bad', families with the most efficient available heating installations would also be punished for their efficient and optimal use of a natural resource. It is obvious that families with inefficient heating systems would pay much more taxes. We should however also consider taxing inefficient burners or subsidizing efficient types[3]. Therefore, we will work out some policy instruments that promote the most efficient use of energy (in heating installations, for cars and other engines and in households).

Furthermore, if we relate CO_2 to the external effects of generating and using energy - an approach in line with the Fifth Environmental Action Programme (5EAP) of the EU -, we have to consider the greenhouse external effects of transport, industry and other sectors. It is not easy to calculate these effects because there is still a significant element of uncertainty in many assessments of the consequences of global warming. As an example, the human-induced greenhouse effect has completely different consequences for countries that strongly depend on winter tourism compared to countries that will have better agricultural possibilities if average temperatures increase by some 1 or 2°C.

The Extern-E project "Externalities of Energy" by DGXII (Joule Programme) calculated the complete external effects of energy generation and transport. The first results clearly demonstrate that emissions of Particulate Matter (PM) are much more important - in terms of external costs - than emissions of CO_2. PMs can have significant health effects for people with respiratory problems. For transport, PMs account for 80% of all external costs[4].

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[3] A similar reasoning can be used when it comes to emissions of methane, one of the other important greenhouse gases. After eating grass, cattle or other animals emit methane. If we want to reduce emissions of methane, we can tax grass (like an energy tax) or the cattle. People with a lawn but without animals will clearly prefer the latter option.

[4] PM do not account for 80% of all transport emissions. CO (carbon monoxide), NO_X (nitrogen

As could be expected, the same survey shows that burning coal generates much higher external costs compared to using other energy inputs.
Similar results - for transport - are presented by Proost and Van Regemorter (1998). Using the TRENER model for the EU JOULE II programme, they found that existing energy taxes per passenger kilometre already strongly exceed the external costs in terms of air pollution per passenger kilometre. Only for public transport where taxes are much lower (or even negative), the external costs for air pollution are not covered by the reference taxes.
To conclude, if we motivate a CO_2 tax by means of the Polluter Pays Principle (PPP), we open the door for many other taxes that better correct for external effects like a health tax on PMs or a tax on diesel. A strict application of the PPP would lead to reducing many energy taxes in private transport because they are already too high.

2. Subsidies

The sectors that contribute most to the emissions of CO_2, all have a tradition of subsidies and preferential regimes. Energy has always been a crucial resource for economic development and energy policies are closely linked to industrial and social policies. The oil crises and the Gulf War did bring energy back on the political agenda.
Since the 19th century, nations invested massively in their energy structure and many subsidies still have a clear impact on energy prices. According to a recent OECD-survey (1997), adding up all subsidies and subsidy-equivalent market distortions still gives a total of $ 100 billion or 0.75% of the OECD-GDP. The total greenhouse gas mitigation opportunities identified in the case studies would total some 400 to 500 million tonnes of CO_2 in 2010 - about half of it in Russia. Some promising areas for subsidy reform are :
- removing coal producer grants and price supports ;
- reforming subsidies to electricity supply industry investments or protection from risk, where these support investments in coal-fired power stations ;
- removing barriers to trade that discourage the use of energy forms with fewer environmental effects (i.e. opening of markets for foreign suppliers);
- removing sales tax exemptions for electricity (and other energy forms) ;
- eliminating subsidies and cross-subsidies to consumers in remote areas or to other groups ;
- removing electricity subsidies for energy-intensive industries.

The burning of coal generates most emissions of CO_2 (compared to oil and gas) and subsidies

oxides), benzene, SO_2 (sulphur dioxide), lead and dust are also found in transport emissions (RMNO, 1998). For a detailed definition of PM, please see note 6.

for coal - even for brown coal - industries were during the 1990s still very high. Total subsidies (and equivalents) in 1993 were $ 428 m in France, $ 6 688 m in Germany, $ 1 034 m in Japan, $ 856 m in Spain, $ 416 m in Turkey and $ 873 m in the United Kingdom (OECD, 1997). Substituting coal for oil and gas could be stimulated by eliminating these coal subsidies.

New - but different - subsidies can be used for stimulating behaviour that contributes to reduced CO_2 emissions. For industry, basic research, R&D programmes or clear implementation programmes could be sponsored to develop and diffuse new processes and applications to save energy during industrial activities.

For the residential and tertiary sectors, subsidies could be used for stimulating a wide range of energy-efficiency investments (from central heating systems and insulation materials to freezers, micro waves, computers, washing machines and many more). For transport, similar subsidies for clean cars should be elaborated.

3. Environmental agreements

Since the late 1980s, there has been increasing use of Environmental Agreements (EAs) as a new policy instrument in industrial environmental management. Since industry has most detailed information on its processes and their environmental impact, this knowledge should be used to work out various measures. EAs have also the advantage of encouraging a pro-active approach and allow industry to adjust environmental investments to their medium term capital investments. In some cases, Environmental Agreements with clear targets could prevent new regulations. For the European Commission, EAs should be designed according to the principle of shared responsibility and need to be applied in a mix of policy instruments (COM(96)561).

Concerning energy-efficiency, CEFIC’s Voluntary Energy Efficiency Programme (VEEP 2005) is a good illustration of a European agreement to increase energy efficiency in the chemical industry. Energy is a very important element of costs in the basic chemical industry and since European prices were in 1996 already on average 65% to 24% higher than in the US, the European chemical industry, grouped by CEFIC, strongly opposed and will continue to oppose any European energy tax proposal. As an alternative, voluntary investments for saving energy have been made. The results are rather positive. Over the period 1980-1995, while chemical output growed by 55%, fuel and power consumption increased by ‘only’ 9% (CEFIC, 1997). This is a 30% improvement in specific energy consumption. Over the same period, following the substitution of gaseous fuels for liquid ones, CO_2 emissions per unit were reduced by nearly 40%. Since 1992, the European chemical industry has been implementing VEEP 2005, a unilateral commitment to reduce its specific energy consumption by a further 20% between 1990 and 2005, provided that no additional energy taxes are introduced.

According to CEFIC, to undertake the necessary efficiency investments, companies need a long-term stability of the business environment in which they operate.

