bio Intelligence Service

European Commission (DG TAXUD)

A study on the costs and benefits associated with the use of tax incentives to promote the manufacturing of more and better energy-efficient appliances and equipment and the consumer purchasing of these products

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EXECUTIVE SUMMARY

Climate change is one of the greatest environmental challenges of our time and has been the subject of increasing political attention worldwide. Various scientific sources link climate change directly to increasing emission of Greenhouse gases (GHG), and more specifically CO_2. Rising CO_2 emissions are pushing up the Earth's carbon stock and increasing global temperatures.

Following two climate-change related targets were presented by the European Commission (EC) on January 23rd 2008, in the integrated proposal for climate action:

- A reduction of at least 20% in GHG emissions by 2020[1]
- A 20% share of renewable energies in EU energy consumption by 2020

In addition, achieving a 20% savings of energy consumption by 2020 through energy efficiency measures is underlined as one of the key ways in which CO_2 emission savings can be realised, as has been recently reaffirmed by the EC[2]. Earlier, the Green Paper for Energy Efficiency (March 2006) also identified energy efficiency as the most effective, most cost-effective and rapid manner for reducing greenhouse gas emissions.

Lastly, in the context of the Action Plan on Sustainable Industrial Policy (SIP) and Sustainable Consumption and Production (SCP) adopted by the European Commission on 16 July 2008, it was mentioned that Member States are free to set "incentives" in order to complement other policy instruments aiming at fostering eco-friendly products (e.g. eco-design requirements following from the EuP Directive, Ecolabel Regulation). Indeed, as energy efficient appliances often represent a higher purchase price than competing products, their sales remain inadequate and industry is not encouraged to invest in such products. Finding ways of strengthening demand would allow manufacturing of eco-friendly products at a larger scale, so that their production costs and final prices for consumers would go down. In order to boost demand in this way, many Member States give incentives for buying eco-friendly products, such as windows with high thermal insulation or white goods with the highest energy class.

In this context, a wide range of initiatives are being promoted in different countries in the world to encourage eco-designed products by changing the production techniques and also by reforming the society towards sustainable consumption patterns. It is often suggested that the energy saved will serve as an important incentive for the consumer as saved energy is money saved. Nevertheless, financial incentives (for manufacturers or users) are being experimented in different countries to further encourage energy efficient products. As the energy using products evolve much faster compared products of other sectors, because of innovation in technologies, a dynamic approach is needed in policies to take into account such innovation which indirectly affects also the consumer behaviour.

The absence of a direct integration of economic criteria in eco-design or energy efficiency indicators makes it difficult to assess the trade-offs in real time and to

[1] Rising to 30% if there is an international agreement committing other developed countries to "comparable emission reductions and economically more advanced developing countries to contributing adequately according to their responsibilities and respective capabilities".

[2] European Commission (2008) Communication on energy efficiency
http://ec.europa.eu/energy/strategies/2008/doc/2008_11_ser2/energy_efficiency_communication_en.pdf

monitor the improvements (both in terms of energy efficiency and economic efficiency). A deeper insight is therefore needed on possible approaches for integrating economic criteria with energy efficiency and what kind of financial incentives are feasible to motivate the consumers and manufacturers further.

To understand better the interaction of various fiscal incentive approaches and an inter-policy comparison, the present study assessed the impacts of various tax incentives options both from economic and environmental perspectives through a cost-benefit analysis (CBA). Following four product groups were identified by the EC due to their relevance, i.e. penetration rate, sales in the EU, and environmental impacts.

- Refrigerators
- Washing Machines
- Compact Fluorescent Lamps (with integrated ballast) (CFLi)
- Boilers

In the first step of this study, the current market of the four product groups was analysed and the data required for CBA was also collected. Except for boilers, the EU Energy Label provides criteria to compare the appliances according to their energy efficiency. For white goods, sales of the most efficient products (energy class A++ and A+ for refrigerators and A+ for washing machines) are quite low within EU-27 even if there are some differences across Member States (MS), for example, the market share of washing machines with energy class A+ represented about 9.5% in Italy in 2007 but only 2.4% in Poland. Further, manufacturers' pricing strategies as well as market characteristics explain that average prices of white goods, as well as for the other two product groups, are often higher in Western Europe than in Eastern Europe (e.g. +27.1% higher in 2004 for A+ refrigerators).

In the case of CFLi, which are about 4 times more efficient than traditional incandescent lamps, the market penetrations have varied widely since their introduction. In some cases, the public perception of CFLi has been compromised by consumers' experiences with the first generation of CFLi that came on the market about twenty years ago. These early CFLi were found to have cold light colour, poor colour rendering, fairly heavy weight, and large dimensions. In the meantime, most of these disadvantages have been significantly reduced.

For boilers, the most efficient ones i.e. gas condensing boilers, are widely used within the EU. However, consumers do not really choose a specific model with regard to its energy efficiency, but mostly follow installers' advice. An important issue for this product category is the wide price difference between MS, e.g. with a ratio of about 5 between Sweden and Czech Republic or Poland.

For most of the products analysed in this study, the high purchase price of the most efficient models compared to other models remains the main barrier for the uptake of these "green" alternatives. Indeed, even if the Life Cycle Cost (LCC) of a CFLi is about 70% lower than the LCC of a traditional incandescent lamp, most consumers focus on the initial cost. Nevertheless, one can observe a rise in consumer awareness on environmental issues.

Tax incentives (subsidy or tax credit) are one of the possible mechanisms in order to transform the market towards more energy efficient appliances. Such policy instruments have been (or are currently being) used in several MS to promote energy efficient appliances. Examples include:

- A tax credit for consumers in Italy for refrigerators (since 2007);
- Subsidies in Spain and in Hungary for white goods (since 2006 in Spain and several campaigns in 2006 and 2007 in Hungary);
- A subsidy in Poland for CFLi (1995-1997);
- A tax credit for consumers in France for boilers (since 2005).

The results of these schemes clearly show market changes and an increase in the market shares of the most efficient and cost-effective products.

The second step of the study involved a thorough literature review regarding the state-of-play of the tax incentives both in EU and United States, as well as a review of economic and engineering models. The EU review shows that assessments of energy-related policies are in general carried out on the basis of consumption of energy or another energy-efficiency indicator when engineering models are used. In contrast, econometric analyses focus on the demand for energy and the estimation of the price-elasticity of the demand for energy, which is an important tool to enable analysts to predict how policies impacting energy prices will affect consumption of energy.

In the US, there are various measures in place to promote energy efficiency. The measures generally fall into two groups: 1) those that directly assess the energy-efficiency gains of stricter energy standards through tax incentives for individual items; and 2) those that evaluate and compare the impacts of energy prices, tax mechanisms and other incentives by studying the impacts they have on various parameters that determine the demand for energy.

This study compares the effectiveness of tax incentives with other policy options such as the increase of the energy price due to the Emissions Trading Scheme (ETS). Three tax-incentive options were chosen following the schemes already used in some MS as well as to understand the impacts on the consumers and manufacturers: subsidies for consumers, tax credits for consumers, and tax credits for manufacturers.

Further, the effectiveness of tax incentives is expected to vary among Member States due to price differences, as well as market penetration of ‘green’ products. Therefore, it is relevant for the same tax incentive option and for the same appliance to compare effects for two MS representative of various European regions or usage patterns. Four MS were selected on the basis of the existence of relevant policies in the countries as well as the availability of the necessary data. The selected countries were: France, Italy, Denmark, and Poland.

Altogether, eight CBA cases have been carried out and a summary of the conclusions is presented in Table 1.

An economic model of consumer behaviour towards the provision of services by the appliances was used to evaluate how the sales of energy efficient appliances would be affected by tax incentives. It was assumed that consumers compare the net present value of the operational costs of services provided by appliances during its lifetime and choose the cheapest alternative.

The results of the CBAs are presented as the difference between the monetary value (expressed in Euros) of CO_2 emissions reduction, which represents the benefit side of the CBA balance, and the administrative and net welfare costs. The method used to estimate the welfare gains and losses in this study is one based on a partial equilibrium approach, i.e. by looking at one market at a time and does not consider the impacts of changes in prices across markets. An economy-wide approach would certainly be more inclusive of other effects but would run into problems of estimation of many of the parameters, for which data availability is very limited.

The way to calculate the net welfare costs (or gains) for different policy options is explained below:

- In case of subsidies or tax credits, welfare costs are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits of the extra sales revenue varying between 6% (CFLi) and 8.5% (boilers) – 8% for refrigerators and washing machines; and (c) the gain from the reduction of the emissions of non-GHG pollutants from the energy generation (electricity and gas), such as SOx, NOx, particulate matter, POPs, and heavy metals.
- In case of removing less-efficient product categories from the market, the welfare cost arises from the fact the consumers are made to buy more expensive equipments than they otherwise would. The cost is the difference in price (adjusted for quality) between the appliance bought without the policy and the one bought after the policy is implemented. The welfare gains arise from the increased sales of more profitable equipments and the reductions of the emissions of non-GHG pollutants. For comparability reasons, the value of energy savings to consumers from the use of more efficient appliances is not included in welfare gains.
- In the case of energy taxes, welfare costs are calculated as follows. First, we consider the deadweight loss from the imposition of the tax, based on the consumption of energy. Second, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no tax. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Third, we have a welfare gain arising from the fact that the policy generates tax revenue and therefore reduces the cost of raising a similar amount of tax from other sources. This gain is calculated using the marginal cost of public funds. Fourth, we have the welfare gain to producers from the sale of more profitable equipment. Finally, there are gains from the reduction of non-GHG emissions in the generation of electricity, calculated at the average external cost per kWh for each MS considered.

The outcomes of these calculations show some significant differences based on the type of instrument, the Member State and the product group considered. For instance, implementing a tax credit for consumers purchasing efficient boilers in Italy allow both higher CO_2 emissions reduction and higher welfare gains than increasing the energy price (405 $MtCO_2$ and -287 M€ vs. 38 $MtCO_2$ and -23 M€). To take another example, increasing the energy price is preferable (in terms of energy consumption and CO2 emissions) to removing washing machines with energy class 'B' from the Polish market. However, the two options are quite similar when looking at the welfare gains (271 $ktCO_2$ and 2.6 M€ vs. 223 $ktCO_2$ and 3.2 M€).

The analysis presented in this report indicates that incentives to promote the use of energy efficient appliances can be cost effective, but whether or not they are depends essentially on the product, the Member State, the market conditions and the design of the instrument. From the cases considered, tax credits on boilers appear to be a feasible option in both Denmark and Italy, while subsidies on CFLi bulbs in both France and Poland are cost effective in terms of €/ton of CO_2 abated. As it can be observed, the results cannot be generalised and need to interpreted with great attention. However, some general observations can be made:

- additional energy taxes have positive net benefits in all cases
- for boilers tax credits to consumers generate higher net benefits and higher energy saving than the increase of energy taxes, the same applies to the subsidies for CFLi in Poland
- tax credits to manufacturers have the highest net welfare costs relative to benefits of all policy options
- removing less efficient product categories from the market has also a relatively low capacity to generate energy saving compared with other policy options and therefore a fairly negative benefit-cost balance[3]

The results of the cost–benefit analysis are summarised in Table 1. In this table the following indicators are used to describe the results:

- Benefits–costs: benefits consist of the monetary value of the savings in GHG (CO_2) emissions and the costs are net welfare costs, the calculation of which is explained above for different policy options.
- Energy savings: energy savings in physical units (GWh) over the life-cycle of the product in question generated by policy options.
- Benefits-costs per GWh saved: benefits-costs per energy saved (€/GWh) over the whole life-cycle of the product. This is simply the ratio of the two previous indicators, which gives a more meaningful insight, e.g. boilers in Denmark where the benefits-costs per GWh indicator is easily comparable across the two policy options than the absolute values of the two indicators individually.

This first analysis presents some interesting insight to the issue. However, additional future work is required to understand the subject from different perspectives, especially regarding whether incentives will lead to higher consumption levels. One policy approach could be to complement the incentives for efficient products with a penalty on non-efficient ones, an approach currently under implementation and testing in France (*Bonus-Malus*), which is under trial for cars since 2007. In conclusion, the tax incentives policies cannot be considered mutually exclusive. For example, a higher energy tax combined with targeted tax credits could be used in conjunction to ensure modest broad gains in energy efficiency across several sectors, with targeted tax credits for those cases where additional benefits can be generated. This approach would also ameliorate concerns about distributional issues associated with increasing energy taxes.

[3] It should be pointed out that for comparability reasons the analysis applied in this study does not include the value of energy savings as welfare gain in net welfare cost calculation. However, as far as the benefits of the policy for the consumers are concerned, the energy savings from the use of more efficient appliances over the life-cycle of the product about offsets, in the cases considered in this study, the costs from the need to buy more expensive equipment, which is included as welfare cost.

Table 1: Results of the CBA carried out for the eight case-studies

Product	Member State	Baseline scenario	Policy option 1*				Policy option 2*			
			Details	Benefits-Costs (€)	Energy savings (GWh)	Benefits-costs per GWh saved (€/GWh)	Details	Benefits-Costs (€)	Energy savings (GWh)	Benefits-costs per GWh saved (€/GWh)
Refrigerator	France	Increase in electricity price (12%)	Subsidy for consumers (€50 class A+ only)	-8,978,311	1,433	-6,265	Energy tax: further increase in electricity price (10%)	3,371,769	237	14,227
	Denmark			288,450	114	253		418,889	47	8,913
Washing-machine	Italy	Increase in electricity price (12%)	Tax credit for manufacturers (€100 per appliance cl. A+; sold above historical levels - 3 years average)	-18,558,636	59	-314,553	B-class and lower removed from the market (market share of classes B and C shifted to class A)	-5,052,113	26	-194,312
	Poland			-2,944,188	18	-163,566		-2,315,257	22	-105,239
Boiler	Denmark	Increase in gas price (15%)	Tax credit for consumers (deducted from income tax; 25% of the appliance price for condensing boiler)	4,565,857	310	14,729	Energy tax: further increase in gas price (10%)	1,231,331	102	12,072
	Italy			692,476,292	40,294	17,186		61,634,591	3,825	16,114
CFLi	Poland	Increase in electricity price (12%)	Subsidy for consumers (€1 classes A and B)	78,695,440	3,549	22,174	Energy tax: further increase in electricity price (10%)	22,110,662	226	97,835
	France			10,471,437	5,504	1,903		24,613,529	430	57,241

(*) Policies 1 and 2 are applied on top of baseline scenario.

1. INTRODUCTION

This report presents the preliminary results of the study reviewing the costs and benefits associated with the use of tax incentives to promote the manufacturing and the purchase of efficient energy-using products. The analysis is focused on following four product groups:

- Refrigerators
- Washing Machines
- Compact Fluorescent Lamps
- Boilers

The study analyses the effectiveness of tax incentives in complement with other available instruments and attempts to tackle the following questions:

- What environmental benefits can be achieved through energy efficient appliances, the type and scale of any resulting costs, and the degree to which these costs are likely to be proportionate to the benefits?
- What are the most relevant financial instruments to foster energy efficient products?
- What is the value added of tax incentives compared to other available financial instruments?

This report includes an analysis of the current situation for the four product groups cited above and also provides an overview of the impacts of tax incentives both in Europe and in the US.

Finally, results of the cost-benefit analysis in the form of 8 case-studies are presented.

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2. CURRENT SITUATION

Energy consumption in the EU-27 has continued to increase in the last years, despite numerous energy efficiency policies and programmes at the European Union (EU) and Member State (MS) levels.

According to Eurostat, the gas consumption in the residential sector of the EU-25 has continued to grow during the period 1999-2004 from 4721 PJ to 5399 PJ representing an increase of 14%, while the yearly growth rate in the period 2003-2004 has been 2.2%. The electricity consumption in the residential sector for the EU-25 has grown by 10.8% in the period 1999-2004, from 690 TWh in year 1999 to 765 TWh in year 2004 and by 1.8% in the period 2003-2004. The electricity consumption in the residential sector of the EU-25 represented 28.8% of the total electricity consumption in 2004.

Increased electricity consumption is due to different factors such as:

- more penetration of "traditional" appliances (e.g. dishwashers, tumble driers, air conditioners, personal computers) which are all still far from saturation levels
- introduction of new appliances and devices, mainly consumer electronics and information and communication technology (ICT) equipment (set-top boxes, DVD players, broadband equipment, cordless telephones, etc.) many with significant standby losses
- increased use of "traditional" equipment: more hours of TV watching, more hours of use of personal computer (driven by some e-working practice and increased use of internet), more washing, and increased use of hot water
- increased presence of double or triple appliances in the same household, mainly TVs and refrigerators/freezers
- more single family houses, each with some basic appliances and larger houses and apartments. This results in more lighting, more heating and cooling, and last but not least, an increased older population demanding higher indoor temperatures and all-day heating in winter and cooling in summer, and spending more time at home

The distribution of the residential electricity consumption by appliance is presented in Figure 1 for EU-15[4] and in Figure 2 for EU-12[5] (+ Croatia). Within EU-15, refrigerators and freezers contribute to 15% of the electricity consumption in households (22.4% within new EU-12 + Croatia (HR)), washing machines for 4% (10.5% within new EU-12 + Croatia), lighting for 12% (20% within new EU-12 + Croatia), and heating and cooling for 27%[6] (9.9% within new EU-12 + Croatia).

[4] AT, BE, DE, DK, EI, FI, FR, GR, IT, LU, NL, PT, SE, SP, UK

[5] BG, CZ, CY, EE, HU, LV, LT, MT, PL, RO, SK, SI

[6] Including 'Residential electric heating', 'Central heating circulation pumps' and 'Room air-conditioners'.

Figure 1: Electricity consumption in residential appliances in EU-15 in 2004[7]

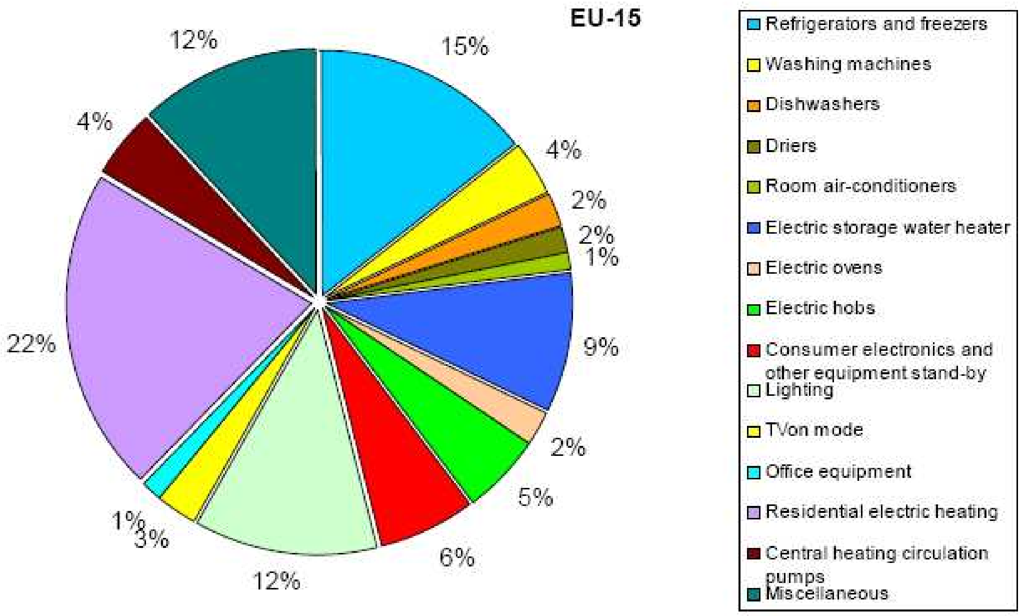
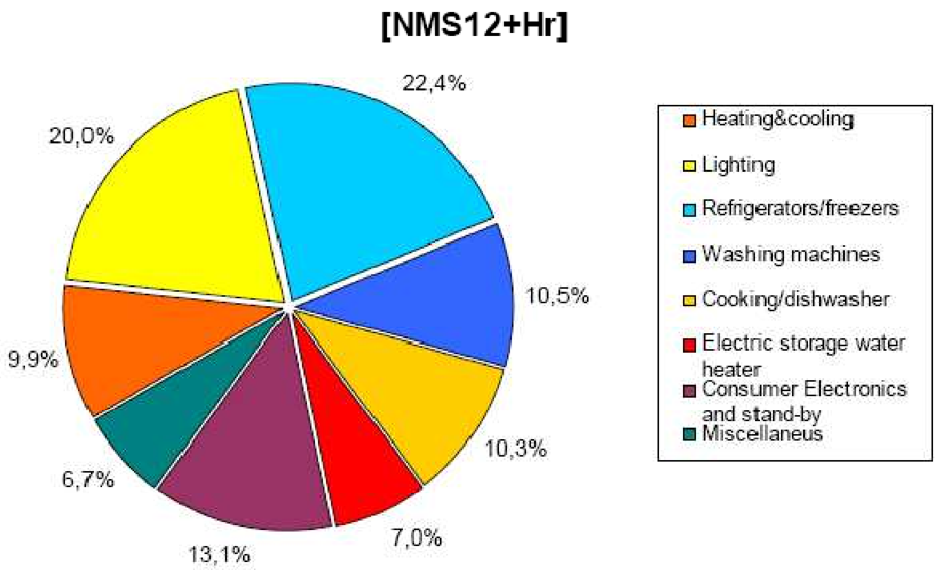


Figure 2: Electricity consumption in residential appliances in new MS (+Croatia) in 2004[7]



The electricity consumptions by end-use equipment in the domestic sector are presented in Table 2 both for EU-15 and EU-12 (+ Croatia).

[7] European Commission DG JRC (2006b)

Table 2: Electricity consumption of residential appliances in EU-15 and EU-12 in 2004[7]

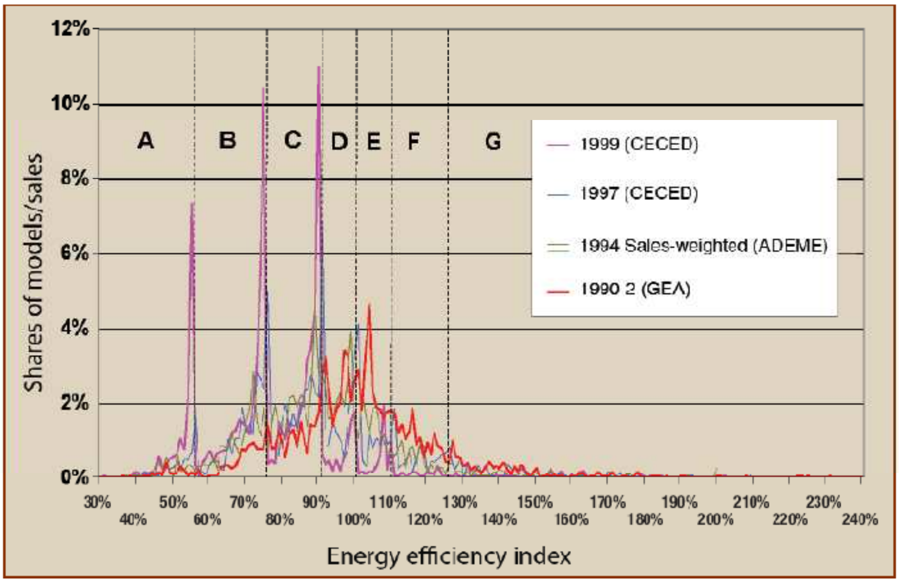
Application Area	EU-15 (in TWh)	EU-12 + Croatia (in TWh)
Heating & Cooling	187	9
Lighting	85	17
Refrigerators & Freezers	102	19
Washing Machines	26	9
Cooking/Dishwasher	66	9
Hot Water	65	6
Consumer Electronics & Stand-by	45	11
Miscellaneous	128	6
TOTAL	**704**	**87**

2.1. EXISTING EU REGULATORY MEASURES AND INSTRUMENTS

There are two main EU Directives which directly influence the market of energy-using products, namely:

- The **European Directive 94/2/EC defines the energy label** appearance, information to be given to consumers, and information required from the manufacturers. The aim of this energy label is to allow consumers comparing several products in a neutral manner by providing the main characteristic of the product. Furthermore, this comparative energy label has stimulated manufacturers to propose energy efficient models in order to increase the competitiveness. Once a label is seen as having an actual or potential consumer impact, manufacturers are often motivated to remove their worst models from the market and improve the efficiency of their current models. For example, evaluations have shown that many new products produced in the EU in the 1990s were designed to just cross the threshold of the higher-efficiency categories, as can be clearly seen in Figure 3. Within a few years after the launch of EU energy labelling programme, the EU market moved from a random distribution of sales by energy efficiency prior to labelling to a distribution that shows very large peaks at the thresholds of the efficiency classes, demonstrating the clear influence of the Directive on energy labelling.
- The **European Directive 2005/32/EC establishes a framework for the setting of eco-design requirements for Energy-using products (EuP)**. Adhering to the Integrated Product Policy (IPP) approach, the EuP Directive is an initiative attempting to improve the energy and environmental performances of the products from the design phase itself, while taking into account the market, consumer, and all other stakeholders' concerns. The first series of preparatory studies covering 14 products have been either completed or reached their final stage and a second series of 5 studies is in progress (see Table 3). After being presented at the consultation forum, these implementing measures will be subjected to an impact assessment before presenting them to the regulatory committee for final vote and adoption. For instance, implementing measures will define minimum energy performance standards (MEPS) that will change the market towards more energy efficient products. Additional new studies on several product groups (3 by DG Enterprise and 8 by DG TREN) are planned for 2009-2011.

Figure 3: Impact of EU refrigerator energy label on sales by efficiency index



Further, a study launched by the EC (DG Environment) aiming to assess the contribution that EuP implementation can make in terms of greenhouse gases emissions reductions in 2020. This assessment will be made per product and per Member State, and therefore could be useful in identifying the products that need incentives so as to promote the most efficient ones.

In addition to EuP and energy labelling Directives, following two initiatives will indirectly affect energy prices and energy consumption of appliances:

- **The EU Emission Trading Scheme (ETS)**[8] aims at helping EU Member States achieve their commitments to limit or reduce greenhouse gas emissions in a cost-effective way. Allowing participating companies to buy or sell emission allowances means that emission cuts can be achieved at least cost. It currently covers over 10,000 installations in the energy and industrial sectors which are collectively responsible for close to half of the EU's emissions of CO_2 and 40% of its total greenhouse gas emissions. The reduction in the EU-wide quantity of allowances to be issued in the third trading period will increase scarcity in the allowance market and hence the price of allowances can be expected to increase. The price of electricity can be expected to increase correspondingly but, taking into account today's carbon prices, the rise is expected to be limited to 10 to 15% by 2020 compared with business as usual. Other factors such as oil and gas prices may have a much bigger impact.[9] Such an increase of energy prices is expected to raise the awareness of energy consumption and waste, and provide further incentives to energy saving.

[8] The EU ETS is based on Directive 2003/87/EC which entered into force on 25 October 2003.

[9] European Commission, DG ENV (2008a) Answer to Question 26

Table 3: Status of different product groups in the EuP process (as of June 2008)

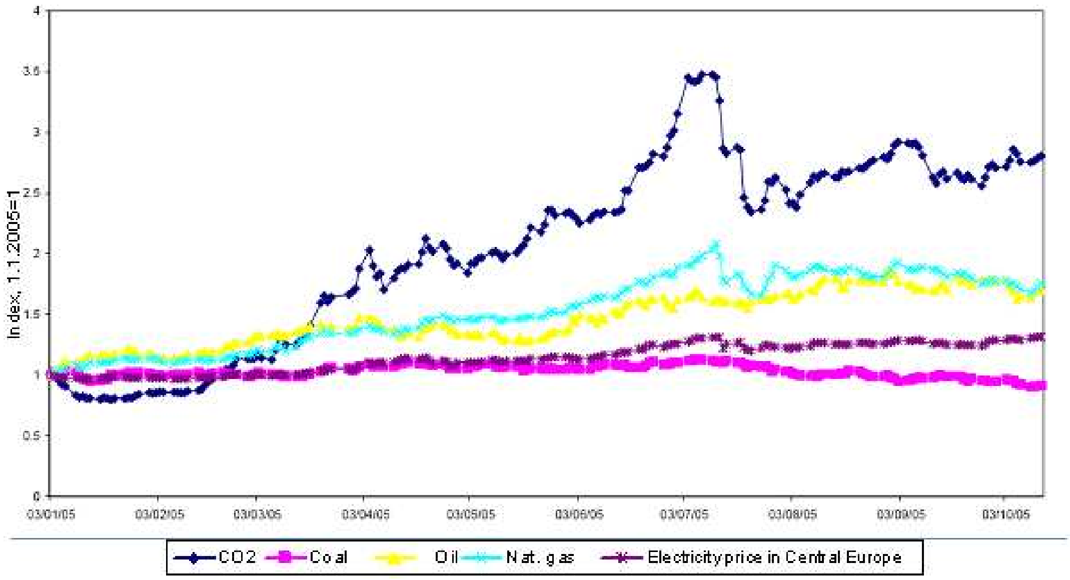
EuP Lot	Product List	Status
Measures planned to be adopted by the Commissions in 2008		
9	Street lighting products	completed
8	Office lighting products	completed
6	Stand-by and off-mode losses	completed
7	External power supplies	completed
0	Simple set top boxes	completed
Measures planned to be adopted by the Commission in spring 2009		
19	Domestic lighting products I (including CFLi)	completed
5	Televisions	completed
Measures to be submitted for vote in the committee in 2008 and 2009		
1	Boilers	completed
2	Water heaters	completed
14	Washing machines, dishwashers	ongoing
13	Domestic refrigeration, freezers	ongoing
12	Commercial refrigeration	completed
11	Electric motors, water pumps, circulators, and industrial fans	completed
3	Computers	completed
4	Imaging equipment	completed
10	Room Air Conditioners & domestic fans	ongoing
Other measures (preparatory studies finishing in 2009)		
18	Complex set top boxes	ongoing
16	Laundry Driers	ongoing
17	Vacuum Cleaners	ongoing
19	Domestic lighting products II	ongoing
15	Solid Fuel Boilers	ongoing

- **The Energy Taxation Directive**[10] (ETD) sets the minimum levels of taxation for energy products and provides a common framework for taxing energy in the EU Member States. The Commission intends to present a proposal for a revised ETD soon building on the analysis presented in the Green Paper on the use of market-based instruments for environment and related policy purposes of 2007. The revision aims at ensuring the full compatibility between the ETD and the EU climate change package, so that the Member States can use energy taxation more effectively to achieve ambitious energy and climate policy goals. In practical terms, the revision would provide for CO_2-related taxation in the areas not covered by the EU ETS, and would align the remaining part of taxation according to the energy content of the respective energy sources. The purpose is to ensure that consistent price signals across all forms of energy would be given to incentivise energy savings in a non-distortive manner.

In addition to regulatory measures, there are several other factors such as oil and gas prices may which can influence the energy price (see Figure 4).

[10] Directive 2003/96/EC

Figure 4: Evolution of energy price and of CO_2 allowance during 2005[11]



2.2. ANALYSIS OF THE 4 PRODUCT GROUPS

This study focuses on the following four product groups which are analysed in this sub-section:

- Refrigerators
- Washing Machines
- Compact Fluorescent Lamps
- Boilers

Each product groups is analysed under three headings:

- Product characteristics
- Market analysis
- Major barriers for energy efficient appliances

Note: For each product group, the market analysis is being carried out to collect the basic economic and market data (sales, stock and prices). Data presented in this report mainly comes from the EuP preparatory studies (lot 1 for boilers, lot 13 for refrigerators, lot 14 for washing machines, and lot 19 for domestic lighting). Furthermore, the CECED[12] provided us its technical database to complete the market picture.

These data are also used in the cost-benefit analysis. Certain assumptions have been made to fill the data gaps which are presented in a transparent manner. Economic data used for the CBAs are presented in section 3.2.

[11] Tiina Koljonen (2006)

[12] CECED - European Committee of Domestic Equipment Manufacturers

2.2.1. REFRIGERATORS

1.1.1.1 Product characteristics

- ***Functional description***

- **Definition**

The European standard EN 153: 2006, “Methods of measuring the energy consumption of electric mains operated household refrigerators, frozen food storage cabinets, food freezers and their combinations, together with associated characteristics”, used for the conformity assessment defines refrigerators (as well as freezers) as “electric mains operated household refrigerating appliances”. Further, the definition of “refrigerating appliances” is included in the standard EN ISO 15502: 2005, “Household refrigerating appliances – Characteristics and test methods”, as “factory-assembled insulated cabinet with one or more compartments and of suitable volume and equipment for household use, cooled by natural convection or a frost-free system whereby the cooling is obtained by one or more energy-consuming means”.

Household refrigerating appliances can also be classified with the following criteria:

- The refrigeration technology:
  - Absorption: refrigeration based in an absorption process using heat as energy source
  - Compression: refrigeration using a motor-driven compressor
- The installation:
  - Built-in: intended to be integrated in a cabinet or in a prepared recess in a wall
  - Freestanding
- The application:
  - Refrigerator: refrigerating appliance intended for the preservation of food, one of those compartments is suitable for the storage of fresh food
  - Refrigerator-Freezer: refrigerating appliance having at least one compartment suitable for the storage of fresh food and at least one other suitable for the freezing of fresh food and the storage of frozen food under three-star storage conditions.
  - Frozen-food storage cabinet: refrigerating appliance having one or more compartments suitable for the storage of frozen food
  - Food freezer: refrigerating appliance having one or more compartments suitable for freezing food stuffs from ambient temperature down to a temperature of – 18°C and which is also suitable for the storage of frozen food under the three-star storage conditions.

Further classification are made by the PRODCOM list (2007) as well as by the energy labelling European Directive 94/2/EC, confirmed by the Directive 2003/66/EC defining efficiency classes A+ and A++ for cold appliances. The classification defined by the energy labelling Directive was also used by the Directive 96/57/EC establishing energy efficiency requirements as well as by the Eco-label Decision 2000/40/EC.A comparison of these various classifications is presented in Table 5.

For the purpose of this study, the appliances considered will be refrigerators (i.e. containing at least one compartment for the storage of fresh food), and therefore will exclude categories 8 and 9 of the classification of the energy labelling Directive described in Table 5.

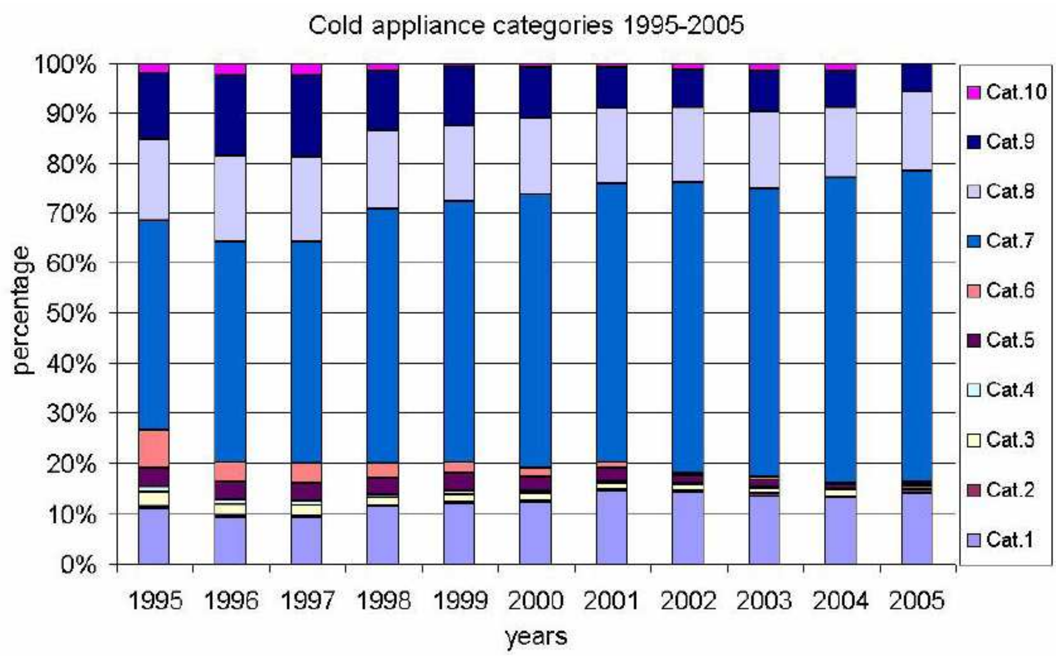
The "star" classification of the low temperature compartment is detailed in the Directive 94/2/EC (Annex V) and presented in Table 4.

Table 4: Temperature of the low temperature compartment

temperature of coldest compartment	equivalent appliance category
> -6 °C	1-3
≤ -6 °C	4
≤ -12 °C	5
≤ -18 °C	6
≤ -18 °C with freezing capacity	7

Figure 5 presents the share of each category defined in the energy labelling Directive according to the number of models proposed to consumers within the European Union. Two main categories of refrigerators stand out: category 7 (household refrigerator/freezers with low temperature compartments (***)*) with approximately 60% of the market of domestic cold appliances and category 1 (household refrigerator without low temperature compartment) with about 14%.

Figure 5: Share of models of cold appliances put on the EU market[13]



[13] European Commission, DG TREN (2007b)

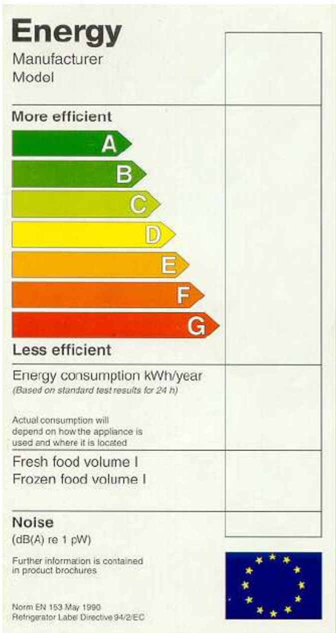
Table 5: Comparison of the different classifications for cold appliances in EU

EN 153		electric mains operated household refrigerating appliances	
Directives 94/2EEC, 2003/66/EEC, 96/57/EC and Decision 2000/40/EC		**PRODCOM**	**EN ISO 15502** (EN 153)
Category (number)	Description	**29.71.11 -** Refrigerators and freezers, of the household type	factory-assembled insulated cabinet with one or more compartments and of suitable volume and equipment for household use, cooled by natural convection or a frost-free system whereby the cooling is obtained by one or more energy-consuming means
1	Household refrigerators, without low temperature compartments	**29.71.11.33** – Household-type refrigerators (including compression-type, electrical absorption-type, excluding built-in) **29.71.11.35** – Compression-type built-in refrigerators	**refrigerator:** refrigerating appliance intended for the preservation of food, one of whose compartments is suitable for the storage of fresh food
2	Household refrigerator/chillers, with compartments at 5 °C and/or 10 °C		
3	Household refrigerators, with no-star low temperature compartments		n.a.
4	Household refrigerators, with low temperature compartments (*)		**frozen-food storage cabinet**: refrigerating appliance having one or more compartments suitable for the storage of frozen food
5	Household refrigerators, with low temperature compartments (**)		
6	Household refrigerators, with low temperature compartments (***)		**refrigerator-freezer**: refrigerating appliance having at least one compartment suitable for the storage of fresh food (the fresh-food storage compartment) and at least one other (the food freezer compartment) suitable for the freezing of fresh food and the storage of frozen food under three-star storage conditions
7	Household refrigerator/freezers, with low temperature compartments (***)*	**29.71.11.10** – Combined refrigerators-freezers, with separate external doors	
8	Household food freezers, upright	**29.71.11.70** – Upright freezers of a capacity ≤ 900 litre	**food freezer**: refrigerating appliance having one or more compartments suitable for freezing foodstuffs from ambient temperature down to a temperature of −18 °C and which is also suitable for the storage of frozen food under three-star storage conditions
9	Household food freezers, chest	**29.71.11.50** – Chest freezers of a capacity ≤ 800 litre	
10	Household refrigerators and freezers with more than two doors, or other appliances not covered above	**29.71.11.10** – Combined refrigerators-freezers, with separate external doors	n.a.

EU Energy label

The European Directive 94/2/EC defines what the energy label has to look like, which information has to be given to consumers and which information may be included. The aim of this energy label is to allow consumers comparing several products in a neutral manner by providing the main characteristic of the product. Besides, an energy rating using various colours is clearly visible and understandable for consumers. The energy label for refrigerators and combined (as well as freezers) is shown in Figure 6.

Figure 6: EU Energy label for refrigerators and combined (as well as freezers)



Furthermore, the Directive 2003/66/EC includes the energy efficiency classes A+ and A++ for domestic cold appliances in order to discriminate the more efficient products. Indeed, since the effectiveness of the Directive 94/2/EC technical improvement have been made by manufacturers aiming at reducing the electricity consumption of domestic cold appliances (as well as other products). Therefore, this new energy labelling scheme allows producers to pursue their efforts of manufacturing energy efficient products.

The energy class is defined based on the energy efficiency index (I). This index takes into consideration all technical parameters of a product: net volume of each compartment, electricity consumption, net volume of each compartment, temperatures of the compartments, and other factors such as whether they are frost-free, built-in, or climate class.

The index is calculated by dividing the electricity consumption of the product measured according to the test standard EN 153: 2006 by the electricity consumption of a standard product presenting the same characteristics, the "reference". This reference was calculated based on products available on the European market between 1990 and 1992.

The correlation between the energy efficiency index and the energy class is highlighted in Table 6. Thus, a G-class product uses 125% or more of the electricity used by an average cold appliance of the same type, while an A++ product uses less than 30%.

Table 6: Energy efficiency classes according to the EU energy labelling scheme

Energy Efficiency Index, I (%)	Energy Efficiency Class
$I < 30$	A++
$30 \leq I < 42$	A+
$42 \leq I < 55$	A
$55 \leq I < 75$	B
$75 \leq I < 90$	C
$90 \leq I < 100$	D
$100 \leq I < 110$	E
$110 \leq I < 125$	F
$125 \leq I$	G

Currently, there is a stakeholder consultation launched by the European Commission (DG TREN) in order to revise the Energy Labelling Framework Directive, 1992/75/EC. Indeed, the continuous improvement of energy efficiency of refrigerators, as well as of all domestic appliances, requires the revision of the current scheme for a continuous promotion of the most efficient products. Moreover, this revision aims at reinforcing the impact of energy labelling in order to help the EU to reach its 20% energy saving target by 2020, while promoting sustainable production and consumption, and a competitive sustainable industrial policy. Further, the revision of this Directive 1992/75/EC was defined as priority 1 in the Energy Efficiency Action Plan adopted by the European Commission in October 2006.

Average lifetime and replacement patterns

The UK Market Transformation Programme (MTP) estimated the lifetime of domestic cold appliances based on historical sales data (provided by GfK). The figures are provided in Table 7.

Table 7: Assumed lifetime of domestic cold appliances in UK[14]

	Refrigerator	Combined Fridge-Freezer
Lifetime (years)	12.8	17.5

In 2004, CECED estimated that the average lifetime of refrigerators and combined was about 14.4 years within the EU[15]. Moreover, about one third of the installed refrigerators (and freezers) are older than 10 years (88.1 million for a total of 265.4 million in 2005[15]) in the 12 major MS (Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden, UK).

According to GIFAM[16], the equivalent of CECED in France, about 72% of sales of domestic cold appliances are replacement sales. Besides, most of these replacement sales occur when the old appliance is broken. Therefore, based on an average lifetime of 14 years, it will take some time to replace the whole installed stock with energy-efficient refrigerators.

[14] UK Market transformation Programme (2008)

[15] CECED (2007)

[16] Groupement Interprofessionnel des Fabricants d'Appareils d'Equipement Ménager

Speed of innovation

The manufacturing of more efficient cold appliances implied a revision of the energy labelling scheme and the creation of two new classes: A+ and A++.

For the two main categories of refrigerators (categories 1 and 7), which represent currently about 95% of the European market, Figure 7 and Figure 8 give the share of products put on the EU market according to the energy class. Thus, trends are the same for both types of refrigerators with an increase of the share of A-class products (including A+ and A++) proposed by manufacturers over the years. This increase implies a reduction of the numbers of less efficient appliances; in 2005 the lowest efficiency class was B (representing about 13% for category 1 and 18% for category 7) whereas the majority of new models were A-class (about 63% for categories 1 and 7).

Figure 7: Share of energy efficiency classes for refrigerators category 1[17]

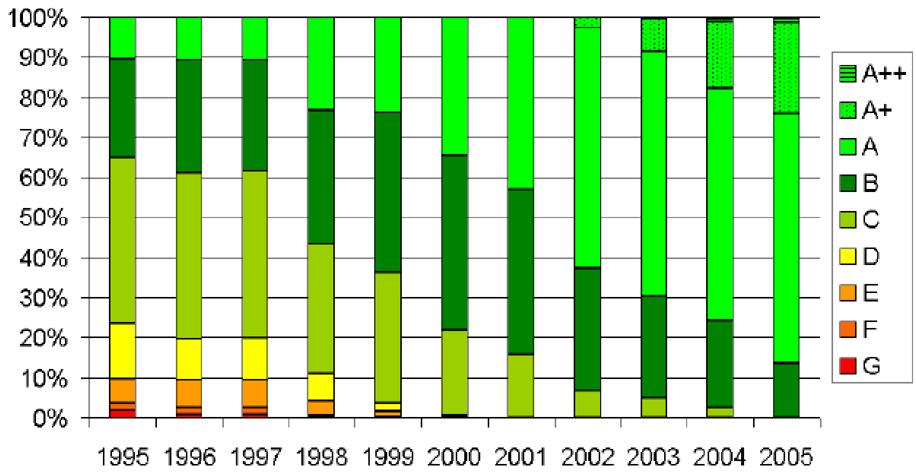
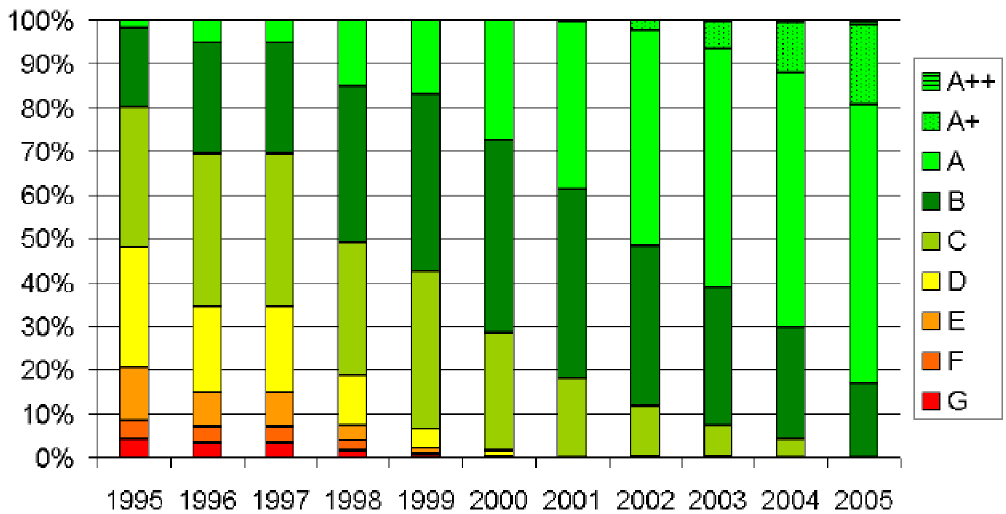


Figure 8: Share of energy efficiency classes for refrigerators category 7

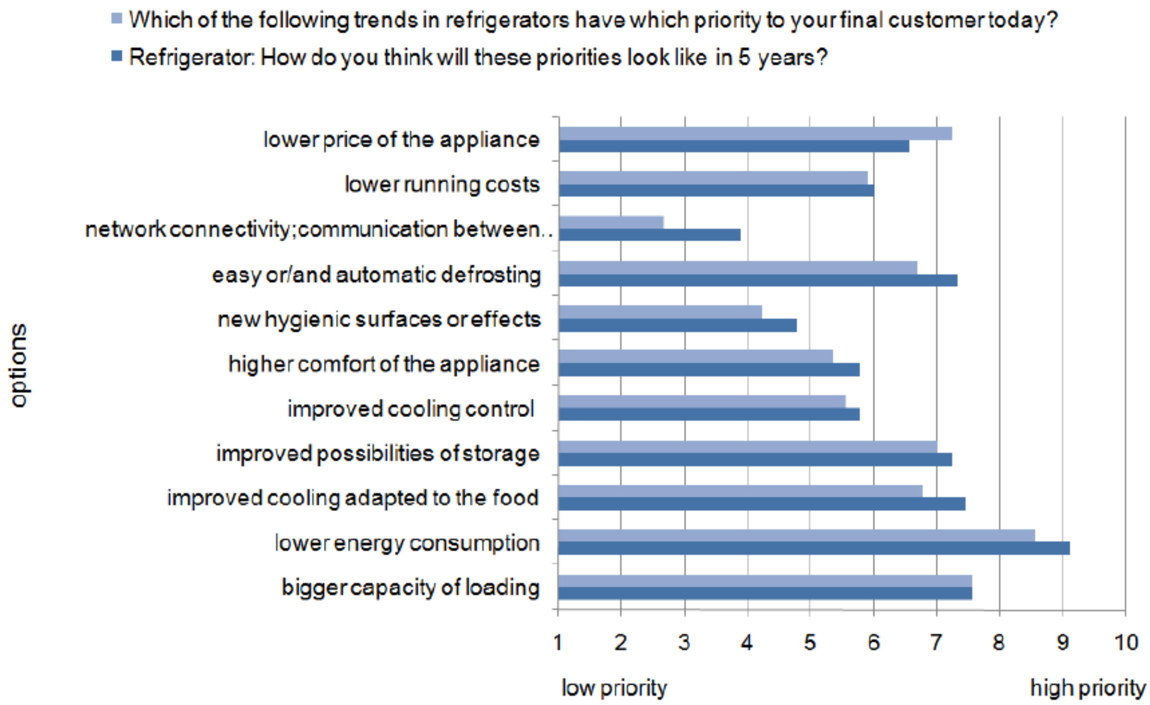


This trend is still continues with the use of more and more efficient technologies. Sales data by efficiency class will be further discussed in the section related to the refrigerators market.

[17] European Commission, DG TREN (2007b)

Figure 9 shows results of the question related to the current and future manufacturers' priorities from a manufacturer survey carried out in the EuP lot 13 preparatory study,. Therefore, the energy consumption of the refrigerator is nowadays the first priority of producers and will still remain in the future (5 years). However, it could be surprising that the product price is currently the third priority (after the 'bigger capacity of loading') and will become the sixth in 5 years. Moreover, it is the only trend of which the priority will decrease in the future.

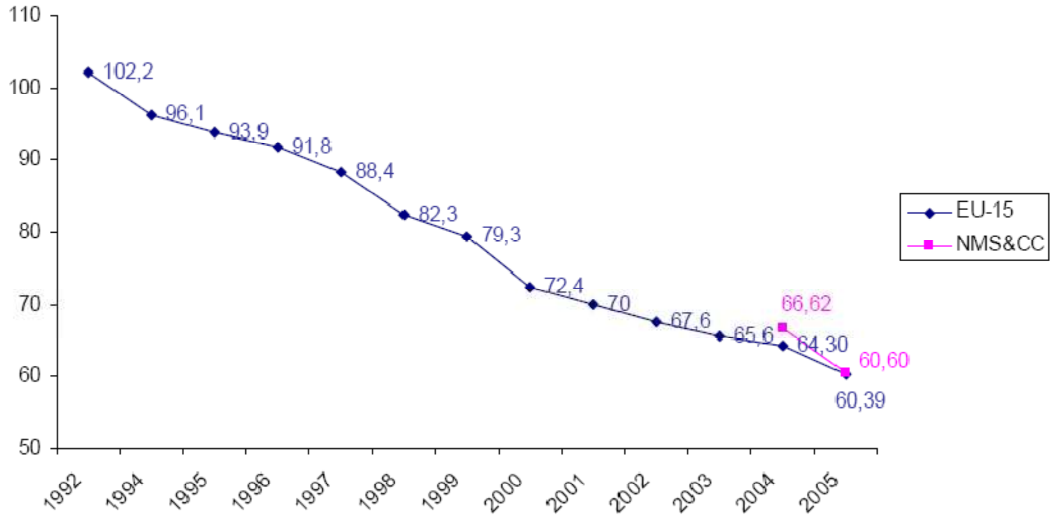
Figure 9: Priority ranking for refrigerators manufacturers



▶ ***Scope for environmental improvement***

Environmental impacts of a refrigerator mainly occur during the use phase of its life-cycle due to its electricity consumption. As mentioned earlier, manufacturers are proposing more and more efficient appliances. Thus, the energy efficiency index has continuously decreased, and producers still aim at improving it, i.e. putting A++ and A+ refrigerators on the market (Figure 10).

Figure 10 : Evolution of the EEI (new model sales weighted average) for domestic cold appliances[18]



1.2.1.2 Market analysis

- ***Sales data***

No reliable sales data for the whole EU-27 is currently available. Nevertheless, GfK has published relevant information for major Western Europe MS as well as for 4 new MS (Czech Republic, Hungary, Poland and Slovakia)[19].

Table 8 presents sales data of refrigerators classified according to their energy efficiency class in the two European regions. For both regions, sales increase was observed between 2002 and 2004 (+7.70% in the Western Europe MS and +17.54% in the Eastern Europe MS). Also, as highlighted earlier, customers are choosing more and more energy efficient appliances and as expected market shares of A+ and A washing machines increased (red numbers in Table 8). Using the sales data from Table 8 and extrapolating it according to the number of households, the sales figures for the whole EU-27 were calculated and such rough estimates suggest that in the EU-27 about 13.91 million units were sold in 2002 and 15.20 million units in 2004, i.e. an increase of 9.3%.

Sales distributions in 2002 and 2004 according to the energy class are presented in Table 9. A-class products represent the major share of sales in 2002 and 2004 for West European MS, whereas there was a shift in Eastern Europe MS from B to A refrigerators (red numbers in Table 9). Figure 11 and Figure 12 present sales data between the years 2000 and 2007 in Western Europe MS and new MS. In both regions, the trend is to buy more energy efficient refrigerators. Therefore, market share of A-class or better appliances increased by about 64% in the Western Europe and about 79% in the Eastern Europe. Even if these figures show that more efficient refrigerators are sold in Eastern Europe, it should be noted that this data is based on only 4 MS and the sales distribution may be different for the 12 new MS.

[18] Waide, Lebot and Harrington (2004)

[19] Eckl, GfK (2008)

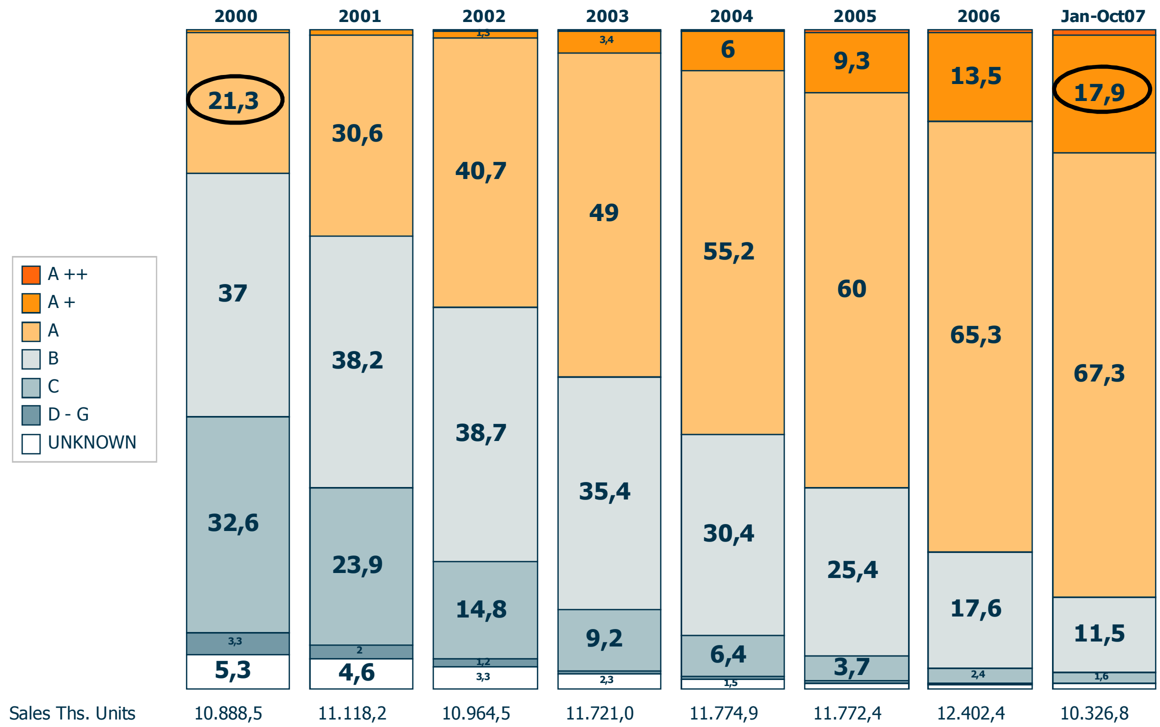
Table 8: Refrigerators sales data in Europe in 2002 and 2004

Energy Class	Western Europe MS (AT, BE, DE, DK, ES, FI, FR, GR, IT, NL, PT, SE, UK)			Eastern Europe MS (CZ, HU, PL, SK)		
	2002	**2004**	**Variation 2004/2002**	**2002**	**2004**	**Variation 2004/2002**
A ++	5,552	20,811	*274.84%*	0	25	-
A +	125,509	724,853	*477.53%*	282	41,140	*14488.65%*
A	4,651,801	6,825,883	*46.74%*	345,144	932,093	*170.06%*
B	4,455,311	3,730,621	*-16.27%*	761,130	494,211	*-35.07%*
C	1,695,030	798,017	*-52.92%*	193,774	70,694	*-63.52%*
D	106,789	40,800	*-61.79%*	1,692	787	*-53.49%*
E	18,626	5,330	*-71.38%*	357	93	*-73.95%*
F	10,350	1,902	*-81.62%*	286	1	*-99.65%*
G	13,719	5,973	*-56.46%*	18	0	*-100.00%*
Unknown	459,304	236,929	*-48.42%*	12,799	7,157	*-44.08%*
TOTAL	**11,541,989**	**12,431,120**	*7.70%*	**1,315,482**	**1,546,201**	*17.54%*

Table 9: Refrigerators sales evolution by energy class

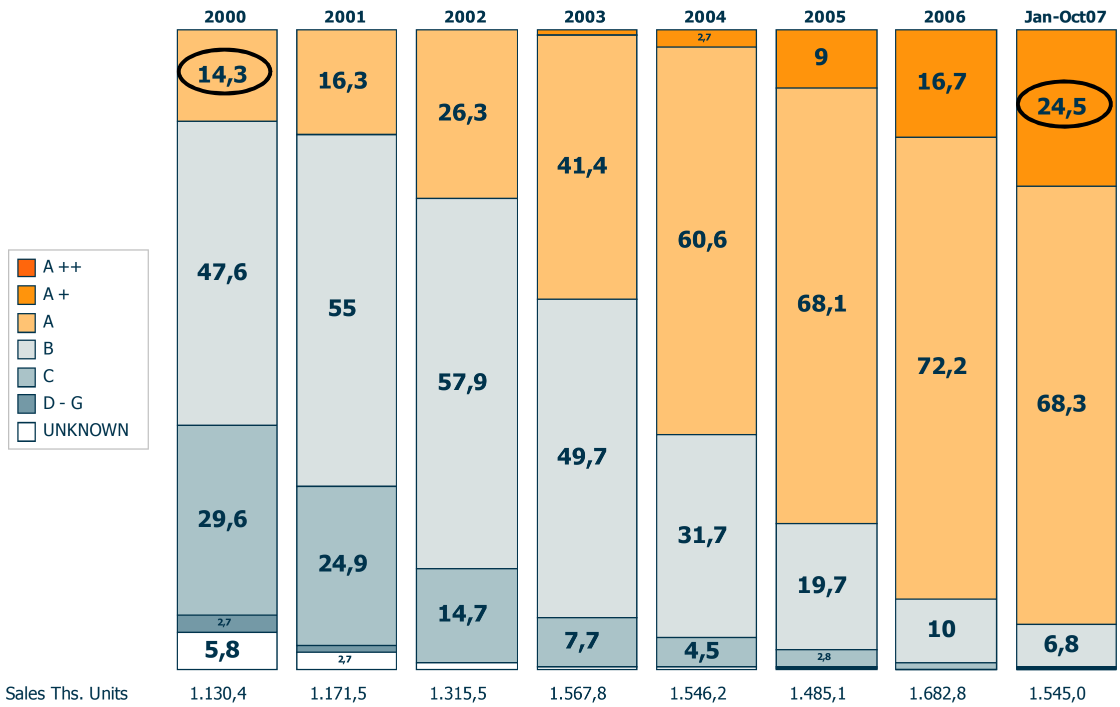
Energy Class	Western Europe MS (AT, BE, DE, DK, ES, FI, FR, GR, IT, NL, PT, SE, UK)		Eastern Europe MS (CZ, HU, PL, SK)	
	2002	**2004**	**2002**	**2004**
A ++	0.05%	0.17%	0.00%	0.00%
A +	1.09%	5.83%	0.02%	2.66%
A	40.30%	54.91%	26.24%	60.28%
B	38.60%	30.01%	57.86%	31.96%
C	14.69%	6.42%	14.73%	4.57%
D	0.93%	0.33%	0.13%	0.05%
E	0.16%	0.04%	0.03%	0.01%
F	0.09%	0.02%	0.02%	0.00%
G	0.12%	0.05%	0.00%	0.00%
Unknown	3.98%	1.91%	0.97%	0.46%
TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 11: Sales division by energy class in Western Europe MS*



* AT,BE,DE,ES,FR,GB,IT,NL,PT,SE

Figure 12: Sales division by energy class in Eastern Europe MS*



*CZ,HU,PL,SK

Figure 13 and Figure 14 provide sales variations between 2002 and 2004. It is clearly visible the global trend to purchase the most efficient refrigerators. Therefore, sales of B-class and C-class appliances decreased in most MS (except Greece). Moreover, in the Netherlands, even sales of A-class products are lower in 2004 than in 2002.

Figure 13: Sales variation in Western Europe MS between 2002 and 2004

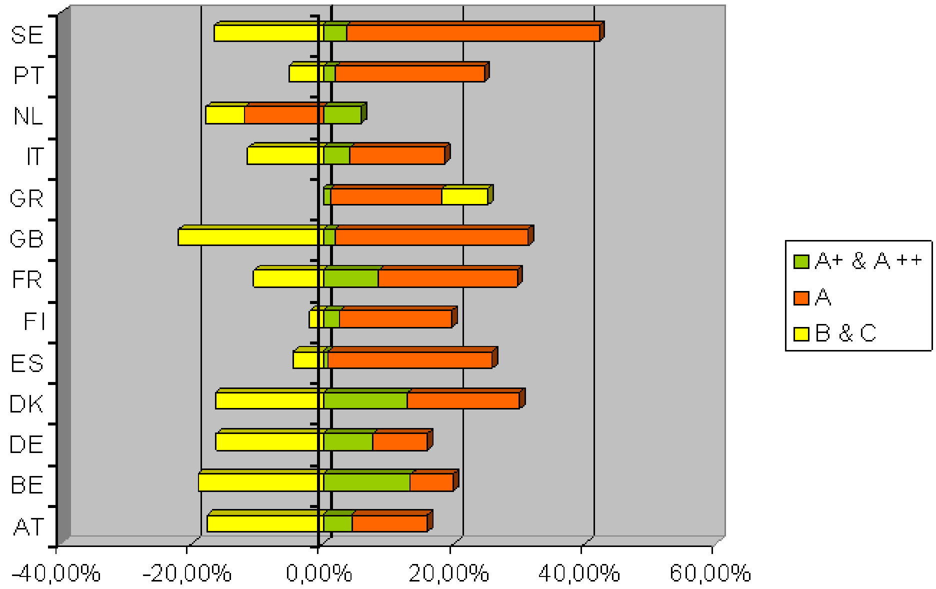
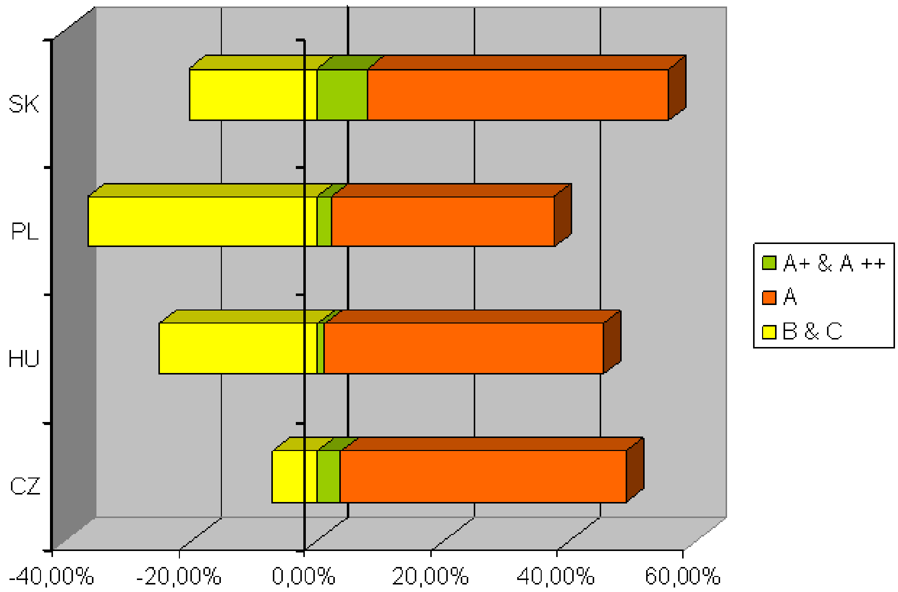


Figure 14: Sales variation in Eastern Europe MS between 2002 and 2004



The energy efficiency is not the only one criterion used to segregate sales of refrigerators. One approach could be to analyse the sales data per volume (or litre class).

