DG TAXUD

Reduced VAT for Environmentally Friendly Products

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INFORMED DECISIONS

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Preface

In July 2007, the Commission presented a Communication on the effects of differentiated VAT rates to the Council and the European Parliament based upon a study from Copenhagen Economics.

The study focussed primarily on the effect of differentiated VAT on labour intensive services. Since then, the debate has spread to environmentally friendly goods. Some Member States have asked for the possibility to apply reduced rates to the supply of environmentally friendly goods, not the least to energy efficient consumer appliances.

Coherence suggests that the current application of reduced rates in areas that may have an adverse impact on the environment, notably by encouraging energy consumption, should be reviewed at the same time.

The focus of the current report is then on the potential use of reduced VAT on environmentally friendly goods and the current application of reduced VAT on energy consumption by households. Furthermore, we emphasize the importance of placing our findings in the context of EU's policy approach to climate change and energy security, including interaction with other policy instruments at the EU and national levels.

Executive Summary

This report focuses on the role that differentiated VAT rates can play relative to two central policy objectives that have gained significantly in importance in the most recent years.

The first policy objective is about reducing emissions of greenhouse gases (GHG) while at the same time reaching goals of energy security within the EU; both of which requires reductions in energy consumption. Should this policy objective be encouraged by way of reduced VAT rates on energy efficient consumer goods? For instance, Member States could encourage consumers to buy a freezer with low electricity consumption relative to other more electricity consuming freezers through a lower purchase price due to a lower VAT rate.

The second policy objective is about distributional concerns and the competitiveness of fragile industries. Rising global energy prices may adversely impact low income families and energy intensive industries as both spend a relatively large share of their budget on fuels and heating. Should this policy objective be encouraged by way of reduced VAT rates on energy consumption? For instance, Member States could shield low income families from the effect of higher energy prices by way of reduced VAT rates on the consumption of heating as it is in fact common in many EU countries.

Our main conclusions concerning the first policy objective are:

Generally, we believe that the best approach to reducing GHG emissions is to tax at root. Putting a proper price on the emissions of, for example CO_2 emissions and thereby also energy use, will give consumers and industries incentives to reduce them. The EU Emissions Trading Scheme (ETS) is a prime example of this; indeed emissions of CO_2 from nearly all electricity consumption and district heating by households are already covered by the ETS. So any new measures encouraging lower electricity use by households will lead to a lower price of ETS emission allowances but will leave the level of CO_2 emissions unchanged: the level of emissions is determined exclusively by the number of allowances allocated.

Consequently, the real question here is whether supplementary action such as providing subsidies to the most energy efficient variant of a specific product is able to reduce the cost of CO_2 abatement beyond what the EU ETS offers. Promotion of energy efficient product variants should be about lowering the costs of meeting climate and energy policy targets by pushing consumers in the direction of "low hanging fruits". By this is meant savings that have lower abatement cost than the price of ETS allowances, or outside the ETS sector, the level of appropriate national tax rates. If the answer is "yes", then the EU can promote supplementary action and in turn set higher ambitions in terms of future reductions of GHG and energy savings.

Clearly, it is essential that consumers are provided with accurate information about how much energy different variants of the same product, for example freezers, consume. This allows them to save money *and* energy by choosing the most energy efficient product. The EU Commission launched a major programme in July 2008 to encourage more widespread and improved energy labelling of products, thus allowing consumers to choose the products with the lowest overall costs during the lifetime of the product. Consumers are, in many countries, also encouraged to carry out so-called "energy audits" to identify how to save energy cost-effectively.

However, even with improved labelling in place, consumers may in practice be reluctant to switch to more energy efficient products even if such products save them money. The price of energy using products may be so low – for example light bulbs – that consumers are not really focused on the energy costs associated with the *use* of the product when buying it. This situation may call for either minimum efficiency standards to remove the "worst" performing (inefficient) products from the market and potentially a subsidy such as a reduced VAT rate to promote the "best" performers (efficient). Furthermore, some products may actually be so expensive that cash-constrained households choose the less expensive but more energy consuming variant. In both cases, the idea is to reduce the upfront purchase price rather than letting price incentives work through lower user costs during the life time of the product.

We provide three main conclusions on the effectiveness and efficiency of using reduced VAT rates to encourage consumers to save energy.

First, it is not clear if energy savings will unambiguously follow from such purchase rewards. Products, such as household electrical appliances, consumer electronics and boilers for domestic heating constitute only about 3 per cent of total consumption, but account at the same time for nearly 60 per cent of all energy consumption from households. So yes, energy efficient refrigerators will gain market shares from non-efficient, but at the same time more and larger freezers may be bought as these products falls significantly in price. This will shift overall consumption towards products that are very energy intensive in use.[1] For example, spending €100 on the purchase of even a very energy efficient air conditioner will lead to more energy use than spending €100 on furniture. In fact, our modelling results suggest that net effects on energy consumption are highly depending on both how the VAT subsidy is calibrated in terms of product coverage, energy efficiency requirements, as well country specific circumstances. The results should be read with caution: they are depending on a number of price reactions to changes in relative prices, and there limited consensus on their size. This suggests that any subsidy scheme would need to be well designed simply to achieve a decrease in energy consumption and that such schemes need to reflect national circumstances.

Second, a lower VAT rate is a crude subsidy and may also lead to compliance problems in the real world. These problems could most likely be reduced or eliminated by using alternative measures that provide more targeted incentives as regards consumers' purchase deci-

[1] By "energy intensive" we mean a high amount of energy associated with the production and use of the good or service over its lifetime relative to the price of the product.

sions. For instance, rather than offering a VAT rate cut to all boilers/freezers that are classified as being energy efficient, consumers could be offered a fixed amount in monetary terms. Price premiums for energy efficient products not only reflect more energy efficiency, but often also more luxurious standards in other product characteristic which hardly deserve a subsidy.

Third, a lot of the products considered for being covered by lower VAT rates, such as freezers, have "cross-border trade potential" because they are relatively expensive. Consumers may purchase the product in other countries in order to exploit lower price. Since the differences in price would be due to the VAT rates rather than ability to sell products more cost effectively, this would advocate against a system of voluntary lower VAT rates, if "cross-border" groups are included. The effect could be overcome if member states use a subsidy scheme requiring the consumer to be a resident. This will be an important point if reductions of VAT rates are optional rather than mandatory.

All in all, we are sceptical about the merits of reduced VAT rates on energy efficient products. First, there are simply too many conflicting constraints in designing a package that should both help individual member states reach their climate and energy objectives while at the same time be consistent with internal market objectives. Second, fixed amount subsidies can be targeted better while avoiding internal market problems. Thirdly, as stated above, national residence based subsidy schemes can overcome the internal market problem.

Our main conclusions on the second policy objective of *distributional concerns* are:

First, the most cost-effective and focused way of addressing any adverse distributional impacts caused by higher energy and food prices – whether from global forces or as a result of climate policies – is by way of social policies providing targeted subsidies to low income families.

Second, by increasing the incentive to buy fuels through the current use of a reduced VAT rate on heating and electricity in several countries, policy makers are forced to provide stronger incentives elsewhere in the economy to meet CO_2 and energy savings targets. This may equally harm low income families. For example, a reduced VAT rate on district heating in one country will lead to an expansion of demand for energy within the EU ETS, leading to higher energy prices for other consumers. Other consumers include low income families in other countries, as well as energy intensive industries exposed to external competition.

Third, reduced VAT rates on energy consumption leads to transfers to oil producing countries. With the EU being still a main, though declining, player in the global energy markets, reduced VAT rates on energy consumption have lead to slightly higher energy prices from slightly higher EU energy demand, raising the EU's import bill for oil and gas. This may harm low income families. Furthermore, it is a bad signal to send to the global community which currently is moving in the direction of unwinding substantial subsidies to energy consumption (Asia, Middle East and Latin America) or wavering in the resolve to maintain current energy taxes (USA).

Chapter 1 SUMMARY OF FINDINGS

The EU has declared the objectives of combating global climate change and improving energy security as prime objectives for energy policies. For this purpose, the EU has committed itself to reduce GHG emissions by 20 per cent between 1990 and 2020; even 30 per cent if a strong global agreement can be reached at the climate summit in Copenhagen in 2009. More or less at the same time, more attention has been devoted to the geopolitical risks associated with imports of oil and gas from potentially unstable regions. This has been a key argument to set a target for reducing energy use by 20 per cent over the same period as well as expanding the share of renewable energy to 20 per cent.

The implications of these objectives are clear. The EU needs to promote energy savings both to reduce GHG emissions and to reduce import dependency. But at the same time, expand renewable energy, partly because relying too much on energy savings may imply too high energy prices. This is the so-called affordability argument.

For this reason, the EU has put in place a comprehensive international cap-and-trade system to reduce greenhouse gases in a cost-effective way, namely the Emission Trading Scheme (ETS). It covers nearly all electricity and district heating produced as well as some industrial CO_2 emissions and non-CO_2 greenhouse gases. At the same time, Member States are to an increasing extent using their tax system to complement the ETS in the sectors outside the ETS, such as individual heating and road transportation. In addition, a number of other, more regulatory policy measures are being introduced at the EU and national level.

The core of this study is what role – if any – should VAT rate policy play in underpinning these objectives. We look at two specific options.

First, a number of countries have currently reduced VAT rates on energy consumption of households. This raises a potential trade-off problem between two competing policy objectives:

On the one hand, this may mitigate the effect of higher global energy prices which tend to fall harder on low income families' budgets. Indeed, some countries have specifically used this argument to argue for extension of low rates also to fuel taxes for cars and not only to lower rates on heating and electricity.

On the other hand, it is in the interest of the EU and other net importers of fossil fuels that taxes do more of the work to keep global energy prices from rising too much. Not only is energy taxation a cost-effective solution to abate CO_2 emissions, but it also produces terms-of-trade gains. With lower oil, gas and coal prices less consumer wealth is being transferred to the Middle East, Russia etc.

We, therefore, examine as *our number one VAT rate policy option* a scenario where all present VAT reductions on the use of heating and electricity are removed and replaced by the standard rate. What are the effects on energy consumption and income distribution; how can adverse effects on the latter be mitigated?

Second, some countries have proposed that the purchase of the efficient variants of energy using goods should be allowed reduced VAT rates. This is not currently allowed by the VAT directive. The purpose is to encourage energy savings in line with the key objectives of the EU's climate and energy policies.

We, therefore, examine as *our number two VAT rate policy option* scenarios with either voluntary or mandatory reductions of VAT rates on energy using products. We estimate net effects on energy consumption and review the proposals also on the basis of cost-effectiveness and internal market concerns.

1.1. REMOVING REDUCED VAT RATES ON ENERGY CONSUMPTION

The study has first looked at a scenario where all present reductions of VAT on energy consumption are removed. At present, seven countries have reduced rates on both electricity and heating in households, six countries only have reduced VAT rates on heating and one country only has reduced the VAT rate on electricity. Replacing the reduced rates with standard rates – which can be lowered marginally due to higher revenues – leads to effective increases in VAT rates on heating and electricity of 3 to 4 percentage points in EU cf. Table 1.1. It will at the same time bring in new revenues.

Table 1.1 Electricity and heating: VAT rates and energy consumption, 2008

Country group	Standard rate, per cent	Present average reduction in VAT, percentage points		Effect on	
		Heating	Electricity	Energy consumption, per cent	Revenue gain, per cent of GDP
A: lower rate on heating	19.4	2.5	-	-0.8	0.01
B: lower rate on electricity	18.0	-	13.0	-	-
C: lower rate on electricity and heating	18.6	9.8	11.0	-1.4	0.08
D: no reductions	20.4	-	-	0.0	0
EU average	19.5	3.8	3.3	-0.8	0.03

Note: Country group A encompasses Austria, Belgium, Estonia, France, Germany and Hungary. Group B contains Malta. Group C encompasses Greece, Ireland, Italy, Latvia, Luxembourg, Portugal, and United Kingdom. Group D contains the remaining EU27. No effects are estimated for Malta due to lack of data. The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.

Source: Copenhagen Economics.

Without taking into account the workings of the ETS covering electricity and district heating, energy consumption should fall by nearly 1 per cent in total; somewhat more for the countries presently with reduced rates. Revenue gains as share of GDP will range from 0 in the countries with no present reductions up to nearly 0.2 per cent of GDP in the countries which presently have substantial reductions of VAT rates on both heating and electricity.

The removal of reduced VAT rates for heating and electricity will have some adverse impact on the income distribution. The households in the bottom 20 per cent of the income scale spend nearly 5 per cent of their disposable income on electricity and heating expenditures versus 3 per cent for households in the top 20 end. Put differently, first quintile families allocate over 50 per cent more of their total spending to these goods than do fifth quintile families (relative spending shares over 150 per cent). This stands in sharp contrast to spending on transport fuels, largely for cars, where high income families allocate a relatively larger share cf. Table 1.2. So, reduced VAT rates on heating/electricity have quite different distributional effects as compared to reduced VAT rates on gasoline and diesel.

Table 1.2 Spending on energy as per cent of total spending for five income quintiles in EU27, 2005.

Sector	Quintile1 (lowest income)	Quintile2	Quintile3	Quintile4	Quintile5 (highest income)	Relative spending shares first to fifth quintile, per cent
District heating	0.6	0.6	0.6	0.5	0.4	150
Electricity	2.1	2.2	2.0	1.8	1.4	157
Gas	1.1	1.1	1.0	0.9	0.6	167
Heating oil	0.7	0.7	0.6	0.5	0.4	173
Solid fuel	0.4	0.4	0.4	0.3	0.2	161
Transport fuel	2.1	2.9	3.3	3.6	3.3	65
Total energy, excl. transport fuel	4.8	4.9	4.5	4.0	3.0	161.6

Note: Per cent of total household consumption expenditure. COICOP structure of household expenditure, 2005. Czech Republic excluded due to lack of data. Quintile 1 is the lowest income; Quintile 5 is the highest income. Countries are weighted by size of final household consumption expenditure.

Source: Eurostat (2008) and Copenhagen Economics.

If revenues are recycled by way of a reduced standard VAT rate, the net increase in costs of consumption for the bottom 20 per cent will be 0.04 per cent. At the same time, the richest 20 per cent will face a reduction in cost of the same order cf. Table 1.3. For median income groups, net effects on disposable income will be insignificant.

Table 1.3 Net impact on consumer prices across households: abolition of reduced rates of VAT on heating/electricity financed by lower standard rate

Country group	Income quintile				
	Quintile1 (lowest income)	Quintile2	Quintile3	Quintile4	Quintile5 (highest income)
A	0.02	0.02	0.00	-0.01	-0.03
B	-	-	-	-	-
C	0.05	0.06	0.03	-0.01	-0.12
D	0	0.00	0.00	0.00	0.00
EU 27 average, (unweighted)	0.02	0.03	0.01	-0.01	-0.05

Note: For each country group we calculate the difference in the percentage change in COICOP consumption expenditure between the poorest and richest income quintile households. Czech Republic is excluded due to lack of data. Country group A encompasses Austria, Belgium, Estonia, France, Germany and Hungary. Group B contains Malta. Group C encompasses Greece, Ireland, Italy, Latvia, Luxembourg, Portugal, and United Kingdom. Group D contains the remaining EU27. The values are to be interpreted as the percentage change in consumption expenditure under a given scenario relative to the baseline. A positive value indicates an increase in consumption expenditures relative to baseline. No effects are estimated for Malta due to lack of data.

Source: Copenhagen Economics

As the reduced rates are in most cases motivated by income distribution concerns, the logic would be to recycle an appropriate part to the same groups. The most general and least distorting mechanism would be through social policy instruments (higher unemployment benefits, public pensions) and tax policy instruments (thresholds for paying social security contributions, income taxes etc). More targeted but potentially also more distorting are higher direct subsidies linked to the size of energy bills for low income families. It will in practice be difficult to construct such schemes that do not at the margin provide a net subsidy to energy consumption.

The recommendation for the EU is thus to move in the direction of abolishing the reduced rates on heating and electricity while leaving it to Member States to find the proper mechanisms in the social and general tax arsenal to compensate for adverse effects on the income distribution.

1.2. Reduced VAT rates for energy efficient products

The basic idea of reduced VAT rates for energy efficient products is pretty simple. The consumer is faced with two versions of the same product, e.g. one version of a freezer consuming a lot of energy and a second version of a freezer consuming less energy. If we could get more consumers to buy energy efficient variants, then the EU could reduce energy use. The idea is then to reduce prices on products with certified higher standards of energy efficiency by charging lower VAT rates. It is expected that this will lead to market shares being shifted in favour of the less energy consuming variant.

We evaluate this idea focusing on three questions:

- Will lower VAT rates reduce energy consumption?
- Will lower VAT rates be a cost-effective mechanism in practice?
- Will lower VAT rates be compatible with internal market objectives?

We answer these questions in the next three subchapters, respectively.

1.3. Question 1: Will lower VAT rates reduce energy consumption?

The basic idea of lowered VAT rates contains a carrot but no stick; this gives uncertain a priori effects on energy consumption. We do move market shares in the direction of energy efficient variants but we also reduce the price of products with high energy intensity, pushing other private consumption in that direction. Indeed the group of products to potentially benefit from reduced rates on energy efficient variants – household appliances, consumer electronics and domestic boilers – account only for 2.9 per cent of total private consumption[2] but 56 per cent of the total direct and indirect energy use of households.

So which effect is the dominant one?

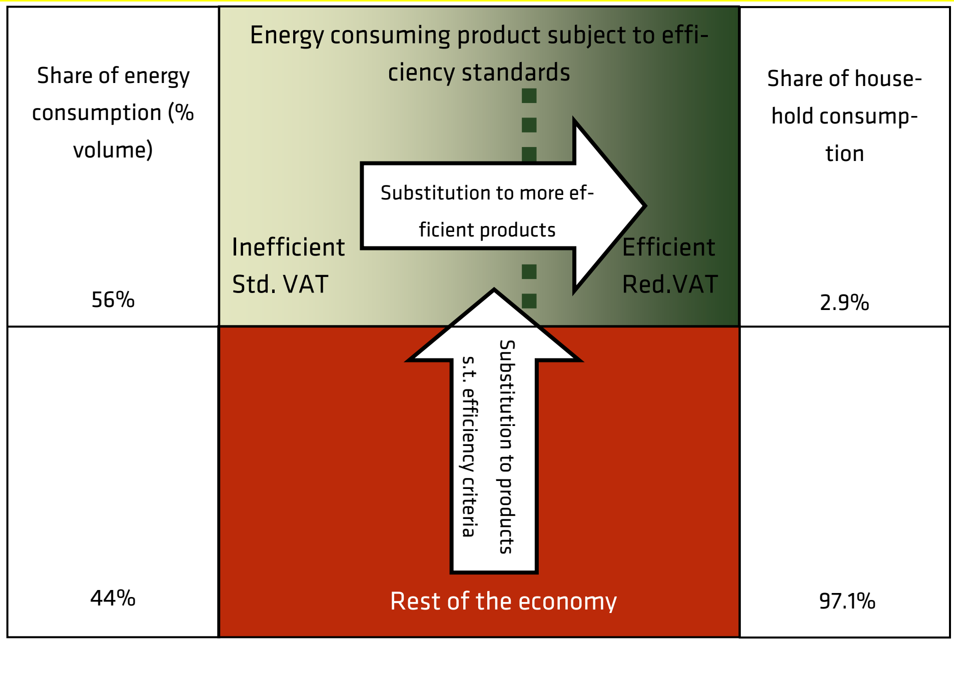
- Gains of market shares of efficient relative to inefficient freezers, etc. (the arrow pointing right in Figure 1.1)
- ...or the increase in the purchase of freezers relative to other and less energy consuming household expenditure (arrow pointing upwards in Figure 1.1), the so-called "rebound" effect?

The rebound effect can take many forms such as switching into larger freezers or buying a new one and installing the inefficient in the summer house or the basement.[3]

[2] The data on household consumption expenditures on energy using products (household appliances, consumer electronics and boilers) is sourced from the GTAP6 database. Household appliances, consumer electronics and boilers are durable goods. Consumption expenditures on durable goods in the GTAP6 are calculated using the national accounts methodology. Household consumption of durable goods is derived from the value of the sales of durable goods. Costs of installation, energy consumption or repair costs are not included. The cost of energy consumed by household appliances, consumer electronics and boilers is available separately.

[3] BIO (2009), p. 15, suggests that "increased presence of double or triple appliances in the same households, mainly TVs and refrigerators/freezers" is one of several factors explaining increased electricity consumption" in the EU. It suggests that consumer "saturation" with white goods does not stop when all households have one of each type of appliance.

Figure 1.1 Illustration of the rebound effect



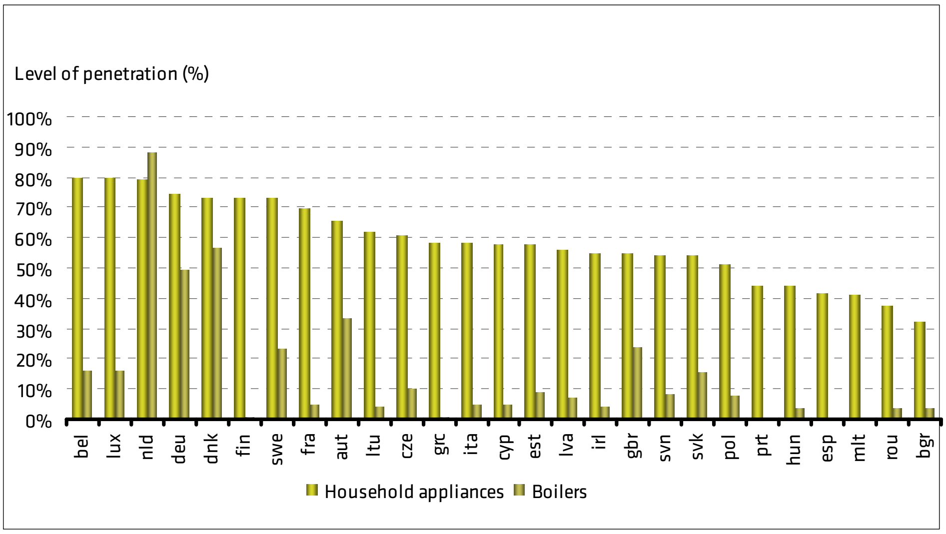
Source: Copenhagen Economics, Bertoldi and Atanasiu (2007a), Eurostat. GTAP6.

A priori, at least three specific products and country characteristics should determine the relative size of these effects:

- How much more efficient is the energy efficient as opposed to the in-efficient product variant?
- How large is the potential to expand the market share of the energy efficient variant? (If a country already is selling only energy efficient variants then not much can be gained.)
- Generally how strongly do consumers react to changes in relative prices: (1) lower price of energy efficient variant to non-efficient variant and (2) lower price of energy consuming products relative to other products?

The variation in penetration of energy efficient appliances across countries is also large. For high income countries such as Belgium, Denmark, the Netherlands and Sweden, the share of energy efficient appliances as a whole is above 70 per cent. By contrast, it is below 50 per cent in Hungary and Malta and as low as 30 per cent in Bulgaria. For domestic boilers almost the same pattern appears, though with lower overall penetration ratios cf. Figure 1.2.

Figure 1.2 Penetration of energy efficient appliances across countries



Source: Copenhagen Economics, Bertoldi and Atanasiu (2007a), Kemna et al. (2007).

Energy savings from reduced VAT rates on household appliances are, therefore, likely to be minor in the high income countries, for two reasons. First, there is little scope for further expansion. Second, the overall reduction of prices of efficient variants of energy using products relative to other products will be large, as the benefited group accounts for the bulk of products. This suggests that the rebound effect could be potentially large.

To illustrate these effects with some ballpark estimates of net savings, we have set up an economic model (explained in chapter 3). We then review a simple experiment:

- All product variants belonging to the top classes A (A, A+, A++) are taxed at a reduced VAT rate of 5 per cent in all EU countries (other experiments are presented in chapter 3).
- We finance the VAT loss by raising the standard VAT rate

Table 1.4 A VAT scenario with reduced VAT rate on energy efficient products

Product group	Share of consumption today, per cent	VAT rate, in per cent	
		Today (average)	Decrease with mandatory reduction 5 % VAT
Household appliances	1.1	19.6	14.6
Consumer electronics	1.1	19.6	14.6
Boilers	0.7	19.6	14.6

Source: EC (2008), GTAP and Copenhagen Economics.

The results suggest that electricity consumption will go up while demand for fuels for heating will go down. This is hardly surprising: as shown in Figure 1.2 the share of energy efficient variants of household appliances are already large in a large number of countries. This implies that the rebound effect will be very large: a large reduction in the overall price of efficient variants of household appliances and consumer electronics shifts a significant amount of overall private consumption towards highly energy intensive products. By contrast, penetration of energy efficient boilers is much smaller. Chapter 3 provides more details on country groups. Overall, some reduction of energy consumption may result from the experiment.

Table 1.5 Change in energy consumption in per cent, EU27 average

	Mandatory reduction 5%
Fossil fuels for heating (non-district)	-1.91
Electricity	0.48
Total effect **Change in total energy consumption in EU**	**-1.34**

Note: The results presented in this table relate to a scenario where VAT rates for energy efficient variants of household appliances, consumer electronics and boilers are reduced mandatorily in the EU to 5 per cent. The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.

Source: Copenhagen Economics (2008).

Box 1.1 Rebound effects

The rebound effect in these calculations tends to be larger than in standard literature on rebounding. This reflects first of all a fundamental difference in the experiment that we are looking at. The traditional literature on rebounding considers the rebound effect of lower cost of energy due to technological progress. This study considers a change in the VAT rate on a specific group of energy consuming goods.

In the traditional literature on rebound effects, the energy efficiency of energy consuming good is changed, reducing energy consumption, but also reducing the costs of using these goods. In traditional rebound literature, the size of the rebound effect is linked to the improvement in energy efficiency that reduced the running cost of using the product. The size of rebound effects in the literature is contested with a recent survey suggesting that they tend to be underestimated in policy evaluation.