We already referred to Co-generation or Combined Heat and Power (CHP) generation, the process whereby electricity and steam are produced simultaneously. In many countries, CHP is still not widely used because monopolistic electricity structures can limit access to the grid for the generated surplus electricity. Or when access to the grid is given, the transportation prices of this electricity are very high. These (informal) remarks are made by companies that are interested in CHP but see their efforts blocked by existing monopolistic market behaviour. The liberalisation of the electricity market is clearly needed to stimulate CHP.

6. Reducing emissions at the lowest cost

In the following sections, we focus on reducing emissions in transport and in the residential/tertiary sector. We first illustrate how current tax levels differ for the same energy input that is used for a different purpose.

We start with a typical family that has a car on diesel and a central heating system that uses the same fuel, here called heating oil. If the house of the family has an average size and volume and is standing alone, the annual use of heating oil will be between 2000 to 4000 litres, depending on the orientation of the house, the efficiency of the heating system, the level of insulation, the number and surface of windows, lifestyle,... We assume that the burner/boiler of the central heating system dates from 10 to 15 years ago and that the installation consumes 3000 litres of diesel fuel each year.

The same family uses its diesel car each year for some 30000 kilometres. This is a high estimate. If this recent diesel car needs 6.5 liters for 100 kilometres, the engine will burn 1950 litres of car diesel each year. The average European price for car diesel is around 0.65 Ecu. The average European price for heating diesel is around 0.25 Ecu (European Commision, 1997). There is as such already a large difference in price for the same energy that is used for different purposes. The CO_2 emitted by a diesel car is however exactly the same as the CO_2 emitted by the burner of a central heating system.

If we want to reduce CO_2 emissions, green taxes can be used. Higher energy taxes will generate significant tax incomes for reasons of very low energy price elasticities. The long-term price elasticity for the number of kilometres driven is estimated between -0.1 and -0.4 (European Commission, 1997). The elasticity for heating purposes is even lower. But since these taxes are much lower, this category of fuels seems to be a more ‘logical’ choice when introducing additional energy taxes. Car use is already subject to many other (fixed) taxes and this is not the case for heating systems.

Cars are the target of many environmental groups and green political proposals. Suppose we want to reduce diesel consumption for transport purposes by 10% (195 litres). If we assume an elasticity of -0.25, we need a 40% energy price increase. But since the number of cars is expected to grow by at least 20% for the period 1990 to 2020 (Netherland's National Communication, 1997), a higher reduction of average diesel consumption for transport purposes is needed to stabilize transport emissions. A reduction of the number of kilometres by 20% could - in theory - be obtained by a 80% price increase. There will clearly not be many political parties that want to start a campaign with these propositions.

What are the alternatives? In technical surveys, we find many opportunities to reduce the fuel consumption of heating systems. On average, burners/boilers that are installed in the 1970s consume 30 to 50% more than the most recent models that reach an efficiency of more than 95%. Similarly, the best available systems on oil make use of the very clean 'blue flame RE (no soot)' burning technology that limits emissions to record low levels : 120 mg/kWh for NO_X and 20 mg/kWh for CO for systems of 17-28 KW (Buderus, 1998).

Replacing old thermostats, the devices which keep the heating system within a limited temperature range by automatically switching the supply of heat on and off, can reduce fuel consumption by 7%. The best variable swith on/off systems, like the Ecomatic 2000 (Buderus), optimize burning time and can reduce as such start emissions by 40%. Annual maintenance and operational control of burners will also reduce consumption by 4% (Eerste Belgische Nationale Mededeling, 1997) .

Returning to our family that consumes 3000 litres for heating purposes, the investment in a new thermostat (+/- 175 Ecu) could - at least in theory - reduce consumption by some 200 litres. As already illustrated, the same 200 litres could be saved by a 40% price increase of transport diesel. The annual cost of the additional energy taxes would be: [1750*(0.65+40%) - 1950*0.65] = 325 Ecu. In this calculation, we assumed that reducing the use of the car could happen without any cost. If the transport was however needed, we have to include the costs of the other used transportation means, next to information costs and costs for a suboptimal customer satisfaction. 325 Ecu is clearly an underestimation. If the thermostat has a lifetime of 15 years, opting for higher energy taxes on car diesel will cost the family in our *ceteris paribus* example at least 4875 Ecu more over 15 years, compared to the cost of the thermostat. It is obvious that consumers would prefer to invest in equipment that saves energy compared to paying more taxes. Box I summarizes our findings.

If we have doubts on the potential savings by replacing the thermostat, replacing the burner/boiler will have clearer benefits. We assume that the efficiency improvement by installing

Box 1. Comparing costs of reducing diesel consumption

Family uses diesel for :	its car	its central heating system
annual needs :	1950 l	3000 l
diesel price :	0.65 Ecu	0.25 Ecu
CO_2 emitted :	identical	

Suppose : target is to reduce diesel consumption by 200 l.

How?	energy tax	new thermostat
	40% price increase	7% efficiency gain
Costs?	1750*(0.65 + 40%) - 1950*0.65 = 325 Ecu	Thermostat : 175 Ecu
Costs over 15 year :	4875 Ecu	175 Ecu

the new burner is only 25%. The cost of this investment is of course high, from 1500 Ecu to 3000 Ecu, depending on the size of the house. For our average family with a 'normal' house, we take 2250 Ecu as the price of the new burner/boiler.

The 25% improvement of efficiency will enable the family to save 750 litres of heating fuel. With constant energy prices, the pay-back of this investment is 2250/(750*0.25) or 12 years.

Saving 750 litres with an energy tax on car diesel is almost impossible without replacing the car by a new type that consumes less than 5 litres for 100 kilometres. With the actual car, the energy price should by increased by more than 150% to gain the same energy savings.

In terms of reducing CO_2 emissions, the actual technological possibilities clearly indicate that significant residential savings of energy at an acceptable cost can be obtained by replacing 'old' equipment by the newest models. If energy prices remain constant, and there are no indications why they should increase suddenly during the coming years, the pay-backs are still relatively long. To stimulate replacing investments with clear benefits in terms of emissions, subsidies to consumers can be an appropriate instrument.

In the next section, we will work out three types of subsidies ; subsidies for replacing old burners/boilers, subsidies for energy efficient cars and subsidies for other consumer products that have clear energy saving potentials.