Table 10 presents refrigerators sales distribution according to net volume for 2002 and 2004. In both Western and Eastern Europe MS, the 121-250 litres category dominates the market. However, a trend is noticeable toward bigger refrigerators as the sales of all classes larger than 250 litres has increased between 2002 and 2004. This trend is also confirmed by the results of the manufacturer survey presented in Figure 9, where products with larger capacity are considered to be a priority (after the reduction of the electricity consumption).

Table 10: Refrigerators sales evolution by litres classes

Litres class	Western Europe MS (AT, BE, DE, DK, ES, FI, FR, GR, IT, NL, PT, SE, UK)		Eastern Europe MS (CZ, HU, PL, SK)	
	2002	**2004**	**2002**	**2004**
< 120 l	3.6%	5.8%	3.0%	4.9%
121-250 l	51.0%	45.9%	56.3%	48.9%
251-400 l	36.5%	39.8%	38.1%	44.0%
401-500 l	1.9%	2.5%	0.3%	0.6%
501-750 l	1.5%	2.5%	0.3%	0.4%
> 750 l	0.1%	0.1%	0.0%	0.0%
Unknown	5.4%	3.4%	2.0%	1.2%
TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 15 and Figure 16 detail sales distribution from 121 litres to 400 litres, i.e. the two main classes highlighted in Table 10. In Western Europe MS, the main change between 2002 and 2004 is the important increase of the share of refrigerators with a volume from 351 litres to 400 litres, which was about 4% in 2002 and 16.5% in 2004. For this litres class, no significant change was observed between 2002 and 2004 in Eastern Europe MS (1% in both years).

Figure 15: Sales distribution by litre classes in Western Europe MS

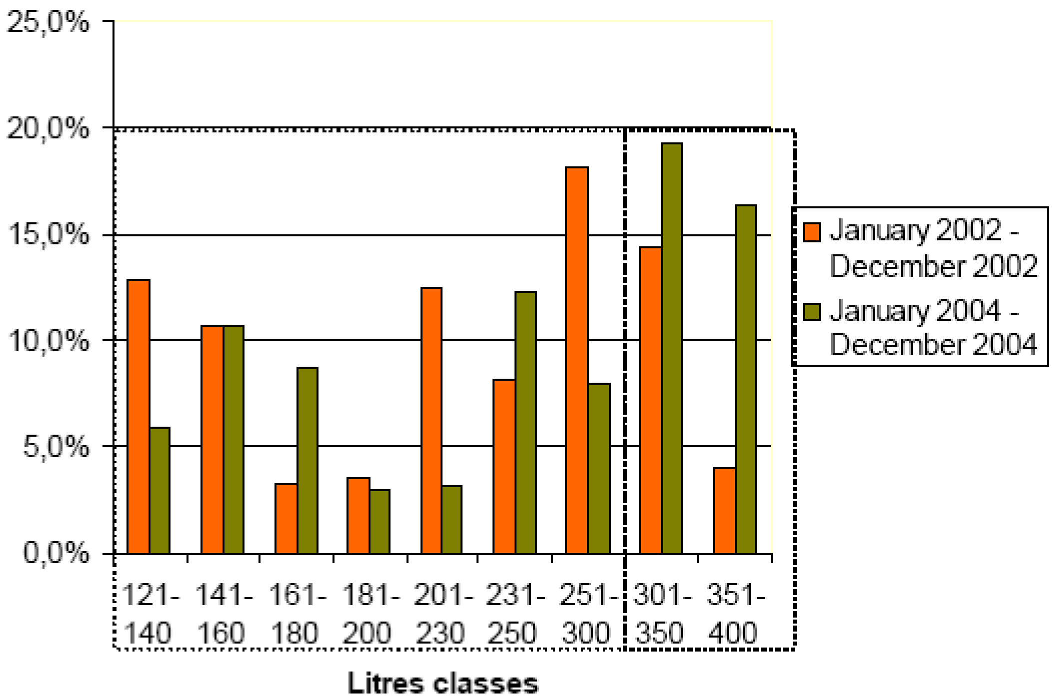
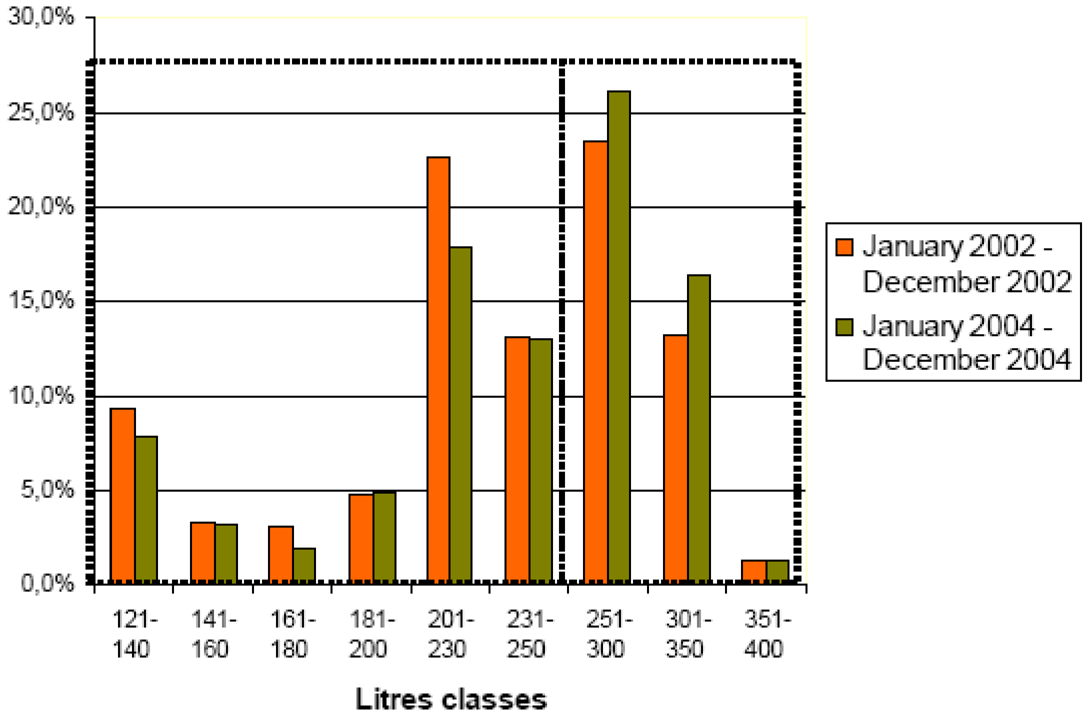


Figure 16: Sales distribution by litre classes in Eastern Europe MS



It could be interesting to understand the correlation between the refrigerator size and energy class, however, no available sales data allows analysing this aspect.

Stock data

The stock of refrigerators in EU-25 in 2005 was about 181.6 million units, of which 84.5% are located in EU-15 (i.e. Western Europe) and 15.5% in EU-10 (i.e. Eastern Europe)[20], as presented in Table 11.

Table 11: Stock of refrigerators (in million units)

	EU-25	EU-15	EU-10
1995	163.6	138.5	25.1
2000	174.2	147.5	26.7
2005	181.6	153.4	28.2

Price data

Average prices of refrigerators have been observed to decrease[21] between 2002 and 2004 both in Western and Eastern Europe MS. The reduction was higher in the Eastern region (-13.8% compared to -5.2% in Western Europe). Moreover, refrigerators are more expensive in Western Europe MS and this trend increased between 2002 and 2004 (Table 12).

[20] European Commission, DG TREN (2007b)

[21] Source: GfK

Nevertheless, it can be surprising to note that A++ refrigerators prices are higher in Eastern MS, as well as for A+ appliances in 2002. It could be explained by the fact that A++ products were put on the market in 2004 in the East whereas this class existed since several years in the Western region.

Table 12: Prices by energy classes between 2002 and 2004

Energy Class	**Western Europe** (AT, BE, DE, DK, ES, FI, FR, GR, IT, NL, PT, SE, UK)			**Eastern Europe** (CZ, HU, PL, SK)			**Variation Western EU/Eastern EU**	
	2002	**2004**	**Variation 2004/2002**	**2002**	**2004**	**Variation 2004/2002**	**2002**	**2004**
A++	444 €	516 €	*+14 %*	-	627 €	-	-	-17.7 %
A+	439 €	534 €	*+17.7 %*	695 €	420 €	*-65.5 %*	-36.8 %	+27.1 %
A	538 €	496 €	*-8.4 %*	394 €	342 €	*-15.4 %*	+36.6 %	+45.0 %
B	450 €	392 €	*-14.8 %*	358 €	273 €	*-31.2 %*	+25.7 %	+43.6 %
C	411 €	358 €	*-14.8 %*	308 €	224 €	*-37.2 %*	+33.4 %	+59.8 %
Weighted average	**481 €**	**457 €**	***-5.2 %***	**360 €**	**316 €**	***-13.8 %***	**+33.6 %**	**+44.6 %**

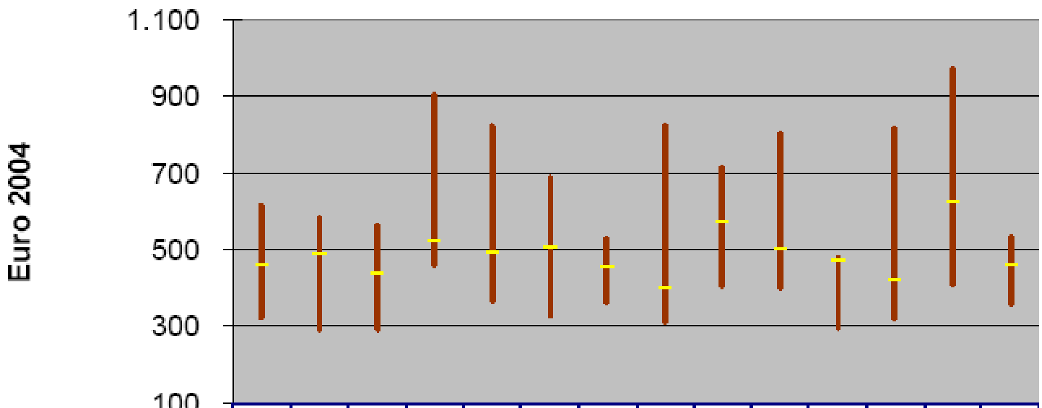
The pricing strategies of manufacturers are often confidential in a very competitive white goods market. Following are some of the factors affecting the price differences between the various energy classes:

- The most efficient refrigerators usually propose also additional functionalities or modern design which implies additional production costs and therefore higher product price.
- Generally, profit margins are higher for products of best quality, and not only in the white goods sector (e.g. in the automobile sector). Thereby, refrigerators manufacturers are assumed to make more profit with an A+ model than with a B-class model.
- An A+ refrigerator is more energy efficient than a B-class model and to benefit from such improvement, sometime a premium can be put on the price.
- When a new very efficient model (e.g. A++) is launched, the price hikes are related to not only the production costs but also the R&D costs in developing an innovative product. With few years of sales, this however, becomes a minor factor in the pricing when many competitors have developed similar models and a great deal of R&D expenses is recovered in the first sales.
- Finally, the price differences are also representative of a kind of 'market imperfection'. Nevertheless, due to a lack of information it is difficult to detail the market imperfection influence on the pricing strategy.

A comparison of refrigerators prices in Western Europe MS is presented in Figure 17. Average product prices are between 401 € in Great-Britain and 622 € in Sweden. Furthermore, price ranges are not similar in all MS; whereas it is about 163 € in France, this range is about 561 € in Sweden.

Moreover, as A-class products represented almost 55% of the market in 2004, weighted average prices are close to A-class product prices (difference of 9% for the whole EU-15).

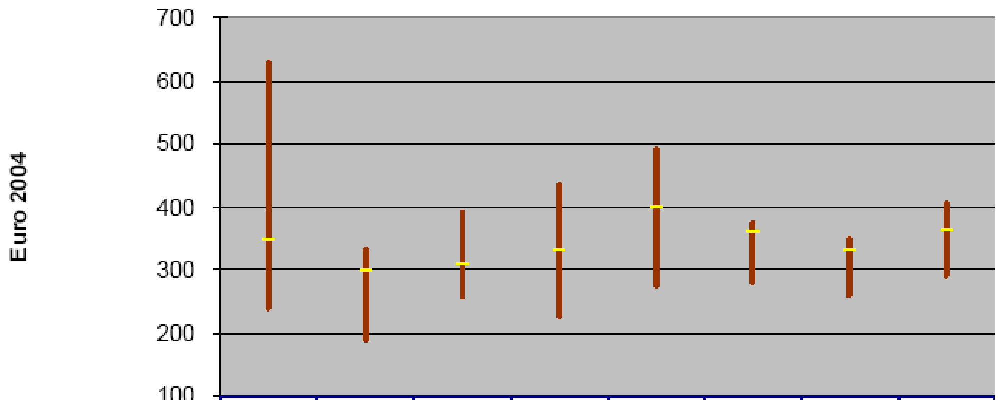
Figure 17: Price ranges in Western Europe MS in 2004



	AT	BE	DE	DK	ES	FI	FR	GB	GR	IT	NL	PT	SE	EU 15
Min = C	324	292	295	459	365	327	364	313	404	403	299	322	407	358
Max = A++ or A+	613	581	563	905	823	688	527	822	713	801	480	813	968	534
W. Average	460	491	436	519	495	505	457	401	573	502	470	421	622	457
Class A	484	513	443	518	620	562	504	447	704	565	477	534	637	496

The comparison of refrigerators prices for Eastern MS in given in Figure 18. In Czech Republic, the maximum price of refrigerators available on the market is 627 €, high compared to other MS. This is explained by the fact that this price corresponds to A++ appliance in Czech Republic while in all other cases to A+ or A class refrigerators.

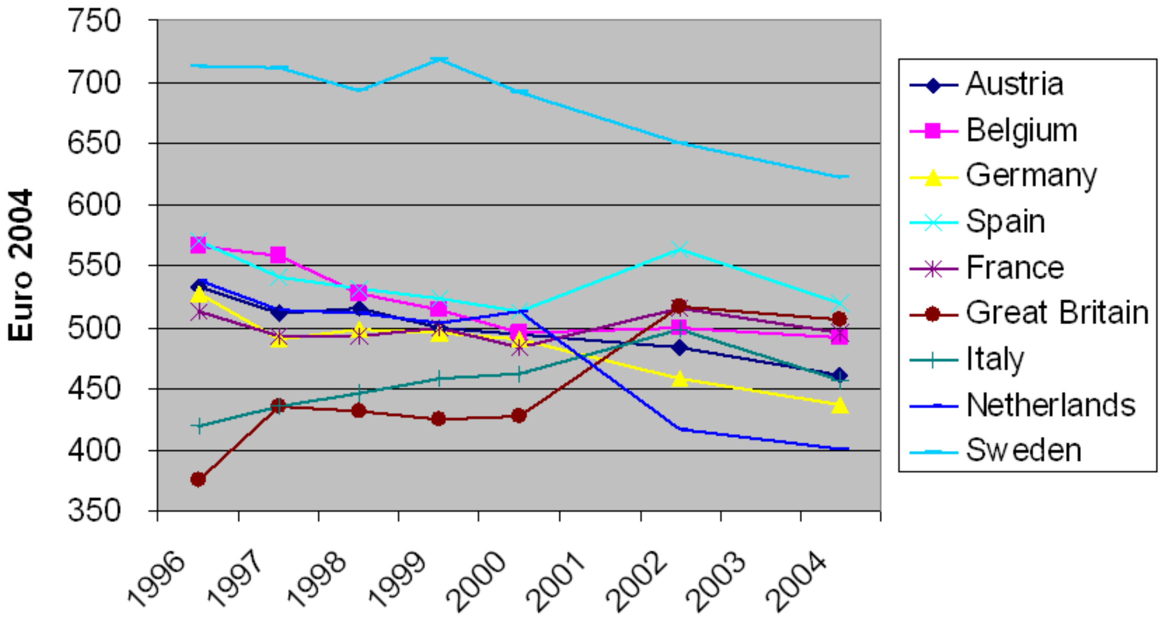
Figure 18: Price ranges in Eastern MS in 2004



	CZ	HU	PL	SK	EE	LT	LV	SI
Min = C	240	190	257	225	276	279	259	291
Max = A+ or A	627	330	391	435	492	374	349	405
W. Average	347	298	308	332	399	361	331	363
Class A	377	330	327	354	413	364	349	405

Figure 19 shows prices trends in several Western Europe MS for refrigerators from the year 1996 up to the year 2004. As already mentioned, the highest average price is in Sweden. Further, while there was not a general trend until 2002, prices decreased in some MS and increased in other ones, it is noticeable that in every country prices decline from this year.

Figure 19: Prices trends in Western MS between 1996 and 2004



Such prices differences between Western Europe and Eastern Europe and also between Member States within same region could be explained by following:

- Economies of MS have not reached the same level especially for Eastern Europe MS. Indeed, the purchasing power and the labour costs are generally lower in these countries and obviously such difference is reflected in the price of refrigerators.
- VAT rates vary across the European Union. For instance, the VAT rate for white goods in Denmark is 25% whereas it is of 17.5% in United Kingdom. This partly results in the discrepancies of refrigerators prices.
- The price is related to the energy class but also to the net volume of the refrigerator. As highlighted in the previous section on 'sales data', refrigerators sold in Western Europe are bigger than those sold in Eastern Europe, which obviously implies a higher product price.
- Western Europe MS are 'wealthier' than Eastern Europe MS and customers in this region more and more require refrigerators with specific colours or coatings for aesthetic reasons. Moreover, new functionalities are integrated in some products such as LCD flat-screens, cool water and/or ice cube dispenser, special shelves or baskets for cans and bottles, and no/low frost technology. In addition, a concern has increased about the hygiene and the quality of food and dairy products which motivates the manufacturers to propose hygienic filter, anti-bacterial surfaces, and controllers. These additional features effectively increase the overall price.
- More and more white goods are manufactured in Eastern Europe MS as wages are lower than in the Western part. Therefore, a refrigerator sold in France or in Spain if often transported from MS such as Romania or Poland. This additional transport costs could also lead to an increase in the final price.
- Retailers favour "no name" white goods as well as their own brand which are cheaper. Further, in Eastern Europe MS, national or regional manufacturers have a high share of the market compared to Western Europe MS where big

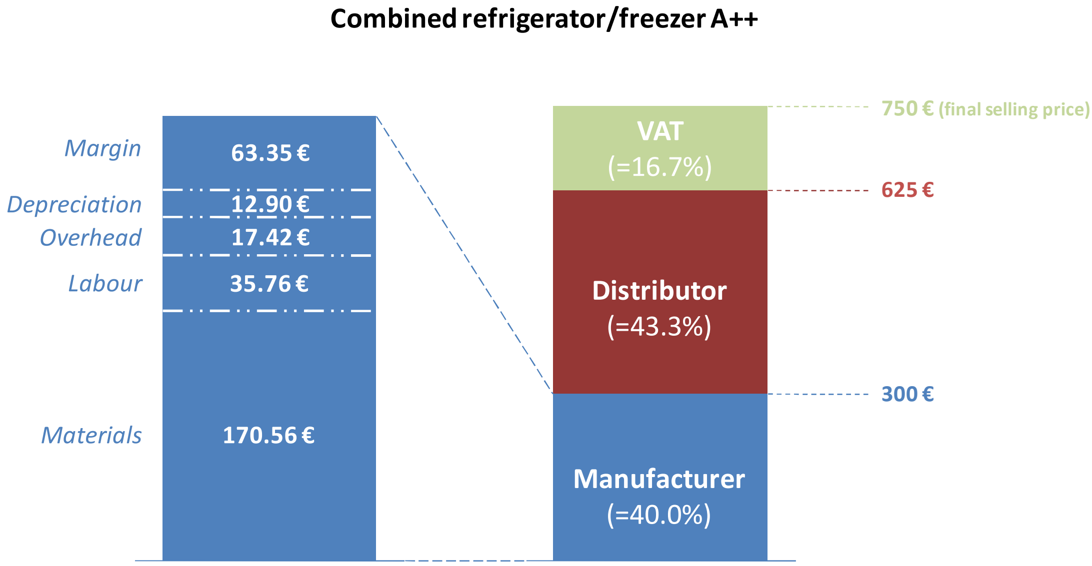
companies are well implemented (Electrolux, Whirpool, BSH, Indesit, FagorBrandt, etc.). For instance, the Gorenje group has absorbed most of the small manufacturers in Slovenia and dominates the national market[22].

A study conducted for CECED[23] presented the cost division of combined refrigerator/freezer with energy class A++ and A for which the selling prices to consumers are 750€ and 580€ respectively (see Figure 20 and Figure 21).

Unit sales and capacity of the production line(s) for the A++ model is assumed to be 10,000 units/year. An upgrade to the A++ category product is assumed with a net price of 625€. At 20 percent, this implies a value added tax of 125€ per unit for a total consumer price of 750€. With the typical distributor/retailer mark-up, the manufacturers' price becomes 300€. Therefore, for a combined refrigerator/freezer with energy class A++ sold 750 € to the final consumer, 40% (i.e. 300€) of this price goes to the manufacturer, 43.3% (i.e. 325€) goes to the distributor/retailer and 16.7% (i.e. 125€) goes to the State with the VAT.

A detailed analysis of the shares of the various costs for the manufacturer shows that materials contribute to 57% to the manufacturer selling price, followed by the profit margin (21%) and labour costs (12%). Overhead costs and depreciation (assumed to be about 4.3%) complete the balance.

Figure 20: Consumer selling price split up for an A++ combined

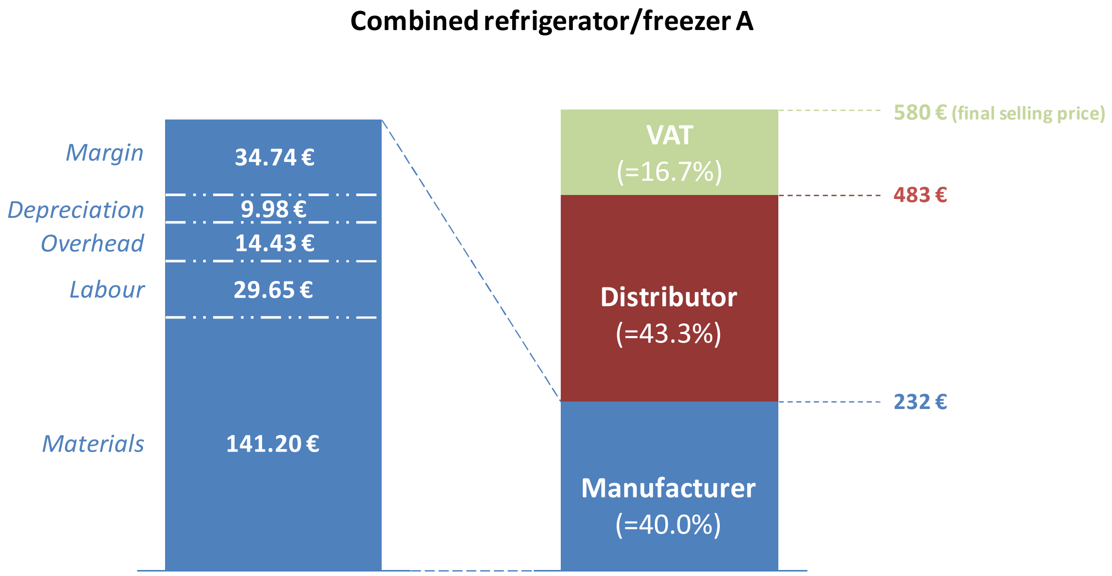


In the case of a combined refrigerator/freezer with an energy efficiency class A, the production capacity is assumed to be 0.990 million units. The split-up of the final selling is the same as for the A++ model (i.e. 40% for the manufacturer, 43.3% for the distributor/retailer and 16.7% of VAT). In this case, the manufacturing cost is changed and is more than that for A++ models (84% of price), because they have been on the market longer and margins have been reduced. Therefore, for an A-class combined refrigerator sold at 232€ to the distributor, the manufacturer's margin is about 35€.

Figure 21: Consumer selling price split up for an A-class combined

[22] European Commission, DG TREN (2007b)

[23] Mebane, B. and E. Piccinno (2006)

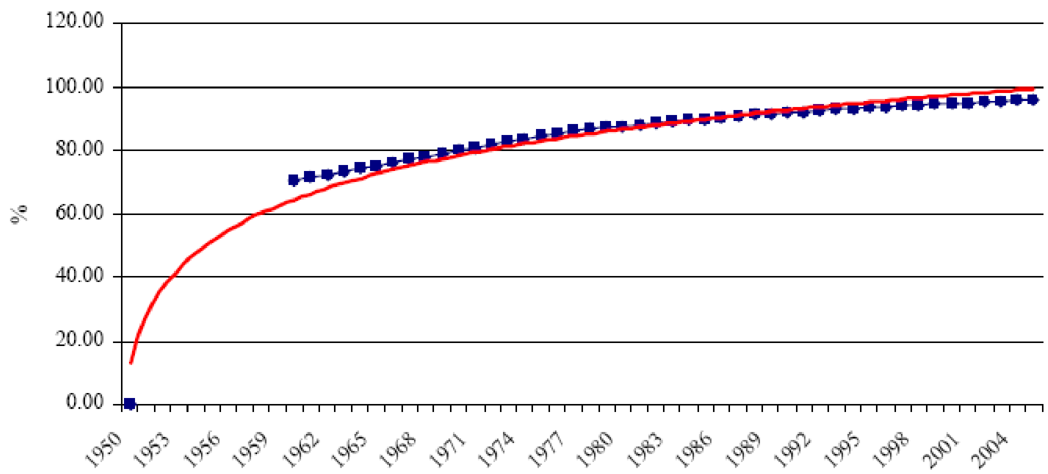


- ***Market maturity***

Figure 22 presents the penetration rate for refrigerators based on the following assumptions:

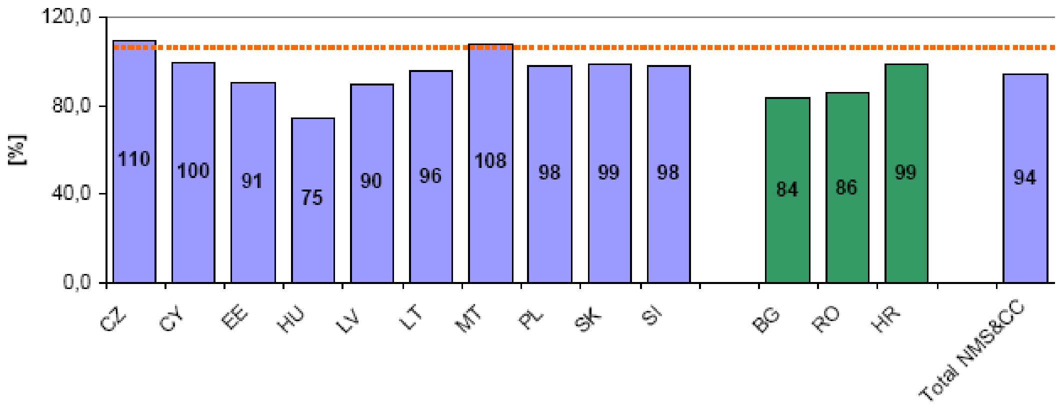
- before the year 1950 there were no refrigerators, and
- the growth since then has been logarithmic. The refrigeration market is almost saturated and is supposed to go beyond 100% as many households now own more than one refrigerator

Figure 22: Refrigerators penetration rate in EU-15 (red curve)



The penetration rate of refrigerators was also estimated for Eastern Europe MS as well as for candidate countries in 2004 (see Figure 23) and the average ownership rate in new EU-12 (+ Croatia) is about 94%.

Figure 23: Penetration rate of refrigerators in new MS in 2004[24]



Refrigerator is not a leisure product like consumer electronics. Consumers buy a second refrigerator for a particular need and therefore setting incentives to promote the purchasing of energy efficient refrigerator might not stimulate people to buy additional products.

1.2.1.3 Major barriers

- ***Price***

The low penetration rate of energy efficient refrigerators (see figures provided in market analysis, section 1.2) indicates that tax incentives could play a role to promote consumer purchasing of these products. Indeed, the higher purchase price of energy efficient refrigerators is often a barrier for consumers who do not take into account the life cycle cost. Therefore, the product price and product functionalities are the main criterion affecting the purchase decision. However, as illustrated in Figure 24, it seems that more and more consumers are aware of the high consumption of domestic refrigerators and 83.9 % state that energy and water consumptions are of high importance when purchasing a new domestic appliance.

According to another consumer survey carried out in 2004 by Forsa in Germany (Figure 25), the energy consumption of a refrigerator (or a combined fridge-freezer) is the main criterion for 62% of German consumers, followed by the purchase price (33%). However, consumer surveys have to be analysed with caution as they do not always reflect the real consumer behaviour. Indeed, most of people claim that they really take care of environment in their daily life but it may be over-estimated.

- ***Repairing and maintenance***

Usually, average households use refrigerators until they break down. It can be estimated that a replacement of old models with new ones happens only after a technical failure. However, many households choose to repair their refrigerator and continue to use it for several years and prolonging the lifetime of old inefficient models. 12.3% of total refrigerators are found to have been repaired or serviced[25] (see Figure 26). The repairing rate in each country covered by the study, ranges from 5% in Germany to 19% in Italy (Figure 27).

[24] European Commission DG JRC (2006b)

[25] European Commission, DG TREN (2007b)

Figure 24: Buying criteria when purchasing a new domestic appliance[26]

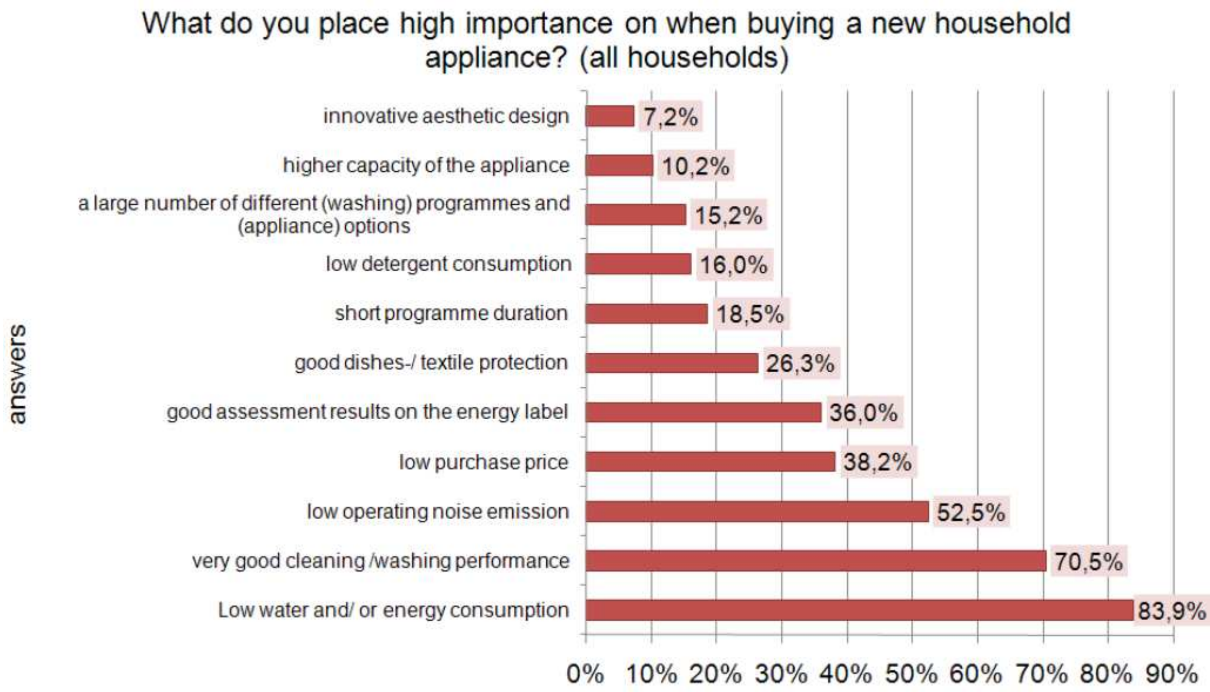
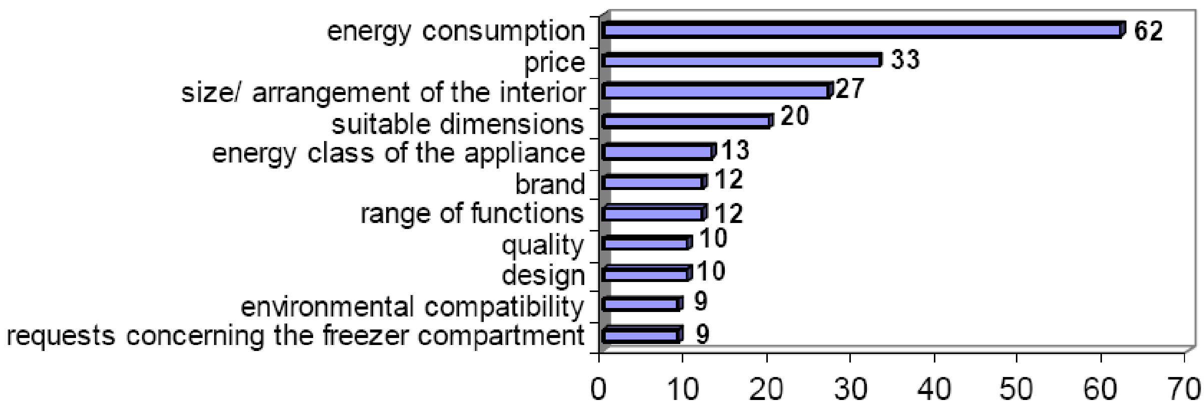


Figure 25: Important issues for German consumers when buying a refrigerator (in %)



[26] European consumer survey carried out in 10 Member States (Czech Republic, Finland, France, Germany, Hungary, Italy, Portugal, Spain, Sweden, United Kingdom) and 250 households per MS, Source: European Commission, DG TREN (2007b)

Figure 26: Repairing/service rate of home appliances[27]

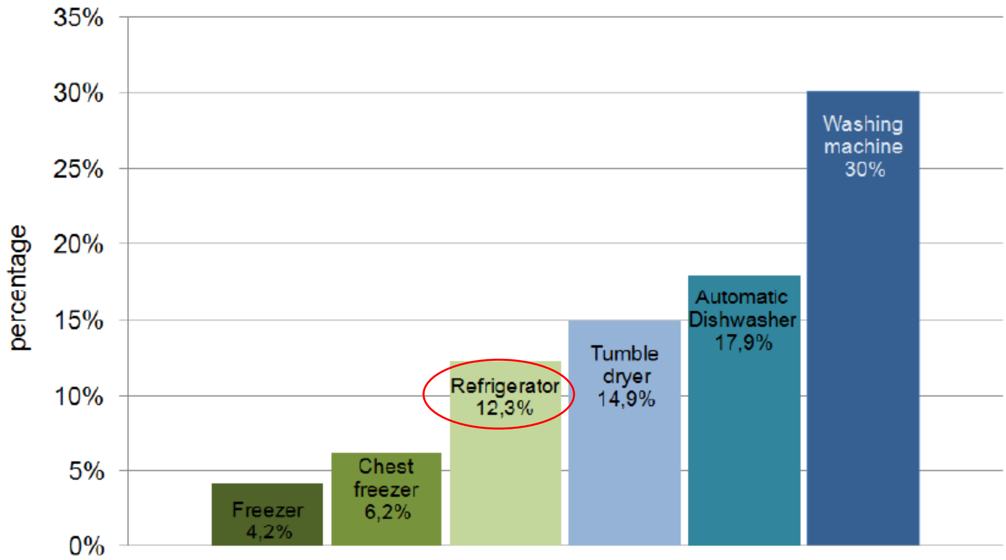
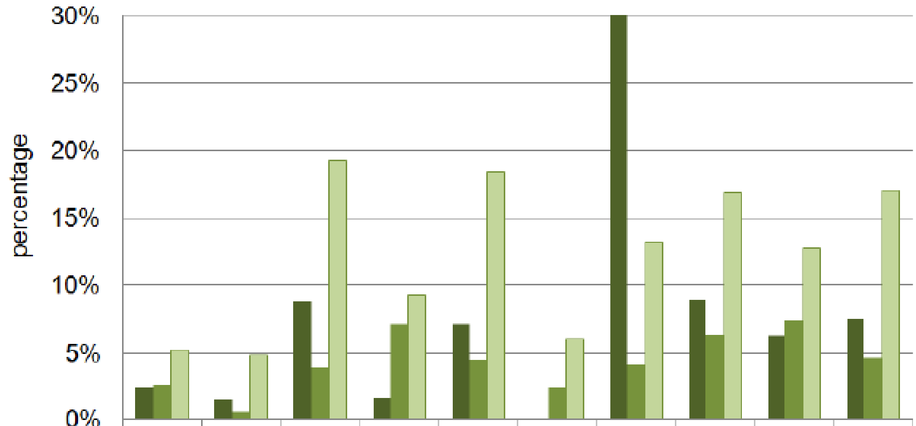


Figure 27: Repairing/service rate of cooling appliances, by country



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
Chest freezer	2%	1%	9%	2%	7%	0%	30%	9%	6%	7%
Freezer	3%	1%	4%	7%	4%	2%	4%	6%	7%	5%
Refrigerator	5%	5%	19%	9%	18%	6%	13%	17%	13%	17%

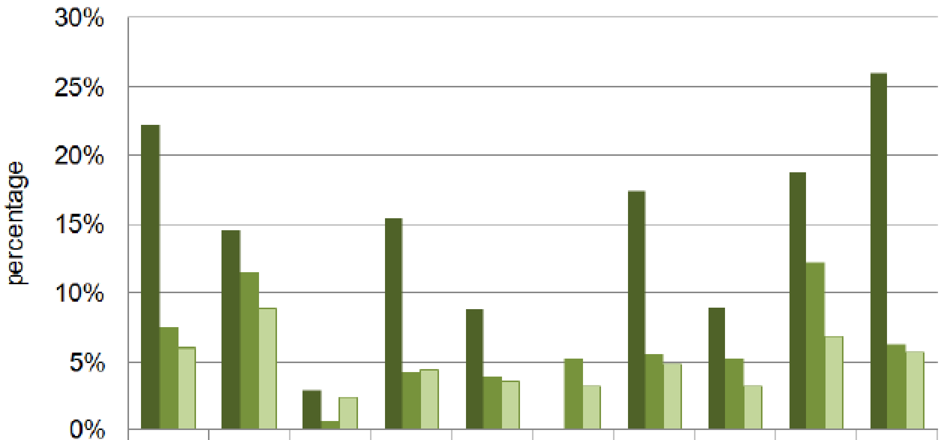
- ***Second-hand market***

Second-hand appliances are also chosen by consumers to replace broken down products. The share of second-hand refrigerators can reach up to 9% in some MS (Figure 28). Besides, a refrigerator is often installed in the existent kitchen when the new owners move in. Some 30% of the questioned households had a kitchen with an installed refrigerator when they moved into their house. Few people will choose to change it before the model appears to be good at carrying out its freezing functions. With the quick development in energy performance of refrigerators in recent years, the use of second-hand appliances is not an energy saving behaviour[28].

[27] European Commission, DG TREN (2007b)

[28] Lepthien K. (2000)

Figure 28: Cold domestic appliances purchased second-hand, per country[29]



	UK	DE	IT	FR	ES	SW	PL	HU	FI	CZ
Chest freezer	22%	14%	3%	15%	9%	0%	17%	9%	19%	26%
Freezer	7%	12%	1%	4%	4%	5%	6%	5%	12%	6%
Refrigerator	6%	9%	2%	4%	4%	3%	5%	3%	7%	6%

- ***Food protection concerns***

The hygiene necessity of food protection is another possible barrier for energy saving innovations of refrigerators. It is recognised that the lower the refrigeration temperature is the less pathogenic micro-organisms can survive. According to the World Health organisation (WHO), 44% of foods borne diseases in Europe are caused by inappropriate temperatures including insufficient cooling[30]. A temperature of 3 to 5°C is recommended to be maintained for the conservation of perishable food. As a result, the further decrease of energy consumption can be realized only when the food security temperature is ensured.

[29] European Commission, DG TREN (2007b)

[30] World Health organisation (2004)

2.2.2. WASHING MACHINES

1.3.2.1 Product characteristics

Functional description

- **Definition**

The European standard EN 60456: 2005 "Clothes washing machines for household use – Methods for measuring the performance (IEC 60456: 2003, modified)" defines Washing machines as "clothes washing machines for household use with or without heating devices and for cold and/or hot water supply", and further specifies the definition in the "Scope" section as "appliance for cleaning and rinsing of textiles using water which may also have a means of extracting excess water from the textiles".

The Energy Labelling Directive 95/12/EC (and 96/89/EC) also gives the definition of washing machines, which is "electric mains operated household washing and spin drying vessels (such as twin tubs), and combined washer-driers. Appliances that can also use other energy sources are excluded". This definition is later adopted by the EU Eco-label Scheme with Commission Decision 2005/384/EC of 12 MAY 2005, prolonging the criteria established in Decision 2000/45/EC.

With the emphasis on the energy sources in the definition by the Energy Labelling Directive, this definition will be used for the purpose of this study. Categorisation of different types of washing machines has been made by EN 60456: 2005 and PRODCOM 2007, which are presented in Table 13.

The functional unit, i.e. the primary product performance parameter, of washing machines is the weight of the laundry washed per cycle, when its functional performance is represented by the cleaning and spinning performance.

- **EU Energy Label**

The energy efficiency scale for washing machines is calculated using a cotton cycle at 60°C with a maximum declared load, which is typically 6 kg. The label provides the consumers with an A (most efficient) to G (least efficient) scale (Figure 29) for the model's energy efficiency, washing performance and spin drying performance. The energy efficiency index is in kWh per kilogramme of washing (Table 14).

Washing performance is defined as the ratio of the water consumption of the machine under test compared to a reference machine. Though there are several parameters influencing the overall washing performance, high water and energy consumptions often leads to good performance. Therefore, the relation between energy consumption and washing performance is a very important piece of information.

The spin drying efficiency is correlated to maximal spin speed. The energy consumption of this process is even higher than that of the washing. Thus, the technology improvement of the spin process contributes to an important saving of energy, especially for those who often use electric drying after the washing process. Besides these three criteria, the label also contains information on total energy consumption per cycle, maximum spin speed, the total cotton capacity in kg, water consumption per cycle in litres, and noise in the washing and spinning cycles dB(A).

Table 13: Comparison of the different classification scheme for washing machines at European level

<table>
<tr><td>EN 60456: 2005</td><td colspan="2">clothes washing machines for household use with or without heating devices and for cold and/or hot water supply</td></tr>
<tr><th>Directive 95/12/EC; Decision 2005/384/EC</th><th>PRODCOM</th><th>EN 60456: 2005 (to be changed)</th></tr>
<tr><td rowspan="5">electric mains operated household washing machines, excluding machines with no spin capability, - machines with separate washing and spin drying vessels (such as twin tubs), and combined washer-driers. Appliances that can also use other energy sources are excluded</td><td>29.71.13 - Cloth washing and drying machines, of the household type</td><td>washing machine: appliance for cleaning and rinsing of textiles using water which may also have a means of extracting excess water from the textiles</td></tr>
<tr><td rowspan="4">29.71.13.30 – Fully-automatic washing machines of a dry linen capacity ≤10 kg (including machines which both wash and dry)

29.71.13.50 – Non-automatic washing machines of a dry linen capacity ≤10 kg (including machines which both wash and dry).</td><td>agitator washing machine: washing machine in which the textiles are substantially immersed in the washing water, the mechanical action being produced by a device moving about or along its vertical axis with a reciprocating motion (an agitator). This device usually extends above the maximum water level</td></tr>
<tr><td>horizontal drum washing machine: washing machine in which the textiles are placed in a horizontal or inclined drum and partially immersed in the washing water, the mechanical action being produced by rotation of the drum about its axis, the movement being either continuous or periodically reversed;</td></tr>
<tr><td>impeller washing machine: washing machine in which the textiles are substantially immersed in the washing water, the mechanical action being produced by a device rotating about its axis continuously or which reverses after a number of revolutions (an impeller). The uppermost point of this device is substantially below the minimum water level;</td></tr>
<tr><td>nutator washing machine: washing machine in which the textiles are placed in a vertical axis basket and partially immersed in the washing water, the mechanical action being produced by a nutation plate in the bottom of the basket, the movement being either continuous or periodically with or without reversion</td></tr>
</table>

Figure 29: EU energy label for washing machines

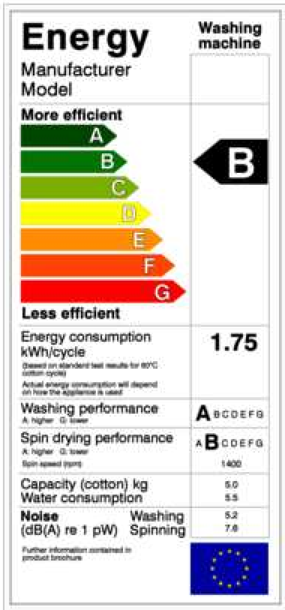


Table 14: Energy efficiency classes for washing machines

	A	B	C	D	E	F	G
Energy efficiency index	I ≤ 0.19	0.19<I≤0.23	0.23<I≤0.27	0.27<I≤0.31	0.31<I≤0.35	0.35<I≤0.39	0.39 < I
Washing performance	I > 1.03	1.00<I≤1.03	0.97<I≤1.00	0.94<I≤0.97	0.91<I≤0.94	0.88<I≤0.91	I ≤ 0.88
Spin drying efficiency	I ≤ 45%	45%<I≤54%	54%<I≤63%	63%<I≤72%	72%<I≤81%	81%<I≤91%	90% ≤ I

Average lifetime and replacement patterns

According to a customer survey conducted in several European countries[31], nearly 50% of the washing machines are younger than four years with 90% younger than ten years (Figure 30) and the calculated average age of washing machines in the interviewed households is 5.5 years (Figure 31), though the results vary from one MS to another. The actual lifetime of washing machines is much longer due to maintenance and repair services provided by manufacturers and the existence of a well-developed second-hand market. It is claimed that the average lifetime of a washing machine is over ten years.

Regarding the development of the energy efficient washing machines in the last decade (further information in the "Speed of innovation" section), the difference of energy consumption between the old models and the new ones is more and more noticeable. Use of over-aged washing machines, therefore, leads to unnecessary energy consumption.

[31] European Commission, DG TREN (2007c)

Figure 30: Age of washing machines in different MS[31]

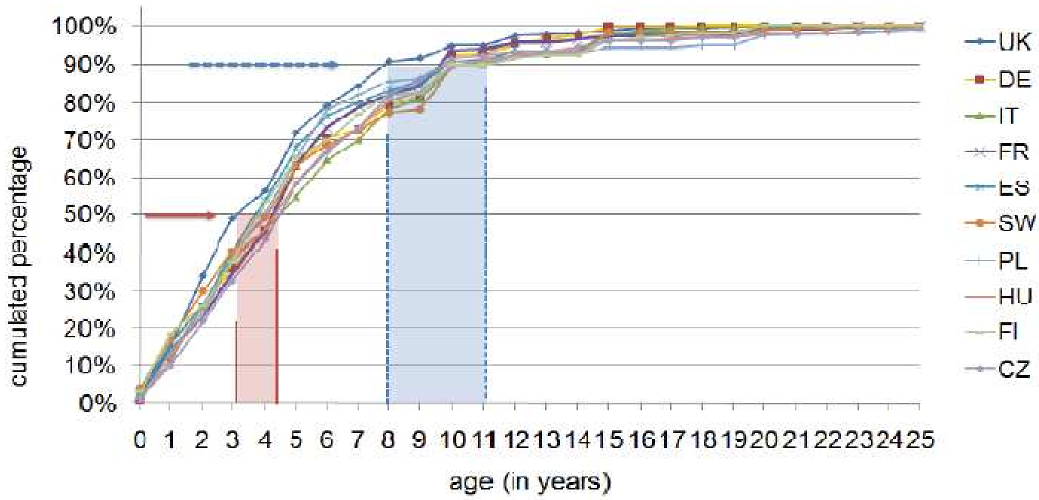
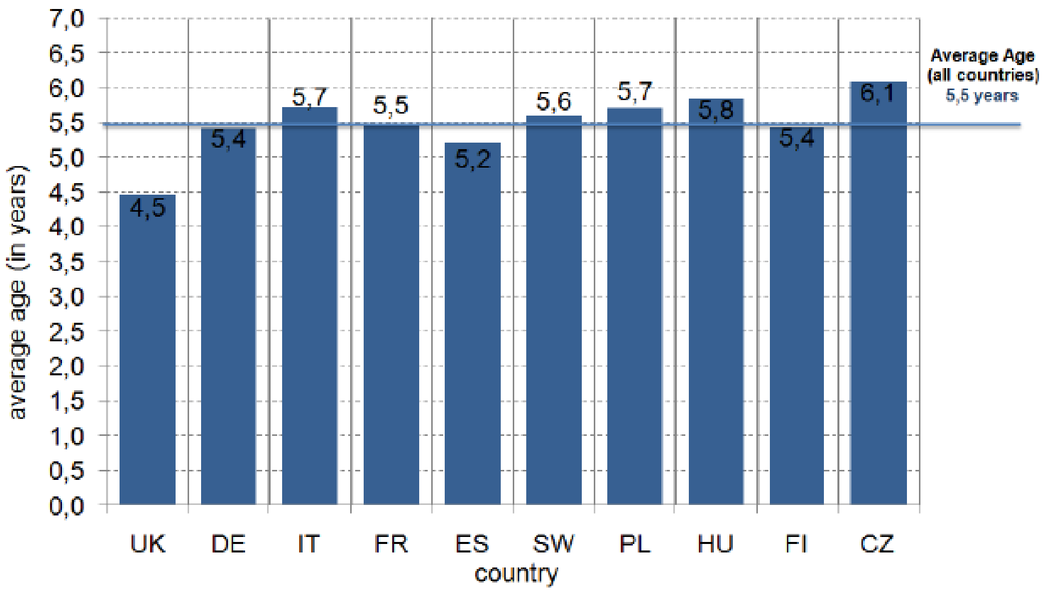


Figure 31: Average age of washing machines in different MS[31]

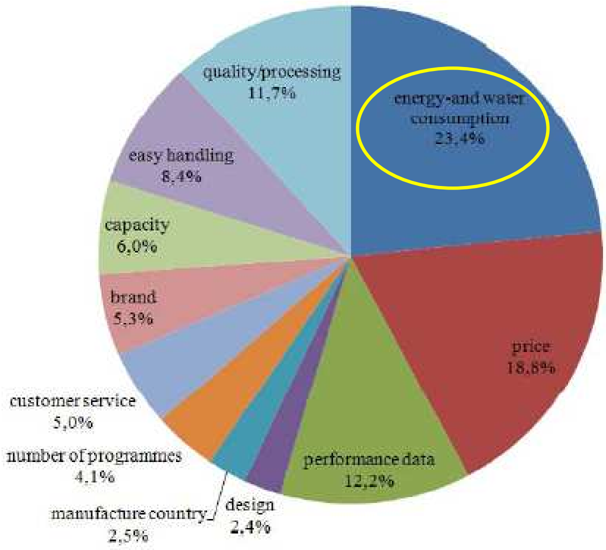


- ***Buying criteria***

Despite the price and functionality of a washing machine being the most important purchase criteria for most consumers, the energy and water consumption performance do influence the final purchase decisions. In a German study[32], over 23% of the consumer mentioned that energy and water consumption are the main criteria when they choose a washing machine, followed by the price (18%) and the performance data (12.2%) as shown in Figure 32.

[32] Innofact AG(2005)

Figure 32: Buying criteria for washing machine in Germany

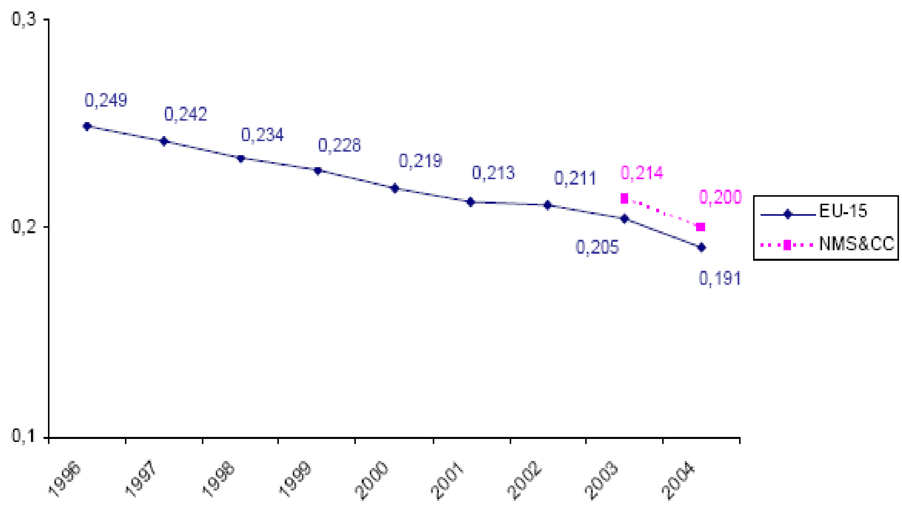


This illustrates that the availability of information for consumers on environment/energy aspects at retail shops is crucial in order to increase the sales of efficient washing machines.

Speed of innovation

In response to the change in the consumers' buying attitude, the manufacturers have been altering their product design, by highlighting the performance of the machines in terms of less water and energy consumption. As a result, a continuous improvement of energy efficiency (Figure 33) and a simultaneous reduction of water consumption (Figure 34) in EU-25 can be observed in the past decade.

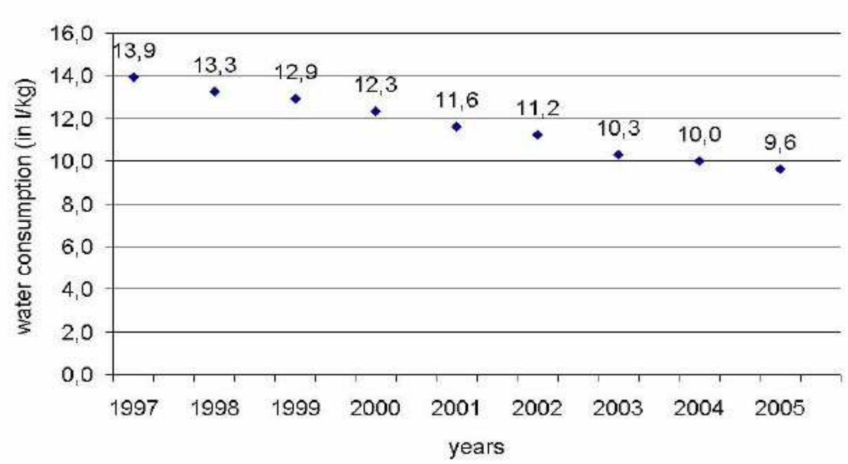
Figure 33: Evolution of washing machines' energy efficiency index (kWh/kg) [33]



[33] Waide, Lebot and Harrington (2004)

The average energy efficiency index of washing machines in EU-15 countries reduced by 23% from 0.249 kWh/kg in 1996 to 0.191 kWh/kg in 2004. A similar trend is observed in New Member States (NMS) and candidate countries (CC)[34] from 2003.

Figure 34: Evolution of water consumption by washing machines in EU-25[35]



Another indicator of the development of more efficient washing machines models is the reduction of average water consumption among all MS, about 31% from the initial 14 L/kg in 1997. It should be mentioned that the EU has been enlarged from 15 MS to 27, with a 100 million increase in the population. This increase in market size seems to have little impact on the average water consumption of the washing machines.

Meanwhile, following innovations corresponding to the other buying criteria of consumers have also been happening:

- Towards bigger machines with larger loading capacity: wider drum diameter, 180°C door opening, inclined drum, etc.
- Towards intelligent machines adaptable to consumer habits: changeable programmes according to textiles, automatic sensors, etc.
- Towards a higher compatibility with consumers' daily life: time delay options, digital time displays, etc.

Scope for environmental improvement

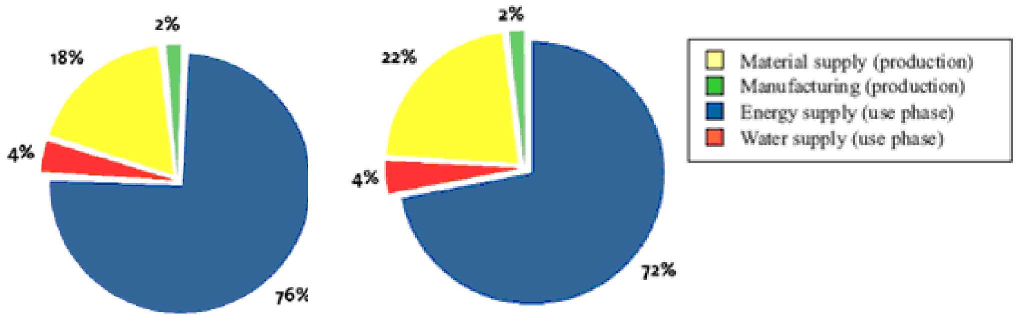
According to a 'simplified' life-cycle analysis (LCA)[36] of an old washing machine (2,000 cycles i.e. duration of 11.4 years), the energy supply in the use phase occupies a dominant position in cumulated energy demand with a share of 76% (Figure 35) among other factors including manufacturing and distribution. In terms of Global Warming Potential, its contribution being a little lesser, the energy consumption in the use phase is still far beyond the overall impact of all the other three contributors (material supply, manufacturing and water consumption).

[34] Bulgaria, Romania, Croatia

[35] European Commission, DG TREN (2007c)

[36] CECED (2006)

Figure 35 : Cumulative Energy Demand (CED) and Global Warming Potential (GWP) in the manufacturing and use phases of washing machines [CECED, 2006]



Cumulative Energy Demand *Global Warming Potential (GWP)*

This analysis indicates that the priority should be given to encourage the households to replace their old inefficient washing machines with new efficient models. The information availability to consumers on the energy efficiency aspects can be important in achieving this goal. Energy Label is one measure taken by the EU in order to provide the consumers with a profile of life-cycle performance of a model. Since the introduction of the Energy Label for washing machines in 1996, it has largely impacted the choices of consumers and the development of the products on the market.

- Impacts of the Energy Label on consumers and manufacturers

The energy label informs consumers about relevant consumption values concerning energy and water and other relevant performance criteria like capacity, cleaning/washing performance or noise emissions. Consumers are able to compare different appliances on the market based on the data provided by the label. 86% of all German Consumers regarded the Energy Label as a source of information when they choose a new appliance[37].

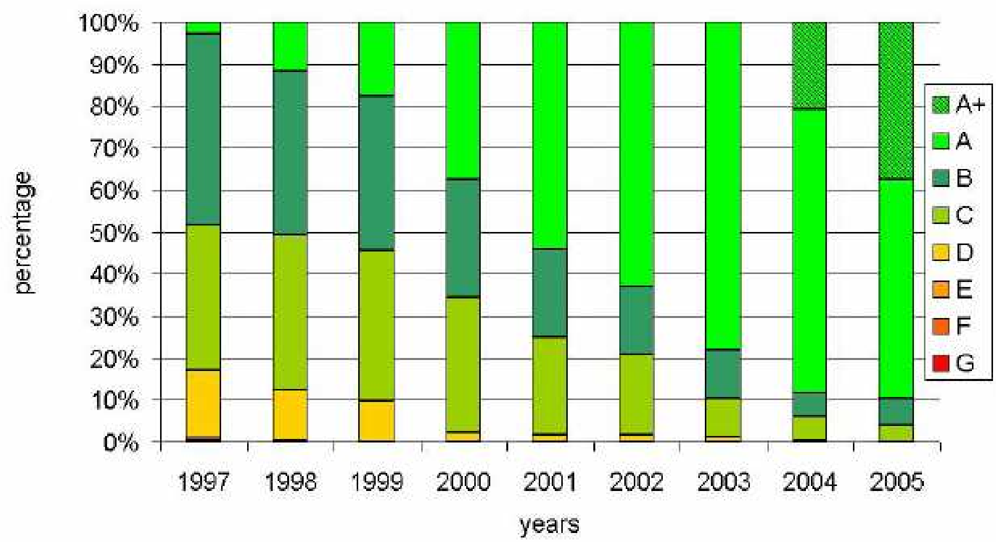
In order to comply with energy consumption requirements of the energy efficiency and to stand in a competitive position of the market share, the manufacturers have largely optimised the washing machine models.

In terms of environmental improvement, the evolution of the energy efficiency is of major concern. By comparing the distribution of the specific energy efficiency class from 1997 to 2005 in EU-25 (Figure 36), it can be concluded that about 90% of the machines are in class A or better[38] and no machines worse than class C existed in 2005 resulting from a continuous improvement since 1997.

[37] http://www.greenlabelspurchase.net/Licht_EU_Energie_Label.html

[38] The introduction of a new energy efficiency class "A+" in the energy labelling scheme for washing machines was not accepted by the European Commission and the Member States in 2002. But the industry has then agreed on the creation of a commercial label "A+" to specific energy consumptions of ≤ 0.17 kWh/kg and to require that washing performance to be in class A as well.

Figure 36: Distribution of washing machines by energy efficiency class in the EU-25 [39]



These statements are in line with the trends presented in the previous section "Speed of innovation", which proves the important role of the Energy Label in environmental improvement as well as in consumers' buying decision. The evolution of the other two parameters (washing performance and spin drying efficiency) should also be taken into consideration, with their indirect relation with environment impact of the washing machine. The development of the spin dry efficiency is not very evident over the years and B-class products represent the biggest market share in 2005 in EU-25, with about 41% (Figure 37). The least efficient classes (E, F and G) still exist in the market but with a continuously decreasing share (21% in 2005).

The washing performance displays an analogous development with the energy consumption. Models with a D-class or worse performance are no longer offered in the market in 2005 in EU-25 as shown in Figure 38. This means that manufacturers have been focusing their technology innovation on achieving low energy consumption and high washing performance.

1.3.2.2 Market analysis

- ***Sales data***

No reliable sales data for the whole EU-27 is currently available. Nevertheless, for the major Western Europe MS, GfK has published relevant information as well as for 4 Eastern MS (Czech Republic, Hungary, Poland and Slovakia).

Table 15 presents sales data of washing machines according to their energy efficiency class in the two European regions. First of all, for both regions sales increased between 2002 and 2004 (+8.64% for Western MS and +26.04% for Eastern MS). As already highlighted, customers are choosing more and more energy efficient appliances and as expected market shares of A+ and A-class washing machines has been increasing.