In this study, energy efficiency is improved by shifting consumers' choice in the direction of more energy efficient variants of energy goods without changing the underlying energy efficiency of the variants. For this purpose a VAT change is introduced that directly affects the purchase price of the product leaving running costs unchanged.

We underline that rebound effects in our experiment can be substantially higher than in the classical example. This happen in particular when:

- the market share of highly energy efficient variants is already large
- the energy efficiency differential between efficient and non-efficient product variants is small

In this case, we need a large decrease in the purchase price to obtain a given overall increase in the overall efficiency of purchased boilers, freezers, etc, while at the same time risking a substantial increase in the overall purchase of such products.

Note: See also Chapter 2.

Source: Copenhagen Economics.

We have reviewed the sensitivity of the results with respect to three set of alternatives. First, we look at results if only the class A+ would benefit from reduced VAT rates for electrical appliances and not, as in the present version, all class A and better. This will lead to marginally better results in terms of energy savings in countries such as Netherlands, while rendering effects near zero in countries where the penetration rates of A+ is miniscule cf. Table 1.6. Second, we look at the result of having either larger or smaller shifts from less energy efficient towards more energy efficient products as a response to reduced VAT rates for the energy efficient variant.

If we restrict the use of reduced rates to energy using products rated A+ and A++ rather than all A rated products, then households electricity consumption in the Netherland is unchanged rather than going up by ½ per cent cf. Table 1.6. Similar results hold for Spain. If we assume that consumers are reacting more aggressively in their shift towards energy efficient variants – price elasticity of 4 rather than the benchmark rate of 3 – then household energy consumption falls by nearly 2 per cent rather than near 1 ½ per cent.

Table 1.6 Sensitivity analysis of scenario 2 assumptions

Analysis	**Effect in percent**
Classes of household appliances, consumer electronics and boilers eligible for reduced VAT	Effect on household electricity consumption in Netherlands
A, A+ and A++	*0.6*
A+ and A++	0.1
Classes of household appliances, consumer electronics and boilers eligible for reduced VAT	Effect on household electricity consumption in Spain
A, A+ and A++	*0.4*
A+ and A++	0.0
Substitution elasticity between energy efficient and conventional variants of household appliances, consumer electronics and boilers	Effect on household energy consumption in EU
Elasticity = 2	-0.95
Elasticity = 3	*-1.34*
Elasticity = 4	-1.93

Note: Italicised text refers to main scenarios. The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.
Source: Copenhagen Economics.

A final sensitivity analysis concerns the degree of substitution between energy and non-energy goods. If the substitution elasticity between energy and non-energy goods is set to for example 0.3 rather than the used 0.8, the rebound effect in scenario 2 can be reduced significantly, cf. Chapter 3. However, assuming a lower rate of substitution between energy using goods and non-energy goods implies that scenario 1 will be less effective in reducing energy consumption, because higher prices on energy have less effect in the way of inducing a substitution away from energy goods.

It is important to bear in mind, the restrictive assumptions involved in these results. The EU has introduced and will introduce further measures such as improved labelling and higher minimum standards for energy efficient products, to push consumers in the direction of energy efficient product variants. There is strong evidence that both higher energy prices and improved labelling significantly affects the energy efficiency of the energy using products on sale and the products being bought.[4] At the same time member states are considering complimentary action including – for some countries – higher energy taxes on energy consumption, particularly outside the ETS covered industries, such as individual heating. We have

[4] Newell et al. (1998) in a study of energy products on sale in the US over the period from 1955 to 1995.

not built in the effects of these policies: by definition this implies that the energy savings that can be reached by reduced VAT rates on energy efficient product variants are overestimated by orders of magnitude.

1.4. Question 2: Will lower VAT rates be cost effective in practice?

Irrespective of whether energy savings can be reached or not, the real issue is whether reduced VAT rates on energy efficient products is the most effective instrument. We look at this from three main angles:

- Comparing with root taxation: can supplementary measures, including subsidies to energy efficient products, reduce abatement costs for consumers?
- Are reduced VAT rates the most effective subsidy instrument in practice?
- Public finance implications: revenue losses and distortions.

Comparing with root taxation

Taxing an environmental problem at root is generally considered the most effective approach. If too much CO_2 is emitted or energy consumed, tax CO_2 or energy with the same amount irrespective of how and where it is used. This provides equal incentives to save CO_2 or energy across the economy, pushing savings in the direction where they are the cheapest to reap.

More indirect measures are less likely to ensure equal abatement costs across sectors and also tend to be cruder. It is, for example, difficult to ensure that the marginal cost of reducing energy use of freezers by way of reduced VAT rate on the energy efficient variant equals the marginal cost of reducing energy use from light bulbs by disallowing the least efficient variants.

Indirect measures also tend to be crude in terms of ”targeting”. As discussed in chapter 4, countries are increasingly punishing gas guzzlers and rewarding cars which run many miles on a litre of gasoline by way of energy efficiency criteria being built into purchase and circulation taxes. Such schemes will laudably push consumers in the direction of less consuming cars, but (1) they do not affect the drivers actual use of the car and (2) they are built upon relatively arbitrary measurement of fuels' efficiency that do not take into account tyres used, whether the car is driving in the city or in rural area etc.

Taxing at root is precisely what the ETS does.[5] In 2005, the EU introduced the ETS that set a total cap on CO_2 emissions from the power sector, thus covering basically all electricity use and district heating. More stringent caps have ensured, and will in the coming years ensure, reductions in emission along with higher prices for allowances. The allowance price is currently just over €20 per ton for the 2008-2012 allocation period, and is expected by the EU Commission to rise to €39 per ton in the 20 per cent reduction scenario post 2012. It will also encourage energy savings by adding to electricity prices in the EU post 2012.

Essentially all[6] electricity consumption by the household is covered by the ETS.

What is outside the ETS in the context of this discussion is mainly heating of the households delivered by boilers installed in individual households and housing blocks. Presently, most member states impose tax rates on natural gas and mineral oils for heating purposes that are well below present price of ETS allowances and even further below the expected future price (measured as price per ton of CO_2 emitted). As district heating – in particularly in the form of co-generation with electricity – is one of the most energy efficient ways of delivering heating to households, this distortion in favour of domestic boilers clearly weakens incentives to overall energy efficiency. Further fiscal promotion of domestic boilers by way of reduced VAT rates, even if only on the most efficient ones, may further distort incentives in the heating market, discouraging the most energy efficient production.

While ETS and national taxes, for example on heating oil and gas for boilers, are thus recommended as primary instrument to reduce CO_2 emissions and energy consumption, we review six arguments for additional policy action. Common for the six arguments is that consumers for a number of reasons fail to capitalise on potential energy savings from buying energy efficient appliances that over the full life cycle of the product would actually save them money. The question to be addressed is what role subsidies to energy efficient products could play in this regard.

First, consumers may fail to buy a product because there is inadequate information about size of savings. Such information failures call first of all for improved labelling and dissemination campaigns. Improved labelling – providing each product with information about energy use in "normal" circumstances – is precisely what the EU Commission has proposed to do, most recently in July 2008.[7]

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[5] The differences between the ETS and a uniform and harmonised EU tax system covering the same industries become smaller and more technical with the new proposal from the EU Commission from January 2008. In the ETS, the level of CO_2 allowances and the allowances' price will be determined, by supply and demand factors to ensure compliance with that target. If the EU were to meet the same reduction target by way of a tax it would need to redefine the tax rate continuously to ensure target compliance. However, with the proposed full auctioning with possible exemptions for energy intensive industries in international competition, the system resembles in many aspects energy tax systems in countries such as Germany, Sweden and Denmark that operates with reduced energy tax rates for the same kind of industries.

[6] Small combustion installations are outside the ETS.

[7] EU Commission (2008b)

Second, energy savings may constitute only a fraction of the total cost of buying/using the product. That is for example the case for computers in households: they typically have a life-span of 3-5 years and consumers are not likely to make the choice between a MAC, Dell or Lenovo computer depending on their energy use. So companies' efforts to expand market shares by reducing for example standby power use may prove an investment with only limited financial return. This provides a potential case for "outlawing" computers which, for instance, do not switch off energy use when not used. By contrast, reducing the VAT rate on a product costing €1,000 to save the consumer annual energy costs of perhaps €10 makes little sense.

Third, sometimes the purchaser of the service/good is not paying the user cost. The classical example is construction of buildings, where the future tenants' focus on running costs may have low priority in the developers overall aim to keep construction costs within a promised budget.

We find that this so-called "principal agent problem" has some, but difficult to measure, relevance for the discussion of VAT rates in relation to energy efficient boilers. As allowed by VAT directives, member states can refrain from charging VAT on rented accommodation. This implies that landlords – professional or private – will benefit from a lower VAT rate on energy efficient inputs as incoming VAT on purchases cannot be deducted from an outgoing invoice where VAT is exempt. However, we are less convinced that we have a classical principal-agent problem here with opposing interests. The buyer of the boiler and the landlord is one and the same person in contrast to the situation described above. At the same time, the (prospective) tenant may shop around for the best renting offer. If the landlord can bring down energy costs by buying a more efficient boiler, he/she should be able to attract tenants at conditions that are more attractive to both parties than if just staying with the inefficient boiler. We discuss some empirical evidence from the Netherlands in chapter 2 on this issue that we do not find entirely conclusive in terms of the significance of the principal-agent problem.

Fourth, the consumer may find that it takes too much time, relative to the energy costs savings, to pick out the most energy efficient variant. Buying light bulbs in a supermarket may be a good example. If consumers buy light bulbs in small quantities, rather than an entire year's consumption, then they may refrain from seeking out the most efficient bulb down in the supermarket even if a slightly higher purchase price would be compensated by energy savings over the coming months/year. A subsidy reducing the price of energy efficient product may have a stronger effect on purchase behaviour than an attached label qualifying the product as energy efficient.

Fifth, the up-front purchase costs of buying the energy efficient variant may prove a hurdle for cash-constrained households, even though households may recognise that there are long term savings. This may potentially be the case for some white goods as well as boilers: the price tag for energy efficient variants is in the range of €1,000-2,000 which is a sizable share of a low income families yearly, let alone monthly, budget. The argument essentially hinges on poor and expensive borrowing conditions for such households with borrowing rates well above standard market rates.

Sixth, consumers may be aware of the potential of net cost savings but fail to react on it because they tend to disregard future benefits relative to present up front costs. This argument is known as the myopia argument. Technically, this can be presented as future benefits being discounted at very high rates, well above market rates. While a lot of the literature focus on the myopia argument, the empirical evidence in support of it is not very strong.

Some care should be taken to make a distinction between buying the product with the lowest net costs when operating under certain conditions and the question of cost-effectiveness in a more general context. The simple fact that households are not buying the most energy efficient variant despite ample information available and no financial constraints is no proof of myopia:

- He/she may use the product only rarely in which case it may in fact be cost effective to buy the cheapest version freezer, light bulb, boiler etc. for example for the summer cottage.
- He/she may prefer the lighting quality going with a traditional light bulb rather than the efficient alternative.
- He/she may postpone replacing the boiler even if it representing costs savings because it is not convenient right now.

Arguments three, four, five and six provides possible justifications for providing subsidies that affects the purchase price rather than the running costs of energy using products to encourage higher efficiency.

However, the costs savings that consumers can reach by moving towards efficient variants of energy using goods differ considerable. Using UK data, we find that efficient refrigerators save you 40 kWh per year but cost €91 more than the non-efficient variant cf. Table 1.7. By contrast, there seems to be a very little price premium for efficient washing machines, while relative energy savings are even higher. For boilers the gains are very large.

Table 1.7 Average energy savings and price differences for white goods in UK, 2007

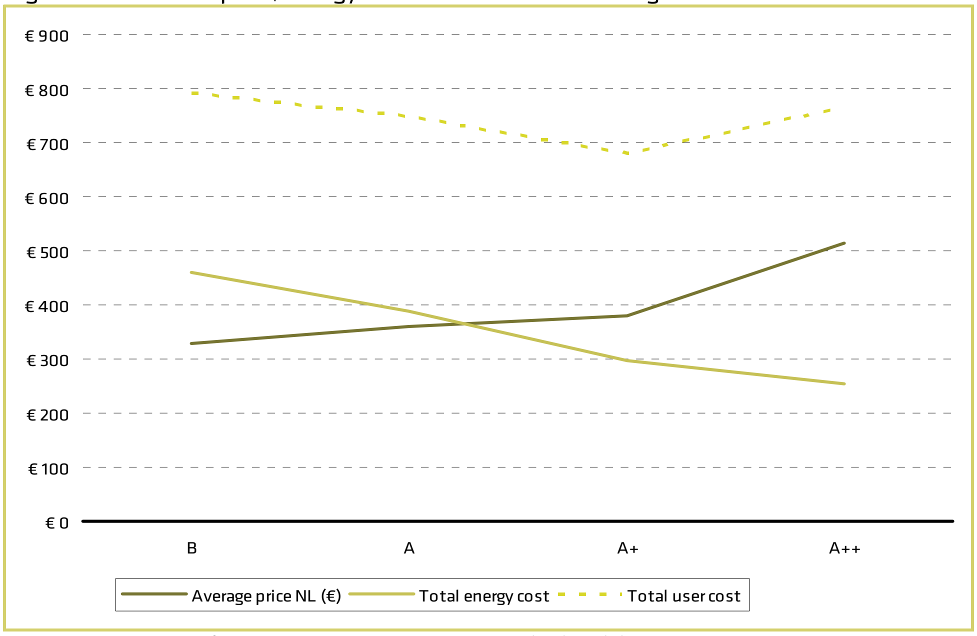
Product	Energy consumption savings (kWh) per year	Difference in price (€)
Refrigerators	40	91
Freezers	92	74
Washing Machines	69	-7
Dishwashers	57	52
Ovens	41	134
Domestic Lighting	50	2
Domestic boilers	9, 000	400

Note: The savings are calculated as the difference between the weighted average energy consumption of products rated A and better and products rated B or worse. Difference in price is calculated as the weighted average price of energy efficient products minus weighted average price of energy inefficient products. For boilers the difference concerns standard boilers versus condensing boilers.

Source: Copenhagen Economics; IVM (2008); Chalkley et al. (2001).

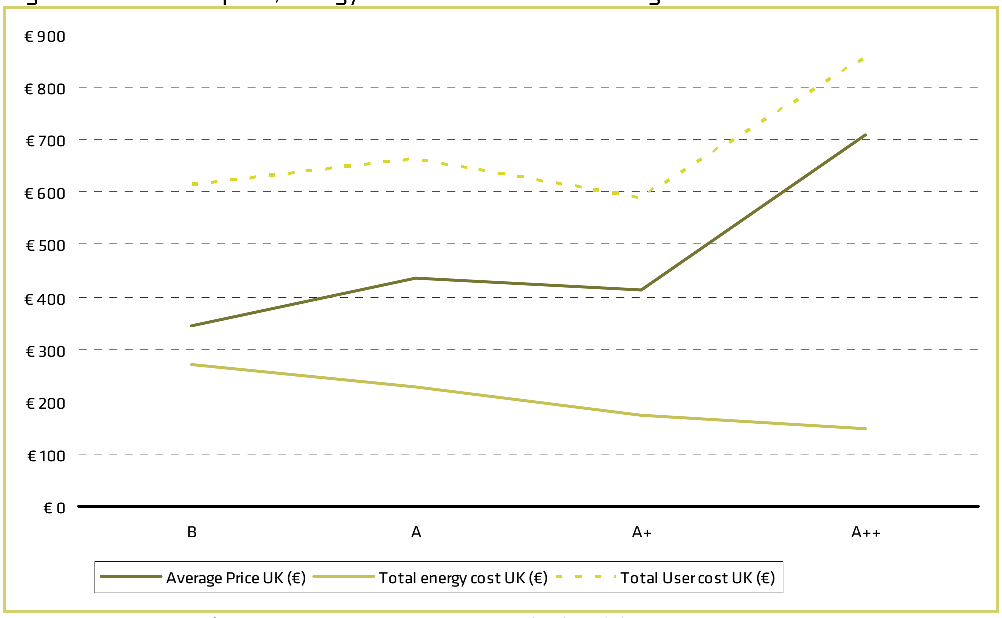
Moreover, the marginal efficiency gains to be reached by moving up through the energy efficiency classes (C to A++) are falling while price premiums are rising. For instance, in the Netherlands, choosing an A rated refrigerator instead of a B rated refrigerator would cost an additional €31 in purchase price, while it would save €70 worth of electricity. But an A++ rated refrigerator compared to an A+ rated costs an additional €130 but only saves €45 worth of electricity. Indeed, while moving from class B to class A+ leads to long term savings, moving from class A+ to A++ leads to higher user cost, cf. Figure 1.3. User costs are defined here as up-front purchase price plus discounted value of future energy costs. Bear in mind that the example is from the Netherlands where consumers pay taxes on electricity well above the expected value of CO_2 allowances. This already provides a very strong private return on energy savings. A similar pattern appears in the UK; however the shift from a B rated to an A rated refrigerator does not lead to lower total user cost, cf. Figure 1.4.

Figure 1.3 Purchase price, energy cost and total cost of refrigerators in NL 2008



Note: Assumptions: Lifespan 11 years, energy price € 0,283 / kWh and discount rate 5%
Source: Copenhagen Economics, IVM (2008), www.energy.eu (2008), EC (2007c), NAHB/Bank of America Home Equity (2007).

Figure 1.4 Purchase price, energy cost and total cost of refrigerators in UK 2008



Note: Assumptions: Lifespan 11 years, energy price € 0,166 / kWh and discount rate 5%
Source: Copenhagen Economics, IVM (2008), www.energy.eu (2008), EC (2007c), NAHB/Bank of America Home Equity (2007).

Both of these observations have clear implications for policy design. First, equal subsidy rates across the white goods sector will have strongly different net benefits. Second, promotion of the present top energy performers may not be cost-effective.

This conclusion provides a difficult policy trade-off. To avoid large rebound effects, VAT rate subsidies may have to be restricted to A+, A++ as discussed above and not include A. But that may not be cost-effective in present conditions. We discuss in chapter 4 whether promotion of top performing classes such as A+, A++ could nonetheless be justified due to future lower production costs associated with quicker and larger scale deployment of such products promoted by VAT or other financial instruments. However, the empirical evidence does not support that this be cost effective. Yes, these products may become cheaper, but it will come at the costs of lost innovation efforts elsewhere in the economy.

Are VAT rate subsides the most effective subsidy instrument?
If it is deemed worthwhile to move forward with a subsidy scheme to encourage consumers to purchase products that can save them money even in the absence of a subsidy, the question of what the most effective instrument is, remains. A key issue here is the choice between a reduced VAT rate on the energy efficient variant to be allowed in the relevant VAT directive or a national subsidy scheme. We will review this choice from two main perspectives namely the ability to *target* the subsidy precisely to its purpose and possible *compliance costs*.

As regards targeting, a VAT based system has two disadvantages. The first has to do with the way classifications are carried out. For each product group that is energy efficiency labelled, there are subcategories, typically defined by capacity; a freezer's energy efficiency is not measured by its absolute energy use but by how much energy it uses relative to other freezers with same "size". So a large freezer may well receive an A and a small freezer a B, even if the latter in fact uses less energy. Reducing the VAT rate on the big A rated freezer while keeping it constant on the B rated small freezer may well encourage households to exchange a small for a larger freezer -- and a small boiler with a larger boiler – with more energy being consumed. That is one of the ways how the rebound effect is going to work in practice.

Both a VAT rate reduction and a national subsidy scheme could be restricted to cover only smaller categories. However, this would leave out incentives to reduce energy consumption for the larger categories. The advantage of a national subsidy scheme is that it also could cover larger freezers etc., by way of a very simple benchmark mechanism: you define a standard sized B freezer, measure its efficiency and provide a subsidy to all freezers with higher energy efficiency. The size of the subsidy would depend directly on the distance in terms of energy efficiency to this standard. An A++ rated larger freezer might then get a subsidy provided it was more efficient than the smaller B rated benchmark model.

The second disadvantage results from the fact that high rated products such as A+ and A++ not only are more energy efficient, but also tend to be more luxurious. That is one of the reasons for them being more expensive. So a lower VAT rate is not only a subsidy to energy efficiency within a given size class, but also a subsidy to more luxurious products. Here a national subsidy system could provide a fixed absolute premium to products that meet certain standards.

These two examples provide a key lesson. Just as root taxation is the prime instrument to achieve energy GHG and energy savings, so are "root" subsidies the most effective subsidies with ad valorem subsidies such as reduced VAT rates falling behind in effectiveness.

On compliance costs, the relative verdict between VAT and other subsidies are more mixed but again fall out mainly to the benefit of a targeted national subsidy system. A clear example of the latter is the so-called *mixed supply problem*. Boilers for domestic heating and larger white goods are typically sold as a mix of a service (installation) and physical item. The product may for example be linked to a larger renovation of a residence. If VAT rates for the good is lower than for the service,[8] consumers and suppliers have a joint interest in over declaring the value of the reduced rate item and under declaring the value of the service sold at a standard rate. The same argument applies to a situation where a family at the same time is buying a B rated refrigerator for the summer house and an A rated freezer for the main residence.

This problem could largely be overcome in a national subsidy system with a given absolute premium for a given product as discussed above. Under such a system, the VAT rate on the installation service and actual product would be the same while the consumer would simply pay the absolute reduced price of the energy efficient boiler. The supplier could be made responsible for the administration of this subsidy and essentially make a discount in the final price of that amount. The customer could verify the transaction to the relevant budgetary authority through the vendor.

Public finance consequences: revenue losses and distortions

Root taxation with selective subsidies on top has public finance costs that are largely absent from the policy debate but can nonetheless be important.

The basic premise starts with root taxation as main instrument to punish externalities. EU has ETS for the power sector and selected industries plus national taxes for non-covered sectors such as domestic heating. Revenues will be recycled to ensure broad neutrality on labour market etc.

[8] VAT rates in the context of renovations is currently being discussed in the Council following the EU Commissions recent proposal to allow lower rates in this areas to reduce non-tax declared work etc.

Now we introduce a selective subsidy, namely a lower VAT rate on energy efficient variants. With unchanged consumption patterns this provides VAT losses equal to between 1 and 2 per cent of the VAT revenues cf. Table 1.8. However, the lower rate on the energy efficient good leads to dynamic tax losses as the consumption share of the products with reduced VAT rate increases. This requires a higher standard VAT rate than if only static gains were included. In addition to this come revenues losses from lower revenues from auctioned ETS allowances and energy taxes outside the ETS sector *if and only if* the exercise leads to reduced energy use, the whole purpose of the exercise.

Table 1.8 VAT revenue effects in scenario 2 applying the mandatory 5% VAT rate

Country group	Static revenue loss, per cent of VAT revenues	Determinants of dynamic loss: changes in efficient products'		Dynamic revenue loss, share of VAT revenues	Total revenue loss, per cent of VAT revenues	Total VAT revenue loss, per cent of GDP
		VAT bases	VAT rates*			
1	-1.7	18	-16	-0.3	-2.0	-0.1
2	-1.2	21	-14	-0.2	-1.5	-0.1
3	-0.9	21	-14	-0.2	-1.1	-0.1
4	-0.6	18	-14	-0.1	-0.7	-0.0
EU aggregate	-1.2	19	-14	-0.2	-1.5	-0.1

*Note: * Percentage points. Static, dynamic and total losses are calculated as percentage of benchmark VAT revenue. The static calculation captures the effect of changes in the structure of the VAT in scenario. The dynamic effect captures the effect of the consumption adjustments in the general equilibrium setting. The total effect is a sum of the two. VAT base change is in percentage of benchmark value. VAT rate change is in percentage points. Weighted averages. The results for the dynamic revenue loss and the total revenue loss have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.*

Source: Copenhagen Economics and Eurostat.

If we leave the issues of energy taxes aside, selective VAT leads to a net increase in the effective marginal tax rate on labour. The argument is relatively straightforward. First we reduce taxes on energy efficient products while financing it with a higher VAT rate, leaving aside for the moment the dynamic effects. Assume, for simplicity, that from a marginal tax rate perspective, these two effects are netting each other out.[9]

Second, consumers are switching from other consumption to energy efficient goods. Such a shift in consumption leads to a tax loss. This dynamic tax loss needs to be financed through higher taxes, in our model with higher VAT rates, which are necessary in order to compensate for both static and dynamic revenue losses from lower taxes on energy efficient products. So were are ending up in a situation where the overall tax burden – VAT revenues as a share of consumption -- is unchanged while the marginal rate of tax on labour goes up. That will lead to a welfare loss through reduced labour supply.

This implies an additional criterion in the evaluation of cost effectiveness. The value to consumers of being induced to buy product that actually would have saved them money even in

[9] This would be the case if the income elasticity of energy goods was roughly equal to 1. In this case, consumers will spend one per cent more on energy efficient goods when they earn one per cent more, and hence regard a lower rate on these goods as having increased incentive to work that matches the effect of a lower VAT-rate.

the absence of the subsidy, need to exceed the economic distortions from a higher marginal tax rate or labour. Such an evaluation would require more in-depth knowledge of key data etc. than has been possible for this study and would need to be carried out country by country and product by product for the particular subsidy scheme considered.[10]

1.5. Question 3: Will lower VAT rates distort Internal markets

The present political debate on reduced VAT centres around two versions as discussed in Chapter 4.

We look at the pros and cons of these two versions from a joint national and internal market perspective

The main arguments for a mandatory alternative are internal market concerns at the EU level. National schemes may be skewed in the interest of national producers, ensuring that their products benefit from subsidies. A more uniform business environment across the EU with less dispersion in fiscal incentives may prove helpful for innovation. Companies producing and selling electrical appliances or domestic boilers will then face the same conditions in all countries. Furthermore, allowing individual countries the option of reducing their VAT rates may trigger non-trivial cross-border trade.

