



Quantification of the effects on greenhouse gas
emissions of policies and measures
Reference: ENV.C.1/SER/2007/0019

Final Report Appendix I: Detailed policy
methodology and results chapters



A final report to the European Commission

Restricted - Commercial
ED05611

December 2009



Title	Quantification of the effects on greenhouse gas emissions of policies and measures: Final Report Appendix I: Detailed policy methodology and results chapters
Customer	European Commission
Customer reference	ENV.C.1/SER/2007/0019
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File reference	ED05611
Reference number	ED05611

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1 Introduction

This is the first appendix to the Final Report of the European Commission funded project “Quantification of the effects on greenhouse gas emissions of policies and measures” (ENV.C.1/SER/2007/0019). It includes further details on the methodologies applied during the study and the overall results. A separate chapter has been prepared for each of policies chosen as case-studies, as outlined below:

Transport sector

- Voluntary agreement with car manufacturers to reduce CO2 emissions (ACEA, KAMA, JAMA)
- Biofuels Directive (Dir 2003/30/EC)

Energy sector and Industry

- RES-E Electricity production from renewable energy sources (Dir 2001/77/EC)
- Promotion of cogeneration (Dir 2004/8/EC)
- EU Emissions trading scheme (Dir 2003/87/EC) (including the linking Directive)
- Integrated pollution prevention and control (IPPC) (Dir 96/61/EC)
- Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases

Households and Service Sector

- Energy performance of buildings (Dir 2002/91/EC)
- Energy labelling of household appliances (Dir 2003/66/EC, 2002/40/EC, 2002/31/EC, 99/9/EC, 98/11/EC, 96/89/EC, 96/60/EC)

Waste

- Landfill Directive (Dir 1999/31/EC)
- Waste incineration Directive (Dir 2000/76/EC)

Agriculture

- Common rules for direct support schemes under CAP (Regulation (EC) No 1782/2003)
- Nitrates Directive (Dir 91/676/EEC)

In addition to the Final Report, a separate **Methodologies Report** contains detailed information and guidelines related to the individual methodologies developed under the project.

2 Case study: Voluntary agreement with car manufacturers

2.1 Introduction

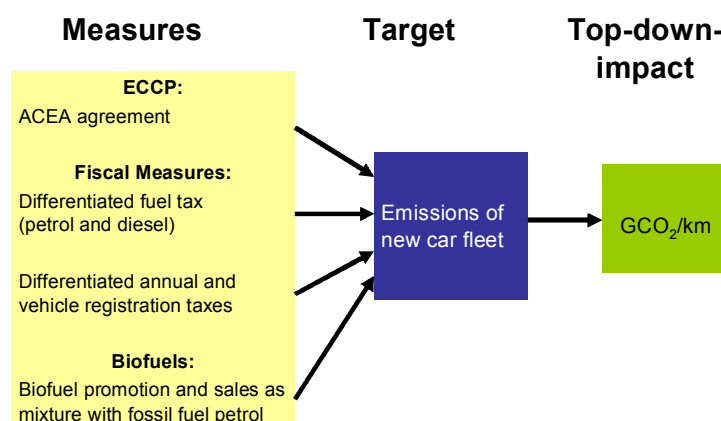
2.1.1 Overview of policy

In 1995, the EU set itself an ambitious goal of reducing emissions of carbon dioxide from new cars to 120 grams per kilometre (g/km) as a measure to combat climate change. The Commission tried to achieve this target through a voluntary agreement with European car manufacturers, who promised to gradually improve the fuel efficiency of their new cars¹. The 1998 voluntary agreement between ACEA (the EU's Automobile Manufacturers Association) and the Commission included a commitment by the European carmakers to achieve a target of 140g/km by 2008. Japanese and Korean car producers made a similar commitment for 2009. Although significant progress has been made, average emissions have only fallen from 186g/km in 1995 to 163g/km in 2004.

This voluntary agreement with car manufacturers was part of the first European Climate Change Programme. The EU Strategy on CO₂ emissions reductions from cars and LDVs has since been reviewed by the European Commission (EU, 2007). The review found that most of the reductions have been due to technological improvements, rather than demand side measures. Further, *"The progress achieved so far goes some way towards the 140 g CO₂/km target by 2008/2009, but in the absence of additional measures, the EU objective of 120 g CO₂/km will not be met at a 2012 horizon."* (EU, 2007, p.6). A series of supply and demand side legislative measures are proposed to achieve the 120g CO₂/km target. ECCP 2 measures have yet to be implemented; legislation has recently been adopted² setting mandatory emission limits for manufacturers of passenger cars.