[39] European Commission, DG TREN (2007c)

Figure 37: Distribution of spin drying performance classes for washing machines in the EU-25

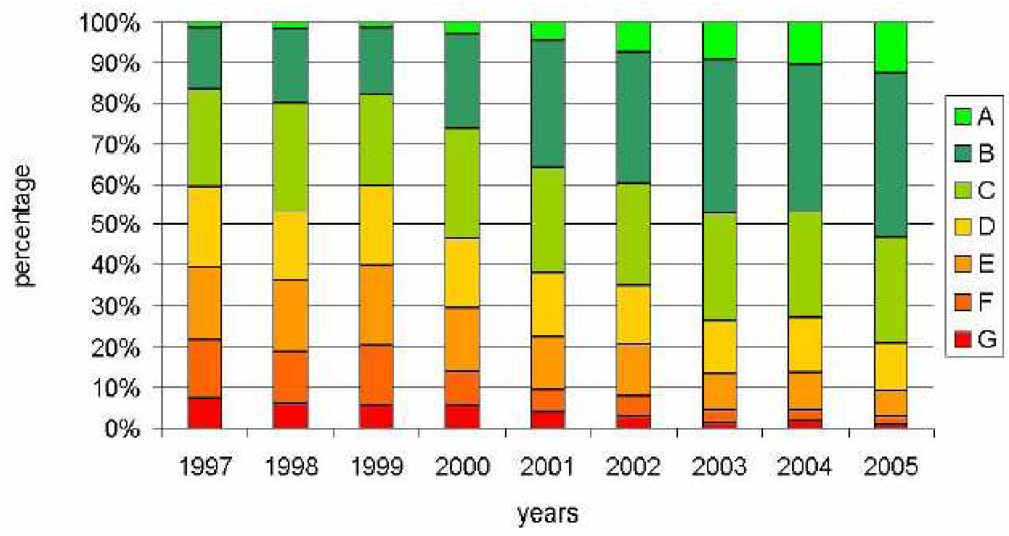
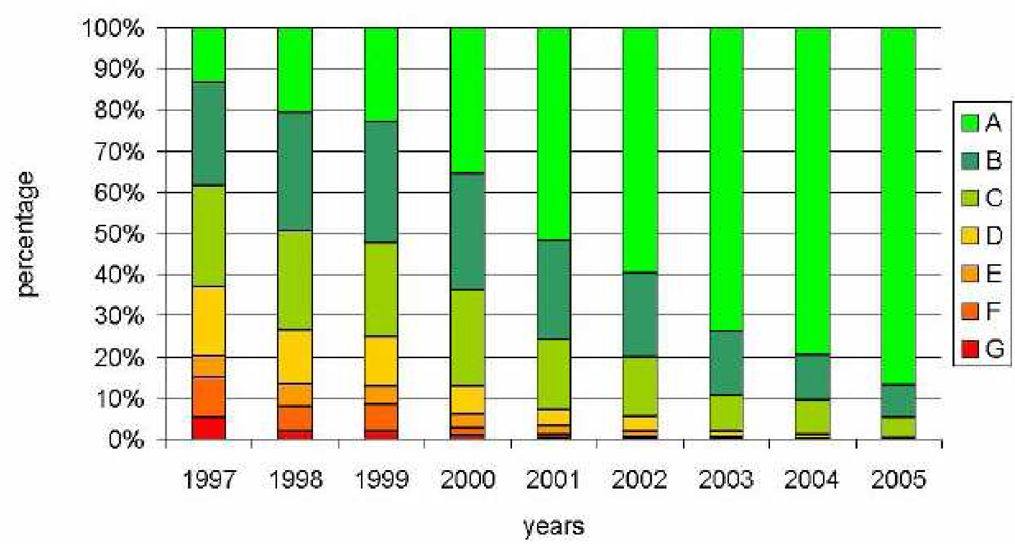


Figure 38: Distribution of washing performance classes for washing machines in the EU-25



Using total sales data presented in the table below and household population of MS included in this table, it is possible to extrapolate the sales data for the whole EU-27. It can be estimated that about 13.46 million units were sold in 2002 and 14.99 million units in 2004, i.e. an increase of 11.4%.

Sales distributions in 2002 and 2004 according to the energy class are presented in Table 16. A-class products represent the major share of sales in 2002 and 2004 both for Western and Eastern MS of the EU. Table 16 can be complemented by Figure 39 which presents the evolution of washing machines sales by energy class in Western Europe (10 MS compared to 13 in Table 16) since 2000. In seven years, appliances with class A or A+ always increased and represented 92.2% of sales in 2007 (until October). Further, the energy class of 11% of washing machine sold in 2000 was unknown, this share decreased strongly by 2007 and represents only 0.7%.

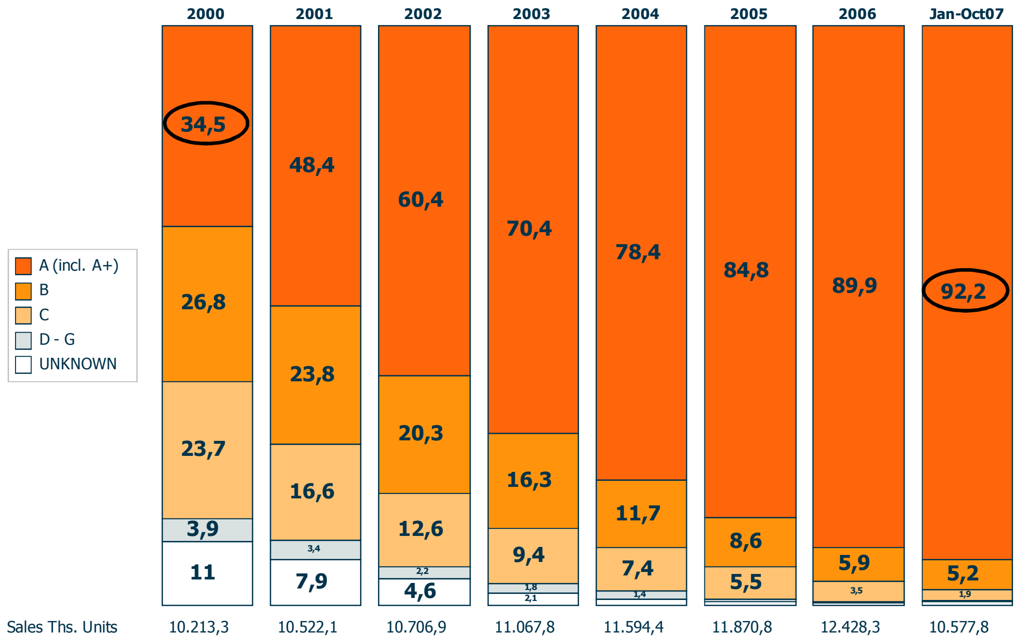
Table 15: Washing machines sales data in the EU

Energy Class	Western Europe MS (AT, BE, DE, DK, ES, FI, FR, GR, IT, NL, PT, SE, UK)			Eastern Europe MS (CZ, HU, PL, SK)		
	2002	**2004**	**Variation 2004/2002**	**2002**	**2004**	**Variation 2004/2002**
A ++	0	2	-	0	0	-
A +	9,699	929,225	*9480.63 %*	30	24,816	*82620.00 %*
A	6,749,547	8,549,715	*26.67 %*	556,986	1,243,710	*123.29 %*
B	2,235,786	1,441,018	*-35.55 %*	365,304	184,230	*-49.57 %*
C	1,412,140	909,048	*-35.63 %*	214,610	55,020	*-74.36 %*
D	150,126	88,656	*-40.95 %*	16,280	6,327	*-61.14 %*
E	25,926	15,649	*-39.64 %*	2,347	296	*-87.39 %*
F	52,447	56,923	*8.53 %*	79	13	*-83.54 %*
G	5,744	1,438	*-74.97 %*	8	0	*-100.00 %*
Unknown	557,472	174,759	*-68.65 %*	97,704	65,350	*-33.11 %*
TOTAL	**11,198,889**	**12,166,433**	***8.64 %***	**1,253,348**	**1,579,762**	***26.04 %***

Table 16: Washing machines sales distribution by energy class

Energy Class	Western Europe MS (AT, BE, DE, DK, ES, FI, FR, GR, IT, NL, PT, SE, UK)		Eastern Europe MS (CZ, HU, PL, SK)	
	2002	**2004**	**2002**	**2004**
A +	0.09 %	7.64 %	0.00 %	1.57 %
A	60.27 %	70.27 %	44.44 %	78.73 %
B	19.96 %	11.84 %	29.15 %	11.66 %
C	12.61 %	7.47 %	17.12 %	3.48 %
D	1.34 %	0.73 %	1.30 %	0.40 %
E	0.23%	0.13%	0.19%	0.02%
F	0.47%	0.47%	0.01%	0.00%
G	0.05%	0.01%	0.00%	0.00%
Unknown	4.98%	1.44%	7.80%	4.14%
TOTAL	**100.00 %**	**100.00 %**	**100.00**	**100.00 %**

Figure 39: Washing machines sales by energy class in Western EU*



* AT,BE,DE,ES,FR,GB,IT,NL,PT,SE

For each of the 13 Western Europe MS, Figure 40 presents sales variations by energy class between 2002 and 2004. The focus is also put on 6 major Western Europe MS in Figure 41 for the years 2002 and 2004. Among the Western Europe MS, Greece showed the lowest sales share of A+ and A class washing machines even if it was about 80% in 2007. Nevertheless, the sales growth rate of the most efficient appliances (A+ and A-class) was the highest (+14.9%) in Greece.

Figure 40: Washing machines sales variation (2002 – 2004) in Western Europe MS

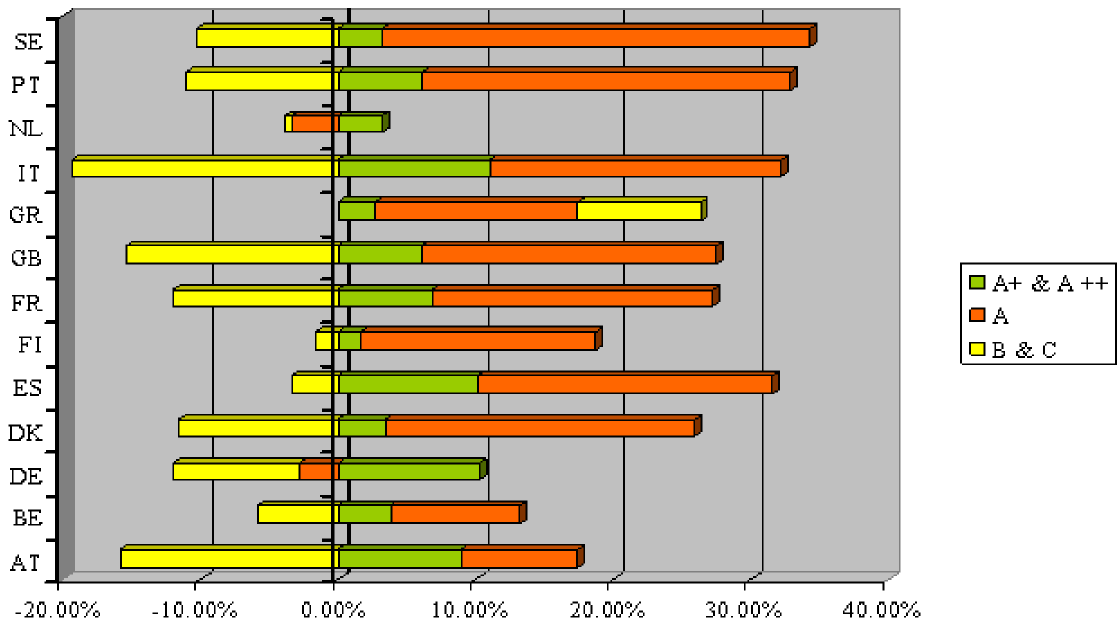
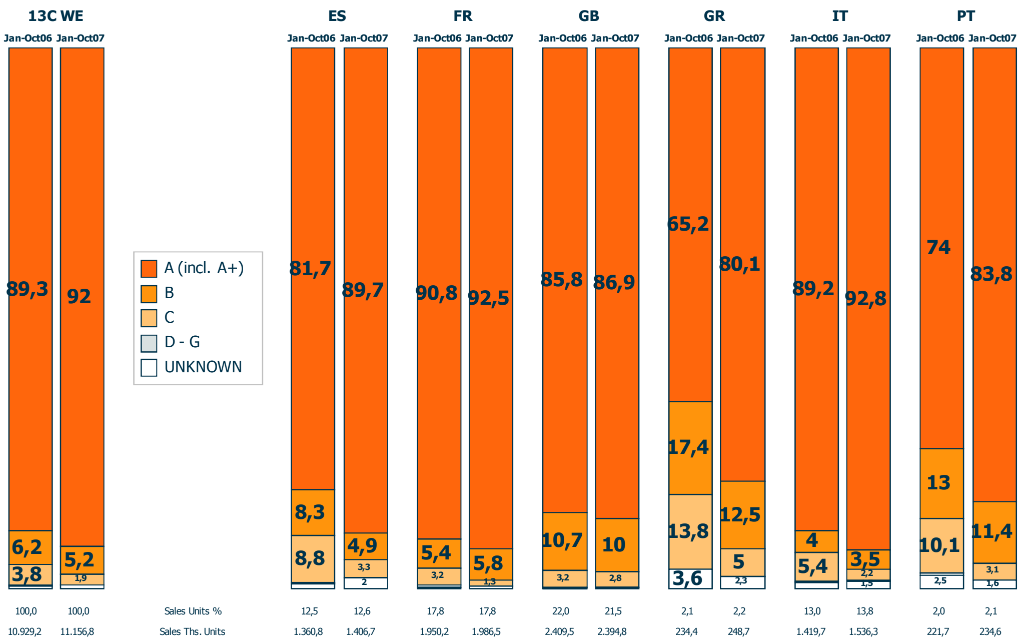


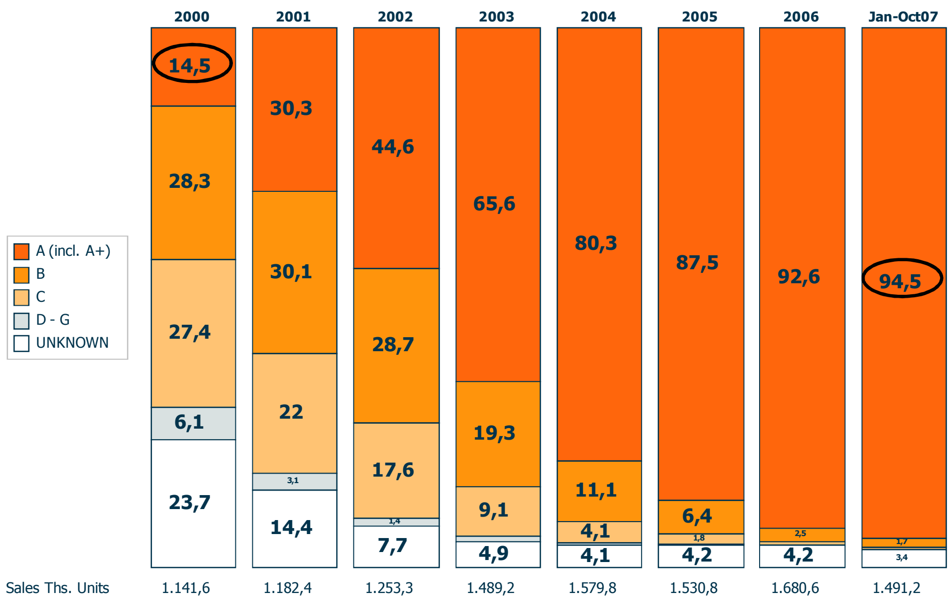
Figure 41: Sales distribution of washing machines in Western Europe MS*



* AT,BE,DE,DK,ES,FI,FR,GB,GR,IT,NL,PT,SE

As for Eastern Europe MS, Figure 42 to Figure 44 show sales distribution and variation by energy class for several MS. It is interesting to note that while in 2000 the share of A+ and A-class products was 14.5% in Eastern Europe MS and 34.5% in Western Europe MS, this trend changed in 2007 when market share of efficient washing machines was higher in Eastern MS than in Western ones (94.5% compared to 92.2%). Nevertheless, these results are based on 4 MS (CZ, HU, PL and SK) only and the picture might be different for all 12 new MS.

Figure 42: Sales distribution of washing machines in Eastern Europe MS*



*CZ,HU,PL,SK

Figure 43: Sales variation (2002 - 2004) of washing machines in Eastern Europe MS

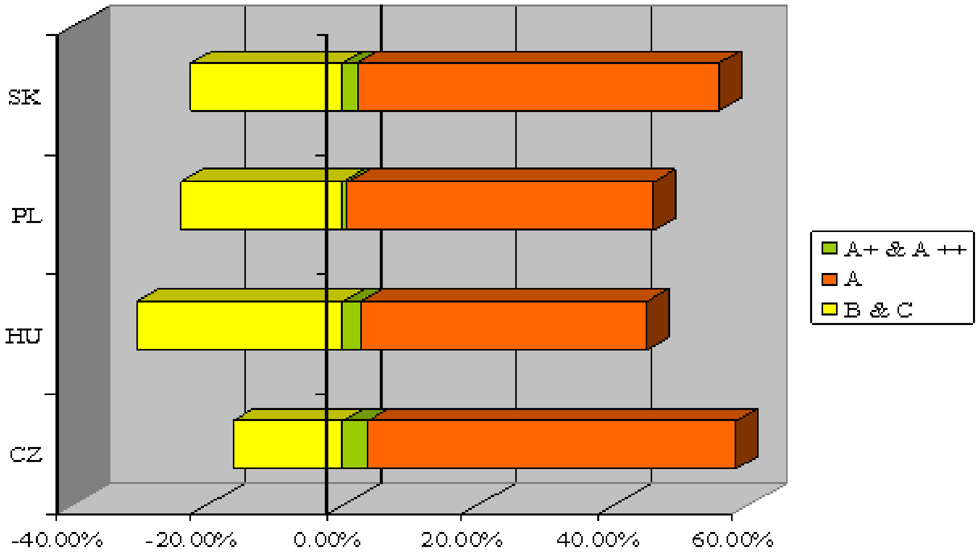
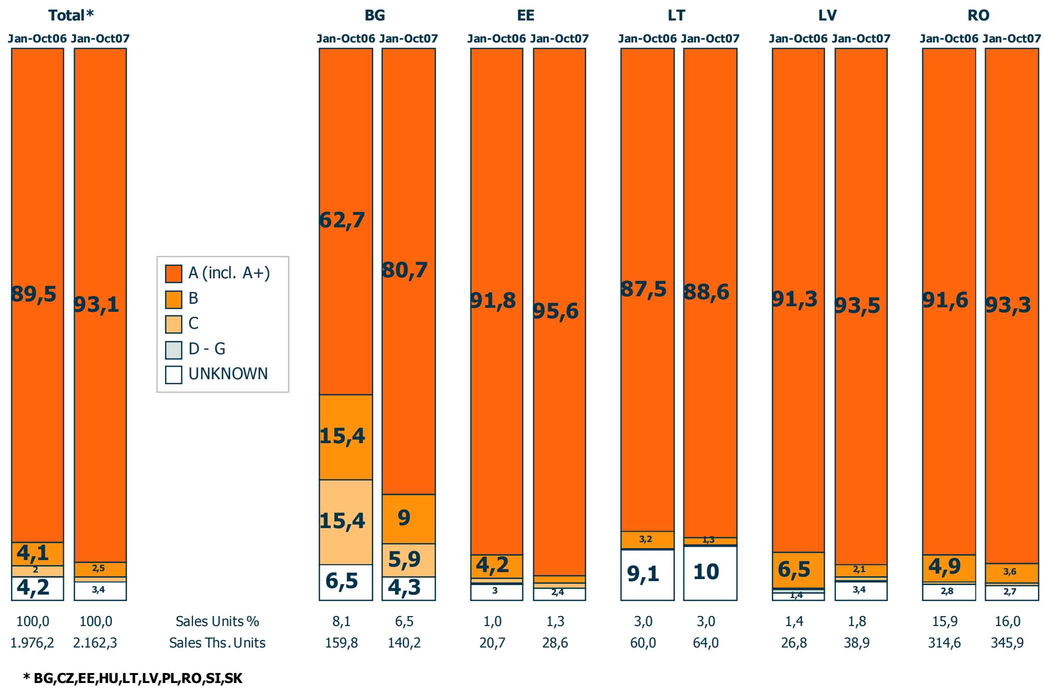


Figure 44: Sales distribution by energy class in Eastern Europe MS*



Stock data

In 2005, the estimated stock of washing machines in the EU-25 was about 167.3 million units, of which 85.6% are located in the 15 MS of Western Europe and 14.4% in the 10 new MS[40] (Table 17). These figures are in line with the CECED's estimation of the stock in EU-25 in 2004 which is 162.9 million washing machines.

[40] European Commission, DG TREN (2007c)

Table 17: EU Stock of washing machines (in million units)

	EU-25	EU-15	EU-10
1995	140.9	124.4	16.5
2000	156.7	136.5	20.2
2005	167.3	143.2	24.1

- ***Price data***

Average prices of washing machines decreased between 2002 and 2004 both in Western Europe MS and in Eastern Europe MS for all energy efficiency classes, and the higher the energy class the higher was the decrease (see Table 18). The average reduction of the weighted average product price is about the same for the two European regions (-13.30% for Western Europe and -13.03% for Eastern Europe).

Further, the product prices in Western Europe are higher than in Eastern Europe. The maximum difference occurs for B-class washing machines (48.28%) and regarding the average product price, the gap is still high (43.34%).

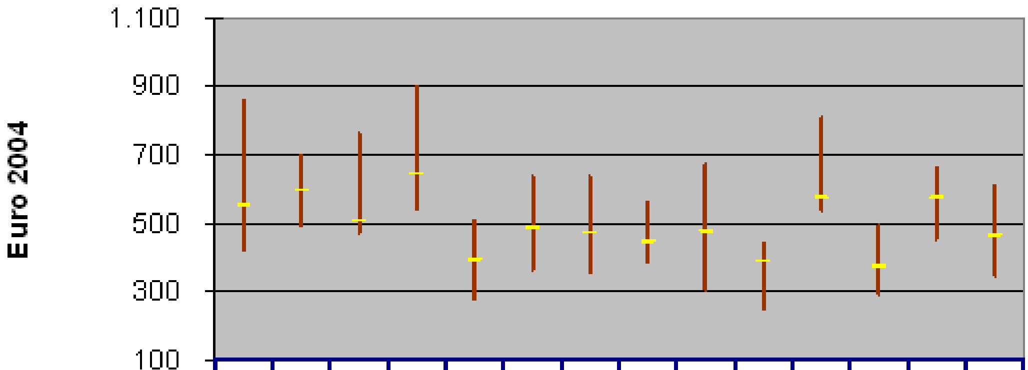
Table 18: Prices by energy classes between 2002 and 2004

Energy Class	**Western Europe MS** (AT, BE, DE, DK, ES, FI, FR, GR, IT, NL, PT, SE, UK)			**Eastern Europe MS** (CZ, HU, PL, SK)			**Variation Western/Eastern Europe MS**	
	2002	**2004**	**Variation 2004/2002**	**2002**	**2004**	**Variation 2004/2002**	**2002**	**2004**
A+	983 €	607 €	*-38.21 %*	628 €	441 €	*-29.84 %*	56.53 %	37.64 %
A	598 €	473 €	*-20.85 %*	426 €	333 €	*-21.84 %*	40.38 %	42.04 %
B	440 €	387 €	*-11.95 %*	329 €	261 €	*-20.64 %*	33.74 %	48.28 %
C	379 €	346 €	*-8.69 %*	306 €	274 €	*-10.56 %*	23.86 %	26.28 %
Weighted average	534 €	463 €	*-13.30 %*	372 €	323 €	*-13.03 %*	43.55 %	43.34 %

Figure 45 and Figure 46 show the prices interval of washing machines sold in the West and East EU markets in 2004, as well as the average price of A class products. As Figure 45 and Figure 46 indicate, the average washing machine price is very close to the appliances with class A. It is noticeable that the MS from Southern Europe (Italy, Portugal, and Spain) have the lowest washing machines prices, both the maximum and the weighted average.

At a first glance, the closer is the yellow mark (the weighted average price) to the top of the vertical bars the faster is the market transformation. Indeed, in Germany, Austria, Denmark or Netherlands, where the weighted average price is higher than the A-class price, the penetration of A+ washing machines was higher in 2004 compared to other MS.

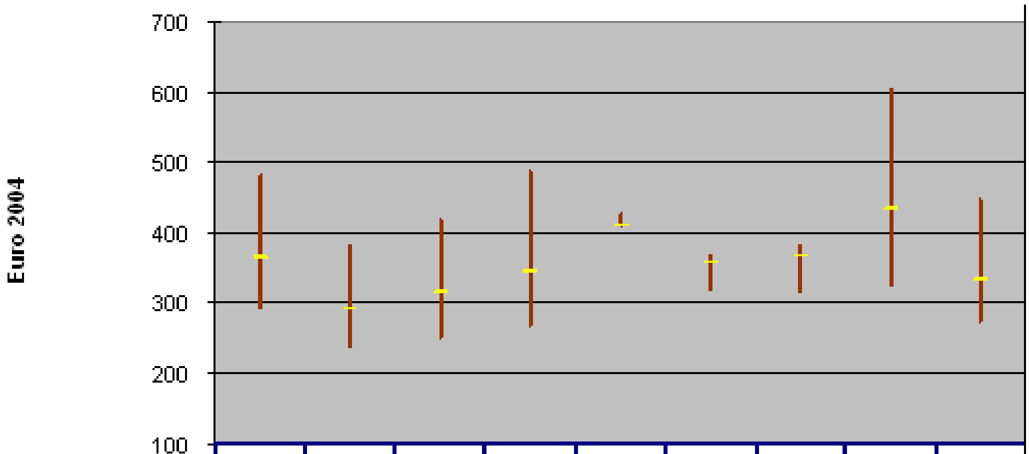
Figure 45: Price ranges in Western MS in 2004



	AT	BE	DE	DK	ES	FI	FR	GB	GR	IT	NL	PT	SE	EU 15
Min = C or B	423	495	472	540	276	364	356	389	306	249	538	293	454	346
Max= A or A+	855	696	758	899	507	635	637	558	669	441	806	493	664	607
W. Average	552	594	506	645	393	483	471	446	475	388	575	376	573	463
Class A	541	593	472	639	433	504	473	446	580	418	568	416	583	473

As mentioned earlier, washing machines prices are lower in Eastern Europe, with a reduction of 28% for the weighted average appliance as well as for A-class products compared to Western Europe in 2004 (average of 8 MS from Eastern Europe).

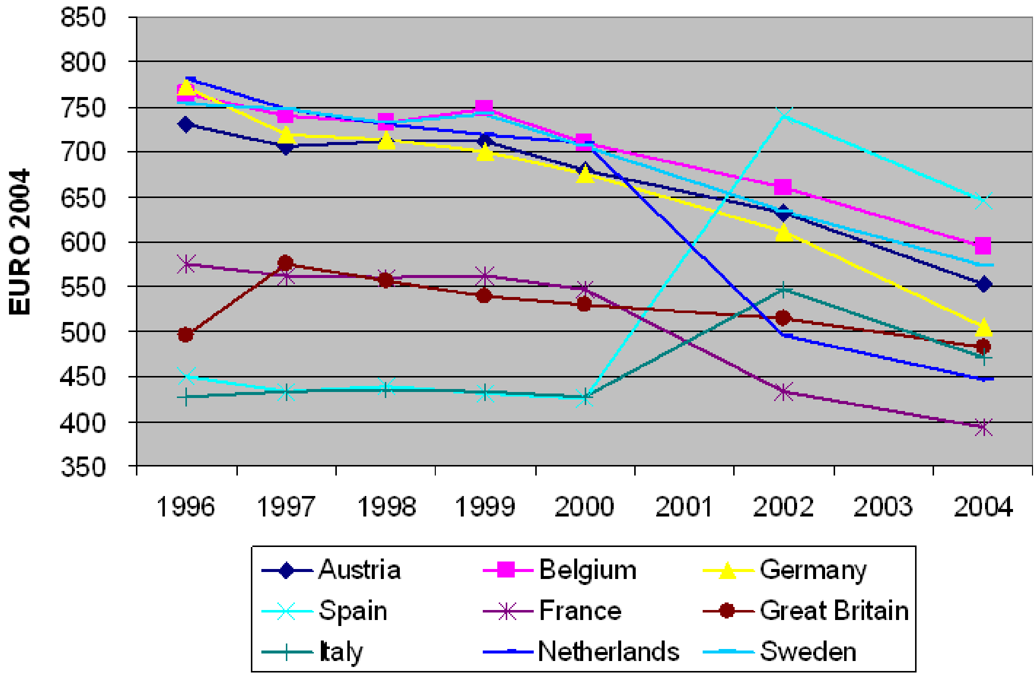
Figure 46: Price ranges in Eastern Europe MS in 2004



	CZ	HU	PL	SK	EE	LT	LV	SI	E. EU 8
Min = C or B	294	240	251	269	426	319	318	325	275
Max = A or A+	480	382	419	487	426	366	381	603	446
W. Average	365	292	315	346	410	358	367	433	333
Class A	369	298	327	358	426	366	381	449	342

Figure 47 presents the evolution of average washing machine price between 1996 and 2004 for some MS in the Western Europe. It is interesting to note that at the beginning in 1996 and until the year 2002, price trends were different among MS; in most of them the prices steadily decreased while a price increase was observed in Italy and Spain. After 2002, prices in all MS declined in coherence with the data presented in Table 18. This global trend is probably the consequence of the deep market transformation occurred during the 90s in these Western Europe MS.

Figure 47: Washing machines price trends in Western Europe MS



The cost division of a typical washing machine could be assumed as for a refrigerator and presented previously according to a study conducted for CECED[41]. As manufacturers of refrigerators often produce also washing machines and same retailers distribute all white goods, the pricing strategy can be assumed to be similar. Therefore, the final selling price of a washing machine is split as follow: 43.3% for the distributor, 40% for the manufacturer and 16.7% for the government through the VAT.

Moreover, materials costs represent about 60% of the manufacturer selling price of a washing machine, this share being lower for the most efficient models. The manufacturer's margin for the most efficient appliances (i.e. energy class A+) is higher than for an A-class model, due to a longer presence on the market and the recovering of R&D expenses for this production line.

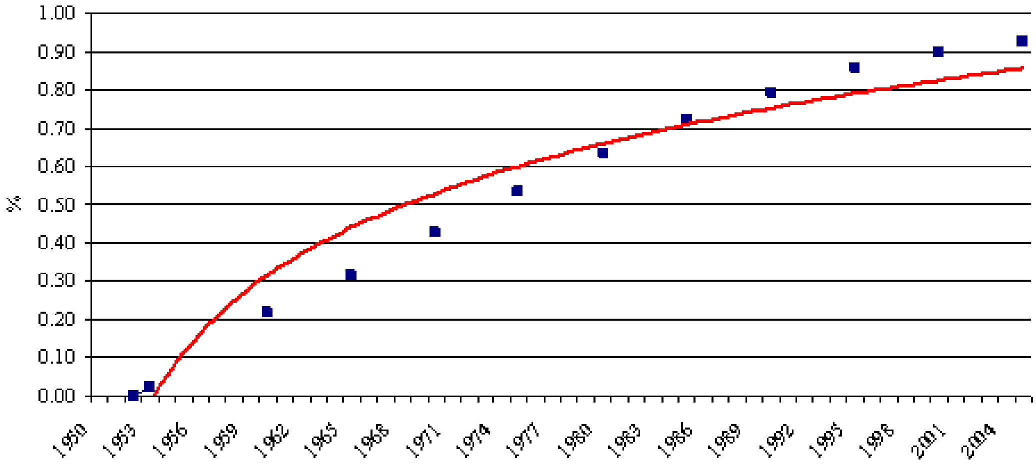
Market maturity

The penetration rates presented in Figure 48 are based on following assumptions:

- before year 1953 there were no washing machines;
- the growth is depicted through a linear logistic function. In the case of the washing machines, the stock is steadily and slowly saturating to an ownership rate of 90%. Probably it will never reach the 100% of saturation because of the habit of many households to use collective laundry shops.

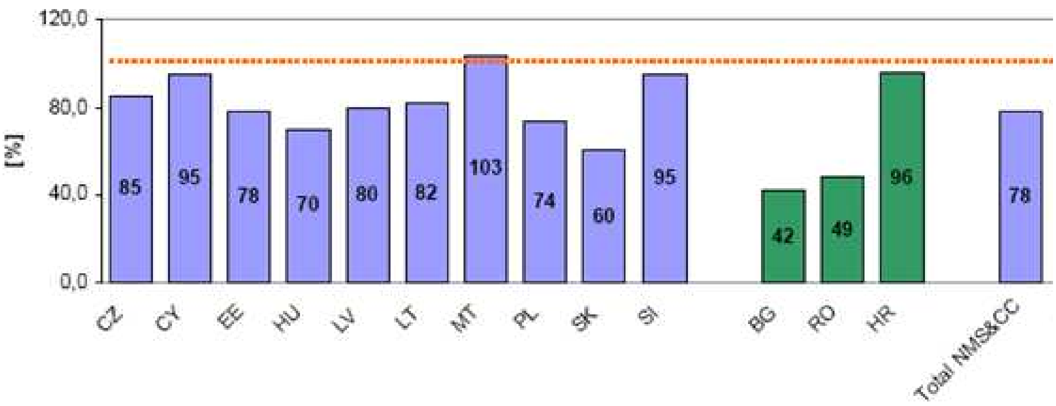
[41] Mebane, B. and E. Piccinno (2006)

Figure 48: Washing machines penetration rate in the EU-15 (red curve)



The penetration rate of washing machines was also estimated for Eastern Europe MS and for candidate MS in 2004 (see Figure 49) and the average ownership rate in EU-12 (+ Croatia) is about 78%.

Figure 49: Penetration rate of washing machines in new MS in 2004[42]



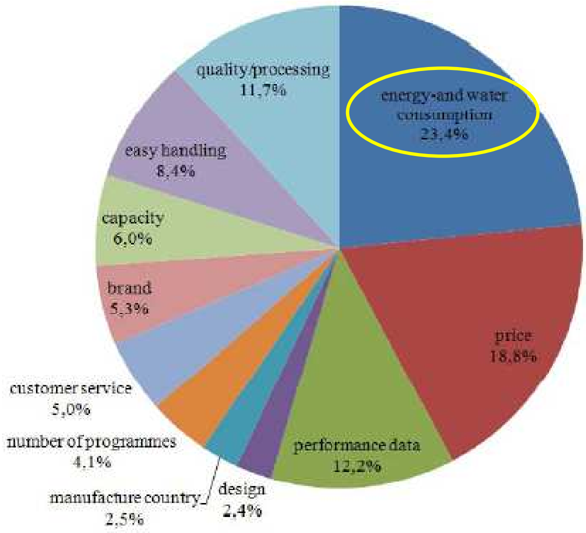
1.3.2.3 Major barriers

Despite the price and functionality of a washing machine being an important purchase criteria for most consumers, the energy and water consumption performance do influence the final purchase decisions. In a German study[43], over 23% of the consumer mentioned that energy and water consumption are the main criteria when they choose a washing machine, followed by the price (18%) and the performance data (12.2%) as shown in Figure 50.

[42] European Commission, DG JRC (2006b)

[43] Innofact AG (2005), *Purchase decision- washing machines*

Figure 50: Buying criteria for washing machines in Germany



This illustrates that the availability of information for consumers on environment/energy aspects at retail shops is crucial in order to increase the sales of efficient washing machines.

Repairing and maintenance

Replacement patterns also affect the penetration of energy efficient washing machines. In the case of breakdown, most consumers prefer repairing the old washing machine instead of buying a new one.

Figure 51: Repairing/service rate of home appliances[44]

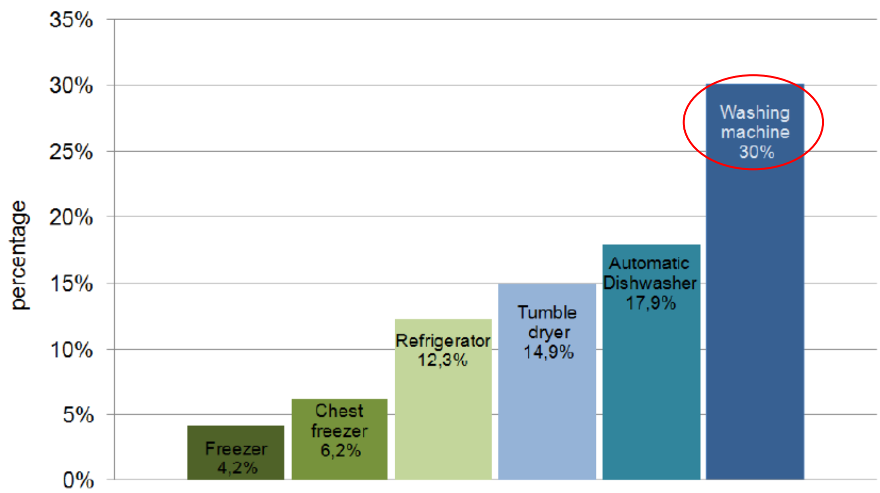
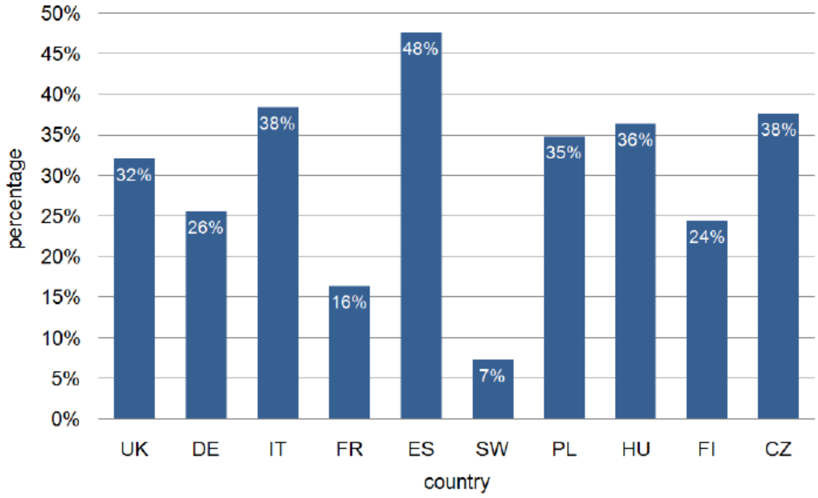


Figure 51 indicates that about 30% of washing machines owned by the European respondents of the survey are reported to have been repaired/serviced, ranking first among all home appliances (Figure 51). Repairing rate in MS ranges from 7% in Sweden to 48% in Spain (Figure 52). The prolonged lifetime of repaired washing machines also extends the time of increased energy consumption by inefficient washing machines.

[44] European Commission, DG TREN (2007c)

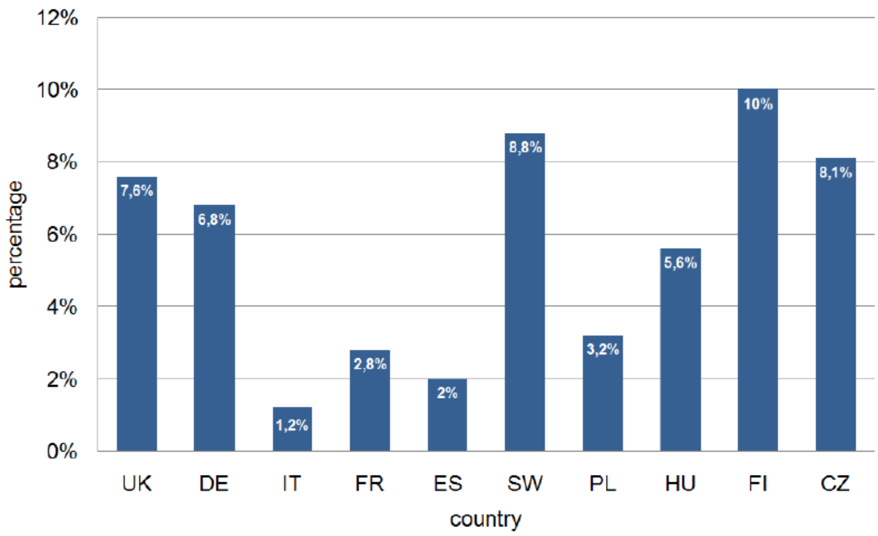
Figure 52: Repairing/service rate of washing machines in some MS



Second-hand market

Another possible choice for the replacement of washing machines is the second-hand models. The share of second-hand washing machines can reach up to 10% in some MS (Figure 53). The average age of second-hand washing machines are 7.3 years old, 1.8 years older than the average age of all washing machines. This leads to an excess energy consumption of using second-hand appliances and a delay of using new models with efficient technology.

Figure 53: Second-hand purchase of washing machines[45]



Consumer training and education

Finally, the consumer training and education is a very important for the decrease of energy and water consumption in real life, considering the large difference in resource consumption of the same model under different washing modes.

45 European Commission, DG TREN (2007c)

2.2.3. Compact Fluorescent Lamps (CFL)

Compact fluorescent lamps can be grouped into two main categories[46]:

- CFL with integrated ballast[47] (CFLi), also called 'energy-saving lamp'
- CFL without integrated ballast (CFLni)

About 90% of the lamps in the first category are used for domestic applications whereas the majority of CFLni lamps are used in office buildings. Also, the overall efficiency of a CFLni also depends on the efficiency of the ballast, essential device for its operation. Finally, in offices CFLni represent only 10% of the installed lamps, whereas linear fluorescent lamps (LFL), which are more efficient than CFLni represent about 80 %[48].

In this study, we will focus on CFL with integrated ballast (CFLi).

1.3.3.1 Product characteristics

Functional description

- **Definition**

CFLi can be classified according to following criteria (see Figure 54):

- Form
- Socket type
- Visual appearance

These design characteristics allow customers to replace their incandescent lamps with CFLi without changing the luminaires or the light fixture.

Figure 54: Examples of CFL with integrated ballast[49]

Several performance parameters can be used to compare CFLi as well as to compare CFLi with incandescent lamps, as defined in the international test standard EN 12665 ('Light and lighting – Basic terms and criteria for specifying lighting requirements'):

[46] In the context of the EuP Directive, two different preparatory studies including CFL were launched. Lot 8 related to office lighting discus with CFLni whereas lot 19 related to domestic lighting discuss with CFLi.

[47] A ballast is a device for starting and regulating the current in a fluorescent lamp.

[48] Estimations based on expert inquiry for the EuP preparatory study on office lighting (lot 8)

[49] Source : Philips

- Rated luminous flux (ϕ) measured after 100 operating hours (expressed in lumen, lm);
- Lamp power (expressed in Watt, W),
- Lamp Survival Factor (LSF), fraction of the total number of lamps which continue to operate at a given time under defined conditions and switching frequency;
- Lamp Lumen Maintenance Factor (LLMF), ratio of the luminous flux emitted by the lamp at a given time in its life to the initial luminous flux;
- Luminous efficacy of a lamp (η_{lamp}), quotient luminous flux emitted by the power consumed by the source (expressed in lm/W);
- Colour temperature (expressed in Kelvin, K);
- Colour rendering (expressed with the Colour Rendering Index, CRI), describing the colour appearance of the surfaces being illuminated by the lamp compared to illumination by daylight;
- Start-up time, required time to provide a continuous light output, but possibly at reduced light output (expressed in seconds);
- Run-up time, required time to provide full brightness (expressed in seconds)
- Lamp lifetime (expressed in hours).

A specific characteristic of fluorescent lamps, both compact and linear, is that they contain mercury for their operating. According to the RoHS Directive[50] entering into force from 1 July 2006, the maximum mercury content in CFLi is 5mg, due to its hazardous properties. Further, CFLi are covered by the WEEE Directive[51] (category 5) and must be collected and treated at their end-of-life.

EU Energy label

The Directive 98/11/EC, which was published on 10th March 1998 and which implemented the Directive 92/75/EC, applies the energy labelling requirements for household electric lamps supplied directly from the mains (CFLi and incandescent lamps) and to household fluorescent lamps (including linear fluorescent lamps and CFLni), even when marketed for non-household use.

The label must include the following information (see Figure 55):

- energy efficiency class ;
- luminous flux in lumens;
- input power (wattage) ;
- average rated life in hours.

[50] Directive 2002/95/EC

[51] Directive 2002/96/EC

Figure 55: Energy efficiency label for lamps

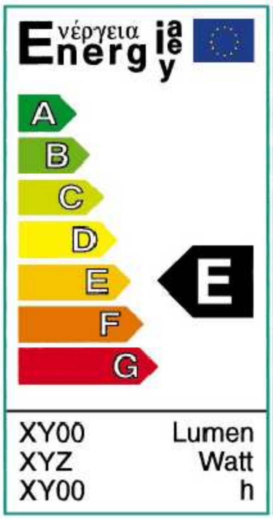


Table 19 presents the energy efficiency class of the main lamp types: CFLi, halogen, and incandescent. Incandescent lamps are the least efficient bulbs, and most of them are E-class. Although CFLi is the best product in environmental terms, two categories can be defined according to their energy class: A-class and B-class.

The main technical parameter allowing a fair comparison of several lamp types is the lamp efficacy. Indeed, for a defined lumen output, e.g. 500 lumen the required lamp power are 50W for an incandescent lamp with a lamp efficacy of 10 lm/W and 10W for a CFLi with a lamp efficacy of 50 lm/W. Therefore, the use of a CFLi implies a reduction of the electricity consumption of 80%.

Table 19: Lamp type according to their energy efficiency class

Energy Class	**A**	**B**	**C**	**D**	**E - G**
Lamp type	'efficient' CFLi	'inefficient' CFLi	'efficient' halogen	'inefficient' halogen	incandescent filament
Average lamp efficacy (lm/W)[52]	48 - 65	40 – 50	16 - 25	10 – 16	8 - 13

Average lifetime and replacement patterns

Two main categories of CFLi can be defined according to their lifetime. Indeed, basic CFLi can operate for about 6,000 hours whereas new bulbs have a longer lifetime of 10,000 hours or even more (up to 15,000 hours) according to manufacturers' data.

The lumen output of a lamp deteriorates during its lifetime. This decrease is not identical for all lamp types and is expressed by the Lamp Lumen Maintenance Factor (LLMF) as presented in Table 20 for typical domestic lamps.

[52] The higher the lamp power, the higher the lamp efficacy.

Table 20: LLMF and LSF data for some commonly used lamps[53]

			Burning hours in thousand hours							
		differences	0.1	0.5	1	2	4	6	8	10
Incandescent	LLMF	moderate	*1.00*	*0.97*	*0.93*					
	LSF	big	*1.00*	*0.98*	*0.50*					
Halogen	LLMF	big	*1.00*	*0.99*	*0.97*	*0.95*				
	LSF	big	*1.00*	*1.00*	*0.78*	*0.50*				
CFL	LLMF	big	*1.00*	*0.98*	*0.97*	*0.94*	*0.91*	*0.89*	*0.87*	*0.85*
	LSF	big	*1.00*	*0.99*	*0.99*	*0.98*	*0.97*	*0.94*	*0.86*	*0.50*

At the end-of-life, lumen output of a basic CFLi (with a lifetime of 6,000 hours) is about 89% of its initial flux and about 85% for a CFLi with longer lifetime (about 10,000 hours). The lifetime of an average incandescent lamp is estimated of 1,000 hours.

Speed of innovation

Improvements have been made by CFLi manufacturers in order to improve the lamp quality. These improvements also allowed reassuring a lot of consumers who had bad experiences with the use of CFLi due to long warm-up and run-up times as well as to the low light output compared to the incandescent lamps.

Nowadays, several 'Best Available Technologies' available are implemented in CFLi to improve their efficiency (i.e. lamp efficacy) or their lifetime. Moreover, new CFLi with reduced mercury content (2 mg) have been put on the EU market.

The European CFL Quality Charter

In 1998, the European Commission developed the European Quality Charter for CFLs to support the Europe wide initiative for the promotion of efficient lighting in the residential sector. The aim of the European CFL Quality Charter is to offer a high quality standard to be used by utilities and other bodies in their promotion and procurement campaigns. The ultimate goal of the European Quality Charter for CFL is to increase consumer confidence in this environmentally friendly technology, which saves money and the environment. This will increase sales of CFLs in the EU and thus contribute to the goals of the EU energy and environmental policies.

During the year 2002, the first revision of the European CFL Quality Charter took place. Nowadays, the European CFL Quality Charter aims at raising consumer awareness and confidence in the CFL, by assuring that certain quality and performance levels are reached. The European CFL Quality Charter is a voluntary set of criteria established by the European Commission in collaboration with a number of private and public organisations, including:

- The European Federation of Lamp Manufacturers, ELC;
- The European Association of the Electricity Industry, Eurelectric;
- ADEME, the French National Agency for Energy and Environmental Management;

[53] CIE, International Commission of Illumination (2005)

* The UK Energy Saving Trust;
* The Danish Electricity Saving Trust;
* SenterNovem (the Dutch Energy Agency).

The above indicated organisations have agreed to support and promote the present European CFL Quality Charter and recommend to public and private organisations, when running promotion, procurement campaigns, to prescribe/procure CFLs, which meet the requirements of the European CFL Quality Charter. The most recent version of the European CFL Quality Charter dates from February 2005 and is currently under revision.

Scope for environmental improvement

Typical current lamps available on the EU market are presented in Table 21.

Table 21: Technical parameters of typical CFLi and incandescent lamp

	Incandescent lamp	*CFLi*
Lamp power (W)	54	17
Lamp efficacy (lm/W)	11.0	48.5
Lumen output (lm)	594.0	824.5
Lamp lifetime (h)	1000	6000

Based on their bill of materials and electricity consumptions, life cycle assessments (LCA) were carried out in order to evaluate environmental impacts of the various type of lamps during the whole life cycle (including the production phase, the manufacturing phase, the distribution, the use phase and the end-of-life).

Table 22 presents the comparison of the outcomes of the LCA for the typical (frosted) incandescent lamp and the typical CFLi. This comparison has been made by dividing the environmental impacts by the lumen output and by the lamp lifetime. It is clearly visible that a CFLi is more efficient than an incandescent lamp with a reduction of the energy consumption of 77%. Moreover, the global warming potential is also reduced (-77.85%).

In 2007, the ELC federation[54] proposed to phase out the least efficient lamps in the domestic sector with a 'step by step' approach (see Table 23). Moreover, minimum lamp efficacy is defined according to the lamp power (see Table 24). Nevertheless, this proposal does not directly concern compact fluorescent lamps with integrated ballast as their lamp efficacy is already higher than the minimum values.

[54] The European Lamp Companies Federation represents the leading European lamp manufacturers representing 95% of total European production. The members of ELC are: Aura, BLV, General Electric, Havells Sylvania, Narva, Osram and Philips.

Table 22: Comparison of environmental impacts of a CFL and an incandescent lamp

		Incandescent lamp	*CFLi*
Environmental indicators	**unit**	**value per lumen per hour**	**value per lumen per hour**
Total Energy (GER)	J	**0.00%**	**-77.00%**
of which, electricity	J	**0.00%**	**-76.07%**
Water (process)	µltr	**0.00%**	**-73.95%**
Waste, non-haz./ landfill	µltr	**0.00%**	**-76.17%**
Waste, hazardous/ incinerated	µg	**0.00%**	**-77.18%**
Emissions (Air)			
Greenhouse Gases in GWP100	mg CO2 eq.	**0.00%**	**-77.85%**
Acidifying agents	µg SO2 eq.	**0.00%**	**-76.75%**
Volatile Org. Compounds	ng	**0.00%**	**-75.99%**
Persistent Org. Pollutants	10^{-3} pg i-Teq	**0.00%**	**-77.85%**
Heavy Metals	ng Ni eq.	**0.00%**	**-78.73%**
PAHs	ng Ni eq.	**0.00%**	**-84.37%**
Particulate Matter (dust)	µg	**0.00%**	**-84.27%**
Emissions (Water)			
Heavy Metals	ng Hg/20	**0.00%**	**-59.61%**
Eutrophication	ng PO4	**0.00%**	**-53.97%**

Table 23: ELC proposal for phasing out inefficient lamps (in domestic lighting)

Lamp Category	Phase 1 2009	Phase 2 2011	Phase 3 2013	Phase 4 2015	Phase 4+ 2017[iv]
>100W	ABCD ~~EFG~~	ABC ~~DEFG~~			
75W+		ABCD ~~EFG~~	ABC ~~DEFG~~		
60W+			ABCD ~~EFG~~	ABC ~~DEFG~~	
25W+				ABCD ~~EFG~~	ABC ~~DEFG~~

Table 24: ELC proposal for minimum lamp efficacy per wattage

Lamp Category	Phase 1 2009	Phase 2 2011	Phase 3 2013	Phase 4 2015	Phase 4+ 2017[vi]
>100W	18 lm/W	20 lm/W			
100W		14 lm/W	17 lm/W		
75W		14 lm/W	16 lm/W		
60W			13 lm/W	15 lm/W	
40W				11 lm/W	14 lm/W
25W				10 lm/W	12 lm/W

1.3.3.2 Market analysis

- ***Sales data***

EU-27 CFLi sales in 2006 were estimated between 220 and 300 million (340-420 million CFL (source Eurostat) minus 120 million CFLni (estimated based on ELC CFLni sales). This is about 4 – 6 times lower than GLS sales (1,350 million in 2006 according to ELC). ELC also estimated that 186 million of CFLi were sold in EU in 2004. Further, recent data published by Eurostat allow estimating CFLi sales in 2007 of about 353 million units. Thus, the growth between 2004 and 2007 is about +185%.

Based on ELC sales data from 2001 to 2006, estimates of CFLi sales have been made and are presented in Table 25. A huge increase is visible since 2005 with a variation of 44% compared to 2004 and continued in 2006 (+60% assuming that 250 million units were sold) and in 2007.

Table 25: Evolution of CFLi sales

	2001	2002	2003	2004	2005	2006	2007
CFLi sales (million)	87	90	102	124	165	250	353

- ***Stock data***

A survey carried out in 2004 in different MS aimed at estimating numbers of lamps used in typical national households, including CFLi. The stock could be estimated by multiplying the number of households by the number of CFLi per household (including households without CFLi). Using this approach, the stock of CFLi in the EU was estimated to be 520 million units (see Table 26). According to the EuP preparatory study on domestic lighting, in 2006 the stock of CFLi in the EU was assumed to be about 750 million units, i.e. an increase of 44% compared to 2004. Further, the recent sales data provided by Eurostat show that the stock in CFLi in 2007 was about 1,010 million units, 35% higher than in 2006.

- ***Price data***

Table 27 lists the price of a typical CFLi available in IKEA shops in EU-27 (Figure 56)[55]. The characteristics of this lamp are:

- Enveloped
- Power = 11 W
- Lifetime: approx. 10,000 hours
- Socket: E14
- Energy efficiency class: B
- The majority of these lamps are manufactured in China.

The price of this CFLi varies from 3.50 € in the Netherlands to 5.62 € in Slovakia. However, in the majority of MS, the price is about 4.25 – 4.50 €.

[55] European Commission DG JRC (2006a)

Table 26: Stock data for CFLi in 2004

EU region	Country	Number of households (HH)	CFLi/HH incl. HH without CFLi	Stock
		millions	no/HH	thousands
Central and Eastern	BG	2.90	0.2	580
	CZ	3.83	2.9	11,107
	CY	0.32	2.0	640
	EE	0.60	0.3	150
	HU	3.75	1.0	3,750
	LV	0.97	0.4	407
	LT	1.29	0.3	323
	MT	0.13	1.0	130
	PL	11.95	0.5	5,975
	RO	8.13	0.2	1,626
	SK	1.67	1.0	1,670
	SI	0.68	1.0	680
Middle	AT	3.08	4.0	12,320
	BE	3.90	2.5	9,750
	FR	22.20	2.3	50,172
	DE	39.10	6.5	254,150
	EI	1.44	1.5	2,160
	LU	0.20	2.0	400
	NL	6.73	4.0	26,920
	UK	26.20	2.0	52,400
Northern	DK	2.31	4.9	11,319
	FIN	2.30	1.0	2,300
	SE	3.90	2.2	8,580
Southern	GR	3.66	1.0	3,660
	IT	22.50	0.8	18,000
	PT	4.20	1.7	7,140
	ES	17.20	2.0	34,400

EU region	Number of households	CFLi/HH incl. HH without CFLi	Stock
	millions	No/HH	thousands
Central+Eastern	36.21	0.7	27,038
Middle	102.85	4.0	408,272
Northern	8.51	2.6	22,199
Southern	47.56	1.3	63,200
EU 27	**195.12**	**2.7**	**520,709**

Figure 56: Typical CFLi (B-class) available in EU IKEA shops

Table 27: IKEA price of typical CFLi (B-class)

MS	Lamp price
Austria	4.50 €
Belgium	4.50 €
Czech Republic	4.47 €
Cyprus	4.25 €
Denmark	3.95 €
Finland	4.48 €
France	4.25 €
Germany	4.75 €
Greece	4.25 €
Hungary	4.63 €
Italy	5.19 €
Luxemburg	4.50 €
Netherlands	3.50 €
Poland	4.25 €
Portugal	4.50 €
Romania	4.50 €
Slovakia	5.62 €
Spain	4.50 €
Sweden	3.69 €
UK	3.62 €

CFLi prices can include an anti-dumping tax in EU-27. By Council Regulation (EC) 1470/2001, the European Commission imposed anti-dumping duties ranging from 0% to 66.1% on imports of CFLi originating in China. By Council Regulation (EC) 866/2005 these duties were extended to Vietnam, Pakistan, and Philippines. In October 2007, the Council adopted a regulation for a one year extension (Council Regulation (EC) 13040/1/07).

Several countries have an added 'disposal/recycling' cost that is included in the sales price. For example, Belgium's transposition of WEEE Directive specifies that a cost is added to the sales price for recycling. It is not a tax since it is not raised by the government but a cost to take care of the recycling. The cost is at present 0.30 € and is added for CFL, linear fluorescent lamps (LFL) and other discharge lamps while there is no additional cost for incandescent and halogen lamps.

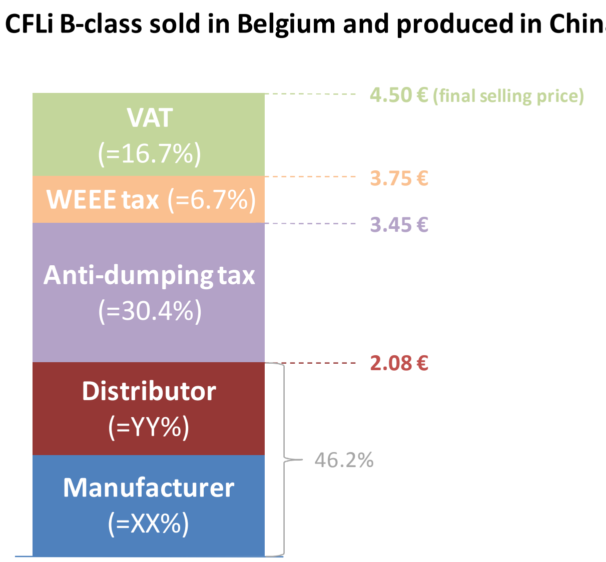
Even if no data is available regarding the evolution of the price of CFLi, a constant reduction has been observed since several years. This explains the change in demand and the high increase of sales, mainly since 2005. One can argue that such a decrease was necessary in order to promote the purchasing of CFLi after bad experiences due to a lack of information and a poor quality of lamps. However, the range of prices is important for CFLi (on average between 2.5€ and 10€) due to several factors:

- The wattage of the lamp (generally the higher the wattage the higher the purchase price)
- The form (bare or enveloped) and the socket of the lamp (manufacturers propose CFLi fitting with almost all types of luminaires)
- The energy label (A or B)
- The overall quality of the lamp, including the quality of light, the colour temperature and the run-up time.

Compared to other products such as refrigerators or washing-machines, there is no clear price difference between Western and Eastern Europe MS, as demonstrated in Table 27. Nevertheless, one has to keep in mind that these prices are presented for the same lamp type sold by IKEA and manufactured by the same company in China. This could also explain such homogeneity.

Unlike white goods, it is not easy to estimate the split of the final selling price of CFLi, especially the share of manufacturer and distributor. However, when considering a typical CFLi available in IKEA shops in Belgium with energy class B, Figure 57 presents the costs division. It was assumed that this lamp was manufactured in China and that the anti-dumping tax was set to the maximum available, i.e. 66.1%. Therefore, about 46% of the final selling price is distributed between the manufacturer and the distributor/retailer. Further, about 30% is due to the anti-dumping tax. The phasing out of the anti-dumping tax could lead to a decrease of the final selling price of CFLi.

Figure 57: Consumer selling price split up for CFLi B-class



A study[56] conducted for Danish Energy Association indicated that the price of A- class bulbs, i.e. CFLi, in the retail sector has fallen dramatically, especially within the supermarket segment. This is true both of ordinary A-bulbs and those recommended by The Danish Energy Saving Trust. The average price of an Energy "A" bulb recommended by The Danish Energy Saving Trust has fallen by approximately two thirds since the spring of 2005.

Despite this marked fall in price there exist wide variations between the price of supermarket own brand and traditional branded bulbs, and this is true both of Energy "A" bulbs and recommended "A" bulbs. On average, branded Energy "A" bulbs are approximately 79% more expensive than supermarket own brand products. Similarly, branded recommended Energy "A" bulbs are more than twice the price of supermarket own brand recommended Energy "A" bulbs. In recent years these price differences have been on the decrease, with the exception of ordinary Energy "A" bulbs where the trend has been for an increased price difference.

In terms of price differences between different types of Energy "A" bulbs, bar shaped bulbs are the cheapest both amongst supermarket own brand Energy "A" Bulbs and branded Energy "A" Bulbs. The price difference between branded and super market own brand Energy "A" bulbs in 2006 was about 4€. Branded Energy "A" bulbs retailed for an average price of 9.1€, supermarket own brand Energy "A" bulbs on the other hand cost 5.1€ on average. The long term trend has been for a narrowing of the gap in prices between supermarket own brand and branded products. It is to be expected that this trend will continue to be in evidence in the future despite a broadening of the gap by 0.1€ between 2005 and 2006.

The same tendency can be observed for a reduced gap in prices between supermarkets own brand bulbs and branded bulbs is seen with reference to Energy "A" bulbs recommended by The Danish Energy Trust. 4.6€ separated the two types of products in the spring of 2006 – compared to a difference of 13.4€ in 2003. This narrowing of the price gap has been brought about primarily as a consequence of a fall in the prices of branded, recommended Energy "A" bulbs.

Market maturity

National experts within EU provided in 2004 data on the penetration rate of CFLi in the MS (see Table 28). There are some huge discrepancies among MS. While 70% of German or Czech households owned at least one CFLi, there are used in less than 20% households in Latvia or Spain. On average, about half of European households own CFLi.

[56] Catinet (2006)

Table 28: Share of households with CFLi[57]

Austria	70 %
Belgium	71 %
Bulgaria	34 %
Czech Republic	70 %
Cyprus	79 %
Denmark	65 %
Estonia	20 %
Finland	50 %
France	52 %
Germany	70 %
Greece	50 %
Hungary	60 %
Ireland	38 %
Italy	60 %
Latvia	19 %
Lithuania	20 %
Luxemburg	70 %
Malta	50 %
Netherlands	60 %
Poland	50 %
Portugal	54 %
Romania	40 %
Slovakia	50 %
Slovenia	70 %
Spain	15 %
Sweden	55 %
UK	50 %
EU-15 (Western EU)	**55 %**
EU-12 (Eastern EU)	**47.9 %**
EU-27	**53 %**

1.3.3.3 Major barriers

- ***CFLi quality and comparison with incandescent lamps (GLS)***

The quality of CFLi has been the focus of several eco-label or quality charter initiatives. This is also true for correctly correlated lamp power of a GLS and a CFLi. Despite several initiatives for the sake of quality very little up-to-date market surveillance data is available. Other lamp types, such as GLS, were paradoxically not often in the focus of such quality initiatives.

[57] European Commission, DG JRC (2006a)

The image of CFLi is not as good[58] mainly due to the experience with the first generation of CFLi that came on the market twenty years ago with cold light colour, poor colour rendering, fairly heavy weight and large dimensions. In the meantime, most of these disadvantages were eliminated. Nowadays, some people also have bad experience with CFLi of poor quality e.g. the light output is not enough, the lifetime is less than declared, etc. Although the quality of an incandescent lamps is often also not good enough, the bad experience with CFLi can damage the image of higher quality products and can make people afraid of buying CFLi again.

In some MS, lists are produced with 'good quality' CFLi that fulfil the requirements of the European CFL Quality Charter[59]. These lists are based on information from the manufacturers as well as on independent testing.

- ***The need for right comparison of light output between CFLi and GLS***

The user should know how to replace incandescent lamps with CFLi giving the same amount of light (lumen). Unfortunately, the manufacturers generally do not give correct information about this replacement. Most manufacturers admit this but have over the years continued to claim that it is not so important. The customers often say 'CFLi don't give good lighting' while they could mean that 'they do not give enough light'. For example, an 11 W CFLi lamp with 550 lamp lumen can suggest on the package to be equivalent to a 60 Watt incandescent lamp (GLS) (see Figure 58). As can be found in chapter 4, a 60 Watt GLS lamp has a lamp lumen output of 710 lumens, which is as a matter of fact about 30% more. In order to obtain the same lumen output, a 60 W incandescent lamp should be replaced by a 13 W but this wattage is not commonly available on the market.

This has been and is still giving the CFLi a bad image and creates a barrier. Many people probably have stopped using the energy saving CFLi because of these negative experiences. Users have the need to be correctly informed at the packaging of the CFLi.

Figure 58: Example of misleading information in the product package of CFLi lamp

The new version of the European Quality Charter recommends an equivalence of 4:1 where a 60 W incandescent should be replaced by a 15 W CFL. This equivalence is

[58] LRC, Rensselaer Polytechnic Institute (2003)

[59] E.g. the Danish Electricity Saving Trust list at:

http://application.sparel.dk/asp/a-paere/query/paerewiz/liste.asp decided taking into account lumen output and lower real life performance of the CFLi compared to GLS due to lamp position, temperature effects and faster decrease in lumen output during lifetime.

Run-up time

Energy Star[60] defines run-up time (also called warm-up time) as the time needed for the lamp to reach 80% of its stable light output after being switched on. The new version of the European Quality Charter requires that the 80% level is reached within a minute for the 'finger-type' CFLi (i.e. bare CFLi) while it takes more time for the 'look-a-like' CFLi (i.e. enveloped CFLi) where there are no requirements.