The main arguments for voluntary reduced rates are mainly based on efficiency concerns at the national level. Results reported above suggest that uniform subsidies to countries with widely different circumstances, such as different levels of penetration of energy efficient variants, make little sense. In fact some countries may even see their energy consumption increase. At the same time, Member States are faced with national targets to reach climate and energy policy goals. Moreover, the potential fiscal costs and uncertain cost-effectiveness in general, makes it difficult to suggest a mandatory solution.

Indeed our analysis suggests that energy efficient products to a very large extent have the characteristics that drive cross-border trade. They have global brand quality, relatively high prices, EU-wide guarantees and are typically not damaged by transport. Most problematic are consumer electronics, with white goods being on a close second place. For example, a class A oven that is sold at a price of €1500 is more likely to be traded across borders, in case of voluntary VAT reduction, than insulation materials of the same size with a price of €150, cf. Table 1.9.

[10] In a study for DG TAXUD, BIO (2009) confirm that net welfare benefits are highly depending on specific country circumstances as well as uncertain assumptions about a number of key variables see for example page 10-11 in the executive summary.

Table 1.9 Ranking of the cross-border tradability of appliances.

Product	Price	Potential for cross border trade
Cars	High	High
Computers	Mid	High
Televisions	High	High
Electric ovens	High	High
Domestic refrigeration, freezers	Mid	Mid
Washing, dishwashing	Mid	Mid
Central heating boilers	Mid	Mid
Electric Boilers	Low	Mid
Imaging equipment	Low	Mid
Commercial refrigeration	High	Mid
Air conditioning	Mid	Mid
Motors, pumps	Mid	Mid
Fluorescent lighting	Low	Mid
Batteries, power supply	Low	Mid
Office lighting	Mid	Mid
Insulation materials (10m^2)	Mid	Mid
Water heaters	Mid	Low
Domestic lighting	Low	Low
Organic food	Low	Low

Note: The ranking is based on four parameters; price, weight, brand value and perishability during transport, cf. Chapter 4.
Source: Copenhagen Economics.

1.6. OVERALL ASSESSMENT

This study has reviewed two options for VAT rate policy adjustment in line with EU's climate policy objectives, namely (1) imposing standard rates on consumption of electricity and heating (2) introducing reduced rates on energy efficient household appliances, consumer electronics and domestic boilers.

On option one we recommend to move away from reduced rates on energy. It is in sharp conflict with moves towards pricing carbon and energy, and the adverse effects on income distribution can be dealt with more efficiently elsewhere. Furthermore, EU has, along with other importers of fossil fuels, an interest in reducing world prices of these goods inter alia through taxes to improve terms-of-trade. Bearing in mind the upcoming international climate negotiations, this would be the right signal to send.

On option two, we maintain that root taxation, such as the successful ETS, is by far the most important instrument to encourage CO_2 and energy savings. In addition to that, the EU is already planning to improve labelling, allowing consumers to react on higher energy prices as well as imposing minimum standards in areas where consumers are unlikely ever to react to price signals even with the best information possible.

The role for yet another instrument on top is of course smaller. The aim for a reduced VAT rate for energy efficient products would be to push the consumer who, in despite of all these initiatives, will not buy such products. If financial instruments are to be used on top, then national fixed amounts subsidy are superior in effectiveness and can be constructed so that they have no internal market complications.

We therefore conclude that the hurdle rate for such reduced VAT rates should be very high and be given many green scores on our balanced scoreboard approach below c.f. Table 1.10. It is clear from our model experiments, that imposing the same VAT subsidy rules on all countries simply does not make sense, given highly different starting conditions. We therefore need to see what, if any, room there is for voluntarily reduced rates while keeping in mind the pressures on the internal market this may imply.

Under these circumstances, we have the following assessments:

Low priced white goods have the most potential, i.e. appear with the fewest red and most green lights in our scoreboard. Relatively low prices suggest that internal market issues are less problematic. Reduced targeting relative to a fixed amount subsidy is less of a problem because of relatively limited production variation within the group and little scope for tilting prices upwards for the targeted product to save tax in mixed supply situations.

For all other products, the problems are too extensive, i.e. too many red marks. Internal market concerns with optional VAT rates are non-trivial. At the same time, much higher levels of targeting and less compliance burdens can be achieved with national subsidy schemes, while direct internal market problems with cross border sales are reduced: the subsidy is not linked to a VAT rate but may, where relevant, be restricted to a delivery to resident households.

Table 1.10 Balanced scoreboard approach

Modelled sectors	Product	Financial subsidy relevance...		VAT instrument effectiveness relative to other subsidies...			Avoidance of internal market problems
		due to search costs relative to savings per unit	due to financial hurdles	due to lower compliance costs	due to better targeting at energy efficiency	due to mixed supply avoidance	
Household appliances	Electric ovens	Red	Green	Orange	Red	Orange	Red
	Refrigeration, freezers	Red	Green	Orange	Red	Orange	Orange
	Washing, dishwashing	Red	Green	Orange	Red	Orange	Orange
	Electric Boilers	Red	Green	Orange	Red	Red	Orange
	Air conditioning	Orange	Green	Orange	Red	Red	Orange
	Motors, pumps	Orange	Green	Orange	Red	Red	Orange
	Fluorescent lighting	Orange	Red	Green	Orange	Orange	Orange
	Batteries	Orange	Red	Green	Orange	Orange	Orange
	Water heaters	Red	Green	Orange	Red	Orange	Green
	Domestic lighting	Green	Red	Green	Orange	Orange	Green
Consumer electronics	Computers	Red	Green	Orange	Red	Orange	Red
	Televisions	Red	Green	Orange	Red	Orange	Red
	Imaging equipment	Red	Orange	Orange	Red	Orange	Orange
Boilers	Boilers	Red	Green	Orange	Red	Red	Orange
	Cars	Green	Green	Orange	Red	Orange	Red

Note: Green = High potential; Orange = Medium potential; Red = Low potential.
Source: Copenhagen Economics.

Chapter 2 | Cost Effectiveness in Reaching Environmental Objectives

In this chapter we discuss cost-effectiveness of VAT differentiation to support environmentally friendly goods in comparison to other instruments for reducing GHG emissions.

We start by describing the conventional wisdom about taxing emissions where they originate. We then discuss under which circumstances these taxes should be supplemented by other regulatory measures and discuss the potential supplementary measures.

Further, we identify and describe implementation problems of reduced VAT that threaten to render the scheme cost inefficient. Lastly, we discuss problems that arise from the increasing demand for energy consuming products that would follow a reduction of VAT.

This study finds that even the best conceived VAT differentiation scheme may fail to reduce emissions due to rebound effects, i.e. more intensive use of energy efficient products. In addition, a reduced VAT on energy efficient goods would promote other characteristics than energy efficiency if they are typical for the highest rated goods. The study therefore calls for alternative instruments that are candidates to supplement ETS in reducing emissions.

2.1. Why is root taxation cost effective in reducing GHG emissions?

Root taxation (taxing emissions where they originate) is typically considered the most cost effective solution meeting GHG emission reduction goals.

The argument in favour of root taxation is that the tax on emissions communicates the cost of environmental damages to the polluters and ensures that they take it into account when deciding how much to pollute, because it is costly for them to pollute. Therefore, with functioning root taxation, energy efficiency is expected to spread in a bottom-up manner via economic incentives and without the need to be encouraged by separate regulation.

In practice, adding the cost of pollution to prices by means of the tax gives polluters an incentive to use energy efficiently. Polluters can be the end users of energy, i.e. households. For example, in the case of electricity, the EU ETS can be considered an example of root taxation of CO_2 emissions. The tax is levied on the supplier of electricity in the form of an emission allowance whose price is passed through to energy consumers. In response to higher prices, consumers reduce their electricity consumption through adopting energy efficiency. In order for this process to take place in a cost effective manner, the customer must have access to information on energy efficiency, e.g. via labelling of electricity consuming products.

Root taxation can also be applied to emissions outside the ETS. Currently, the inclusion of emissions from transportation and agriculture is being considered into the ETS. Furthermore, a range of other taxes are already in place, including excises on energy and the VAT – although the level of taxation differs. Low taxes, in general, encourage energy use and hinder energy efficiency – while the opposite is true for high taxes.

The level of excises varies between countries, but also in relation to the ETS CO_2 emission quota prices, cf. Table 2.1. 17 member states maintain relatively low excises on both natural gas and heating oil – which in fact are below the average ETS quota prices at €20. Those countries are likely to face more significant adjustment costs than e.g. Slovenia, Finland, Austria or Italy where the level of fuel excises is not markedly different from average ETS quota prices. On the other hand, Denmark and Sweden levy excises that exceed the average ETS quota prices.

Table 2.1: Excise duties on heating energy fuels in the EU vs. ETS quota prices

		Heating oil		
		Excise duty lower than 15 € / t CO_2	Excise duty between 15-25 €/ t CO_2	Excise duty higher than 25 € / t CO_2
Natural gas	Excise duty lower than 15 € / t CO_2	Belgium Bulgaria Czech Rep. Estonia Greece Spain France Hungary Ireland Lithuania Luxembourg Latvia Malta Poland Portugal Romania Slovakia	Finland	United Kingdom
	Excise duty be-tween 15-25 €/ t CO_2		Slovenia	Italy
	Excise duty higher than 25 € / t CO_2	Cyprus Germany Netherlands	Austria	Denmark Sweden

Note: Excise rates quoted in € / GJ are converted into € / tCO2 using emission factors for the respective fuels.
Kilde:DG Taxud(2008) and Energistyrelsen, DK.

The principle of taxing at root can be applied to achieve cost-effective abatement for non-CO_2 pollution as well. In general, to correct environmental problems one should consider first whether a tax can be applied at the root of the problem. For example, to reduce methane (CH_4) emissions, a tax may be considered on its main sources, i.e. agriculture and mining. To reduce water consumption, a tax on water use may be considered, to reduce the use of pesticides, a tax on pesticide use may be considered and so forth.

2.2. Motivation for suplementary measures

Root taxation may have to be supplemented with other measures to ensure full cost-effectiveness of climate and energy policies. We identify four *potential* market failures stemming from:

- lack of awareness or information about the benefits of energy efficiency
- size of energy savings
- affordability of more efficient products
- occurrence of principal-agent problems

The constraints of the internal market, including cross border trade, may also in certain cases prevent member states from increasing gasoline and diesel taxes: private consumers and haulers may respond by tanking up in other countries with lower consumer prices. We explore this issue in chapter 4.

In this subchapter we investigate each of the above problems and discuss measures that could be used to remedy them.

Lack of awareness or information

Potentially the most rudimentary barrier in the adoption of energy efficiency is the lack of awareness on the side of consumers that energy efficient products are economically more favourable than their inefficient alternatives. If customers are not aware of the merits of energy efficient products, they will not demand them and the overall efficiency will not improve. Financial instruments would not directly increase the consumers' awareness of energy efficiency, but there are other more focused measures that could be taken. Two such initiatives are labelling schemes and energy auditing.

Labelling schemes have been developed to provide information. In a nutshell, labelling should communicate that energy efficient products have lower consumption of energy and other resources so that their cost over their lifetime is lower in comparison to less efficient alternatives. Labelling has been shown to have a very strong impact on consumer choice.[11]

However, the presence of labelling does not guarantee that customers are aware of their existence or are able to interpret the benefits. As of present, some products may have their own labelling schemes, and not all labelling schemes may be unified across sectors and countries. The lack of harmonisation may be a barrier to the spreading of information on energy efficiency. This is also acknowledged by the Commission in their proposal for a community labelling scheme for environmentally friendly products.[12]

A supplementary path to better informed consumers is energy auditing which has proven to be effective, cf. Box 2.1. A possible policy might therefore be to reduce the VAT rate for energy audits. One snatch is energy auditors might not be hired in the first place because consumers may have a lack of awareness of its´ effects. If consumers knew that there were cost-effective improvements that reduce energy consumption available, then they would have im-

[11] Newell et al. (1998) in a study covering the period from 1955 to 1995 in the US showed that the effect of higher energy prices on the product mix of energy using products were strongly amplified by the introduction of labelling schemes.

[12] European Commission (2008)

plemented those improvements already. Financial support for energy audits would not help overcome this lack of information. In this respect its effect will differ from reduced rates on white goods and boilers which often will have effects on purchasing decisions the consumer has already taken: we need a new fridge, the question is which one? Here the purpose is to trigger a decision which the consumer has not yet thought above.

However, financial support could give incentives to hire energy auditors and thereby reduce energy consumption when consumers are facing financial constraints in financing audits they believe could lead to cost savings.

If a financial instrument should be applied in this area, we believe that a reduced VAT is less effective than a fixed sum subsidy. In particular, the *ad valorem* structure of a VAT rate reduction gives incentives to fit as many services as possible into the energy auditing, firms might in addition to energy auditing offer broader advice services at the reduced VAT rate. In short: both with a reduced VAT and a fixed sum subsidy there is a need to define what an energy audit consist of and verify that: the advantage of fixed sum subsidy is that it can be limited to what is considered necessary to carry out a basic service. It is for example not obvious that prosperous families with no financial constraints living in very large houses – and thus with a large potential for savings – should be subsidised to undertake activities in their own interest beyond this basic amount.

Box 2.1 Energy auditing – A means of information dissemination

An energy audit is an inspection, survey and analysis of energy flows in a building, process or system with the objective of understanding the energy dynamics of the system under study. An energy audit is typically conducted to seek opportunities to reduce the amount of energy input without negatively affecting the output(s). When the object of study is an occupied building then reducing energy consumption while maintaining or improving human comfort, health and safety are of primary concern. Beyond simply identifying the sources of energy use, an energy auditor seeks to prioritise the energy uses according to cost-effectiveness and suggest improvements where they are cost-effective.

According to article 12 in the directive on energy end-use efficiency and energy services Member States are obliged to ensure the availability of energy audits for market segments where they are not sold commercially. Programme level energy audit activities, both pure energy audit programmes and other programmes where energy audits play an important role, are quite well represented in the EU Member States and Norway as well as in the Central and Eastern European Countries (CEECs) . Some level of energy auditing can be said to exist more or less in all countries. In the EU Member States and Norway the total number of pure energy audit programmes is 13 in 7 countries.

Finland as role model
The country with the longest tradition of energy auditing as a key instrument in the national energy efficiency policy and a main tool in the energy conservation activities since 1992, is Finland. There, a substantial system of method development, training, quality control and data management has been established and trained auditors are authorised to perform audits that may enjoy government subsidy (40-50 per cent), provided that the results are delivered to the central audit data bank. There are tailored energy auditing methods for each type of energy consuming facility as well as for the various phases of the lifetime of these facilities. For example, there are specified auditing methods for industrial plants and residential buildings, for new or renovated buildings, and for follow-up after several years have passed since the previous audit or after some essential changes have taken place in the use of the facility.

Energy auditing in other countries
France launched a full scale energy audit programme called "Aide à la Décision" (Decision Making Support Scheme) in 1999. This programme has complete management procedures, detailed guidelines, a monitoring procedure and a charter for auditors. Audits are subsidised by different percentages according to the used auditing model and are targeted at all sectors (building, industry) excluding individual houses, for which a self-auditing tool is available through the internet.

In **Germany** the Federal Ministry of Economics launched an energy saving promotion programme called "Vor-Ort-Beratung" in 1991. The programme has been running since then and is considered very effective, especially in the rehabilitation of old buildings. The energy audit services are authorised to engineers and consulting companies around the nation but due to a diversified nature of the programmes very little collective information on the results, total volumes of audited buildings and implemented energy saving measures is available.

In **the Netherlands** the Energy and Environmental Advice, an individual energy audit support programme and commonly used energy audit model, was finalised in 2000. Target groups were all small and medium-sized enterprises, governmental and non-profit organisations. Small and medium sized companies could apply for support (max 50 per cent of the costs) to undertake an audit on a voluntary basis. For private homes, Energy Performance Advice (EPA) is a support scheme for private homes. Owners of homes built before 1998 can apply for an EPA by approaching a local adviser who will pay a visit and see what energy-saving measures are to be taken.

The effectiveness of this format of information dissemination is exemplified by the results of a Finnish study by Department of Home Economics, VTT Building Technology and Finnish District Heating Association. They found that following monthly feedback and focused energy saving advice, 54 per cent of households reduced energy consumption by turning off lighting in empty rooms, 27 per cent lowered room temperature, 27 per cent dressed more warmly and 23 per cent paid attention to thermostat valves. Furthermore, 40 per cent of respondents reported that the monthly meter reading feedback they received on their energy consumption made them think about their consumption, and 13 per cent altered their habits following the feedback. The results also showed that households were able to reduce monthly electricity consumption by 11-16 per cent without compromising their level of comfort. Furthermore, heating energy consumption decreased by an average of 5 per cent following meter readings and by 3-9 per cent following feedback on consumption compared to previous year. Electricity consumption in the treatment groups decreased an average of 17-21 per cent following feedback, however, there was little influence linked to advice which was given after feedback.

Source: Official Journal of the European Union (2006); EC (2006) (1995) Seppo et al.(2006) Sussex Energy Group (2007)

Size of energy savings

If the size of energy savings in a single unit is insignificant in absolute monetary terms, it may be disregarded by the consumer. The lower the energy saving, the greater the likelihood that the search costs borne by the consumer to buy the product will prevail over the efficiency saving, and the consumer will not make the most energy efficient purchase. Furthermore, the lower purchase price today may be preferred to small savings if they come dispersed over time, although the empirical evidence for such effects in a situation with full consumer knowledge about future cost savings is limited in general see Box 2.2 below. For example, replacing a 75W incandescent light bulb with the equivalent energy efficient light bulb may generate savings of the order of magnitude of €75 over a five year lifetime[13] of the bulb, amounting to €15 per year so only €1.25 per month[14] which may be barely noticeable on the monthly energy bill. In consequence, consumers may disregard taking a separate trip to another vendor carrying compact fluorescent bulbs if their local store only carries incandescent bulbs – even though they know that fluorescent bulbs save money over their lifetime. The size of average energy savings for any separate product is typically less than € 20 per annum, cf. Table 2.2. A notable exception is boilers where the savings potential is much larger.

Table 2.2 Average energy savings for different products

Product	Savings energy consumption (kWh) per year	Savings in € per year
Refrigerators	40	7.10
Freezers	92	16.40
Washing Machines	69	12.20
Dishwashers	57	10.00
Ovens	41	7.30
Boilers	9000	1620.00

Note: Assumed energy price 18 €cent/kWh, the average energy price in Europe including taxes. The savings are calculated as the difference between the weighted average energy consumption of products rated A and better and products rated B or worse. Energy consumption is weighted by average sales in each efficiency class. The boilers that are compared are standard boilers versus condensing boilers.

Source: Copenhagen Economics, energy.eu, IVM (2008), Chalkley et al (2001)

Since consumers may fail to react on marketing declarations about the long term savings obtained from buying the energy efficient variant, a financial instrument that lowers the purchase price would help remedy this problem. In short, consumers notice a lower price, not information on the back of the product.

[13] US News & World Report, 19 December 2007.

[14] Chernoff (2008)

Box 2.2 Consumer discount rates: what do we really know?

A literature survey by Train (1985) is used as the key reference on consumer discount rates in a study for TAXUD by BIO et al. (2009). The report states that consumers systematically discount future energy saving at rates way above market rates of interest. Apart from the literature survey being rather old, we first state that the methodologies used to derive the estimates tend to be biased. Basically, they look at energy using products being bought by households and then estimate the savings consumers could reach by switching to the most energy efficient models. If these savings are very large relative to the purchase price, it is inferred that consumer have very large discount rates. But this approach systematically contains a potential bias by assuming that all products are put to the same use. *A priori* reasoning suggests households that use energy consuming products at low intensity – e.g. heater placed in summer cottages or a bachelor residence – rationally may prefer a product with a lower purchase price even at the cost of some higher energy costs in use. So they do not necessarily have high discount rates. Second, we note that Train (1985) suggests that the high estimated discount rates may imply that consumers had problems detecting "differences in energy uses" for the products being bought. This suggests that lack of labelling is the problem i.e. an information problem. This is empirically supported by another US study by Newell (1998) that found that the impact of higher energy prices in terms of consumers preferring more energy efficient product variants were amplified once improved labelling came into place.

Source: Train (1985), BIO et al. (2009) pp. 146-149, Newell (1998).

Affordability of energy efficient products

The efficient products are typically more expensive to purchase than the inefficient products; therefore some households may be prevented from purchase efficient products due to failures associated with financing. For instance, hybrid or electric cars are at present 1.5 – 2 times more expensive than combustion engine cars. Let us assume that the higher purchase price is retrieved during the cars life span through lower fuel expenses. The difference in purchase prices in practice entails that households are required to take a higher loan which may be refused by a financial institution – in spite of long term benefits of using a hybrid car. Therefore, a household may be forced to purchase a combustion engine car which is more expensive over its lifetime, but cheaper to acquire. In consequence, a market failure on the side of financing the household's purchases of energy efficient products may hinder the adoption of efficient products. So that even if the household would like to acquire the energy efficient car, in this case, it is not able to due to problems with financing.

The argument is strongest for goods with relatively high costs such as cars or white goods. An interesting example of the potential effects on the effect lower prices on energy efficient variants is presented by the UK retailer Comet that in March 2008 cut VAT on some of their products, cf. Box 2.3.

Box 2.3 UK experiment – VAT cut on energy efficient goods

COMET'S VAT PROMOTION – MARCH / APRIL 2008

Recently, an experiment, proving customers' sensitivity to price changes on electrical appliances, was performed in the British market.

On the back of Prime Minister Gordon Brown's plan to cut VAT on greener electrical appliances, the electrical specialist Comet participated in a trial with deduction of VAT on energy efficient white goods. The trial lasted for 29 days, starting on the 20th of March, 2008.

In the trial, the VAT equivalent of 14.9 per cent was cut from the price of 150 A, A+ and A++-rated products sold by Comet in it's over 250 stores across the country. The items covered by the trial represented a wide variety of products, spread all over the price range. However, the majority of the A, A+ and A++-rated products marketed by Comet were not included. This enabled analysis of sales figures for those products that were energy efficient, but still not covered by the VAT reduction.

The results indicated the importance of purchase price in consumption decisions taken by customers – there is a willingness to buy energy efficient products, but the purchase also has to make short term financial sense

The sales of energy efficient products included in the trial rose by more than two thirds when the VAT cost was removed. The impact of the price decrease was consequent across the entire product range, and in more than 90 per cent of the products covered by the trial, an increase in sales was seen. The growth in sales was even more significant for A+ and A++-rated products than A-rated products. Sales of products not covered by the VAT cut declined by about a third. The most significant decline in sales was seen on those A, A+ and A++-rated products not covered by the trial. This was an expected effect, however, as these products form a closer substitute to the ones included in the project, then the products with a lower rating in energy efficiency.

Nevertheless, there is a problem with the interpretation of this kind of temporary experiments. When the price decrease is limited to a short period of time, there is an increased incentive for customers to make their purchases during this particular period; compared to if the price change was permanent. Consequently, we can expect the increase in sales to be less significant in case of a permanently cut VAT than during the temporary price change in the experiment.

Source: Correspondence with HM Treasury, Comet (2008)

While this case study does suggest that lower prices may lead to higher markets shares of more energy efficient products, it does not imply that the purchase of an energy efficient appliance is a cost-effective way to reduce emissions of GHG.

Principal-agent problems

Principal-agent problems, often involving the landlord-tenant relationships, may hinder the adoption of energy efficiency. Several types of principal agent problems have been identified in this setting of which the situation when the landlord purchases the appliance but the tenant pays the running costs is the most frequent. A recent study suggested that principal agent problems may in principal affect up to 30 per cent of energy consumption in the OECD countries (IEA 2007).

As housing rental marked is mostly VAT-exempt, landlords would in fact benefit from a reduced VAT rate on energy efficient boilers, insulation materials etc[15].

[15] As a rule, the leasing or letting of buildings is exempted from VAT (without right of deduction of the input VAT). However, Member States may apply exclusions to the scope of this exemption or may allow enterprises ("taxable persons" for VAT purposes) a right of option for taxation (in which case the output is taxed and the input VAT can be deducted) (Art. 135 and 137 of the VAT Directive 2006/112/EC). This means that both a (VAT) tax-

However, hard core evidence in support of a slow adoption of energy saving equipment as a result of Principal Agent problems is not that strong. An example of the ambiguity of the evidence is a study which uses experience from the Netherlands. In support of the PA problem, it is observed that owner occupied housing which by definition has zero PA problems had a much higher level of implementation of energy savings measures over a whole range of products than private lettings cf. Table 2.3.

However, at the same time implementation of such measures in social housing is broadly at the same levels as in owner occupied housing? Are there a priori arguments for PA problems being smaller there? Moreover, the study itself suggest that families living in owner occupied housing may use more energy per square meter per year[16]. The unstated implication is that they also have a larger return on energy savings investments. This just underlines that the cost-effectiveness of any energy saving device or measure is directly linked to the intensity of the use of the underlying product. What may be a good investment for a large family with five children using a lot of hot water, electricity, etc. may not be so for a young, single adult spending limited time in his or her apartment.

Table 2.3 Energy measures implemented in the residential sector in the Netherlands, 2000

Measure	Building segment		
	Owner occupied	Social housing	Private letting
Roof insulation	70%	59%	40%
Wall insulation	52%	55%	29%
Floor insulation	39%	30%	21%
Insulated glazing	70%	67%	48%
Boiler (improved yield)	43%	60%	54%
Condensing Boiler (high yield)	47%	26%	25%

Source: IEA (2007)

More generally, a private landlord will have a long term interest in reducing the energy bill of his tenants. Tenants are likely to put some weight on their energy bills when they choose where to live. In a perfect housing market, higher energy costs would have to be compensated through lower rents. Alternatively, a landlord that implements equipment that can effectively reduce total costs of energy – both capital costs and running cots – will be able to offer lower rents and yet make more profits.