A simplified measures map for the ACEA agreement is shown at Figure 2-1. It shows that the ACEA agreement interacts with various other measures, in particular vehicle and fuel taxation and policies to stimulate the use of biofuels. A more detailed measures map can be found in the Tier 3 report on this policy (see methodologies report).

Figure 2-1 Simplified measure map for the EU CO₂ and cars strategy and other complimentary measures impacting on the achievement of the strategy



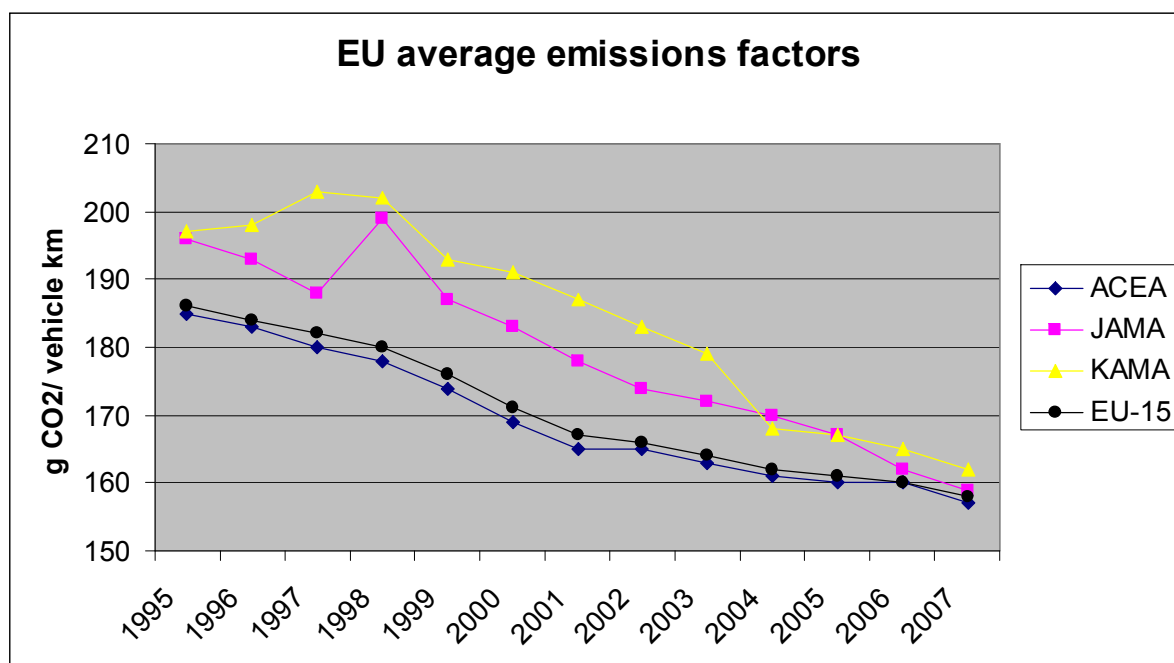
¹ Commission Communication - Fourth Annual Report Year 2002, COM (204)78 final, Brussels, 11.02.2004

² See http://ec.europa.eu/environment/air/transport/co2/co2_home.htm

2.2 Emission trends and drivers

The targets for the agreements with the car manufacturers are defined in terms of the average specific CO₂ emissions (in g CO₂/km) of new cars sold. This data is reported by Member States and is shown here. Over the period of the voluntary agreement, there has been a small but significant decline in specific emissions.

Figure 2-2 EU average specific CO₂ emission for new cars (g CO₂/km)



Source: EU (2008) draft

There are several factors that drive GHG emissions from passenger cars. These are surveyed in EEA (2008). The main socio-economic factors are increasing wealth, enabling EU consumers to purchase more and larger cars. Also, there is a recent trend in consumer preferences towards larger cars. The main policy factors are the taxation and charging of vehicle purchases, ownership and road use, as well as the taxation and hence price of fuel. The other major policy factor is the public provision of roads, where the provision of extra infrastructure together with urban development optimised for car use combine to increase demand for passenger car transportation.

2.2.1 Impact upon greenhouse gas emissions

Passenger cars burn fossil fuels as their power source, directly emitting GHGs. The ACEA agreement therefore acts on GHGs by reducing fuel requirements. The use of biofuels can change this relationship, as then there is a lower (net) GHG emissions factor for the fuel (depending on the biofuel used), but for the period of the analysis, biofuels are a relatively small proportion of fuel used in passenger cars.