To reduce the influence of ambient temperature on the light output of a CFLi, manufacturers nowadays use amalgam. An adverse consequence of this use is the longer run-up time of the lamp. This means that either you have CFLi that produce the same light output at all ambient temperatures, but run-up slowly, or you have CFLi that run-up quickly, but give less light at some ambient temperatures.

Nevertheless, manufacturers begin to propose CFLi with a good quality as well as with a shorter run-up time with the use of electronic control circuit with a good quality.

Colour temperature and colour rendering

Various colour temperatures are available for the different types of lamps. In the Southern part of Europe, people prefer a higher temperature (higher content of blue lighting) while people in the Northern parts of Europe prefer a low temperature (higher content of yellow/red lighting).

Incandescent lamps have a CRI (Colour Rendering Index) close to 100 while it is lower existing CFLi which is typically 82-85. At the latest Quality Charter revision meeting in October 2007, several participants recommended the manufacturers to start production and sales of CFLi with higher CRI.

Alleged negative health effects due to UV radiation from CFLi

Some stakeholder groups (Lupus UK, Eclipse Support Group, Spectrum (UK) and Lupus DK) have brought to the attention that some people who are light-sensitive are concerned that shifting to other lighting sources than low wattage incandescent lamps may affect their quality of life. This health effect of CFLi could be a barrier for the phasing out of incandescent lamps.

[60] Energy Star is a voluntary labelling scheme to promote energy efficient consumer products.

2.2.4. BOILERS

1.3.4.1 Product characteristics

Functional description

A boiler is "an appliance designed to provide hot water for space heating". Thus, the primary function of a boiler is "the capability to reach and maintain the indoor climate of an enclosed space (building, dwelling, room) at a desired level under normal and extreme circumstances, in as much as is possible through heating, using hydronic heat emitters".

The (nominal) heating capacity in kW is the most obvious performance parameter of boilers. The other parameters like resources input, emissions, and relevant outputs should also be included in the evaluation of the overall performance for boilers. However, no existing test standards are able to qualify the above parameters in reality due to numerous relevant factors: load operations (full load/30% part-load/stand-by load), size, return (or average) boiler water temperatures, operation mode (steady-state mode/cycling-mode) and etc.

The main criteria for the categorisation of boilers are:

- Fuel type: gas, oil, coal, biomass, electricity, solar energy
- Condensation[61]
    - Standard boiler: a boiler for which the average water temperature can be restricted by design.
    - Low-temperature boiler: a boiler which can work continuously with a water supply temperature of 35 to 400°C, possibly producing condensation in certain circumstances, including condensing boilers using liquid fuel.
    - Gas condensing boiler: a boiler designed to condense permanently a large part of the water vapour contained in the combustion gases.
- Mounting position: Floor-standing, wall-hung (WH)

Power class, materials, pump type, ignition type, and other criteria are used by different standards, statistics and researches to define a category of boilers as well. In this study, which focuses on domestic sector, six categories of boilers are identified as follows based on multiple criteria:

- Gas WH non-condensing
- Gas WH condensing
- Gas floorstanding
- Gas jet burner
- Oil jet burner
- Electric boiler

[61] Source: Boiler Efficiency Directive (BED) 92/42/EC

Average lifetime and replacement patterns

Considerable differences in the average age of boilers of different fuel type are observed as shown in Table 29. The oil-fired boilers show an age of 12.5 to 25.9 years, whereas gas-fired boilers have an average age of 9.5 to 14.2 years. Similar results are indicated by another study[62] that an average boiler age of 12.4 years for gas-fired boilers and 12.7 to 15 years for oil-fired boilers in Belgium.

The overall life of a boiler depends on the respective lives of its components: burners, pumps, fans, and other components which may fail and then are replaced in the lifetime of the boiler. The technical life of a boiler is to some extent decided by a comparison between the cost of repair and that of replacement. Another comparison between the running costs of an old system and that of a new system is also argued to be related to a boiler's technical life. However, consumers would rather rely on advice by installers than to calculate the total cost by themselves. It is recommended by most installers to replace a wall hung gas boiler after a life of 15 years and 20 to 25 years for a floor standing gas or oil boiler.

Table 29: Average Boiler age[63]

reference year 1999		Denmark		France		Germany		Italy		Netherlands		Sweden		UK	
Periods	Average age in period	gas	oil	gas	oil	gas	oil	gas	oil	gas	oil	gas	oil	gas	oil
older than 30 yrs	35	0,00	0,31	0,00	0,19	0,00	0,00	0,00	0,01	0,01	na	0,00	0,46	0,01	0,08
between 20 and 30 yrs	25	0,19	0,28	0,22	0,34	0,19	0,33	0,11	0,24	0,14	na	0,00	0,27	0,16	0,11
between 10 and 20 yrs	15	0,54	0,33	0,48	0,30	0,28	0,31	0,48	0,56	0,44	na	0,45	0,17	0,45	0,28
less than 10 yrs	5	0,27	0,09	0,30	0,18	0,53	0,36	0,41	0,19	0,41	na	0,55	0,10	0,39	0,54
Overall average age	(calculation)	14,20	23,25	14,20	20,55	11,60	14,70	12,00	15,70	12,50	na	9,50	25,90	13,05	12,5

Consumer behaviour

Table 30 presents the spread of the first idea that sprung into the UK householders' mind when they were asked "what motivated you to decide for the installation of a boiler".

The most important reason to install a boiler for UK consumers is the motivation of breakdown of an existing one (49%) or concerns related to that (14%), which together count for approximately two-thirds of the total installation, followed by other motivations including building reorganisation projects, home refurbishments or improvements.

[62] Vekemans, Guy (2004)

[63] European Commission, DG TREN (2001)

Table 30: Reason for new installation[52]

	percentage
Fault or breakdown	49
Old installation prone to breakdown (but still working)	14
Reorganisation due to other building project	7
New requirements (e.g. more capacity, combi functions)	7
New kitchen	6
No heating before	6
Efficiency concerns	4
Safety	2
Extension	2
Wasting money concerns	1
Comfort / level of service concerns	1
Other	3
Total	100

The householders are further asked the first reason why they opted for certain brand or make (Table 31). The majority of respondents (from 50% to 65%) had used only the information supplied by the installer for choosing their boiler. The impact of brand/make and price on the consumers' decisions is far smaller than that of the installer's recommendation. The remaining some 15% to 30% people put other reasons in a dominant place.

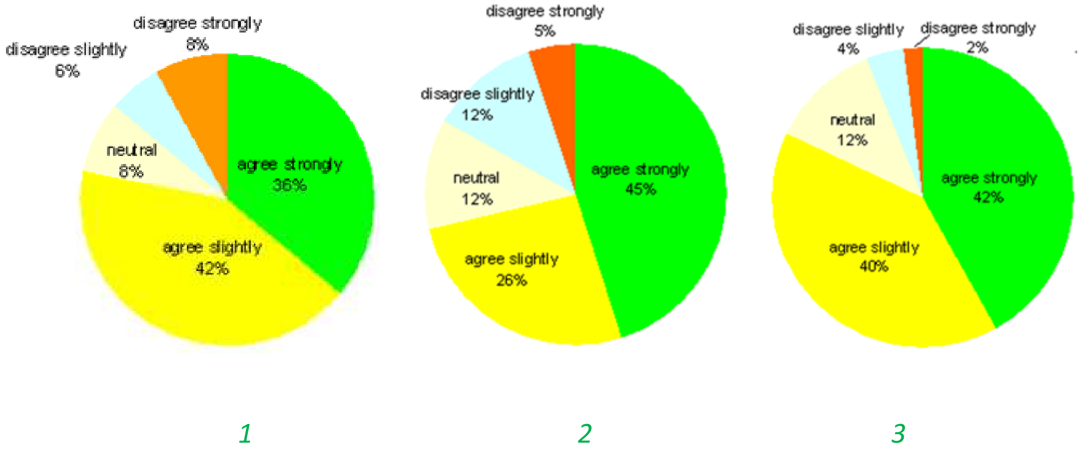
Table 31: Selection of brand or make[52]

	1994	1995	1996	1997	1998
Recommendation by installer	50	50	54	61	65
Well known make/brand	10	11	9	8	10
Price	9	7	6	7	10
Fuel savings / running costs	7	6	8	5	5
Appearance	5	4	5	6	4
Other	19	22	18	13	6

In spite of the fact that only 4% households mentioned efficiency as their first criterion and that 5% to 7% choose a brand/make principally based on energy efficiency, the results do not clarify the relative importance of energy efficiency among all the factors influencing consumers' choices (see Figure 59).

A large majority of respondents indicated their interest in energy efficiency and reducing home energy using. Furthermore, over 80% householders declare to be prepared to spend significantly to heat the home in an environmentally friendly way.

Figure 59: Consumers' energy concerns



1. Are you interested in energy efficiency?

2. Are you interested in reducing home energy using?

3. Are you prepared to spend significantly to heat the home in an environmentally friendly way?

Speed of innovation

Since the implementation of the Boiler Efficiency Directive in 1992, boilers' efficiency has gone through great improvements. Products developments have also taken place, of which the two major trends are:

- The growing share of condensing boilers, and
- The increases in sales of biomass boilers though in small scale.

A great impact of newer technologies on the boiler market and on the environmental performance of the heating sector is predicted. The sales of biomass boilers are already experiencing an upsurge and are believe to continue for years before its market saturation. The initiatives on solar thermal boilers in Spain and the launch of a plan of Micro CHP gas motor systems in the UK have also aroused wide attention. Some discussions are going on about the real impact of these new technologies, for example, regarding the environmental friendliness of the biomass boilers since they are still responsible for significant polluting emissions, though they use renewable energy source.

Scope for environmental improvement

The 1992 Boiler Efficiency Directive launched an EU wide labelling scheme. A boiler can be awarded from one star to four stars based on the comparison of its efficiency at rated output and its efficiency at part load between those values for standard boilers. The detailed efficiency requirements for each class are indicated in Table 32.

Table 32: Energy performance labelling in BED[64]

Label	Efficiency requirement at nominal output Pn and at an average boiler-water temperature of 70 °C %	Efficiency requirement at part-load of 0,3 Pn and at an average boiler-water temperature of ≥ 50 °C %
★	≥ 84 + 2 log Pn	≥ 80 + 3 log Pn
★★	≥ 87 + 2 log Pn	≥ 83 + 3 log Pn
★★★	≥ 90 + 2 log Pn	≥ 86 + 3 log Pn
★★★★	≥ 93 + 2 log Pn	≥ 89 + 3 log Pn

However, this labelling scheme has not had a remarkable impact on consumers. Instead, it initiated a proliferation of a number of test standards. Nowadays, there are over 30 EN product test standards and amendments for oil- and gas-fired heating boilers and burners. With multiple criteria to define a category of a boiler, the related EN standards are also split up by:

- flue gas system: type C room-sealed, type B without a fan, type B with forced draught burner
- capacity class: up to 70 kW, 70-300 kW, 300-1000 kW
- fuel: oil, gas
- configuration: boilers, combi-boilers, boiler-burner assemblies and separate burners
- condensing: low temperature and non-condensing boilers

The Energy Performance of Buildings Directive 2002/91/EC set new minimum requirements on boiler efficiency, making condensing boilers an ideal choice. The labelling Scheme for boilers is put onto the table again by the Energy-using Products Directive 2005/32/EC.

Since 1992, MS have also been taking individual initiatives to improve boiler efficiency. For example, in UK, the “Seasonal Efficiency of Domestic Boilers in the UK” Programme was launched in 1999 which gives a A-G rating (Figure 60) on gas and oil-fired domestic boilers based on equation calculation. Another case in Denmark, it has carried out a one-year pilot on boiler labelling, which provides consumers with the model’s energy consumption, electricity consumption and emissions[65] (Figure 61).

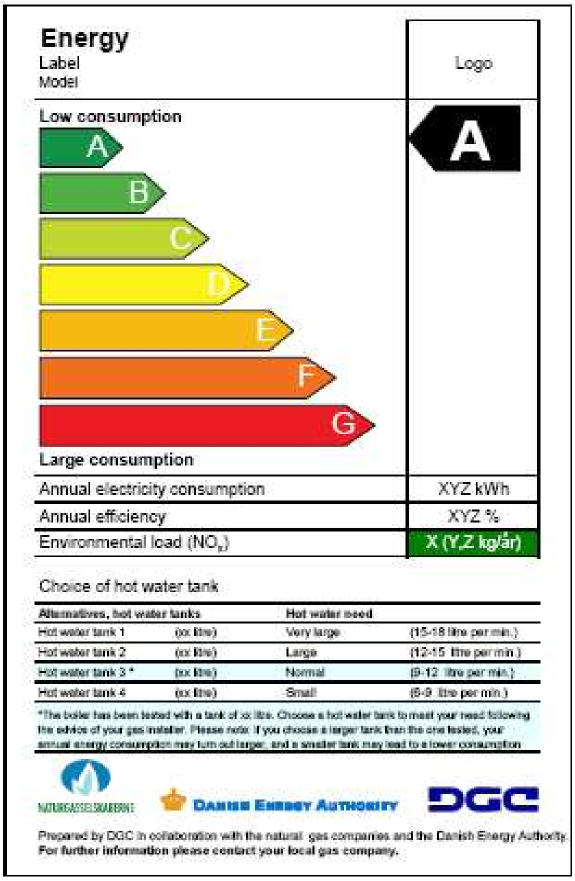
[64] The boiler efficiency Directive (BED) 92/42/EC

[65] Terry Williams, European initiatives on labelling of central heating gas boilers, Advantica, UK

Figure 60: Boiler efficiency label in UK (Sedbuk's energy efficiency chart)

Band	SEDBUK range
A	90% and above
B	86% - 90%
C	82% - 86%
D	78% - 82%
E	74% - 78%
F	70% - 74%
G	below 70%

Figure 61: Boiler efficiency label in Denmark



1.3.4.2 Market analysis

- ***Sales data***

The volume of EU heating boiler market reached some 6.6 million units in 2004 after a 49% growth from 4.5 million units in 1990[66] (see Table 33). A MS wise boiler sales in (EU-22) in 1990 and 2004 is presented in Table 34. The forecasts for the years 2010 and 2025 are presented in Table 35 and Figure 62. The annual sales growth rate is forecasted to be 1% between 2004 and 2010, leading to a 5.5% overall sales increase during the period. The annul sales growth rate is expected to reach 1.2% for the period 2010-2025, which means about 20% increase in total sales.

Table 33: Domestic Heating Boilers' sales in 1990 and 2004 for EU-22 (*000 units)

Product	**1990**		**2004**	
	*000	*%*	*000	*%*
Gas wall hung non-condensing	2502	*52.5*	3986	*57*
Gas wall hung condensing	67	*1.4*	1296	*18.5*
Gas floor standing	949	*19.9*	434	*6.2*
Gas/oil jet burner	900	*18.9*	880	*12.6*
Electric	36	*0.8*	39	*0.6*
Total	**4454**		**6635**	

The progression of market volume during 1990-2004 is largely due to the rapid increase of sales volume of gas wall hung models, together with a slight increase of electric boilers. It is important to notice the significant development of condensing technology in terms of market share, which arrived 18.5% in 2004 from the 1990 level of 1.4%. By contrast, the market share of gas floor standing boilers and jet burners has decreased by 3.7% and 6.3% respectively.

[66] BRG Consult (2006)

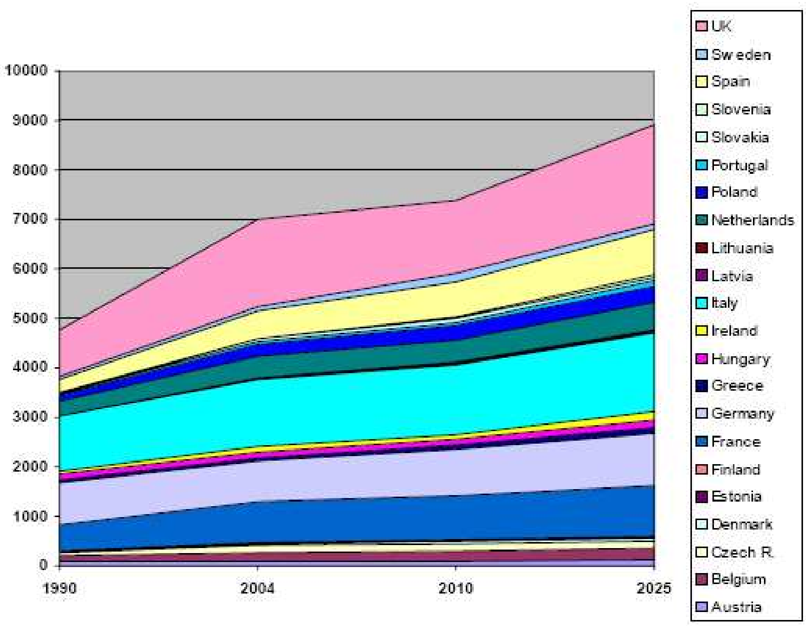
Table 34: Boiler sales, by country, by type in 1990 and 2004

	GAS Wall Hung non-condensing		GAS Wall Hung condensing		GAS Floor Standing		GAS/OIL Jet Burner		ELECTRIC		TOTAL		% of EU22	
	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004
Austria	29	26	1	18,2	12	5,3	33	12,9	0	0	75	62,4	1,68%	0,94%
Belgium	26	78,2	0	27	29	26,6	51	41,7	0	0	106	173,5	2,38%	2,62%
Czech R.	7	76,5	0	8	25	12	0,5	1,12	2	10,8	34,5	108,42	0,77%	1,63%
Denmark	9	6,6	0	16,65	0,7	0,65	6,5	5,8		0	16,2	29,7	0,36%	0,45%
Estonia	0,4	2	0	0,27	0,1	0,43	0,1	0,675	0	0,2	0,6	3,575	0,01%	0,05%
Finland	0	0	0	0	0	0	9,6	12,4	0,7	0,2	10,3	12,6	0,23%	0,19%
France	318	505	14	32,3	62	68,8	130	198,7	0	0	524	804,8	11,76%	12,13%
Germany	292	155	8	340	215	80	294	202	0	0	809	777	18,16%	11,71%
Greece	0,7	11,5	0	0,2	0	0,65	58	67	0	0	58,7	79,35	1,32%	1,20%
Hungary	43	84	0	2,05	65	20	1	1	0	0	109	107,05	2,45%	1,61%
Ireland	12	55,3	0	2,7	1,25	2,4	26	47	0,9	1,4	40,15	108,8	0,90%	1,64%
Italy	848	1171,3	0	59,1	160	64,9	99	46,4	0	0	1107	1341,7	24,85%	20,23%
Latvia	0	5	0	0,5	0,1	1	0,6	0,5	0	0	0,7	7	0,02%	0,11%
Lithuania	0	7,6	0	0,45	1	3,2	0	0,49	0	0	1	11,74	0,02%	0,18%
Netherlands	196	44	43	364	47	7,9	1	0,8	0	0	287	416,7	6,44%	6,28%
Poland	15	115	0	11,4	15	17,9	7	17	0	0	37	161,3	0,83%	2,43%
Portugal	1,8	33	0	0	0,3	1,3	0,5	16	0	0	2,6	50,3	0,06%	0,76%
Slovakia	1	20,5	0	5,8	12	17,9	0	0,39	0	0,4	13	44,99	0,29%	0,68%
Slovenia	0,5	6,45	0	1,45	0,2	0,8	12	9,6	0	0,13	12,7	18,43	0,29%	0,28%
Spain	160	437	0	1	4	7,6	90	100	0	0	254	545,6	5,70%	8,22%
Sweden	0	0,25	0	0,9	0,5	0,5	12,5	3	22,5	7,5	35,5	12,15	0,80%	0,18%
UK	543	1144,8	1	403,97	297	83,827	70	106	10	18	921	1756,6	20,67%	26,48%
Total EU 22	**2502,4**	**3985**	**67**	**1295,94**	**947,15**	**423,657**	**902**	**890**	**36**	**39**	**4454,95**	**6633,7**	**100%**	**100%**

Table 35: Sales outlook 1990-2005-2010-2025 (incl. solid fuel boilers & heat pumps)

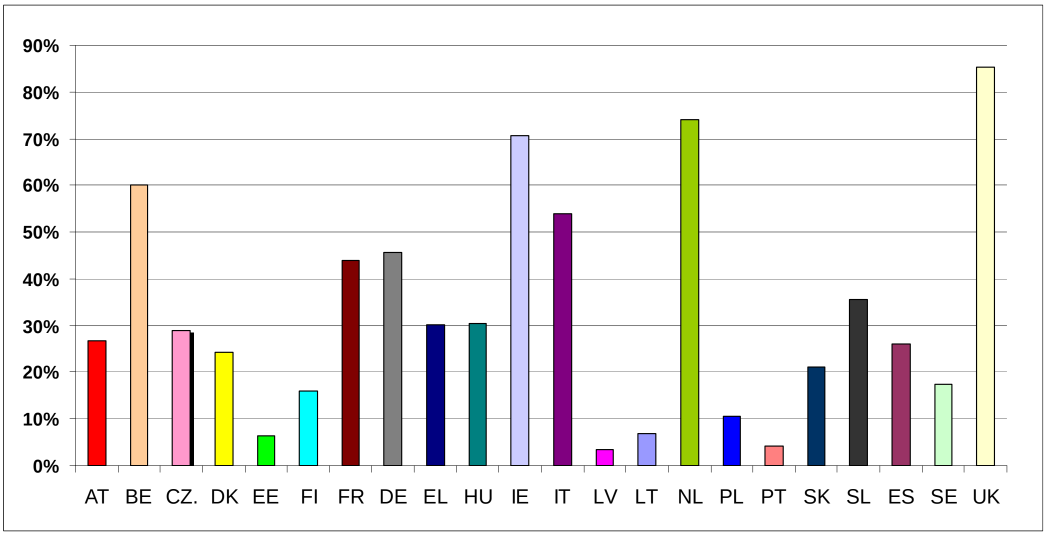
MS	1990	2004/'05	2010	2025
	*000	*000	*000	*000
Austria	97	84	98	110
Belgium	107	175	199	230
Czech R.	63	148	158	160
Denmark	17	34	46	55
Estonia	1	5	11	13
Finland	12	19	23	25
France	541	834	882	1020
Germany	828	810	929	1050
Greece	62	80	104	133
Hungary	127	111	95	150
Ireland	46	113	110	160
Italy	1114	1360	1403	1600
Latvia	3	13	18	25
Lithuania	5	22	28	30
Netherlands	292	420	457	550
Poland	137	237	301	350
Portugal	5	50	59	100
Slovakia	27	60	67	70
Slovenia	20	27	31	40
Spain	260	546	723	930
Sweden	68	81	182	100
UK	935	1762	1450	2000
Total EU 22	**4767**	**6991**	**7374**	**8901**

Figure 62: Sales Forecast for boilers



Notable difference of the sales distribution in the European market is discovered based on a further analysis of sales data in different MS. In the UK and the Netherlands, annual sales compared to the number of dwellings are 85% and 74% respectively, while this index is lower than 10% in some MS (Figure 63).

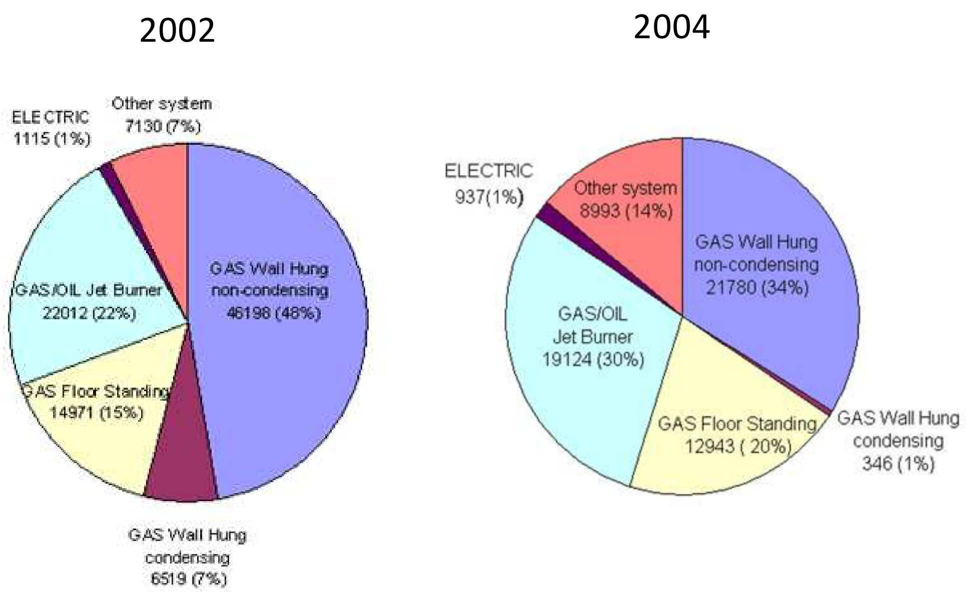
Figure 63: Heating boiler units per dwelling in EU-22 (2004)



- ***Stock data***

In the period 1990-2004, during which the number of dwellings increased by 16%, the boiler stock per dwelling has enjoyed a 52% growth from 64 million in 1990 to 98 million in 2004 (Figure 64).

Figure 64: Individual wet central heating system stock in EU-22 (*000 dwelling)



For detailed park of main boiler types in MS, please refer to Table 36.

Table 36: Park of main boiler types, by Country, in *000 dwellings

	GAS Wall Hung non-condensing		GAS Wall Hung condensing		GAS Floor Standing		GAS/OIL Jet Burner		Electric boiler		Total		Total number of dwellings	
	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004	1990	2004
Austria	264	340	1	175	201	134	327	426	0	0	793	1075	3529	4020
Belgium	318	692	0	84	386	475	841	984	0	0	1545	2235	3751	3724
Czech R.	86	742	0	25	90	376	2	4	16	11	194	1158	4084	3994
Denmark	124	227	0	59	10	17	607	374	0	0	741	677	2573	2800
Estonia	1	13	0	0	1	3	19	21	1	3	22	40	602	622
Finland	0	0	0	0	0	0	391	455	5	6	396	461	2434	2871
France	3450	6697	120	184	1735	2026	3580	4361	0	0	8885	13268	26338	30218
Germany	1602	4150	32	1243	2054	3577	6004	8507	0	0	9692	17477	33350	38398
Greece	4	30	0	0	0	1	1490	1677	0	0	1494	1708	4837	5650
Hungary	324	768	0	7	169	477	3	13	0	0	496	1265	3853	4173
Ireland	75	435	0	6	16	29	170	460	29	37	290	967	982	1370
Italy	4667	12022	0	223	1072	1683	3641	1150	0	0	9380	15078	24719	27941
Latvia	0	25	0	1	9	5	1	3	0	0	10	34	1003	965
Lithuania	0	55	0	1	1	24	6	10	0	0	7	90	1153	1304
Netherlands	3513	1548	193	3310	155	180	0	0	0	0	3861	5038	5802	6810
Poland	236	856	0	26	58	214	97	247	0	0	391	1343	11032	12683
Portugal	3	179	0	0	1	7	2	37	0	0	6	223	4097	5271
Slovakia	16	136	0	14	163	251	0	0	0	0	179	401	1757	1899
Slovenia	1	41	0	3	0	10	190	229	0	0	191	283	639	796
Spain	715	4094	0	3	32	69	413	1554	0	0	1160	5720	16830	22098
Sweden	5	15	0	0	0	0	396	390	459	472	860	877	4725	5060
UK	6381	13143	1	1150	6790	5412	937	1100	427	587	14536	21392	21710	25055
Total EU 22	21785	46208	347	6514	12943	14970	19117	22002	937	1116	55129	90810	179800	207722
% of total	39,5%	50,9%	0,6%	7,2%	23,5%	16,5%	34,7%	24,2%	1,7%	1,2%				

Price data

The European market has varied prices for different types of models (Table 37). The average consumer price for a gas wall hung non-condensing boiler is about 1014 €, and the gas wall hung condensing and gas floor standing models are about 100 – 150 € more expensive than it.

Table 37: Average consumer (street) price (incl. VAT) of boilers in EU-22 (2004)[67]

	Average consumer price (€ incl. VAT)
Gas wall hung non-condensing	1014 €
Gas wall hung condensing	1115 €
Gas floor standing	1152 €

Price differences exist in the markets of different MS, which can be divided into five categories: high, higher than average, average, lower than average and low. In order to simplify the calculation of prices in national markets, factors are defined as follows. For example, in Poland (PL), the average consumer price of a gas wall hung non-condensing boiler is about 500 € (=1014 € * 0.5).

- High: SW (2.6), DK (2.2), AT (2.6)
- Higher than average: DE(1.65), FIN (1.55)
- Average: FR (1.1), UK/BE/SL (0.9), NL/IT (0.85)
- Lower than average: IRL/ES/GR/SK/ES/LT/LV (0.7), PT (0.65)
- Low: PL/CZ/HU (0.5)

In the EuP preparatory study on boilers, estimates were made regarding the split up of the consumer street price with a typical distribution channel as follow: manufacturer/importer → wholesaler → installer. Figure 65 presents this split up assuming that the manufacturer selling price (MSP) is 812€ (excluding VAT), and wholesale margins of 30% and installer margins of 20% and a VAT rate of 19%. Therefore, about 54% of the consumer street price is due to the manufacturer selling price.

Further, Table 38 provides a split up of the manufacturer selling price into its main components: overhead, labour, purchases from OEM (Original Equipment Manufacturer) and raw materials industry. OEM purchases are assumed to represent 50% of manufacturer's costs and the only direct labour costs (i.e. 15%) are attributed to activities such as final assembly, testing and packaging. Direct purchases of raw materials are almost non-existing, as most of components are purchased in a finished and pre-assembled state.

A fairly large share of the manufacturer selling price is made up of overhead costs, related to marketing, administration and margins. For the manufacturer, this is around

[67] BRG Consult (2006)

35% of the MSP, but also the primary and secondary OEMS have overhead costs. Thus, almost half of the manufacturer selling price is made up by overhead costs (i.e. 47%), and the rest is divided in a quite equal way between direct labour and raw materials costs.

Figure 65: Assessment of consumer street price for boilers[68]

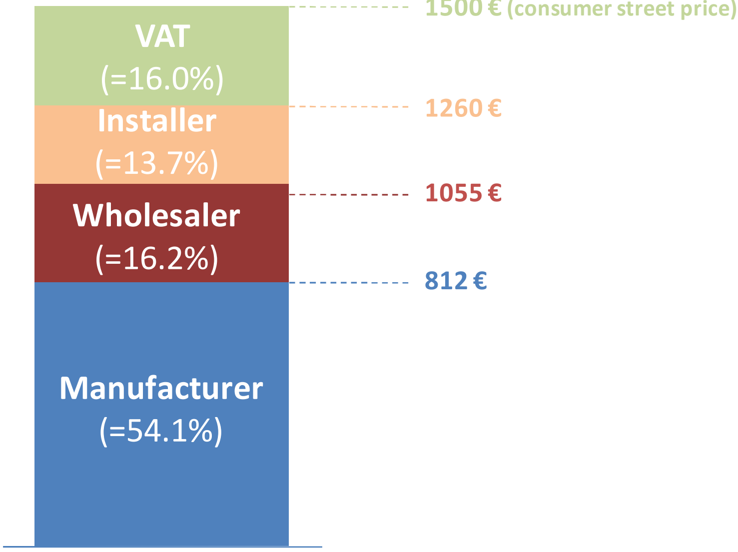


Table 38: Manufacturing selling price split up for boilers

			€	€	€
MSP (manufacturer selling price)	100%		812		
Overhead (marketing, admin, margin)	35%		284		
Labour (finishing, assembly, testing, packaging)	15%		122		
Subassemblies & components (OEM)	50%		406		
of which					
OEM: Overhead				81	
OEM: Labour		15% (=7,5% * msp)		61	
OEM: Raw materials		35% (=17,5% * msp)		142	
OEM: Secondary OEMs		30% (= 15% * msp)		122	
of which					
Sec. OEM: Overhead		15% (=2,2% * msp)			18
Sec. OEM: Labour		20% (=3% * msp)			24
Sec. OEM: Raw materials		65% (=9,8% *msp)			79

Overall: Overhead 47,2% (€ 383), labour 25,5% (€ 205), materials 27,3% (€ 221)

Market maturity

First time installation and displacement of central heating by individual installation have been a major reason for the boiler market growth in EU in the last ten years. As is indicated by the sales data, the quick development of condensing technology has

[68] European Commission, DG TREN (2007a)

introduced a corresponding development of market penetration of models incorporated with the very technology.

Figure 66 shows that the market is almost saturated in some MS (Netherlands, UK and Denmark). In other EU MS, there exists a large potential for increasing the market share. Besides, the demand for replacement of the boilers installed in the past decade has increased in recent years (Table 39 and Table 40) and is expected to continue in the coming years.

Besides, the transition from floor standing boilers to wall hung boilers in several MS results in a higher frequency of replacement, concerning a shorter lifetime of the new models. The enlargement of EU would probably create new opportunities in the boiler market with the improving living conditions in NMS.

Figure 66: Market penetration of condensing technology, 2006

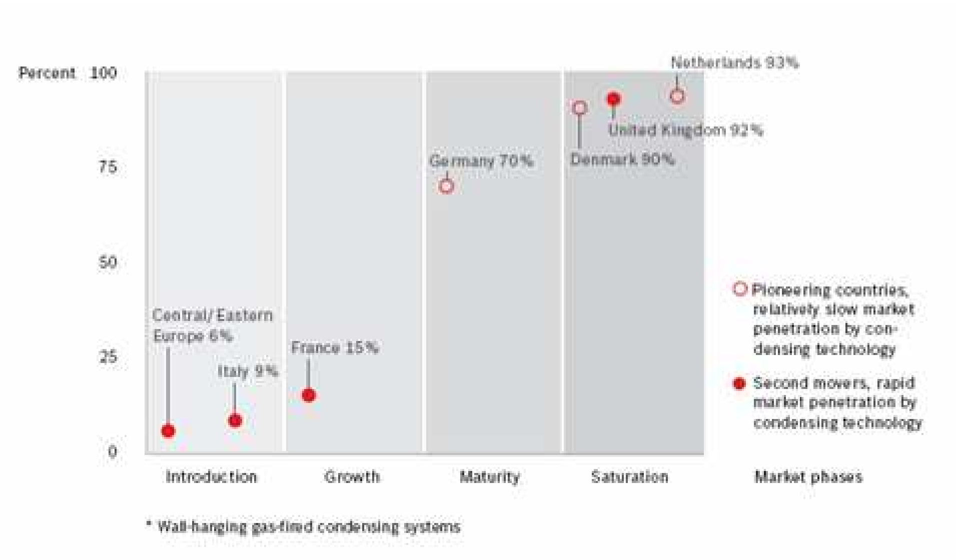


Table 39: Boilers sales by end-use segment, EU-22 (2004)

Product	New housing	1st installation	Replacement	Non-housing
Gas wall hung non-condensing	23,2 %	14,6 %	60,9 %	1,3 %
Gas wall hung condensing	25,3 %	13,7 %	57,1 %	3,9 %
Gas floor standing	12,8 %	11,1 %	66,0 %	10,0 %
Gas/oil jet burner	15,7 %	12,5 %	61,4 %	10,5 %
Electric	10,5 %	19,5 %	67,9 %	1,0 %

Based on these reasons, the market penetration of efficient boilers, i.e. the condensing boiler, is predicted to continue to grow in the next ten years. Some companies expect the market penetration of condensing boilers will reach 58% in 2010 from the current level of 42%, and a correspondent decrease penetration of conventional boilers.

Table 40: Boilers market trends in 2005

Country	Trends 2005	Explanation
Austria	- 0.8 %	Wall hung gas growth, floor standing gas + oil decline
Belgium	+ 6.5 %	All growth from wall hung gas
Czech R.	- 1 %	Decline for all categories except solid fuel
Denmark	+ 12 %	Most of growth in solid fuel (pellet) boilers
Estonia	+ 27%	Mostly wall hung gas boilers and solid fuel boilers
Finland	+ 3.6%	Growth almost entirely heat pumps
France	-/+	Strong growth in wall hung gas, strong decline in oil boilers, and growth for solid, heat pumps and dry electric.
Germany	- 10%	Decline in all categories except heat pumps and solid fuel
Greece	+ 4.4%	Growth entirely in wall hung gas
Hungary	- 8%	Decline in all sectors except solid fuel
Ireland	+ 4.9%	For both wall hung gas and oil boilers
Italy	+2.5%	Growth mostly from wall hung gas
Latvia	+ 7%	Growth mostly from wall hung gas
Lithuania	+ 9%	Growth in wall hung gas and solid fuel
Netherlands	+ 5.3%	Mainly replacement of wall hung gas
Poland	+ 1%	Growth in solid fuel, decline in gas/oil (even wall hung gas)
Portugal	+ 3%	Mainly jet burner boilers in non-gasified areas
Slovakia	+ 2.3%	Growth in wall hung gas and solid fuel (pellet) boilers
Slovenia	+ 2%	Mainly wall hung gas and some solid fuel
Spain	+ 8.3%	Mainly wall hung gas in new housing
Sweden	+ 20%	Mainly electric heat pumps, electric immersion and solid fuel boilers
UK	- 4%	Decline in cast iron, floor standing and back boilers.

1.3.4.3 Major barriers

- ***New installation***

Buyers of boilers for the first installation are mainly the housing developers who are not confronted with the energy costs (Table 41). For them, the additional costs from the installation of more efficient boilers cannot be directly added to the price of a new house. They tend to be reluctant to make energy efficiency improvements beyond the standards required by the legislation, with the need to maximise their profit by reducing the construction costs. This is especially true for the countries where the energy tariffs or awareness of the potential house-owners of the energy bill are comparatively low, resulting in a barely small impact of the energy efficiency on the price of the building.

Table 41: Reason for new installation[69]

	percentage
Fault or breakdown	49
Old installation prone to breakdown (but still working)	14
Reorganisation due to other building project	7
New requirements (e.g. more capacity, combi functions)	7
New kitchen	6
No heating before	6
Efficiency concerns	4
Safety	2
Extension	2
Wasting money concerns	1
Comfort / level of service concerns	1
Other	3
Total	100

Replacement

The main decision for boiler replacement is not made by the direct user. Installers play a dominant role on the consumers' decision on the type of boiler. The absence of energy labelling for boilers in Europe (except for several countries) makes it impossible for consumers to compare the energy efficiency and other performance parameters of boilers themselves. Thus they usually do not go against the installers' "expert" advice.

However, this influence of installers is not seen as positive on boiler energy efficiency improvement of households. Having the experience with certain brand and/or type of boilers, tools and spares available, the installers have a strong preference for a certain group of products, which they believe are steady, reliable and lower in call back rates. The bound between installers and manufacturers is made tighter by the manufacturers' promoting measures like bonus, gifts and training. Moreover, there seems to be a low recognition among installers of the potential benefits delivered by energy efficient technologies to households.

[69] Vekemans, Guy (2004)

2.3. EXPERIENCES OF TAX INCENTIVES IN THE EU

2.3.1. Refrigerators & Washing Machines

1.4.1.1 The Netherlands

General description

- Name of the programme: *Energy Premium Regulation (EPR)*
- Objective: *Energy efficiency*
- Duration: *4 years*
- Period: *2000 till 2003*
- Type of tax incentive: *Subsidy provided by the Government after the purchase*
- 'Target' of the tax incentive: *Consumers*
- Initiator of the programme: *The Dutch Government and SenterNovem (Dutch Energy Agency)*

Scope

Refrigerator

Combined

Freezer

Dishwasher

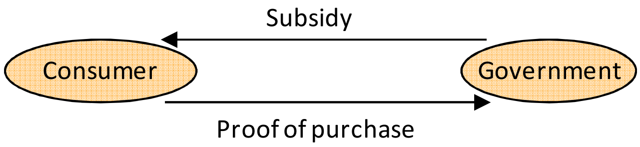
Washing Machine

Tax incentive

- Subsidy delivered for the purchase of an efficient appliance (not only in case of replacement)
- Subsidy scheme in 2001:

Item	Subsidy (€/unit)
Fridge/freezer A-label	50
Fridge/freezer A-label with EEI =0,42 (e.g. A+)	100
Dishwasher A (energy), A or B for performance and drying	50
Dishwasher A-label for energy	50
Washing machine, A, A, A	100
Electrical tumble drier A-label for energy	160
Gas-fired tumble drier	160
Washer-drier with A-label for energy	205

Conditions of implementation



- Government:
  - *Deliver the subsidy to consumers within 6 weeks after receipt of the proof of purchase*
  - *The EPR programme (covering also buildings and renewable energies) was financing with the energy tax, Regulating Energy Levy, set in 1996 and taxing energy using products (electricity, oil and natural gas) sold to households and SMEs*
- Consumer: *Send the Treasury the proof of purchase*

<u>Impacts</u>

	2000-01 (2 years)
Costs for the Government (for refrigerators & combined)	~ 60 M€
Market share for refrigerators & combined	A : 23% in 1999 and 70% in 2001 (75% in 2003, at the end of the scheme) A+ : 0% in 1999 and 6% in 2001 (23% in 2003, at the end of the scheme)
CO_2 reduction (for cold appliances and washing machines)	31,5 kt CO_2

Share of A-class appliances in the Netherlands and in EU (Source: GfK)*

Appliance	1999	2000	2001
Refrigerators			
NL	26%	55%	67%
EU*	12%	19%	27%
Freezers			
NL	29%	55%	69%
EU*	12%	16%	n.a.
Washing machines			
NL	40%	71%	88%
EU*	15%	26%	45%
Dishwashers			
NL	27%	55%	73%
EU*	n.a.	n.a.	n.a.

*EU = Germany, UK, Ireland, France, Austria, Belgium, Netherlands, Portugal, Sweden, Spain

The Energy Premium Regulation scheme was stopped in 2003 because of budgetary reasons and the large number of 'free riders' (people who would buy efficient appliances regardless the subsidy). Indeed, a consumer survey showed that 84% of questioned customers were not influenced by the EPR subsidy in their buying decision.

1.4.1.2 Spain

General description

- Name of the programme: *Plan Renové Electrodomésticos, in the context of the Spanish Strategy of Energy Efficiency and Energy Savings*
- Objective: *Energy efficiency + End-of-Life*
- Duration: *2-3 months per year, depending on the region and the year*
- Period: *2006 till 2010 or 2011 or 2012*
- Type of tax incentive: *Rebate provided directly at the checkout*
- 'Target' of the tax incentive: *Consumers*
- Initiator of the programme: *The Spanish Ministry of Industry with the support of ANFEL[70], the Spanish CECED*

Scope

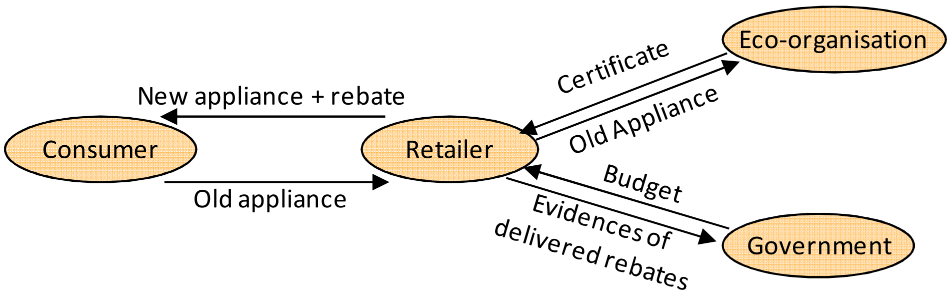
Tax incentive

- Rebate delivered only in case of replacement of the old appliance
- Rebate between 75€ and 105€ according to the appliance and the region, with a maximum amount of 25% of the initial product price
- Example of rebate scheme in 2007 in the region of Valencia (duration = 2 months):

	Refrigerators and Combined	**Freezers**	**Dishwashers**	**Washing Machines**
A++	100 €	100 €	x	x
A+	90 €	90 €	x	x
A	80 €	80 €	80 € (with washing class A or B)	80 € (with washing class A or B)

[70] Asociación Nacional Fabricantes Electrodomésticos Línea Blanca

Conditions of implementation

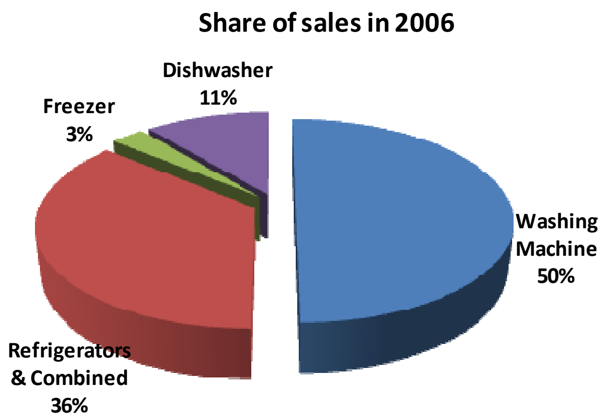


- Federal Government: *Defines the budget allowance and divides it by regions according to the number of inhabitants*
- Regional Government: *Decides the conditions of the programme (duration, amount of the rebates) and gives retailers communication tools*
- Consumer:
  - *Receives the rebate at the checkout*
  - *Receives a receipt with the initial product price and the rebate*
- Retailer:
  - *Receives 5€ per sale of appliances with rebate in compensation of administrative and treasury costs*
  - *Takes off the old appliance when delivering the new one, and gives it to the eco-organisation*
  - *Receives the reimbursement by the Regional Government at the end of the campaign for the rebates delivered and for the compensation of administrative and treasury costs*
- Surveillance: *An official laboratory verifies randomly the electricity consumption (i.e. the energy class) of 25 appliances*
- Communication: *The Regional Energy Agency establishes a database with the energy class of available appliances, based on data provided by ANFEL*

Impacts[71]

	2006	2007
Costs for the Government	62 M€	62 M€
Sales of appliances with rebate	607 103	750 000 (estimation)
Energy savings	185 GWh (= 15.9 ktoe)	*Not available*

[71] Source: ANFEL



1.4.1.3 Hungary

General description

- Name of the programme: *The Forgo Morgo campaign*
- Objective: *Energy efficiency + End-of-Life*
- Duration: *2-3 months depending on the appliance category*
- Period: *17 September 2006 – 16 December 2006 for domestic cold appliances*

  22 March 2007 – 2 June 2007 for washing machines

  16 September 2007 – 24 November 2007 for electric cooker (only advertising campaign, no rebate)
- Type of tax incentive: *Rebate provided directly at the checkout*
- 'Target' of the tax incentive: *Consumers*
- Initiator of the programme: *Hungarian CECED and a big manufacturer*

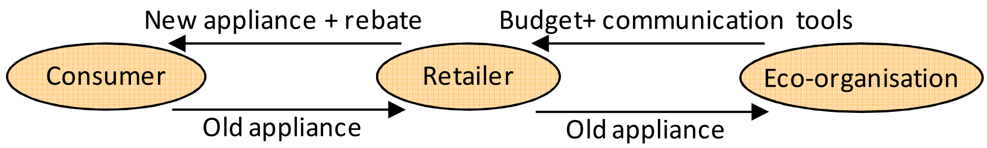
Scope

Tax incentive

- Rebate delivered only in case of replacement of the old appliance
- Rebate scheme:

	Refrigerators and Combined	Freezers	Washing Machines
A++	20 €	20 €	x
A+	20 €	20 €	x
A	20 €	20 €	20 €

Conditions of implementation



- Government: *Not involved in this programme*
- Consumer: *Receives the rebate at the checkout*
- Retailer:
  - *Indicates in its store which appliances can benefit of a rebate*
  - *Takes off the old appliance when delivering the new one, and gives it to the eco-organisation*
  - *Receives the reimbursement by the eco-organisation, Elektro-cord, at the end of the campaign for the rebates delivered*
- Eco-organisation (Elektro-cord):
  - *Reimburse retailers for the delivered rebates*
  - *Provide communication tools to retailers*
- Surveillance: *Carried out by Elektro-cord*
- Communication: *TV spots, dedicated website with an eco-calculator*[72]*, opening and closing ceremonies, financing by Elektro-cord*

Impacts[73]

	Domestic Cold Appliances	Washing Machines	Electric Cookers
Sales of appliances with rebate	7 600	10 300	No significative effect on sales

[72] www.energiakalkulator.hu

[73] Source : CECED Hungary

1.4.1.4 Italy

General description

- Name of the programme: *Law of 27 December 2006, Article 1, point 353*
- Objective: *Energy efficiency + End-of-Life*
- Duration: *initially 1 year, but extended to 4 years due to CECED's lobbying*
- Period: *2007 till 2010*
- Type of tax incentive: *Tax credit of the income tax*
- 'Target' of the tax incentive: *Consumers*
- Initiator of the programme: *the Italian Government supported by the Italian CECED*

Scope

Refrigerator

Combined

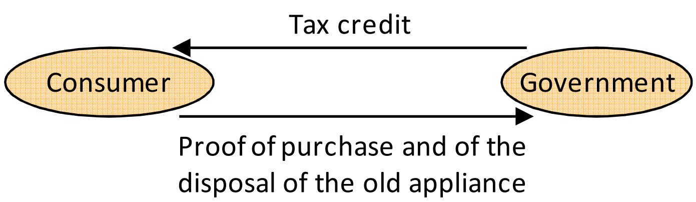
Freezer

Tax incentive

- Tax credit delivered only in case of replacement of the old appliance
- Tax credit scheme:

<table>
<tr><th></th><th>Refrigerators and Combined</th><th>Freezers</th></tr>
<tr><td>A++</td><td colspan="2" rowspan="2">20% of the initial product price
(maximum amount = 200 €)</td></tr>
<tr><td>A+</td></tr>
<tr><td>A</td><td>x</td><td>x</td></tr>
</table>

Conditions of implementation



- Government: *Deducts the tax credit from the income tax*
- Consumer: *Sends with his income tax return the proof of purchase of the new cold equipment (A+ or A++) and a proof of the disposal of the old appliance (certificate of the eco-organisation or self attestation)*

Impacts[74]

	2007 (9 first months)
Costs for the Government	between 90 and 130 M€ (estimations)
Sales with tax credit	+ 28% for A+ and A++ compared to 2006 A+ and A++ = 67% of the total sales of new models
Energy savings	43.6 GWh (9,6 ktoe)
CO_2 reduction	27,7 kt CO_2

1.4.1.5 Denmark

In 1999, the Electricity Saving Trust launched a 2-months programme to promote the purchase of energy efficient cold appliances and laundry dryers (from the 20th of September until the 5th of December). Therefore, consumers buying a domestic cold appliance (refrigerator, vertical freezer and combined) with an energy class A or better could obtain a 100 $ rebate directly at the checkout (200 $ rebate for the purchase of a A-class or better laundry dryer).

Retailers were in charge of the promotion of these efficient products in their stores. Stickers were used in order to allow customers identifying them as showed in Figure 67.

Figure 67: Example of sticker used for refrigerators with subsidy

The campaign was a success as the market share of A-class sales was of 50%, whereas it represented only 10% before[75].

In 2004, the Electricity Saving Trust initiated a similar programme for A+ and A++ labelled fridges.

1.4.1.6 Switzerland

In the region of Zurich, customers of the local electricity supplier (EWZ) can receive a 120€ subsidy for the purchase of an A++ domestic cold appliance from May 2007 until 2011.

EWZ had already initiated a similar campaign between 2003 and 2006 for the A+ and A++ refrigerators, freezers and their combinations. The subsidy was of 60€ for the A+

[74] Source: CECED Italy

[75] Source: Norden, *Environmental communication to consumers*, 2006

product and of 120€ for the A++ product. During this period 6,500 appliances were sold, which represented a direct cost of 533 k€ for EWZ, but annual energy savings of 750 MWh[76].

2.3.2. Compact Fluorescent Lamps (CFLi)

International survey

An international survey was carried out between September and December 2006 by the Efficient Lighting Initiative (ELI), with support from Joint Graduate School for Energy and Environment, to lean from internationally implemented programmes to promote market penetration of CFLs. 26 programmes in 14 countries (see Table 42) answered the questionnaire.

Table 42: List of programmes surveyed

	Country	Programme Name
1	Australia	Equipment Energy Efficiency Programme – Greenlight Australia
2	Australia	Energy Australia – Energy Efficiency Campaign
3	Canada	Switch and Save Campaign (2004)
4	Canada (BC)	CFL Giveaway Campaign (4 phases)
5	Canada (BC)	Lighting Rebate Campaign (2 phases)
6	Canada (BC)	Lighting Fixture Campaign
7	Canada (Manitoba)	Power Smart CFL Program
8	Canada (Nova Scotia)	Lighten Up
9	Canada (Quebec)	Programme d'éclairage Efficace Mieux Consommer
10	Canada (Ottawa)	Project Porchlight
11	Canada (Saint John)	Lighting the Way, Save Everyday
12	China	China Green Lights Program
13	Europe	Energy Efficient Residential Lighting Initiative (EnERLIn)
14	Europe (Hungary)	European Efficient Residential Lighting Initiative –Hungarian part
15	India (Bangalore)	BESCOM Efficient Lighting Program (BELP)
16	New Zealand	National CFL Program
17	New Zealand	Ecobulb projects
18	Philippines	Philippine Efficient Lighting Market Transformation Project (PELMATP)
19	Poland	Poland Efficient Lighting Program (PELP)

[76] Source : Topten.Info, *Cold Appliances : recommendations for policy design*, 2007

	Country	Programme Name
20	South Africa	Efficient Lighting Initiative, (ELI)
21	South Africa	DSM Recovery Programme
22	Sri Lanka	CEB – CFL Program
23	United Kingdom	Energy Saving Recommended
24	USA	ENERGY STAR
25	USA, China, Brazil	CFL Harmonization
26	Vietnam	Compact Fluorescent Lamp Promotion Program

There is a wide range of programmes depending on their implementing agency (Figure 68), their type (Figure 69), their budget (between $ 200,000 and $ 15 million) and their duration (between a few months and 10 years).

Thus, about 62% of the 26 programmes were initiated by public authorities, either governments or utilities.

Figure 68: Type of implementing agency[77]

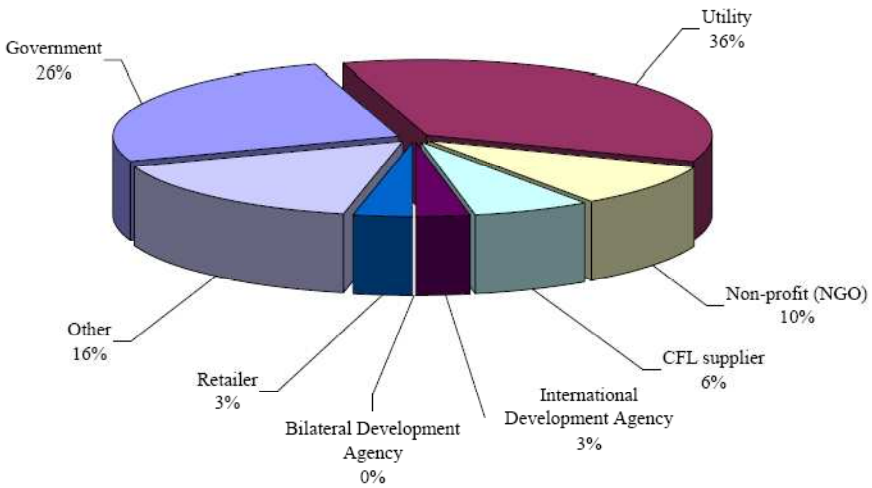
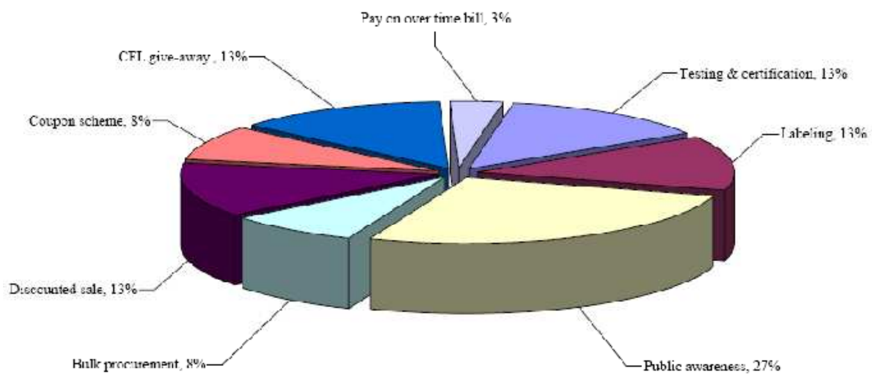


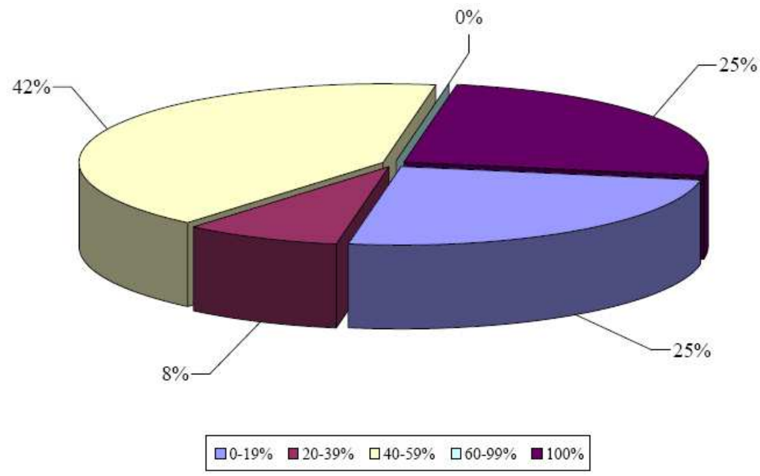
Figure 69: Type of programme[77]



[77] P. Du Pont, *International survey of CFL program experience*, October 2007

Amongst programmes providing subsidies for the purchase of a CFL, 25% give these energy saving lamps for free, whereas 42% propose a rebate between 40% and 59% of the initial product price as highlighted in Figure 70.

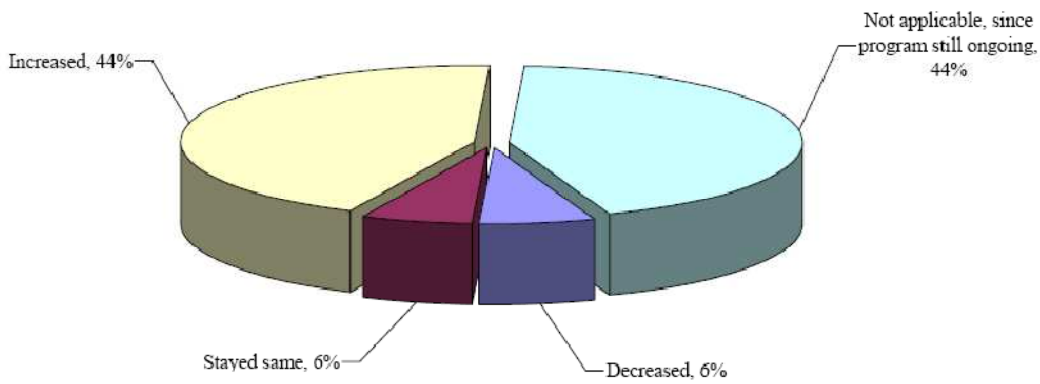
Figure 70: Level of CFL subsidy/incentive (in relation to the initial product price)



Based on results of programmes which are over, in many cases CFL sales increased. Depending on the initiative, 3,000 up to 5 million CFLs were sold. Therefore, the market penetration relative to incandescent lamps was between 5% and 33%.

The direct and indirect energy savings were estimated respectively of 465 GWh/year and of 2,328 GWh/year. The relative reduction of CO_2 emissions was up to 559 kt.

Figure 71: Impact of programmes on CFL sales



- ***Germany***

Germany was the Bright North Rhine Westphalia DSM action. 80 utilities participated in the programme. As results about 500,000 CFLs were directly delivered to customers or bought via vouchers[78]; in addition participants were motivated by the programme to buy additional CFLs. Also nonparticipants increased their purchase of CFLs. Another interesting CFL campaign reported by Thomas was carried out by Stadwerke Hannover as part of a least cost planning project. Every customer could get a rebate of 5.11 € on

78 P. Bertoldi and B. Atanasiu, *Residential lighting consumption and saving potential in the enlarged EU*, June 2006

every CFL bought. Most of incentive programmes in Germany by utilities for efficient appliances or CFLs were stopped by the end of 1999.

- ***Denmark***

Denmark has a taxation on lighting sources added to the sales price:

- CFL: no tax
- Incandescent: 3.75 DKK (= 0.5 Euro)
- Fluorescent tube: 7.5 DKK (= 1 Euro)
- Halogen low voltage: 0.75 DKK (0.1 Euro)
- Halogen 230V: 3.75 DKK (= 0.5 Euro)
- Metalhalogen: 7.5 DKK (= 1 Euro)
- Emission lamp: 7.5 DKK (= 1 Euro)

The Danish taxation is basically a tax to collect state income and could also be seen as an energy efficiency effort because there is no tax on CFLi but nevertheless there is a tax for fluorescent tubes and metalhalide lamps which are considered as energy efficient lamps.

- ***Portugal***

According to a decree-law of April 12, 2007, Portugal has such an added cost or 'tax' for low energy efficiency lamps to compensate for environmental influence from this type of lighting. The tax is calculated based on the following parameters: electric power and life cycle of the lamp compared to energy efficient lamps and the average value of CO_2 emission factor and cost for Portugal. The tax income will feed the Portuguese Fund for Carbon (80%) and the Energy Efficiency Fund (20%).

2.3.3. Boilers

Although there is no tax incentives programme at national level, several MS have launched initiatives to foster the purchase of energy efficient boilers. Table 44 lists these past of current schemes.

As condensing boilers are considered as the environmental alternative to traditional boilers, they are in the scope of the tax incentive programmes except in Denmark where only natural gas and biomass boilers are eligible.

Regarding the type of tax incentives, only France proposes a tax credit (since 2005) for individuals buying a condensing boiler. The other schemes deliver subsidies.

Subsidies amounts delivered in Austria depend on the lands as shown in Table 43.

Table 43: Overview of subsidies for gas condensing boilers in Austria in 2000[79]

[79] H. Ritter and G. Benke, *Natural gas for domestic appliances in Austria – Future perspectives and the potential of energy efficient technologies*, 2000.

Land	Subsidies
Vienna	no subsidies for gas condensing boilers
Lower Austria	In Lower Austria, the *Land* grants a 15% subsidy for replacing boilers. The utilisation of a gas condensing boiler increases the maximum subsidy by ATS 5 000.
Upper Austria	An additional investment subsidy of ATS 2 040 is paid to new gas customers by *Ferngas Oberösterreich*, the regional gas supplier, for the use of a gas condensing boiler.
Burgenland	no subsidies for gas condensing boilers
Styria	In Styria, the utilisation of gas condensing boilers is strongly promoted by the gas supplier. If a condensing boiler is used, costs per m^3 gas are reduced by a total of 0.6 ATS. This equals a cost reduction of approx. 10% . In addition, *Ferngas Steiermark* grants an investment subsidy of ATS 10 000.
Salzburg	The *Land* of Salzburg provides a powerful subsidising instrument for gas condensing boilers. Since 1996, the only gas boilers subsidised by the *Land* in the course of renovation activities have been condensing boilers. As of March 2000, this regulation will also be applicable to new buildings. From January 2000, the renovation subsidy will be increased from ATS 6 000 to ATS 9 000 for every boiler replaced. In addition, a subsidy of ATS 5 000 is granted by *Stadtwerke Salzburg*, the local utility from the city Salzburg.
Carinthia	In the service area of *KELAG*, there is an investment subsidy that is dependent on the boiler rating. This subsidy is ATS 3 600 for devices of up to 50 kW and increases to ATS 9 600 for devices of more than 255 kW.
Tyrol	The subsidisation system of the Land provides extra plus points for the utilisation of gas condensing boilers in new buildings. These points may increase the amount of the subsidy granted. A specific subsidy of ATS 5 000 is available from *TIGAS*, the regional gas supplier. In the service area of *Innsbrucker Stadtwerke*, a considerable proportion of the basic annual charge (approx. ATS 1 600 per year) is waived if condensing boilers are used.
Vorarlberg	In Vorarlberg, a priority campaign for boiler replacement was carried out in 1998 and 1999. The only boilers subsidised during this campaign were condensing boilers. In these cases, subsidies of up to ATS 15 000 were granted by the Land, while an additional ATS 7 000 was provided by the gas supplier. A subsidy of yet another ATS 1,500 was given if chimneys were renovated at the same time

Table 44: Summary of tax incentives programmes at national level

MS	Programme Name	Period	Type of tax incentive	Scope	Rate	Target	Initiator
Austria			Subsidies	Condensing boilers	Different in regions	Consumers	
Denmark		1999 - 2001	Subsidies	Natural gas boilers (& biomass boilers)	2500 DKK for natural gas boilers (1999-2001), about 335 € (10 to 30% of the investment for biomass boilers)	Consumers	Government
France	French National Climate Change Program	2005 - present	Tax credits	Condensing boilers	25%, or 40% if boilers installed in a dwelling constructed before 1/1/1977	Consumers	Government
Ireland	National Energy Efficiency Action Plan	from 2008	Subsidies	Condensing boilers	255.65 € / year for 8 years	Consumers	Government
The Netherlands	National Insulation Program	1978 - 1987	Subsidies	Condensing boilers (& solar boilers)		Consumers	Government
	Compensation of energy saving investments				Rental price increase		
	Environmental Action Plan	1995 - 2000					
	The EIA (Energy Investment Deduction) and the EINP (Energy Investment Deduction for Non Profit Organisations)	1995-present			up to 15% of the investment costs		
	EINP (Energy Investment Deduction for Non Profit Organisations)	1995 - 2002					

2.4. IMPACT OF EXISTING TAX INCENTIVES IN EUROPE: LITERATURE REVIEW

This section focuses on the quantitative analyses developed to assess the existing policy measures that aim to increase production and consumption of domestic appliances in **Europe** (American studies are reviewed in section 2.5). This section reviews the literature on the quantitative assessment of policy measures that aim to provide incentives for the production and consumption of certain durable goods, specifically (i) boilers; (ii) refrigerators; (iii) washing machines; and (iv) compact fluorescent lamps (CFLs).