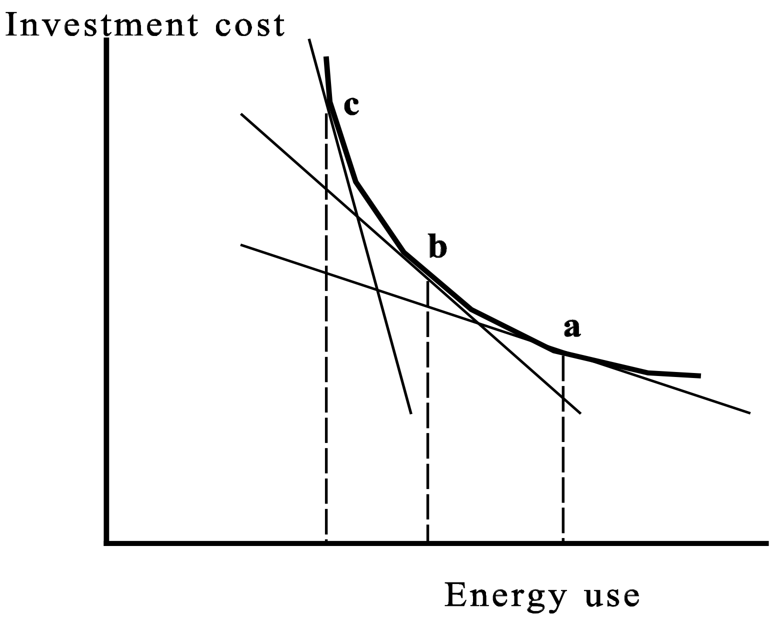
7. Consumer subsidies

7.1 The microeconomics of consumer subsidies versus energy taxes

In the previous section, we considered the low energy price elasticity and high investment costs for consumers that want to replace inefficient burners or cars. If we reduce in our period of analysis the total costs of using a heating burner or a refrigerator to only two categories namely investment costs and total energy costs, the rational consumer will base his decision on these two factors. He will opt for the product with the lowest total cost. In figure I, we present three options for a consumer that wants to buy a product with specific characteristics (like the cooling capacity or volume of a refrigerator). The three types **a**, **b** and **c** have identical characteristics. The relative energy prices determine the slopes of the lines through the three points on the iso-product curve.

If we assume that more energy efficient equipment will cost more than inefficient types (for using special components, better insulation,..) this price difference will be important in the investment decision. Starting from model **a** on the iso-product curve in figure I and with energy prices that increase as a result of energy taxes, this will provide an incentive to buy a more efficient type (**b** or **c**). Compared to model **a**, the reduced energy needs of model **b** over the period will more than compensate the additional investment cost for the period. But if the consumer already thinks of buying model **c**, it is clear that a further increase in energy prices will not result in replacing this type by a more efficient type on the left side from model **c**. Due to budget limitations (model **c** is already very expensive) , the consumer has no choice but paying the higher energy prices. In this analysis, we did not include technological progress in later periods. As a consequence, no new types will enable to reduce further emissions. But if new and expensive new types would be available, a subsidy offered to consumers that want to invest in a better model could then be a solution for governments that would like to stimulate household energy efficiency without introducing additional energy taxes.

Figure I - Balancing investment and energy costs for identical products

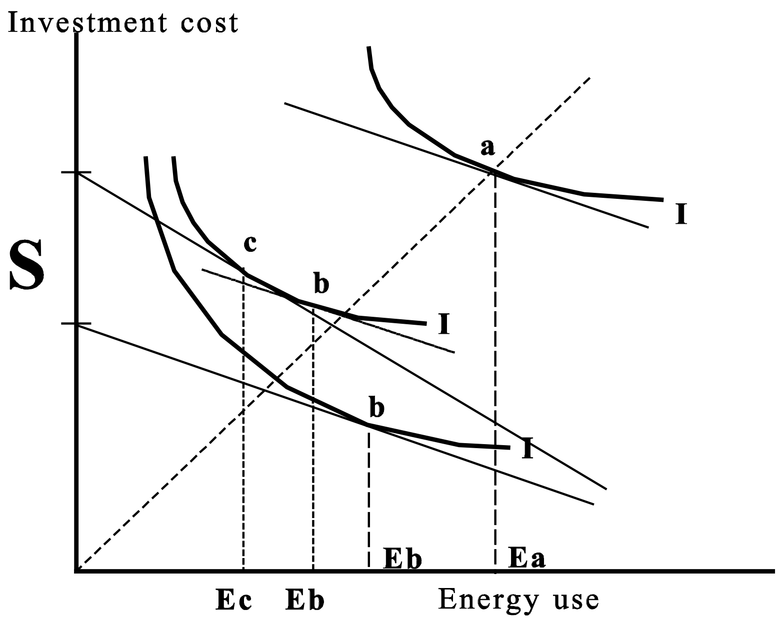


In Figure II, we introduce technological progress in the next period. We define technological progress as the ability for producers to offer better models in terms of energy efficiency at a lower cost. In our analysis, the consumer has to replace his old model **a** with I as characteristics. The new sets of products have identical characteristics, so I = I’ = I”. Again, the rational consumer will opt for the models with the lowest total costs. In our analysis, we are only interested in reducing energy needs.

If the government does not change energy prices, the consumer could opt for model **b** on I’. This means that as a result of this replacement, energy use over the period is reduced by the horizontal distance **|Ea - Eb|**. There is however a more energy efficient set of products (I”) on the market but their price is much higher. With unchanged energy prices and no subsidies, the rational consumer compares the vertical distance **|b’ - b|** to the horizontal distance **|Eb - Eb’|** and will not opt for **b’** on I”. If the government would pay a subsidy S to this consumer on the condition that he buys the most energy efficient model from the I” set, the relative prices would change because energy becomes relatively more expensive. The subsidy reduces the pay-back period for this investment. As a result, the consumer will use the subsidy and buy the product suggested by the government, namely model **c** on I”. The consumer now compares the vertical distance **|c - b + S|** to the horizontal distance **|Eb - Ec|**. In this case, the price difference is compensated by the subsidy. Choosing for product **c** will result in strongly reduced energy needs.