The current housing markets are typically far from perfect and may not facilitate cost-effective adoption of energy savings devices even when landlords so wish. The landlord may for example be unable to recuperate the capital costs associated with the upgrading or may

able transaction with right of deduction of input VAT and an exempted transaction without right of deduction are possible.

[16] IEA (2007) page 135.

have to go through a lengthy consultation process with tenants to achieve such objectives. However, that may represent more a failure of rent regulation law than a PA problem per se.

Our conclusion is then twofold. First, the empirical evidence at least as offered in the large survey from IEA does not contain strong evidence of PA problems related to tenant-landlord problems. Second, weak adoption of energy saving measures may result from other structural barriers such as rent regulation that could be directly addressed.

2.3. Labelling, minimum standards, promotion of the best performers

In view of the market failures hindering the adoption of energy efficiency, it may in selective case be justified to introduce supplementary legislation to correct for them. The possible regulation considered can be broken into three steps:

- Enforcing (mandating) and harmonizing labelling schemes – labelling directives
- Taking the worst performing products out of the market – minimum efficiency standard directives
- Promoting the best performing products – e.g. proposed reduced VAT

In the case of some products, the EU has already moved a long way along the lines of the above regulation, while more products are added to the coverage. The legislation has a number of implications for promoting energy efficiency.

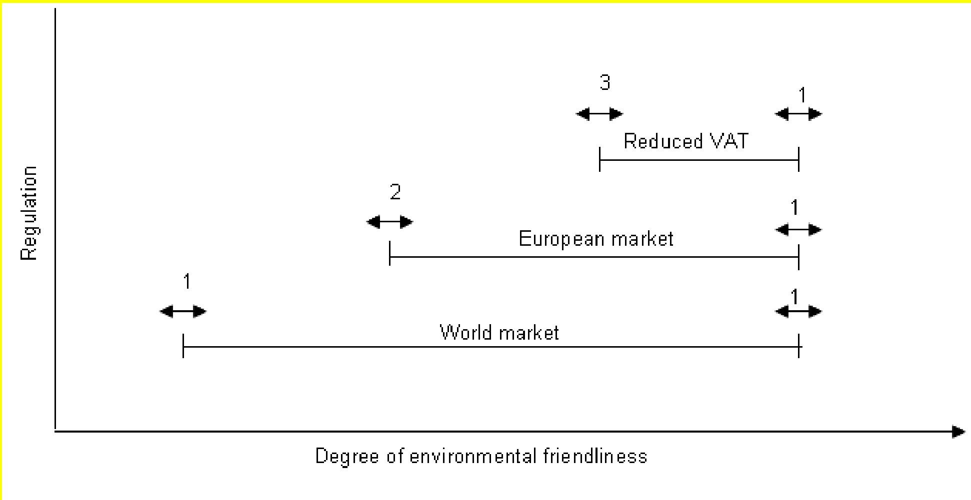
Mandatory and harmonized labelling defines the energy efficiency of a product and communicates that to the consumer. In short, labelling reduces the potential market failure of lack of information or lack of awareness about energy efficiency.

Minimum efficiency standards (MES) prevent consumers from choosing the least efficient products – the worst performers. Together with labelling, the presence of MES effectively bans the least efficient products from the EU market. As a result the EU market comprises only the range of more efficient products available on the world market, cf. Figure 2.1.

Labelling also serves to make the best in class more visible and thereby promote energy efficiency. In this way, labelling provides incentives for the best performers – although they may still be more expensive than less efficient alternatives. Therefore, with the labelling and minimum efficiency standards alone, consumers may not necessarily realise full gains from adopting energy efficient goods. Labelling does not solve the market failure that has to do with higher purchase prices of energy efficient products. A budget-constrained consumer may still prefer products with low purchase price, especially if the remaining market failures – low absolute size of energy savings and low relative size of energy savings are present alongside the higher price of energy efficient products. Labelling alone does not make it cheaper to buy the energy efficient product.

Therefore, additional instruments may be required to supplement labelling and minimum efficiency standards to promote the best in class products by lowering their prices. The proposed lower VAT on the most energy efficient products would serve to lower their purchase price relative to the less efficient products on the EU market, cf. Figure 2.1.

Figure 2.1 Regulation promoting energy efficiency



Note: Threshold 1 is defined by technological development, policies around the world and consumer choice. Thresholds 2 and 3 are defined by European policy. Thresholds 1, 2 and 3 may be set differently for different products.
Source: Copenhagen Economics

An integrated use of different means of regulation has been proposed by the Commission in the action plan on the Sustainable Consumption and Production and Sustainable Industrial Policy[17]. In brief, it suggests that minimum requirements shall apply to all energy-using products and that the scope of the current labelling directive is extended.

[17] EC (2008d)

2.4. VAT RATE REDUCTION VERSUS ALTERNATIVE SUBSIDIES

A financial subsidy such as reduced VAT rates may correct for market failures that stems from the adversities described above In particular, a reduced price could encourage retailers to more broadly market products that in fact are in the consumer's best interest, affects purchase decision directly by the consumer not needing spend too much time on reading labels. It could also tip the cash-constrained household to buy a class A refrigerator that they know is more energy efficient but do not have the means to buy. They need a reasonably sized refrigerator so they cannot simply trade down to a smaller but more efficient refrigerator as easily as they can with a car. However it would have little meaningful effect in situations where the energy use of a product is very small relative to total price. There is, for example, little meaning in having computers graded by electricity use and then providing a purchase subsidy for the most efficient.

The question to be addressed here is whether a reduced VAT rate is the best instrument to provide such a subsidy. We would here make a distinction between four variants of financial instruments and then finishing the section with an overall evaluation of these based upon three evaluation criteria:

- targeting the objective ("efficiency")
- compliance costs
- internal market complications

As regards the four variants, they are created by a combination of two dimensions of the subsidy. We can have either a fixed amount of subsidy determined by energy class or an ad valorem subsidy being a function of both the price of the product and its energy class. This is what we call the "*determination of the subsidy*" in Table 2.4, below. Moreover, we can provide this subsidy either at the retail level to all consumers irrespective of their nationality or only to residents of the country choosing to operate this system. This is what we call the "*method of distribution of the subsidy*". When we mix the combinations we get four variants with the VAT subsidy based on energy class being an example of one of these four variants cf. Table 2.4.

Table 2.4 The four variants of financial instruments

		Method of distribution of subsidy	
		Retail based for all consumers	Only for residents of a country
Determination of subsidy level	Fixed amount determined by energy class	Fixed amount to all consumers	Fixed amount only for residents
	Ad valorem subsidy based on energy class	Ad valorem for all consumers (VAT rebate one version)	Ad valorem only for residents

Source: Copenhagen Economics

Fixed versus ad valorem subsidy such as VAT rate reductions
On *efficiency* grounds, we conclude first that a fixed amount subsidy is superior to a VAT reduction. Consumer choice and price differences are affected by a number of other factors than differences in development costs associated with building more efficient products. So a reduced VAT rate on all products fulfilling energy efficiency criteria will in fact also be a subsidy to buy more upmarket versions of A-rated products or larger A-rated products.

A few practical examples show that such concerns are important. Firstly, for each product group that is energy efficiency labelled, there are subcategories, typically defined by capacity: so appliances´ energy efficiency is not measured by its absolute energy use but by how much energy it used relative to other freezers with same "size". In consequence, a large freezer may well receive an A and a small freezer a B, even if the latter in fact uses less energy. Reducing the VAT rate on the big A rated freezer while keeping it constant on the B rated small freezer may well encourage households to exchange a small for a larger freezer, and a small boiler with a larger boiler – with more energy being consumed. In short, you may be tempted to exchange a SAMSUNG with the larger and more expensive Siemens if you want more capacity cf. Table 2.5.

Second, high rated products such as A+ and A++ not only are more energy efficient, but also tend to be more luxurious. That is one of the reasons for them being more expensive. So a lower VAT rate not only is a subsidy to energy efficiency within a given size class, but also a subsidy to more upmarket products. For instance, the price spread of A rated washing machines is substantial even within the same capacity category, possibly due to brand value and design. Furthermore, there are A rated washing machines that are less expensive than B rated models, cf. Table 2.5. So, in practice you would get a subsidy to upgrade in luxury value from a Hotpoint to a SAMSUNG with no energy efficiency gain as counterpart (both with wash load of 6 kilos).

Table 2.5 Price spread of washing machines in the UK

Brand and model	Energy efficiency grade	Maximum wash load	Wash grade	Spin efficiency grade	Price (£)
Zanussi ZWC1300W	B	3 kg	A	B	389.95
Hotpoint WML540G	A	6 kg	A	B	248.97
SAMSUNG WF-B1456GW/XEU	A	6kg	A	B	349.99
Siemens WM14S795GB	A	8 kg	A	B	957.00

Source: UK electronics retailer Comet

The primacy of root taxation/root reward as the best instrument is even more paramount with respect to reducing environmental damage from the use of pesticides and fertilisers where the role of VAT rates has also been raised. While emissions of CO_2 from the use of a ton of coal in power plant near Paris has the same climate effect as in power plant near Warsaw, that is clearly not the case for the use of fertilisers and pesticides. The damage depends both on the soil it is used on and the damage increases exponentially with its local use. The first kilo may in fact not be problematic at all, the second potentially while the third and fourth kilo on the same surface creates real problems in terms of pollution of rivers, drinking water quality. Our conclusion in line with a number of studies is then that effective financial incentives and penalties need to recognise the local character of the environmental problem. We discuss the VAT rate policy with respect to pesticides and fertilisers in somewhat more detail in a case study following chapter 2, very briefly also raising issues such as effect on agricultural production etc.

In conclusion, just as a fixed sum charge on the specific damaging activity ("root taxation"), is the best way to discourage negative externalities such as CO_2 emissions, so is a fixed sum reward the best way to reward good behaviour. This could be attained by a national subsidy scheme that would provide a fixed absolute premium to products that meet certain standards providing. Such a scheme has the advantage as compared to a VAT reduction (or any other ad valorem subsidy) that it does not promote more luxurious products or upgrades to larger capacity. Further its size can be better targeted, taking into account price elasticities.

Seen from the consumer perspective, there would not be much difference between a fixed amount subsidy and a VAT reduction provided that they were both administered at the retail/supplier level. The supplier/retailer would simply subtract the relevant rebate from the bill. If there are strings attached as in a residence based system, the compliance costs are also likely to be equal for the consumer. To increase the effectiveness of the scheme as much administration should be on the vendor so to relieve the customer from having to contact tax/subsidy responsible authorities directly.

For enterprises and tax authorities a fixed amount of subsidy will have by far the lowest compliance costs relative to VAT rate subsidy. This should be seen in conjunction with the mixed supply problem. The mixed supply problem relates to the fact that a product subject to reduced VAT is consumed together with other product(s) or service(s) not subject to reduced VAT: this issue was discussed intensively in our previous report on reduced VAT. One example is a customer buying both an expensive A rated freezer and at the same time a B-rated washing machine. Both vendor and purchaser has an incentive to inflate the recorded sales price on the former and reduce it for the later, thus reducing the total VAT bill while then splitting the gain. Tax authorities will face non-trivial costs in monitoring or challenging such billing practice. However, if the subsidy was a fixed amount, the vendor and purchaser would reap no gain from such shifting of prices.

The presence of mixed supply issues can potentially also generate incentives to shift "value added" towards the low rate within the building sector are presented in Box 2.4. This issue is linked to the Council discussion of the EU Commission proposal from July 2008 that provides an optional reduced rate on services rated to renovation etc. inter alia to reduce non-tax worked in this sector[18]. Essentially, to avoid such mixed supply problems, the proposal

[18] The Proposal for a Council Directive amending Directive 2006/112/EC as regards reduced rates of value added tax (COM(2008) 428) presented by the Commission on 7 July 2008 includes the possibility for Member States to apply a reduced VAT rate to, among other things, "the supply of services consisting in the renovation ,repair, altera-

would oblige countries also to have lower rates on the building materials involved in such operation. In other words, the service and the good would be both standard rated *or* reduced rated.

The conclusion in terms of use of financial instruments regarding this sector is pretty straightforward. If the Council follows the Commission proposals then rates are either standard rated or reduced rated for both the service and the good, in which case a fixed amount subsidy outside the VAT system is both *best* and the *only* instrument that can be used. Or, the rate for the service can be lower than the good, in which case a fixed amount subsidy outside the VAT system is just the *best* instrument, including eliminating mixed supply problems.

Retail based with no strings attached or residence requirement
The second issue is whether the subsidy should be retail based provided to all consumers with no strings attached or requiring proof of domestic residence. The potential advantage of the latter option is that internal market consequences from cross-border shopping can be avoided. Second by making the subsidy depending on residence, one could at the same time require that the old inefficient appliance is retired: that is impossible with a non-conditional supply to all consumers at the retail level[19].

For consumers, retailers, suppliers and public authorities a pure no strings attached retail based system is the least costly to operate. There will slightly administrative higher costs if consumers have to verify address and other conditions, the retailer/supplier to take responsibility for the verification and public authorities the obligation to check it.

Overall evaluation of four subsidy variants
Our all summary of the four variants of instruments are then summarised in Table 2.6. Fixed amount subsidies have the lowest compliance costs and are most targeted. Residence based systems avoid internal market problems at the cost at some, but not necessarily large, compliance costs. The VAT instrument is the least targeted instrument possible while representing the largest compliance costs and internal market complications. So our recommendation is very clear *if* a subsidy is to be used:

- Use a fixed amount subsidy at the retail level available for all consumers for goods that have low “cross-border” trade potential see chapter 4

tion, maintenance and cleaning of housing and of places of worship and of cultural heritage and historical monuments recognised by the Member State concerned" This encompasses for example the supply and installation of insulation material. The Commission took the view that the supply of this service cannot be split into "the installation part" and "the materials part" and considers that "one single transaction" (and thus one rate) is envisaged here. The Proposal is currently under discussion in the Council (as well as in the EP and ECOSOC).

[19] It is important to note, though, that measures such as scrapping equipment with many years of useful service is not necessarily sensible in a broader economic context. A conflict may here arrive between efficiency -- useful exploitation of economic resource – with effectiveness - making sure that energy savings are reached. When you leave the narrow road of root taxation and uses specific instruments to further increase energy savings, it may be difficult to reconcile that with overall high levels of economic efficiency.

- Use a fixed amount subsidy with national residence verification for goods with high "cross-border" trade potential
- We do not see a VAT rate reduction as a first choice for any product.

Table 2.6 Evaluation of the four subsidy variants

<table>
<tr><th colspan="2"></th><th colspan="2">Method of distribution of subsidy</th></tr>
<tr><th colspan="2"></th><th>Retail based for all consumers</th><th>Only for residents of a country</th></tr>
<tr><td rowspan="2">Determination of subsidy level</td><td>Fixed amount determined by energy class</td><td>Good
High targeting
Low compliance costs for consumers
Low compliance costs for enterprises and government
Bad
Potentially internal market problems</td><td>Good
Targeting
Low compliance costs for enterprises and government
No internal market complications
Bad
Potentially more compliance costs for verification</td></tr>
<tr><td>Ad valorum subsidy based on energy class</td><td>Bad
Low targeting particular VAT version with inflexible subsidy level
Higher compliance costs (mixed supply problem)
Internal market problems</td><td>Bad
Low targeting particular in VAT version with inflexible subsidy level
Higher compliance costs (mixed supply problem)
God
No internal market problems</td></tr>
</table>

Box 2.4: Mixed supply related to housing sector – An illustration

For major installations such as new heating systems, there will inevitably be a joint supply of a service installation and equipment. If the VAT on the equipment is reduced while the VAT on the equipment remains unchanged then the service and the equipment will be separated tax wise, which allows households to gain from the lower VAT rate on the equipment. As a consequence, there is a risk that the price of the service from installers will be reduced, whereas the price of the equipment will be raised. Such a pricing strategy would decrease the overall price and thereby increase sales.

To see the logics behind the installers pricing behaviour, consider the following example:
A firm both sells and installs heating systems. Today the same VAT rate applies to both the physical equipment and the installation service. The firm charges € 2 000 euro for equipment and € 2 000 for installation exclusive of VAT, the VAT rate is 25 per cent which renders a cost of € 5 000 inclusive of vat. Now, the VAT rate on the equipment is reduced to 5 per cent while the VAT on the installation service is held constant. This results in a € 4 600 for the consumer, VAT on installation is still € 500 but the VAT on the equipment is reduced to € 100.

The firm would now benefit from lowering their prices on installation while increasing prices on equipment. If they charge € 4 000 for equipment and install it for free, the consumer price would be only € 4 200 while the firm has the same revenue. Hence, they are able to lower their prices by € 400 due to the VAT reduction and an additional € 400 by altering their pricing strategy.

The consumers do enjoy a reduction in price and the sales of heating systems with reduced VAT are likely to rise. These effects were most likely also the intention of the policymaker. However, the government's loss of tax revenue is € 800 per installed heating system instead of the intended € 400. Further, there are compliance costs due to, for instance, printing of new brochures and increased administrative burdens. The compliance costs fall on the installer.

UK
Where reduced rates are available under European VAT rules, these have been applied where they provide the most cost-effective and well-targeted support for the environmental objectives. For example, a 5 per cent, reduced rate applies to the installation of boilers that are designed to be fuelled solely by wood, straw and other vegetal matter; and to certain grant-funded installations of other boilers and heating appliances. Moreover, a reduced 5 per cent VAT applies to the installation of gas fired boiler plus radiators and pipe work in homes of poorer pensioners and the installation of "heating system measures" fitted in the homes of the less well-off. The reduced VAT rate is also widened to cover installation of energy saving materials in all homes. The cut in the VAT rate, from 17.5 per cent to 5 per cent applies to all insulation, draught stripping, hot water and central heating system controls that people pay to have fitted in their homes. *(HM Treasury Finance Bill 2000, clause 131)*

The introduction of reduced VAT rates on certain energy saving equipment is an extension of a reduced rate for a range of energy saving materials. The compliance costs of dealing with multiple VAT rates would most probably fall on installers, if they also install standard rated equipment.

France
Under the 2003 Finance Law, the reduced VAT rates apply to equipment for renewable energy production and use which is installed in primary or secondary residencies built for more than two years. The VAT rate is 5.5 per cent in France and Corsica and 2.1 per cent in Guadeloupe, Martinique and Reunion. The equipment must be bought from and installed by the same company.

Source: Copenhagen Economics Copenhagen Economics, UK Parliament (2007), UK financial secretary to the Treasury (2005)

2.5. Political economy problems with VAT and other subsidies

The effectiveness of reduced VAT will differ due to features underlying the promoted product – as well as issues with the design and implementation of labelling, and generic costs of operating a differentiated VAT system.

Implementing reduced VAT on energy efficient products carries certain costs of compliance applying equally to all products.

Standards and labelling must be binding (they cannot be voluntary) – there is a need to define legally binding standards for all products where reduced VAT is considered. Voluntary standards or labelling are not appropriate because of the risk of non-compliance and lack of enforcement. Tax authorities would obviously have difficulties operating a tax system if the goods to be taxed are not well defined. In other words, in order to apply a reduced VAT, all products must always carry a label identifying which VAT is due.

The need to have legally binding standards is not particularly a requirement of the reduced VAT – it would also be required for alternative instruments – but with VAT reductions there is more risk of entering into a political battlefield. A political level conflict could be that the government wants to safeguard tax revenues while business organisations push for a lower VAT for more goods in order to increase demand. In practice, a number of products are already subject to mandatory rules while more products are being constantly added. DG Transport and Energy monitors the status of implementation of efficiency and labelling criteria in the Ecodesign directives.

Producers of environmentally friendly goods have an incentive to provide labels that induce consumers to buy; they do however not share that incentive with non-environmental producers. So there is a risk that voluntary standards by market participants may be weakly developed or of poor quality. The ANEC (2007a) study reports that 20-30 per cent appliances found in shops investigated in the study were unlabelled. Furthermore, there is evidence in the same study of generally lax enforcement of labelling.

The binding efficiency and labelling criteria need constant and rapid revaluation to keep up with technological progress. Keeping the criteria fixed will result in greater penetration of a given efficiency standard due to technological progress – more technological progress means that more freezers will be classified as A++ if the criteria remain unchanged. As the prevailing standard increases, the share of the market receiving subsidies increases. Furthermore, producers lose the incentive to innovate once they reach the highest attainable label of efficiency. To maintain innovative drive, standards should be continually increased. Ad hoc solutions should be avoided; however, as ANEC (2007a) study contains evidence that introducing the A+ and A++ has sometimes led to confusing the consumers used to the old A-G scheme. Is the new A class – the third highest class – the same as the old C class?

In addition to the general compliance issues, there are several characteristics of the design and implementation of labelling schemes which apply universally to all products. Of these, specific problems with implementation of the labelling schemes and classical reduced rate problems are most important.

The ANEC (2007a) study documents some problems with the implementation of labelling on a product level. The main problems concern the quality of measurement due to the assumptions in measurement methodologies and the allowed range of measurement tolerances.

The problem is more prevalent in cases when a product has different 'modes of use'. For example, a compact fluorescent light bulb operates in an on and off mode, therefore it is relatively easy to measure energy consumption. A computer screen however has on, stand-by and off modes. Therefore, assumptions are necessary about the use of the on and standby modes. A photocopier has work, idle, standby, sleep and off (or more) modes, similarly washing machines have different programs with different energy uses. Measurement methodologies must take these aspects of use into account, which can be subject to debate.

Evidence in ANEC (2007) study shows large measurement tolerances which make it possible to classify a dishwashers and washing machines as A-class despite greater energy consumption than that formally required by the class. This is possible due to the size of permitted measurement tolerances, whereby the product correctly labelled A despite the excess energy consumption. The implication is that the wrong products may be promoted by reduced VAT is some specific cases.

2.6. Problems with increasing demand – rebound effects

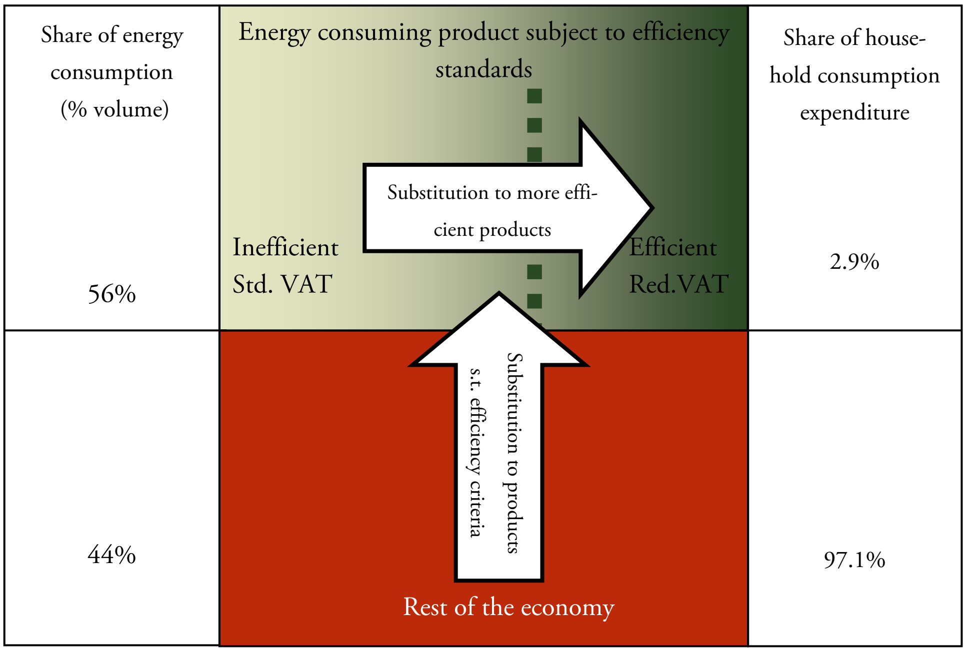
Promoting energy efficiency e.g. by means of the reduced VAT does not necessarily lead to lower emissions. Lower VAT functions to shift the stock of energy consuming appliances towards greater efficiency but this does not control for a rebound effect in terms of more use or more intensive use of these products – leading to more energy consumption and emissions.

Lower prices on energy efficient products increase the sales of energy efficient products and might also lower the share of the household budget that is devoted to the purpose of purchasing energy-consuming products. The latter effect depends on effect pulling in different effects. On the one hand, the lower VAT rates reduced the costs of buying an en efficient energy using product. On the other hand, the more efficient products have an upfront purchase before tax price premium that is often higher than the VAT reduction.

However, the shift towards more energy efficient variants does not ensure that the consumption of energy declines. This is because of the rebound effect. Lower prices of energy consuming products mean all other consumption, such as package holidays or garden furniture becomes relatively more expensive for the household. Therefore, the household substitutes part of its consumption of package holidays and garden furniture to buy more energy-consuming products – because the price of energy consuming products is relatively lower. Because of this substitution, energy use and emissions may increase rather than decline. In other words, the lower VAT inducing the move from inefficient to more efficient does not control for the possibility that energy consumption decreases less than the improvement in energy efficiency. This is the essence of the rebound effect[20], represented by the vertical arrow in Figure 2.2.

[20] If the improvement in energy efficiency leads to an increase in energy consumption, it is sometimes called a "backfire" effect.

Figure 2.2 Illustration of the rebound effect



Source: Copenhagen Economics, Bertoldi and Atanasiu (2007), Eurostat (2008)

The size of the rebound effect depends on the initial efficiency of the stock of energy consuming products prior to the promotion of energy efficiency through. In countries with a large share of energy inefficient products, the rebound effect from purchasing more energy efficient products is likely to be low. On the other hand, in countries where the stock of efficient energy consuming products is high, lowering the price of these products is more likely to lead to more purchases, and therefore the rebound is more likely. It follows that in countries where energy efficient products already constitute a significant share of the stock, further promotion of energy efficiency e.g. via VAT reductions is redundant. For example, in the Netherlands energy efficient boilers have a market penetration of about 90 per cent and hence a VAT reduction on such boilers would not have much effect on total energy consumption from boilers, cf. Box 2.5.