This section is organised as follows: a short review of the main approaches and methodologies used to evaluate the impact of policies are presented in section 2.4.1. Section 2.4.2 reviews the studies that used an economic approach to assess (i) the impact of policies over the consumption and production of durables in Europe; and (ii) the price-elasticity of the demand for energy related to the goods of interest, while section 2.4.3 presents the studies that used non-economic or engineering approaches to address the issues of interest. Conclusions and summary are presented in section 2.4.4.

2.4.1. ASSESSMENT METHODOLOGIES

A number of alternative approaches can be used to measure changes in the economy induced by a policy measure. In addition to generating direct effects, a policy measure can result in indirect or induced economic effects across the economy as a whole or in related sectors of the economy. From the industry perspective, when a policy has significant impacts on the costs of producing a particular good this may affect the demand for substitute and complementary goods and services produced by other sectors. When the change in demand for the substitute goods is followed by a change in their prices, this may lead to indirect effects on producers and consumers of the substitute good or service. These indirect effects may be either negative or positive, depending on the supply and demand relationships that are affected by the policy measure. A policy that leads to significant direct compliance costs for one sector may nevertheless generate net gains for the economy as a whole, as a result of changes in the demand for different goods and services. Alternatively, it may create net losses to the economy as a result of investments being diverted from activities that would increase output.

Approaches for assessing the impacts of policy measures can focus on the supply side, or the demand side, or on both sides of the economy. There is also a distinction between 'top down' approaches that are based on economic behavioural models and 'bottom up' approaches that use a more engineering framework to evaluate the impacts of different measures.

Economic models focussing on the **supply-side** of the economy use supply data (e.g. labour supply or energy supply) to generate estimates of the impact that might occur from changes in policy measures on the level of economic activities. The obvious failing of such models is the lack of any consideration of demand effects. Since many of the policies specifically target the demand for energy, supply side approaches are not helpful in such contexts. For example, Neij *et al.* (2003) analysed the impact of energy-related policy measures on production costs of renewable energy. The use of supply-side models may be useful in providing order-of-magnitude estimates of the indirect effects arising from a change in the policy measure when a policy focussed on factors that influence supply costs, such as R&D but is less useful in most contexts of interest to this study.

The **demand-side approach** assesses the economic impacts of a policy measure through a range of different models, for example, input-output models, Keynesian multiplier-based models, and econometric analysis for estimating the impacts that expenditure or compliance costs have on the economic variables via the demand for the products in question. At the macroeconomic level the demand-side approach recognises that the implementation of the policy measure by individual users of energy and energy-consuming products is influenced by a number of policy parameters, especially ones that influence the price of energy and that of energy-using products.

Both the demand and supply side effects can be evaluated through the use of **Computable general equilibrium** (CGE) models. Such models are the most sophisticated type of top-down approach and are used to evaluate the benefits and costs of implementing a proposed policy measure. They are able to quantify direct and indirect effects of policy measures on many aspects of the economic, like its structure and predicted growth, and the allocation of resources. CGE models take into consideration both demand and supply interactions, being able to deal with longer planning horizons, which allow analysts to examine long-term movements in a wide range of economic variables. Essentially, these models simulate markets with systems of equations specifying supply and demand behaviour across the investigated markets.

According to the pertinent literature, a reasonable general equilibrium model is supposed to have the following elements: (a) a description of the utility functions and budget constraints of each household in the economy; (b) a description of the production functions of each company in the economy; (c) the government's budget constraint; (d) a description of the resource constraints of the economy; (e) assumptions relating to the behaviour of households and companies in the economy. General equilibrium models compare two distinct states of the economy, before and after the implementation or consideration of the policy. The difference between the two states represents the net economic benefit or cost of implementing the policy measure in question.

Whichever approach is taken it is clear that quantitative estimates of the supply and demand side impacts will require information on the quantitative effects, especially the price and other 'elasticities' of demand and supply. For this purpose it is essential to use **econometric models.** Such models statistically relate a variable of interest (dependent variable) to several macroeconomic and policy variables in order to investigate which of these variables impact the dependent variable. The estimated coefficients of the policy variables indicate the significance and magnitude of the impact of the policy variable(s) over the relevant variable or indicator. As can be seen below a common use of econometric models in policy analysis is the estimation of the demand function for specific goods or services in order to observe how this demand is affected by important policy variables. For example, economists may estimate the demand for energy and, consequently, the price-elasticity and/or income-elasticity of the demand for energy consumption. These statistics are important to foresee how policies that affect energy prices will impact the consumption of energy. This type of analysis is also very useful at the microeconomic level, when individual (household or firm) data are available.

In order to undertake analyses using the methods described above a substantial effort is necessary to gather the data, which is not always available. In addition to the data limitation, the complexity inherent in modelling this data and the econometric estimation of the models may add to the difficulty in undertaking policy assessment using economic models. An alternative approach that has been taken in the literature is the use of **engineering models**. These models are based on detailed engineering information regarding technical aspects of different technologies (Larsen and Nesbakken, 2004). Therefore they have a narrower perspective, targeting mainly the technological (non-economic) aspect of the analysis. For example, some methods assess the impact of a policy on energy consumption and/or other energy efficiency indicator. Nevertheless, when making predictions of changes in energy consumptions even such models make implicit assumptions about behavioural responses. The problem is that often such responses are not made clear in the published papers.

An example of an engineering based approach to evaluate the ex-post impact of policies in Europe was developed under the project "Monitoring Tools for Energy Efficiency in Europe – the ODYSSEE and MURE Project"[80]. The methodology, named **Backcasting**, aims at the retrospective evaluation of the impact on energy efficiency indicators (EEI) of past policy measures. The real performance of the EEI is compared to simulated results of the EEI in the absence of the policy measures. The simulation tool, MURE[81], is a bottom-up, technology-related simulation tool that allows analysts to (a) choose the end-use sector for the simulation (household or transport or industry or tertiary); (b) identify and select the scope of the interventions (or policies) that one wants to simulate or at whatever combination of those; (c) describe the interventions in detail; (d) make assumptions on the future performance of the technologies (or devices, etc.) involved by the interventions that has been selected; (e) make assumptions on the future penetration rates that can be expected for each of the envisaged technologies. The model produces results in terms of technical energy savings potential corresponding to the entire (and cumulated) set of interventions that has been selected. Note that the model requires information on future adoptions rates, which are determined by policy factors and the information on which has to come from some kind of econometric or statistical assessment.

In summary, the backcasting methodology consists in backward predicting or simulating how energy efficiency indicators would have been in the absence of the policy package (reference scenario) and how those EE indicators would have been in case the policy measures were implemented at full realization of technical improvements (policy case). The predicted EE indicators are then compared to actual values observed and the impact of the policy measures upon the EE indicators can be measured. The steps followed in the backcasting methodology are as follows:

- Step 1: characterisation of the policy measures packages; it aims to identify the measures to be retrospectively simulated and to analyse their real implementation processes[82];

[80] "Backcasting: A methodology for the Evaluation of Energy Efficiency Policies", available online at http://www.mure2.com/doc/MURE_Backcasting.pdf

[81] MURE – Mesures d'Utilization Rationnelle de l'Energie.

[82] In general the regulatory process has a built-in time in order to enable the market to adjust to the specific regulatory requirements before the implementation date (e.g. industry and consumers consultations). Therefore, the impacts of regulations are often evident beforehand, as the market introduces more efficient products in time to meet the requirements (Ellis *et al.*, 2007).

- Step 2: parameterisation of a reference case; selection of parameters affected and non-affected by the policy measure. In the reference case all parameters not affected by the policy measure are set to their real value, whilst all parameters affected by the policy are set to their trend before the policy implementation;
- Step 3: parameterisation of the policy case; definition of the technical parameters that the measure acts upon and the timing of the penetration rates;
- Step 4: selection of energy efficiency indicators (EEI);
- Step 5: comparison of results; the simulated results – what would have been the energy consumption trends without the policy measure – are compared to the observed figures to indicate the impact of the policy measure in terms of energy consumption.

2.4.2. ECONOMIC MODELS

The economic literature consists of studies using computable general equilibrium as well as macro and micro-econometric models to investigate the effects of energy-related policies in Europe. For example, Jansen and Klaassen (2000) analysed ex-ante the macroeconomic impacts of the EU energy tax scheme using three different models and concluded that a positive macroeconomic impact could be observed in all MS when the tax revenues are used to reduce social security contributions paid by employers (double-dividend)[83]. In this study, however, we will focus our literature review on studies that aimed to analyse the effectiveness of energy-related policies on the specific sectors and appliances of interest for our study. That is, we will not review studies that focus on the wider macroeconomic effects of energy policies in Europe but those studies that are related to the energy market and somehow related to the appliances we are interested in.

The reasons for this choice are: (a) CGE models are not capable of assessing the detailed policies and sectors we are interested in and (b) the models themselves require as inputs information on the key supply and demand responses, which are the focus of our study. Hence we concentrate on micro or sectorial level studies, from which we summarise estimates of the income and price elasticity of the demand for energy. These elasticities are critical to describe future energy consumption trends and help analysts to assess the impact of fiscal and financial policy measures that potentially have an impact in energy prices.

Household sector

Leth-Petersen and Togeby (2001)

The impact of policy measures aiming to reduce the consumption of energy for space heating in **Denmark** was estimated by Leth-Petersen and Togeby (2001). The authors used panel data containing information about technical characteristics and energy consumption for space heating in apartment blocks to analyse the effects of building regulations on energy consumption for space heating, as well as the effect of a **Danish**

[83] The reader can refer to Heady *et al.* (2000) for a review of other macroeconomic studies on the effectiveness of energy-related policies in Europe and a discussion of the double-dividend issue.

advisory/labelling scheme aiming to improve the level of information about energy efficient technologies. The scheme involved consultants giving recommendations for improving the energy efficiency of heating systems in order to bring them up to the level of buildings complying with the building regulation (**heat audits**). In case the suggestions of the advisory service were implemented, the building could be '**energy test**ed' and granted a certificate of compliance. In addition, the authors estimated energy price elasticities conditional on the availability of the heating technology.

Leth-Petersen and Togeby (2001) estimated an **econometric model** reflecting the energy demand equation at the building level **conditional** on the type of heating system present in the building. Additional to the consumption of energy, the type of energy carrier and the respective prices, the model included a trend term to capture deterministic unobserved components of energy consumption, and dummy variables indicating the presence (=1) or not (=0) of the policy measures. The econometric model could be estimated using fixed-effect regression and a conditional demand model that allowed for correlations between observed and unobserved components of the demand relation. The results of the conditional demand model indicated the (short-run) **price-elasticity** of the demand for energy of **buildings using oil** was estimated to be **-0.08**, while the price elasticity for **buildings using district heating** was equal to **-0.02**.

Regarding the effect of policy measures, the results indicated that building regulations may have been important in reducing energy consumption in new buildings in Denmark. They indicated a small short-term effect of fuel taxes on energy consumption in apartment blocks, and a moderate effect of the advisory support scheme implemented with the purpose of improving knowledge about the potential or energy savings. As can be seen in Table 45, the effect of undertaking the heat audit was estimated to be between almost zero and 1.3% while the effect of energy tests was 3.1% and 12.3%, depending on which model is used.

Table 45: Estimated effectiveness of heat audit and energy tests in Denmark[84]

	Heat audit	Energy test
Estimates from conditional demand model	-0.0125	-0.1233
Estimates from fixed-effects regression model	-0.0007	-0.0310

Nesbakken (1999)

Nesbakken (1999) investigated the relationship between the choice of **heating technology** and household energy consumption using cross-sectional data from the **Norwegian** consumer expenditure surveys between 1993 and 1995. The **econometric model** was formulated to take into account energy consumption and different features of the heating equipment – electric heaters; electric heaters combined with stoves for oil/kerosene; electric heaters combined with wood stoves; and electric heaters combined with stoves for oil/kerosene and stoves for wood. The model assumed that the utility of consumers depended on energy consumption (at a given price), consumption of other goods, observable characteristics of the household (including

[84] Source: Leth-Petersen and Togevy, 2001.

income) and the dwelling, unobservable characteristics of the household and the heating equipment.

The econometric model was initially estimated separately on data for the 3 years (1993 to 1995) to compare the estimation results along the time dimension (Table 46). The results show relatively low income elasticities but relatively high short- run price elasticities. No estimates were available for the long-run price elasticities. In a sequence, a pooled model was estimated combining all 3 years. The author claims that the pooled model gave more precise estimates than the results for each separate year because of more observations. In order to test whether income, energy prices and other variables have the same impact on energy consumption when the income levels rise, the author estimated income and energy price elasticity for different income groups (above and below the average income level in the sample) and results are in Table 47, which shows generally similar elasticities across all groups, but lower elasticities for those on below average income compared to those on above average income.

Table 46: Income and price elasticity of the demand for energy for household heating – 1993 to 1995[85]

	1993	1994	1995
Short run income elasticity	0.01	0.01	0.01
Long run income elasticity (a)	0.28	0.21	0.15
Short run energy price elasticity	-0.57	-0.33	-0.53

Note: Elasticities estimated at sample means; (a) includes the impact of income on the dwelling size, which has impact on energy consumption.

Table 47: Income and price elasticity of the demand for energy for household heating – Pooled data 1993-1995[85]

	All households	Income < average	Income > average
Short run income elasticity	0.01	0.01	0.01
Long run income elasticity (a)	0.20	0.18	0.22
Short run energy price elasticity	-0.50	-0.33	-0.66

Note: Elasticities estimated at sample means; (a) includes the impact of income on the dwelling size, which has impact on energy consumption.

[85] Source: Nesbakken, 1999.

Industry sector

Bjorner and Jensen (2000)

Bjorner and Jensen (2000) presented an **econometric analysis** of industrial consumption of energy and their value added in **Denmark**, estimating the demand for energy of Danish industrial companies. In addition, the authors assessed the effect of **energy taxes, energy agreements and subsidies to investments in energy efficiency**. The database used in this study had a panel format, where information about each of the companies was obtained over several years – 1983 and 1997, allowing analysts to observe the energy consumption before and after policy measures were implemented.

The model can be summarised as follows: total energy means the companies' consumption of eight major types of energy (coal, fuel oil, heating oil, LPG, natural gas, city gas, electricity and district heating), and is regarded as an input in production together with labour and capital. Assuming that all companies treat energy price and other factors as exogenous and that each company minimises its production cost, the demand for energy was expressed as a function of factor price and level of production. Data for 3762 companies of 56 sub-sectors were obtained for years 1983/85/88/90/93/95/96 and 97. The preferred econometric model was estimated assuming company-specific fixed-effects and demand elasticity with respect to value added and price were estimated. **The overall energy-demand price elasticity with respect to energy price in the whole Danish industry was estimated equal to -0.44** (Table 48)**.** The price-elasticity of demand for energy per industrial sub-sector ranged between -0.21 and -0.69; with energy intensive sub-sectors responding less to changes in energy prices.

Table 48: Price elasticities of the demand for energy in the Danish industry[86]

Industrial sub-sector	**Price elasticity**
Extraction of gravel, clay, stone, salt	-0.43
Food, beverages and tobacco	-0.45
Textiles, wearing and leather	-0.35
Wood and wood products	-0.39
Paper, printing and publishing	-0.35
Chemicals	-0.51
Rubber and plastic products	-0.52
Other non-metallic mineral products	-0.21
Basic metals (manufacturing and processing)	-0.51
Machinery and equipment	-0.48

[86] Source: Bjorner and Jensen, 2000.

Industrial sub-sector	Price elasticity
Electrical and optical instruments	-0.69
Transport equipment	-0.56
Furniture and manufacturing	-0.56
Total industry	**-0.44**

Note: Mean price elasticities weighted with share of energy consumption.

The estimates of price-elasticity presented in Table 48 were in accordance to estimates found in the international literature based on time series studies and summarised by the authors in Table 49. Cross section studies tend to generate somewhat higher elasticities[87]. However, these estimates were higher than previously found in other Danish studies, which suggests that existing energy taxes may have had a larger effect than previously assumed.

Table 49: Energy price elasticities from international studies[88]

	All studies	Time-series study	Pooled cross-section studies
Median	-0.47	-0.38	-0.84
Mean	-0.66	-0.44	-1.06
Minimum	-0.06	-0.06	-0.27
Maximum	-2.05	-1.06	-2.05
Number of studies	25	16	9

Note: calculated from studies surveyed in Atkinson and Manning (1995) "A Survey of International Energy Elasticities" in Barker, T. P. Elkins and N. Johnstone (eds) *Global warming and Energy demand*, including studies published between 1975 and 1993.

As to the **effect of energy agreements** on energy consumption, the authors concluded that the activities carried out when entering an energy agreement have led to reduction in energy consumption (the range is from **-9% to -14%**), after controlling for the discount in energy taxes to these companies. With regard to investment **subsidies**, the parameter obtained was not significantly different from zero (the mean value ranged from **-1.2% to -1.7%**), which indicates that the hypothesis that subsidies had no effect on energy consumption could not be rejected. Finally, Bjorner and Jensen (2000) concluded that the energy consumption in the whole industrial sector would have been

[87] "Time series studies have resulted in lower price elasticities as compared with studies based on aggregated cross-section data (included pooled time series)…this supports the often stated view that time series studies produce short-run or medium-run elasticities, while the cross-section studies yield elasticities with a long-run nature" (Bjorner and Jensen, 2000).

[88] Source: Bjorner and Jensen, 2000.

10% higher in 1997 if there had been no **taxes** on energy used in the Danish industrial sector.

Aalbers et al. (2004)

The effectiveness of **subsidies for energy-saving technologies** was assessed in the **Dutch** industry sector. Aalbers et al. (2004) used data on investments of firms in energy saving technologies and measured the impact of the payback period of the technology on the probability of adopting the technology in the absence of tax and subsidies incentives. The data was obtained from the Dutch tax rebate scheme in the profit sector (EIA – Energy Investment Deduction) and a subsidy programme in the non-profit sector (EINP – Energy Investments in Non-Profit sectors), for 862 subsidised investments in 20 technologies across 57 sub-sectors. The programmes consisted of incentives to a number of energy-saving technologies, including energy-efficient lightning and acquisition of high efficient boilers.

The model used by Aalbers et al. (2004) considered a firm having two investment options: investing in a standard technology with one cost and investing in an energy-saving technology with another cost, which include a subsidy or a tax deduction which are associated with a pay-back period. The discrete model in which the firm invests in the energy-saving technology was estimated using **econometric** (Probit) **analysis**. The **effectiveness** of a programme was **measured as the percentage of firms (all sectors) that would not have bought the technology in the absence of the subsidy**, and estimated to equal **45.4% for the EIA programme** and **47.1% for the EINP programme**. The authors also estimated the effectiveness of the subsidy programme per energy-saving technology (Table 50). Aalbers et al. (2004) concluded that the decision to adopt energy saving technologies varies according to the type of firm – for-profit and not-for-profit and by technology. On average, about 45.5% of firms would have bought the energy-saving technology without the subsidy or tax credit.

Table 50: Effectiveness of the subsidy programme per technology – Dutch industry sector – by technology[89]

Technology	Subsidy scheme	Effectiveness
Combined heat and power	EIA	45.2%
Energy efficient lightning	EIA and EINP	52.8%
High efficient boiler	EINP	43.4%

2.4.3. Engineering models

MURE (2002) (Backcasting)

MURE (2002) presented earlier, reports several study cases where the backcasting methodology was used to evaluate specific policy measures in Europe. Those of interest for the objectives of our study are related to household appliances (**refrigerators, including fridges and freezers**) in **Sweden and in EU15**. The first study case aimed at assessing how the measures implemented since 1995 impacted the

[89] Source: Adapted from Aalbers *et al.,* 2004.

energy efficiency performance of refrigerators in Europe. The measures that apply to refrigerators and were assessed in this study case included:

- Labelling of cold appliances (Directives 92/75/EEC and 94/2/EC);
- Mandatory standards for cold appliances (Directive 96/57/EC);
- Energy tax on electricity (some EU countries only); and
- Other policies and measures (e.g. procurement programmes at the national level).

The parameterisation of the reference and policy cases included the following assumptions, among others:

- The growth rates in the stock of appliances in each country were provided by the ODYSSEE database;
- Refrigerators' lifetime was assumed to equal 15 years;
- The replacement rate in 4 years was assumed to equal 24%;
- Penetration rate of the appliances were observed in market data for A/B/C devices[90];
- For the policy case full realisation of the technical improvement was assumed according to the intensity ratios between efficiency classes as indicated in the Labelling Directive. This means that new refrigerators would have the same volume as replaced refrigerators (constant structure), and also that refrigerators/fridge-freezers could not be separated, since a shift from the former to the latter would increase the energy consumption of the new unit and reduce the technical improvement; [91]
- The set of energy efficiency indicators concerned the actual energy consumption for refrigerators, were disaggregated into energy efficiency (EE) classes was constructed by a model since energy consumption per EE classes was not directly observable.

The comparison of the simulated overall energy consumption of refrigerators in Europe between 1995 and 1999 in the absence of the policy package with the actual figures observed in 1999 showed that[92]:

- Comparison of the simulated energy consumption figures for 1999 with the values observed in 1995 shows that the technical autonomous progress – business as usual – reduced energy consumption at a rate of 1.8% per year, corresponding to 800TJ final energy savings between 1995 and 1999;

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[90] Energy efficiency classes for refrigerators ranging between class A (energy efficiency index < 55) and class G (energy efficiency index < 125).

[91] The combined assumptions about (i) the lifetime of refrigerators; (ii) the percentage of the annual stock replacement; and (iii) the observed market penetration rate of new appliances (per type) are used to estimate the substitution of old refrigerators in the model. Hence, there is no need to obtain data about the age of the existing stock.

[92] The authors presented their results in terms of total energy reduction given in TJ and did not provide sufficient information in the paper to allow us to convert the given energy unit into percentage reduction of total energy consumption, which would be the relevant unit for assessing the impact of the policy measures.

- The results of the policy case (simulated scenario with full realization of technical improvement) were compared to the simulated reference case (no policy in place) for 1999, indicating that the impact of the policy package assessed equalled 1100TJ;
- Comparing the actual energy consumption at constant activity with the value simulated in the policy case indicated that the potential reduction in energy consumption was not totally achieved, the difference being explained, among other factors like behaviour, to the fact that new appliances replacing existing ones did not realise the full technical potential of replacement because newer units were either larger or because there was a shift from refrigerators to fridge-freezers, a structural effect that the authors could not capture in their model.

The second study case of interest in MURE (2000) was similar to the previous one on the EU – same assumptions and policy package, excluding procurement programmes due to lack of data – but included an attempt to separate electricity taxation and was related to Sweden only. The main results were[93]:

- Comparison of the predicted energy consumption figures (reference case) for 1999 with the values observed in 1995 shows that the technical autonomous progress – business as usual – reduced energy consumption at a rate of 2.4% per year, corresponding to 45TJ final energy savings between 1995 and 1999;
- The results of the policy case (simulated scenario with full realization of technical improvement) were compared to the predicted reference case for 1999, indicating that the impact of the policy package assessed equalled 40TJ. Using estimates of price-elasticity of the demand for energy in Sweden (the actual values are not provided) the authors estimated that the impact of electricity taxes could be estimated at around 5TJ, suggesting that the largest impact occurred from the implementation of the labelling Directive;
- Comparing the actual energy consumption at constant activity with the value simulated in the policy case indicated that the reduction in energy consumption was not totally achieved, as occurred in the EU study case.

Eichhammer and Weidemann (1999)

Other study cases presented in MURE (2000) included household space heating in Italy and France; passenger transport in Italy and France; and combined heat and power (CHP) industry in the Netherlands and the UK. The study cases concerning space heating assessed a policy package that included the establishment of minimum efficiency standards for boilers, among other measures such as building codes and grants for audits and dwellings improvement. These study cases are not reviewed here since there was no attempt to separate the impact of policies of interest to our study. However, among other study cases undertaken in the MURE project, one is particularly interesting for our purposes and deals with the impacts of the introduction of the **EU Boiler Directive** (Eichhammer and Weidemann, 1999).

[93] Again, the results were given in terms of total energy reduction and no sufficient information were available in the paper to allow us to convert the given energy unit into percentage reduction of total energy consumption, which would be the relevant unit for assessing the impact of the policy measures.

Eichhammer and Weidemann (1999) used the MURE simulation tool and database to evaluate the impact of the boiler Directive in EU Member States (EU15). The authors calculated (by predicting forward) the energy savings in 2005 and 2010 due to the Directive. The approach used for calculation for 2005 was the static one, that is, the estimates were based on 1995 figures, which means that the demand for energy was assumed unchanged until 2005 (no change in the number of households, in the fuel structure, in comfort levels, and no further increase in insulation). The results of this particular analysis can, therefore, be seen as the upper limit of the energy savings obtained with the implementation of the Directive.

Estimations for year 2005 assumed country-specific parameters which were obtained through questionnaires sent to experts at the national level: lifetime of boilers; fuel efficiency for old boilers; share of total energy consumption of new buildings. Results presented in Table 51 show that in total 317.2PJ or 21.3 million tCO_2 could be saved in 2005 corresponding to 3.8% of the fuels concerned by the Directive (gaseous and liquid fuels) or to 2.9% of the energy used for space heating and warm water in households and for space heating in the tertiary sector. Since this assessment looks at a Directive that mandates the shift to a new technology the comparison of interest is the cost of implementing the Directive against the savings shown. Unfortunately, there were no references in the paper to the implementation costs of the Boiler Directive in the various countries in the study.

Table 51: Energy savings in 2005 due to the implementation of the Boiler Directive in EU15[94]

	PJ	Mio tCO_2
Space heating in the households	217,2	14,3
Sanitary hot water preparation of the households	33,6	2,2
Space heating in the tertiary sector	66,8	4,8
Total	317,2	21,3

In order to estimate energy savings for 2010 (Table 52), Eichhammer and Weidemann (1999) used a different approach which included scenarios developed to investigate the interaction with building insulation measures that tend to decrease the savings from the boiler Directive. The scenarios were defined as[95]:

- Scenario A: the static approach used in the previous analysis, based on the 1995 demand for heating and no new regulation to improve thermal insulation standards (the status quo alternative);
- Scenario B: new regulation to improve thermal insulation of new buildings (Danish Standard);

[94] Source: Adapted from Eichhammer and Weidemann, 1999.

[95] All scenarios are future simulations of the implementation of the Boiler Directive (plus other policies in scenarios B and C). The resulting energy savings are then given in comparison to the no policy (Boiler Directive) scenario.

- Scenario C: new regulation to improve thermal insulation of new buildings plus intensification of insulation of old buildings.

Table 52: Energy savings in 2010 due to the implementation of the Boiler Directive in EU15[96]

Households (space heating only)	PJ	Mio tCO_2
Scenario A (no other new regulation)	352,89	23,19
Scenario B (plus Danish Standard)	334,34	21,97
Scenario C (plus Danish Standard and intensification of insulation)	282,36	18,56

Boonekamp (2007)

Boonekamp (2007) investigated whether policy measures implemented in the **Netherlands** between 1990 and 2000 had influenced the response of **households** to changing energy prices. The author simulated the energy developments for households using a **bottom-up model of household energy consumption (SAVE-Households** model), which determined energy effects of various **policy measures, including standards for insulation; subsidies for more energy efficient appliances and energy taxes**. The model allowed the author to separate the price elasticity effect from the effect of the different policy measures.

The analysis used micro data from household surveys and the model used divided household energy consumption in to seven energy functions: space heating, supply of hot water, cleaning, cooling, cooking, lighting and other appliances, each with specific demand driving factors and systems/appliances (e.g. the driving factors of the space heating function were the type of dwelling and central of local heating; occupation rate etc; and the corresponding system/appliances were boilers or heaters and central ventilation units). The energy consumption of every system or appliance was defined as a function of the ownership rate (share of households that use the system or appliance), the intensity of use (yearly number of hours of use) and the energy efficiency (reduction in energy use of the system or appliance compared to that of the reference system producing the same output) of the system or appliance. For every conversion system or appliance a number of more efficient alternatives for the reference system were available in the model. Costs arose from additional investments in the more energy efficient option, and benefits were considered as the saved energy times mean price (costs considered subsidies as well as benefits considered taxes affecting prices)[97]. If costs were lower than benefits for an energy-saving option then the model assumes that the option should always be chosen from an economic point of view.

The model was used to simulate past energy consumption trends and to compare with actual figures (in this sense the method used by Boonekamp (2007) is similar to the

[96] Source: Adapted from Eichhammer and Weidemann, 1999.

[97] Cost-benefit ratio = [(investment – subsidy)*annuity] / [saving*(price+tax)].

backcasting methodology). The model was capable of simulating energy trends, using inputs that departed from the fitted base case trend for the period 1990-2000. The effect of a number of price changes (keeping all other factors unchanged) on total energy consumption was determined as the ratio between the relative change in energy consumption and the relative change in energy price (Table 53). Although the author refers to this ratio as the price elasticity, he remarks that the calculated ratio reflects changes over 5 years (results for 1995), thus lying between the periods relevant for short-run and long-run elasticities. As a consequence, the elasticity estimates in Table 53 are lower than most long-term elasticity values found in the literature.

Table 53: Price elasticity for household gas and electricity consumption for different energy price cases[98]

Total price changes	1995		2000	
	Gas	Electricity	Gas	Electricity
Minor increase - gas and electricity (+20%)	-0.07	-0.07	-0.13	-0.11
Major increase - gas and electricity (+100%)	-0.04	-0.05	-0.08	-0.07
Major decrease - gas and electricity (-50%)	-0.05	-0.06	-0.10	-0.09
Gas only (+20%)	-0.08	+0.02	-0.15	+0.03
Electricity only (+20%)	+0.01	-0.09	+0.02	-0.13

Boonekamp (2007) also analysed the effect of a price change with and without the presence of some policy measures (standards for new dwellings, which included energy efficient boilers; subsidies for energy efficient systems or appliances; regulatory tax on energy carriers). Results are in Table 54. The authors concluded that the elasticity value in the case without policy measures can be 30-40% higher than in the case with all measures in place. However, a more detailed analysis of the interaction between the effects of higher prices and subsidies or taxes concluded that the total influence of taxes or subsidies on the elasticity value depends on the stock of energy saving alternatives, since in the 'take-off' phase of the option the presence of subsidies and taxes enhances the effect of higher prices, while in the phase of 'saturation' of the option the opposite effect can be expected.

[98] Source: Boonekamp, 2007.

Table 54: Price elasticity for household gas and electricity consumption in the presence of policy measures (year 2000)[99]

Policy variants	Gas	Electricity
No policy case	-0.138	-0.124
Standards only	-0.113	-0.124
Subsidies only	-0.142	-0.119
Taxes only	-0.125	-0.100
Taxes/subsidies/standards	-0.103	-0.091

Note: The estimates are for a change of +20% in the price without regulatory tax.

Lund (2007)

A different type of engineering analysis was undertaken by Lund (2007) to assess the effectiveness of several public policy measures in creating energy impacts. The author undertook 20 policy cases related to renewable energy and efficient energy use. The study cases related to the **EU region** are described in Table 55. The policies were grouped in subsidy type and catalysing measures based on the use of the public financial resources.

The analysis of the impacts and costs of policy measures did not consider exogenous factors that may affect the impacts, such as energy prices, cultural aspects, local innovation system etc. Instead, the methodology used by Lund (2007) measured the effectiveness of public policies through the impacts achieved (outputs) for the resources (inputs) used, that is, the author estimated the additional cost per energy effect (€/MWh). This was subsequently translated into a public cost of saved CO2 emissions by dividing the specific costs with the specific emissions of the reference energy source used. The methodology used to measure the effectiveness of the public support (e.g. subsidy) considered not only immediate observed impacts but also the future impacts. The energy impacts were obtained from the cumulative installed capacity or number of installations (e_t) in each country, by multiplying with unit energy production or savings per unit (u). Public support is denoted (i_t) and the specific cost of the public measures can be given as:

$$c_{\text{cumulative}} = \frac{\int_A^B i(t)dt}{u\Delta t_{\text{life}}.\int_A^B \frac{\partial e(t)}{\partial t}dt}$$

Several assumptions were necessary to obtain the energy impacts of the policy measures and the market development of the different technologies over time. For example, the market development of the different technologies over time was assumed differently in each country. These assumptions were not detailed here due to the large number of assumptions. The public support was assumed to last for 10 years

[99] Source: Boonekamp, 2007.

and as most of the cases studied by Lund (2007) were new technologies it was assumed that natural occurring penetration would have been improbable without the policy measures.

The policy cost-effectiveness was estimated including the observed effects and lifetime accumulated effects from the investments made. Lund (2007) concluded that the policy cost of subsidies ranged between 1€/MWh and 100€/MWh (Table 55), the feed-in tariffs being the most expensive choice of policy measure. The measures that catalyse market breakthroughs ranged between 0.1 and 1€/MWh, mostly due to a stronger market and business sensitiveness, focusing on the end-use sector with active stakeholder involvement.

Table 55: Impacts and costs of public policy measures[100]

Policy instrument	Region	Technology/sector	Type	Policy category	Energy impact, PJ	Policy cost effect €/MWh
Feed-in tariffs	Germany	Wind power	Volume	Fiscal	1840	60
Investment grant	Finland	Wind power	Volume	Fiscal	14	7.25
Investment grant, R&D	Finland	Biomass	Volume	Fiscal, R&D	1840	1.96
Investment grant, niche	Austria	Biomass plants	Volume	Fiscal	281	1.28
Investment grant	Austria	Solar heating	Volume	Fiscal	99	19.71
Green certificates	EU	Renewables	Catalysing	Fiscal, legislative	61	0.30
Feed-in tariffs	Germany	Photovoltaic	Volume	Fiscal	53	400
Business driven, niche	Finland	Photovoltaic	Catalysing	Information	0.4	0.92
Investment grant	Norway	Heat pumps	Volume	Fiscal	94	6.41
Technology procurement	Sweden	Heat pumps	Catalysing	Portfolio	410	0.01
Business driven	Finland	Heat pumps	Catalysing	Information	157	5.76
Investment grant	Austria	Heat pumps	Volume	Fiscal	115	0.06
Technology procurement	Sweden	Lighting (ballast)	Catalysing	Portfolio	20	0.78
Building auditing	Finland	Office buildings	Volume	Information,	40	1.70

[100] Source: Adapted from Lund, 2007.

				assisting		
Energy labelling	Denmark	Buildings	Volume	Assisting, legislative	19	1.11
Energy labelling	UK	Energy efficiency	Volume	Fiscal, information	66	0.65
Portfolio	Norway	Electricity efficiency	Catalysing	Portfolio	33	4.17

2.4.4. Summary and conclusions

This section reviewed the literature on the quantitative assessments of energy-related policies in Europe associated, directly or indirectly, with the consumption and production of refrigerators, washing machines, boilers and CFLi. Not many studies were found, as summarised in Table 56 and in Table 57. We did not review the macroeconomic studies (using macro-econometric or CGE models) that investigated the wider economic impacts of energy taxes in EU since we understand that these studies do not refer to the specific objective of this study. Thus, we focused on policies and/or effects to the specific appliances of interest.

Table 56: Summary table – econometric analyses

Study / approach	Country	Sector	Policy measure	Policy effectiveness[a]	Price elasticity
Leth-Petersen &Togeby (2001)	Denmark	Household Apartment blocks	Labelling scheme: heat audit and energy test	Heat audit: Model 1: -1.25% Model 2: -0.07% Energy test: Model 1: -12.33% Model 2: -3.10%	-0.08 buildings using oil -0.02 buildings using district heating
Nesbakken (1999)	Norway	Household	---	---	-0.50 short-run
Bjorner & Jensen (2000)	Denmark	Industry	Energy taxes Agreements Energy subsidies	-10% -9% to -14% -1.2% to -1.7%	-0.44 total industry -0.21 to -0.69 per sub-sector
Aalbers et al (2004)	The Netherlands	Industry	Energy subsidies	45.4% EIA 47.1% EINP	---

Note: (a) Policy effectiveness is given as a percentage reduction in energy consumption, except in Aalbers *et al.* (2004) where the policy effectiveness is given as the percentage of firms that would not have bought the energy-saving technology in the absence of the subsidy.

Table 57: Summary table – engineering models

Study / approach	Country	Sector	Policy measure	Policy effectiveness[a]	Price elasticity
MURE (2000)	EU15	Household	Labelling Standards Energy tax Procurement	1100 TJ	---
	Sweden	Household	Labelling Standards Energy tax	40TJ	---
Eichhammer & Weidemann (1999)	EU15	Household	EU Boiler Directive	2005 Space heating: 217,2PJ Hot water: 33,6PJ 2010 282,4 – 352,9PJ	---
	EU15	Tertiary sector	EU Boiler Directive	2005 Space heating: 66,8PJ	---
Boonekamp (2007)	The Netherlands	Household	Standards Subsidies Energy taxes	Price elasticity 30 – 40% higher if no policy in place	Gas: -0.138 Electricity: -0.124
Lund (2007)	Several EU countries	All	Subsidy-type Catalysing	1-100 €/MWh 0.1 – 1 €/MWh	---

Note: (a) Policy effectiveness is given as total reduction in energy consumption (engineering models). Except in Boonekamp (2007) where the policy effectiveness is given as the percentage impact on price elasticities.

It can be concluded from the review above that assessments of energy-related policies are in general carried out over the consumption of energy or other energy efficiency indicator when engineering models are used. Instead, econometric analyses focus on the demand for energy and the estimation of the price-elasticity of the demand for energy, which is an important tool to enable analysts to predict the impact on energy consumption of policies that will have an impact on energy prices.

2.5. IMPACT OF EXISTING TAX INCENTIVES IN THE UNITED STATES: LITERATURE REVIEW

The policy measures that have been implemented in the United States (US) to promote energy efficiency as well as the impacts of energy prices on energy consumption are described and evaluated in this note. We divide the discussion into assessments based on engineering models and those based on economic models.

Policy instruments aimed at increasing energy efficiency first appeared after the oil shocks in the 1970s when the price of oil increased sharply. The first policies focused on the introduction of efficiency standards for vehicles (Corporate Average Fuel Economy initiative) and appliances. The first federal efficiency targets for appliances were voluntary (Energy Policy and Conservation Act of 1975) and became mandatory from 1987 (National Appliance Energy Conservation Act). Parallel to these, various State appliance-efficiency standards were introduced. More recently, environmental issues have enhanced the importance of energy-efficiency and in fact standards have continued to tighten over time, independently of oil price.

The 2005 Energy Policy Act sets national energy efficiency standards on various products. In particular:

- CFLs (compact fluorescent lamps) must meet 2001 ENERGY STAR® specifications;
- Refrigerators and freezers must meet the California Energy Commission (CEC) standard (that is very similar to the Energy Star specification);
- Clothes washers must have a Modified Energy Factor (MEF)[101] of at least 1.26 and a Water Factor (WF) lower than 9.5.

In addition, it also sets energy efficiency tax incentives on house appliances for existing and non-business homes that are summarised in Table 58.

Table 58: Summary of the financial incentives granted by the 2005 Energy Policy Act[102]

PRODUCT	INCENTIVE	YEARS	DESCRIPTION
Gas and oil boilers			Only for those products that are included in the qualified product list
High combustion efficiency equipment	150 $	2006-7	
High electric efficiency equipment	50 $	2006-7	
Water heaters			Only for those products that are included in the qualified product list

[101] The Modified Energy Factor is an equation for the Energy Factor that takes into account the amount of dryer energy used to remove the remaining moisture content in washed items.

[102] Source: Adapted from 2005 Energy Policy Act

Electric with 2.0 EF[103]	300 $	2006-7	
Gas and oil with 0.8 EF	300 $	2006-7	
Refrigerators			Incentives go to manufacturer, not to consumer, though manufacturer is expected to reduce prices accordingly
Save 15-19.9% energy relative to federal standard	75 $	2006	
Save 20-24.9% energy relative to federal standard	125 $	2006-7	
Save 25% or more energy relative to federal standard	175 $	2006-7	
Clothes washers with 1.72 MEF and 8.0 WF[104]	100 $	2006-7	Incentives go to manufacturer, not to consumer, though manufacturer is expected to reduce prices accordingly

2.5.1. Engineering Models

The **2007 Energy Policy Act**, whose key facts were published in December 2007, will require producers to:

- Reduce energy consumption of common light bulbs (through standards) by about 25-30% by 2012-14 by over 60% by 2020; aiming at large scale use of CFLs to meet such targets;
- Meet new standards for residential boilers (update current federal standard);
- Determine revised standards for refrigerators by 2011;
- Determine revised standards for clothes washers by 2012;
- Develop new standards for commercial heating and water heating by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

Potential energy and carbon savings from the whole 2007 Energy Policy Act have been calculated by the American Council for an Energy Efficient Economy (ACEEE). Table 59 reports such estimates.

[103] Energy Factor (EF)

[104] These levels now correspond to the 2007 ENERGY STAR® specifications

Table 59: Preliminary estimates of energy and carbon savings from the 2007 Energy Policy Act[105]

	Electricity (TWh)	Direct Natural Gas (Billion Cubic Feet, BCF)	Indirect Natural Gas (BCF)	Carbon (Million Metric Tonnes)
Annual Energy Savings Estimates				
Residential Boiler Efficiency Standards				
Estimates for 2020	N/A	7.6	N/A	0.11
Estimates for 2030	N/A	16.5	N/A	0.24
Energy Standards for home appliances				
Estimates for 2020	23.0	N/A	118	4.6
Estimates for 2030	46.5	N/A	227	9.3
Efficient Light Bulbs				
Estimates for 2020	80.96	N/A	410	16.1
Estimates for 2030	142.8	N/A	698	1.44
Tax Exempt Bonds				
Estimates for 2010	2.4	15.2	12.35	0.74
Estimates for 2020	3.9	24.6	20.00	1.20
Estimates for 2030	2.4	14.7	11.98	0.7
Tax credits for appliances				
Estimates for 2010	0.5	16.6	2.70	0.36
Estimates for 2020	2.6	81.0	13.16	1.74
Estimates for 2030	1.2	39.9	5.93	0.8
Cumulative Energy Savings Estimates				
Residential Boiler Efficiency Standards				
Estimates for 2020	N/A	38	N/A	0.56
Estimates for 2030	N/A	163	N/A	2.39
Energy Standards for home appliances				
Estimates for 2020	128	N/A	647	25.5
Estimates for 2030	488	N/A	2,386	97.3
Efficient Light Bulbs				
Estimates for 2020	601	N/A	3044	119.8
Estimates for 2030	2,029	N/A	9,914	404.4
Tax Exempt Bonds				
Estimates for 2010	3.7	22.9	18.7	1.1
Estimates for 2020	50.0	310.8	253	14.5
Estimates for 2030	80.1	498	391	23.3
Tax credits for appliances				
Estimates for 2010	1.1	33.2	5.4	0.7
Estimates for 2020	17.0	530	86	11.2
Estimates for 2030	36.5	1,154	178	24.2

[105] Source: Adapted from 2005 Energy Policy Act

The **Lawrence Berkeley National Laboratory** (LBNL, University of California) has conducted a study to estimate the energy, environmental, and consumer economic impacts of federal residential energy efficiency standards that became effective in the period 1988-2007. The evaluation took into consideration nine products. Table 60 lists the products and the years considered.

Table 60: U.S. DOE energy efficiency standards for residential appliances and equipment included in the LBNL impact estimation study [Source LBNL].

Product	Effective Date																			
	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07
Refrigerators			X			X								X						
Freezers			X			X								X						
Room Air Conditioners			X										X							
Central ACs and Heat Pumps					X														X	
Clothes Washers	X						X										X			X
Clothes Dryers	X						X													
Dishwashers	X						X													
Water Heaters			X														X			
Gas Furnaces					X															
Oil Furnaces					O															
Ranges and Ovens			O																	
Pool Heaters			O																	
Direct Heating Equipment			O																	

X = Included in this study's estimates
O = Not included in this study's estimates

The impacts of the policies are estimated[106] comparing actual data with a no-standard base case scenario for average energy efficiency, energy consumption, and product price. The base case scenario is constructed to include the increase in energy efficiency due to various factors other than federal energy-efficiency standards, including other energy efficiency policy instruments.

Moreover, the study takes into consideration the additional consumer costs for higher efficiency appliances, by assuming that prices without standards would have been lower than those actually observed.

The results of the study indicate that:

- Standards will reduce **energy consumption** in 2020 by 8%, with refrigerators as the biggest savers, followed by clothes washers. Cumulative savings are 54 quads (quadrillion British thermal units) in 2030, and 67 quads in 2045.
- Standards have made U.S. consumers save approximately $30 billion by 2005; while present value of projected **net savings** over the entire 1987-2045 period is $141 billion. In particular, the ratio of consumer savings ($239 billion) to additional consumer expenditures ($98 billion) is 2.45 to 1 (see Figure 72).

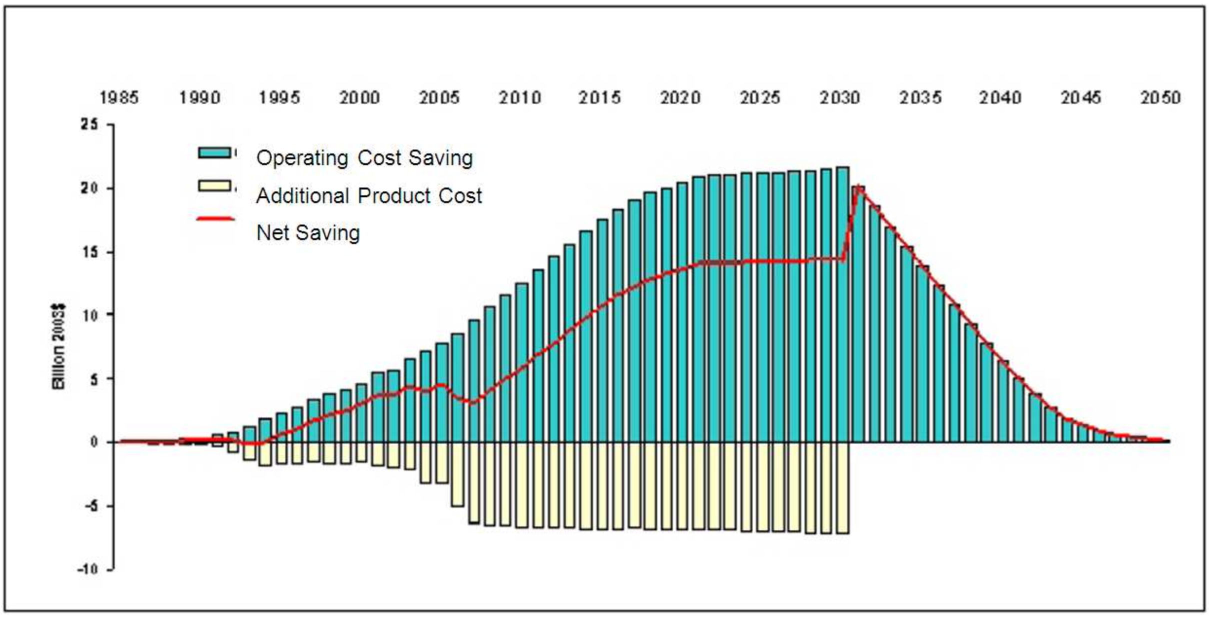
[106] The study is based on a spreadsheet accounting model that calculates national energy savings and consumer benefits for each product standard. The variables used for the estimation are: (i) the average annual energy efficiency and energy consumption of the product sold in each year; (ii) the average product price in each year; calculated for each product, using actual data and projections of future trends.

Again, the greatest net savings are associated with standards for refrigerators and clothes washers.

- Standards are expected to reduce, by 2020, **CO_2 emissions** by 8% and **NO_x** by 0.2 million ton/year, considering both savings in electricity production and primary natural gas consumption. To get an idea of the scale of these effects, the estimated reduction of 8% of CO_2 emissions in 2020 corresponds to 36 MtC that are equivalent to the annual CO_2 emissions by 28 million of today's average cars. Moreover, 0.2 million ton corresponds to about 5% of current NO_x emissions from U.S. electric utilities.

The economic value of such reductions, estimated using National Research Council estimates of values of avoided tons[107], amounts to $2.8-5.1 billion for avoided CO2 emissions and $7-14 billion for avoided NOx emissions[108].

Figure 72: Net present value[109] of costs and benefits from DOE standards, over the expected lifetime of products, measured in Billion of 2005US$ [Source LBNL]



A quantitative analysis of the energy market impacts of different potential energy efficiency policies has also been undertaken by the **Energy Information Administration** (EIA).

[107] In particular they took between 6-11$ for a metric ton of carbon and $2,300 to $11,000 for a metric ton of NOx. For NOx, the LBNL research used a range of $2,300-$4,600 to account for the fact that emissions from power plants are less damaging than those from motor vehicles in urban areas.

[108] The estimates presented in this study are subject to a certain degree of uncertainty, arising from: (a) the estimation of the baseline scenarios, (b) the average efficiency of new appliances, (c) the impact of standards on the market outcome, (d) incremental costs for consumers, and (e) the interest and discount rate used to determine net present values of past and future costs and benefits. Nevertheless the authors believe these results to be a reasonable approximation of the national benefits resulting from DOE's appliance efficiency standards.

[109] Using a real discount rate of 7% for future costs (in line with DOE's analysis of appliance standards) and an annual 3% interest rate for the past costs (average return on long-term government bonds).

The study compares various potential policies to a reference case where all current regulations remain enacted and no additional instruments are introduced. The policies more closely related to our analysis are described in Table 61.

Table 61: Description of the policies analysed in the EIA study[110]

POLICY	DESCRIPTION
Tax credit on Residential Equipment, 2006-2010: boilers	Based on EFFECTER, homeowners receive tax credits of $50 for "Tier 1" appliances and $150 for "Tier 2" appliances[111]. The credits apply from 2006 to 2007 for Tier 1 appliances and from 2006 to 2010 for Tier 2 appliances.
Tax credit on Commercial Equipment, 2006-2010: boilers	Based on EFFECTER, businesses receive a tax deduction of $150 or $450 for "Tier 1" equipment and $900 for "Tier 2" equipment The credits apply from 2006 to 2007 for Tier 1 appliances and from 2006 to 2010 for Tier 2 appliances.

The policy impacts on energy use, measured in quads (Quadrillion British Thermal Units) with respect to the reference case, are reported in Table 62.

Table 62: Impacts on energy use of 4 different policies analysed in the EIA study measured in Quadrillion British Thermal Units[110]

POLICY	2010	2015	2020	2025	Cumulative 2006-2025
Residential l Equipment Tax credit	-0.011	-0.011	-0.008	-0.005	-0.166
Commercial Equipment Tax credit	-0.005	-0.003	-0.002	-0.001	-0.053

The percentage effects on energy use of these policies, with respect to the energy consumption projections up to 2025 of the reference case, are reported in Table 63. The reference case values of primary energy use by sector and by year are reported in Table 63.

Table 63: Reference case values of primary energy use considered in the EIA study, expressed in Quadrillion British Thermal Units[112]

SECTOR	2010	2015	2020	2025	Cumulative 2006-2025
Residential	23.47	24.58	25.56	26.62	491.5
Commercial	20.29	22.18	24.24	26.74	449.6

[110] Source: Adapted from EIA

[111] Tier 1 appliances tend to be the in the middle of the range of efficiency available for that product class. Tier 2 appliances tend to be near the upper limit of efficiency available.

[112] Source: Adapted from 2005 Energy Policy Act

Table 64: Impacts on energy use of 4 different policies analysed in the EIA study, expressed in percentage change with respect to the reference case

POLICY	2010	2015	2020	2025	Cumulative 2006-2025
Residential Equipment Tax credit	-0.05%	-0.04%	-0.03%	-0.02%	-0.03%
Commercial Equipment Tax credit	-0.025%	-0.014%	-0.008%	-0.004%	-0.012%

Notice that these percentages are calculated against total primary energy use of the residential and commercial sector.

State policies

At present, the effort to increase appliance energy efficiency is also strongly guided by State policies.

The main categories in which it is possible to divide all the main initiatives are:

- Appliance and Equipment Efficiency Labels
- Appliance and Equipment Efficiency Standards
- Building Energy Codes (that might include requirements for installed appliances)
- Financial Incentives
- Information/Education Campaigns

In particular, the financial incentives that have been introduced by single States can be further divided in the following categories:

- Bond Programs
- Corporate Tax Incentives
- Grant Programs
- Loan Programs
- Personal Income Tax Incentives
- Property Tax Incentives
- Rebate Programs
- Sales Tax Incentives

All current financial policies by single US State initiatives are listed in the following tables. These tables report the main characteristics of the schemes: State, type of instrument, targeted product and qualified beneficiaries.

In particular, two States, New Mexico and Montana, have set up bond programs of several million dollars ($20 million in New Mexico and variable amounts depending on technology in Montana) to fund energy efficiency and renewable energy improvement projects in State government and school buildings (Table 65).

Table 65: Existing State Bond Programs in the US

Bond Programs			
Montana	State Buildings Energy Conservation Bond Program	Boilers, Lighting	State buildings
New Mexico	Energy Efficiency & Renewable Energy Bond Program	Lighting, solar heating	State buildings, schools

Corporate tax incentives are built to give corporations tax credits or deductions to promote energy efficient equipment. More in detail, the two federal incentives listed in Table 66, are quite different:

- the first one gives tax credits to U.S. manufacturers that produce high efficiency residential appliances. Credits are calculated as fixed amounts for each extra unit produced, varying with the type of appliance; calculations are made over a three-year baseline;
- the second tax incentive establishes a tax deduction to owners of commercial buildings for the installation of certain energy efficient equipment. The incentive is in the form of a tax deduction of $1.80 for square foot if the energy saving reached are of at least 50% compared to a minimum standard building.

Table 66: Existing State Corporate Tax Incentives in the US

Corporate Tax Incentives			
Federal	Energy Efficient Appliance Tax Credit for Manufacturers	Refrigerators/freezers, Clothes washers	Increase in production
	Energy Efficient Commercial Buildings Tax Deduction	Boilers	Efficient Commercial Buildings

As Table 67 shows, many States offer grant programs to support the diffusion of energy efficient appliances. Many of these programs are utility funded and are aimed at helping their residential and/or commercial customers improve their overall energy efficiency by the installation of high standard equipment. The amount of the grant can either be calculated as a percentage of the cost of the installation or as a fixed amount for each type of appliance.

- For example the New York State program, "Assisted home performance grants", funds up to 50% of the cost of the improvements; giving also the chance to home owners to cover the remaining costs with a low-interest loan.
- While the Delaware program "Energy An$wers for Home Appliances", for example, offers $100 for Delaware residents who replace inefficient refrigerators and washing machines with selected high efficiency products ($50 for freezers and $25 for electric water heaters).

Table 67: Existing State Grant Programs in the US

State	Program	Products	Eligibility
California	Energy Efficiency Grant Program	CFL, Energy efficient equipment	Commercial customers of Alameda Power & Telecom
	Weatherization Cash Grant Energy Efficiency Program	CFL, Energy efficient appliances	Residential customers of Alameda Power & Telecom
	Residential Energy Efficiency Grant Program	Heating and lighting retrofits;	Anaheim Public Utilities low-income residential customers
	Business Bucks Energy Efficiency Grant Program	Refrigeration, lighting and water heating energy-efficient retrofits	Small and mid-sized business customers of Burbank Water & Power
Connecticut	Energy Conservation Program for State Facilities	Boilers	State facilities
	Energy Conscious Blueprint Grant Program	Lighting, Commercial Refrigeration, Boilers	New commercial or industrial buildings
Delaware	State program: Energy An$wers for Business	Refrigerators/Freezers, Lighting, Boilers	Non-residential electric customers
	State program: Energy An$wers for Home Appliances	Refrigerators/Freezers, Lighting, Water heaters replacement	Residential customers
Indiana	Low Income Weatherization Program	Refrigerators/Freezers replacement, CFL installation	Duke Energy low-income residential customers
Minnesota	Commercial and Industrial Custom Energy Grant Program	Energy-efficient products which exceed conventional models	Dakota Electric's customers
	Commercial and Industrial Grant Program	Energy-efficient lighting	Minnesota Valley Electric Cooperative commercial and industrial customers
	Utility Grant Program	Refrigeration, lighting	Otter Tail Power residential customers
	Utility Grant Program	Refrigerators/Freezers, Water Heaters,	Otter Tail Power low-income residential customers
New Hampshire	Low-Income Energy Assistance Grant Program	Clothes Washers, Refrigerators/Freezers, Lighting	New Hampshire Electric Co-Op low-Income residential customers

State	Program	Products	Eligibility
New York	State Grant Program	Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting	Low-income home owners
	State Grant Program	Refrigerators/Freezers, Lighting	Multi-Family and Low-Income Residents
Ohio	State Grant Program	Lighting, Boilers, Refrigeration	Manufacturing facilities
Oregon	Utility Grant Program	Boilers	Natural gas users

Another policy instrument that has been used by states is that of personal income tax deductions or credits (Table 68).

- In some cases, like for the District of Colombia, Montana and Oregon initiatives, the credit is calculated as a percentage of the expenses incurred with the purchase.
- The Californian program instead offers a tax deduction of the interest (100%) paid on loans used to purchase energy efficient appliances.
- The federal incentive has been to legislate that energy conservation subsidies are not taxable.

Table 68: Existing State Personal Income Tax Incentives in the US

Personal Income Tax Incentives			
Federal	Exemption of Residential Energy Conservation Subsidy (non taxable)	Installations that reduce energy consumption	Residents
California	Tax Deduction for Interest on Loans for Energy Efficiency	Lighting, Boilers	Residents
District of Columbia	Residential Energy Conservation Tax Credit	Clothes Washers, Refrigerators/Freezers, Boilers, Lighting	Residents
Montana	Energy Conservation Installation Tax Credit	Boilers	Taxpayers
Oregon	Residential Energy Tax Credit	Clothes Washers, Refrigerators/Freezers, Boilers	Homeowners and renters

The State of New York is the only U.S. state that has introduced a property tax exemption for energy efficiency measures (Table 69). Under this scheme, energy efficiency improvements to homes are exempt from real property taxation to the extent that the addition would increase the value of the property.

Table 69: Existing State Property Tax Incentives in the US

Property Tax Incentives			
New York	Energy Conservation Improvements Property Tax Exemption	Boilers	Taxpayers

Sales tax reduction or exemptions reduce the final cost to the buyer at the time of the purchase. Four States have implemented this kind of instrument that exempt certain products from the regular tax rate (Table 70). Exemptions can be permanent or take the form of "tax holidays" for which the tax is lifted only for a few days in the year.

Table 70: Existing State Sales Tax Incentives in the US

Sales Tax Incentives		
Connecticut	Sales and Use Tax Exemption for Energy-Efficient Products	CFL, Natural gas boilers
Georgia	Four-Day Sales Tax Exemption for Energy-Efficient Products	Clothes Washers, Refrigerators/Freezers, Water Heaters, Lighting
Texas	Memorial Day Weekend Sales Tax Holiday for Energy-Efficient Products	CFL, Clothes Washers, Refrigerators/Freezers
Virginia	Sales Tax Exemptions for Energy-Efficient Products	CFL, Clothes Washers, Refrigerators/Freezers

It is not possible to list all of the existing loan and rebate programs promoted by single states, because there are over 800 programs. Loan programs offer low-interest loans to households or businesses that invest in energy efficiency improvements while rebate programs offer rebates on the purchase of energy efficient appliances. Many of these programs are not promoted by government agencies but by utilities, as a form of demand side management.

Demand-Side Management programs (DMS) can be enacted by public utilities and companies as an answer to agreements with public authorities or to the introduction of Energy Efficiency Resource Standards (EERS) that set efficiency and saving targets to the utilities themselves. These are market based mechanisms that are currently attracting interest in the U.S. and are aimed at encouraging more efficient generation, transmission and use of electricity and natural gas. Demand Side Management programs can include individual billing systems, the provision of information and technical assistance to customers and supplemental financial incentives to favour the upgrade of appliances.

It is estimated, by the ACEEE, that a national EERS target that was to start at modest levels, such as savings of 0.25% of annual sales, and then increase to 0.75% would reduce by about one quarter the currently projected growth in electricity sales over the 2007-2020 period and about one half of the projected growth in natural gas sales. The detailed results are represented in Table 71.

Table 71: Summary of estimated savings from a National EERS programme[113]

EFFECTS	2010	2020
Annual electricity savings (TWh)	87	386
Estimated peak demand savings (MW)	28,100	124,200
Annual direct gas savings (TBtu)	355	1,570
Total savings, all fuels (quads)	1.29	5.59
Cumulative net benefits (billions $)	-13.7	64.0
CO_2 emissions savings from an EERS (MMT)	76	320
Benefit/cost ratio	2.6	2.6

Notice that a national EERS of this kind would reduce energy use in 2020 by about 5.6 quads that are equivalent to 4.6% of the projected U.S. energy use for that year.

Notice also that these savings are significantly greater than those generated by the combined energy efficiency measures of the 2005 Energy Policy Act.

2.5.2. Economic Models

- ***Effectiveness of tax incentives and the so-called "Energy Paradox"***

It is widely accepted that the stock of household appliances is less energy efficient than it would be economically optimal at current prices. This has lead to the discussion regarding the inadequate diffusion of apparently cost-effective energy-conservation technologies.

Indeed, investment tax credits that in various markets have proved to be effective tools for inducing investments seem to have not been so successful in the energy-efficiency context. Many empirical studies find that tax incentives are not influential (i.e. coefficient estimates statistically not different from zero) or that they can, even, decrease investments.

Hassett and Metcalf (1995) investigate the effectiveness of tax incentives and find that they are statistically significant and increase the probability of investing in energy-efficient technology when accounting for fixed effects. More precisely, their work reaches the same results as the previously cited literature when not controlling for individual specific effects - that are likely to be correlated with some explanatory variables - and opposite ones when controlling for the latter. This result is noteworthy because it implies that consumers do indeed respond rationally to energy-efficiency incentives, so that both energy prices and tax-incentives influence consumer's purchasing behaviour.

113 Source: 2005 ACEEE

The study investigates the effectiveness of tax incentives on the log odds ratio of the probability of investment in conservation measures in the U.S. in 1978-1985, when incentives were present at both the federal and single state level. The U.S. federal Energy Tax Act of 1978 that provided homeowners with tax credits to encourage conservation investments, such as: insulation, boiler replacements, weather stripping, storm and thermal door/window installation. The credit covered 15 % of the expenditure with a 300$ cap and was valid only for houses built prior to 1977. Along with the federal tax credit - that remained the same during all the years considered in the study - nine states offered energy efficiency incentives. These programs are what provide the authors with the variation in the tax price of the conservation investments that allows them to evaluate the relevance of tax incentives on such investments.

Hassett and Metcalf (1995) use an econometric model that analyses a panel dataset containing federal returns by taxpayers – that include details about federal residential tax credit claims – plus additional information on the household characteristics. The fraction of returns taking the credit is reported in Table 72.

Table 72: Federal returns and fraction that took the US federal residential energy credit[114]

YEAR	NUMBER of RETURNS	RETURNS WITH CREDIT	%
1978	89,772	5,843	6.51
1979	92,694	4,775	5.15
1980	93,902	4,670	4.97
1981	95,396	3,870	4.06
1982	95,337	3,136	3.29
1983	96,321	NA	NA
1984	99,439	NA	NA
1985	101,660	2,979	2.93

Mean conservation expenditure range from 257$ up to 1,202$ across states, while average credit received ranges from 38$ up to 156$

The authors use the variable "filed a tax-credit claim"/not as a proxy of the variable "have invested"/not in home conservation measures.

The theoretical setting is that of an investment model with exponentially raising energy prices, where each individual wants to minimize the lifetime costs of energy expenditure for a given level of heating comfort, taking into consideration any tax incentive that may be available. Each consumer has to choose when (if ever) to invest in some energy-saving capital that will reduce its future energy expenditure by a certain percentage. The first order conditions of this minimization problem indicate the threshold (for a quantity depending on the following: discount rate, a variable that determines if energy savings accrue to the investor or not, percentage of energy savings from investments, energy price at the final period, available tax incentives and investment amount) for which it is optimal to invest. It is not possible to measure this

[114] Source: Hassett and Metcalf (1995)

quantity directly but only perturbations of it. This leads to the need of using econometric techniques to estimate its real value. Actually, as the focal point is not the value itself but, rather, its sign, the authors set up a discrete choice model.