As a final remark, the subsidy could also be used the stimulate products on the left from model **b** on I’, if they are marketed. The cost of the subsidy will then be reduced. If energy labels are used, like in the coming section, it is however more interesting to attach the subsidy to products with the best energy label. As a consequence, labeling and the subsidies will encourage manufacturers to use efficiency as a feature of their sales campaign.

Figure II - Subsidies and the best choice



7.2 Subsidies for

replacing heating systems

Investing in efficient burners will reduce emissions of CO_2, CO, NO_X and PM. The long pay-back could be a barrier for many people that will keep, as a consequence, their old and inefficient burners as long as possible.

In many countries, technical certification agencies provide efficiency labels that enable consumers to recognise the best installations. In the Netherlands, subsidies were available for the most efficient heating systems on gas, the HR-types. The subsidy policy started in 1988 and was immediately a great success. The number of installed HR-installations increased from year to year (50000 in 1988, already 200000 in 1989) and in 1994, 40% of total private residential heating installations were burners of the most efficient types (Energieverslag Nederland, 1994).

If we provide a subsidy of 500 Ecu for each investment in high efficiency burners, the pay-back in our example will be around 9 years (compared to the 12 years without the subsidy). If at the same time, a campaign supports this policy instruments, the reaction of consumers might be significant.

For each country, we can estimate the energy efficiency potential of new installed burners starting from the number of new houses built. It can be expected that in new houses that have an insulation efficiency that reduces the potential energy losses by at least 50% compared to houses built before 1970, only the newest models will be installed. The energy needs of new houses are therefore 50 to 75% lower than of similar older houses.

In existing houses, replacements will depend on the age of the burner and the incentives offered by the government. If the investment subsidies are announced as an initiative that will only be available for 2 or 3 years, the reaction can be expected to be direct.

In Belgium, with some 30000 to 40000 new houses built each year and with a potential of 50000 to 100000 replacements per year, the annual cost of the subsidy will 'only' be between 40 to 60 million Ecu. If the subsidy will be available for 8 years and the public reacts as can be expected, the total residential energy needs can be reduced by 25%, especially if we assume that in older houses other replacing investments will also take place over time (energy efficient glass, new roofs with better isolation, foams, insulating injections). In Belgium, emissions from total residential heating amounted to 23.8% of total emissions in 1994 (Belgian National Communication, 1997). The European average for 1990 was 20.4%.

A reduction of 25% of these emissions can reduce total national emissions by 5 to 6% if all the other sectors do not increase their emissions. Over this period of 8 years, the reductions of national emissions by 5% will cost some 400 to 500 million Ecu. At the same time, the sectors that produce and install heating installations will see their markets expand. These labour intensive sectors will create employment and generate additional revenues.

If this price is too high for the budget, governments could use the facilities offered by the

Energy Product Tax that will install higher minimum energy taxes on all fuels. From experiences in the past, we can assume that increasing the price of fuels for heating from 0.25 ECU to 0.35 Ecu per litre can generate annually 200 to 250 million Ecu in Belgium, at least in the first years after the higher energy taxes (Federaal Planbureau, 1995) . This price increase will further reduce the pay-back to 6.6 years (1750/750*0.35). The generated incomes can also be used to finance other subsidies, like those presented in the following subsections.

7.3 Subsidies for energy efficient cars

7.3.1 Potentials

We already referred to the Extern-E project that concludes that the bulk of the external costs of transport (cars, buses, trucks and other vehicles) is caused by the emissions of PM resulting from inefficient burning of fuels. Reducing emissions is closely related to reducing energy consumption.

Since the average age of cars on the European roads has been increasing and is now around 7 years, the actual average fuel consumption of cars on gasoline is still between 8 and 11 litres for 100 kilometres. For diesel cars, the average fuel consumption is between 6 and 9 litres because older diesels typically have heavy engines (2500-3000 ccm).

There are however many possibilities to reduce these energy needs by half since gasoline is used very inefficiently in internal combustion engines. About 80% of its energy capacity is lost (see table III).

In 1997, the fuel cell technology reached the potential of short-term commercialisation. In the US, a partnership with the auto industry, funded by the Department of Energy, has lead to the potential creation of a new generation of vehicles that will use 84% of the gasoline in the fuel cell. This means that the energy efficiency will be increased by a factor four. Similar results were obtained from projects funded by the Defense Advanced Research Products Agency and the Commerce Department’s National Institute of Science and Technology.

General Motors, Ford, Chrysler and other members of the project already announced to commercialize fuel cell vehicles at competitive prices starting from 2002 or 2003 (USIS, Embassy of the United States of America, 1997). In the next century, powerful cars will be available that need only 2 to 3 litres per 100 kilometres. Emissions, other than CO_2, will be reduced by 90%. The first prototypes were presented at the 1998 Detroit automobile show where General Motors announced the development of a hybrid-based vehicle that achieves a fuel efficiency of 80 miles per gallon or some 3 litres per 100 kilometres (Yellen, 1998).

In Japan, Honda did also develop fuel cell prototypes and will start commercialisation around 2002. Toyota will build next year hydro-cars that need only water and the Toyota Prius, a hybrid-based car with an electrical and conventional engine that both reduce energy needs to less than 5 litres per 100 kilometres is already a big success in Japan. In 1999, this car will be redesigned and commericalized for the European markets.

In 1998, Honda presented the J-VX, a hybrid car with Integrated Motor Assist (IMA). This car has a small conventional engine, a small electrical engine without heavy batteries and an 'ultra-capacitor' that saves electricity generated by the conventional engine as a by-product. This capacitor even captures kinetic energy during deceleration and braking. As a result, hardly any energy will be lost. The J-VX is a powerful car that consumes only 3 litres for 100 kilometres (Honda, 1998).

One of the most radical new engines that reached the international press is the MDI EV3 that only needs compressed air to function. This engine has been developed by Guy Nègre, an engineer with experience in F-1 racing. Cars with this engine can reach 100 km/h and make 1000 kilometres at a 'fuel' cost of 1.5 Ecu. This engine will be used in the coming years for the 87000 taxicabs in Mexico City.

Of course, these promising developments are no reason to wait. On our markets, there are already many efficient cars. The new diesel engines from Volkswagen and Seat just broke the record of fuel efficiency. Another recent example is the GDI engine from Mitsubishi reduces energy consumption by 10% and CO_2 emissions by 20%. Volvo did already buy this GDI technology.