Box 2.5 Penetration of energy efficient boilers in the Netherlands

The Netherlands provides a case in point concerning the use of efficient condensing gas boilers. A significant amount of Dutch households do not have access to district heating and operate private heating systems based on natural gas boilers. In the mid-80s, the predominant technology was the non-condensing boiler, reaching maximum efficiencies in the range of 60-70 per cent. The more efficient condensing gas boiler technology was used by a small amount of households, primarily because plumbers were reluctant to install the new technology due to lack of expertise. Following a national information campaign targeted at the plumbers, the installation of more efficient boilers increased dramatically, such that currently, the penetration of energy efficient boilers in the country is in the order of 90 per cent. The high rate of penetration means that further promotion of boiler energy efficiency via reduced VAT in the Netherlands is redundant.

Source: Bertoldi & Atanasiu (2007), Kemna et al. (2007)

In fact, the penetration rate of energy efficient products varies notably across the European Union, cf. Table 2.7. This of course makes the task of the policymaker more complicated since a VAT reduction might make sense in one country but not in another. Energy efficient freezers are, for instance, common in e.g. Belgium, the Netherlands and Germany (red squares in the table) but not in e.g. Spain or Poland (green squares in table).

Table 2.7 Penetration rates of energy efficient products (rated A or better), per cent 2006

Country	Refrigerators	Freezers	Washing Machines	Dishwashers	Ovens	Domestic Lighting	Boilers
Austria	55	59	80	75	59	15	33
Belgium	78	76	96	95	61	10	16
Czech R.	66	50	80	88	43	21	10
Denmark	76	44	87	78	62	19	57
Germany	68	70	96	78	60	20	49
Estonia	68	4	75	78	39	2	9
Greece	53	40	75	87	39	8	0
Spain	37	7	63	69	23	8	0
France	63	37	79	88	67	12	5
Ireland	65	33	72	81	23	8	4
Italy	53	40	75	87	39	4	5
Cyprus	53	40	75	87	39	13	5
Latvia	67	4	67	78	39	3	7
Lithuan,	81	4	79	78	39	3	4
Luxemb.	78	76	96	95	61	10	16
Hungary	53	16	72	74	27	6	4
Malta	39	11	60	70	32	7	0
Netherla.	88	76	96	89	50	10	88
Poland	61	4	79	78	39	3	8
Portugal	39	11	60	70	32	15	0
Slovenia	58	25	77	78	39	11	8
Slovakia	69	44	70	78	39	7	15
Finland	76	44	87	78	62	4	1
Sweden	76	44	87	78	62	10	23
United K	65	33	72	81	23	10	24
Bulgaria	41	7	38	74	27	4	4
Romania	52	2	54	74	27	2	4

Note: High penetration (red) > 65%; Medium penetration (orange) 35%-65%; Low penetration (green) < 35%
Penetration rate of efficient Domestic lighting regards CFL and penetration of efficient boilers regards condensing boilers.
Source: Bertoldi & Atanasiu (2007), Kemna et al. (2007)

Based upon a recent extensive survey on rebound effects, we would like to stress three conclusions in the context of the quantification of such rebound effects[21]. The first conclusion is that existence of such rebound effects are well known from the empirical literature while at the same time subject to huge amount of discrepancy in terms of their magnitude.

[21] UKERC(2007)

The second conclusion is that rebound effect tends to be systematically downplayed in policy evaluations which tend to provide a too optimistic view of the potential of energy saving policies[22].

The third conclusion is that rebound effects from policy induced energy savings need to evaluated on a case-by-case and cannot be assumed to be in a specific narrow ex ante range. In this context, it is particularly important *to make a distinction between to types of rebound effects.*

The first type of rebound is identified in the classical literature on rebound effects, where focus is on the effects of technology improvements that reduces the consumption of energy during the lifetime of product. The rebound effects come then from two sources:

- Direct rebound: "the user costs" of cars, white goods etc. go down which through a relative price effect increases the demand for such products ("relative price" or "substitution effect)
- Indirect effects: the technology progress that allows reduced energy consumption represents genuine net savings for consumer. Such savings will lead to increased demand some of which, depending on income elasticity of such goods as cars, white goods, will go in the direction of energy using products ("income effect").

The review of rebound effect provides a very wide range of estimates for different type of household energy demand as well as confidence see Table 2.8. Rather than focusing on specific numbers, two qualitative issues are worth reminding. Consumers may react stronger over time to lower user costs with direct rebound. Moreover, rebound effects are larger when energy cost constitutes a larger part of total user costs, i.e. when running costs are important relative to purchase price. So rebound effects from energy efficiency gains are larger for washing machines than for computers and higher in the EU than in the US due to higher energy prices in the former region[23]. The review suggests that bringing in indirect effects as well, the total rebound may often exceed 50 per cent on an economy wide basis[24].

[22] UKERC (2007), executive summary page 1: "In general, rebound effects have been neglected when assessing the potential impact of energy efficiency policies. A key conclusion of this report is that rebound effects are of sufficient importance to merit explicit treatment. Failure to take account of rebound effects could contribute to shortfalls in the achievement of energy and climate policy goals".

[23] This suggest that studies focusing on the US market such as Grenning et al (2000) would underestimate the size of rebound effects from technology progress driven energy savings in EU.

[24] UKERC(2007) page 88.

Table 2.8 Estimates of the long run direct rebound effect for consumer energy services in the OECD, in per cent

End use	Range of values	"Best guess"	No. of studies	Degree of confidence
Personal automotive transport	5-87	10-30	17	High
Space heating	2-60	10-30	9	Medium
Space cooling	1-26	1-26	2	Low
Other consumer energy services	0-49	Less than 20	3	Low

Source: UKERC (2007), page 26

The second type of rebound effects will be realised in the kind of policy experiment that this study is focused on and differs in several important aspects from the traditional rebound effects. While the rebound effect above comes *from running costs* being reduced, it is the *purchase price* that is being affected here. Indeed, the whole rationale for policy experiment as explained in some detail in Section 2.2 that (some) consumers are more affected by up front economic incentives saving them funds here-and-now than on incentives working through the lifetime of the washing machine, boiler etc. Moreover, while energy savings in the traditional literature comes from technological progress saving energy, the effect of energy savings come from shifting the purchases towards energy efficient variants.

In short, it is a somewhat different set of parameters that determines the size of the rebound effect in this experiment relative to a situation with technology driven energy savings. We provide a numerical example of that in. Box 2.6, which shows that under certain conditions we can easily get rebound effects over 100 per cent with subsidy targeting efficient variants of energy using products ("backfire") where a more traditional technology improvement affecting the same energy using product would lead to clear energy savings.

Box 2.6 Classical and purchase price driven rebound effects

The classical rebound effect is driven by increased technological progress, increasing energy efficiency. The reduced user costs that are due to the increased energy efficiency encourage increased use of the energy consuming good. Studies from western European countries show that this rebound effect is often substantial, cf. Table 2.6 above.

The rebound effect that would stem from a reduced VAT rate would be of a different kind. The increased average energy efficiency would be due to a shift from the use of inefficient products towards the use of efficient products. The prices would have to be reduced in order to achieve the same increase in average energy efficiency. In most cases this price reduction would result in a larger reduction in user cost and hence cause a larger rebound effect.

The rebound effects estimated in the literature on classical rebound should therefore be viewed as a lower boundary for the expected rebound effect in this study.

The difference between the two drivers of rebound effect is illustrated below, where we provide a hypothetical example based on freezers in the Netherlands and the United Kingdom.

As to the classical rebound, imagine that all freezers would become more energy efficient so that their energy consumption would drop 5%. This increase in energy efficiency would render user costs to drop 2-3% depending on energy price and discount rate.

We now turn to the price driven rebound effect and calculate which price cut would lead to a 5% drop in energy consumption. In order to test the strength of our hypothesis, we assume consumers to be extremely price sensitive with respect to the choice between energy efficient and inefficient goods. We apply a substitution elasticity of 4 between efficient and inefficient goods.

We find that the user cost would have to be reduced by 17% and 26% in The United Kingdom and the Netherlands, respectively. Note that this would require a price reduction beyond the scope of what is feasible through VAT reductions, cf. table below.

Cost reductions necessary to reduce energy consumption by 5%, discount rate 5%

	Reduction in user cost	Reduction in purchase price
The Netherlands	26%	54%
The United Kingdom	17%	28%

A reduction in user cost in the range of 17-26% would naturally render a much larger rebound effect than a reduction in user cost of 2-3%. We draw the conclusion that, given a reduction in energy consumption, the price driven rebound effect is stronger than the classical rebound effect.

Larger user cost reduction gives a larger rebound effect. Our rebound is therefore expected to be even larger than the survey benchmark.

Note: Assumptions underlying the calculation; energy price UK €0,166 energy price NL € 0,283: life expectancy 11 years: difference in energy consumption between efficient and inefficient freezers 106 kWh/year: difference in purchase price between efficient and inefficient€ 267 in UK and € 106 in NL.

Source: EU Commission (2007), IVM (2008), NAHB/Bank of America (2007), Energy EU (2008) and IEA (2007).

CASE STUDY: VAT RATES ON PESTICIDES, FERTILISERS AND ORGANIC FOOD

The primary objective of this study is to review the role that VAT rate policy can play relative to environmental objectives. In this small case study we review in this perspective also VAT rates on pesticides, fertilisers and organic food but with the added element that the present use of reduced rates on pesticides and fertilisers have their motivation in other concerns such as reducing production costs for small farming in particular.

The case study then addresses the following three questions:

- Is reduced VAT rates on fertilisers and pesticides a cost-effective instrument to help small scale farming in view of alternative instruments an?
- Should reduced VAT rates on fertilisers and pesticides be restricted to 'environmentally friendly' plant protection chemicals, e.g. defined according to their low toxicity – taxing the remaining chemicals at the standard rat
- Is reduced VAT on organic foodstuffs – taxing the remaining foodstuffs at the standard rate – an effective instrument to encourage health and environmental objective

Reduced rates on pesticides and fertilisers to boost incomes in (small scale) farming
For most industries, a reduced VAT rate on inputs has no impact on income and output prices for the industry, as normally the input VAT is deductible from the output VAT. So there is no profit gain for the enterprises and not price gain for the consumer.

However, normally smaller and specialist farmers, have in a number of countries the option to operate within a special VAT system, under which they do not pay VAT on outputs, but are also not able to reclaim the VAT on inputs, cf. table 1. The system, however, provides flat-rate compensation for the "lost" VAT on inputs[25]. This compensation often de facto exceeds the "lost" VAT: a recent OECD surveys identified 8 countries with such special treatment schemes for farmers cf. Table 2.9. In such cases it is possible that farmers also benefit from reduced rates on input such as pesticides and fertilizers. However, the effect of this should be zero or very small as this VAT should normally be part of the flat-rate compensation as last mentioned.

[25] OECD (2005), p. 121, contains a comprehensive summary of the special provisions member states apply for the VAT treatment of inputs to and outputs from agriculture. The simplified VAT system allows farmers to operate with simplified bookkeeping which means that they do not charge VAT on outputs, but are also not able to reclaim VAT on inputs. Instead, they receive compensation – in different forms – for the VAT paid on inputs. According to OECD (2005), in many member states the simplified system overcompensates the farmers, de facto offering a subsidy.

Table 2.9: Special VAT treatment of farmers vs. reduced VAT on fertilizers/pesticides

		VAT on fertilizers and/or pesticides	
		Standard	**Reduced**
Special VAT treatment of farmers	**Not available**	Denmark, Finland, Slovakia, Sweden	Austria
	Available	Netherlands, United Kingdom	Belgium, Germany, Spain, France, Italy, Ireland

Note: Subsample of 13 member states: Austria, Belgium, Denmark, Finland, Slovakia, Sweden, France, Netherlands, Germany, Ireland, Italy, United Kingdom, Spain
Source: Copenhagen Economics, OECD (2005), DG TAXUD (2008)

So farmers applying the special VAT scheme benefit (partly) from reduced rates on pesticides and fertilisers in a number of countries. Within the EU, at least 6 countries combine these two options creating such effects cf. table 1, namely the countries marked with red.

We would, however, question whether reduced VAT on specific inputs – to the extent there would be a benefit for farmers anyway – is an effective way to support small scale farming. First, some of the benefits will be harvested by private consumers not only small scale farming. Second, the subsidy size for the individual small farmer is linked to the level of their consumption of these two products not the specific criteria that may have justified the subsidy such as low income generation, soil conditions, regional employment aims in remote rural areas etc. Thirdly, the budgetary support is highly non-transparent with the effect being a combination of being outside the standard VAT system and the size of the VAT reduction. Fourthly, it may raise standard compliance costs issues such as qualifying what exactly constitute a fertilisers or pesticide. Fifthly, it may create standard distortions relative to other standard rated inputs that may have the same effects on productivity etc.

Sixthly, there may an internal market dimension although it is likely to minor. First, small farmers constitute only a small part of the farming sector, implying that the cost reductions from reduced rates on pesticides and fertilisers should have only a smaller impact on the market. Second, direct effect on consumer purchase decisions must be absolutely limited as consumers do not do a lot of "cross-border" shopping for food.

In policy terms, a standard rate could be combined with a number of other instruments that would deliver the same objectives in terms of job/income creation in the specific sector namely agriculture or preferably by some other instrument that was not industry specific. So even the direct effect on jobs and growth from such an adjustment may well be zero.

Reduced rates only on less toxic variants of pesticides and fertilisers

A possible variant of having standard rates on all pesticides and fertilisers, is to promote less toxic chemicals by keeping them reduced rated – while punishing the use of toxic fertilizers with the standard rate. We see two main problems with this approach.

Firstly, according to OECD (2007), pollution from pesticide or fertilizer misuse is localised – e.g. more significant in certain regions of e.g. Netherlands, Denmark or the UK, – so it needs to be addressed in the precise areas where it is a problem. VAT is not geographically constrained; therefore it will fail to fully bring in the required effects in the relevant areas. Because of its general geographic incidence, reduced VAT may also create adverse incentives e.g. to avoid fertilizer or plant protection chemical use in areas or cases where their increased use is rational – e.g. in farms achieving high yields. A tax scheme can target the root cause of the problem more directly. For example, in Denmark – in addition to taxing fertilizer purchases with a dedicated tax – there are limits on nutrient concentration in soils for individual farms – to prevent fertilizer misuse. The system has been effective in meeting the target of decreasing the so called 'nitrogen surplus' without affecting the level of agricultural production.

Secondly, the environmental cost of pollution from fertilizers or plant protection chemicals increases exponentially with their misuse. Once the nutrient or a protective chemical concentration exceeds a certain threshold, it no longer increases crop yields but pollutes groundwater, drinking water sources, causes eutrophication and other pollution, cf. OECD (2007). In contrast to specific taxes, the VAT is not able to punish misuse of fertilizer in production stronger than its correct use. In Denmark, farms exceeding limits of nutrient concentration in soils are subject to heavy fines – on top of the tax already paid for fertilizers and pesticides use. The thresholds are set to prevent nutrient leaching whose likelihood varies between agricultural produce and local conditions, such as soil fertility or climate conditions. Because the Danish tax scheme works on the farm level, it is able to take local specificities into account – and punish misuse accordingly. A reduced VAT on organic food, on the other hand, cannot guarantee a similar degree of precision in punishing the specific polluters.

Reduced VAT rates for organic food for environmental reasons

An alternative to taxing input chemicals is to give VAT advantages to organic food. Organic foodstuffs are produced according to standards defining – among other things – maximum levels of use of fertilizers and plant protection chemicals – chosen to limit environmental pollution. Currently, no countries identify organic foodstuffs in their VAT systems.[26] However, there are both practical and more general problems with this approach. At the practical level, most foodstuffs are often reduced rated in EU with some exceptions for processed foods in some member states.

Taxing foodstuffs with the reduced VAT already creates an implementation problem. To promote organic foodstuffs, it follows that either a reduction to a super-reduced or zero VAT would be necessary – or an increase of the non-organic food rate to the standard level. Reductions to super reduced or zero will bring about relatively low price differentials because of the relatively small differences between reduced rates and super-reduced or zero rates. The retail price differential favouring organic foodstuffs are too small for farmers to justify a shift to organic farming.

[26] Italy uses a reduced rate on *inputs* to organic agriculture.

Increasing the VAT on non-organic foodstuffs to the standard level may bring about larger price differentials. But it will also be more difficult to reconcile with income distributional objectives – the reason why many member states apply the reduced rates on foodstuffs in the first place. The basic general problem will remain the fact documented above that the negative impact is highly associated with its use on a very local level which VAT rate policy can be definition not address.

There are other problems, in addition. Several national case studies documented in OECD (2007) give support to the intuition that especially VAT reductions on organic foodstuffs are ineffective in addressing the root cause of pollution in agriculture stemming from misuse of plant protection chemicals or fertilizers For example; organic wheat can be processed into relatively inexpensive organic flour or relatively expensive organic bread. With a generic VAT reduction on organic food, a client buying a kilo of organic bread will save more Euros than a client buying a kilo of organic flour. But the higher saving on bread may not necessarily be justified by larger environmental benefits from the avoided use of pollutants in making a kilo of organic bread. The larger saving from reduced VAT on bread may be due to the fact that a lot of value is added by the use of expensive distribution channels, for example. However, a client may react stronger to the larger monetary decline in prices, and therefore increase the consumption of bread – leading to more production of bread – and diminishing environmental benefits.

Another related aspect of the ad valorem nature of the VAT is that high income consumers buying more expensive bread will benefit more than lower income consumers buying less expensive bread. Thus, the low income consumers are likely to bear the burden of reducing the VAT on both varieties of bread.

Reduced rates for organic food to encourage a healthy lifestyle

According to the WHO, overweight and obesity contribute to a number of diseases, including diabetes, cardiovascular diseases and cancer.[27] Unhealthy nutrition habits are more prevalent in low income, low education groups, in rural settings. A study by DG Health and Consumers established that wrong nutrition habits become a key cause of preventable deaths, currently on par with but set to outpace smoking soon.[28] Can reduced VAT on healthy foods be used to promote a healthy lifestyle to reduce the societal cost of disease treatment? In principle, reduced VAT can be used to promote 'healthy foods' such as fruit or vegetables, while standard VAT can punish 'unhealthy foods' such as sugars or fast-food. Indeed, UK and France already use differentiated VAT on foodstuffs applying the standard rate on highly processed foods, such as ready meals, chocolate or ice cream, while using the reduced or zero on the rest.

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[27] WHO (2008); http://www.who.int/topics/obesity/en/

[28] In Denver and Smed (2004)

But according to Dejgård Jensen (2007), there is no guarantee that reduced VAT automatically translates into to a healthy lifestyle, although it may somewhat contribute to it. Reduced VAT may increase consumption of healthy foods overall, but it is less effective in targeting the socio-demographic, income or geographic groups with poor dietary habits. Furthermore, reduced VAT on healthy foods does not diminish consumption of unhealthy foods. Furthermore, the VAT does not affect other aspects of a healthy lifestyle, such as exercise. Finally, economic costs of reduced VAT on healthy food will be skewed across social groups since those with unhealthy nutrition habits will bear larger costs.

Denver and Smed (2004) using data on foodstuff consumption of 2000 Danish households in 1997-2000, document that VAT reductions change dietary habits in the desired way, although fall short of affecting the groups with the worst habits to a sufficient degree[29]. Reduced VAT does increase consumption of vegetables and fruits. But reduced VAT is not effective in promoting all types of healthy foods, e.g. fish and poultry. Reduced VAT may also lead to unintended increase in consumption of unhealthy foods, such as sugar, in which case it is recommended to tax their consumption. Therefore, the study concludes that a combination of reduced VAT and taxes targeting unhealthy foods is the most effective economic instrument in achieving the objective of greater consumption of healthy foodstuffs across different groups.

However, even such a combination system may be difficult to implement in practice. Firstly, a clear distinction between healthy and unhealthy foods will be necessary at the right level of aggregation, which is complicated and costly. For example, should consumption of sweet potatoes containing more carbohydrate calories – on health grounds – be punished vis-à-vis regular potatoes?[30]. Moreover, even if sugar becomes punished with a standard VAT, the price of sugar containing foods may increase by an amount insignificant to produce any changes in consumer behaviour. The VAT structure may also give incentives to adjust contents of processed foods in a way to gain the subsidy while not necessarily improving their dietary characteristics. Furthermore, according to Dejgård Jensen (2007) taxes on unhealthy foods may increase consumption of untaxed unhealthy foods – thus all foods will need to be taxed – possibly leading to less customer choice. Finally, distribution of economic costs will be skewed as high income households consuming more e.g. expensive organic truffles are likely to benefit from VAT reductions to a larger degree than low income households purchasing cheaper organic carrots.

The overarching conclusion from the literature review is that the use of reduced VAT does bring about changes in the structure of foodstuffs consumption but may not be an effective in achieving health objectives. Nor is reduced VAT alone an efficient way to do it.

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[29] Alternatively, the groups consuming healthy

[30] One possibility to improve the precision of the VAT is to promote 'healthy substances' such as fibre with reduced VAT, while using standard VAT to punish 'unhealthy substances' such as sugars, cholesterol, or saturated fats – instead of 'entire' foodstuffs such as potatoes.

Chapter 3 | Overall results on energy consumption and public finances

The purpose of the chapter is to assess overall effects that the changes in VAT rates related to energy consumption and energy consuming products may have, on energy consumption and income distribution as well as VAT revenues. In section 3.1, we define the two main types of scenarios investigated in this study and the model used to review effects. In section 3.2, we describe the effects of the removal of VAT rate reductions on the consumption of heating and electricity on energy consumption, public finances and the distribution of income. In section 3.3, we describe the environmental and income distribution effects of a mandatory EU-wide reduction in VAT rates on energy efficient goods.

3.1. Scenarios for VAT rate changes and model used

To analyse the national effects, as well as internal market aspects of differentiation of VAT rates, we have defined a number of scenarios of possible changes to the present set of configuration of VAT rates in member states, which reflect more general options as well as more specific changes that member states have put forward or considered, either nationally or in the context of EU as discussed in preface and summary of findings.

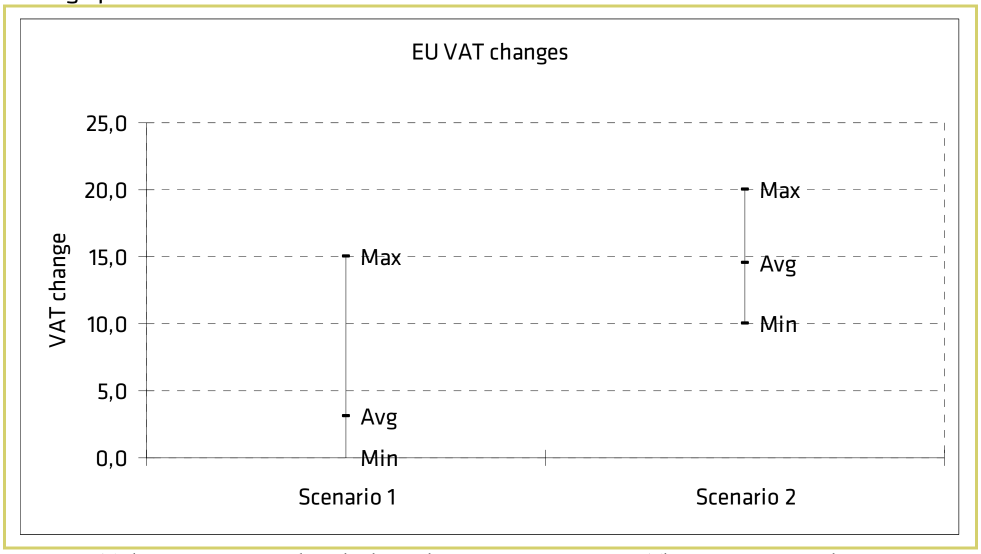
In this chapter we analyse two scenarios or policy options in which the VAT is changed in order to reduce the emissions of greenhouse gasses.

Removal of VAT reductions on energy In scenario 1, all EU countries remove all present VAT reductions on the use of heating and electricity and replace them by the country specific standard rate. Currently VAT reductions on the use of heating and electricity can be found in many countries of the European Union, and often the VAT rates on heating and electricity are markedly lower than the standard VAT rate. For example, in UK the VAT rate on heating consumption is 5.25 per cent, while the standard VAT rate is 17.5 per cent.

Mandatory VAT reductions for environmental friendly goods In scenario 2 all European Union countries reduce the VAT rate on environmental friendly goods, which are energy efficient household appliances, energy efficient consumer electronics, energy efficient boilers and organic foodstuffs. This results in an EU-wide VAT rate for these goods of 5 per cent.

The change in VAT rates in each of the scenarios is different for the different countries of the European Union. First, the countries have different standard rates, so when e.g. the VAT rate on consumption of heating and electricity is set to standard rate it implies different levels for the countries. Second, in the case of scenario 1 the countries have widely differing starting points, because they charge different VAT rates on energy consumption, and because the VAT rate on energy consumption is often different for consumption of heating and electricity.

Figure 3.1 Maximum, average and minimum VAT changes in different scenarios, percentage points



Note: VAT changes are measured in absolute values or percentage points. The average is a simple average across the countries of EU27. "Max" means "maximum", "Avg" means "Average", "Min" means "minimum".
Source: Copenhagen Economics.

Scenario 1 has the highest differences between countries in the VAT changes cf. figure 3.1. These range from 0 to 14 percentage points as some countries do not have any reductions on the VAT for energy goods, while others have large reductions. However, scenario 1 also has the lowest average VAT change of the scenarios. Scenario 2 has the highest average VAT change for all the European Union, but still with a large variation.