The relationship of the regressors with the dependent variable is defined by the sign with which they appear in the first order condition. Because of the difficulty in measuring certain parameters (discount rate, a variable that determines if energy savings accrue to the investor or not, percentage of energy savings from investments), the regressions actually performed by the authors include other variables that are likely to be a function of the former. In particular, the new variables included are (certain) household characteristics.

The innovation brought by this paper is, in fact, the inclusion of individual specific effects that account for conservation "taste" and unobservable characteristics of the housing stock that individuals choose. Such effects are likely to be correlated with the explanatory variables, including the tax incentive. Failing to take into account these effects produces an omitted variable bias that will affect the tax incentive coefficient. Controlling for these factors has instead shed light on some paradoxical results existing in literature.

As the setting is that of a discrete choice model, the analysis does not answer the question on how do changes in the regressors change the probability of making a conservation investment. It instead indicates by what proportion such a probability will change, because we are considering the ratio of the probability to invest and not invest (log odds ratio).

The authors perform five different regressions on a random sample of returns for the years 1979-1986. The results of each regression are reported on the different columns of Table 73. Within this sample 5.7 of tax payers take a credit for residential energy conservation; their conservation expenditures and credit range between [0; 16,970]$ and [0; 301]$, respectively.

Table 73: Results from the five regressions performed by Hassett and Metcalf (1995)[115]

VARIABLE	(1)	(2)	(3)	(4)	(5)
Tax price	0.978	-2.428	-2.271	- 2.081	-2.552
Energy price	- 5.111	11.541	26.434	0.255	10.454
AGI (x $1000)	0.0006	0.0110	0.0109	0.792	0.0111
Homeowner	1.508	0.948	-	0.917	0.947
HDD	0.144	0.201	0.079	0.200	0.204
Change in employment rate	- 0.037	- 0.017	- 0.026	- 0.016	- 0.016
Trend	- 0.162	- 0.186	- 0.291	- 0.170	- 0.182
Fixed effects	no	yes	yes	yes	yes
Sample size	74,792	12,915	8,496	12,915	12,915

115 Source: Adapted from Hassett and Metcalf (1995)

The first regression is on the pooled sample. The dependent variable is a dummy variable indicating the presence/absence of a credit due to conservation expenditures. The authors find, as expected, that the probability of investment decreases with unemployment and increases with income, ownership and location in colder climates. Nevertheless, such specification produces, in the level regression, wrong sign estimates of the energy price and tax-price coefficients.

The second regression introduces fixed effects and is conditional on individuals making investments in at least one year (conditional logit fixed effects). With the addition the fixed effects that control for specific characteristics the sign of the estimated coefficients are all coherent with what is expected. More precisely, the values of the tax price and energy price coefficients are –2.4 and 11.5 respectively. This means that for example a 10 percentage point decrease in the tax price of conservation capital will increase the probability of investing by 24 percent.

The third regression restricts the sample further, to consider only homeowners. This leaves the tax-price coefficient essentially unchanged with respect to the second regression.

In the fourth regression the authors include the log of the tax price, energy price and income variables. This allows them to compare the effectiveness of tax incentives programs against energy prices effects. From theory the effects of a 10 percent increase in energy prices should equate those of a 10% cut in the cost of conservation capital. Contrary to such theoretical predictions, the coefficients of energy price and tax price are not similar, in absolute values. In fact, the tax price coefficient is about eight times the size of the energy price one. This indicates that the energy price changes are perceived as temporary. Results that go in same direction will be discussed with the Jaffe and Stavins (1995) paper.

The final regression tests if the tax-price effect is a spurious result. It does this by including in the model a dummy variable that indicates if the state had a credit program the following year or not. The estimate of the future tax variable is positive, though statistically not significant. Therefore, tax timing is not driving the result of this analysis that indicates that indeed tax incentives can increase the probability at the margin of making conservation investments.

Jaffe and Stavins (1995) empirically address the long-standing debate on the most effective policy instruments, comparing market-based approaches with command-and-control ones. In the literature, economists favour market-based mechanisms (emission taxes, subsidies and tradable permits), in particular, for their capability of stimulating only the most cost-effective actions and because of their dynamic efficiency, i.e. the fact that they generate a continuous incentive to improve performances. On the contrary, command-and-control approaches, such as standards, tend to drive emission reductions to the level required – at whatever cost is necessary- and not stimulate any further improvement. Although the economic argument is quite clear and generally accepted, policy-makers often prefer command-and-control regulations. This supports the need for analyses that compare the effectiveness of alternative policy instruments in addressing energy efficiency goals.

In their paper, Jaffe and Stavins make the comparison between market-based mechanisms with performance and technological standards by analysing their relative cost-effectiveness and dynamic efficiency.

The theoretical setting is based on two models. The first is a pollution-abatement-technology choice problem with a firm having to choose both whether or not and when to adopt an already available environmental protection technology. The model is based on an optimization problem where the firm chooses the time of adoption in order to minimize the sum of the present discounted values of:

- regular variable costs prior to adoption plus any pollution tax payment;
- variable costs subsequent to technology adoptions plus any pollution tax payment;
- costs of adoption;
- implicit costs of violating any performance or technology standard prior and subsequent to adoption.

The introduction in the model of the costs of violating the two types of standard provides the means to compare such quantity instruments with price ones[116]. The second model focuses on new sources of emissions: new plants or expansions of existing facilities[117]. The setting is now of an optimisation model where the firm only chooses if to incorporate the already available environmental protection technology.

For data availability reasons, the authors apply this second model to real data regarding thermal insulation decisions by builders in the presence of varying economic incentives and command-and-control regulations. In this context, the firm not only has to decide whether or not to incorporate the technology, but also its level of efficiency. The timeframe considered is that of the 1970's -80's[118]; during this period the large oil price fluctuations generate, according to the authors, a "natural experiment". Indeed, the increase in oil prices gave rise to a variety of regulatory efforts aimed at reducing energy consumption. The higher energy cost generated also economic incentives for conservation that diminished when oil prices dropped. This setting allows the authors to analyse the use of energy-saving practices across geographic areas and time wise. Indeed, citizen's responses to these "natural" variations in costs can be used to infer the likely response to economic incentives set up by governments.

More precisely, the study focuses on thermal insulation measures for ceilings, walls or floors of newly constructed single-family homes. The authors use the available real data to estimate the dependency of the prevailing level of efficiency in each jurisdiction on:

- costs of adoption;
- previous period prevailing state efficiency level;
- lagged average price of energy;
- presence of relevant mandatory building provisions;
- presence of relevant voluntary heating building provisions;

[116] Note that the probability of a sanction being imposed is modelled as a function of the level of excess pollutant emissions.

[117] The first model is suitable for already operating facilities as it splits the optimization problem in the two intervals before and after T (time of adoption).

[118] More precisely, the National Association of Home Builders' annual survey between 1979 and 1988, for 48 states.

- heating degree days;
- cooling degree days;
- mean education of heads of households;
- fraction of state population resident in urban areas;
- median household income.

The results are reported in Table 74.

Table 74: Estimated values of the partial effects of each independent variable of the model on the average value of the prevailing efficiency practice for the year 1979[119]

VARIABLE	Ceilings	Walls	Floors
Adoption costs	-10.08	-10.77	-25.15
Energy price	6.74	5.14	11.00
lagged efficiency	0.302	0.391	0.428
Mandatory code	0.925	-0.450	-1.433
Voluntary code	-0.409	-0.560	-0.835
Heating DD	23.895	- 3.89	7.939
HDD^2	-1.013	0.521	-0.129
Cooling DD	-11.95	-9.90	7.24
CDD^2	1.17	0.859	- 0.316
Education	123.44	41.87	134.02
Percentage Urban	-2.97	0.281	1.35
Income	-18.23	-9.208	-29.45

The authors find that the adoption cost coefficients have, as expected, a negative sign and have large magnitude in all three cases. Also energy price coefficients show the expected (positive) sign, but they are lower than the coefficients relative to the costs for installing the technology, as in Hassett and Metcalf (1995). The lagged prevailing-state-efficiency level is generally significant but with small magnitude coefficient. Interestingly, the building code variable coefficients are consistently not significant. This means that there is no evidence, among the used data, that building standards have any effect on average state-efficiency levels. Also the climate variables are found to be not statistically significant; while income and education are, with a positive and negative sign, respectively.

The estimated coefficients are then used to perform dynamic simulations of the model using variations of the present values of the energy price and adoption cost regressors.

[119] Source: Jaffe and Stavins (1995)

In this way, the authors aim at comparing the effects of taxes versus subsidies. More precisely, they are able to compare the effects of a tax on energy with a technology subsidy that decreases adoption costs. The results are reported in Table 75. The simulations are performed on all three datasets - regarding ceilings, walls, and floors respectively - and compare the effectiveness of a 10% tax on energy in all years (energy tax case) with a 10% subsidy on the cost of adoption in all years (cost subsidy case). The values reported are the national average level of efficiency practice in the initial and final year of the study for the three cases: base case (values at time of study), energy tax case and cost subsidy case.

Table 75: Simulation results: effects of energy prices (tax) and adoption costs (technology subsidy)[120]

	Ceilings			Walls			Floors		
YEAR	BASE CASE	ENERGY TAX	COST SUBSIDY	BASE CASE	ENERGY TAX	COST SUBSIDY	BASE CASE	ENERGY TAX	COST SUBSIDY
1979	24.7	24.7	24.7	12.2	12.2	12.2	14.4	14.4	14.4
1988	29.3	30.0	30.4	14.2	14.7	15.3	18.3	19.4	21.1
(%) increase	18.6%	21.5%	23.1%	16.4%	20.5%	25.4%	27.1%	34.7%	46.5%

The most interesting simulation to comment is that of floors. In this simulation, the average level of efficiency went from 14.4 to 18.3 between 1979 (initial year) and 1988 (end of period); the model simulation suggests that the efficiency level that would have been reached in 1988 with an energy tax and with a technology subsidy would have been 19.4 and 21.1 respectively. This indicates that a 10% energy price increase due to a tax, in place throughout the period, would have increased adoption in 1988 by 6% relative to the base case, while a 10% decrease in adoption cost due to a subsidy, in place throughout the period, would have increased adoption in 1988 by about 15%[121]. Therefore the authors find that, for what concerns floors, both tax and subsidies are important incentives for conservation technology adoption; but that the effects of technology costs are nearly three times as large as the energy price ones. This is an interesting result because economic theory would instead predict such effects to be of the same magnitude. Similar results are found in Hassett and Metcalf (1995) and, as indicated by the authors, they are in line with conventional beliefs among non-economists.

The other two simulations - ceilings and walls - confirm the stronger effects of the subsidy with respect to the tax, but these policies are not as effective on conservation decisions as in the floor insulation case, nor are the difference in the size of the effects of the two policies as large.

[120] Source: Jaffe and Stavins (1995)

[121] The value reported by the author in the original paper is 17%, this though is calculated disreguarding the decimal figures of the simulated effects of taxes and subsidies on adoption reported in Table 75. The values reported in this work are instead evaluated using the available extra decimal figure.

Table 76 indicates the additional percentage increases due to the two policies with respect to the base case; while Table 77 the percentage increase in technology adoption due to cost subsidies with respect to the energy tax case.

Table 76: Simulation results: percentage increase in technology adoption due to energy tax and cost subsidy with respect to the base case[122]

Ceilings		Walls		Floors	
ENERGY TAX	COST SUBSIDY	ENERGY TAX	COST SUBSIDY	ENERGY TAX	COST SUBSIDY
2.4%	3.7%	3.5%	7.7%	6.0%	15.3

Table 77: Simulation results: percentage increase in technology adoption due to cost subsidies with respect to the energy tax case[122]

Ceilings	Walls	Floors
1.3%	**4.0%**	**8.8%**

These results indicate that both kind of market-based policies are effective. Because of the stronger effects ascribed to subsidies, the model simulation results seem to indicate that consumers are more concerned with initial costs than with energy savings over the life of the investment. Though, it must be specified that in this model relevant parameters - such as consumer discount rates and the parameter that accounts for the market failure to reflect the full value of the investments - affect only the intercept term and not the regressor's coefficients.

Evidence on the Rebound effect

The literature highlights that the potential reductions in energy use that can be induced by energy efficiency improvements may be deflated by the so-called "rebound effect".

This effect refers to the fact that an increase in energy efficiency, due to technological improvements, can generate an increase energy demand because more services can be obtained using the same quantity of energy. This effect can be regarded as analogous to a reduction in price that produces an increase in demand that, from our point of view, could erode the technological efficiency savings. It must be noticed that the effects of price reduction on consumers are not completely transformed in an increase of the good's demand but can be decomposed in two components:

- a substitution effect: whereby consumption of the now cheaper energy service substitutes for the consumption of other goods and services, keeping utility constant.
- an income effect: whereby there is an increase in real income that allows an increased consumption of all goods and services, leading to a higher level of utility.

[122] Calculated using Jaffe and Stavins (1995) results

Especially for the case analysed in this report, concerning four appliances, consumer satiation issues are expected to be relevant. Although there are no specific studies dedicated to the analysis of the income effect, we can expect that a decrease in the price of services will not result in an indefinite increase in the number of appliances of the same type, but more likely in a certain increase of consumption of appliances attributes, i.e. bigger appliances.

It is therefore very important to consider the rebound effect when evaluating the potentials of any policy aimed at increasing energy efficiency.

Greening, Greene and Difiglio (2000) study the relationship between energy efficiency and consumption. The authors have analysed over 75 literature estimates of the rebound effect that derive from direct measurements (surveys) or econometric studies. They found that although estimates vary, all studies report that for all end-uses taken into consideration (space-heating, space cooling, water heating, residential lighting, appliances and automotive transport) a 1% increase in energy efficiency produces a lower than unit increase in energy consumption. Detailed results are reported in the Table 78.

Table 78: Empirical estimates for the rebound effect at the consumer level for a 100% increase in energy efficiency[123]

END USE	POTENTIAL SIZE OF REBOUND	COMMENTS	NUMBER OF STUDIES
Space heating	10-30%	These measures don't include space cooling which is best for our analysis that takes into consideration boiler and not air conditioning.	26
Water heating	10-40%	Increased shower lengths or purchase of bigger heating units are reported, though they cannot be measured.	5
Residential lighting	5-12%	An indirect effect on increase in working hours was reported.	4
Appliances	0%	Indirect effects in terms of purchase of larger units with more features were reported.	2

Conditional demand surveys have shown that residential space heating is responsible for about 53% of household fuel (electricity and natural gas) use. This implies that any rebound effect on this kind of energy use can be significant.

Table 78 shows that, for space heating, the rebound effect is estimated between 10 and 30% of the total increase in energy efficiency. This means that any improvement in energy efficiency will be effective at 70 to 90% of its potential.

Efficiency improvements for residential hot water heating will be effective between 60-90% in reducing energy consumption, while lighting upgrades will be 88-95% effective. From this review of various studies it seems that the rebound effect for appliances such as refrigerators and washing machines is irrelevant, so policies targeting such products are expected to be 100% effective.

[123] Source: Adapted from Greening, Greene and Difiglio, 2000.

The **UK Energy Research Centre** (UKERC) has recently published a report on the rebound effect, whose aim is that of extending the literature review of Greening et al. and also of placing greater emphasis on indirect rebound and economy-wide effects. The report, in fact, distinguishes between direct and indirect rebound effects. In addition to the already defined matter - i.e. that many energy efficiency policies may not be as effective as calculated by engineering models due to the fact energy efficiency improvements make energy services cheaper and therefore stimulate consumption - (direct rebound effect), there are other reasons for which the effectiveness of energy efficiency improvements might be smaller than predicted, even if consumption of energy services remains the same (indirect rebound effect).

The indirect rebound effects reported in the paper are the following:

- The equipment used to improve energy efficiency will itself require energy to manufacture and install and this "embodied" energy consumption will offset some of the energy savings achieved;
- Consumers may use the cost savings from energy efficiency improvements to purchase other energy-intensive goods and services;
- Producers may use the cost savings from energy efficiency improvements to increase output, thereby increasing consumption of capital, labour and materials inputs which themselves require energy to provide. If the energy efficiency improvements are sector wide, they may lead to lower;
- Cost-effective energy efficiency improvements will increase the overall productivity of the economy, thereby encouraging economic growth. The increased consumption of goods and services may in turn drive up energy consumption.
- Large-scale reductions in energy demand may translate into lower energy prices which will encourage energy consumption to increase. The reduction in energy prices will also increase real income, thereby encouraging investment and generating an extra stimulus to aggregate output and energy use.
- Both the energy efficiency improvements and the associated reductions in energy prices will reduce the price of energy intensive goods and services to a greater extent than non-energy intensive goods and services, thereby encouraging consumer demand to shift towards the former.

Taking into account quantitatively all these economy-wide issues is a complex matter and different studies may use different definitions of rebound effects and also of the notion of energy efficiency improvements; this has led to vary sparse empirical evidence that is currently sustaining the strong dispute over the importance of the rebound effects. This uncertainty over the relevance of such effects has been often translated into the exclusion of the rebound effect matter in official policy analysis, but this UKERC report shows that its effects are sufficiently important to merit explicit treatment when assessing the contribution that energy efficiency improvements can make to the reduction of energy consumption and CO_2 emissions.

More in detail, the report produces the following results:

- When analysing rebound effect evaluation studies, that aim at measuring the change in the demand for the targeted energy service, evidence of a shortfall in energy savings by space heating efficiency measures is found. The magnitude of the effect varies across studies but ranges between 10% and 50% of the expected energy savings. A positive temperature take-back was observed in most studies, on average between 0.4-0.8°C, though not always statistically significant. The author, reasoning on the fact that energy savings may be overestimated up to 50% and that temperature take back only account for a portion of the shortfall, concludes that the rebound effect for space heating efficiency improvements should typically be less than 30%.

- When analysing rebound effect econometric studies, the author reports that the meta-analytical work of Espey and Espey suggests an upper bound of rebound effect for household electricity services in the short and long run of 20-35% and 80-85%, respectively.
- More specifically, the results of studies that use data on energy efficiency (or capital cost) of household appliances estimate the direct rebound effect for household heating between 10-58% in the short run and 1.4 to 60% in the long run. The author concludes that a reasonable figure is again 30%. For household cooling the estimates range between 1-26%, while for water heating estimates are 34-38%. The details of some of the studies that explicitly target appliances have been summarised in Table.
- For what concerns secondary effects from energy efficiency improvements in consumer technology, a number of analysts have claimed that they are relatively small because energy constitutes a small part of consumer expenditure and because the energy content of most other consumer goods and services is low. This though is in contrast with other quantitative studies that consider a broader range of effects in addition to that of reducing energy expenditure.

CGE models seem to find high values of high values of rebound effects (all studies > 37% and most studies >50%) or even backfire effects. These results depend on a wide range of variables, such as elasticities of substitution between inputs, or between capital and labour, own price or income elasticities, and other factors.

The author states repeatedly that these results are not very reliable, as they come from different studies that have different methods, scope and methodological quality, and therefore the only conclusion that can be made relates to a “best-guess” on the value of the rebound effect. The final conclusion of the UKERC is that the rebound effect is significant, although not enough to make energy efficiency policies ineffective in reducing energy demand. Quantitatively, the direct rebound effect is unlikely to exceed 30%, while it is difficult to give estimates of the indirect rebound effect, although several studies suggest that economy-wide effects may exceed 50%.

Figure 73: Empirical estimates for the rebound effect at the consumer level for a 100% increase in energy efficiency.

Study	Data	Direct Rebound Effect	Specifications
Hseuch and Gerner (1993)	appliances – 1281 US households	58% (gas heated homes) 35% (electrically heated homes)	Short-run R.E.
Klein (1988)	capital cost equipment – 2000+ US household	25-29%	Short-run R.E.
Guertin et al. (2003)	Energy efficiency appliances – 440 Canadian households	29-47%	Long-run R.E.

Source: UKERC (2007)

Consumer discount rates in energy efficiency decisions

In order to evaluate the potential impact of policy measures aimed at promoting the purchase of energy efficient appliances, it is important to study consumer's discount rates relative to these appliances.

This discount rate is a measure of how much consumers discount the saving from less energy use against the higher costs of a consumer durable that uses energy. If the discount rate is high, they will tend to buy the cheaper, less energy efficient, item, whereas if the discount rate is low they will tend to go for the more energy efficient item. Hence this parameter is important in determining the effects of any policy to subsidize energy efficient durables.

Train (1985) analysed several studies present in the literature, regarding consumer discount rates for space heating systems, refrigerators and water heaters and other appliances. Various authors have used different methods to estimate these discount rates, such as:

- Logit/Probit Models: these are econometric models that describe consumer choices. These models aim at calculating consumers' willingness to pay for reduced energy costs observing their choices. The consumer is assumed to be choosing among several alternatives and the desirability of each good is assumed to be related to the capital and operating costs of each alternative;
- Stated preference models: these models are based on surveys that ask direct questions to consumers and discount rates are calculated from the answers;
- Observed points along a continuum: these models infer implicit discount rates observing which investments consumers make, among the broad range of available choices;
- Ranges for discount rates: these methods compare nearly identical models of the same appliance that only differ in energy efficiency and price. From sales data they estimate consumers' average discount rate;
- Hedonic price analysis: these models are constructed on the assumption that consumer's willingness to pay (WTP) for a certain good depends on its attributes. Hedonic price analysis models estimate consumers' WTP by regressing the sales prices of the goods against the consumer's valuation of the attributes of such goods.

The results and the characteristics of each study are reported in Table 79, divided by type of product. Notice that refrigerators have the highest values of discount rate; the author justifies this peculiarity with the fact that it is difficult for consumers to detect differences in energy uses among different models of refrigerators.

An interesting result is that of McRae (1980) that in his stated preference study asked respondents: "*Suppose you were buying a new refrigerator and could get one that cost $100 more but saved on electricity bills. How much would you have to save per month to spend the extra $100 for the refrigerator?* The savings require to induce this extra $100 are reported in Table 80.

Table 79: Consumer discount rates in choice of energy efficient appliances[124]

Author	Estimated average discount rate	Estimation model
Space heating system		
Goett (1978)	**36 %**	**Logit**
Dubin	**2 - 10 %**	**Logit**
Goett and McFadden (1982)	**6.5 - 16 %**	**Logit**
Goett (1983)	**4.4 % with central air conditioning**	**Logit**
	21% without central air conditioning	**Logit**
Berkovec, Hausman, and Rust	**25 %**	**Logit**
Lin, Hirst, and Cohn	**7 - 31 %**	**Logit**
Refrigerators		
Cole and Fuller	**6 l - 108 %**	**Continuum of efficiency levels and prices**
Gately	**45 - 300 %,**	**Ranger for discount rates**
Meier and Whittier	**34 -58 % depending on region**	**Ranger for discount rates**
McRae	**53 %**	**Stated preferences**
Water heating and other appliances		
Goett (1983)	**36 %**	**Logit**
Dubin	**24 %**	**Logit**

[124] Source: Train, 1985.

Author	Estimated average discount rate	Estimation model
Goett and McFadden (1982)	**67 %**	**Logit**
Berkovec, Hausman, and Rust	**33 %**	**Logit**
Freezers		
Lin, Hirst, and Cohn	**23.5 %**	**Logit**

Table 80: Required savings to induce a $100 investment when purchasing a refrigerator, from the McRae study[124]

Dollar savings required/month	Implicit discount rate	Proportion of respondents
1	12 %	0.045
2	24 %	0.485
3	36 %	0.061
4	48 %	0.152
5	60 %	0.136
6+	72 %	0.121

Other interesting studies have investigated consumer's discount rates for energy-cost savings without specifying the measure that could produce them. This has been achieved by asking for example: "*how much would you be willing to pay in order to reduce your annual heating bills by $20?*" Table 81 reports the results.

Table 81: Consumer discount rates for an improvement that reduces the energy bill by $20/year[125]

Author	Estimated average discount rate	Estimation model
McRae	16.67 %	Stated preferences
Houston	22.5 %	Stated preferences
Johnson	3.7 %	Hedonic price analysis

To summarise, consumers' average discount rates for the purchase of efficient models of energy using appliances are reported in Table 82.

[125] Source: Train (1985)

Table 82: Average consumers discount rate for energy efficient appliance purchase

Appliance	Average consumer discount rate
Space heating system	4.4 – 36 %
Refrigerators	39 – 100 %
Water heaters	18 – 67 %
Unspecified actions	3.7 – 22.5 %

The authors of the various studies have also analysed the relationship between discount rates and socioeconomic characteristics, finding that income is a significant explanatory variable. In particular, lower income households are not always able to invest in energy efficient measures even when the return on the investment is perceived, because of liquid capital restrictions. This makes the role of incentives and, in particular, of subsidies crucial.

Education and age have not been found to be statistically significant as explanatory variables, while ownership status has an ambiguous effect: with more structural improvements owners are found, as it would be expected, to have lower discount rates than renters; while with appliances such as fridges discount rates are similar.

All above studies date back to the 1980's; their results might, therefore, not precisely approximate current discount rates, but could constitute a good baseline against which evaluate the effectiveness of consumer sensitisation measures toward appliance energy efficiency. This is reasonable if it is possible to assume that preferences over other (non-energy efficient related) attributes have remained similar. Energy efficiency information campaigns and labelling programs to promote energy efficiency measures among consumers were, in fact, introduced later on.

Price-Elasticities of Demand for Energy

Mark A. Bernstein and James Griffin (2005) investigate the relationship between energy demand and energy prices in the United States. In particular they are interested in finding if there are regional differences. This is an important issue when you have to compare performances and cost-effectiveness of different policies in different regions.

The authors analyse three energy demand components:

- Electricity use in the residential sector;
- Electricity use in the commercial sector;
- Natural gas use in the residential sector.

They find that the relationship between energy price and energy demand is small, that means that demand is relatively inelastic to price.

In addition, their study shows that demand price elasticity in the U.S. has not changed significantly over the past 20 years. This result is probably due to the fact that consumers do not have many alternative options available. The authors notice that in the past few years, in which energy prices have risen briskly, there are signs of a slowdown in demand growth. They ascribe this trend to the increasing prices but also to economic slowdown.

Short-run and long-run price elasticities of demand for energy, at the national level, are reported in Table 83.

Table 83: Short-run and long-run price elasticity of demand for energy in the U.S., at the national level[126]

	Residential electricity	Commercial electricity	Residential natural gas
Short-run elasticity	-0.24	-0.21	-0.12
Long-run elasticity	-0.32	-0.97	-0.36

Figure 74: Estimates of short-run residential electricity price elasticity for each state (1977-2004)[126]

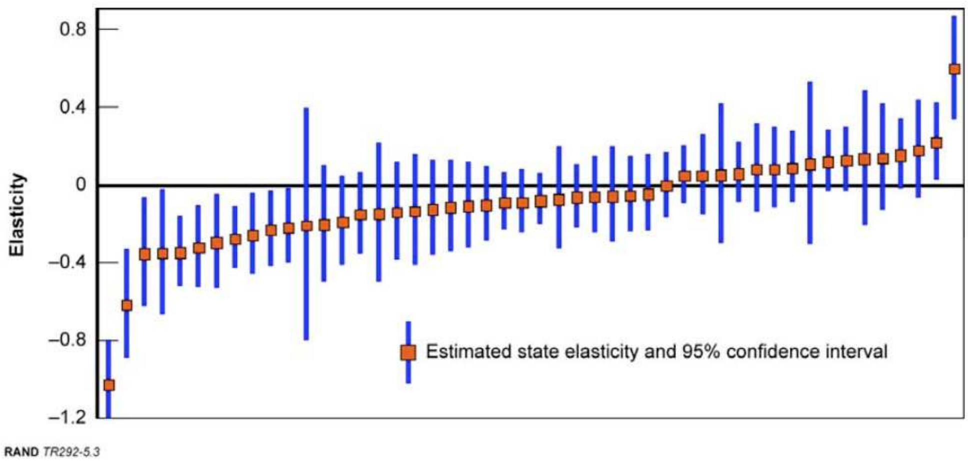
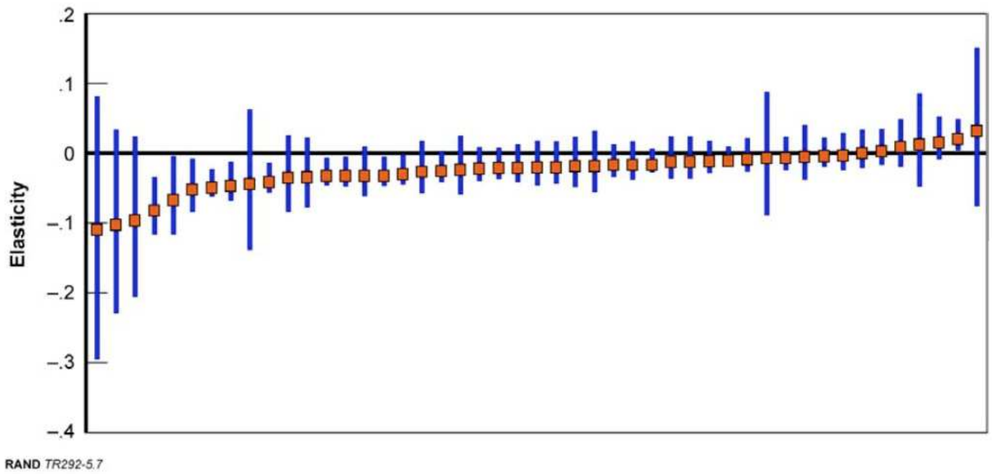
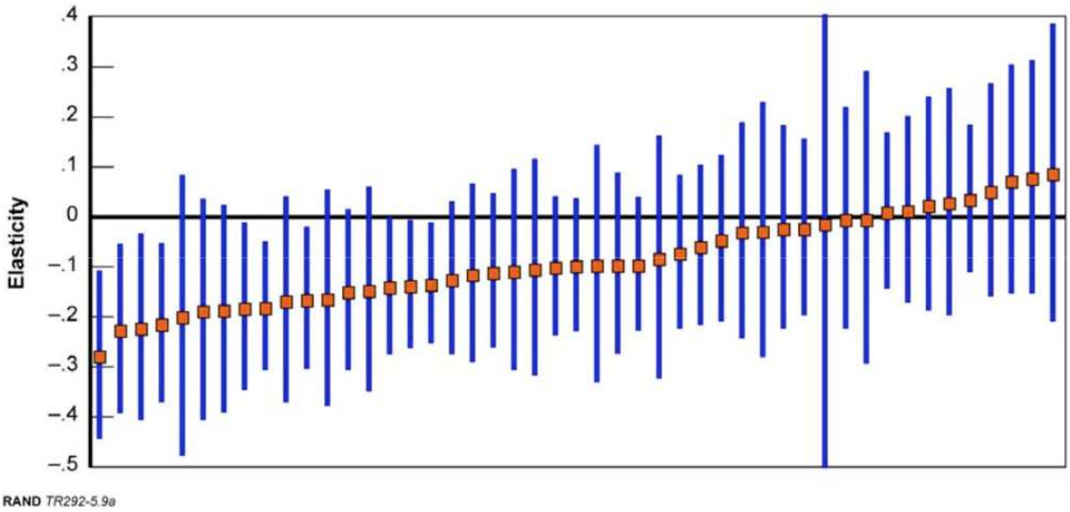


Figure 75: Estimates of short-run elasticity in electricity intensity in the commercial sector for each state (1977-1999)[126]



126 Source: Mark A. Bernstein and James Griffin (2005)

Figure 76: Estimates of short-run residential price elasticity for natural gas at the state level (1977-2004)



The results, reported in Figure 74 to Figure 76, show that indeed there are regional and state differences in price demand relationship; and it is therefore important to value impacts of policies at a disaggregate level, in particular for residential electricity use.

A detailed list of all short-run and long-run price elasticity for each State and its variance are reported in the original paper, available at https://www.rand.org/pubs/technical_reports/index3.html

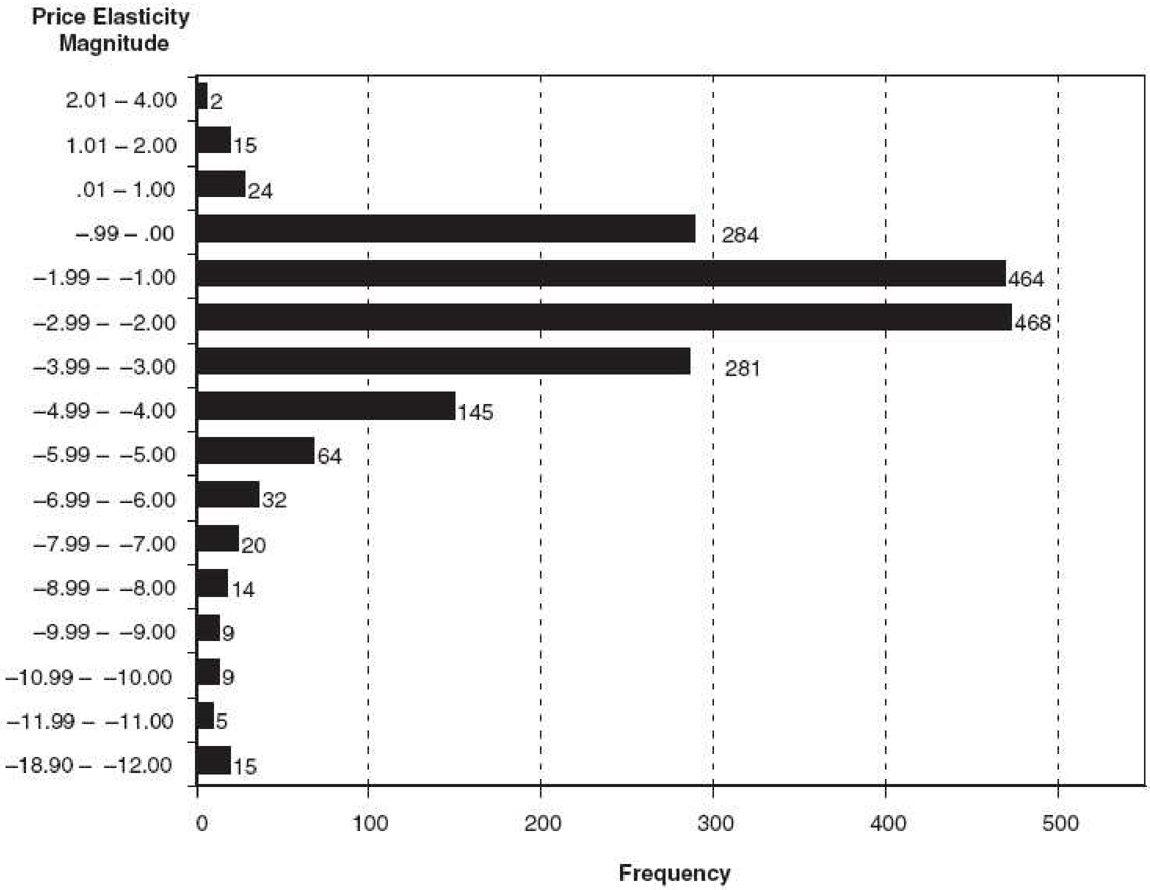
Economists have also attempted to analyse the determinants of consumers' price elasticity. Research has been carried out following different models and measures. **Tellis** (1998) conducted the first important meta-analysis that analyses and summarises the econometric studies on price sensitivity of demand up to 1986. The work is based on 367 price elasticities published between 1961 and 1986. Major findings are that:

- price elasticity is significantly negative;
- the distribution of the price elasticity estimates is very peaked (–1.76 mean and –1.5 mode);
- the absolute mean value of price elasticity found is eight times larger than what literature indicates as the advertising elasticity, indicating a high sensitivity of markets to advertising;
- the omission of quality from the models positively biases price elasticity;
- there is greater sensitivity to prices in the latter stages of the product's life cycle;
- price elasticities are found to be homogeneous across some research settings, such as data sources, functional forms, number of observations and parameters; but model specifications can bias the values. The type of dataset, temporal aggregation, country considered and estimation method bias the estimated values.

More recently **Bijmolt, Van Heerde and Pieters** (2005) have built on this work to update and extend its findings. They have conducted a new meta-analysis to examine which extrapolations still hold and which need to be revised.

This work is based on 1851 values of price elasticity taken from 81 different publications, dating from 1961 to 2004. The overall mean from these studies is -2.62, with a 2.21 standard deviation. The median is –2.22 and the distribution, reported in Figure 77, is strongly peaked. 50% of observations lay between the values [-3; -1], and 81% between [-4; 0]. The mean value confirms the negative sign of price elasticity but is quite higher than the average value found by Tellis, that was -1.76.

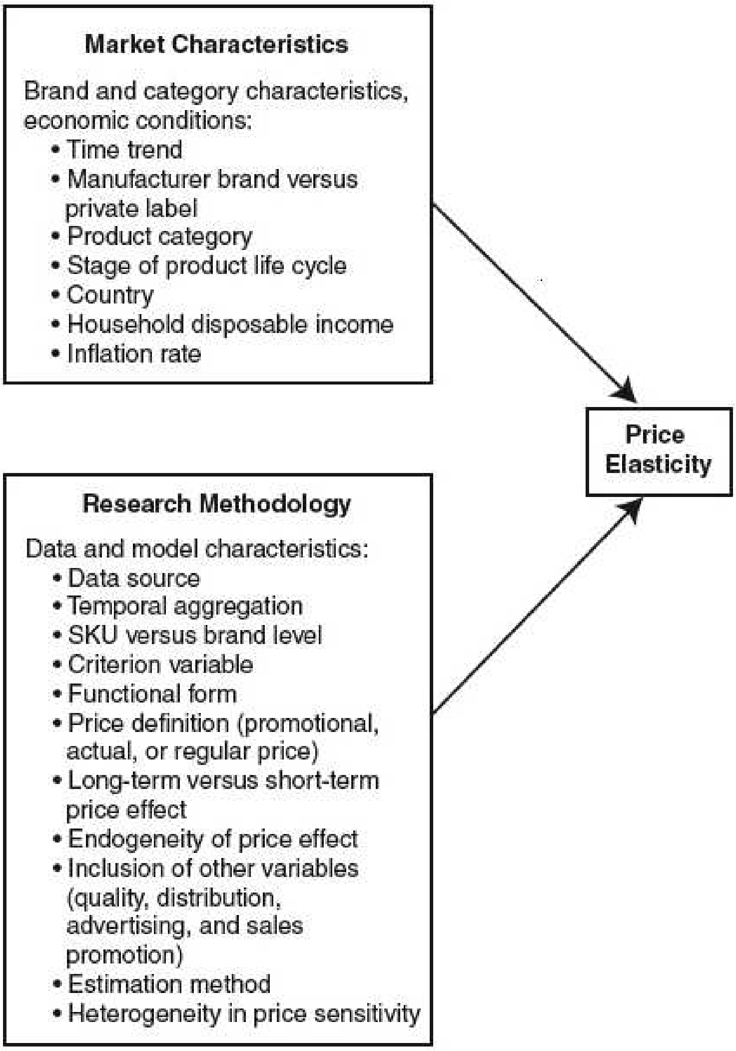
Figure 77: Frequency distribution of observed price elasticities[127]



Price elasticities are modelled as a linear function of their determinants and estimations are performed with iterative generalized least squares. The factors that may affect the estimated value of price elasticity considered in the study are reported in Figure 78.

[127] Source: Bijmolt, Van Heerde and Pieters (2005)

Figure 78: Factors influencing observed price elasticity[128]



For what concerns the analysis of the determinants of price elasticity, i.e. the factors that systematically affect the estimate, some results are similar to those of Tellis (1988) while others are quite different. In particular, the authors find that:

- Consumers are more price elastic for durables than for other products;
- price elasticities are homogeneous across data sources and functional forms;
- no significant differences in price elasticities are found between models including or excluding quality, nor across countries, levels of temporal aggregation or estimation models;
- price elasticity is higher in the initial stages of the life cycle of the product, i.e. at the time of introduction into the market. This would suggest that penetration pricing strategies (from low to high) are more effective than a skimming price strategy (high to low);
- no significant income effect, contrary to what might be expected;

[128] Source: Bijmolt, Van Heerde and Pieters (2005)

- inflation leads to higher price elasticity, probably because consumers become more aware and sensitive to price changes;
- price elasticities are stronger if endogeneity issues are considered;
- omitted variable are also a source of correlation between price and the error term that leads to biased results. Omitting advertising and sales promotions from the predictors decreases the estimated value of price elasticity;
- promotional-price elasticity is larger, in absolute values, than the actual price elasticity;
- no significant overall trend in the price elasticity across the data sample period. Sales elasticities in the last forty years have increased significantly, while share and choice elasticities have remained fairly constant.

The authors explain the differences from Tellis (1988) findings as being driven by the considerable changes in the relative frequency of the various determinants level that has occurred, more than by methodological differences.

Green Marketing

An interesting study on green marketing strategies and product design has been conducted by **Ab Stevels** at Delft University of Technology. This study analyses consumer behaviour in the field of consumer electronics and finds new strategies to promote "green appliances" that could be also applied for the household appliances considered in this review.

Eco-design was introduced in the early nineties, but it was mainly a defensive measure and aimed at compliance with laws and regulations. It was only later that firms realised that many environmental measures could create significant cost savings and also raise their environmental profile. However, the latter effect has been relatively unsuccessful in changing consumer decisions. Analyses of consumer behaviour indicate that about 25% of consumers are sensitive to the green performance of products, even though interviews show higher levels of environmental awareness. This situation motivated the author to carry out a more in depth analysis of consumers green behaviour. This has lead to the definition of the seven archetypes of consumers reported in Table 84.

Table 84: Environmental attitude archetypes[129]

ARCHETYPES	CHARACTERISTICS	AVERAGE % in NORTH EUROPE
Environmentally engaged	Strong interest in environmental issues; has adapted its lifestyle. Strong support for green organizations, little trust in governments and technology. This group has strong information needs, is prepared more for green but will not buy from big multinationals.	15
Environmental optimist	Interest in environmental issues but more positive about future solutions than EE group; high trust in governments and technology. Their education and income level is clearly above average.	15
Disorientated consumer	Recognizes that there is an environmental problem but is not capable of handling it. There is both 'fear' and trust in government and	13

[129] Source: Adapted from Ab Stevels (2000)

ARCHETYPES	CHARACTERISTICS	AVERAGE % in NORTH EUROPE
	technology. Below average education and income. Information needs are high, but this group is definitely not prepared to pay more for green.	
Environment too complicated	Neutrality towards environmental issues; "Yes, there are green issues but stakeholders like governments, industry and scientific world might (also) use the issue to extract more money from us".	15
Environmental pessimist	Doubt strongly then effectiveness of environmental programs, although they have a more positive attitude "In the end we will be all swamped by the population increase"	15
Growth optimist	Basic negative attitude towards environment; advocate that economic growth is necessary to pay for environmental measures and reproach environmental proponents that they want to block growth and go "back to pre-industrialization";	10
Enjoy life	Deny environmental problems : "if there is a problem will be in future, however each generation has to solve its own problems'	17

Analysing and comparing these attitudes the author concludes that "there is sympathy for green", but that environmental issues alone play a minor role in buying decisions. In fact, often "green" products are perceived to be more expensive and/or less performing.

The main contribution of this paper is the suggestion to link environmental benefits to other benefits that directly affect the consumer. These can be divided into three categories (Table 85).

Table 85: Types of consumer benefits[130]

TYPE OF BENEFIT	EXAMPLES
Material benefits	as lower price or lower cost of ownership;
Emotional benefits	feeling good, quality of life and reduced fear for environmental disasters.
Immaterial benefits	Convenience, simplicity and fun;

This suggestion has been applied by Philips Consumer Electronics. In this trial, the environmental attributes of products have been split into five focal areas:

- Energy Consumption;
- Materials application;
- Packaging and transport;
- Chemical content;
- Durability and recyclability.

These attributes have been coupled with the direct benefits to the consumer listed in Table 85. The results are reported in Table 86 and show that the linkage suggested by

[130] Source: Adapted from Ab Stevels (2000)

Stevels (2000) makes the majority of buyers interested. In this way, environmental attributes can be considered a positive force for marketing.

Table 86: Link between environmental effects and consumer benefits for the five focal areas[131]

ATTRIBUTE	ENVIRONMENTAL EFFECT	CONSUMER BENEFIT	% of BUYERS ATTRACTED
Energy Consumption	less emissions	Material = lower cost	80
Materials application	Less resources	Immaterial = simply, easy	75
Packaging and transport	Less resources, less emissions	Immaterial = convenient	75
Chemical content	Less emissions	Emotion-al = less fear	60
Durability and recyclability	Less resources	Emotion-al = quality, feel good	75

The principles that should be followed during the product creation process, suggested in the paper, are:

- Eco-design should not only bring benefits for the environment but also for the consumer;
- Customers benefits should be a mix of material, immaterial and emotional benefits;
- The benefit issue has to be addressed during the idea generating phase, i.e. at the very beginning;
- Benefits are perceived by consumers on a relative scale, i.e. comparing with the competition.

Following the papers findings now Philips Consumer Electronics considers the following five issues when designing its products:

- Environmental benefits;
- Business benefits;
- Customer benefits;
- Societal benefits;
- Technical and financial feasibility.

Although it is difficult to separate the market effects of the consumer and environmental benefits, a preliminary analysis indicates that margins for green products are about 3% higher than other products.

In a subsequent paper **Stevels, Agema and Hoedemaker** investigate the role of gender and the role of trade by sales staff in the sales process.

[131] Source: Ab Stevels (2000)

In the last years, the segmentation of consumer electronics purchasers has changed and, in particular, women are taking a more active role in such buying decisions. Up to the mid nineties, in Europe, men accounted for 70% of buying decisions, 20% were taken jointly and only 10% by women alone. More recently men account for 50%, partner decisions for 25% and women for 25% of the purchasing decisions. Because of differences in the on average tastes – for example, women on average attach more value to environmental attributes than men – these percentage changes influence the product mix that should to be supplied and, in particular, it offers more opportunities to increase the sale of green products and therefore encourage the development of green attributes.

The paper focuses on Audio products and confirms that there is indeed a difference in the ranking of product aspects with respect to the average consumer.

The authors also find that sales staff has an important influence on buying decisions: approximately on 50% of the purchases. This figure may increase up to 80% when considering low price goods. The research shows that for expensive items a higher percentage of people (about 50%) make the purchasing decision before going to the retailer, by means of outside information.

The authors find that price, reliability/durability/quality are the most important attributes that can be linked with the environmental issues.

Although the case study reported in the paper focuses on audio products, it is still interesting to report the ranking of the environmental aspects that interest consumers the most, according to sales staff[132]. This is reported in Table 87.

Table 87: Relative importance of environmental aspects according to sales staff[133]

ENVIRONMENTAL ASPECT	% of sales staff that included such aspect
Energy Consumption	100
Hazardous substances	53
Material application	37
Recyclability	23
Life cycle impact	37
Packaging	30

The authors continue their analysis and propose a market-based criterion for firms to evaluate and prioritise possible environmental design improvements of their appliances. This criterion is very subjective and the application relates to audio products, but the suggestion is that eco-design should focus more on energy efficiency.

[132] More precisely, the question to the sales staff was on the environmental aspects that consumer inquire about.

[133] Source: Stevels, Agema and Hoedemaker

2.5.3. Summary and conclusions

There are hundreds of measures in place to promote energy efficiency in the US. Not all have been analysed but quite a lot has been done to look at various aspects of the policies that exist. The research follows into two camps: the first that directly assesses the energy efficiency gains of adopting stricter energy standards and that looks at some tax incentives at the individual item level; and the second that evaluates and compares the impacts of energy prices, tax mechanisms and other incentives by studying the impacts they have on various parameters that determine the demand for energy.

The first set – loosely referred to as engineering studies – focus mostly on standards. They provide estimates of savings that have been or can be achieved from the adoptions of stricter standards for boilers, home appliances, light bulbs etc.; as well as the savings from tax exemptions and tax credits related to these items. Since the published results do not provide a detailed methodology it is difficult to assess the validity of the findings. It is certain that some assumptions have been made regarding (a) the impacts of the standards on prices, (b) the impacts of the prices and energy savings on consumer decisions to acquire the new items and (c) the 'rebound' effect, by which consumers may use more energy if an item has an increased level of energy efficiency. The latter is discussed further below.

Recognizing the above limitations we report in Table 88 the results obtain that could be useful for the present study. From these we note the following:

- The impact of all federal standards from 1988 to 2007 has been to reduce energy use from 9 appliances covered (refrigerators, freezers, room air conditioners, central air conditioners and heat pumps, clothes washers, clothes dryers, dishwashers, water heaters and gas furnaces) by about 8 percent in 2020. The study accounts for the higher costs these items and concludes that over the period 1987-2045 the savings in energy are worth nearly 2.5 times the additional cost to the consumers. [The LBNL study].
- A much smaller level of reduction is reported by the Energy Information Administration [EIA]. It looks at federal standards for ceiling fans and commercial refrigerators, and tax credits on residential equipment and on commercial boilers, starting from 2006. As Table 25 shows, the savings are of the order of 0.01 to 0.6 percent over the period 2006-2025 relative to a baseline level of consumption over that period.
- A third study of interest is an estimate of the national program for Energy Efficiency Resource Standards (EERS) that sets efficiency and saving standards to the utilities themselves. This program starts with modest standards in 2007, progressively becoming stricter over time. The expected savings are of the order of 5 percent in 2020.
- The above are estimates for federal programs. Policies at the state level include a number of tax incentives as well as awareness and promotional campaigns. Evaluations of these programs have not been accessible in the publicly available literature. One exception is the Northwest region program for CFL bulbs, which included a combination of financial incentives (lower prices) and aggressive promotion from 2000 to 2003. The impact is to have increased the market share of these bulbs from almost zero to about 9 percent of the bulb market.

Table 88: Summary Table – engineering models

STUDY	SECTOR	POLICY MEASURE	RESULTS	YEARS
ACEEE' REVIEW OF 2007 ENERGY POLICY ACT	HOUSEHOLD	BOILER EFFICIENCY STANDARDS	-7.6 TBTU/YEAR GAS (DIRECT SAVINGS) -0.4 MMT/YEAR CO_2	REFERRED TO 2020
	HOUSEHOLD	APPLIANCES EFFICIENCY STANDARDS	- 23 TWH/YEAR ELECTRICITY -118 TBTU/YEAR GAS (INDIRECT SAVINGS) -16.6 MMT/YEAR CO_2	
	HOUSEHOLD	EFFICIENT LIGHT BULB PROGRAM	- 81.0 TWH/YEAR ELECTRICITY -410 TBTU/YEAR GAS (INDIRECT SAVINGS) -58,0 MMT/YEAR CO_2	
	HOUSEHOLD	TAX EXEMPT BONDS	- 3.9 TWH/YEAR ELECTRICITY -24.6 TBTU/YEAR GAS (DIRECT SAVINGS) -20.0 TBTU/YEAR GAS (INDIRECT SAVINGS) -4,3 MMT/YEAR CO_2	
	HOUSEHOLD	TAX CREDITS FOR APPLIANCES	- 2.6 TWH/YEAR ELECTRICITY -13.2 TBTU/YEAR GAS (DIRECT SAVINGS) -20.0 TBTU/YEAR GAS (INDIRECT SAVINGS) -6.3 MMT/YEAR CO_2	
ACEEE	UTILITIES	ENERGY EFFICIENCY RESOURCE STANDARDS (EERS)	- 386 TWH/YEAR ELECTRICITY -1,570 TBTU GAS (DIRECT SAVINGS) -5.59 QUADS (TOTAL FUEL SAVINGS) -320 MMT CO_2 +$64 BILLION CUMULATIVE SAVINGS BENEFIT/COST RATIO = 2.6	REFERRED TO 2020
LBNL	HOUSEHOLD	RESIDENTIAL EFFICIENCY STANDARDS (1988-2007)	-8% ENERGY CONSUMPTION (QUADS) -8% PROJECTED CO_2 EMISSIONS (2020) -5% CURRENT NO_X EMISSIONS +$141 BILLION NET SAVINGS (1987-2045) SAVINGS/COST RATIO = 2.45	SEE BRACKETS
EIA	HOUSEHOLD	CEILING LIGHT FAN STANDARDS	-0.6% OF ENERGY USE (QUADS)	CUMULATIVE SAVINGS OVER 2006-2025
	HOUSEHOLD	TAX CREDITS ON APPLIANCES	-0.013% of energy use (quads)	

STUDY	SECTOR	POLICY MEASURE	RESULTS	YEARS
	COMMERCIAL	REACH-IN REFRIGERATORS STANDARDS	-0.03% of energy use (quads)	
	COMMERCIAL	TAX CREDITS ON APPLIANCES	-0.012% of energy use (quads)	

The economic models generate a number of interesting findings. These are summarized in Table 89. Key features are the following:

- The effectiveness of tax credits in the energy efficiency context has been analysed. Many empirical studies do not find significant relations between tax incentive and the adoption of energy efficient technology. Hassett and Metcalf find that if fixed effects are accounted for then tax incentives indeed increase the probability of investing in such technologies, confirming the rationality of consumers in responding to market-based incentives and disproving the so-called energy paradox. The effects can be significant, for example it is estimated that a 10 percentage point decrease in tax price of conservation measures will increase the probability of investment by 24%. Tax incentives that lower up-front costs have been compared to "natural" energy price changes and their effectiveness has been shown to be greater, mainly due to the fact that changes in energy prices are perceived to be more transitory.

  Tax incentives have also been compared to Command & Control mechanisms, such as technology and performance standards. In particular, in the context of thermal insulation building codes have been found to not have affected the average level of energy efficiency adopted by builders.

- In the context of technology adoption by firms, two market-based mechanisms have been compared to each other: energy taxes with subsidies aimed at lowering implementation costs. It has been found that these two instruments do not have similar effects, in absolute values, but that subsidies are more effective in increasing technology adoption by consumers: 1.3%, 4% up to 8.8% more effective than energy taxes for ceiling, wall and roof insulation, respectively.

- When energy efficiency is improved, the cost of energy services declines. Consequently consumers will use them more intensively. This 'rebound effect' can be significant, although it varies from practically zero for small appliances, to 5-12 percent for residential lighting, 10-40 percent for water heating and 10-30 percent for space heating. The above figures are the increase in energy consumption per 100 percent increase in energy efficiency. The implication is that policies and measures that increase efficiency will not necessarily result in a reduction in energy consumption equal to that predicted by models that measure the rate of adoption of the new equipment: account must be taken of the rebound effect. There are also indirect rebound and economy-wide effects that need to be considered, though quantitative estimates are difficult to make as the range of elements to consider is very broad; CGE models indicate that their potential effect may be above 50%.

- The second important parameter estimated in the literature is the discount rate. As explained earlier, the higher this rate, the less likely it is that a consumer will buy an item that is more energy efficient and the greater the subsidy that will be needed to encourage him or her to purchase it. The studies carried out indicate quite a wide range of discount rates. In general they tend to be rather high, although some studies have found figures as low as 4 percent for space heating systems and 'unspecified actions'. It is important to note that the rates vary considerably across the population, with poorer households having much higher rates than richer ones. One study has found rates to range from 12 to 72 percent for refrigerators.

- In addition economic models have estimated household and commercial demand for energy. As expected the short run price elasticities are lower in absolute value than the long run elasticities. For household electricity they go from -0.24 to -0.32 and for household gas they go from -0.12 to -0.36. Commercial use is more price elastic in the long run – going from -0.21 to -0.97 for electricity. When analyzing durable goods the price elasticity raises: the most updated meta-analysis study - that summarizes all research findings from 1961 to 2004 - finds an overall mean of –2.62. Such value is based on over 1800 published price elasticity estimates. The review also includes generalizations on the main determinants of price elasticities.
- Finally, the last part focuses on new green marketing strategies and their growing relation with energy efficiency. To overcome past failures of some labelling schemes, the suggestion is to link the environmental performances and attributes of "green" products with direct benefits to the consumer.

Table 89: Summary Table – economic models

STUDY	SECTOR	OBJECT	Further Specification	RESULT
HASSETT AND METCALF	HOUSEHOLD	MARGINAL EFFECT	Tax-price	-2.428
			Energy-price	11.541
			Income	0.0110
JAFFE AND STAVINS	COMMERCIAL	PARTIAL EFFECTS	Adoption costs	[-25.15; -10.08]
			Energy price	[5.44; 11,00]
			Income	[-29.45; -9.21]
			Mandatory and voluntary building codes	Not significant
		RELATIVE PERFORMANCE	Cost-subsidies vs. no policy	2.4 –6,0 %
			energy -tax vs. no policy	3.7 –15.3 %
GREENING, GREENE AND DIFIGLIO	HOUSEHOLD	SIZE OF REBOUND EFFECT	Space heating	10 - 30%
			Water heating	10 - 40%
			Residential lighting	5 -12%
			Appliances	0%
SORRELL (UKERC)	HOUSEHOLD	SIZE OF DIRECT REBOUND EFFECT	Household heating	10-58% short-run 1.4-60% long-run "best guess": 30%
			Household cooling	1-26%

STUDY	SECTOR	OBJECT	Further Specification	RESULT
			Water heating	34-38%
		SIZE OF INDIRECT REBOUND EFFECT		>37%
TRAIN	HOUSEHOLD	AVERAGE CONSUMER DISCOUNT RATE	Space heating system	4.4 – 36 %
			Refrigerators	39 – 100 %
			Water heaters	18 – 67 %
			Unspecified actions	3.7 – 22.5 %
BERNSTEIN AND GRIFFIN	HOUSEHOLD	SHORT-RUN PRICE DEMAND ELASTICITY FOR ENERGY	ELECTRICITY	-0.24
	HOUSEHOLD		NATURAL GAS	-0.12
	COMMERCIAL		ELECTRICITY	-0.21
	HOUSEHOLD	LONG-RUN PRICE DEMAND ELASTICITY FOR ENERGY	ELECTRICITY	-0.32
	HOUSEHOLD		NATURAL GAS	-0.36
	COMMERCIAL		ELECTRICITY	-0.97
TELLIS	HOUSEHOLD	MEAN PRICE ELASTICITY OF DEMAND	**across studies**	- 1.76
BIJMOLT, VAN HEERDE AND PIETERS	HOUSEHOLD	MEAN PRICE ELASTICITY OF DEMAND	**across studies**	-2.62

3. COST-BENEFIT ANALYSIS

3.1. DEFINITION OF TAX INCENTIVES OPTIONS

In discussion with the steering committee for this study, several tax incentives options and scenarios have been identified for the execution of the cost-benefit analysis. Following issues were taken into consideration when elaborating this list:

- The effectiveness of tax incentives is expected to vary between Member States due to price differences, market penetration of 'green' products. Therefore, it is relevant for a same tax incentive option and for a same appliance to compare effects for two MS representative of various European regions or usage patterns. Thus, 4 MS have been chosen in this regards, and also based on available economic data: France, Italy, Denmark, and Poland.
- Various types of tax incentives exist and should be analysed. Three options, already used in some countries, have been chosen: subsidy for consumers, tax credit for consumers and tax credit for manufacturers.
- The natural increase of energy prices due to the EU Emission Trading Scheme will serve as baseline. Therefore, 3 scenarios have been suggested: (a) baseline, which includes a 12% energy price increase; (b) policy 1 – subsidies/tax credits on 'green' products; and (c) policy 2 - energy tax equivalent to additional 10% energy price increase. For washing machines, policy 2 is replaced by the remove from the market of B-class and C-class appliances. This policy could be a potential implementing measure following the EuP preparatory study on washing machines (lot 14).

Eight case-studies which were assessed with a CBA are summarised in Table 90.

Table 90: Description of case-studies and tax incentives options for CBAs

Case-study	Product	Member State	Baseline scenario	Policy option 1 (parameters)*	Policy option 2 (parameters)*
1	Refrigerator	France	Increase in electricity price (12%)	Subsidy for consumers (€50 class A+ only)	Energy tax: further increase in electricity price (10%)
2		Denmark			
3	Washing-machine	Italy	Increase in electricity price (12%)	Tax credit for manufacturers (€100 per appliance cl. A+; sold above historical levels - 3 years average)	B-class and lower removed from the market (market share of classes B and C shifted to class A)
4		Poland			
5	Boiler	Denmark	Increase in gas price (15%)	Tax credit for consumers (deducted from income tax; 25% of the appliance price for condensing boiler)	Energy tax: further increase in gas price (10%)
6		Italy			
7	CFLi	Poland	Increase in electricity price (12%)	Subsidy for consumers (€1 classes A and B)	Energy tax: further increase in electricity price (10%)
8		France			

(*) Policies 1 and 2 are applied on top of baseline scenario.

3.2. SYNTHESIS OF ECONOMIC DATA USED FOR CBA

3.2.1. ECONOMIC DATA FOR REFRIGERATORS

In order to carry out the CBAs, economic data is required, namely:

- Sales data
- Prices data
- VAT rate
- Average electricity consumption

When data was not available, estimates or mathematical extrapolations were made in order to fill the gaps. Obviously, the more assumptions have been made, the less reliable are the outcomes of the CBAs although the order of magnitude is correct.

For the product group "refrigerator", Table 91 presents economic data that will be used in the case-studies 1 (France) and 2 (Denmark).

Legend

In black = data from published sources (EuP lot 13, Gfk, DG JRC, CECED)

In red = estimates

In orange = extrapolation from data from CECED

In green = linear extrapolation

In purple = benchmark on websites

In pink = data from the VAT differentiation study (DG ENV)

Table 91: Economic data used for case-studies 1 & 2

		Sales (thousands)							Price including VAT (€)							VAT (%)	Electricity consumption (kWh/y)
Member State	Energy class	2001	2002	2003	2004	2005	2006	2007	2001	2002	2003	2004	2005	2006	2007		
France	A++	0	0	0	0	0	2	2	-	-	-	-	-	816	816	19.6	114
	A+	0	0	125	190	289	445	488	-	-	850	527	536	519	527		192
	A	819	846	1,219	1,280	1,407	1,622	1,780	560	560	550	504	492	476	476		271
	B	1,241	930	1,021	744	569	363	194	450	440	430	371	362	341	346		279
	C & others*	80	444	120	104	63	38	54	395	390	390	364	356	300	304		300
	TOTAL	2,140	2,220	2,485	2,319	2,330	2,469	2,519	490	510	510	500	462	462	473		-
Denmark	A++	0	0	0	0	0	0	2	-	-	-	-	-	-	738	25.0	114
	A+	0	0	5	43	64	76	84				680	642	602	565		192
	A	109	152	166	182	173	190	198				518	510	501	495		271
	B	119	90	77	42	25	17	15				485	457	446	436		279
	C & others*	15	11	8	4	4	2	2				459	424	399	384		300
	TOTAL	243	253	248	271	266	285	301				519	535	524	516		-

(*): "others" mainly include not-labelled appliances but were considered in the CBAs as C-class products

3.2.2. Economic data for washing-machines

Economic data used for carrying out CBAs in Poland and Italy is presented in Table 92.

Prices data for the years 2005 and 2006 were neither available from source nor estimated due to a lack of reliability as no particular trend was visible between 2002 and 2004.

Legend

In black = data from sources (EuP lot 14, GfK, DG JRC, CECED)

In red = estimates

In brown = market shares for each energy class known

In green = linear extrapolation

In orange = extrapolation from prices variations known for Western Europe MS

In grey = extrapolation from prices variations known for 4 Eastern Europe MS including Poland

In blue = extrapolation from sales variations known for 4 Eastern Europe MS including Poland

In purple = benchmark on websites

In pink = data from the VAT differentiation study (DG ENV)

Table 92: Economic data used for case-studies 3 & 4

		Sales (thousands)							Price including VAT (€)							VAT (%)	Electricity consumption (kWh/y)
Member State	Energy class	2001	2002	2003	2004	2005	2006	2007	2001	2002	2003	2004	2005	2006	2007		
Poland	A+		0	1	5	10	16	23		597	508	419			550	22.0	201
	A		373	500	666	610	775	839		418	373	327			535		210
	B		245	170	95	16	14	11		355	319	282			450		238
	C & others*		222	130	84	188	100	90		281	266	251			380		250
	TOTAL	850	840	802	850	824	905	963		362	339	315					-
Italy	A+	185	202	210	222	45	210	175		714	678	441			520	20.0	201
	A	705	862	940	1,121	984	1,402	1,536		528	502	418			451		210
	B	230	170	145	125	43	68	65		435	413	383			400		238
	C & others*	630	450	344	322	789	24	68		273	259	249			230		250
	TOTAL	1,750	2,001	1,679	1,790	1,860	1,704	1,844	470	550	520	388					-

(*): “others” mainly include not-labelled appliances but were considered in the CBAs as C-class products

3.2.3. Economic data for boilers

Few economic data was available for boilers in EU. Regarding sales data, quite reliable assumptions have been done for 2005 and 2007 based on market data for 2004 and 2010 provided by the EuP preparatory study (lot 1) as well as from market data for 2006 from the BBT[134] market report in 2006. For prices data, the EuP preparatory study only provided figures for the year 2004. Prices for 2007 have been assumed based on prices used in the "VAT differentiation" study carried out by DG ENV.