Many other efficient cars can be detected in the European ECO-Tour, an annual contest in Europe. Each manufacturer can participate with a standard car. All cars have to follow an identical route of around 2000 kilometres on highways, in cities, in the mountains,... The best cars can pass the test with an average fuel consumption of less than 5 litres. The winning cars are surely not micro cars with very modest engines. The winner of 1994 was the Honda Civic VEi (1.6L, 90 HP), a car that can reach 195 km/h.

7.3.2 European proposals

Concerning energy efficiency and emissions, several European initiatives and proposals were taken. In COM(97)481, we read : "The Council has already adopted a CO_2 emission target which corresponds to an improvement in the average fuel economy of new cars in the market in the order of 30% by 2005." On these reduction targets, the European Commission negociated since September 1996 with ACEA, the European Automobile Manufacturers Association. It is no surprise that ACEA offers an engagement on reducing CO_2 emissions while at the same time presenting some conditions like no negative measures against diesel-fuelled cars and the full availability of improved fuels by 2005, in particular with low sulphur content (ip/98/234). The first proposals by ACEA had been rejected by the Commission and the Council. This seems to be a good strategy by the Commission because in the most recent proposal of ACEA (June 1998), the emission commitment of 140 g/km for 2008 is no longer depending on certain conditions (ip/98/499). This proposal has been accepted in October 1998. Fiscal incentives can be used to encourage marketing of cleaner vehicles, if the measures apply to all new vehicles in conformity with future emissions limits foreseen by EU law.

Begin 1998, the Council reached a political agreement on two draft directives which set strict limits on emissions from cars and on quality standards for fuels. The directives are part of the EU's Auto-Oil Programme[5] aimed at a better cooperation between the Commission, EU oil producers and car manufacturers. Emissions from private cars shall be reduced by setting limit values for certain pollutants (carbon monoxide, hydro-fuels, nitrogen oxide, particles from diesel), being indicative for all new vehicles from 2000 and compulsory from 2005. Member States that introduce vehicles that prematurely respect the limit values set for 2000 and 2005 will be allowed to introduce fiscal incentive measures, unless these incentives should disturb the functioning of the internal market. Manufacturers shall be held responsible for ensuring that their cars conform to the standards and that the pollution control mechanisms work properly. These measures are expected to lead to a 50% reduction in old vehicle emissions (EUR-OP Info, 3/1997).

The proposals currently on the table for minimum quality standards for petrol and diesel fuel will enter into effect on 1 January 2000. There is however a five-year derogation from new standards for a number of Member States in Southern Europe (Team Time, Volume 50, April 1998).

The Auto-Oil programme will also reduce emissions from light commercial vehicles from the year 2000. The objective is to reduce polluting emissions from road traffic by 60-70% between 1996 and 2010 (COM(97)248). This measure targets commercial vehicles such as vans up to 3.5 tonnes and cars over 2.5 tonnes which have been identified as being one of the major sources of urban pollution.

[5] This progamme has five sections : fuel quality, emissions from private cars, emissions from light commercial vehicles, emissions from heavy goods vehicles and adaptation of provisions relating to roadworthiness testing .

The European proposals might look ambitious but when weighted by the actual state of technology, they are not. The technology to reduce emissions from buses trucks and vans by more than 60% is already available and patented. A good illustration is Turbodyne Systems that introduced last year its Turbopac and Dynacharger systems. These retrofit kits were tested on transit buses in Sao Paulo and other cities and demonstrated a 67% reduction in harmful emissions and an 11% improvement in fuel economy (Tubodyne Press Releases, 1998) . These results are mainly due to the shortening by Turbopac of the 'turbo-lag', the time lag during acceleration before the exhaust energy level rises sufficiently to activate the turbocharger rotor[6]. The Turbodyne systems can be installed on both gasoline and diesel applications.

Detroit Diesel Corporation (DCC), a leading global manufacturer of diesel engines purchased already 2500 Turbopac bus kits. On 7 April 1998, the United States Environmental Protection Agency gave official certification to Turbodyne under the Urban Bus Retrofit/Rebuild Program. Currently, Turbopac units have been installed for evaluation on representative public transit buses in Paris. If the test prove as succesfull as in other cities, all RATP (Régie Autonome des Transports Parisiens) buses might be retrofitted in the near future.

The Turbopac model 1500 gave the same results when tested on passenger cars. In addition, the kit demonstrated a 25% average increase in rated engine power and a 30% improvement in engine torque, at substantial lower engine speeds. The Turbopac was installed on vehicles manufactured by Alfa Romeo, Fiat, Volkswagen, Audi, Toyota and Rover.

When relatively inexpensive technological solutions are already available at this moment, why does the EC works with a time horizon of more than 10 years? We clearly need to accelerate the diffusion processes of clean technologies using other instruments than the slow regulatory process.

7.3.3 The fiscal burden on cars

Next to excise duties on motor fuels, there are taxes levied on the purchase and registration of new and old cars. Another important category are the annual car taxes. In some countries, these taxes generate more than 5% of total tax revenues.

To illustrate the tax differences in the EU, Table IV compares some European consumer prices before and after taxes.

The purchase tax or registration tax is in most countries decreasing with the age of the car. This means that the registration tax when buying a Jaguar 3.6L from 1984 can be lower than

[6] Particulate emissions (PM) are the solid and liquid emissions resulting from the incomplete combustion of fuel. In turbocharged engines, the turbocharger provides the engine with more air than it can induce through natural aspiration. At low idle speed of the engine, there is very little energy in the engine exhaust and this prevents the turbocharger from providing a significant level of boost in the engine intake air system. The results of this inefficiency (the time lag) is the excessive smoke during acceleration.

for a new Volkwagen Golf Diesel 1.9L. It is clear that the driver of the Volkswagen will pollute only a fraction of the pollution generated by the Jaguar. Since value added taxes are taxes on the price, the other taxes could be redesigned in terms of age or pollution to stimulate the diffusion of cleaner cars. The benefits of these tax shifts could be used to finance other instruments like a subsidy for clean and energy efficient cars.