The computable general equilibrium model

In order to take into account all the factors which affect energy consumption, we have developed a model Europe; a mathematical model of the European economy specifically constructed to provide insights into the best choice of VAT rates in Europe. The model is called the Copenhagen Economics VAT Model (CEVM) and it encompasses a detailed description of the economies of the 27 member states in 2008, including a very detailed representation of the current VAT structure, cf. Box 1. The CEV-model can be used to simulate how the European economy would react to changes in the VAT system, and on this basis we can calculate the change in energy consumption.

The CEV-model has an economic structure and an economic motor that together determine the outcome of the simulations we are going to conduct.

The model has eight sectors which represent all economic activity of the European countries. They have been set up to focus attention on the goods targeted for derogations. Thus, in the model there is a separate economic sector producing e.g. boilers, fossil fuels and household appliances.

The economic motor is a classical global, multi-sectoral, general equilibrium framework capturing both the direct effects on sectors targeted by VAT changes and the indirect effects on their suppliers, consumers and competitors. Price elasticities are different between sectors and chosen on the basis of a literature search.

Box 3.1 Modelling differentiated VAT rates

The CEVM is a global, multi-regional, multi-sector, general equilibrium model, and is specially designed to study the economic effects of VAT policies. The model captures all linkages between the different sectors of the economy, and it therefore allows for an economy-wide assessment of VAT policies. Specifically, the model captures both the direct effects on sectors targeted by the specific policy, and the indirect effects on their suppliers, consumers and competitors. Therefore, the model is suitable for answering a question such as how large is the total economic cost of a VAT reduction when taking into account all spillover effects.

The model represents all current 27 EU Member States. The rest of the world is aggregated into a single region labelled *Rest of the World*. Each of the regions has a representative consumer, a government and a production sector for each of the 8 sectors included.

The households in the model economy consume a group of energy goods, which are subdivided into energy efficient and non-energy efficient goods. These energy goods are household appliances, consumer electronics, boilers and other energy goods. As input to these goods, the households also consume fossil fuels and electricity.

Besides, model households consume non-energy goods in the form of food, which can be organic or non-organic, and other goods.

The GTAP database, version 6, provides the majority of the data for the empirical implementation of the model. The database is the best and most updated source of internally consistent data on production, consumption and international trade by country and sector, and is based on detailed national accounts and balance of payments data from both national sources and international organisations. The CEVM therefore draws directly on the state-of-the-art in global databases for general equilibrium analysis.

Assumptions about the degree of substitutability between energy efficient and non-efficient appliances become crucial for both the direction and size of the effects. We have looked through the related literature to find plausible estimates of the key parameters. Based on this search, we find it reasonable to assume that the substitution elasticity between energy efficient and non-energy efficient goods is in the neighbourhood of 3. A specific set of experiences, which lend support to this assumption, was found from the Polish IFC/GEF efficient lighting project, where fluorescent light bulbs were subsidized to help market penetration of these more energy efficient light bulbs.[31]

Similarly, the assumed elasticity of substitution between energy and non-energy goods is crucial for the response of total energy consumption to changing average prices of energy goods. We assume in line with the literature that the substitution elasticity is 0.8 (see Conrad and Löschel (2005)).

Source: Copenhagen Economics.

Avoiding technical issues, the following features of the calculations are worth underlining:

- We are measuring long term effects.
- We assume full pass-through of VAT changes to prices in all sectors. This stems mainly from two conclusions. First we find this to be by far the most likely reaction in most industries in a long term perspective as discussed in Copenhagen Economics (2007). Secondly, we do not possess sufficiently precise information to allow us to define different levels of pass-through with any reasonable certainty.

[31] The numbers are approximations based on findings in PELP (1998).

- The chosen balancing of public finances, when changing individual VAT rates, is an adjustment of the standard VAT. There are two reasons for this. First, it clarifies that the central issue here is the net benefit of having higher or lower VAT across different goods and services. Adjusting by way of income taxes, lump sump transfers etc. raises larger issues about the most appropriate tax structure and the relations between parts of the tax system which lie beyond the scope of the present study.

- None of the standard VAT rates can be below 15 per cent in the scenarios. For countries where this is the case the standard VAT rate is set to 15 per cent.

3.2. Scenario 1: Standard rates on heating and electricity

In the following, we first describe the trade-off between achieving income distribution and environmental objectives by changing the VAT rate. Then we present a typology of European Union countries according to their present usage of VAT reductions for energy consumption. Finally, we present results of implementing scenario 1 on energy consumption and the distribution of income.

Income distribution concerns are important reasons why many countries of the European Union apply reduced VAT rates to energy consumption. Energy is consumed in almost equal quantities by both low and high income households in the European Union. Therefore VAT on energy consumption places a relatively larger economic burden on low income households than on high income households, and a reduction in VAT on energy consumption can help achieve objectives of a more equal distribution of incomes.

On the other hand reduced VAT on energy consumption is a stimulus to the consumption of energy, resulting in higher consumption of energy and increased emissions of greenhouse gasses. Hence, a reduced VAT on energy consumption works against the achievement of environmental objectives of the individual countries and of the European Union.

Finally, reduced VAT rates on energy consumption has a range of other effects in terms of administrative burdens for the tax authorities and reduced innovation activity in the area of environmental friendly products.

It is useful to group the countries of the European Union according to their use of reduced VAT on energy consumption because the effects of scenario 1 are different for the groups, cf. Table 3.1.

Table 3.1 Country groups according to use of reduced VAT

	Reduced VAT on electricity consumption	**No reduced VAT on electricity consumption**
Reduced VAT on heating consumption	**Group C**: Greece, Ireland, Italy, Latvia, Luxembourg, Portugal, United Kingdom	**Group A**: Austria, Belgium, Estonia, France, Germany, Hungary
No reduced VAT on heating consumption	**Group B**: Malta	**Group D**: Bulgaria, Cyprus, Czech Republic, Denmark, Finland, Lithuania, Netherlands, Poland, Romania, Slovakia, Slovenia, Spain, Sweden

Source: Copenhagen Economics.

Scenario 1 can be expected to lead to a reduction in total energy consumption in the EU. This is because energy consumption either in the form of heating or electricity consumption becomes more expensive, which makes households reduce their consumption of energy.

The effects of scenario 1 on the consumption of the components of energy, electricity and heating, depend the absolute change in the VAT rates on electricity and heating in the different countries, and the change in the size of the VAT rate on heating relative to the VAT rate on electricity. The absolute increase in the VAT rate leads to reduced consumption of heating or electricity. On the other hand, the change in the relative VAT rates may lead to an increase in the consumption of either heating or electricity. That is because heating and electricity are to some extent substitutes, and if e.g. the VAT rate on electricity increases much more than the VAT rate on heating, the consumption of fossil fuels for heating may increase. An intuitive reasoning is linked to the fact that electricity can indeed be used for heating.

Table 3.2 illustrates the changes in the absolute VAT rates and the relative VAT rates. For example, in country group C the VAT rate on electricity relative to the VAT rate on heating increases.

Table 3.2 VAT changes by country group in scenario 1, percentage points

Country group	**Standard rate, per cent**	**Average reduction in VAT, percentage points**	
		Heating	**Electricity**
A	19.4	2.5	-
B	18.0	-	13.0
C	18.6	9.8	11.0
D	20.4	-	-
EU average	19.5	3.8	3.3

Note: The results presented in this table relate to scenario 1, where VAT reductions on heating and electricity are removed.
Source: Copenhagen Economics.

The change of VAT rates has important effects which go beyond the markets for electricity and heating.

One important such general equilibrium effect comes through the balancing of the public budget: When the VAT rates on electricity and heating are increased, public revenue increases, allowing for increased public expenditure or lower taxes in other areas. Based on the considerations in Copenhagen Economics (2007) we assume that the increased VAT revenue is used to lower the standard VAT rate. The reduced standard VAT rate primarily leads to higher consumption of non-energy goods, but may also lead to an increase in the consumption of energy goods.

Another important general equilibrium effect is that the decrease in households' energy consumption leads to a reduction in the price of fuel. This is likely to increase the demand for fuel by industry, including power generation but also to improve current account position of the EU.

Effects of scenario 1 on energy consumption

Country groups A and C, which implement the VAT increases in scenario 1, experience a decline in energy consumption cf. Table 3.3. The countries of group C implement the largest VAT increases and experience the largest declines in energy consumption. The average effect on the entire EU is a decline in energy consumption of 0.8 per cent.

Table 3.3 Effects on household energy consumption, 2008, per cent

Country group	Effects on energy consumption
A	-0.8
B	-
C	-1.4
D	0.0
EU average	-0.8

Note: The results presented in this table relate to scenario 1, where VAT reductions on heating and electricity are removed. The results in the table concern only electricity and heating. No effects are estimated for Malta due to lack of data. Note: The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.

Source: Copenhagen Economics.

The size of the effects is sensitive to the assumed substitutability between energy goods and non-energy goods. The more consumers are willing to substitute non-energy goods for energy goods, the greater will be the effect of scenario 1 VAT derogations on energy consumption, and vice versa. An important parameter here is the so-called "elasticity of substitution" between energy goods and non-energy goods. In our main scenarios this elasticity is set to 0.8. If it were changed to 0.3, the effect of scenario 1 on energy consumption would be a decrease of 0.3 percent.

Distributional effects

Low income groups will experience a worsening of their household budgets, while high income families will gain. This is because energy accounts for a larger share of the budget in low income quintiles than in the high income quintiles. On average, in the EU27 the lowest income quintile spends 1.5 percent more on energy than the highest income quintile, cf.

Table 3.4. Therefore the direct effect of higher VAT on energy consumption is likely to be a relatively greater increase of household expenditure for poor households.

Table 3.4 Consumption shares of energy for five income quintiles, EU26, 2005, per cent

Sector	Quintile1 (lowest income)	Quintile2	Quintile3	Quintile4	Quintile5 (highest income)	Quintile1 / Quintile5
District heating	0.6	0.6	0.6	0.5	0.4	1.5
Electricity	2.1	2.2	2.0	1.8	1.4	1.6
Gas	1.1	1.1	1.0	0.9	0.6	1.7
Heating oil	0.7	0.7	0.6	0.5	0.4	1.7
Solid fuel	0.4	0.4	0.4	0.3	0.2	1.6
Transport fuel	2.1	2.9	3.3	3.6	3.3	0.7
Total energy, net of transport fuel	4.8	4.9	4.5	4.0	3.0	1.6

Note: Per cent of total household expenditure. COICOP structure of household expenditure, 2005. Czech Republic excluded due to lack of data. Quintile 1 is the poorest / Quintile 5 is the richest. Countries are weighted by size of final household expenditure.

Source: Eurostat and Copenhagen Economics.

The actual effects confirm that the incidence of VAT increases is largest on the lowest income quintiles, although the absolute size of the effects is small. In the group of countries with a reduced rate on energy used for heating, the loss of the lowest income quintile is about 8 times the gain of the richest quintile household. The same ratio of losses to gains in the groups of countries with reduced VAT on electricity and both electric and heat energy is about 4. The average for the EU26 is only about 3.5, since a significant number of countries do not have reduced VAT on energy and therefore the scenario has no effects in these countries.

The small size of the effect is partly due to the small initial shares of energy consumption e.g. relative to expenditures on food, and partly due to the gains from the reductions in the standard VAT rates which are required by the assumption of a balanced public budget.

Table 3.5 Removal of reduced VAT on energy

Country group	Income quintile				
	Quintile1 (lowest income)	Quintile2	Quintile3	Quintile4	Quintile5 (highest income)
A	0.02	0.02	0.00	-0.01	-0.03
B	-	-	-	-	-
C	0.05	0.06	0.03	-0.01	-0.12
D	0	0.00	0.00	0.00	0.00
EU 27 average (unweighted)	0.02	0.03	0.01	-0.01	-0.05

Note: For each country group we calculate the difference in the percentage change in COICOP consumption expenditure between the poorest and richest income quintile households. Czech Republic is excluded due to lack of data. Country group A encompasses Austria, Belgium, Estonia, France, Germany and Hungary. Group B contains Malta. Group C encompasses Greece, Ireland, Italy, Latvia, Luxembourg, Portugal, and United Kingdom. Group D contains the remaining EU27. The values are to be interpreted as the percentage change in consumption expenditure under a given scenario relative to the baseline. A positive value indicates an increase in consumption expenditures relative to baseline.

Source: Copenhagen Economics

VAT revenue effects

Scenario 1 results in increased VAT revenues for the countries that raise VAT rates on electricity and heating, c.f. table 3.6. The effects are between one and approx. three per cent increase in VAT revenue. The revenue gain is largest in group C where the absolute VAT change is the largest.

Table 3.6 VAT revenue gains with removal of rate reductions on energy consumption

Country group	Aggregate VAT revenue gain (€ million)	VAT revenue gain, percentage change relative to baseline VAT revenue	VAT revenue gain, percentage of GDP
A	454	0.14%	0.01%
B	-	-	-
C	2944	1.18%	0.08%
D	0	0.00%	0.00%
EU aggregate	3398	0.64%	0.03%

Note: The total effect captures the changes in VAT revenue as a result of the VAT rate changes in scenario as well as the dynamic adjustment in VAT bases due to substitution between heat and electric energy and away from energy consumption into the rest of the economy. The total effect is calculated as a percentage increase over the benchmark VAT revenue. 1.18% means that VAT revenue increases due to the Scenario, prior to rebalancing the public budget. No effects are calculated for Malta due to lack of data. Note: The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.

Source: Copenhagen Economics and Eurostat.

3.3. Scenario 2: Reduced rates on energy efficent energy using products

In this subchapter we review the effects on energy consumption from applying reduced rates to energy efficient goods reviewing effects mainly on energy consumption and public revenues.

Heating (boilers)

We first review the effects on domestic boilers used for heating. The change in VAT rates affects heating consumption in two ways:

- The within group effect
- The rebound effect (or between group effect)

The within group effect refers to the change in the share of energy efficient boilers out of the total market for boilers. The direction of the within group effect in isolation is generally a lower heating consumption, because for a given total consumption of boilers, an increase in the market share of energy efficient variants leads to a decline in heating consumption. The size of the within group effect depends on four things, i) the substitutability between energy efficient boilers and conventional boilers – the substitution elasticity, c.f. Box 3.1, ii) the market share of energy efficient boilers prior to the VAT derogations, iii) the difference in energy consumption per unit of energy efficient boiler relative to the energy consumption of a conventional boiler and iv) the size of the VAT change.

The rebound effect refers to the change in the consumption share of energy goods relative to other consumption groups when the average price of energy goods changes. The direction of the rebound effect in isolation is to increase heating consumption. The size of the rebound effect depends on i) the substitutability between energy goods and other consumption groups, ii) the consumption share of energy goods, iii) energy goods' share of total energy consumption and iv) the size of the VAT change. We have already in chapter 2 discussed why the rebound effect from this type of policy experiment may be larger than orders of magnitude from the rebound that follows from technological progress that enhances energy efficiency of different product groups.

To assess the importance of the market share of energy efficient boilers prior to the VAT derogations it is useful to classify the European Union countries according to this initial market share.

Table 3.7 Classifying EU-countries for the heating analysis

Grouping according to market share of efficient boilers			
Group 1, first quartile: Sweden, United Kingdom, Austria, Germany, Denmark, the Netherlands	**Group 2, second quartile:** Poland, Slovenia, Estonia, Czech Republic, Slovakia, Belgium, Luxembourg	**Group 3, third quartile:** Romania, Ireland, Lithuania, France, Italy, Cyprus, Latvia	**Group 4, fourth quartile:** Malta, Portugal, Spain, Greece, Finland, Hungary, Bulgaria

Note: Malta and Portugal have a share of efficient boilers=0, as no division between efficient and non-efficient boilers exists.

Source: Copenhagen Economics.

The countries of the European Union overall have relatively low market shares of energy efficient boilers. This implies that for small absolute reduction in the VAT rate of energy efficient boilers the change in the number of energy efficient boilers will be small and the decline in the number of conventional boilers will be large. The net effect of this change on heating consumption depends on the energy efficiency of the two groups of boilers and the size of the VAT change.

Table 3.8 Characteristics of the country groups

Country group	Average in group, market share, per cent	Average in group, consumption share of boilers, per cent	Energy consumption of energy efficient variant relative to conventional variant, per cent
Group 1	46	0.6	76
Group 2	12	1.3	87
Group 3	5	0.6	88
Group 4	2	0.5	88

Note: Note: Malta and Portugal are excluded in Market share average as there is no division between efficient and non-efficient boilers in these countries. Malta is excluded in consumption share. The shares are denoted in percentage of volume.
Source: Copenhagen Economics.

The energy efficient boilers in the European Union countries are generally about 10 per cent to 25 per cent more energy efficient than conventional boilers. On the other hand, for the Netherlands, energy efficient boilers are about twice as energy efficient as conventional boilers. This is smaller than is the case for household appliances and consumer electronics, c.f. next subsection. In isolation this lessens the expected effect of the VAT derogation on heating consumption.

Finally, the size of the VAT change is generally large. This serves to magnify the expected reduction in the heating consumption.

The different factors which determine the size of the rebound effect have different implications for the size of the rebound effect. Energy goods constitute a relatively small part of the total consumption; hence the total quantity of energy goods will only increase a little in response to a VAT change. On the other hand, the share of energy consumption by energy goods is very high, which works to ensure a large rebound effect. The large change in the VAT rate also works to ensure a large rebound effect.

Scenario 2 leads to a reduction in the total heating consumption in the EU, c.f. Table 3.9. The reductions are largest in the Netherlands and Denmark. In the case of group 1, which includes among others the Netherlands, Germany and Denmark, the relatively large VAT reduction in combination with a high initial market share of energy efficient boilers appears to drive the large effects. On the other hand, in group two the low market share of energy efficient goods means that the effect is smaller than in group 1, even though the VAT decrease is larger. In group 3 the effect is smaller than in group 1 and 2 because of a smaller VAT reduction and a smaller market share of efficient goods.

Table 3.9 VAT change and effects on heating consumption in scenario 2

Country group	Average VAT change , percentage points	Effects on heating consumption, percentage change
Group 1	14.3	-2.8
Group 2	15.6	-1.8
Group 3	12.6	-0.9
Group 4	13.5	-0.9

Note: Bulgaria, Malta and Romania excluded in VAT change due to lack of data. The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.
Source: Copenhagen Economics.

The results in Table 3.9 are sensitive to assumptions made about consumers' willingness to substitute energy efficient variants of boilers for conventional variants, and on the willingness to substitute energy goods for non-energy goods. The substitution elasticities which underlie the results presented in this report are 0.8 for energy goods vs. non-energy goods and 3 for efficient variants of boilers vs. conventional boilers. The total effect on heating consumption using these assumptions is a decrease of 1.9 percent cf. Table 3.9. If instead the substitution elasticity between energy efficient variants and conventional variants of energy goods were set to 2 or 4, then the total effect on heating consumption would be a decrease of respectively about 1.4 percent or about 2.5 percent. If the substitution elasticity between energy and non-energy goods were set 0.3 then the decrease in EU heating consumption would be 2.8 percent.

Effects on electricity consumption

The approach to analyse the effects of scenario 2 on electricity consumption is the same as the approach used for the analysis of the effects on heating consumption. First, the countries of the European Union are classified according to the market share of energy efficient household appliances and consumer electronics. Then the share of energy goods and the relative energy efficiency of the different groups are described, and finally the size of the VAT change in the different country groups is described.

Table 3.10 Classifying EU-countries for the electricity analysis, scenario 2

Grouping according to volume market share of efficient household appliances and consumer electronics			
Group 1, first quartile: Luxembourg, Belgium, the Netherlands, Germany, Denmark, Sweden, Finland	**Group 2, second quartile:** Czech Republic, France, Austria, Cyprus, Slovak Republic, Greece, Italy	**Group 3, third quartile:** Slovenia, United Kingdom, Lithuania, Ireland, Estonia, Poland, Latvia	**Group 4, fourth quartile:** Hungary, Portugal, Malta, Romania, Bulgaria, Spain

Source: Copenhagen Economics.

In general the market share of energy efficient variants of household appliances is high in the countries of the European Union, and for the purposes of modelling it is assumed that the market for consumer electronics shares the features of the market for household appliances in this respect. We would expect this to imply that the effect of scenario 2 on the total number of household appliances and consumer electronics sold, is larger than the effect of scenario 2 on the number of boilers sold. This increases the likelihood that the total electricity consumption will increase, in spite of the change in the market share in favour of energy efficient variants.

The high budget shares of household appliances and consumer electronics also indicates a large rebound effect, because the VAT reduction implies a large saving of expenditure for households. This saving can be used to buy energy consuming goods.

Table 3.11 Characteristics of the country groups

Country group	Average in group, market share per cent	Average in group, share of household appliances and consumer electronics, per cent	Energy consumption of energy efficient variant relative to conventional variant, per cent
Group 1	76.3	2.2	38.7
Group 2	60.6	2.3	50.8
Group 3	55.9	1.6	53.0
Group 4	40.1	1.7	60.8

Note: Malta excluded in share of energy goods due to lack of data.
Source: Copenhagen Economics and Bertoldi and Atanasiu (2007a).

The groups do not differ a lot with respect to the improved energy efficiency of energy efficient variants relative to conventional variants, but the general level of energy efficiency is high for the energy efficient variants. The gain from improved energy efficiency can thus be expected to be relatively large for a given shift in the market shares in the direction of more energy efficient goods.

The size of the average VAT changes do not differ much between the different country groups, hence the differences in VAT changes cannot be expected to make a significant difference in the effects on the country groups. However, the average sizes of the VAT changes are relatively large, implying that the effect on sales of household appliances and consumer electronics can be expected to be large.

Table 3.12 Average VAT changes and effects on electricity consumption in scenario 2

Country group	Average VAT decrease, 5%, percentage points	Effect on electricity consumption, per cent
Group 1	15.3	0,7
Group 2	14.6	0.5
Group 3	13.7	0,3
Group 4	12.6	0.1

Note: Bulgaria and Romania excluded in VAT decrease due to lack of data. . The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.
Source: DG TAXUD (2008)

Scenario 2 leads to an increase in electricity consumption as shown in Table 3.12. This is a rebound effect: The countries with large market shares of energy efficient household appliances increase their consumption of electricity the most. Thus, even though there is a gain in average energy efficiency within the group of energy products, total energy consumption increases. The large rebound effect on electricity consumption comes from household appliances having a great share of household consumption and general high market shares of efficient variants.

The results in Table 3.12 are sensitive to assumptions made about consumers' willingness to substitute energy efficient variants of household appliances and consumer electronics for conventional variants, and on the willingness to substitute energy goods for non-energy goods. The substitution elasticities which underlie the results presented in this report are 0.8 for energy goods vs. non-energy goods and 3 for efficient variants of boilers vs. conventional boilers. The total effect on electricity consumption using these assumptions is an increase of about 0.5 percent, c.f. Table 3.13. If instead the substitution elasticity between energy efficient variants and conventional variants of energy goods were set to 2 or 4, then the total effect on electricity consumption would be an increase of about 0.9 percent or a decrease of about 0.2 percent. If the substitution elasticity between energy and non-energy goods were set 0.3 then scenario 2 would result in a decrease in EU electricity consumption of about 0.3 percent.

Total effect on energy consumption

The total effect of scenario 2 on energy consumption is a reduction in energy consumption in the European Union. The reduction in the consumption of heating dominates the increase in electricity consumption, because heating consumption constitutes a larger share of the households' total energy consumption than electricity consumption on average for the European Union. The effects of scenario 2 on total energy consumption in the European Union is calculated by weighing the estimated effects on heating and electricity consumption by the shares of heating and electricity consumption of total energy consumption.

Table 3.13 Change in energy consumption in per cent, EU27 average

	Mandatory reduction 5%
Fossil fuels for heating (non-district)	-1.91
Electricity	0.48
Total effect **Change in total energy consumption in EU**	**-1.34**

Note: The results presented in this table relate to a scenario where VAT rates for energy efficient variants of household appliances, consumer electronics and boilers are reduced mandatorily in the EU to 5 per cent. The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.

Source: Copenhagen Economics (2008).

The results are sensitive to the assumed substitutability of energy efficient and conventional variants of energy goods, c.f. Table 3.14. Similarly, the assumptions regarding households' substitution between energy goods and non-energy goods are important. The results in this chapter are based on a substitution elasticity of 0.8 between energy goods and non-energy goods. If instead this substitution elasticity is set to 0.3, then the effect of scenario 1 on household energy consumption in the EU is a 0.3 percent decrease and the effect of scenario 2 is a 2.5 percent decrease[32]. That data description of the end of the report has a short discus-

[32] Not many econometric estimates exist of the substitution elasticity between energy goods and non-energy goods.

sion on the economic literature in this area. The reason for these effects are that a higher substitution elasticity between energy efficient variants and conventional variants lead consumers to change their consumption structure in the direction of more energy efficient household appliances, consumer electronics and boilers instead of conventional variants. The higher the substitution elasticity between energy efficient variants and conventional variants, the greater the increase in average energy efficiency when VAT is reduced on energy efficient variants. Similarly, the greater the substitution elasticity between energy goods and non-energy goods, the greater the rebound effect, because the VAT reduction leads consumers to increase the consumption of energy goods more than they would have done if the substitution elasticity were lower.

Table 3.14 Effects of change in substitution elasticities between energy efficient and conventional variants

	Substitution elasticity=2	Substitution elasticity=3 (base)	Substitution elasticity=4
Effect on energy consumption, EU average	-0.95%	*-1.34%*	-1.93%

Note: The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.
Source: Copenhagen Economics.

The results are also sensitive to the definition of energy efficient household appliances and consumer electronics. The results presented so far for scenario 2 are based on a definition of energy efficient variants of household appliances and consumer electronics as those having energy class A or better. If instead we define the energy efficient variants as those having A+ and A++, the results change markedly as shown in Table 3.15. Netherlands is a country where the market share of energy efficient variants is among the highest in the EU, and in Spain the corresponding market share is slightly below EU average. The rebound effect is reduced markedly, so that the increase in electricity consumption from scenario 2 is all but eliminated.