Legend

In black = data from sources (EuP lot 1, BBT Marker report 2006)

In red = estimates

In green = linear extrapolation

In blue = based on prices from UK and NL used in the study on VAT differentiation (DG ENV) and on 'prices factors' defined in EuP lot 1 and mentioned in the 1st interim report (page 74)

In pink = data from the VAT differentiation study (DG ENV)

[134] BBT Thermotechnik GmbH is company of the Bosch group.

Table 93: Economic data used for case-studies 5 & 6

		Sales (thousands)							Price including VAT (€)							VAT (%)	Gas consumption (m^3/y)
Member State	Boiler type	2001	2002	2003	2004	2005	2006	2007	2001	2002	2003	2004	2005	2006	2007		
Denmark	Condensing Boiler				17	20	24	28				2453			3168	25.0	1726
	Other Boiler*				13	11	9	7				2383			2396		2000
Italy	Condensing Boiler				59	86	112	138				948			1,224	20.0	1726
	Other Boiler*				1,283	1191	1,100	1009				921			926		2000

(*): "other boiler" mainly include non-condensing gas boiler

3.2.4. Economic data for CFLi

For the product group "CFLi", it was complicated to obtain sales data for Poland and France as no detailed market report is available. Thus, the EuP preparatory study on domestic lighting (lot 19) was the main source of information even if sales data is not clearly divided by Member States. Further, prices data was not found for these countries and IKEA prices were used both for CFLi and for GLS (i.e. incandescent lamp). This data is provided in Table 94.

Legend

In black = data from sources (EuP lot 19, ELC, DG JRC)

In red = estimates

In blue = estimates based on Eurostat data including both incandescent lamps (GLS) which can be replaced by CFLi and others

In grey = using variations of ELC sales

In purple = extrapolation order 2

In orange = extrapolation order 3

In green = prices from national IKEA website (see Table 27)

Table 94: Economic data used for case-studies 7 & 8

		Sales (million)							Price including all taxes (€)							Taxes (%)	Electricity consumption (kWh/y)
Member States	**Lamp type**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**		
Poland	**CFLi**				4.2	5.0	8.5	14.7							4.25	22.0	10.9
	GLS*				79.6	81.3	85.4	91.9							0.5		21.6
France	**CFLi**	6.8	7.4	8.3	10.1	13.7	18.4	23.0							4.25	19.6	10.9
	GLS*	135.6			173.6	164.1	152.0	142.5							0.4		21.6

(*): A GLS (General Lighting Service) is a typical incandescent filament lamp.

3.3. CBA OF TAX INCENTIVES OPTIONS

3.3.1. INTRODUCTION

Previous internal reports prepared by the consultants presented a methodology to undertake cost-benefit analyses of selected tax incentives for electrical appliances in EU-27. The potential and limitations of the proposed methodology were demonstrated by using a case-study developed for refrigerators in France. After comments and suggestions received from the EC team and other colleagues the parameters and policy options to be investigated in further studies of data we agreed upon. The coverage was to include data from France, Denmark, Italy and Poland for four appliances – refrigerators, washing machines, boilers and compact fluorescent lamps (CFLi). The initial results of these eight case studies were discussed during the second Interim meeting that took place in Brussels in June and further improvements in the model were suggested.

This final report presents the results of the cost-benefit analysis undertaken for different policy options that could potentially increase sales of energy-efficient appliances in Europe. The objective is to assess the effects of these policy options on sales of energy efficient appliances, estimate the energy savings and CO_2 reductions resulting from the observed changes in sales of different kinds of appliances. The benefits are then compared to some costs of the selected policy options. This report differs from our previous report in regard to:

- Country-specific parameters have now been used for tCO_2/kWh;
- Estimation of the welfare gain associated with producers profit has been included;
- The model imposes the assumption that changes in sales due to energy price increases are made up of shifts from adjacent energy classes so that the total numbers of sales are constant;
- The formula to estimate the welfare cost associated with equipment has been corrected;
- The content of the summary tables has been simplified;
- Changes in units of energy consumption for lamps have been made and a revised calibration of the model for that appliance has been undertaken;
- A sensitivity analysis of key parameters has been carried;
- Lifetime of boilers assumed to be equal to 15 years in all countries instead of different values in different countries;
- Benefits from reduced energy use in the form of lower non-GHG emissions have been included.
- A set of responses to further queries sent to the consultants on 14th October on the last draft has been added.

This section is organised as follows: section 3.3.2. summarises the methodology used; each case-study is presented in a separate section, starting by describing the data available, the main assumptions and the results for a baseline scenario (an increase in energy prices due to the Emission Trading Scheme (ETS)). Results for policy options 1 (subsidy or tax credit) and 2 (energy tax) are presented in sequence in sections 3.3.3. to 3.3.10. , as well as a comparison between the policy alternatives. Section 3.3.11. presents a sensitivity analysis of some parameters of our analysis.

3.3.2. METHODOLOGY – ECONOMIC MODEL

The approach used to evaluate how sales of energy efficient appliances would be affected by tax incentives involves an economic model of consumer behaviour towards the provision of services of appliances. We assume that consumers compare the net present value (NPV) of the operational costs of services provided by appliances, during its lifetime (*T*), and choose the cheapest alternative. In mathematical terms:

$$NPV_i = \lambda.[s - \pi.e_i] - P_i$$

$$\lambda = \frac{(1-\delta^T)}{(1-\delta)} \quad \text{and} \quad \delta = \frac{1}{(1+r)},$$

Where:

NPV_i	Net present value from equipment of type (*i*);
i	Energy class of appliance;
s^j	Service provided by appliances in period (*j*), (j = 1,…,T) assumed to be constant in each period and equal to *s*;
T	Lifetime of appliance;
π	Price per unit of energy;
e_i	Amount of energy used per energy class type (*i*);
P_i	Price of appliance of type (*i*);
r	Discount rate;
λ	Discount factor;

In deriving the above it is assumed that (i) each consumer buys one product only; (ii) the products have a fixed lifetime; and (iii) products are identical in terms of service provided (*s*) but vary in terms of energy efficiency. Thus, for each preferred choice (i^*) it must be true that:

$$\lambda.[s - \pi.e_{i^*}] - P_{i^*} > \lambda.[s - \pi.e_k] - P_k, \qquad \text{for all } (k \neq i^*)$$

From assumption (iii) above we have:

$$-\lambda.\pi.e_{i^*} - P_{i^*} > -\lambda.\pi.e_k - P_k, \qquad \text{for all } (k \neq i^*)$$

Or $$\lambda.\pi.e_{i^*} + P_{i^*} < \lambda.\pi.e_k + P_k, \qquad \text{for all } (k \neq i^*) \qquad (1)$$

We estimate choices based on inequality (1) using the market data for the most recent year available and assuming discount rates ranging between 0% and 50%. The results would show us, for each type of product (energy class), the range of the discount rates for which inequality (1) holds; i.e. the discount rates that make the NPV of appliances of each type the cheapest, and then preferable for consumers. The interpretation of the expected results is as follows: buyers of the most efficient (and expensive) types should have lower personal discount rates, while consumers of cheaper types of appliances should present higher personal discount rates.

In general, further adjustments in the real data are necessary to fit the data to the model; otherwise the most inefficient type of appliance often turns out to be the one with lowest NPV for all discount rates. Note that the model above considers appliances of all types as having the same characteristics, i.e. products of the same quality, which may not be true. Furthermore, the model does not consider consumers' satisfaction associated to the consumption of more efficient appliances. For example, it may be the case that consumers who buy more efficient appliances are willing to pay an extra premium for the public good of 'saving the planet', which is not included in our simple analysis of operational costs only. Again we introduce this aspect in the modelling where necessary to explain observed patterns of purchases.

We based our assumptions of personal satisfaction on a similar study developed by Revelt and Train (1998)[135], who estimated WTP for more efficient refrigerators ranging between 22% and 25.5% of market prices in the U.S. We also benefited from other results in Revelt and Train (1998), namely that the observed WTP for more efficient refrigerators implied consumers' discount rate of 39% with a normal distribution around that mean, and standard deviation of 18.7[136].

Market prices were adjusted to account for differences in quality among the appliances of different energy classes and for WTP for more efficient appliances so that prices reflect purely differences in energy classes (standardised prices). Once inequality (1) is satisfied for all energy classes (*i*), then we can estimate the maximum discount rate at which equation (1) holds. For example, assume that the actual number of refrigerators of energy class 'A+' – 488,250 in 2007; the shaded area under the probability density function in Figure 80– implies a maximum discount rate equal to 13% in our model (i.e. at higher discount rates other energy types of appliances are cheaper and preferred by consumers) for this class of refrigerators. The same procedure is undertaken for new prices corresponding to the tax incentive (Figure 80) and the difference between the shaded areas represent the forecast additional number of sold appliances of class 'A+'.

135 Revelt and Train (1998), "Mixed Logit with replaced choices: households' choices of appliance efficiency level", *The Review of Economics and Statistics*, 80(4).

136 The choice of the quality adjustment and the adjustment for the WTP for public good reasons is, we agree, somewhat arbitrary. We did the calculations using only a quality adjustment and not making any adjustment for WTP for the case of those countries where two adjustments are reported (e.g. France) and found the result were substantially the same as those presented here.

Figure 79: Discount rates normally distributed with mean 39% and standard deviation 18.7% - business as usual prices

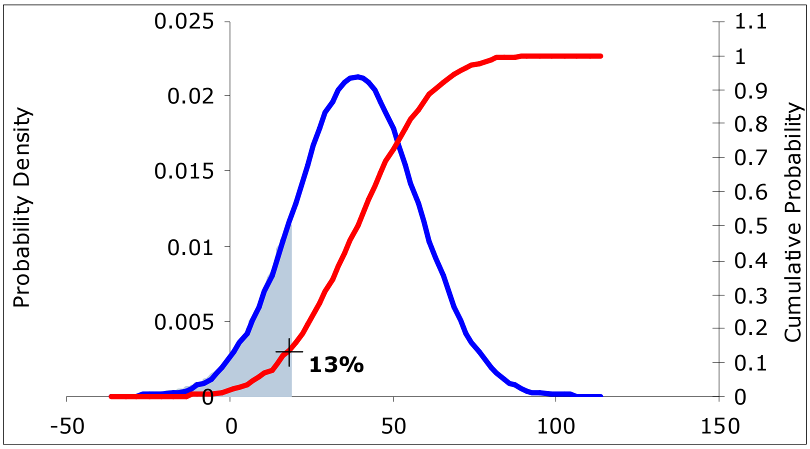
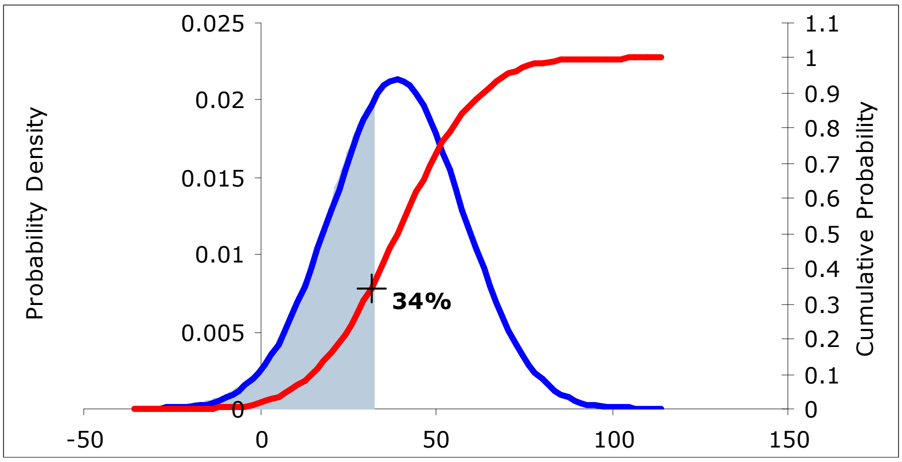


Figure 80: Discount rates normally distributed with mean 39% and standard deviation 18.7% - after price changes due to tax incentive



Note: Red line indicates the cumulative density function.

Once we have estimated the change in sales of each type of appliance given a change in electricity and/or the price of the appliance, as described above, we can estimate the gains and losses, for consumers, the government and industry, derived from the observed change in sales of the appliances.

Subsidies and Tax Credits

In the case of subsidies and tax credits we calculate the following:

- The outflow of funds from the government equal to the total number of sales predicted times the subsidy or tax credit per unit;
- The potential administrative and welfare costs (we further discuss these costs below);
- The change in energy use (energy savings) by multiplying the change in the number of appliances and the average consumption of energy per type of appliance;

- The change in GHG emissions137 by multiplying the total energy consumption by a country-specific parameter indicating the average tons of CO_2 generated to produce one kWh of electricity;
- The financial gains for manufacturers with extra sales of more expensive equipments.

Energy Taxes

In the case of energy taxes we calculate the following:

- The gain in tax revenue for the government equal to the energy consumed times the increase in tax rate;
- The potential administrative and welfare costs (we further discuss these costs below);
- The energy use (energy savings) by calculating energy consumption under the new tax regime compared with that under the previous tax regime;
- The change in GHG emissions by multiplying the change in total energy consumption by a country-specific parameter indicating the average tons of CO_2 generated to produce one kWh of electricity;
- The financial gains for manufacturers with extra sales of more expensive equipments.

We present below the detailed calculations of the different components described above, in the context of carrying out a cost effectiveness estimation:

1) Welfare Costs

Based on the above, we calculate the welfare costs for **subsidies and tax credits** as follows:

a.1) Welfare cost – marginal cost of public funding (MCPF): assumed as 26% of the revenue gained with the policy;

a.2) Welfare gain – profit of producers: assumed product-specific margins based on market data collected by the consultants, varying between 6% (CFLi) and 8.5% (boilers) – 8% for refrigerators and washing machines;

a.3) Welfare gain – reduced emissions of non-GHG pollutants: the average non-GHG external cost of one unit of kWh generated per country; it is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Based on the above, we calculate the welfare costs of **energy taxes** as follows:

b.1) Welfare cost – dead-weight loss of consumers: the inefficiency caused by the imposition of a tax;

[137] We use the term GHG in this report but all our estimates refer to CO_2.

b.2) Welfare cost – more expensive equipments: the difference in quality-adjusted prices of equipments bought with and without the imposition of the tax;

b.3) Welfare gain – profit of producers: defined as in (a.2);

b.4) Welfare gain – savings in costs of raising funds from other taxes: tax policies generate revenue for the government and reduce the cost of raising similar amounts from other sources. We use the same MCPF (26%) as in (a.1);

b.5) Welfare gain – reduced emissions of non-GHG pollutants: defined as in (a.3);

2) Administrative costs

We reviewed the pertinent literature in order to identify empirical estimates of administrative costs of different economic incentives. Sandford *et al*. ("Administrative and Compliance Costs of Taxation", Perrymead: Fiscal Publications, 1999) estimated administrative costs of different types of taxes in the US in terms of percentage of the total tax revenue, a metric that is convenient for our purposes. Administrative costs ranged between 0.12% (petroleum tax revenue) and 1.53% (income tax). Electricity taxes were not included in Sandford's study. Given that an energy tax is more complex than a petroleum tax, but still relatively simple, we will assume administrative costs of energy taxes in our case studies to be equal to 0.20% of the tax revenue.

No data could be obtained regarding administrative costs of subsidies and tax credits. It is understood that administrative costs of subsidies are potentially much higher than those for taxes, given the extra personnel and procedures in place to administrate the scheme. Regarding tax credits, we understand that administrative costs are potentially low given the existing structures in place to administrate existing taxes. Therefore, we will roughly assume that the administrative costs of subsidies correspond to 5% of the revenue cost of the subsidy, while the additional administrative costs of tax credits (for consumer and for producers) are negligible (equal to zero).

3) GHG savings

We benefit from recent EU projects (e.g. CASES) that estimated the average emission per unit of kWh generated in several EU countries, based on the typical technology (ies) adopted in each country.

Cost Effectiveness Analysis and Other Indicators

We consider that the best way of presenting the results of the welfare analysis is in terms of the welfare costs per ton of CO_2 removed as a result of the measure. These costs include losses or gains in welfare, including those arising from non GHG emissions. We then divide these by the change in CO_2 removed or by the reduction in energy used in kWh, to get a cost per ton of CO_2 removed or per kWh of energy saved. These are widely used measures of the cost effectiveness of the policies, which can be compared with many other interventions that seek to promote energy efficiency or carbon efficiency.

A number of other indicators that are of interest to policy makers are also reported. These include:

- Revenue costs to government or revenue gains to government

- Energy savings in total (GWh)
- CO_2 savings in total (tons)
- Financial gains to producers (i.e. revenue gain in Euros)
- Welfare cost divided by tax revenue of the policy (Euros). This gives an idea of the cost in terms of welfare of each unit of subsidy provided by the programme.

Commentators from the Commission on the report have asked two other questions, which we answer below:

1) "Why the consultant only looks at purchase price and not to use phase cost in his policy decision rule?"

   Answer: We have estimated changes in the energy use during the lifetime of the equipment, and the associated costs and benefits. We have not included the energy costs of producing the equipment and the disposal of the equipment. This is standard analysis of a partial equilibrium nature in which one looks as the commodity subject to a tax or subsidy and calculates the welfare costs in terms of changes in consumer and producer surplus. To go further into the inter linkages between the inputs and outputs of the commodity in question would entail a full input-output type of analysis that was never envisaged or promised in this exercise. Such an analysis would require an order of magnitude more resources than we have had at our disposal. Moreover we believe that in comparing the options of taxes versus subsidies the results would not change materially compared to what we have produced.

2) "Why welfare gains don't include savings of energy bill for consumers?"

   Answer: When a consumer is taxed, he or she reduces the consumption of the good in question. That generates a loss of consumer surplus. It also generates a gain in government revenue. The two almost cancel each other out, but not entirely: the loss of consumer surplus is slightly greater than the gain in revenue and the difference is a deadweight loss that we measure.

   In the case of a tax consumers' spending on energy actually increases so there is no saving in energy bills as such. But that is not relevant to the welfare estimation. What matters is only the change in consumer surplus and we have measured that already.

   In the case of the subsidy we should treat the changes in energy expenditure similarly and not include them in the welfare measure, otherwise there is a lack of comparability. Also, if we consider the savings in energy expenditure as a gain, then we should also consider the increase in spending on more expensive appliances as a cost and take only the net gain. Such a position may be defensible, but not in our view if we are to maintain comparability with the tax case.

The next eight sections (i.e. sections 3.3.3. to 3.3.10.) provide detailed analysis for the different cases considered.

3.3.3. CASE-STUDY 1: REFRIGERATORS IN FRANCE

2.3.3.1 Data report and baseline scenario

Table 95: Sales and prices of refrigerators in France per energy classes

	A++	A+	A	B	C and others
Sales[(a)] (2007)	2,072	488,250	1,779,871	194,367	54,263
Prices[(b)] (2007)	816.20 €	527.22 €	476.40 €	346.30 €	304.18 €
Consumption (kWh/year)	114	192	271	279	300
Energy price (€/kWh)	0.1211				

Summary of main assumptions

(i) Each consumer buys one product only;

(ii) Refrigerators have a fixed lifetime (12.8 years);

(iii) Refrigerators are identical in terms of service provided but vary in terms of energy efficiency and quality;

(iv) Refrigerators classes 'C' and 'B' have inferior quality and had their market prices adjusted upwards by +11%;

(v) Refrigerators class 'A' have superior quality and had their market price adjusted downwards by 15.96%;

(vi) WTP for more efficient refrigerators: class 'A++' = 40%; class 'A+' = 25%; class 'A' = 18%; class 'B' = 7.5% and class 'C' = 0;

(vii) The personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7%;

(viii) When energy use is reduced this also reduces emissions of non-GHG pollutants. The average value per kWh of the reduction is taken as €cent 0.254 for France. This is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Table 96: Refrigerators; France – Baseline scenario - increase in 12% of electricity prices due to ETS

2007	BAU			Baseline scenario			
Class	Sales	Price (€)	mkt share	Revised sales	mkt share	Δsales	Δmkt share
C	54,263	337.97	0.022	50,706	0.020	-3,557	-0.0014
B	194,367	384.78	0.077	243,176	0.097	48,808	0.0194
A	1,779,871	400.34	0.707	1,611,634	0.640	-168,237	-0.0668
A+	488,250	527.22	0.194	610,856	0.243	122,606	0.0487
A++	2,072	816.20	0.001	2,452	0.001	380	0.0002
Total	2,518,824	422.73	1.000	2,518,824	1.000		

2.3.3.2 Policy option 1: Subsidy for consumers (€50 for class A+)

Table 97: Refrigerators; France: Subsidy for more energy efficient refrigerators: €50 for energy class 'A+'

2007	BAU			Policy option 1 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt shr
C	54,263	337.97	0.022	18,518	337.97	0.007	-35,745	-0.0142
B	194,367	384.78	0.077	64,041	384.78	0.025	-130,326	-0.0517
A	1,779,871	400.34	0.707	553,148	400.34	0.220	-1,226,724	-0.4870
A+	488,250	527.22	0.194	1,882,673	477.22	0.747	1,394,423	0.5536
A++	2,072	816.20	0.001	443	816.20	0.000	-1,629	-0.0006
Total	2,518,824	422.73	1.000	2,518,824	457.02	1.000		

- Costs of policy option 1

(i) Revenue costs to the government

Table 98: Refrigerators; France: Revenue costs of a subsidy for more energy efficient refrigerators (€50 for energy class 'A+') – total number of refrigerators held constant

2007	**Policy option 1 + baseline**		
Class	Revised sales	Tax incentive (€)	Revenue cost (€)
C	52,651	0	0
B	188,564	0	0
A	1,726,465	0	0
A+	549,106	50	94,133,658
A++	2,038	0	0
Total	**2,518,824**		**94,133,658**

(ii) Administrative costs

Table 99: Refrigerators; France: Administrative costs of a subsidy for more energy efficient refrigerators (€50 for energy class 'A+') – total number of refrigerators held constant

Parameter:	5% of total revenue cost
Administrative costs	**4,706,683 €**

(iii) Welfare costs

These are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits at 8% of the extra sales revenue, which is based on information provided by the consultants by drawing on direct data collection; and (c) the gain from reduced non-GHG emissions.

Table 100: Refrigerators; France: Welfare costs of a subsidy for more energy efficient refrigerators (€50 for energy class 'A+') – total number of refrigerators held constant

1	Welfare cost (marginal cost of public funds = 26% of the revenue cost) (€)	24,474,751
2	Welfare gain (profit of producers = 8% of sales revenue) (€) (0.08*[14])	14,440,930
2a	Welfare gain from reduced emissions of non-GHG pollutants	3,640,789
3	Net welfare cost (€) [1-2-2a]	6,393,033
3a	Welfare Cost per Ton of GHG ([3]/[15]) (€/tCO_2)	60.27

- Benefits of policy 1

These are summarised in the following four tables giving energy savings, GHG emissions, and financial gains to producers and net changes in welfare:

(i) Energy savings

Table 101: Refrigerators; France: Estimates of energy savings after the implementation of policy option 1 – total number of refrigerators held constant

2007		BAU		Policy option 1 + baseline	
Class	Energy use [(a)]	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
C	300	54,263	16,279,009	18,518	5,555,515
B	279	194,367	54,228,485	64,041	17,867,528
A	271	1,779,871	482,345,069	553,148	149,903,000
A+	192	488,250	93,743,945	1,882,673	361,473,246
A++	114	2,072	236,210	443	50,509
Total	---	2,518,824	646,832,719	2,518,824	534,849,799
Energy savings (GWh) / year					**112.0**
Savings on expenditure on energy (€)					**15,188,467**
Lifetime energy savings (GWh)					**1,433.4**
Lifetime revenue savings (€)					194,412,381

Note: (a) kWh/year;

(ii) GHG emissions

Table 102: Refrigerators; France: GHG emissions of a subsidy for more energy efficient refrigerators (€50 for energy class 'A+') – total number of refrigerators held constant

Parameter: tCO2/kWh	0.000074
Parameter: €/tCO2	€20
GHG savings / year (tCO_2)	8,287
Lifetime GHG savings (tCO2)	106,070

Lifetime savings (€)	**2,121,404**
Revenue cost to Government/ tCO2 (€)	887.47

(iii) Financial gains for manufacturers with extra sales

Table 103: Refrigerators; France: Financial gains – sales revenue – policy option 1

	BAU			Policy option 1 + baseline		
Class	Sales	Price (€)	Revenue	Revised sales	Price (€)	Revenue
C	54,263	337.97	18,339,521	18,518	337.97	6,258,704
B	194,367	384.78	74,787,732	64,041	384.78	24,641,512
A	1,779,871	400.34	712,546,710	553,148	400.34	221,444,971
A+	488,250	527.22	257,415,721	1,882,673	527.22	992,585,672
A++	2,072	816.20	1,691,181	443	816.20	361,630
Total	2,518,824		1,064,780,866	2,518,824		1,245,292,489
Financial gains for manufacturers						**180,511,623**

➢ Summary of policy 1

Table 104: Refrigerators; France: summary of policy option 1 (€50 subsidy to class 'A+')

Summary	**Policy 1 + baseline**
Revenue cost to government (€)	94,133,658
Net welfare cost to society (€)	6,393,033
GHG reductions	
Revenue cost / tCO_2 (€)	887.47
Net welfare cost / tCO_2 (€)	60.27

2.3.3.3 Policy option 2: Energy tax - additional increase in electricity price (10%)

Table 105: Refrigerators; France – additional increase in 10% of electricity prices

2007	BAU			Policy option 2 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δ mkt share
C	54,263	337.97	0.022	45,149	337.97	0.018	-9,115	-0.0036
B	194,367	384.78	0.077	289,879	384.78	0.115	95,511	0.0379
A	1,779,871	400.34	0.707	1,453,393	400.34	0.577	-326,478	-0.1296
A+	488,250	527.22	0.194	728,173	527.22	0.289	239,924	0.0953
A++	2,072	816.20	0.001	2,230	816.20	0.001	158	0.0001
Total	2,518,824	422.73	1.000	2,518,824	434.48	1.000		

- Costs of policy option 2

(i) Revenue gains

Table 106: Refrigerators; France: Tax revenue with policy option 2 – energy price increase (10%); total number of refrigerators held constant

Tax revenue (lifetime)	**109,087,826 €**

(ii) Administrative costs

Table 107: Refrigerators; France: Administrative costs of policy option 2 – energy price increase (10%); total number of refrigerators held constant

Parameter:	0.20% of total tax revenue
Administrative costs	**218,176 €**

(iii) Welfare costs

The welfare changes from the tax are made up of the following. First, we have the deadweight loss from the imposition of the tax, based on the consumption of energy. Second, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no tax. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Third, we have a welfare gain arising from the fact that the policy generates tax revenue and therefore reduces the cost of raising a similar amount of tax from other sources. This gain is calculated using the marginal cost of public funds. Fourth, we have the welfare gain to producers from the sale of more profitable equipment. This is calculated as in the case of the subsidy (see Table 100). Finally, there are gains from the reduction in the generation of electricity, calculated at the average external cost per kWh for France (see section 2.3.3.2).

Table 108: Refrigerators; France: Welfare costs of policy option 2 – energy price increase (10%); total number of refrigerators held constant

4	Dead-weight loss	(ΔQ x ΔP) / 2
5	Welfare cost of the tax (DWL) – energy (€)	3,322,706
6	Welfare cost of the tax (DWL) – equipments (€)	24,768,306
6a	Welfare gain from savings in costs of raising funds from other taxes (€) (0.26*[17])	28,362,835
7	Welfare gain (profit of producers = 8% of sales revenue) (€) (0.08*[14])	2,367,264
7a	Welfare gain from reduced emissions of non-GHG pollutants	600,791
8	Net welfare cost (€) [5+6-6a-7-7a]	-3,239,878
9	Marginal cost of policy (welfare cost/tax revenue) (€) [5+6]/[17]	3.88
9a	Welfare Cost per Ton of GHG ([8]/[15]) (€/tCO_2)	-185.10

- Benefits of policy 2

These are summarised in four tables below giving energy savings, GHG emissions, and financial gains to producers and net changes in welfare:

(i) Energy savings

Table 109: Refrigerators; France: Estimates of energy savings after the implementation of policy option 2 – holding the total number of refrigerators constant

2007		BAU		Policy option 2 + baseline	
Class	Energy use [(a)]	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
C	300	54,263	16,279,009	45,149	13,544,603
B	279	194,367	54,228,485	289,879	80,876,113
A	271	1,779,871	482,345,069	1,453,393	393,869,402
A+	192	488,250	93,743,945	728,173	139,809,287
A++	114	2,072	236,210	2,230	254,256

Total	---	2,518,824	646,832,719	2,518,824	628,353,661
Energy savings (GWh) / year					**18.5**
HH expenditure change per year (€)					**-6,016,135**
Lifetime energy savings (GWh)					236.5
Lifetime expenditures with energy (€)					-77,006,526

Note: (a) kWh/year

(ii) GHG emissions

Table 110: Refrigerators; France: GHG emissions of policy option 2 – additional electricity price increase (10%) – total number of refrigerators held constant

Parameter: tCO2/kWh	0.000074
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	1,367
Lifetime GHG savings (tCO2)	17,503
Lifetime savings (€)	350,067
Revenue cost to Government / tCO2 (€)	6,232.39

(iii) Financial gain with extra sales

Table 111: Refrigerators; France: Financial gains – sales revenue – policy option 2: additional energy price increase (10%)

	BAU			**Policy option 2 + baseline**		
Class	Sales	Price (€)	Revenue	Revised sales	Price (€)	Revenue
C	54,263	337.97	18,339,521	45,149	337.97	15,259,008
B	194,367	384.78	74,787,732	289,879	384.78	111,538,080
A	1,779,871	400.34	712,546,710	1,453,393	400.34	581,845,580
A+	488,250	527.22	257,415,721	728,173	527.22	383,908,621
A++	2,072	816.20	1,691,181	2,230	816.20	1,820,381
Total	2,518,824		1,064,780,866	2,518,824		1,094,371,669
Financial gains for manufacturers						**29,590,803 €**

- Summary of policy 2

Table 112: Refrigerators; France: summary of policy option 2(10% electricity price increase)

Summary	Policy option 2 + baseline
Revenue raised in tax (€)	109,087,826
Revenue gains to producers (€)	29,590,803
Higher costs to consumers in capital exp. (€)	24,768,306
Higher costs to consumers in energy exp. (€)	77,006,526
GHG reductions	
Net welfare cost (€)	-3,239,878
Welfare cost/tCO2 (€)	-185.10

2.3.3.4 Comparison of policy options

Table 113: Refrigerators; France: Cost-benefit summary

			Policy option 1 + baseline	Policy option 2 + baseline
10	Costs	Net welfare costs	6,393,033	-3,239,878
11		Administrative costs	4,706,683	218,176
12	Benefits	GHG	2,121,404	350,067
13	Benefit – costs		-8,978,311	3,371,769
14	Revenue gain to producers (€)		180,511,623	29,590,803
15	Energy savings (GWh)		1,433.4	236.5
15a	Lifetime GHG Savings (t/CO_2)		106,070.2	17,503.4
16	Expenditure in energy by households (€)		194,412,381	-77,006,526
17	Revenue cost to government (€)		94,133,658	-109,087,826
18	Welfare cost/tCO_2		60.27	-185.10

2.3.3.5 Conclusions

The subsidy policy has a welfare cost of about €6.4 million while the energy tax has a gain of €3.2 million. The subsidy generates a bigger saving in GHGs than the energy tax, almost six times greater. In terms of the welfare costs per ton of CO_2, the subsidy has a cost of €60/ton while the tax option has a welfare benefit of €185/ton. The admin cost of the subsidy option is almost 22 times higher than the energy tax option. Finally, the producers' revenue gains are €180 million with the subsidies, while they only gain €30 million in higher value sales with an energy tax.

3.3.4. CASE-STUDY 2: REFRIGERATORS IN DENMARK

2.3.4.1 Data report and baseline scenario

Table 114: Sales and prices of refrigerators in Denmark per energy classes

	A++	A+	A	B	C and others
Sales[(a)] (2007)	2,000	84,000	198,000	15,000	2,000
Prices[(b)] (2007)	737.58 €	565.00 €	495.00 €	436.45 €	383.56 €
Consumption (kWh/year)	114	192	271	279	300
Energy price (€/kWh)	0.2579				

Summary of main assumptions

(i) Each consumer buys one product only;

(ii) Refrigerators have a fixed lifetime (12.8 years);

(iii) Refrigerators are identical in terms of service provided but vary in terms of energy efficiency and quality;

(iv) Refrigerators classes 'A' and 'B' have superior quality and had their market price adjusted downwards by -17.17 % (class 'A') and –8.25% (class 'B');

(v) No adjustment for WTP for more efficient refrigerators was necessary;

(vi) The personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7%;

(vii) When energy use is reduced this also reduces emissions of non-GHG pollutants. The average value per kWh of the reduction is taken as €cent 1.048 for Denmark. This is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Table 115: Refrigerators; Denmark – Baseline scenario - increase in 12% of electricity prices due to ETS

2007	BAU			Baseline scenario			
Class	Sales	Price (€)	mkt share	Revised sales	mkt share	Δsales	Δmkt shr
C	2,000	383.56	0.007	382	0.001	-1,618	-0.0054
B	15,000	400.45	0.050	9,976	0.033	-5,024	-0.0167
A	198,000	410.00	0.658	176,815	0.587	-21,185	-0.0704
A+	84,000	565.00	0.279	111,122	0.369	27,122	0.0901
A++	2,000	737.58	0.007	2,705	0.009	705	0.0023
Total	301,000	454.78	1.000	301,000	1.000		

2.3.4.2 Policy option 1: Subsidy for consumers (€50 for class A+)

Table 116: Refrigerators; Denmark: Subsidy for more energy efficient refrigerators: €50 for energy class 'A+'

2007	BAU			Policy option 1 + baseline				
Class	Sales	Price (€)	mkt share	Revised sales	Price (€)	mkt share	Δsales	Δmkt shr
C	2,000	383.56	0.007	246	383.56	0.001	-1,754	-0.0058
B	15,000	400.45	0.050	6,437	400.45	0.021	-8,563	-0.0284
A	198,000	410.00	0.658	95,969	410.00	0.319	-102,031	-0.3390
A+	84,000	565.00	0.279	197,462	515.00	0.656	113,462	0.3770
A++	2,000	737.58	0.007	885	737.58	0.003	-1,115	-0.0037
Total	301,000	454.78	1.000	301,000	479.62	1.000		

- <u>Costs of policy option 1</u>

(i) Revenue costs to the government

Table 117: Refrigerators; Denmark: Revenue costs of a subsidy for more energy efficient refrigerators – total number of refrigerators held constant

2007	**Policy option 1 + baseline**		
Class	Revised sales	Tax incentive (€)	Revenue cost (€)
C	246	0	0
B	6,437	0	0
A	95,969	0	0
A+	197,462	50	9,873,109
A++	885	0	0
Total	301,000		**9,873,109**

(ii) Administrative costs

Table 118: Refrigerators; Denmark: Administrative costs of a subsidy for more energy efficient refrigerators – total number of refrigerators held constant

Parameter:	5% of total revenue cost
Administrative costs	**493,655 €**

(iii) Welfare costs

These are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits at 8% of the extra sales revenue, which is based on information provided by the consultants by drawing on direct data collection; and (c) the gain from reduced non-GHG emissions.

Table 119: Refrigerators; Denmark: Welfare costs of a subsidy for more energy efficient refrigerators – total number of refrigerators held constant

1	Welfare cost (marginal cost of public funds = 26% of the revenue cost) (€)	2,567,008
2	Welfare gain (profit of producers = 8% of sales revenue) (€) (0.08*[14])	1,387,966
2a	Welfare gain from reduced emissions of non-GHG pollutants	1,194,932
3	Net welfare cost (€) [1-2-2a]	-15,890
3a	Welfare Cost per Ton of GHG ([3]/[15]) (€/tCO_2)	-0.41

➢ Benefits of policy 1

(i) Energy savings

Table 120: Refrigerators; Denmark: Estimates of energy savings after the implementation of policy option 1 – total number of refrigerators held constant

2007		BAU		Policy option 1 + baseline	
Class	Energy use [(a)]	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
C	300	2,000	600,000	246	73,936
B	279	15,000	4,185,000	6,437	1,795,935
A	271	198,000	53,658,000	95,969	26,007,660
A+	192	84,000	16,128,000	197,462	37,912,740
A++	114	2,000	228,000	885	100,901
Total	---	301,000	74,799,000	301,000	65,891,171
Energy savings (GWh) / year					**8.9**
Reductions in Expenditure on Energy (€)					**2,573,009**
Lifetime energy savings (GWh)					114.0
Lifetime expenditure savings on energy (€)					32,934,510

Note: (a) kWh/year;

(ii) GHG emissions

Table 121: Refrigerators; Denmark: GHG emissions of a subsidy for more energy efficient refrigerators (€50 for energy class 'A+') – total number of refrigerators held constant

Parameter: tCO2/kWh	0.000336
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	2,993
Lifetime GHG savings (tCO2)	38,311
Lifetime savings (€)	766,216
Revenue cost to Government / tCO2	257.71

(iii) Financial gains for manufacturers with extra sales

Table 122: Refrigerators; Denmark: Financial gains – sales revenue – policy option 1

	BAU			Policy option 1 + baseline		
Class	Sales	Price (€)	Revenue	Revised sales	Price (€)	Revenue
C	2,000	383.56	767,123	246	383.56	94,529
B	15,000	400.45	6,006,705	6,437	400.45	2,577,695
A	198,000	410.00	81,180,000	95,969	410.00	39,347,382
A+	84,000	565.00	47,460,000	197,462	565.00	111,566,134
A++	2,000	737.58	1,475,168	885	737.58	652,831
Total	301,000		136,888,996	301,000		154,238,573
Financial gains for manufacturers						**17,349,576 €**

- Summary of policy 1

Table 123: Refrigerators; Denmark: summary of policy 1 (€50 subsidy to class 'A+')

Summary	Policy 1 + baseline
Revenue cost to government (€)	9,873,109
Net welfare cost to society (€)	-15,890
GHG reductions	
Revenue cost / tCO_2 (€)	257.71
Net welfare cost / tCO_2 (€)	-0.41

2.3.4.3 Policy option 2: Energy tax - additional increase in electricity price (10%)

Table 124: Refrigerators; Denmark – additional increase in 10% of electricity prices

2007	BAU			Policy option 2 + baseline				
Class	Sales	Price (€)	mkt share	Revised sales	Price (€)	mkt share	Δsales	Δmkt shr
C	2,000	383.56	0.007	151	381.96	0.001	-1,849	-0.0061
B	15,000	400.45	0.050	8,003	400.45	0.027	-6,997	-0.0232

A	198,000	410.00	0.658	163,084	410.00	0.542	-34,916	-0.1160
A+	84,000	565.00	0.279	126,635	565.00	0.421	42,635	0.1416
A++	2,000	737.58	0.007	3,127	737.58	0.010	1,127	0.0037
Total	301,000	454.78	1.000	301,000	478.35	1.000		

- Costs of policy option 2

(i) Revenue costs

Table 125: Refrigerators; Denmark: Tax revenue with policy option 2 – energy price increase (10%); total number of refrigerators held constant

Tax revenue (lifetime)	**26,303,840 €**

(ii) Administrative costs

Table 126: Refrigerators; Denmark: Administrative costs of policy option 2 – energy price increase (10%); total number of refrigerators held constant

Parameter:	0.20% of total tax revenue
Administrative costs	**52,608 €**

(iii) Welfare costs

The welfare changes from the tax are made up of the following. First, we have the deadweight loss from the imposition of the tax, based on the consumption of energy. Second, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no tax. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Third, we have a welfare gain arising from the fact that the policy generates tax revenue and therefore reduces the cost of raising a similar amount of tax from other sources. This gain is calculated using the marginal cost of public funds. Fourth, we have the welfare gain to producers from the sale of more profitable equipment. This is calculated as in the case of the subsidy (see Table 119). Finally, there are gains from the reduction in the generation of electricity, calculated at the average external cost per kWh for Denmark (see section 2.3.4.2).

Table 127: Refrigerators; Denmark: Welfare costs of policy option 2 – energy price increase (10%); total number of refrigerators held constant

4	Dead-weight loss	$(\Delta Q \times \Delta P) / 2$
5	Welfare cost of the tax (DWL) – energy (€)	1,399,512
6	Welfare cost of the tax (DWL) – equipments (€)	6,340,073

6a	Welfare gain from savings in costs of raising funds from other taxes (€) (0.26*[17])	6,838,999
7	Welfare gain (profit of producers = 8% of sales revenue) (€) (0.08*[14])	567,454
7a	Welfare gain from reduced emissions of non-GHG pollutants	490,262
8	Net welfare cost (€) [5+6-6a-7-7a]	-157,131
9	Marginal cost of policy (welfare cost/tax revenue) (€) [5+6]/[17]	3.40
9a	Welfare Cost per Ton of GHG ([8]/[15]) (€/tCO_2)	-10.00

- Benefits of policy 2

(i) Energy savings

Table 128: Refrigerators; Denmark: Estimates of energy savings after the implementation of policy option 2 – holding the total number of refrigerators constant

2007		**BAU**		**Policy option 2 + baseline**	
Class	Energy use [a]	Sales	Energy consumption [a]	Revised sales	Energy consumption [a]
C	300	2,000	600,000	151	45,171
B	279	15,000	4,185,000	8,003	2,232,885
A	271	198,000	53,658,000	163,084	44,195,724
A+	192	84,000	16,128,000	126,635	24,313,991
A++	114	2,000	228,000	3,127	356,482
Total		301,000	74,799,000	301,000	**71,144,254**
Energy savings (GWh) / year					3.7
HH expenditure change per year (€)					**-999,321**
Lifetime energy savings (GWh)					46.8
Lifetime expenditures on energy (€)					-12,791,314

Note: (a) kWh/year;

(ii) GHG emissions

Table 129: Refrigerators; Denmark: GHG emissions of policy option 2 – additional electricity price increase (10%) – total number of refrigerators held constant

Parameter: tCO2/kWh	0.000336
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	1,228
Lifetime GHG savings (tCO2)	15,718
Lifetime savings (€)	314,367
Revenue cost to Government / tCO2	1,673.45

(iii) Financial gain with extra sales

Table 130: Refrigerators; Denmark: Financial gains – sales revenue – policy option 2: additional energy price increase (10%)

	BAU			**Policy option 2 + baseline**		
Class	Sales	Price (€)	Revenue	Revised sales	Price (€)	Revenue
C	2,000	383.56	767,123	151	381.96	57,512
B	15,000	400.45	6,006,705	8,003	400.45	3,204,846
A	198,000	410.00	81,180,000	163,084	410.00	66,864,380
A+	84,000	565.00	47,460,000	126,635	565.00	71,548,985
A++	2,000	737.58	1,475,168	3,127	737.58	2,306,448
Total	301,000		136,888,996	301,000		143,982,171
Financial gains for manufacturers						**7,093,175**

➢ Summary of policy 2

Table 131: Refrigerators; Denmark: summary of policy option 2(10% electricity price increase)

Summary	Policy option 2 + baseline
Revenue raised in tax (€)	26,303,840
Revenue gains to producers (€)	7,093,175
Higher costs to consumers in capital exp. (€)	6,340,073
Higher costs to consumers in energy exp. (€)	12,791,314
GHG reductions	
Net welfare cost (€)	-157,131
Welfare cost/tCO2 (€)	-10.00

2.3.4.4 Comparison of policy options

Table 132: Refrigerators; Denmark: Cost-benefit summary

			Policy option 1 + baseline	Policy option 2 + baseline
10	Costs	Net welfare costs	-15,890	-157,131
11		Administrative costs	493,655	52,608
12	Benefits	GHG	766,216	314,367
13	Benefit – costs		288,450	418,889
14	Revenue gain to producers (€)		17,349,576	7,093,175
15	Energy savings (GWh)		114.0	46.8
15a	Lifetime GHG Savings (t/CO_2)		38,310.8	15,718.3
16	Expenditure in energy by households (€)		32,934,510	-12,791,314
17	Revenue cost to government (€)		9,873,109	-26,303,840
18	Welfare cost/tCO_2		-0.41	-10.00

2.3.4.5 Conclusion for this case-study

The subsidy policy has a small welfare benefit of about €15,900 while the tax option also has a benefit of €157,000. In terms of GHG savings the subsidy option reduces emissions by 38,000 tons against 16,000 tons for the energy policy option. In terms of the welfare costs per ton of CO_2, the subsidy option has a benefit of €0.4/ton against a gain of €10/ton with the energy tax. The administrative cost of subsidy option is almost 10 times higher than the energy tax option. Finally producers' revenue gains are much greater with the subsidy option (€17 million against €7 million for the tax option).

While both France and Denmark rank the two options similarly, the Danish case has much smaller welfare costs and benefits than the French case and has the subsidy also generating a welfare gain. One reason for the differences is the much smaller gain in welfare from the reduction of non-GHG gases in France compared to Denmark. In France one kWh is assumed to generate 0.254 eurocents, while in Denmark it generates 1.048 euro cents. This makes the subsidy (which saves relatively more energy than the tax) much more feasible in Denmark than in France.

3.3.5. Case-study 3: Washing-machines in Italy

2.3.5.1 Data report and baseline scenario

Table 133: Sales and prices of Washing machines in Italy per energy classes

	A+	A	B	C and others
Sales[a] (2007)	175,000	1,536,000	65,000	68,000
Average sales (2005 – 2007)	143,333	--	--	--
Prices[b] (2007)	520 €	451 €	400 €	230 €
Consumption (kWh/year)	201	210	238	250
Energy price (€/kWh)	0.2329			

Summary of main assumptions

(i) Each consumer buys one product only;

(ii) Washing machines have a fixed lifetime (5.7 years);

(iii) Washing machines are identical in terms of service provided but vary in terms of energy efficiency and quality;

(iv) Washing machines class 'C' have inferior quality and had their market price adjusted upwards by +56.52 %;

(v) WTP for more efficient washing machines: class 'A+' = 21%; class 'A' = 11%; class 'B' = 7.5% and class 'C' = 0;

(vi) The personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7%;

(vii) When energy use is reduced this also reduces emissions of non-GHG pollutants. The average value per kWh of the reduction is taken as €cent 0.779 for Italy. This is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Table 134: Washing machines; Italy – Baseline scenario - increase in 12% of electricity prices due to ETS

2007	BAU			Baseline scenario			
Class	Sales	Price (€)	mkt share	Revised sales	mkt share	Δsales	Δmkt shr
C	68,000	360.00	0.037	36,791	0.020	-31,209	-0.0169
B	65,000	400.00	0.035	61,123	0.033	-3,877	-0.0021
A	1,536,000	451.00	0.833	1,569,828	0.851	33,828	0.0183
A+	175,000	520.00	0.095	176,258	0.096	1,258	0.0007
Total	1,844,000	452.39	1.000	1,844,000	1.000		

2.3.5.2 Policy option 1: Tax credit for manufacturers (€100 per appliance class A+ sold above average levels)

As described in section 3.3.2. , our model expresses consumers' behaviour given changes either in energy prices and/or the price of appliances. In order to use our model for predicting sales of different energy types of washing machines given the introduction of a tax credit for manufactures we needed to assume that manufacturers would transfer part of their profit on selling extra washing machines type A+ to the market price, in order to make those washing machines more feasible for consumers. That is, we assumed that manufacturers would need to reduce the price of washing machines class 'A+' in order to increase sales of that type of product.

We first calibrated the market data to fit our model by adjusting prices according to differences in quality among energy classes and the public good willingness to pay. We then used our model to predict new sales of washing machines class 'A+' given several price reductions. For each price reduction (and correspondent new sales level of washing machine type A+) we estimated the manufacturers' profit equal to 20% of sales revenue plus the €100 tax credit received for each appliance sold above the 3-years average. We selected the maximum value that manufactures should reduce the final price of products class 'A+' without decreasing their profit with washing machines class A+. For Italy, this price reduction equalled €32.

We acknowledge that this procedure does not reflect the complexity of tax systems in Europe. Tax credits only reduce the tax liability of manufacturers and it may not be the case that manufacturers will benefit of the total amount offered as a tax credit. This will depend on the level of production of the manufacturer, the tax rates in place *etc.* However, we believe that the procedure is based on the credible assumption that manufacturers would need to pass on to consumers part of the expected benefits obtained with the tax incentive in order to induce consumers to shift to class A+ and that they would do so to the extent that is was profitable for them.

Table 135: Washing machines; Italy: Tax credit for manufacturers: €100 for energy class 'A+' above the average sales

2007	BAU			Policy option 1 + baseline				
Class	Sales	Price (€)	mkt share	Revised sales	Price (€)	mkt share	Δsales	Δmkt share
C	68,000	360.00	0.037	18,791	360.00	0.010	-49,209	-0.0267
B	65,000	400.00	0.035	31,219	400.00	0.017	-33,781	-0.0183
A	1,536,000	451.00	0.833	801,794	451.00	0.435	-734,206	-0.3982
A+	175,000	520.00	0.095	992,196	488.00	0.538	817,196	0.4432
Total	1,844,000	452.39	1.000	1,844,000	469.12	1.000		

- Costs of policy option 1

(i) Revenue costs to the government

Table 136: Washing machines; Italy: Revenue costs of a tax credit for manufacturers: €100 for energy class 'A+' above the average sales – total number of washing machines held constant

2007	Policy option 1 + baseline		
Class	Revised sales	Tax incentive (€)	Revenue cost (€)
C	18,791	0	0
B	31,219	0	0
A	801,794	0	0
A+	992,196 – 143,333 = 848,862	100	84,886,243
Total			**84,886,243**

(ii) Administrative costs

As discussed earlier, we assume that this policy option has negligible additional administrative costs.

(iii) Welfare costs

These are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits at 8% of the extra sales revenue, which is based on information provided by the consultants by drawing on direct data collection; and (c) the gain from reduced non-GHG emissions.

Table 137: Washing machines; Italy: Welfare costs of a Tax credit for manufacturers: €100 for energy class 'A+' above the average sales – total number of washing machines held constant

1	Welfare cost (marginal cost of public funds = 26% of the revenue cost) (€)	22,070,423
2	Welfare gain (profit of producers = 8% of sales revenue) (€) (0.08*[14])	2,466,968
2a	Welfare gain from reduced emissions of non-GHG pollutants	455,974
3	Net welfare cost (€) [1-2-2a]	19,147,481
3a	Welfare Cost per Ton of GHG ([3]/[15]) (€/tCO_2)	650.34

- Benefits of policy 1

  (i) Energy savings

Table 138: Washing machines; Italy: Estimates of energy savings after the implementation of a tax credit for manufacturers: €100 for energy class 'A+' above the average sales – total number of washing machines held constant

2007		**BAU**		**Policy option 1 + baseline**	
Class	Energy use [(a)]	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
C	250	68,000	17,000,000	18,791	4,697,761
B	238	65,000	15,470,000	31,219	7,430,074
A	210	1,536,000	322,560,000	801,794	168,376,823
A+	201	175,000	35,175,000	992,196	199,431,348
Total		1,844,000	390,205,000	1,844,000	379,936,006
Energy savings (GWh) / year					**10.3**
Reductions in Expenditure on Energy (€)					**2,678,646**
Lifetime energy savings (GWh)					58.5
Lifetime expenditure savings on energy (€)					15,268,285

Note: (a) kWh/year;

(ii) GHG emissions

Table 139: Washing machines; Italy: GHG emissions of a tax credit for manufacturers: €100 for energy class 'A+' above the average sales – total number of washing machines held constant

Parameter: tCO2/kWh	0.000503
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	5,165
Lifetime GHG savings (tCO2)	29,442
Lifetime savings (€)	**588,845**
Revenue cost to Government / tCO2	2,883

(iii) Financial gains for manufacturers with extra sales

Table 140: Washing machines; Italy: Financial gains – sales revenue – Tax credit for manufacturers: €100 for energy class 'A+' above the average sales

	BAU			**Policy option 1 + baseline**		
Class	Sales	Price (€)	Revenue	Revised sales	Price (€)	Revenue
C	68,000	360.00	24,480,000	18,791	360.00	6,764,776
B	65,000	400.00	26,000,000	31,219	400.00	12,487,519
A	1,536,000	451.00	692,736,000	801,794	451.00	361,609,272
A+	175,000	520.00	91,000,000	992,196	488.00	484,191,532
Total	1,844,000		834,216,000	1,844,000		865,053,100
Financial gains for manufacturers						**30,837,100 €**

➢ Summary of policy 1

Table 141: Washing machines; Italy: summary of policy option 1 (Tax credit for manufacturers: €100 for energy class 'A+' above the average sales)

Summary	Policy 1 + baseline
Revenue cost to government (€)	84,886,243
Net welfare cost to society (€)	19,147,481
GHG reductions	
Revenue cost / tCO_2 (€)	2,883.15
Net welfare cost / tCO_2 (€)	650.34

2.3.5.3 Policy option 2: B-class and lower removed from the market

Table 142: Washing machines; Italy – B-class and lower removed from the market

2007	BAU			Policy option 2 + baseline				
Class	Sales	Price (€)	mkt share	Revised sales	Price (€)	mkt share	Δsales	Δmkt share
C	68,000	360.00	0.037	0	360.00	0.000	-68,000	-0.0369
B	65,000	400.00	0.035	0	400.00	0.000	-65,000	-0.0352
A	1,536,000	451.00	0.833	1,669,000	451.00	0.905	133,000	0.0721
A+	175,000	520.00	0.095	175,000	520.00	0.095	0	0.0000
Total	1,844,000	452.39	1.000	1,844,000	457.55	1.000		

➢ Costs of policy option 2

(i) Administrative costs

As discussed earlier, we assume that this policy option has negligible additional administrative costs.

(ii) Welfare costs

The welfare changes from the removal of B-class or lower from the market are made up of the following. First, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no such policy. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Second, we have the welfare gain to producers from the sale of more profitable equipment. This is calculated as in the case of the tax credit (see Table 137). Finally, there are gains from the reduction of the emissions of non-GHG pollutants in the generation of electricity, calculated at the average external cost per kWh for Italy (see section 2.3.4.2).

Table 143: Washing machines; Italy: Welfare costs of policy option 2 – B-class and lower removed from the market; total number of washing machines held constant

4	Dead-weight loss	(ΔQ x ΔP) / 2
5	Welfare cost of the tax (DWL) – energy (€)	0
6	Welfare cost of the tax (DWL) – equipments (€)	6,274,275
6a	Welfare gain from savings in costs of raising funds from other taxes (€) (0.26*[17])	0
7	Welfare gain (profit of producers = 8% of sales revenue) (€) (0.08*[14])	760,240
7a	Welfare gain from reduced emissions of non-GHG pollutants	201,590
8	Net welfare cost (€) [5+6-6a-7-7a]	5,312,445
9	Marginal cost of policy (welfare cost/tax revenue) (€) [5+6]/[17]	0.00
9a	Welfare Cost per Ton of GHG ([8]/[15]) (€/tCO_2)	408.13

- <u>Benefits of policy 2</u>

(i) Energy savings

Table 144: Washing machines; Italy: Estimates of energy savings after the implementation of policy option 2: B-class and lower removed from the market – holding the total number of washing machines constant

2007		**BAU**		**Policy option 2 + baseline**	
Class	Energy use [(a)]	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
C	250	68,000	17,000,000	0	0
B	238	65,000	15,470,000	0	0
A	210	1,536,000	322,560,000	1,669,000	350,490,000
A+	201	175,000	35,175,000	175,000	35,175,000
Total		1,844,000	390,205,000	1,844,000	385,665,000
Energy savings (GWh) / year					**4.5**

HH expenditure change per year (€)	**1,184,250**
Lifetime energy savings (GWh)	25.9
Lifetime expenditures on energy (€)	**6,750,225**

Note: (a) kWh/year;

(ii) GHG emissions

Table 145: Washing machines; Italy: GHG emissions of policy option 2 – B-class and lower removed from the market – total number of washing machines held constant

Parameter: tCO2/kWh	0.000503
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	2,284
Lifetime GHG savings (tCO2)	13,017
Lifetime savings (€)	260,333
Revenue cost to Government / tCO2	**0.00 €**

(iii) Financial gain with extra sales

Table 146: Washing machines; Italy: Financial gains – sales revenue – policy option 2: B-class and lower removed from the market

	BAU			**Policy option 2 + baseline**		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
C	68,000	360.00	24,480,000	0	360.00	0
B	65,000	400.00	26,000,000	0	400.00	0
A	1,536,000	451.00	692,736,000	1,669,000	451.00	752,719,000
A+	175,000	520.00	91,000,000	175,000	520.00	91,000,000
Total	1,844,000		834,216,000	1,844,000		843,719,000
Financial gains for manufacturers						**9,503,000 €**

➢ Summary of policy 2

Table 147: Washing machines; Italy: summary of policy option 2(B-class and lower removed from the market)

Summary	Policy option 2 + baseline
Revenue raised in tax (€)	0
Revenue gains to producers (€)	9,503,000
Higher costs to consumers in capital exp. (€)	6,274,275
Higher costs to consumers in energy exp. (€)	-6,750,225
GHG reductions	
Net welfare cost (€)	5,312,445
Welfare cost/tCO2 (€)	408.13

2.3.5.4 Comparison of policy options

Table 148: Washing machines; Italy: Cost-benefit summary

			Policy option 1 + baseline	Policy option 2 + baseline
10	Costs	Net welfare costs	19,147,481	5,312,445
11		Administrative costs	0	0
12	Benefits	GHG	588,845	260,333
13	Benefit – costs		-18,558,636	-5,052,113
14	Revenue gain to producers (€)		30,837,100	9,503,000
15	Energy savings (GWh)		58.5	25.9
15a	Lifetime GHG Savings (t/CO_2)		29,442.2	13,016.6
16	Expenditure in energy by households (€)		15,268,285	6,750,225
17	Revenue cost to government (€)		84,886,243	0
18	Welfare cost/tCO_2		650.34	408.13

2.3.5.5 Conclusions

The tax credit has a net welfare cost of €19 million, against a net welfare cost of €5 million from the removal of inefficient appliances from the market, making the removal option more feasible. However, the removal option generates a smaller saving in GHG than the tax credit (13,000 tons against 29,000 tons for the tax credit). In terms of the welfare costs per tCO_2, the removal option is therefore cheaper at €408/ton against €650/ton for the tax credit. Both these figures, however, would be considered unacceptably high for projects designed to reduce GHGs. Finally while producers make a gain from the removal of classes B and C (€10 million), they make an even bigger gain from the tax credit scheme (€31 million). The reason for the bigger gains with the tax credit is a huge shift from A to A+, while the removal of classes B and C only results in a move to class A, which is cheaper than A+.

3.3.6. Case-study 4: Washing-machines in Poland

2.3.6.1 Data report and baseline scenario

Table 149: Sales and prices of Washing machines in Poland per energy classes

	A+	A	B	C and others
Sales (2007)	23,000	839,000	11,000	90,000
Average sales (2005 – 2007)	16,333	--	--	--
Prices (2007)	550 €	535 €	450 €	380 €
Consumption (kWh/year)	201	210	238	250
Energy price (€/kWh)	0.1216			

<u>Summary of main assumptions</u>

(i) Each consumer buys one product only;

(ii) Washing machines have a fixed lifetime (5.7 years);

(iii) Washing machines are identical in terms of service provided but vary in terms of energy efficiency and quality;

(iv) Washing machines classes ‘C’ and ‘B’ have inferior quality and had their market price adjusted upwards by +23.68 % (class ‘C’) and +11.11 (class ‘B’);

(v) WTP for more efficient washing machines: class ‘A+’ = 10%; class ‘A’ = 8%; class ‘B’ = 5% and class ‘C’ = 0;

(vi) The personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7%;

(vii) When energy use is reduced this also reduces emissions of non-GHG pollutants. The average value per kWh of the reduction is taken as €cent 1.225

for Poland. This is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Table 150: Washing machines; Poland – Baseline scenario - increase in 12% of electricity prices due to ETS

2007	BAU			Baseline scenario			
Class	Sales	Price	mkt share	Revised sales	mkt share	Δsales	Δmkt share
C	90,000	470.00	0.093	48,552	0.050	-41,448	-0.0430
B	11,000	500.00	0.011	9,757	0.010	-1,243	-0.0013
A	839,000	535.00	0.871	880,539	0.914	41,539	0.0431
A+	23,000	550.00	0.024	24,152	0.025	1,152	0.0012
Total	963,000	528.88	1.000	963,000	1.000		

2.3.6.2 Policy option 1: Tax credit for manufacturers (€100 per appliance class A+ sold above average levels)

Table 151: Washing machines; Poland: Tax credit for manufacturers: €100 for energy class 'A+' above the average sales

2007	BAU			Policy option 1 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt share
C	90,000	470.00	0.093	41,675	470.00	0.043	-48,325	-0.0502
B	11,000	500.00	0.011	8,375	500.00	0.009	-2,625	-0.0027
A	839,000	535.00	0.871	755,830	535.00	0.785	-83,170	-0.0864
A+	23,000	550.00	0.024	157,119	538.00	0.163	134,119	0.1393
Total	963,000	528.88	1.000	963,000	532.37	1.000		

Note: The maximum value that manufactures should reduce the final price of products class 'A+' without decreasing their profit with washing machines class A+ in Poland equalled 12€.

- Costs of policy option 1:

  (i) Revenue costs to the government

Table 152: Washing machines; Poland: Revenue costs of a tax credit for manufacturers: €100 for energy class 'A+' above the average sales – total number of washing machines held constant

2007	**Policy option 1 + baseline**		
Class	Revised sales	Tax incentive (€)	Revenue cost (€)
C	41,675	0	0
B	8,375	0	0
A	755,830	0	0
A+	157,119 – 16,333 = 140,786	100	14,078,551
Total			**14,078,551**

(ii) Administrative costs

As discussed earlier, we assume that this policy option has no or negligible administrative costs.

(iii) Welfare costs

These are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits at 8% of the extra sales revenue, which is based on information provided by the consultants by drawing on direct data collection; and (c) the gain from reduced non-GHG emissions.

Table 153: Washing machines; Poland: Welfare costs of a Tax credit for manufacturers: €100 for energy class 'A+' above the average sales – total number of washing machines held constant

1	Welfare cost (marginal cost of public funds = 26% of the revenue cost) (€)	3,660,423
2	Welfare gain (profit of producers = 8% of sales revenue) (€) (0.08*[14])	268,746
2a	Welfare gain from reduced emissions of non-GHG pollutants	224,386
3	Net welfare cost (€) [1-2-2a]	3,167,292
3a	Welfare Cost per Ton of GHG ([3]/[15]) (€/tCO_2)	283.93

➢ Benefits of policy 1

(i) Energy savings

Table 154: Washing machines; Poland: Estimates of energy savings after the implementation of a tax credit for manufacturers: €100 for energy class 'A+' above the average sales – total number of washing machines held constant

2007		BAU		Policy option 1 + baseline	
Class	Energy use [(a)]	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
C	250	90,000	22,500,000	41,675	10,418,845
B	238	11,000	2,618,000	8,375	1,993,327
A	210	839,000	176,190,000	755,830	158,724,395
A+	201	23,000	4,623,000	157,119	31,580,887
Total		963,000	205,931,000	963,000	202,717,455
Energy savings (GWh) / year					**3.2**
Reductions in Expenditure on Energy (€)					**437,659**
Lifetime energy savings (GWh)					18.3
Lifetime expenditure savings on energy (€)					2,494,657

Note: (a) kWh/year;

(ii) GHG emissions

Table 155: Washing machines; Poland: GHG emissions of a tax credit for manufacturers: €100 for energy class 'A+' above the average sales – total number of washing machines held constant

Parameter: tCO2/kWh	0.000609
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	1,957
Lifetime GHG savings (tCO2)	11,155
Lifetime savings (€)	223,104
Revenue cost to Government / tCO2 (€)	1,262

(iii) Financial gains for manufacturers with extra sales

Table 156: Washing machines; Poland: Financial gains – sales revenue – Tax credit for manufacturers: €100 for energy class 'A+' above the average sales

	BAU			Policy option 1 + baseline		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
C	90,000	470.00	42,300,000	41,675	470.00	19,587,429
B	11,000	500.00	5,500,000	8,375	500.00	4,187,663
A	839,000	535.00	448,865,000	755,830	535.00	404,369,292
A+	23,000	550.00	12,650,000	157,119	538.00	84,529,937
Total	963,000		509,315,000	963,000		512,674,320
Financial gains for manufacturers						**3,359,320 €**

➢ Summary of policy 1

Table 157: Washing machines; Poland: summary of policy option 1 (Tax credit for manufacturers: €100 for energy class 'A+' above the average sales)

Summary	Policy 1 + baseline
Revenue cost to government (€)	14,078,551
Net welfare cost to society (€)	3,167,292
GHG reductions	
Revenue cost / tCO_2 (€)	1,262.06
Net welfare cost / tCO_2 (€)	283.93

2.3.6.3 Policy option 2: B-class and lower removed from the market

Table 158: Washing machines; Poland – B-class and lower removed from the market

2007	BAU			Policy option 2 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt share
C	90,000	470.00	0.093	0	470.00	0.000	-90,000	-0.0935
B	11,000	500.00	0.011	0	500.00	0.000	-11,000	-0.0114

A	839,000	535.00	0.871	940,000	535.00	0.976	101,000	0.1049
A+	23,000	550.00	0.024	23,000	550.00	0.024	0	0.0000
Total	963,000	528.88	1.000	963,000	535.36	1.000		

- Costs of policy option 2

(i) Administrative costs

As discussed earlier, we assume that this policy option has no or negligible administrative costs.