Table IV - European car prices, before and after taxes (in Ecu)

Country	Nissan Micra 1.0 before taxes	Nissan Micra 1.0 after taxes	Audi A6 2.6 before taxes	Audi A6 2.6 after taxes
Austria	9 307	11 727	24 333	33 288
Belgium	8 475	10 278	23 724	29 505
Denmark	5 833	15 208	25 792	52 244
Ireland	8 313	12 713	22 816	37 770
Netherlands	8 278	11 821	22 992	35 598
Portugal	7 479	10 005	20 992	33 742

Source : European Commision, Tax Provisions with a Potential Impact on Environmental Protection, 1997, Appendix 4.1 and appendix 4.3

7.3.4 Regulatory initiatives

In many countries, the automobile industry argues that policy makers do not stimulate the diffusion of new and clean cars. The high level of taxes like value added taxes (VAT) and registration taxes make that many owners want to use their car as long as there are no important technical problems.

The promotion of clean and energy efficient cars can be achieved by regulation or by giving subsidies (an ecobonus) or preferential tax rates to consumers that buy these cars. Some countries have already taxes that are related to fuel consumption. In Austria, a part of the VAT was replaced by a 'standard fuel consumption tax' for cars that were built in 1992 or earlier. The standard fuel consumption is measured using the ECE-standard when driving at a constant speed of 90 km/h. Cars that consume more than 8.2 litres per 100 kilometres pay the highest tax (EC, 1997).

The Netherlands, Germany, Norway and Sweden used differential tax rates to encourage consumers to purchase low emitting and hence low consuming cars. The tax differentiation seems to work because at the end of the 1980s, 87% of the cars sold in Sweden qualified for the tax advantage. For Germany, the comparable percentage was over 90% (Opschoor and Vos, 1989).

In the United States, the Gas Guzzler Excise Tax and the Corporate Average Fuel Economy (CAFE) federal standards regulate the energy efficiency of cars and light trucks. The Gas Guzzler tax was installed after the oil crises to improve US energy self-sufficiency. It was not an environmental tax. Cars that are less efficient than 22.5 miles/gallon (mpg) or 10.5 litres/100 kilometres were taxed with the Guzzler Tax that started from $ 1000 and could amount to $ 7700 (Westin, 1997).

This tax has been attacked by the European Commission that stated that European cars were disproportionately taxed, especially since light trucks, which are very popular as alternatives to cars in the US, were not taxed under the Guzzler Tax. Light trucks account for one third of the US car market. The GATT Panel rejected the European arguments on the theory that the law lacks a protectionist purpose.

The Guzzler Tax would only have impact on powerful cars and therefore the Corporate Average Fuel Economy provisions of the 1975 Clean Air Act are more important when it comes to the average fuel consumption of the US car fleet. The CAFE standards require that new cars average at least 27.5 mpg (8.5 l/100 km) and light trucks average 20.6 mpg (11.5 l/100 km). The CAFE is an average standard for the complete fleet of a manufacturer. Car makers still can produce vehicles which fail to meet the standards as long as enough other models meet the CAFE standards to balance out the 'guzzlers'. Since foreign manufacturers do not have the opportunity to compensate the fuel inefficiency of their top models - with the highest profit margins - by selling high volumes of their smaller and more efficient cars on the US market, manufacturers like BMW and Mercedes attacked CAFE under the GATT. This time, the CAFE tax case was decided in favor of the protesting nations because it was discriminatory. As a result, there will be no CAFE taxes on imported cars.

Since US car manufacturers reached this CAFE standard already in the 1980s, mainly by reducing weight, improvements in fuel economy have stagnated since then. Manufacturers invested in performance inprovements, safety and luxury aspects.

Environmental groups like the Sierra Club therefore want to adapt the CAFE standards to the actual technological possibilities. In his recent election campaign, President Clinton also suggested an stricter CAFE standard for the coming years. The Sierra Club proposed an update of the CAFE law to 45 mpg (5.2 l/100 km) for cars, and 34 mpg (7.2 l/100 km) for light trucks. If these standards are met in the coming years, the new CAFE would ‘save more oil than the US import from the entire Persian Gulf (Sierra Club,1997)’.

Efficiency gains do not only depend on the fuel cell technology but can be achieved using multivalve engines, variable valve timing, high-strength lightweight structures, optimized gearing, better aerodynamics, low rolling resistance tires and improved fuel quality.

Next to federal standards, some States like Ontario have an own Tax for Fuel Conservation (TFC). In 1989 the Ontario government introduced a tax on car purchases : the Tax on Fuel-Inefficient Vehicles (TFV). The tax varied in proportion to highway fuel consumption ratings above a base level of 9.5 litres per 100 kilometres. Later, the tax was not only renamed but also differentiated. The threshold was lowered and even a rebate was introduced for the most fuel-efficient cars (DeCicco, 1993).

7.3.5 The ecobonus for cars

There are no actual indications that in the near future a European CAFE standard might be imposed. European policy makers that are attracted be the principle will hesitate because structural regulatory changes concerning the international car industry, are expected to come from the European level. Furthermore, working with average fleet standards risks to discriminate certain exporting countries.

An alternative might be to introduce an environmental subsidy (ecobonus) that will be paid to consumers that buy the most energy efficient cars. In a first step, efficiency targets need to be defined. Using the new ECE average fuel consumption standards (a combination of traffic in cities and at 90 km/h), a subsidy could be given for cars than need less than 5.5 litres of gasoline for 100 kilometres and for cars that need less than 4.5 litres of diesel for 100 kilometres.

Depending on the number of new cars that can qualify, a subsidy level can be set. To make the subsidy really attractive for consumers, we will work with an ecobonus of 1000 Ecu. Compared to an average car price of 15000 Ecu, the ecobonus provides a significant discount and can become an essential element in marketing strategies.

An alternative for subsidies are tax credits. Recently, President Clinton proposed his $ 3.6 billion package to encourage consumers’ energy efficiency. In this package, tax credits of $ 3000 to $ 4000 are included for consumers who purchase highly fuel efficient vehicles (Yellen, 1998).

Since our proposed standards are rather strict, we assume that only 10% of the new sold cars meet the requirements for the ecobonus. For Belgium, with 400000 new cars sold each year, the financial impact would be 40 million Ecu. Since some 5 million cars are registered in Belgium, an average increase on annual car taxes by only 8 Ecu will be sufficient to compensate the government budget for the paid subsidies. Average car taxes actually amount to 175 Ecu in Belgium so this is not a dramatic increase. Here we can redesign the car tax in a way that older cars with inefficient engines will be targeted with a higher tax increase than recent clean cars. Or these efficient cars could be exempted from the tax increase. This policy will make the ecobonus or subsidy even more attractive.