Table 3.15 Sensitivity analysis for scenario 2: Restricting VAT reductions to A+ and A++ in Netherlands and Spain, percent

Increase in electricity consumption	VAT reduction for A, A+ and A++ classes (Scenario 2)	VAT reduction for A+ and A++
Netherlands	0.6%	0.1%
Spain	0.4%	0.0%

Note: The results have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.
Source: Copenhagen Economics.

Effects on income distribution

Spending shares on household appliances, consumer electronics and boilers are almost identical across different household categories, cf. Table 3.16. As a result, we consider the direct income distribution effect from lower VAT rates on energy efficient goods to be minor.

However, we would expect some relative improvement for high income families as their spending is likely to be allocated more in the upmarket end where the most energy efficient products tend to be concentrated. The lowest income quintiles lose relative to the high income quintiles because they consume less energy efficient appliances than the high income quintiles

Table 3.16 Consumption shares for five income quintiles, EU27, 2005.

Sector	Quintile1 (lowest income)	Quintile2	Quintile3	Quintile4	Quintile5 (highest income)	Quintile1 / Quintile5
Household appliances	0.5	0.6	0.6	0.6	0.6	0.8
Consumer electronics	0.1	0.1	0.1	0.1	0.2	0.8
Boilers	0.5	0.6	0.6	0.6	0.6	0.8
EU 27 average (unweighted)	1.2	1.3	1.4	1.4	1.4	0.8

Note: Per cent of total household expenditure. COICOP structure of household expenditure, 2005. Czech Republic excluded due to lack of data. Quintile 1 is the poorest / Quintile 5 is the richest. Countries are weighted by size of final household expenditure.
Source: Eurostat and Copenhagen Economics

Public revenue effects

The VAT revenue effect of scenario 2 is relatively small mainly due to the low share of total consumption which is constituted by household appliances, consumer electronics and boilers. Hence the VAT base is relatively small. In addition, the small market share of energy efficient boilers serves to further reduce the VAT base of the reduction. These two effects counteract and dominate two other effects which by themselves imply a large revenue loss due to scenario 2. The first is the deadweight loss arising from the pre-existing large market share of energy efficient household appliances. This implies that a large VAT reduction is given to households which would have purchased energy efficient household appliances even in the absence of a VAT reduction. The second is the relatively high elasticity of substitution between energy efficient variants and conventional variants. This implies that scenario 2 shifts the VAT base away from high VAT rate variants to low VAT rate variants.

Table 3.17 VAT revenue effects in scenario 2 applying the mandatory 5% VAT rate

Country group	Static revenue loss, per cent of VAT revenues	Determinants of dynamic loss: changes in efficient products'		Dynamic revenue loss, share of VAT revenues	Total revenue loss, per cent of VAT revenues	Total VAT revenue loss, per cent of GDP
		VAT bases	VAT rates*			
1	-1.7	18	-16	-0.3	-2.0	-0.1
2	-1. 2	21	-14	-0.2	-1.5	-0.1
3	-0.9	21	-14	-0.2	-1.1	-0.1
4	-0.6	18	-14	-0.1	-0.7	-0.0
EU aggregate	-1.2	19	-14	-0.2	-1.5	-0.1

*Note: Static, dynamic and total losses are calculated as percentage of benchmark VAT revenue. The static calculation captures the effect of changes in the structure of the VAT in scenario. The dynamic effect captures the effect of the consumption adjustments in the general equilibrium setting. The total effect is a sum of the two. VAT base change is in percentage of benchmark value. VAT rate change is in percentage points. Weighted averages. * Percentage points. . The results on the dynamic and total revenue loss have been obtained using Copenhagen Economics' computable general equilibrium model, CEVM, c.f. Box 3.1.*

Source: Copenhagen Economics and Eurostat.

Chapter 4 Effects on the Internal Market and Business Innovation

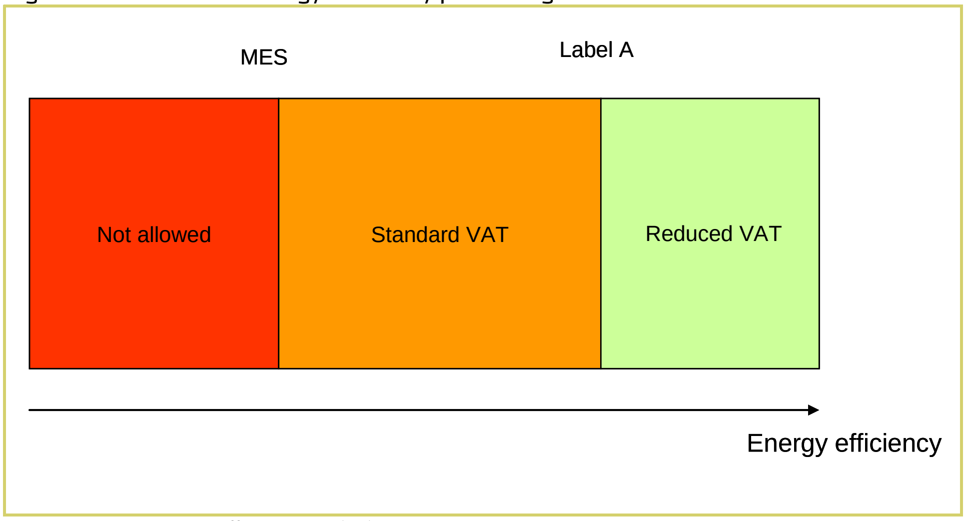
In this chapter we discuss aspects of a VAT reduction policy that concerns the internal market and innovation. First, we discuss whether the overall EU innovation efforts will be improved if root taxation is supplemented with selective support measures focusing on specific areas of abetment (section 4.1). Second, we look at how selective support to energy efficient appliances, such as voluntary/mandatory VAT reduction, affects the uniformity of business conditions on the internal market (section 4.2.). And third, we discuss the risk that cross border trade in energy efficient appliances will be large in the case of a voluntary regime (section 4.3).

4.1. Innovation framework: what set of incentives is best?

Policies that increase demand for energy efficient products within the household will increase incentives to innovate such products, the question is whether this boosts overall innovation in this field of activity. The most logical way to approach this problem is to assume that the EU will reach its climate and energy targets not the least through the use of market based root taxation such as the ETS and national taxes alongside. How will additional measures favouring specific kind of energy savings act on overall innovation?

Minimum efficiency standards (MES) create incentives to innovate efficient products, simply because products that do not meet the MES are not sellable. Labelling schemes visualise energy efficiency, and thereby, increase demand for more efficient products. A VAT reduction increases demand for efficient products through a price cut; Figure 4.1 illustrates the different instruments. To the extent that production costs falls with the scale of production costs, then future deployment costs of energy efficient freezers, air conditioners, boilers fall. This is so-called learning cost argument used as an argument for using subsidies for specific market "ready" products that has been put forward both in the context of energy saving as well as renewable energy production..

Figure 4.1 Overview of energy efficiency promoting instruments



Note: MES = Minimum efficiency standard
Source: Copenhagen Economics

In a setting where all of the above mentioned instruments are in play the demand for products with reduced VAT will be strengthened. The increased demand in turn creates incentives for firms to reallocate some innovation resources to energy efficient product development. However, once a firm has innovated products that qualify for the reduced VAT incentives for further efficiency innovation decrease or vanish. If the thresholds for VAT reduction are not updated this may have the adverse effect that most energy consuming products are subsidised through reduced VAT and that the policy will turn counterproductive. That is indeed why most research suggests a process where upcoming standards lifts are announced to the market in good time.

More generally, there is no empirical evidence nor a priori economic reasoning that suggests that the costs of meeting climate and energy policy coals will be reduced due to such policy directed innovation. Just assume, that we get in place a well calibrated subsidy programme using fixed amount subsidies – not reduced VAT rates – which lead to a net reduction in consumption of electricity. This leads to a fall in the price of ETS allowances and hence a direct reduced incentive to save energy and CO_2 in all other products not covered by the subsidy. The learning curve argument suffers from the same problem: the quicker deployment of market ready but not yet competitive products to reduce future production costs will at be costs of innovation efforts in other areas potentially outside the area of mitigation technologies. Innovation activities are carried out by a relatively small pool of highly qualified pool of researchers in the private and public sector, so accelerated industrial RD efforts induced by policy incentives is likely to be meet by reduced RD efforts elsewhere[33]. So we distort incentives to save energy savings, leading arguably to higher not lower compliance costs[34].

[33] Pizer and Popp (2007) page 5 and 6 underlines the limited supply argument for "scientists and engineers" and refers to another study that concluded that one-half of all energy related – policy directed or not – were at the expense of other RD during the 1970 and 198s. They suggest that cost reductions "from learning by doing" (LBD) may be

The basic issue in terms of innovation boils down to a question of a choice between abatement and innovation being driven by equal abatement costs across sectors or a more selective approach where incentives are more focused in areas where a priori analysis suggest that the market it self will generate innovation below its potential. We recommend in line with recent survey that policy efforts should focus not on boosting market ready innovation but basic research[35].

4.2. Trade offs between Mandatory/voluntary rate reductions

The choice of making a VAT-reduction mandatory or voluntary is signified by a trade-off between efficiency of the policy, which is likely to be larger in the policy is voluntary, and uniformity of business conditions across the EU, which is favoured by a mandatory policy.

As concluded in chapter 2, there are some countries in which certain energy efficient products already have high penetration rates. In those countries and for those products it would probably be inefficient to reduce VAT rates. The obvious reason for this inefficiency is that the penetration rate for efficient products can not increase much. Instead, a VAT-reduction under such circumstances would risk encouraging increased consumption of appliances, and thereby promote higher energy consumption. If, for instance prices on energy efficient products are cut, one might afford to buy a second efficient computer or switch to a larger efficient freezer, this is the rebound effect discussed in Chapter 2. Due to the significant divergence in penetration rates of energy efficient products across Europe this makes a strong argument for a voluntary policy.

On the other hand, a mandatory policy increases the uniformity of business conditions within the European Union which promotes efficiency in the internal market. For instance, unwanted cross border trade would increase if there is a voluntary VAT reduction. A mandatory policy with a fixed VAT rate would, in contrast, reduce cross border trade since it would remove the current differences in VAT between the Member States. Hence, there is a trade-off between the efficiency of the VAT-reduction and the adverse effects on the internal market, cf. Table 4.1.

at lower opportunity costs than innovation because innovation workers are less involved. At the same time, they stress that the empirical literature on LBD fails to make clear whether the cost savings over time is really due to simple scale production effects over time or as well from gains from past innovation efforts in which case this distinction is of less direct use. In any case, LBD gains in one industry will tend to be wholly or partly offset by lower learnings cost reductions in other sectors of the economy. Similar conclusions are reached in Popp (2003).

[34] Aldy and Pizer (2008) concludes in an overall review paper on US climate policies page 22: “”This combination of performance standards and a cap-and-trade programme will tend to increase costs over a cap-and-trade programme standing along with the same environmental outcome”.

[35] Aldy and Pizer 2008) concludes that the case for RD and innovation policies in the area of mitigation “…is strongest in the early phases of RD and weakest for the last step of increasing deployment of existing technologies”.

Table 4.1 The trade-off between policy efficiency and business environment

Type of policy	Uniformity of business conditions	Efficiency of VAT-reduction
Voluntary VAT reduction	Decrease	High
Mandatory VAT reduction	Increase	Low

Source: Copenhagen Economics

An alternative to reduced VAT rates on energy efficient products is national schemes. By national subsidy policy we mean a policy that gives a subsidy to any citizen who buys a certain product regardless of where he or she buys it. This type of subsidy can be applied to the specific products that need subsidies in the concerned country and are in that sense an efficient method. National subsidy policies would decrease the uniformity of business conditions across member states since some products would be subsidised in some countries but not in others. However, an increased use of national subsidy policies would not affect the cross border trade since it applies regardless of where the good has been bought.

4.3. SUBSTANTIAL RISK OF CROSS BORDER TRADE WITH VOLUNTARY POLICY

In this section we conclude that the concerned environmentally friendly goods that are candidates for reduced VAT typically have characteristics that make them suitable for cross border sales, that is when a consumer crosses a border to make a purchase. A scheme under which the reduction of VAT on environmentally friendly goods is voluntary could therefore be troublesome due to increased cross border sales.

If VAT rates differ between Member States we predict that prices will also differ between member states. The difference in prices will be due to the different VAT rates rather than due to differences in production costs or competition between member states. If all consumers would always buy their goods wherever they were the cheapest this situation would create cross border trade and might force efficient, perhaps even the most efficient, local distributors to shut down. An example of where increased cross border trade has had serious consequences is the cross border trade between Northern Ireland and the Republic of Ireland that was caused by a large difference in excise duty on petrol. The cross border trade forced several petrol stations to shut down and large investments to become useless, cf. Box 4.1.

Box 4.1 Cross border trade of petrol in Northern Ireland and Ireland

> Between the years of 2000 and 2001 sales in fuel in Northern Ireland dropped by 47.5 per cent which led to that several filling stations close to the Irish border had to shut down and that large investments in petrol distribution close to the border became close to useless. The reason for the drop in fuel sales were vast differences in excise duty in The Republic of Ireland and Northern Ireland. The resulting price gap, around 30p a litre, between the countries caused motorists to cross the border to fill up their vehicles and also presented a lucrative opportunity for smugglers.

Source: Motor Trader (2002)

Trade between countries with different VAT rates is only an issue when the VAT is paid in the products' country of origin. If the VAT of the country of destination is applied there would be no gains from shopping abroad that were due to differences in VAT. The country of origin principle applies when there is cross border trade, in other words, when the buyer crosses a boarder to purchase a product. The exceptions to this rule mainly concern distance selling, but we judge them to be of minor importance in this context. A detailed overview of the rules governing the country of origin and country of destination principles are provided in Table 4.2. We conclude that the relevant cause of internal market distortion is cross border trade.

Table 4.2 Rules for country of origin and country of destination principles

		Country of Origin Principle	Country of Destination Principle
Cross-border sales	Goods	Main rule	Exception: New means of transport
	Services	Main rule when consumers (tourism, dentistry) or physical products (auto repair, repair of movable property) cross the border	Exception: When service providers (maintenance and repair of property) cross the border
Distance sales	Goods	Exception: Small vendors	Main rule
	Services	Main rule, notably for intra community supply of Telecom & broadcasting, digital content products such as e-books and e-music.	Exception: Telecom & broadcasting, digital content products such as e-books and e-music supplied by third country operators

Note: Special rules apply for non-commercial legal entity such as associations and public authorities if the total buying - from other EU member states during the year - exceeds some threshold value. In this case, the legal entity looses the right of buying in other EU countries at lower VAT rates than the ones that apply in the destination country. When the client is an exempted small business, the same special rules apply as for non commercial and public authorities. The rules governing the place of supply of services have been modified by Directive 2008/08/EC and will change as from 01/01/2010. Concerning telecom & broadcasting, digital content products such as e-books and e-music, the main rule will become, as from 01/01/2015, the destination principle.

Source: European Commission, DG TAXUD

Cross border tradability

In order to decide whether a given product is suitable for cross border trading or not we have identified a number of factors affecting cross border tradability. The considered products typically have a high price per unit, high transportability, high brand value and low perishability during transport. Together, these factors make the products well suited for cross border sales, cf. Box 4.2.

Box 4.2 Indicators of cross border tradability

Price per unit
Everything else equal, a higher price per unit in absolute terms increases the potential price difference across countries and therefore increases the likelihood that a good will be traded across borders.

Transportability
A product that is relatively heavy is less likely to be traded across borders. The reason is simply that it is less convenient and more costly to transport heavy goods as compared to lighter goods. Weight per unit is used as a measure of transportability.

Brand Value
A high brand value might be a reason for shoppers to search for goods abroad in case it is not available on the domestic market. This is confirmed in the Eurobarometer on cross border trade in 2004. We have estimated the brand value within each product category by considering three aspects; whether the design of the products is important in the consumer's purchasing decision, whether it is a typical consumer product and whether the price spread within the product category is large in relation to the quality spread.

Perishability during transport
Goods that quickly perish or break easily during transport will be less attractive to transport for long distances. The perishability during transport of a good is not immediately measurable and has here been estimated by us.

Source: Copenhagen Economics, Optem (2004), Eurobarometer (2004)

We have applied the indicators discussed above to the relevant products. For instance foodstuffs have low cross border tradability because they typically have a low price per unit, are perishable during transport and have low brand value although transportable.[36] Cars on the other hand would have very high cross border tradability as cars have high prices; high brand value, high transportability and they do not perish during transport.[37] A complete ranking of all concerned products is presented in Table 4.3 below. Definition of price interval is as follows: products unit prices below €100 are rated as low price, between €100 and €1000 are rated medium price and above €1000 are rated high price. Further description of the table is found in the table note.

[36] In addition, foodstuffs are typically already subject to reduced VAT.

[37] New cars are however subject to the country of destination principle which means that VAT is paid in the member state where the car is utilised. Therefore, a lower VAT in a neighbouring member state does not constitute an incentive to purchase it abroad. Used cars sold by final consumers are outside the scope of VAT and are not affected. Used cars sold by reseller of second hands goods are subject to VAT in the Member State of origin, on the basis of a special scheme taxing the margin of the supplier (the difference between selling price and purchase price). They might be affected by cross border trading.

Table 4.3 Cross border tradability ranking of concerned products

Product	Cross border tradability	Price	Transport-ability	Price/Weight	Brand value	Perishability
Cars	**High**	High	High	High	High	Low
Computers	**High**	Mid	High	High	High	Low
Televisions	**High**	High	Mid	Mid	High	Low
Electric ovens	**High**	High	Mid	Mid	Mid	Low
Imaging equipment	**Mid**	Low	High	Mid	High	Low
Domestic refrigeration, freezers	**Mid**	Mid	Mid	Low	High	Low
Central heating boilers	**Mid**	Mid	Mid	High	Low	Low
Washing, dish-washing	**Mid**	Mid	Mid	Mid	Mid	Low
Electric Boilers	**Mid**	Low	High	High	Low	Low
Air conditioning	**Mid**	Mid	Mid	Mid	Low	Low
Motors, pumps	**Mid**	Mid	Mid	Mid	Low	Low
Fluorescent lighting	**Mid**	Low	High	High	Low	Mid
Batteries	**Mid**	Low	High	Low	Mid	Low
Insulation	**Mid**	Mid	Mid	Low	Low	Low
Water heaters	**Low**	Mid	Mid	Low	Low	Low
Domestic lighting	**Low**	Low	High	Low	Low	Mid
Foodstuffs	**Low**	Low	High	Low	Low	High

Note: Price categories: Low EUR 0-100; Medium EUR 100-1 000; High EUR 1 000 +
Transportability categories are: Low 100 kg +; Medium10-100 kg ; High 0-10 kg
Price/Weight categories are (EUR/Kg): Low 0-10; Medium11-50; High 50 +
Brand value categories are a combination of whether the design of the products is important in the consumer's purchasing decision, whether it is a typical consumer product and whether the price spread within the product category is large in relation to the quality spread.
Perishablitity is a subjective estimate based on common sense.

Source: www.kjell.se, www.onoff.com, www.elonline.se, www.pricerunner.se, www.siba.se, www.clasohlson.se, www.smaky.se, www.hannus.se, www.tretti.se, conrad-schweden.websale.biz , www.kelkoo.se, www.ikea.se, www.prylportalen.se, www.smartson.se, www.mat.konsumentverket.se, www.testfakta.se, www.nextag.co.uk

Voluntary or mandatory VAT reduction?

The conclusion that the concerned products are suitable for cross border sales entails that cross border sales are likely to increase if differentiated VAT rates would be implemented in some countries and not in others. The increased cross border sales due to differences in VAT would disturb the internal market to some extent.

To see this, imagine the following scenario: France, in their efforts to promote environmentally friendly products, decides to differentiate their VAT. For a certain group of products they decrease VAT to 5 per cent. Now a Belgian citizen planning to reequip his kitchen has the choice of either purchasing the necessary goods in Belgium at a 21 per cent VAT or travel to France to shop at a 5 per cent VAT. A purchase of a refrigerator, a freezer and an electrical oven amounting to €4000 exclusive of VAT would then be €640 cheaper in France than in Belgium, due to the different VAT rates. This disturbs the internal market and the injured party in this example would be the Belgian trader of environmentally friendly white good products.

The extent to which effects like the one described above take place depends on which countries reduce their VAT. In a particular setting, namely scenario 2 as described in chapter 3, a mandatory VAT regime would render eight borders in the internal market with a difference in VAT rate between 13 and 17 percentage units. The borders and the difference in percentage units between a VAT-reducing country and its neighbour are shown in Table 4.4 below.

Table 4.4 VAT difference between neighbouring countries under scenario 2

	France	Ireland	Malta	The Netherlands	Portugal	United Kingdom
Belgium	16	No border	No border	16	No border	No border
France	-	No border	No border	No border	No border	0
Germany	14	No border	No border	14	No border	No border
Ireland	No border	-	No border	No border	No border	0
Italy	13	No border	No border	No border	No border	No border
Luxembourg	13	No border	No border	No border	No border	No border
Spain	17	No border	No border	No border	17	No border
United Kingdom	0	0	No border	0	No border	-

Note: The differences shown in the cells are the differences between the reduced VAT rate (5%) in the VAT-reducing countries in scenario 2 and the standard VAT rate in neighbouring countries that du not reduce their VAT

Source: Copenhagen Economics, DGTAX (2006)

Developing alternative instruments as a response to constraints of internal market

Taxing at the root is the first-best principle, as concluded in chapter 2. However, internal market effects such as cross border trade discussed above may discourage countries from taxing at the root. In this section we provide an example of where the threat of increased cross border trade is likely to have caused countries to adopt second best taxes. Again, fuel taxes serve as an example.

If root taxes – i.e. taxes on gasoline and diesel – are raised, both private consumers and haulers may respond by tanking up in other countries with lower prices. Such "tanker tourism" will have negative fiscal consequences for the country with the higher fuel taxes.

Tanker tourism is an issue both for commercial road haulers and for private consumers. An impact assessment from the European Commission[38] points to the fact that excise duties on fuel account for between 6 and 18 per cent of the running costs of a road haulage business. With high competition and narrow profit margins in the road haulage business, focus is very much on minimizing costs, and tanking cheap fuel is, therefore, an explicit part of the fiscal planning of road haulage businesses. A study by OECD has shown that whereas the annual

[38] EC (2007d)

consumption of diesel per capita was less than 750 liters in some Member States, it amounted to more than 4200 liters in Luxembourg, a Member State which has a diesel excise duty lower than all of its neighbors.

The issue of cross-border trade is likely to have played a major role in the development of alternative policy instruments to encourage both the development and the purchase of less energy consuming vehicles. Thus, many European countries have embedded energy savings incentives in registration taxes and/or user taxes (i.e. vehicle excise duties), cf. Table 4.5. Historically, these second best taxes have in fact been motivated by pure fiscal concerns rather than by CO_2 emissions.

Table 4.5 Countries with vehicle excise duty or registration taxes

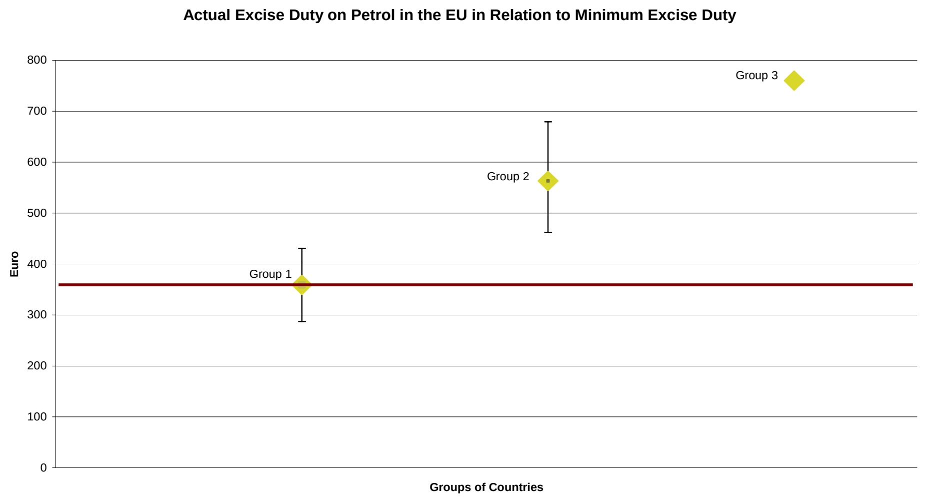
Countries	Vehicle excise duty	Registration tax
CY, DK, FI, IE, NL, SE, BE	X	X
AT, FR, ES		X
DE, IT, LU, UK	X	
BG, EE, GR, HU, LV, LT, MT, PL, PT, RO, SK, SI		

Note: Fourteen Member States have CO_2 emissions-based elements in their car and/or fuel taxation systems.
Source: ACEA (2008)

The problem with such taxes is that they do not provide incentives for reducing car use once the cars are bought – they only provide incentives for consumers to purchase more fuel-efficient cars, and for car manufacturers to improve fuel efficiency (as long as the costs can be passed on to consumers and do not exceed the rebate in vehicle excise duty and/or registration tax). Furthermore, fuel efficiency standards on which the taxes are based are pretty rough approximations of actual use and, hence, do not target CO_2 emissions very well.

Fuel taxes are the first-best option and seen from a community point of view, the upcoming review of the Energy Tax Directive should be used to harmonise – to some extent – the currently large differences in fuel prices between Member States, cf. Figure 4.2 (showing taxes on gasoline). An upward revision of fuel taxes that are well below "average" would at the same time decrease fuel use and decrease the incentive to buy fuel across the border.