(ii) Welfare costs

The welfare changes from the removal of B-class or lower from the market are made up of the following. First, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no such policy. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Second, we have the welfare gain to producers from the sale of more profitable equipment. This is calculated as in the case of the tax credit (see Table 153). Finally, there are gains from the reduction of the emissions of non-GHG pollutants in the generation of electricity, calculated at the average external cost per kWh for Poland (see section 2.3.6.2).

Table 159: Washing machines; Poland: Welfare costs of policy option 2 – B-class and lower removed from the market; total number of washing machines held constant

4	Dead-weight loss	(ΔQ x ΔP) / 2
5	Welfare cost of the tax (DWL) – energy (€)	0
6	Welfare cost of the tax (DWL) – equipments (€)	3,358,250
6a	Welfare gain from savings in costs of raising funds from other taxes (€) (0.26*[17])	0
7	Welfare gain (profit of producers = 8% of sales revenue) (€) (0.08*[14])	498,800
7a	Welfare gain from reduced emissions of non-GHG pollutants	272,876
8	Net welfare cost (€) [5+6-6a-7-7a]	2,586,574
9	Marginal cost of policy (welfare cost/tax revenue) (€) [5+6]/[17]	0
9a	Welfare Cost per Ton of GHG ([8]/[15]) (€/tCO_2)	190.67

➢ <u>Benefits of policy 2</u>

(i) Energy savings

Table 160: Washing machines; Poland: Estimates of energy savings after the implementation of policy option 2: B-class and lower removed from the market – holding the total number of washing machines constant

2007		**BAU**		**Policy option 2 + baseline**	
Class	Energy use [(a)]	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
C	250	90,000	22,500,000	0	0
B	238	11,000	2,618,000	0	0
A	210	839,000	176,190,000	940,000	197,400,000
A+	201	23,000	4,623,000	23,000	4,623,000
Total		963,000	205,931,000	963,000	202,023,000
Energy savings (GWh) / year					**3.9**
HH expenditure change per year (€)					**532,238**
Lifetime energy savings (GWh)					22.3
Lifetime expenditures on energy (€)					3,033,759

Note: (a) kWh/year;

(ii) GHG emissions

Table 161: Washing machines; Poland: GHG emissions of policy option 2 – B-class and lower removed from the market – total number of washing machines held constant

Parameter: tCO2/kWh	0.000609
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	2,380
Lifetime GHG savings (tCO2)	13,566
Lifetime savings (€)	**271,317**
Revenue cost to Government / tCO2	**0.00 €**

(iii) Financial gain with extra sales

Table 162: Washing machines; Poland: Financial gains – sales revenue – policy option 2: B-class and lower removed from the market

	BAU			Policy option 2 + baseline		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
C	90,000	470.00	42,300,000	0	470.00	0
B	11,000	500.00	5,500,000	0	500.00	0
A	839,000	535.00	448,865,000	940,000	535.00	502,900,000
A+	23,000	550.00	12,650,000	23,000	550.00	12,650,000
Total	963,000		509,315,000	963,000		515,550,000
Financial gains for manufacturers						**6,235,000 €**

➢ Summary of policy 2

Table 163: Washing machines; Poland: summary of policy option 2(B-class and lower removed from the market)

Summary	Policy option 2 + baseline
Revenue raised in tax (€)	0
Revenue gains to producers (€)	6,235,000
Higher costs to consumers in capital exp. (€)	3,358,250
Higher costs to consumers in energy exp. (€)	-3,033,759
GHG reductions	
Net welfare cost (€)	2,586,574
Welfare cost/tCO2 (€)	190.67

2.3.6.4 Comparison of policy options

Table 164: Washing machines; Poland: Cost-benefit summary

			Policy option 1 + baseline	Policy option 2 + baseline
10	Costs	Net welfare costs	3,167,292	2,586,574
11		Administrative costs	0	0
12	Benefits	GHG	223,104	271,317
13	Benefit – costs		-2,944,188	-2,315,257
14	Revenue gain to producers (€)		3,359,320	6,235,000
15	Energy savings (GWh)		18.3	22.3
15a	Lifetime GHG Savings (t/CO_2)		11,155.2	13,565.8
16	Expenditure in energy by households (€)		2,494,657	3,033,759
17	Revenue cost to government (€)		14,078,551	0
18	Welfare cost/tCO_2		283.93	190.67

2.3.6.5 Conclusions

The results for Poland are similar to those for Italy: there is a bigger welfare cost from the tax credit option but a smaller reduction in GHG from that option. The cost per ton of CO_2 removed in tax credit option is now €284/tCO_2, while it is €190/ton for the removal option. The revenue gain to producers under the removal option is about €6million, while under tax credit option it is less, at €3 million. This last result is different from that in Italy. Since a lot more people have B and C class machines in Poland compared to Italy, the removal of these in Poland creates a bigger demand (relatively speaking) than in Italy. Hence the profits to producers are bigger under the removal option in Poland.

3.3.7. Case-study 5: Boilers in Denmark

2.3.7.1 Data report and baseline scenario

Table 165: Sales and prices of boilers in Denmark per type

	Non-condensing	Condensing
Sales (2007)	7,000	28,000
Prices (€) (2007)	2,396	3,168

Consumption	2,000 (m3/year) 21,660 (kWh/year)	1,726 (m3/year) 18,693 (kWh/year)
Lifetime (years)	15	
Gas price (€/kWh)	0.45278	

Summary of main assumptions

(i) Each consumer buys one product only;

(ii) Boilers have a fixed lifetime (15 years);

(iii) Boilers types are identical in terms of service provided but vary in terms of energy efficiency;

(iv) No adjustment in price due to quality of products;

(v) WTP for public good assumed 20% for condensing boilers;

(vi) The personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7%;

(vii) Percentage of consumers assumed to pay income tax: 85%;

(viii) Average income tax level: 36.8% of income;

(ix) When energy use is reduced this also reduces emissions of non-GHG pollutants. The average value per kWh of the reduction is taken as €cent 1.048 for Denmark. This is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Table 166: Boiler; Denmark – Baseline scenario - increase in 15% of gas prices due to ETS

2007	**BAU**			**Baseline scenario**			
Class	Sales	Price	mkt share	Revised sales	mkt share	Δsales	Δmkt share
Non-cond.	7,000	2396	0.200	5,744	0.164	-1,256	-0.0359
Condensing	28,000	3168	0.800	29,256	0.836	1,256	0.0359
Total	35,000	3014	1.000	35,000	1.000		

2.3.7.2 Policy option 1: Tax credit for consumers (25% of condensing boilers' prices to be deducted from income tax)

Table 167: Boiler; Denmark : Tax credits for consumers: 25% of condensing boilers deducted from income tax

2007	BAU			Policy option 1 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt share
Non-cond.	7,000	2396	0.200	42	2,396	0.001	-6,958	-0.1988
Condensing	28,000	3168	0.800	34,958	2,877	0.999	6,958	0.1988
Total	35,000	3014	1.000	35,000	2,876	1.000		

- Costs of policy option 1

(i) Revenue costs to the government

Table 168: Boiler; Denmark: Revenue costs of a tax credit for consumers – total number of boilers held constant

2007	Policy option 1 + baseline		
Class	Revised sales	Tax incentive (€)	Revenue cost (€)
Non-cond.	42	0	0
Condensing	(34,958 – 28,000) * 0.85 =5,914	792	4,684,269
Total	5,956		**4,684,269**

(ii) Administrative costs

As discussed earlier, we assume that this policy option has no or negligible administrative costs.

(iii) Welfare costs

These are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits at 8.5% of the extra sales revenue, which is based on information provided by the consultants by drawing on direct data collection; and (c) the gain from reduced non-GHG emissions.

Table 169: Boiler; Denmark: Welfare costs of a tax credit for consumers – total number of boilers held constant

1	Welfare cost (marginal cost of public funds = 26% of the revenue cost) (€)	1,217,910
2	Welfare gain (profit of producers = 8.5% of sales revenue) (€) (0.085*[14])	456,598
2a	Welfare gain from reduced emissions of non-GHG pollutants	3,245,856
3	Net welfare cost (€) [1-2-2a]	-2,484,544
3a	Welfare Cost per Ton of GHG ([3]/[15]) (€/tCO_2)	-23.87

- Benefits of policy 1

(i) Energy savings

Table 170: Boiler; Denmark: Estimates of energy savings after the implementation of policy option 1 – total number of boilers held constant

2007		**BAU**		**Policy option 1 + baseline**	
Class	Energy use (m^3)	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
Non-cond.	2,000	7,000	151,620,000	42	905,098
Condensing	1,726	28,000	523,392,240	34,958	653,459,200
Total		35,000	675,012,240	35,000	654,364,298
Energy savings (GWh)					**20.6**
Savings on expenditure on energy (€)					**91,666**
Lifetime energy savings (GWh)					309.7
Lifetime expenditure savings on energy (€)					1,374,988

Note: (a) Wh;

(ii) GHG emissions

Table 171: Boiler; Denmark: GHG emissions of a tax credit for consumers – total number of boilers held constant

Parameter: tCO2/kWh	0.000336
Parameter: €/tCO2	€20
GHG savings / year (tCO2/kWh)	6,938
Lifetime GHG savings (tCO2/kWh)	104,066
Lifetime savings (€)	2,081,313
Revenue cost to Government / tCO2 (€)	45.01

(iii) Financial gains for manufacturers with extra sales

Table 172: Boiler; Denmark: Financial gains – sales revenue – policy option 1

	BAU			**Policy option 1 + baseline**		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
Non-cond.	7,000	2396	16,772,000	42	2396.00	100,121
Condensing	28,000	3168	88,704,000	34,958	3168.00	110,747,620
Total	35,000		105,476,000	35,000		110,847,741
Financial gains for manufacturers						**5,371,741 €**

➢ Summary of policy 1

Table 173: Boiler; Denmark: summary of policy option 1 (tax credit for consumers)

Summary	**Policy 1 + baseline**
Revenue cost to government (€)	4,684,269
Net welfare cost to society (€)	-2,484,544
GHG reductions	
Revenue cost / tCO_2 (€)	45.01
Net welfare cost / tCO_2 (€)	-23.87

2.3.7.3 Policy option 2: Energy tax - additional increase in gas price (10%)

Table 174: Boiler; Denmark – additional increase in 10% of gas prices

2007	BAU			Policy option 2 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	Mkt share	Δsales	Δmkt share
Non-cond.	7,000	2396	0.200	4,716	2,396	0.135	-2,284	-0.0653
Condensing	28,000	3168	0.800	30,284	3,168	0.865	2,284	0.0653
Total	35,000	3014	1.000	35,000	3064	1.000		

- Costs of policy option 2

(i) Revenue costs

Table 175: Boiler; Denmark: Tax revenue with policy option 2 – energy price increase (10%); total number of boilers held constant

Tax revenue (lifetime)	**4,449,905 €**

(ii) Administrative costs

Table 176: Boiler; Denmark: Administrative costs of policy option 2 – energy price increase (10%); total number of boilers held constant

Parameter:	0.20% of total tax revenue
Administrative costs	**8,900 €**

(iii) Welfare costs

The welfare changes from the tax are made up of the following. First, we have the deadweight loss from the imposition of the tax, based on the consumption of energy. Second, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no tax. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Third, we have a welfare gain arising from the fact that the policy generates tax revenue and therefore reduces the cost of raising a similar amount of tax from other sources. This gain is calculated using the marginal cost of public funds. Fourth, we have the welfare gain to producers from the sale of more profitable equipment. This is calculated as in the case of the tax credit (see Table 169). Finally, there are gains from the reduction in the generation of electricity, calculated at the average external cost per kWh for Denmark (see section 2.3.7.2).

Table 177: Boiler; Denmark: Welfare costs of policy option 2 – energy price increase (10%); total number of boilers held constant

4	Dead-weight loss	(ΔQ x ΔP) / 2
5	Welfare cost of the tax (DWL) – energy (€)	52,008
6	Welfare cost of the tax (DWL) – equipments (€)	1,763,482
6a	Welfare gain from savings in costs of raising funds from other taxes (€) (0.26*[17])	1,156,975
7	Welfare gain (profit of producers = 8.5% of sales revenue) (€) (0.085*[14])	149,896
7a	Welfare gain from reduced emissions of non-GHG pollutants	1,065,578
8	Net welfare cost (€) [5+6-6a-7-7a]	-556,959
9	Marginal cost of policy (welfare cost/tax revenue) (€) [5+6]/[17]	2.45
9a	Welfare Cost per Ton of GHG ([8]/[15]) (€/tCO_2)	-16.30

- Benefits of policy 2

(i) Energy savings

Table 178: Boiler; Denmark: Estimates of energy savings after the implementation of policy option 2 – holding the total number of boilers constant

2007		**BAU**		**Policy option 2 + baseline**	
Class	Energy use (m^3)	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
Non-cond.	2,000	7,000	151,620,000	4,716	102,141,989
Condensing	1,726	28,000	523,392,240	30,284	566,091,764
Total		35,000	675,012,240	35,000	668,233,752
Energy savings (GWh)					**6.8**
Household expenditure change (€)					**-266,567**
Lifetime energy savings (GWh)					101.7
Lifetime expenditures on energy (€)					-3,998,511

Note: (a) Wh;

(ii) GHG emissions

Table 179: Boiler; Denmark: GHG emissions of policy option 2 – additional gas price increase (10%) – total number of boilers held constant

Parameter: tCO2/kWh	0.000336
Parameter: €/tCO2	€20
GHG savings / year (tCO2/kWh)	2,278
Lifetime GHG savings (tCO2/kWh)	34,164
Lifetime savings (€)	683,272
Revenue cost to Government / tCO2 (€)	**130.25**

(iii) Financial gain with extra sales

Table 180: Boiler; Denmark: Financial gains – sales revenue – policy option 2: additional energy price increase (10%)

	BAU			**Policy option 2 + baseline**		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
Non-cond.	7,000	2396	16,772,000	4,716	2396.00	11,298,809
Condensing	28,000	3168	88,704,000	30,284	3168.00	95,940,673
Total	35,000		105,476,000	35,000		107,239,482
Financial gains for manufacturers						**1,763,482 €**

➢ <u>Summary of policy 2</u>

Table 181: Boiler; Denmark: summary of policy option 2(10% gas price increase)

Summary	**Policy option 2 + baseline**
Revenue raised in tax	4,449,905
Revenue gains to producers	1,763,482
Higher costs to consumers in capital exp.	1,763,482
Higher costs to consumers in energy exp.	3,998,511
GHG reductions	

Net welfare cost	-556,959
Welfare cost/tCO2	-16.30

2.3.7.4 Comparison of policy options

Table 182: Boiler; Denmark: Cost-benefit summary

			Policy option 1 + baseline	Policy option 2 + baseline
10	Costs	Net welfare costs	-2,484,544	-556,959
11		Administrative costs	0	8,900
12	Benefits	GHG	2,081,313	683,272
13	Benefit – costs		4,565,857	1,231,331
14	Revenue gain to producers (€)		5,371,741	1,763,482
15	Energy savings (GWh)		309.7	101.7
15a	Lifetime GHG Savings (t/CO_2)		104,065.6	34,163.6
16	Expenditure in energy by households (€)		1,374,988	-3,998,511
17	Revenue cost to government (€)		4,684,269	-4,449,905
18	Welfare cost/tCO_2		-23.87	-16.30

2.3.7.5 Conclusions

The tax credit has a higher welfare benefit than the gas price increase (€2.5 million for tax credit and €557,000 for the gas price increase). The tax credit option therefore is also very cost-effective in per tCO_2 (a gain of €24/ton), while the gas price has a smaller welfare gain of €16/tCO_2. The tax credit reduces GHGs by 100,000 tons against 34,000 tons for the gas price increase. The other big difference between the options concerns the revenue cost for the government – the tax option generates revenue of €4.5 million while the tax credit costs the government €4.6 million.

3.3.8. Case-study 6: Boilers in Italy

2.3.8.1 Data report and baseline scenario

Table 183: Sales and prices of boilers in Italy per type

	Non-condensing	Condensing
Sales (2007)	1,009,000	138,000
Prices (€) (2007)	926	1,224
Consumption	2,000 (m^3/year) 21,660 (kWh/year)	1,726 (m^3/year) 18,693 (kWh/year)
Lifetime (years)	15	
Gas price (€/kWh)	0.19202	

Summary of main assumptions

(i) Each consumer buys one product only;

(ii) Boilers have a fixed lifetime (15 years);

(iii) Boilers types are identical in terms of service provided but vary in terms of energy efficiency;

(iv) No adjustment in price due to quality of products;

(v) WTP for public good assumed 20% for condensing boilers;

(vi) The personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7%;

(vii) Percentage of consumers assumed to pay income tax: 69%;

(viii) Average income tax level: 17.9% of income;

(ix) When energy use is reduced this also reduces emissions of non-GHG pollutants. The average value per kWh of the reduction is taken as €cent 0.779 for Italy. This is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Table 184: Boiler; Italy – Baseline scenario - increase in 15% of gas prices due to ETS

2007	BAU			Baseline scenario			
Class	Sales	Price	mkt share	Revised sales	mkt share	Δsales	Δmkt share
Non-cond.	1,009,000	926.00	1,009,000	960,362	0.837	-48,638	-0.0424
Condensing	138,000	1224.00	138,000	186,638	0.163	48,638	0.0424
Total	1,147,000	961.85	1.000	1,147,000	1.000		

2.3.8.2 Policy option 1: Tax credit for consumers (25% of condensing boilers' prices to be deducted from income tax)

Table 185: Boiler; Italy: Tax credits for consumers: 25% of condensing boilers deducted from income tax

2007	BAU			Policy option 1 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt share
Non-cond.	1,009,000	926	0.880	103,755	926.00	0.090	-905,245	-0.7892
Condensing	138,000	1224	0.120	1,043,245	1,169.23	0.910	905,245	0.7892
Total	1,147,000	961.8	1.000	1,147,000	1147.22	1.000		

- <u>Costs of policy option 1</u>

  (i) Revenue costs to the government

Table 186: Boiler; Italy: Revenue costs of a tax credit for consumers – total number of boilers held constant

2007	Policy option 1 + baseline		
Class	Revised sales	Tax incentive (€)	Revenue cost (€)
Non-cond.	103,755	0	0
Condensing	(1,043,245 – 138,000) * 0.69 = 624,619	306	191,133,374
Total	728,374		**191,133,374**

(ii) Administrative costs

As discussed earlier, we assume that this policy option has no or negligible administrative costs.

(iii) Welfare costs

These are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits at 8.5% of the extra sales revenue, which is based on information provided by the consultants by drawing on direct data collection; and (c) the gain from reduced non-GHG emissions.

Table 187: Boiler; Italy: Welfare costs of a tax credit for consumers – total number of boilers held constant

1	Welfare cost (marginal cost of public funds = 26% of the revenue cost) (€)	49,694,677
2	Welfare gain (profit of producers = 8.5% of sales revenue) (€) (0.085*[14])	22,929,849
2a	Welfare gain from reduced emissions of non-GHG pollutants	313,887,301
3	Net welfare cost (€) [1-2-2a]	-287,122,473
3a	Welfare Cost per Ton of GHG ([3]/[15]) (€/tCO_2)	-14.17

- <u>Benefits of policy 1</u>

(i) Energy savings

Table 188: Boiler; Italy: Estimates of energy savings after the implementation of policy option 1 – total number of boilers held constant

2007		**BAU**		**Policy option 1 + baseline**	
Class	Energy use (m^3)	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
Non-cond.	2000	1,009,000	21,854,940,000	103,755	2,247,338,951
Condensing	1726	138,000	2,579,576,040	1,043,245	19,500,935,745
Total		1,147,000	24,434,516,040	1,147,000	21,748,274,696
Energy savings (GWh)					**2,686.2**
Savings on expenditure on energy (€)					**5,057,460**
Lifetime energy savings (GWh)					40,293.6
Lifetime expenditure savings on energy (€)					75,861,894

Note: (a) kWh;

(ii) GHG emissions

Table 189: Boiler; Italy: GHG emissions of a tax credit for consumers – total number of boilers held constant

Parameter: tCO2/kWh	0.000503
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	**1,351,179**
Lifetime GHG savings (tCO2)	20,267,691
Lifetime savings (€)	405,353,819
Revenue cost to Government / tCO2 (€)	9.43

(iii) Financial gains for manufacturers with extra sales

Table 190: Boiler; Italy: Financial gains – sales revenue – policy option 1

	BAU			**Policy option 1 + baseline**		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
Non-cond.	1,009,000	926	934,334,000	103,755	926.00	96,077,372
Condensing	138,000	1224	168,912,000	1,043,245	1224.00	1,276,931,561
Total	1,147,000		1,103,246,000	1,147,000		1,373,008,932
Financial gains for manufacturers						**269,762,932 €**

- Summary of policy 1

Table 191: Boiler; Italy: summary of policy option 1 (tax credit for consumers)

Summary	**Policy 1 + baseline**
Revenue cost to government (€)	191,133,374
Net welfare cost to society (€)	-287,122,473
GHG reductions	
Revenue cost / tCO_2 (€)	9.43
Net welfare cost / tCO_2 (€)	-14.17

2.3.8.3 Policy option 2: Energy tax - additional increase in gas price (10%)

Table 192: Boiler; Italy – additional increase in 10% of gas prices

2007	BAU			Policy option 2 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt share
Non-cond.	1,009,000	926	0.880	923,063	926	0.805	-85,937	-0.075
Condensing	138,000	1224	0.120	223,937	1,224	0.195	85,937	0.075
Total	1,147,000	961.8	1.000	1,147,000	984.2	1.000		

- Costs of policy option 2

(i) Revenue costs

Table 193: Boiler; Italy: Tax revenue with policy option 2 – energy price increase (10%); total number of boilers held constant

Tax revenue (lifetime)	**68,285,117 €**

(ii) Administrative costs

Table 194: Boiler; Italy: Administrative costs of policy option 2 – energy price increase (10%); total number of boilers held constant

Parameter:	0.20% of total tax revenue
Administrative costs	**136,570 €**

(iii) Welfare costs

The welfare changes from the tax are made up of the following. First, we have the deadweight loss from the imposition of the tax, based on the consumption of energy. Second, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no tax. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Third, we have a welfare gain arising from the fact that the policy generates tax revenue and therefore reduces the cost of raising a similar amount of tax from other sources. This gain is calculated using the marginal cost of public funds. Fourth, we have the welfare gain to producers from the sale of more profitable equipment. This is calculated as in the case of the tax credit (see Table 187). Finally, there are gains from the reduction in the generation of electricity, calculated at the average external cost per kWh for Italy (see section 2.3.8.2).

Table 195: Boiler; Italy: Welfare costs of policy option 2 – energy price increase (10%); total number of boilers held constant

4	Dead-weight loss	(ΔQ x ΔP) / 2
5	Welfare cost of the tax (DWL) – energy (€)	829,766
6	Welfare cost of the tax (DWL) – equipments (€)	25,609,225
6a	Welfare gain from savings in costs of raising funds from other taxes (€) (0.26*[17])	17,754,130
7	Welfare gain (profit of producers = 8.5% of sales revenue) (€) (0.085*[14])	2,176,784
7a	Welfare gain from reduced emissions of non-GHG pollutants	29,798,054
8	Net welfare cost (€) [5+6-6a-7-7a]	-23,289,977
9	Marginal cost of policy (welfare cost/tax revenue) (€) [5+6]/[17]	2.58
9a	Welfare Cost per Ton of GHG ([8]/[15]) (€/tCO_2)	-12.10

- Benefits of policy 2

  (i) Energy savings

Table 196: Boiler; Italy: Estimates of energy savings after the implementation of policy option 2 – holding the total number of boilers constant

2007		**BAU**		**Policy option 2 + baseline**	
Class	Energy use (m^3)	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
Non-cond.	2000	1,009,000	21,854,940,000	923,063	19,993,544,655
Condensing	1726	138,000	2,579,576,040	223,937	4,185,960,223
Total		1,147,000	24,434,516,040	1,147,000	24,179,504,878
Energy savings (GWh)					**255.0**
Household expenditure change (€)					**-4,072,225**
Lifetime energy savings (GWh)					3,825.2
Lifetime expenditures on energy (€)					-61,083,370

Note: (a) Wh;

(ii) GHG emissions

Table 197: Boiler; Italy: GHG emissions of policy option 2 – additional gas price increase (10%) – total number of boilers held constant

Parameter: tCO2/kWh	0.000503
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	128,271
Lifetime GHG savings (tCO2)	1,924,059
Lifetime savings (€)	38,481,184
Revenue cost to Government / tCO2 (€)	35.49

(iii) Financial gain with extra sales

Table 198: Boiler; Italy: Financial gains – sales revenue – policy option 2: additional energy price increase (10%)

	BAU			**Policy option 2 + baseline**		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
Non-cond.	1,009,000	926	934,334,000	923,063	926.00	854,756,341
Condensing	138,000	1224	168,912,000	223,937	1224.00	274,098,884
Total	1,147,000		1,103,246,000	1,147,000		1,128,855,225
Financial gains for manufacturers						**25,609,225 €**

➢ Summary of policy 2

Table 199: Boiler; Italy: summary of policy option 2(10% gas price increase)

Summary	**Policy option 2 + baseline**
Revenue raised in tax (€)	68,285,117
Revenue gains to producers (€)	25,609,225
Higher costs to consumers in capital exp. (€)	25,609,225
Higher costs to consumers in energy exp. (€)	61,083,370
GHG reductions	
Net welfare cost (€)	-23,289,977
Welfare cost/tCO2 (€)	-12.10

2.3.8.4 Comparison of policy options

Table 200: Boiler; Italy: Cost-benefit summary

			Policy option 1 + baseline	Policy option 2 + baseline
10	Costs	Net welfare costs	-287,122,473	-23,289,977
11		Administrative costs	0	136,570
12	Benefits	GHG	405,353,819	38,481,184
13	Benefit – costs		692,476,292	61,634,591
14	Revenue gain to producers (€)		269,762,932	25,609,225
15	Energy savings (GWh)		40,293.6	3,825.2
15a	Lifetime GHG Savings (t/CO_2)		20,267,690.9	1,924,059.2
16	Expenditure in energy by households (€)		75,861,894	-61,083,370
17	Revenue cost to government (€)		191,133,374	-68,285,117
18	Welfare cost/tCO_2		-14.17	-12.10

2.3.8.5 Conclusions

In the case of Italy a much bigger gain is made from switching out of non-condensing boilers. The reason for this is that while in Denmark most boilers are condensing boilers (80% of the market) in Italy most are not (only 12%). Hence both polices in Italy have a bigger impact, but especially the tax credit. This option generates a huge net welfare gain of €287 million because of the profits of producers. On the other hand the tax option has a net welfare benefit of €23 million. As a result the cost per tCO_2 removed is negative with the tax credit at €14.2/ton and €10/ton with the price increase. Both figures would be considered acceptable as a policy for reducing GHGs. We also note that the amount of GHG reduced under the tax credit is very large (1.3 million tons per year) while with the price increase it is 128,000 tons per year. Finally, while tax credit budgetary cost of €191 million the tax option generates a revenue gain of €69 million.

3.3.9. Case-study 7: CFLi in Poland

2.3.9.1 Data report and baseline scenario

Table 201: Sales and prices of lamps in Poland per type

	Incandescent	CFLi
Sales (2007)	91,900,000 15,316,667 [(a)]	14,700,000
Prices (€ 2007)	0.50 3.00 [(a)]	4.25
Consumption (kWh)	0.0540	0.0137
Lifetime (hours)	1,000 6,000 [(a)]	6,000
Energy price (€/kWh)	0.1216	

Note: (a) Harmonised lifetime.

Summary of main assumptions

(i) Each consumer buys one product only;

(ii) Lamps have a fixed lifetime (1,000 or 6,000 hours);

(iii) Lamp types are NOT identical in terms of service provided and vary in terms of energy efficiency. We harmonised the products by assuming that the service provided by one CFLi is given by a set of 6 incandescent lamps;

(iv) No adjustment in price due to quality of products;

(v) WTP for more efficient lamps equal to 5%;

(vi) The personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7%;

(vii) When energy use is reduced this also reduces emissions of non-GHG pollutants. The average value per kWh of the reduction is taken as €cent 1.225 for Poland. This is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Table 202: CFLi; Poland – Baseline scenario - increase in 12% of electricity prices due to ETS

2007	**BAU**			**Baseline scenario**			
Class	Sales	Price	mkt share	Revised sales	mkt share	Δsales	Δmkt shr
Incand [(a)]	15,316,667	3.00	0.510	14,176,069	0.472	-1,140,598	-0.0380
CFLi	14,700,000	4.25	0.490	15,840,598	0.528	1,140,598	0.0380
Total	30,016,667	3.61	1.000	30,016,667	1.000		

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

2.3.9.2 Policy option 1: Subsidy for consumers (€1 for all CFLi)

Table 203: CFLi; Poland: Subsidy for more energy efficient lamps: €1 for all CFLi

2007	BAU			Policy option 1 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt shr
Incand [(a)]	15,316,667	3.00	0.510	658,264	3.00	0.022	-14,658,402	-0.4883
CFLi	14,700,000	4.25	0.490	29,358,402	3.25	0.978	14,658,402	0.4883
Total	30,016,667	3.61	1.000	30,016,667	3.24	1.000		

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

- <u>Costs of policy option 1</u>

  (i) Revenue costs to the government

Table 204: CFLi; Poland: Revenue costs of a subsidy for more energy efficient lamps (€1 for all CFLi) – total number of CFLi held constant

2007	**Policy option 1 + baseline**		
Class	Revised sales	Tax incentive (€)	Revenue cost (€)
Incand [(a)]	658,264	0	0
CFLi	29,358,402	1	29,358,402
Total	30,016,667		**29,358,402**

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

(ii) Administrative costs

Table 205: CFLi; Poland: Administrative costs of a subsidy for more energy efficient lamps (€1 for all CFLi) – total number of CFLi held constant

Parameter:	5% of total revenue cost
Administrative costs	**1,467,920 €**

(iii) Welfare costs

These are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits at 6% of the extra sales revenue, which is based on information provided by the consultants by drawing on direct data collection; and (c) the gain from reduced non-GHG emissions.

Table 206: CFLi; Poland: Welfare costs of a subsidy for more energy efficient lamps (€1 for all CFLi) – total number of CFLi held constant

1	Welfare cost (marginal cost of public funds = 26% of the revenue cost) (€)	7,633,185
2	Welfare gain (profit of producers = 6% of sales revenue) (€) (0.06*[14])	1,099,380
2a	Welfare gain from reduced emissions of non-GHG pollutants	43,472,790
3	Net welfare cost (€) [1-2-2a]	-36,938,986
3a	Welfare Cost per Ton of GHG ([3]/[15]) (€/tCO_2)	-17.09

➢ <u>Benefits of policy 1</u>

(i) Energy savings

Table 207: CFLi; Poland: Estimates of energy savings after the implementation of policy option 1 – total number of CFLi held constant

2007		**BAU**		**Policy option 1 + baseline**	
Class	Energy use	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
Incand [(b)]	0.0540	15,316,667	827,100	658,264	35,546
CFLi	0.0137	14,700,000	200,655	29,358,402	400,742
Total		30,016,667	1,027,755	30,016,667	436,288

Energy savings (GWh)	**0.5915**
Savings on expenditure on energy (€)	**80,553**
Lifetime energy savings (GWh)	3,548.8
Lifetime expenditure savings on energy (€)	483,318,063

Notes: (a) kWh;
(b) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

(ii) GHG emissions

Table 208: CFLi; Poland: GHG emissions of a subsidy for more energy efficient lamps (€1 for all CFLi) – total number of CFLi held constant

Parameter: tCO2/kWh	0.000609
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	**360.20**
Lifetime GHG savings (tCO2)	2,161,219
Lifetime savings (€)	43,224,374
Revenue cost to Government / tCO2 (€)	13.58

(iii) Financial gains for manufacturers with extra sales

Table 209: CFLi; Poland: Financial gains – sales revenue – policy option 1

	BAU			**Policy option 1 + baseline**		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
Incand [(a)]	15,316,667	3.00	45,950,000	658,264	3.00	1,974,793
CFLi	14,700,000	4.25	62,475,000	29,358,402	4.25	124,773,210
Total	30,016,667		108,425,000	30,016,667		126,748,003
Financial gains for manufacturers						**18,323,003 €**

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

➢ Summary of policy 1

Table 210: CFLi; Poland: summary of policy option 1 (€1 for all CFLi)

Summary	Policy 1 + baseline
Revenue cost to government (€)	29,358,402
Net welfare cost to society (€)	-36,938,986
GHG reductions	
Revenue cost / tCO_2 (€)	13.58
Net welfare cost / tCO_2 (€)	-17.09

2.3.9.3 Policy option 2: Energy tax - additional increase in electricity price (10%)

Table 211: CFLi; Poland – additional increase in 10% of electricity prices

2007	BAU			Policy option 2 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt shr
Incand [(a)]	15,316,667	3.00	0.510	14,381,797	3.00	0.479	-934,870	-0.0311
CFLi	14,700,000	4.25	0.490	15,634,870	4.25	0.521	934,870	0.0311
Total	30,016,667	3.61	1.000	30,016,667	3.65	1.000		

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

➢ Costs of policy option 2

(i) Revenue costs

Table 212: CFLi; Poland: Tax revenue with policy option 2 – energy price increase (10%); total number of CFLi held constant

Tax revenue (lifetime)	**80,900,745 €**

(ii) Administrative costs

Table 213: CFLi; Poland: Administrative costs of policy option 2 – energy price increase (10%); total number of CFLi held constant

Parameter:	0.20% of total tax revenue
Administrative costs	**161,801 €**

(iii) Welfare costs

The welfare changes from the tax are made up of the following. First, we have the deadweight loss from the imposition of the tax, based on the consumption of energy. Second, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no tax. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Third, we have a welfare gain arising from the fact that the policy generates tax revenue and therefore reduces the cost of raising a similar amount of tax from other sources. This gain is calculated using the marginal cost of public funds. Fourth, we have the welfare gain to producers from the sale of more profitable equipment. This is calculated as in the case of the subsidy (see Table 206). Finally, there are gains from the reduction in the generation of electricity, calculated at the average external cost per kWh for Poland (see section 2.3.9.2).

Table 214: CFLi; Poland: Welfare costs of policy option 2 – energy price increase (10%); total number of CFLi held constant

4	Dead-weight loss	(ΔQ x ΔP) / 2
5	Welfare cost of the tax (DWL) – energy (€)	3,192,549
6	Welfare cost of the tax (DWL) – equipments (€)	1,168,587
6a	Welfare gain from savings in costs of raising funds from other taxes (€) (0.26*[17])	21,034,194
7	Welfare gain (profit of producers = 6% of sales revenue) (€) (0.06*[14])	70,115
7a	Welfare gain from reduced emissions of non-GHG pollutants	2,772,567
8	Net welfare cost (€) [5+6-6a-7-7a]	-19,515,740
9	Marginal cost of policy (welfare cost/tax revenue) (€) [5+6]/[17]	18.55
9a	Welfare Cost per Ton of GHG ([8]/[15]) (€/tCO_2)	-141.59

➢ <u>Benefits of policy 2</u>

(i) Energy savings

Table 215: CFLi; Poland: Estimates of energy savings after the implementation of policy option 2 – holding the total number of CFLi constant

2007		BAU		Policy option 2 + baseline	
Class	Energy use	Sales	Energy consumption [a]	Revised sales	Energy consumption [a]
Incand [b]	0.0540	15,316,667	827,100	14,381,797	776,617
CFLi	0.0137	14,700,000	200,655	15,634,870	213,416
Total		30,016,667	1,027,755	30,016,667	990,033
Energy savings (GWh)					**0.0377**
Household expenditure change (€)					**-8,346**
Lifetime energy savings (GWh)					226.3
Lifetime expenditures on energy(€)					-50,076,137

Note: (a) Wh;
(b) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

(ii) GHG emissions

Table 216: CFLi; Poland: GHG emissions of policy option 2 – additional electricity price increase (10%) – total number of CFLi held constant

Parameter: tCO2/kWh	0.000609
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	**22.97**
Lifetime GHG savings (tCO2)	137,836.19
Lifetime savings (€)	2,756,724
Revenue cost to Government / tCO2 (€)	**586.93**

(iii) Financial gain with extra sales

Table 217: CFLi; Poland: Financial gains – sales revenue – policy option 2: additional energy price increase (10%)

	BAU			Policy option 2 + baseline		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
Incand [(a)]	15,316,667	3.00	45,950,000	14,381,797	3.00	43,145,390
CFLi	14,700,000	4.25	62,475,000	15,634,870	4.25	66,448,197
Total	30,016,667		108,425,000	30,016,667		109,593,587
Financial gains for manufacturers						**1,168,587**

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

➢ Summary of policy 2

Table 218: CFLi; Poland: summary of policy option 2(10% electricity price increase)

Summary	Policy option 2 + baseline
Revenue raised in tax (€)	80,900,745
Revenue gains to producers (€)	1,168,587
Higher costs to consumers in capital exp. (€)	1,168,587
Higher costs to consumers in energy exp. (€)	50,076,137
GHG reductions	
Net welfare cost (€)	-19,515,740
Welfare cost/tCO2 (€)	-141.59

2.3.9.4 Comparison of policy options

Table 219: CFLi; Poland: Cost-benefit summary

			Policy option 1 + baseline	Policy option 2 + baseline
10	Costs	Net welfare costs	-36,938,986	-19,515,740
11		Administrative costs	1,467,920	161,801
12	Benefits	GHG	43,224,374	2,756,724
13	Benefit – costs		78,695,440	22,110,662
14	Revenue gain to producers (€)		18,323,003	1,168,587
15	Energy savings (GWh)		3,548.8	226.3
15a	Lifetime GHG Savings (t/CO_2)		2,161,218.7	137,836.2
16	Expenditure in energy by households (€)		483,318,063	-50,076,137
17	Revenue cost to government (€)		29,358,402	-80,900,745
18	Welfare cost/tCO_2		-17.09	-141.59

2.3.9.5 Conclusions

The net welfare benefit of the two options is similar: the subsidy option has a gain of €37 million while the tax option has a gain of €20 million. However, the administration costs of the subsidy are much higher: €1.5 million against €160,000 for the tax. On the other hand the subsidy option reduces CO_2 by 2.2 million tons (lifetime basis) million tons per annum while the tax option reduces only 138,000 on the same basis. The cost per tCO_2 removed is negative at €17/tCO_2 while for the tax it is €142/ton. Finally note that while the subsidy option will cost the government €30million the tax option will generate €81million revenue.

3.3.10. CASE-STUDY 8: CFLI IN FRANCE

2.3.10.1 Data report and baseline scenario

Table 220: Sales and prices of lamps in France per type

	Incandescent	CFLi
Sales (2007)	142,500,000 23,750,000 [(a)]	23,000,000
Prices (€) (2007)	0.40 2.40 [(a)]	4.25
Consumption (kWh)	0.0540	0.0137
Lifetime (hours)	1,000 6,000 [(a)]	6,000
Energy price (€/kWh)	0.1211	

Note: Harmonised lifetime.

Summary of main assumptions

(i) Each consumer buys one product only;

(ii) Lamps have a fixed lifetime (1,000 or 6,000 hours);

(iii) Lamp types are NOT identical in terms of service provided and vary in terms of energy efficiency. We harmonised the products by assuming that the service provided by one CFLi is given by a set of 6 incandescent lamps;

(iv) No adjustment in price due to quality of products;

(v) WTP for more efficient lamps equal to 22%;

(vi) The personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7%;

(vii) When energy use is reduced this also reduces emissions of non-GHG pollutants. The average value per kWh of the reduction is taken as €cent 0.254 for France. This is based on (a) the unit values of external costs of each type of fuel cycle from the CASES Project (http://www.feem-project.net/cases) and (b) the fuel mix used for power generation in the country in 2008, as provided by EUROSTAT.

Table 221: CFLi; France – Baseline scenario - increase in 12% of electricity prices due to ETS

2007	BAU			Baseline scenario			
Class	Sales	Price	mkt share	Revised sales	mkt share	Δsales	Δmkt share
Incand [a]	23,750,000	2.40	0.508	22,294,138	0.477	-1,455,862	-0.0311
CFLi	23,000,000	4.25	0.492	24,455,862	0.523	1,455,862	0.0311
Total	46,750,000	3.31	1.000	46,750,000	1.000		

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

2.3.10.2 Policy option 1: Subsidy for consumers (€1 for all CFLi)

Table 222: CFLi; France: Subsidy for more energy efficient lamps: €1 for all CFLi

2007	BAU			Policy option 1 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt shr
Incand [a]	23,750,000	2.40	0.508	1,016,234	3.00	0.022	-22,733,766	-0.4863
CFLi	23,000,000	4.25	0.492	45,733,766	3.25	0.978	22,733,766	0.4863
Total	46,750,000	3.31	1.000	46,750,000	3.24	1.000		

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

- Costs of policy option 1

(i) Revenue costs to the government

Table 223: CFLi; France: Revenue costs of a subsidy for more energy efficient lamps (€1 for all CFLi) – total number of lamps held constant

2007	Policy option 1 + baseline		
Class	Revised sales	Tax incentive (€)	Revenue cost (€)
Incand [a]	1,016,234	0	0
CFLi	45,733,766	1	45,733,766
Total	46,750,000		45,733,766

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

(ii) Administrative costs

Table 224: CFLi; France: Administrative costs of a subsidy for more energy efficient lamps (€1 for all CFLi) – total number of CFLi held constant

Parameter:	5% of total revenue cost
Administrative costs	**2,286,688 €**

(iii) Welfare costs

These are made up of (a) the marginal cost of public funds, estimated at 26% of the amount of revenue raised; (b) gains in producers' profits at 6% of the extra sales revenue, which is based on information provided by the consultants by drawing on direct data collection; and (c) the gain from reduced non-GHG emissions.

Table 225: CFLi; France: Welfare costs of a subsidy for more energy efficient lamps (€1 for all CFLi) – total number of CFLi held constant

1	Welfare cost (marginal cost of public funds = 26% of the revenue cost) (€)	11,890,779
2	Welfare gain (profit of producers = 6% of sales revenue) (€) (0.06*[14])	2,523,448
2a	Welfare gain from reduced emissions of non-GHG pollutants	13,979,766
3	Net welfare cost (€) [1-2-2a]	-4,612,435
3a	Welfare Cost per Ton of GHG ([3]/[15]) (€/tCO_2)	-11.32

- Benefits of policy 1

(i) Energy savings

Table 226: CFLi; France: Estimates of energy savings after the implementation of policy option 1 – total number of CFLi held constant

2007		**BAU**		**Policy option 1 + baseline**	
Class	Energy use	Sales	Energy consumption (a)	Revised sales	Energy consumption (a)
Incand (b)	0.0540	23,750,000	1,282,500	1,016,234	54,877
CFLi	0.0137	23,000,000	313,950	45,733,766	624,266
Total		46,750,000	1,596,450	46,750,000	679,143

Energy savings (GWh)	**0.9173**
Savings on expenditure on energy (€)	**124,416**
Lifetime energy savings (GWh)	5,503.8
Lifetime revenue savings (€)	746,497,473

Note: (a) Wh;
(b) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

(ii) GHG emissions

Table 227: CFLi; France: GHG emissions of a subsidy for more energy efficient lamps (€1 for all CFLi) – total number of CFLi held constant

Parameter: tCO2/kWh	0.000074
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	**67.8808**
Lifetime GHG savings (tCO2)	407,284.51
Lifetime savings (€)	8,145,690
Revenue cost to Government / tCO2 (€)	112.29

(iii) Financial gains for manufacturers with extra sales

Table 228: CFLi; France: Financial gains – sales revenue – policy option 1

	BAU			**Policy option 1 + baseline**		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
Incand [(a)]	23,750,000	2.40	57,000,000	1,016,234	2.40	2,438,961
CFLi	23,000,000	4.25	97,750,000	45,733,766	4.25	194,368,506
Total	46,750,000		154,750,000	46,750,000		196,807,467
Financial gains for manufacturers						**42,057,467 €**

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

➢ Summary of policy 1

Table 229: CFLi; France: summary of policy option 1 (€1 for all CFLi)

Summary	Policy 1 + baseline
Revenue cost to government (€)	45,733,766
Net welfare cost to society (€)	-4,612,435
GHG reductions	
Revenue cost / tCO_2 (€)	112.29
Net welfare cost / tCO_2 (€)	-11.32

2.3.10.3 Policy option 2: Energy tax - additional increase in electricity price (10%)

Table 230: CFLi; France – additional increase in 10% of electricity prices

2007	BAU			Policy option 2 + baseline				
Class	Sales	Price	mkt share	Revised sales	Price	mkt share	Δsales	Δmkt share
Incand [(a)]	23,750,000	2.40	0.508	21,973,871	2.40	0.470	-1,776,129	-0.0380
CFLi	23,000,000	4.25	0.492	24,776,129	4.25	0.530	1,776,129	0.0380
Total	46,750,000	3.31	1.000	46,750,000	3.38	1.000		

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

➢ Costs of policy option 2

(i) Revenue costs

Table 231: CFLi; France: Tax revenue with policy option 2 – energy price increase (10%); total number of CFLi held constant

Tax revenue (lifetime)	**124,085,636 €**

(ii) Administrative costs

Table 232: CFLi; France: Administrative costs of policy option 2 – energy price increase (10%); total number of CFLi held constant

Parameter:	0.20% of total tax revenue
Administrative costs	**248,171 €**

(iii) Welfare costs

The welfare changes from the tax are made up of the following. First, we have the deadweight loss from the imposition of the tax, based on the consumption of energy. Second, we have a welfare cost arising from the fact that consumers are made to buy more expensive equipment than they would if there were no tax. This cost is simply the difference in price (adjusted for quality) between the appliance bought without a tax and the one bought with a tax. Third, we have a welfare gain arising from the fact that the policy generates tax revenue and therefore reduces the cost of raising a similar amount of tax from other sources. This gain is calculated using the marginal cost of public funds. Fourth, we have the welfare gain to producers from the sale of more profitable equipment. This is calculated as in the case of the subsidy (see Table 225). Finally, there are gains from the reduction in the generation of electricity, calculated at the average external cost per kWh for France (see section 2.3.10.2).

Table 233: CFLi; France: Welfare costs of policy option 2 – energy price increase (10%); total number of CFLi held constant

4	Dead-weight loss	(ΔQ x ΔP) / 2
5	Welfare cost of the tax (DWL) – energy (€)	6,065,420
6	Welfare cost of the tax (DWL) – equipments (€)	3,285,839
6a	Welfare gain from savings in costs of raising funds from other taxes (€) (0.26*[17])	32,262,265
7	Welfare gain (profit of producers = 6% of sales revenue) (€) (0.06*[14])	197,150
7a	Welfare gain from reduced emissions of non-GHG pollutants	1,092,202
8	Net welfare cost (€) [5+6-6a-7-7a]	-24,225,299
9	Marginal cost of policy (welfare cost/tax revenue) (€) [5+6]/[17]	13.27
9a	Welfare Cost per Ton of GHG ([8]/[15]) (€/tCO_2)	-761.32

- <u>Benefits of policy 2</u>

(i) Energy savings

Table 234: CFLi; France: Estimates of energy savings after the implementation of policy option 2 – holding the total number of CFLi constant

2007		**BAU**		**Policy option 2 + baseline**	
Class	Energy use	Sales	Energy consumption [(a)]	Revised sales	Energy consumption [(a)]
Incand [(b)]	0.0540	23,750,000	1,282,500	21,973,871	1,186,589

CFLi	0.0137	23,000,000	313,950	24,776,129	338,194
Total		46,750,000	1,596,450	46,750,000	1,524,783
Energy savings (kWh)					**0.0717**
Household expenditure change (€)					**-10,961**
Lifetime energy savings (kWh)					430.0
Lifetime expenditures with energy (€)					-65,763,758

Note: (a) Wh;

(b) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

(ii) GHG emissions

Table 235: CFLi; France: GHG emissions of policy option 2 – additional electricity price increase (10%) – total number of CFLi held constant

Parameter: tCO2/kWh	0.000074
Parameter: €/tCO2	€20
GHG savings / year (tCO2)	**5.30**
Lifetime GHG savings (tCO2)	31,820.06
Lifetime savings (€)	636,401.28
Revenue cost to Government / tCO2 (€)	3,899.60

(iii) Financial gain with extra sales

Table 236: CFLi; France: Financial gains – sales revenue – policy option 2: additional energy price increase (10%)

	BAU			**Policy option 2 + baseline**		
Class	Sales	Price	Revenue	Revised sales	Price	Revenue
Incand [(a)]	23,750,000	2.40	57,000,000	21,973,871	2.40	52,737,290
CFLi	23,000,000	4.25	97,750,000	24,776,129	4.25	105,298,549
Total	46,750,000		154,750,000	46,750,000		158,035,839
Financial gains for manufacturers						**3,285,839 €**

Note: (a) Harmonised lifetime: total number of incandescent lamps equals 6 times the harmonised values.

- Summary of policy 2

Table 237: CFLi; France: summary of policy option 2(10% electricity price increase)

Summary	Policy option 2 + baseline
Revenue raised in tax (€)	124,085,636
Revenue gains to producers (€)	3,285,839
Higher costs to consumers in capital exp. (€)	3,285,839
Higher costs to consumers in energy exp. (€)	65,763,758
GHG reductions	
Net welfare cost (€)	-24,225,299
Welfare cost/tCO2 (€)	-761.32

2.3.10.4 Comparison of policy options

Table 238: CFLi; France: Cost-benefit summary

			Policy option 1 + baseline	Policy option 2 + baseline
10	Costs	Net welfare costs	-4,612,435	-24,225,299
11		Administrative costs	2,286,688	248,171
12	Benefits	GHG	8,145,690	636,401
13	Benefit – costs		10,471,437	24,613,529
14	Revenue gain to producers (€)		42,057,467	3,285,839
15	Energy savings (GWh)		5,503.8	430.0
15a	Lifetime GHG Savings (t/CO_2)		407,284.5	31,820.1
16	Expenditure in energy by households (€)		746,497,473	-65,763,758
17	Revenue cost to government (€)		45,733,766	-124,085,636
18	Welfare cost/tCO_2		-11.32	-761.32

2.3.10.5 Conclusions

The major differences between France and Poland are: (a) the welfare gain of the subsidy option at €4.6million is still lower than the tax option €24million. The reductions in GHG are much greater for the subsidy option but the difference is smaller. The subsidy option reduces CO_2 by 400,000 tons (lifetime basis) while the tax option reduces €32,000. The gain/tCO_2 removed is higher than for Poland. The figures are €11 for subsidy and €761 for the tax option. The main reason for this is that in Poland a reduction in energy consumption generates a higher cost due to the use of coal for electricity generation. Finally note that while the subsidy option will cost the government €46 million while the tax option will generate €124 million revenue. However, the administration costs for the subsidy are much higher: €2.3 million against €250,000 for the tax option.

3.3.11. SENSITIVITY ANALYSIS

For all sensitivity analysis we present only the summary tables but the full set of tables for each sensitivity analysis is available on request.

2.3.11.1 Washing machines, Italy: Class C only removed from market instead of classes B and C

Excluding from the market only washing machines class 'C' significantly increases the relation benefits minus cost when compared to excluding classes 'B' and 'C' (see Table 148 and Table 239):

Table 239: Washing machines; Italy: Cost-benefit summary Comparing Class C only removed from the market with Classes B and C removed from Market)

		Removal B and C	Removal only C
		Policy option 2 + baseline	Policy option 2 + baseline
Costs	Net welfare costs	5,312,445	2,466,167
	Administrative costs	0	0
Benefits	GHG	260,333	46,791
Benefit – costs		-5,052,113	-2,419,376
Revenue gain to producers (€)		9,503,000	2,720,000
Energy savings (GWh)		25.9	4.7
Lifetime GHG savings (t/CO_2)			
Expenditure in energy by households (€)		6,750,225	1,213,256
Revenue cost to government (€)		0	0
Welfare cost/tCO_2			

2.3.11.2 Washing machines, Poland: Class C only removed from market

Excluding from the market only washing machines class 'C' significantly increases the relation benefits minus cost when compared to excluding classes 'B' and 'C' (see Table 164 and Table 240):

Table 240: Washing machines; Poland: Cost-benefit summary (Class C only removed from the market)

		Removal B and C	Removal only C
		Policy option 2 + baseline	Policy option 2 + baseline
Costs	Net welfare costs	2,586,574	2,408,589
	Administrative costs	0	0
Benefits	GHG	271,317	74,980
Benefit – costs		-2,315,257	-2,333,609
Revenue gain to producers (€)		6,235,000	2,700,000
Energy savings (GWh)		22.3	6.2
Lifetime GHG savings (t/CO_2)			
Expenditure in energy by households (€)		3,033,759	838,398
Revenue cost to government (€)		0	0
Welfare cost/tCO_2			

2.3.11.3 Washing machines; Italy: Mean Discount rates

We assumed that the personal discount rate of consumers is normally distributed with mean equal to 39% and standard deviation equal to 18.7% (Revelt and Train, 1998). The results were presented in Table 134 to Table 148. Here we performed a sensitivity analysis of the mean discount rates by assuming mean values equal to 20% and 45%.

- Comparison of policy option 1: tax credit to manufacturers

Table 241: Washing machines; Italy: Cost-benefit summary – policy option 1

		Policy option 1 + baseline		
		DR = 20% Std = 10%	DR = 39% Std = 18.7%	DR = 45% Std = 25%
Costs	Net welfare costs	8,220,609	19,147,481	17,238,332
	Administrative costs	0	0	0
Benefits	GHG	333,917	588,845	519,911
Benefit – costs		-7,886,692	-18,558,636	-16,718,421
Revenue gain to producers (€)		12,701,023	30,837,100	26,719,979
Energy savings (GWh)		33.2	58.5	51.7
Lifetime GHG savings (t/CO_2)				
Expenditure in energy by households (€)		8,658,196	15,268,285	13,480,880
Revenue cost to government (€)		36,520,231	84,886,243	76,071,249
Welfare cost/tCO_2				

- Comparison of policy option 2: removal of class B and lower from the market

Table 242: Washing machines; Italy: Cost-benefit summary – policy option 2

		Policy option 2 + baseline		
		DR = 20% Std = 10%	DR = 39% Std = 18.7%	DR = 45% Std = 25%
Costs	Net welfare costs	5,312,445	5,312,445	5,312,445
	Administrative costs	0	0	0
Benefits	GHG	260,333	260,333	260,333
Benefit – costs		-5,052,113	-5,052,113	-5,052,113
Revenue gain to producers (€)		9,503,000	9,503,000	9,503,000
Energy savings (GWh)		25.9	25.9	25.9

Lifetime GHG savings (t/CO_2)			
Expenditure in energy by households (€)	6,750,225	6,750,225	6,750,225
Revenue cost to government (€)	0	0	0
Welfare cost/tCO_2			

Note: Since the policy option involves the market share shift to class 'A', the discount rates did not affect consumers' choice so the results are identical.

2.3.11.4 Refrigerators; France: Marginal cost of public funds

Table 243: Refrigerators; France: Welfare costs of a subsidy for consumers (€50 for energy class 'A+'

Percentage of the revenue cost	15%	26%	30%
Welfare cost (marginal cost of public funds)	14,120,049	24,474,751	28,240,097

Table 244: Refrigerators; France: Cost-benefit summary

		Policy option 1 + baseline		
		15%	26%	30%
Costs	Net welfare costs	-3,961,670	6,393,033	10,158,379
	Administrative costs	4,706,683	4,706,683	4,706,683
Benefits	GHG	2,121,404	2,121,404	2,121,404
Benefit – costs		1,376,391	-8,978,311	-12,743,657
Revenue gain to producers (€)		180,511,623	180,511,623	180,511,623
Energy savings (GWh)		1,433.4	1,433.4	1,433.4
Lifetime GHG savings (t/CO_2)				
Expenditure in energy by households (€)		194,412,381	194,412,381	194,412,381
Revenue cost to government (€)		94,133,658	94,133,658	94,133,658
Welfare cost/tCO_2				

2.3.11.5 Conclusions on the sensitivity analysis

We investigated the sensitivity of our results to variations in some of the key assumptions used in our model. Namely, we investigated how our results varied when (i) different figures were assumed for the marginal cost of public funding (MCPF); (ii) the mean and standard deviation of consumers' discount rate was varied; (iii) only washing machines energy class 'C' were removed from the market; and (iv) different figures were assumed for the producers' surplus.

Our results proved sensitive to the value assumed for the parameter MCPF, which we assumed to be equal to 26% in Europe. The net welfare cost of a subsidy to more efficient refrigerators in France varied from – €4.0M (a benefit) when MCPF equalled 15% of the revenue cost of the subsidy to €10M when MCPF was assumed equal to 30%. The relative ranking of taxes versus subsidies did change as a result of this modification. Further investigation on the country-specific value of this parameter would contribute to obtaining more precise results with our model.

The choice of consumers' mean discount rate and standard deviation did not affect the results significantly. For example, when increasing the mean discount rate value from 39% to 45% (standard deviation from 18.7% to 25%) the benefit-cost relation did not change significantly when using as an example the tax credit to manufactures of washing machines in Italy (-€18.5M and -€16.7M, respectively). However, when much lower figures were assumed for mean discount rate (20%) and standard deviation (10%) the benefit-cost estimate reduced to -€7.9Mn. None of the modifications changed the ranking of policy options, i.e. the removal of washing machines classes 'C and B' is still more feasible than the tax credit to manufacturers.

The removal from the market of washing machines energy class 'C' instead of classes 'B and C' showed significant benefits in Italy, mainly, due to the lower welfare cost to consumers forced to purchase more expensive appliances when the least efficient models were removed from the market. In Italy, the removal of classes 'B and C' resulted in costs equal to €5M while the removal of class 'C' only resulted in costs equal to €2.4M. However, a different result was observed in Poland, where no change in the relationship benefit minus cost was observed (-€2.3M in both cases). In both countries the removal of washing machines class 'C' only is still more feasible than the tax credit scheme.

4. CONCLUSIONS

The analysis presented in this report indicates that incentives to promote the use of energy efficient appliances can be cost effective, but whether or not this is the case depends essentially on the particular product, the Member State, the market conditions, and the design of the incentive policy instrument. Of the cases considered in this study, tax credits on boilers appear to be a feasible option in both Denmark and Italy, while subsidies on CFLi bulbs in both France and Poland are cost effective in terms of €/ton of CO_2 abated (with the French case having a lower benefit than the Polish one).

There are two key incentive options that are relevant for promoting the use of energy efficient appliances: 1) subsidies, and 2) energy-tax policies. Comparing the subsidies to the energy-tax options, we find that the subsidies in most cases are less cost effective than the energy tax. Subsides are only preferable to taxes in the case of CFLi bulbs in Poland. Tax credits are more cost effective than energy taxes for boilers in both Italy and Poland. The tax option of course has the advantage of generating revenue that could be used for promoting energy efficiency while the subsidy option places a burden on the budget. In principle, this burden has been accounted for in this study by imposing a cost on the subsidy equal to the welfare cost of raising public funds. However, in situations of fiscal constraints additional pressures on the budget may need to be taken into account.

The method used to estimate the welfare gains and losses in this study is one based on a partial equilibrium approach, i.e. it looks at one market at a time and does not consider the impacts of changes in prices across markets. An economy-wide approach would certainly be more inclusive of other effects but would run into problems of estimation of many of the parameters, for which data are very limited. There are studies that look at multi-market impacts that consider energy taxes (see for example Bergin, 2002; and Kim, 2002)[138] but they do not operate at a detailed enough level to consider specific commodities such as energy efficient versions of durable goods. Our study is one of the first to compare energy taxation and subsidies for specific versions of consumer durables. We should also note that we did not have the resources to undertake such an economy-wide analysis, which would indeed be further original work. Nevertheless, we believe the relative results obtained here are valid and would not be overturned in a more sophisticated study, using CGE models. The same applies to the limitation of looking at environmental effects only from the use of the durable equipment and not from its manufacture.

To further strengthen the analysis presented here, a number of issues would need to be considered. First, there are distributional factors to take into account. Although evidence suggests that the long run income elasticity of demand is around unity, implying that a tax on energy is not regressive, there is concern that increasing energy prices hurt the very poor, who face fuel poverty (defined in the UK as spending more than 10 percent of household income on energy). Likewise the option of removing

[138] Bergin *et al.* (2002), "The Macro-economic Effects of Using Fiscal Instruments to Reduce Greenhouse Gas Emissions", available online at http://www.esri.ie/pdf/Sky_JFitz_Paper1.PDF
Kim (2002), "Environmental Taxes and Economic Welfare: The Welfare Cost of Gasoline Taxation in the U.S. 1959-1999," *Public Economics*, 0201003, EconWPA.

cheaper less efficient appliances would have a bigger impact on the budget of the poor than on that of the rich. These considerations need further investigation and possible policies to alleviate serious negative impacts accompanying any tax measures.

Second, the model does not fully allow for 'spill over' effects of the incentives. If a subsidy is provided for an appliance, there will be a tendency for more appliances to be sold, but also the savings in energy from the more efficient appliances could result in increased energy use elsewhere (the so-called 'rebound' effect). We have not accounted for these effects. Bringing this into the analysis would require further work on behavioural economics.

Third, our assumption of the welfare gains of producers (i.e. the producer surplus) is based on somewhat weak data and further studies would be of benefit to estimate this variable more accurately.

Fourth, It should also be noted that for the sake of comparability with tax policy options the value of energy savings over the life cycle of the product were not included in welfare cost calculations. These savings would offset the costs from the need to buy more expensive appliances to consumers and would thus make the option more favourable to consumers than the CBA analysis applied here implies.

Finally, we have to allow for more limited rationality than has been assumed here. Individuals do not make decisions with as much concern for the net costs of appliances as a minimisation of net present value assumes, although that does not mean that such a model cannot be a good representation of statistical regularity in the pattern of purchases. More practically, we would expect adjustment to the full rational choice to take place over time, rather than in one year alone. Introducing a lagged adjustment component to the model, and making it dynamic would be a worthwhile extension to the model presented so far. Another component that could be added is the value of information in improving decision-making among appliances with different energy and environmental attributes.

This first analysis presents some interesting insight to the issue. However, additional future work is required to understand the subject from different perspectives, especially regarding whether incentives will lead to higher consumption levels. One policy approach could be to complement the incentives for efficient products with a penalty on non-efficient ones, an approach currently under implementation and testing in France (*Bonus-Malus*), which is under trial for cars since 2007. The usefulness of incentives has been recently highlighted in the Action Plan for Sustainable Consumption and Production (SCP) and Sustainable Industrial Policy (SIP) of the European Commission. Nevertheless, it is important to keep in mind the perverse or negative effects of a future subsidy scheme (even if devised for a good environmental cause) as the EU is trying hard to eliminate environmentally harmful subsidies[139] as also recommended by the OECD in its international initiative in this direction.

[139] COM(2007) 140 final Green paper on market-based instruments

Table 245: Summary of results of the CBA for the 8 case-studies

Product	Member State	Baseline scenario	Policy option 1*				Policy option 2*			
			Details	Benefits-Costs (€)	Energy savings (GWh)	Benefits-Costs per GWh saved (€/GWh)	Details	Benefits-Costs (€)	Energy savings (GWh)	Benefits-Costs per GWh saved (€/GWh)
Refrigerator	**France**	Increase in electricity price (12%)	Subsidy for consumers (€50 class A+ only)	**-8,978,311**	**1,433**	**-6,265**	Energy tax: further increase in electricity price (10%)	**3,371,769**	**237**	**14,227**
	Denmark			**288,450**	**114**	**253**		**418,889**	**47**	**8,913**
Washing-machine	**Italy**	Increase in electricity price (12%)	Tax credit for manufacturers (€100 per appliance cl. A+; sold above historical levels - 3 years average)	**-18,558,636**	**59**	**-314,553**	B-class and lower removed from the market (market share of classes B and C shifted to class A)	**-5,052,113**	**26**	**-194,312**
	Poland			**-2,944,188**	**18**	**-163,566**		**-2,315,257**	**22**	**-105,239**
Boiler	**Denmark**	Increase in gas price (15%)	Tax credit for consumers (deducted from income tax; 25% of the appliance price for condensing boiler)	**4,565,857**	**310**	**14,729**	Energy tax: further increase in gas price (10%)	**1,231,331**	**102**	**12,072**
	Italy			**692,476,292**	**40,294**	**17,186**		**61,634,591**	**3,825**	**16,114**
CFLi	**Poland**	Increase in electricity price (12%)	Subsidy for consumers (€1 classes A and B)	**78,695,440**	**3,549**	**22,174**	Energy tax: further increase in electricity price (10%)	**22,110,662**	**226**	**97,835**
	France			**10,471,437**	**5,504**	**1,903**		**24,613,529**	**430**	**57,241**

(*) Policies 1 and 2 are applied on top of baseline scenario.

5. REFERENCES

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