Other financing opportunities are increased registration taxes for old and inefficient cars that are sold on the second hand market or higher fuel taxes. This last instrument will also make energy efficient cars more attractive but does not differentiate between efficient and inefficient users of energy. And it is not energy on itself that should be targeted, but the inefficient use of energy.

If we want to reach more people with the ecobonus, a smaller ecobonus of 500 Ecu could be introduced for the first 10% of the new sold cars that did exceed the target. In this case, annual car taxes will have to be increased by 12 Ecu. Owners of old cars will as such have more incentives to replace their car by a more efficient type.

If the ecobonus is introduced, manufacturers will present their most efficient engines in their popular models. This means that the average fuel efficiency of all new cars will improve. After a few years of investing in more efficient engines, the fuel efficiency targets for the ecobonus might be further downsized.

The results in terms of reduced CO_2 emissions are difficult to estimate. It is however a certainty that emissions after the introduction of the ecobonus will be lower than emissions without the ecobonus.

We tried to calculate the impact of this ecobonus for Belgium by assuming that the car fleet will increase by 15% for the period 1998-2010. We divided the actual car fleet in three segments : old cars that were built before 1993 ('guzzlers'), more recent and efficient cars, and finally the cleanest cars. Each category has a different average fuel consumption. The more old cars that will be replaced by the cleanest cars, the faster the average fuel efficiency will increase.

In table V we start with annual sellings of 400000 cars in Belgium of which only a limited fraction will be of the cleanest type. The other new cars will be classified under the recent cars. If the ecobonus will be a succesful instrument, the share of the cleanest cars in the new sold cars will increase strongly. The long term consequences of the accelerated diffusion of the cleanest cars in the total car fleet are very important because these cars will be used for some 9 to 12 years. After a few years, they will be sold on the second hand markets at low prices so everybody will be able to buy an efficient car. The scrapping of old and dirty cars will result in very significant reductions of average energy needs of the total car fleet. Worldwide, every year millions of new cars will be sold, whether some green groups like it or not. This process will be difficult to stop. But if these cars are clean and replace old and inefficient cars, this will have positive consequences for the total environmental impact of the actual car fleet.

If we take for 1998 as average fuel consumption for the three groups of cars in Table V respectively 10, 8 and 5 litres for 100 kilometres, the average fuel efficiency of the actual fleet is 9.06 litres for 100 kilometres. For 2010, we assume that the group of recent cars needs 7 litres and the cleanest cars need only 4 litres for 100 kilometres. This brings the average fuel efficiency of the fleet in 2010 to 5.43 litres for 100 kilometres, a reduction by 40% compared

to 1998.
If the 5.75 million cars in 2010 are used for the same average number of kilometres as in 1998, total energy needs after the growth of the car fleet by 15% will still be reduced by 31%. And if we assume that each car in 2010 will make 10% more kilometres than the average car in 1998, the reduction of energy needs and CO_2 emissions will still be 25%.

Table V - Composition of the Belgian car fleet in million, 1998-2010

Year	Old cars	Recent cars (1993 - ...)	Cleanest cars	Total
1998	2.8	2.1	0.1	5
1999	2.4	2.5	0.2	5.1
2000	2.15	2.8	0.3	5.25
2001	1.8	3	0.5	5.3
2002	1.45	3.2	0.7	5.35
2003	1.1	3.4	0.9	5.4
2004	0.75	3.5	1.2	5.45
2005	0.4	3.6	1.5	5.5
2006	0.25	3.6	1.7	5.55
2007	0.2	3.4	2	5.6
2008	0	3.4	2.3	5.65
2009	0	3.1	2.6	5.6
2010	0	2.75	3	5.75

Of course, also without the ecobonus, average fuel consumption will be reduced as a result of the scrapping of old and dirty cars . The ecobonus can accelerate the diffusion of the cleanest models.
For engines of light vehicles, trucks and buses, similar improvements might be expected over a longer period since the lifetime of the best trucks is around 2 to 2.5 million kilometres. Furthermore, congestion problems may stimulate intermodal shift what can result in additional CO_2 reductions.
Stating that total transport emissions of CO_2 will be reduced in 2010 by some 15% compared

to 1998, is not that speculative. Compared to 1990, a 10% reduction should be possible when cleanest technologies are strongly promoted.

Less combustion of fuel means also less pollution other than CO_2. The next generation of catalytic converters, like the types that will meet the most recent Californian laws on Ultra Low Emission Vehicles (ULEV) in 1999 and 2001, will further reduce other emissions by 90% (!) compared to average car emissions in 1995. The Honda Accord 2.2 EX was the first car that did qualify for the new Californian emission standards (Honda, 1997).

7.4 Subsidies for other consumer products

Using environmental subsidies for heating installations and cars will have more impact than introducing subsidies for energy efficient refrigerators or washing machines. But every improvement in energy efficiency is important so we have to exploit all opportunities to save on domestic and tertiary energy needs.

This is also the European position : "On the end-use side there are numerous ways to improve efficiencies, both in the industrial and in the domestic and tertiary sectors. Refrigerators, computers, televisions, washing machines, light bulbs are only a few examples where use of existing technology will allow the same level of service with much less energy consumption. Electric motors used extensively in industry can similarly be improved. The EU has already developed mandatory energy efficiency labeling schemes for the principal 'white goods' and mandatory standards for refrigerators/freezers to improve efficiency. The Commission is now negotiating standards on a more extensive product range with the relevant industrial sectors (COM(97)481)."

The existing labels for energy efficient or white goods (Dir.92/75/EC, Dir.94/2/EC, Dir.95/13/EC, Dir.96/57/EC, Dir.96/60/EC and Dir.97/17/EC) are the result of the European PACE Programme (Programme d'action communautaire visant à ameliorer l'efficacité d'utilisation de l'éléctricité) of which SAVE (Specific Actions for Vigourous Energy Efficiency) was an important subprogramme.

The European energy label uses a graphical indication of energy efficiency ranging with the labels A (more than 45% more efficient than average) to G (more than 25% less efficient than average). The EU has the intention to continuously update the labels in terms of average energy efficiency and to ban from the European markets in the year 2000 all products with the label G (Electrabel, 1997).