Figure 4.2 Fuel taxes on gasoline



Group 1: BG, CZ, EE, EL, ES, CY, LV, LT, HU, PO, RO, SI, and SK (within a range of 20% around the minimum excise duty of 359€ per 1,000 litres)
Group 2: BE, DK, DE, FR, IE, IT, LU, MT, NL, AT, PT, FI, and SE (bars indicate the lowest and highest value in the group)
Group 3: UK

Source: EU Commission, TAXUD tax data based, IEA conversion tables

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Appendix A: Calculation of VAT rates for scenarios

Country	Energy	Sector	Coicop expenditure	Coicop weight, per cent	VAT, per cent	Coicop weighted VAT
Austria	Electricity	Electricity	571	100	20	20.0
	Heating	District heating	105	14.2	20	17.6
		Gas	223	30.3	20	
		Heating oil	230	31.2	20	
		Solid fuel	179	24.3	10	
Belgium	Electricity	Electricity	618	100	21	20.6
	Heating	District heating	1	0.1	21	
		Gas	437	52.9	21	
		Heating oil	368	44.6	21	
		Solid fuel	20	2.4	6	
Bulgaria	Electricity	Electricity	408	100	20	20.0
	Heating	District heating	88	35.5	20	
		Gas	16	6.5	20	
		Heating oil	1	0.4	20	
		Solid fuel	143	57.7	20	
Cyprus	Electricity	Electricity	724	100	15	15
	Heating	District heating	1	0.2	15	15.0
		Gas	123	28.3	15	
		Heating oil	240	55.3	15	
		Solid fuel	70	16.1	15	
Denmark	Electricity	Electricity	616	100	25	25
	Heating	District heating	794	68.7	25	25.0
		Gas	151	13.1	25	
		Heating oil	150	13.0	25	
		Solid fuel	61	5.3	25	
Estonia	Electricity	Electricity	292	100	18	14.6
	Heating	District heating	249	62.4	18	
		Gas	38	9.5	18	
		Heating oil	9	2.3	18	
		Solid fuel	103	25.8	5	
Finland	Electricity	Electricity	516	100	22	22
	Heating	District heating	101	32.8	22	22.0
		Gas	0	0.0	22	
		Heating oil	124	40.3	22	
		Solid fuel	83	26.9	22	
France	Electricity	Electricity	662	77.7	19.6	16.5
			190	22.3	5.5	
	Heating	District heating	0	0.0	19.6	17.6
				0.0	5.5	
		Gas	142	24.3 *	19.6	
			37	6.3	5.5	
		Heating oil	361	61.6	19.6	
		Solid fuel	46	7.8	5.5	
Germany	Electricity	Electricity	283	100	19	19
	Heating	District heating	283	24.2	19	16.1
		Gas	321	27.4	19	
		Heating oil	283	24.2	19	
		Solid fuel	283	24.2	7	
Greece	Electricity	Electricity	404	100	19	19.0
	Heating	District heating	4	0.7	19	17.2
		Gas9	30	5.4	9	
		Heating oil	452	81.6	19	
		Solid fuel	68	12.3	9	
Hungary	Electricity	Electricity	506	100	20	20.0
	Heating	District heating	163	22.3	20	10.8
		Gas5	449	61.4	5	
		Heating oil	0	0.0	5	
		Solid fuel	119	16.3	20	
Ireland	Electricity	Electricity	550	100	13.5	13.5
	Heating	District heating	0	0.0	13.5	13.5
		Gas	214	29.8	13.5	
		Heating oil	309	43.1	13.5	
		Solid fuel	194	27.1	13.5	

Country	Energy	Sector	Coicop expendi-ture	Coicop weight, per cent	VAT, per cent	Coicop weighted VAT
Italy	Electricity	Electricity	486	100	20	20.0
	Heating	District heating	125	13.1	20	12.1
		Gas	690	72.4	10	
		Heating oil	79	8.3	20	
		Solid fuel	59	6.2	10	
Latvia	Electricity	Electricity	217	100	18	18.0
	Heating	District heating	325	65.0	18	13.5
		Gas	107	21.4	5	
		Heating oil	0	0.0	18	
		Solid fuel	68	13.6	5	
Lithuania	Electricity	Electricity	235	100	18	18.0
	Heating	District heating	326	64.8	18	18.0
		Gas	102	20.3	18	
		Heating oil	0	0.0	18	
		Solid fuel	75	14.9	18	
Luxembourg	Electricity	Electricity	730	100	6	6.0
	Heating	Gas6	450	38.7	6	9.7
		Solid fuel	26	2.2	12	
		District heating	0	0.0	12	
		Heating oil	688	59.1	12	
Malta	Electricity	Electricity	416	100	5	5.0
	Heating	District heating	0	0.0	18	18.0
		Gas	68	79.1	18	
		Heating oil	13	15.1	18	
		Solid fuel	5	5.8	18	
Netherlands	Electricity	Electricity	646	100	19	19.0
	Heating	District heating	56	6.6	19	19.0
		Gas	789	92.6	19	
		Heating oil	4	0.5	19	
		Solid fuel	3	0.4	19	
Poland	Electricity	Electricity	356	100	22	22.0
	Heating	District heating	280	39.9	22	18.0
		Gas	196	27.9	22	
		Heating oil	7	1.0	22	
		Solid fuel	30.4	4.3	22	
			188.6	26.9	7	
Portugal	Electricity	Electricity	550	100	5	5.0
	Heating	District heating	18.5	5.5	20	8.4
		Gas5	258	77.0	5	
		Heating oil	18.5	5.5	20	
		Solid fuel	40	11.9	20	
Romania	Electricity	Electricity	240	100	19	19.0
	Heating	District heating	78	20.6	19	19.0
		Gas	198	52.2	19	
		Heating oil	0	0.0	19	
		Solid fuel	103	27.2	19	
Slovakia	Electricity	Electricity	577	100	19	19.0
	Heating	District heating	511	44.9	19	19.0
		Gas	558	49.0	19	
		Heating oil	1	0.1	19	
		Solid fuel	68	6.0	19	
Slovenia	Electricity	Electricity	586	100	20	20.0
	Heating	District heating	169	17.0	20	20.0
		Gas	152	15.3	20	
		Heating oil	455	45.7	20	
		Solid fuel	219	22.0	20	
Spain	Electricity	Electricity	425	100	16	16.0
	Heating	District heating	0	0.0	16	16.0
		Gas	233	67.0	16	
		Heating oil	101	29.0	16	
		Solid fuel	14	4.0	16	
Sweden	Electricity	Electricity	796	100	25	25.0
	Heating	District heating	57	47.9	25	25.0
		Gas	0	0.0	25	
		Heating oil	42	35.3	25	
		Solid fuel	20	16.8	25	

Country	Energy	Sector	Coicop expendi-ture	Coicop weight, per cent	VAT, per cent	Coicop weighted VAT
United Kingdom	Electricity	Electricity	465	100	5	5.0
	Heating	District heating	0	0.0	17.5	5.2
		Gas	429	85.6	5	
		Heating oil	62	12.4	5	
		Solid fuel	10	2.0	17.5	

Appendix B Data sources and issues

Consumption dataset

Our consumption dataset contains data on the structure of expenditures in the budget of:

- the representative household
- five representative households defined by income quintiles

in each of the EU27 countries. The native level of detail in the dataset is chosen to allow the identification of the product groups of interest, such as household appliances and consumer electronics. Subsequently, the dataset can deliver consumption share statistics on these product groups.

Representative household consumption expenditure

The structure of representative household consumption expenditure is the mean household consumption expenditure of private households, COICOP level 3 in PPS, for 2005. We use the PPS dataset which provides the monetary expenditure amounts, as well as makes it possible to calculate shares. The data is available in Eurostat for all EU countries, except for Czech Republic.

Addition of boiler statistics

COICOP classifies boilers as an investment rather than consumption expenditure, and therefore boilers are excluded from the statistics. For the purpose of this project, it is necessary, however, to approximate the level of expenditure on boilers by the representative household.

To this purpose, our approach is to add boilers as an extra entry alongside the existing expenditure categories of the representative household.

We use market price and sales data from EC (2007b) to estimate the value of national boiler markets, in 2004, as 2005 data is not available. Thereafter, we calculate an implied number of households, by dividing the value of final household consumption expenditure by the size of the expenditures of the representative household for each one of the EU countries where data on the boiler market is available.[39] Finally, we obtain the size of the household expenditures on boilers in 2005, in PPS, by dividing the value of the boiler market in PPS by the number of households in the country. We use EUROSTAT, conversion tables to convert from € or national currency to PPS for each of the countries. The missing values for Slovakia, Bulgaria and Romania are assumed to equal the value for Czech Republic. The missing values for Cyprus, Malta, Luxembourg are assumed to equal the value for Estonia.

[39] Austria, Belgium, Czech R., Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, UK.

Representation of products subject to efficiency regulations in consumption data

DG Transport and Energy is in charge of implementing regulations on efficiency for a range of energy consuming goods. Before energy efficiency standards are imposed for a good, DG Transport and Energy carries out technical studies. The list of candidate goods for which energy efficiency standards are envisioned is available on the website of the DG.[40]

COICOP level 3 categories are broader than the goods subject to energy efficiency requirements. In order to avoid over representing the share of consumption of the goods subject to energy efficiency requirements in consumption data, the relevant COICOP level 3 categories must be disaggregated. For that purpose, estimates of the share of goods subject to energy efficiency criteria in respective COICOP level 3 categories must be derived. For example, light bulbs are a part of COICOP category cp0552 "Small tools and miscellaneous accessories", which in addition includes a large amount of other irrelevant products, cf. Table 0.1. It is assumed that electric bulbs and florescent lighting tubes account for 5% of the consumption expenditure on COICOP category cp0552. [41] The remaining household appliances are represented by splitting categories cp0531 "Major household appliances whether electric or not", consumer electronics representation is based on cp0911 "Equipment for the reception, recording and reproduction of sound and pictures", cp0912 "Photographic and cinematographic equipment and optical instruments", cp0913 "Information processing equipment", whereas boilers are represented as explained above.

Table 0.1 Example of COICOP disaggregation

Product to be represented	Relevant COICOP category	Name of COICOP category	Contents of Coicop category	Weight assumed
Light bulbs and fluorescent lighting	cp0552	Small tools and miscellaneous accessories	Hand tools, such as saws, hammers, screwdrivers, wrenches, spanners, pliers, trimming knives, rasps and files; Garden tools such as wheel barrows, watering cans, hoses, spades, shovels, rakes, forks, scythes, sickles and secateurs; Ladders and steps Door fittings (hinges, handles and locks) , fittings for radiators and fireplaces, other metal articles for the house (curtain rails, carpet rods, hooks, etc.) or for the garden (chains, grids, stakes and hoop segments for fencing and bordering); Small electric accessories such as power sockets, switches, wiring flex, **electric bulbs, fluorescent lighting tubes**, torches, flashlights, hand-lamps, electric batteries for general use, bells and alarms	0.05

Source: Copenhagen Economics and UNSTATS

[40] See: http://ec.europa.eu/energy/demand/legislation/doc/planning.pdf
http://ec.europa.eu/energy/demand/legislation/doc/issues_to_be_studied.pdf

[41] The exact estimation of the share electric bulbs and florescent lighting tubes among all the products in the category cp0552 is beyond the scope of the study.

Structure of consumption expenditure by income quintile
The 2005 data on the structure of consumption expenditure by income quintile is only available at COICOP level 2, in Eurostat. We also use the mean consumption expenditure by income quintile in PPS to obtain the size of monetary expenditures. Boiler statistics are added to each of the quintile expenditures, by assuming that the structure of quintile differences for boilers is the same as for household appliances.

Consolidating the representative household data with data by income quintile
The representative household consumption dataset and the structure of consumption expenditure by income quintile are available at different levels of disaggregation. For modelling purposes, however, it is pertinent to assure the most detailed available split of consumption expenditures, in order to obtain a precise representation of the goods of interest in scenarios. Therefore, the representative household and quintile consumption datasets are consolidated.
Since the representative household dataset is more disaggregated, the approach is to assume that it represents expenditures of quintile 3. Quintile 1,2 and 4,5 expenditure shares are derived by weighting quintile 3 expenditures, per COICOP level 3 category, using the corresponding COICOP level 2 shares from the original quintile data as weights. In this way, a consumption dataset is constructed by quintile, at COICOP level 3, and with the representative household consumption expenditures integrated.

VAT DATASET

Disaggregation in the source publication
Our source of VAT rates is the DG TAXUD publication "VAT rates applied in the member states of the European Community", 2008. For each of the EU countries, the publication gives the VAT rate applicable to a selection of products, economic activities or sectors, such as lemonade, cultural events or passenger transport. The sectors are harmonized across the countries, however, they do not correspond to any standard classification, such as COICOP, NACE or similar.

Consolidation with the consumption dataset
Therefore, we need to integrate the sectoral classification from the DG TAXUD publication to the COICOP, in order to match the level of VAT with consumption expenditures. The consolidation follows the methodology from our earlier study; see Copenhagen Economics (2007).

PRODUCT EFFICIENCY DATASET

Breakdown of energy
For the modelling purposes, it is necessary to distinguish between the energy efficient and inefficient variants of household appliances, boilers, and consumer electronics. The COI-

COP does not offer such split. Therefore, it is necessary to split the original COICOP categories using information on the relative share of efficient and inefficient appliances. Since COICOP represents flows, the necessary information is the relative share of efficient and inefficient appliances in the sales – rather than stock – of products. Our approach is therefore, to obtain the relevant sales statistics broken down by efficiency and use the shares for splitting the COICOP categories defining boilers, household appliances and consumer electronics. Our principal sources are the following:

- Energy efficiency of boiler sales: EC (2007b)
- Energy efficiency of household appliances: IVM (2008), Bertoldi & Atanasiu (2007), www.bycentral.co.uk, Kemna et.al. (2007)

As for energy efficiency of consumer electronics, we did not find relevant statistics on energy efficiency. The lack of data represents the lagging status of labelling and efficiency requirements for electronics vis-à-vis household appliances[42]. For modelling purposes, we assume that the relative efficiency of consumer electronics is the same as that of household appliances, in a given country.

Classification of efficient products

We split household appliances and boilers into categories of energy efficient and inefficient products. For household appliances this is done according to the European Union energy label for refrigerators, freezers, washing machines, dishwashers, and ovens. The energy efficiency of the appliance is rated in terms of a set of energy efficiency classes from A++ to G with A++ being the most energy efficient, G the least efficient. A product is considered energy efficient if it is labelled A or better, all other products are inefficient. Concerning domestic lighting, CFLs (Compact, fluorescent lamps) are considered energy efficient while incandescent lamps are considered inefficient. Boilers are considered energy efficient if they are of a condensing type and inefficient if they are non-condensing. According to our calculations, efficient household appliances (domestic lighting excluded) consume between 64 and 84 per cent of the energy consumed by their inefficient counterparts[43]. The energy efficiency of boilers is calculated based on the average percentage of fuel converted to heat for condensing and non-condensing types and the energy consumption of an efficient boiler is shown to be approximately 88 per cent of that of an inefficient boiler.

Market shares and data treatment

Our data on markets shares is extensive, however not complete. Where data is missing we assume, for modelling purposes, that the market share of a given product in a given country is

[42] Energy efficiency regulation in the area of labelling and minimum efficiency standards is more developed for household appliances than consumer electronics. Therefore, more statistics on the sales of energy efficient and inefficient products is available for household appliances than consumer electronics.

[43] Except for domestic lighting where the energy consumption of CFLs is 23 per cent of that of non-CFLs.

the same as that in another Member State with a similar level of development and GDP per capita[44].

To aggregate the market shares of the various household appliances into a joint measure of market shares for efficient and inefficient household appliances we use weights based on major appliances' penetration in households. These weights are moreover used when calculating the weighted energy consumption of efficient and inefficient products in the Member States.

By collecting information on average prices and average energy consumption per year for the various products, relative prices and energy consumption of efficient vis-à-vis inefficient products are determined. This information is further used when assessing the share of energy efficient products in energy consumption and household expenditure. By multiplying the weighted market share of the particular efficient product with its relative energy consumption compared to a corresponding inefficient product, the share of efficient products in energy consumption is determined for each Member State as well as for EU27.

Market shares in value terms
For our modelling purposes, we need market shares to be in value terms. However, sources only have market shares by volume. Consequently, we have to take these and adjust for the price effect. Information for the price adjustment:

Information for the price adjustment consists of price data and data on market shares by volume and is mainly found in the following sources:

- Prices: European Commission (DG TAXUD) (2008), IVM (2008), Kemna et.al. (2007), and www.bycentral.co.uk
- Market shares by volume: Bertoldi, P. & Atanasiu, B., (2007), Kemna et.al. (2007)

The adjustment itself takes place in the following way:
The market share of a certain appliance of a certain energy class is multiplied with its stated price (e.g. 4% A+ refrigerators in Austria multiplied by the EU-15 price for an A+ refrigerator (534€) = 22). Thereafter, the weighted value for efficient goods is obtained by adding together the market shares value for the appliances marked A or better (and vice versa for the appliances marked B or worse to obtain the weighted value for inefficient products).

[44] The missing values for Denmark and Finland are assumed to equal the values for Sweden, missing values for Estonia, Latvia, Lithuania, Slovenia and Slovakia are assumed to equal the values for Poland, missing values for Greece and Cyprus are assumed to equal the values for Italy, missing values for Luxembourg and the Netherlands are assumed to equal the values for Belgium, missing values for Ireland are assumed to equal the values for the UK, missing values for Malta are assumed to equal the values for Portugal and the values missing for Romania are assumed to equal the values for Hungary.

Data issues

For freezers we only have the price data for A++ down to B-labelled appliances. We thus assume that the price for all appliances labelled C or worse is the same as for the ones labelled B.

Due to lack of price data for freezers, dishwashers and ovens for the Eastern EU countries we approximate these prices using the weighted average of variation in Western EU/Eastern EU prices that we have for refrigerators and washing machines. The weighted average of variation is +44.6% for refrigerators and +43.34% for washing machines. By taking an arithmetic average we get a weighted average variation of 44%. We use this when estimating the prices for the Eastern EU countries (NMS-12) (e.g. to get the price of a certain appliance of a certain efficiency class in Eastern EU we divide the Western EU price by the factor 1,44.).

Weighing together household appliances to an aggregate share efficient/inefficient

For SE, UK, BE, NL, IT, DE, AT, FR, ES and PT the weights are based on the sales of major domestic appliances (refrigerators, freezers, washing machines, dishwashers, tumble driers, ovens, cookers and hobs) in 2005. Due to the absence of data the same weights have been applied to DNK, GRC, IRL, FIN and LUX., in other words the same weights have been given to all EU-15 countries. For the remaining countries (the NMS-12) weights are based on major appliances penetration in households in 2004.

Table 0.2 Selected studies of experiments with promoting household energy efficiency using non-VAT instruments

Product st. energy efficiency requirements	**Alternative promotion instruments to VAT (subsidies)**	**Motivation (goals)**	**Description of the scheme (target group / duration)**	**Evaluation (reference)**	**Effects (what happened actually)**
Electrical appliances	Temporary subsidy to purchase energy efficient appliances (1999-2005) , Denmark	Promote A (1999), A+ (2004) and A++ (2005) appliances	Information campaign (best efficiency and best price websites) and temporary purchase subsidy to consumers,	Evaluation published in 2007 http://www.eceee.org/conference_proceedings/eceee/2007/Panel_1/1.345/	A, A+ and A++ displaced C, D, E as dominant models. Prices of the A-class dropped significantly
Washing machines	Energy Efficiency Commitment, UK	Renew stock of washing machines	Subsidies to purchase of washing machines	Bertoldi & Atanasiu (2006): Electricity consumption in Europe	Subsidisation of 0.8 million washing machines B-class almost disappeared from the market, but also increase of non-labbelled appliances
Freezers	Utility-sponsored subsidy: (Denmark, 1990-1991)	Replace 1000 freezers with energy efficient models among the stock owned by utility customers	ECU 2,7 granted for each year the old appliance exceed 10 years. Average subsidy was 57 ECU or 15% of price of new energy efficient appliance	Evaluation published in 1993 http://www.eceee.org/conference_proceedings/eceee/1993/Panel_3/p3_8/	1400 freezers replaced, but 50% of participants are free riders, negative NPV of measure, distributional effects positive, Campaign had slight socioeconomic loss.
Air conditioners	Rebate program from 1994	Replace low efficiency purchases with high efficiency (central air conditioning)	6202 rebates given out for efficient central air conditioner by a utility to its customers.	Evaluation published 2002 http://www.eceee.org/conference_proceedings/ACEEE_buildings/2002/Panel_8/p8_21/	5% of participants adopted central air conditioning only because of the program – subsidies may encourage additional use and contribute to more energy use.
Consumer electronics (digital to analogue set-top boxes	Subsidies	Energy efficient set top boxes	Subsidies amounting to $1.5 billion are to be granted to purchase digital to analogue set top boxes. The body overlooking the subsidy is to draft energy efficiency standards for set top boxes	http://www.edn.com/article/CA6337591.html	To be determined
Light bulbs	Subsidy to sale energy efficient light bulbs below cost, New Zealand Various in-store informational and promotional campaigns	Sale 65000 subsidised efficient light bulbs by specified deadline. Promote efficient lighting	Sale of light bulbs below cost to test rates of adoption General informational campaigns	http://www.energymad.com/nz/Files/Media_TH_241104.pdf http://www.eurocommerce.be/content.aspx?PageId=40965	45000 sold in first two weeks, declining sales thereafter. No review available
Non-electric boilers	Subsidies to efficient boilers, introduced 1991 (stopped in 1996)	Promote more expensive more efficient boiler (new technology in late 80s),	f 350 per boiler in 1993 granted in cash to households if boiler meets efficiency criteria	Extensive evaluation in 1999 http://www.ecn.nl/docs/library/report/1999/c99060.pdf	320 thousand boilers subsidised Expected that sale of boilers increased Share of smaller efficient boilers grew. No data on free riding. Positive employment effects during the duration of experiment and permanent thereafter. Stopped when no more support w as needed, in 1996.
Organic foodstuffs					
Housing	Heating audit scheme, Denmark	Develop specific recommendations on improving the efficiency of a residential heating system	Residential houses, 5000 heating audits per year	Evaluation published in 1995 http://www.eceee.org/conference_proceedings/eceee/1995/Panel_2/p2_6/	3 recommendations per house (insulation, thermostats). 25% of proposed projects have been carried out within 3 years. Low economic value - improvements would have been carried out anyway.
Housing – cavity insulation and overall energy efficiency	Alternative tax instruments to reduced VAT on insulation or holistic programs targeting energy efficiency in housing.	Contractor installed insulation currently has reduced VAT of 5% in the UK. But of little benefit in DIY and subsidization contexts Are holistic approaches better? (theoretical study)	Currently, there is reduced VAT on insulation, heat pumps, solar panels, etc. Consumers not aware and do not benefit. Analysis of alternative incentive mechanisms and instruments to reduced VAT.	http://www.eceee.org/conference_proceedings/eceee/2005c/Panel_7/7166waterson/	Incentives for installing insulation in housing linked to council taxes or stamp duties are the most promising measures identified (quicker impact and less distortions).

Source Copenhagen Economics:

Table 0.3 Substitution elasticities

Product	Subst.elasticity	Study
Leisure (vs. Goods)	0,77	Bovenberg and Goulder (1996)
Energy goods (vs. Non-energy)	0,8	Conrad and Löschel (2005)
Household appliances	1	Donnelly et al (2004)
Consumer electronics	1	Donnelly et al (2004)
Boilers	1	Donnelly et al (2004)
Food	1	Donnelly et al (2004)
Energy eff. HA	3	
Energy eff. CE	3	
Energy eff. Boilers	3	
Organic food	-5,4-24,7	Hansen (2008), de Haan (2001)

Source: Copenhagen Economics

There are relatively few studies which estimate the relevant substitution elasticities for energy goods and energy efficient variants of household appliances, consumer electronics and boilers. We have chosen the estimates which we believe have the highest quality and are most appropriate for the CGE model used in this study. The criteria for assessing the quality of the estimates are first of all whether they constitute a professional standard – that is, a choice of substitution elasticity should be relatively non-controversial in comparison with other research. Second, the estimates should be based on econometric methods – that is, a choice of substitution elasticity should be backed by high quality econometric evidence.

The estimated substitution elasticity between energy goods and non-energy goods comes from Conrad and Löschel (2005). This paper is relatively well published in the scientific journal *Applied Economics*, and hence the choice of substitution elasticity of 0.8 cannot be considered controversial. Sorrell et al. (2008) is a recent survey of rebound effects of technological progress, which presents a range of substitution elasticities between energy goods and non-energy goods used in the literature. The full range of substitution elasticities used in the studies reviewed is 0.07 to 1. Allan et al. (2006) performs CGE model based analysis of rebound effects and uses a range of substitution elasticities of 0.1 to 0.7 with 0.3 as the baseline.

There is an issue concerning the transferability of the substitution elasticity estimates from previous studies to this study. Previous studies considered substitution between energy and non-energy goods in production, whereas we consider the substitution in consumption. We can defend this to some extent by referring to the fact that consumers are in a sense also producers in our model, as they demand the same goods as industry does, though in different magnitudes. However, it remains a different issue whether the practise from other lines of research are fully transferable – but we have found no evidence that gives us a strong justification for deviating from the practise in the other line of research.

Thus, there appears to be consensus that the substitution elasticity between energy and non-energy goods is between 0 and 1, but no econometric evidence exists to inform the choice within this range. We have chosen 0.8 because it is in line with accepted scientific practise in relatively comparable research, and we perform sensitivity analysis which is presented in the report.

Regarding the substitution elasticity between energy efficient and conventional variants of household appliances, consumer electronics and boilers, we have found no econometric evidence to support the choice of parameter, and we have found no other CGE model comparable to ours. Hence, the choice of substitution elasticity is based on substitution elasticities for comparable energy using goods, c.f. Donnelly et al. (2004) which state substitution elasticities around 3 for electronic equipment for use in the USITC trade model. We therefore choose substitution elasticities of 3 for household appliances, consumer electronics and boilers. We also perform sensitivity analyses for these choices.