In Belgium, the electricity provider Electrabel used the European label in its campaign to improve 'rational energy use'. In order to attract attention, a subsidy of 50 Ecu was provided when consumers did buy a refrigerator or freezer with the label A. Electrabel finances this subsidy from its own resources. This subsidy was a great succes because it partly compensated

for the price difference with less efficient types. As a consequence, many distributors of cooling equipment changed their product selection and started to present many types of the most efficient refrigerators and freezers. In their publicity, annual energy needs are provided for cooling equipment and for washing machines. As such the awareness of the public is strongly increased. In Denmark, after a tax reform that stimulated energy efficiency, the market share of efficient freezers and refrigerators (A, B and C) increased from 40% in 1994 to 85% in 1996 (Jänicke e.a., 1997). This suggests that the public can strongly react on new instruments.
In the near future, the energy label will also be used for washing and drying machines, dish washers, cooking equipment, electric mobile heating devices, light bulbs and air conditionings. From 1999, a subsidy of 75 Ecu will be provided when consumers opt for the most efficient washing machines and dish washers (Nieuwejaers, 1998).
The potential savings on energy and on CO_2 emissions might be considered as limited because we only deal with refrigerators or freezers. But both consumer goods have a long lifetime what makes that their cumulative energy savings can be significant.
Starting from the difference in annual energy needs between an efficient type and an inefficient type, expressed in kWh, table VI calculates the difference in total energy costs and total CO_2 emissions after a period of ten years. The calculations are made using an average electricity price of 5 BEF/kWh (+/- 0.125 Ecu/kWh).

Table VI - Differences in energy costs over a 10 year period

E-difference (yearly)	Difference in energy costs after 10 years	Actualised difference in energy costs	Difference in CO_2 emissions after 10 years
50 kWh	2500 BEF (Belg.Fr.)	2109 BEF	92 kg
100 kWh	5000 BEF	4218 BEF	184 kg
150 kWh	7500 BEF	6326 BEF	276 kg
200 kWh	10000 BEF	8435 BEF	368 kg
250 kWh	12500 BEF	10544 BEF	460 kg
300 kWh	15000 BEF	12653 BEF	552 kg
350 kWh	17500 BEF	14762 BEF	664 kg

Source : VEI, Praktische instructies voor het gebruik van energielabels, p.11 / kWh : kilowatt-hours

In rich countries, a typical family has a big refrigerator with a freezing unit or a smaller refrigerator next to a freezer. This means that for every 4 to 5 people (average family size), we use 1 or 2 refrigerators and/or freezers. Cooling equipment is also used in the commercial

circuit : in all enterprises, in the meat industry, in cold storage warehouses, for mobile cooling units, vending machines,...
If we start with an annual difference in energy needs of 250 kWh for each cooling unit and use a ratio of 1 refrigerator/freezer for 3.5 persons, some 10 million refrigerators are used in the EU and a major part could be replaced by more energy efficient types. Over a period of 10 years, the cumulative reduction of CO_2 emissions as a result of total replacements could be 4.6 million ton. This is 0.7% of total residential/tertiary emissions in the EU in 1990. If the ratio would be 1 refrigerator or freezer for 2.5 persons, around 14 million units could be replaced and over 10 years CO_2 emissions could be reduced by 6.4 million tonnes (almost 1% of all residential emission in 1990).
If we use a subsidy as an incentive to replace all old refrigerators, this policy will cost of course a lot of money. A possible funding can be found in the elimination of other existing energy subsidies like coal subsidies or special electricity prices for large users. Like in the case of Belgium, a part of the monopoly profits of the electricity sector can also be used to finance this instrument of energy efficiency.
If we add all the other consumer products, from washing machines and light bulbs to mobile heating devices, and assume that the 10 million European families can reduce their annual energy needs by 1500 kWh per family, some 12 million tonnes of CO_2 will not be emitted over a period of 10 years. This is almost 2% of the emissions in 1990. If over a longer period, when newer types further reduce energy needs, annual saving can be 3000 kWh per family, 23 million tonnes will not be emitted over a 10 year period.
If this replacement can be stimulated by subsidies, this is an instrument that has clear results.

8. Legal implications of subsidies

Susidies paid to manufacturers can influence competition and are therefore prohibited by Article 92 (State Aid) of the European Treaty. But by paying the subsidy or ecobonus to consumers and not to manufacturers, this instrument does not distort competition, nor protects the domestic market if all manufacturers have the same change of presenting their efficient products on this market. Since we do not work with average performance standards like CAFE, differences in market share or size of the exporter are not crucial.
Potential complaints can be eliminated if all exports have access to all needed information concerning the environmental subsidies. Certification procedures have to be transparent and affordable for small exporters. Government agencies that provide labels for efficient burners can continue their work. Their label can be used to attach a consumer subsidy. Exporters of cars already have to publish average fuel consumption using European standards. If current practices for certification and testing will be maintained in the future, potential protectionist abuses are limited.

9. Conclusions

Reducing CO_2 emissions in the EU by at least 8% will be rather 'easy' compared to the Kyoto obligations for Canada and the US. The reductions will however require actions in all sectors that use or produce energy. Starting from proven technological possibilities, we analysed some opportunities for reductions in the sectors of transport, heating equipment and consumer durables. Compared to paying more energy taxes, consumers will prefer to make investments that save energy and money. This is certainly the case for taxes on tranportation fuels since cars are already the target of many other taxes and the greenhouse external effects of car use are rather modest. In a basic example, we illustrated that small investments (like installing a new thermostat) have greater potentials in reducing energy needs than further increasing energy taxes that are already at a very high level.

For reducing transport and household GHG emissions, the diffusion of clean cars, clean central heating systems and energy-efficient refrigerators can be stimulated by legal incentives, complemented by a subsidy for consumers. Considering the fact that these investment goods have a long lifetime, these measures can result in significant reductions of CO_2.

In terms of ecological efficiency, we found significant emission reduction potentials for the transport and heating sectors. In the best scenarios, total emissions could be reduced by respectively 10 and 5% compared to the 1990-level. Minor reductions can be expected from the diffusion of more efficient refrigerators, freezers and other household durables.

If industry and the energy sector can further reduce their emissions, the Kyoto targets could be met at a very low social cost.

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