2.2.2 Activity and emission trends

Emissions from passenger vehicles represent a significant proportion of EU total GHG emissions. In a recent study, the EEA (2008) indicate that "In the EU-27, total greenhouse gas emissions in 1990 were 5 621 Mt CO₂-equivalent, falling to 5 177 Mt CO₂-equivalent in 2005 (a decrease of 7.9%). In the same period, emissions from the transport sector increased by 26%. In 2005 they represented 22% of total EU-27 greenhouse gas emissions". Table 2-1 shows the time series of new car purchases, which was increasing up to 2000, but then declined as economic conditions in most EU countries worsened.

Table 2-1 Cars purchased in the EU

Year	EU new cars purchased (million)
1990	15.1
1992	11.7
1994	11.6
1996	12.6
1998	17.4
2000	17.2
2002	13.3
2004	14.8
2006	13.9
2008	12.9

Source: ASTRA, based on EUROSTAT and ACEA registrations data

2.3 Impacts of the strategy on emissions of GHGs

2.3.1 Overview of methodologies

The methodologies are described in detail in the accompanying guidelines: Voluntary Agreements for Cars between the European Commission and ACEA, JAMA and KAMA. Figure 2-2 shows the main differences between Tier 1, Tier 2 and Tier 3 methodologies with respect to the main factors of influence on the results of the impact evaluation.

Table 2-2 Main differences between Tier1, Tier2 and Tier3 methodologies with respect to the main factors of influence on the results

Approach	Tier 1	Tier 2	Tier 3
Activity indicator	Vehicle km	Vehicle km	Vehicle km
Emission factor of new vehicles (g CO ₂ /km)	EU average	MS average	MS average
Policy interaction:			
+ Taxation policies (registration tax, annual car tax, mineral oil tax, ecotax)	no	no	yes
+ Biofuels policy	no	no	screened
+ Other policies	no	no	screened
Autonomous development	no	no	yes
Structural effects (Dieselisation trend)	no	yes	yes
Rebound effects (car size, more mileage)	no	no	yes
Multiplier effects	no	no	no
Geographic factors	no	no	no
Timing issues / delay or announcement effects (policy impact starting 1995)	yes	yes	(yes)*
Other exogenous factors (Impact of energy market prices)	no	no	yes

* Brackets mean that the issue should in principle be considered but was not considered relevant for the concrete ex-post evaluation period investigated.

Tier 1 – EU level

The assessment of the policy impact over the period since the voluntary agreement was implemented is made on the following basis:

The upper bound of the policy impact is estimated from the time series of:

- emission rates of new cars;
- number of new registrations; and,
- average distance travelled per passenger car.

No corrections are made for dieselisation or autonomous progress (the performance of new cars is evaluated as compared to the base year 1995), i.e. frozen efficiency at 1995 levels is assumed.

Tier 2 – MS level

In the tier 2 methodology, national data for the emission rate of new vehicles (g CO₂/km) substitutes EU averages.

The assessment of the policy impact over the period since the voluntary agreement was implemented is divided into two components:

1. First, the upper bound of the policy impact is estimated from the time series of:
 - emission rates of new cars;
 - number of new registrations; and,
 - average distance travelled per passenger car.

This is similar to Tier1 but using national emission rates.

2. Then, the impact of the shift from petrol to diesel fuel is calculated and its effects removed from the upper bound. The methodology assumes that the shift to diesel was not influenced by VA and so cannot be attributed to it.

(The correction due to dieselisation is -12% for the EU 15.)

No correction is made for autonomous progress.

Tier 3 – Detailed calculations using the ASTRA model

In summary, the methodology for an ex-post analysis is as follows (for more details, see methodologies report):

1. Reproduce the historical data, given the bottom-up calculation methodology in the ASTRA model.
2. Assess the importance of specific factors. These are:
 - Firstly, what is the rate of autonomous technological progress? This can be identified from the historical trend of gCO₂/km per vehicle in the period before the ACEA agreement, e.g. in the period 1990-1996.
 - Mix of Petrol and Diesel cars, given their different time trajectories in emissions performance.
 - Then, there is a comfort factor increasing the indicator g/km: the change in the composition of the vehicle stock by size class, reflecting the development of manufacturers' marketing policies, consumer preferences and wealth.
 - Fiscal policies such as the car taxation according to CO₂ impact.
 - Fuel price
 - Use of low-emission fuels.

These six factors are not independent, but have causal relationships between them. In particular, the decisions of consumers play a central role. The size and fuel type of car bought is the consumer's decision, influenced of course by manufacturers' marketing policies. This will be dependent partly on their budget constraint, partly on purchase and running costs including taxes, but also on consumer tastes and marketing policies by manufacturers. Hence taxation policy and the fuel price have an impact on diesel vs. fuel shares and the distribution of vehicle size.

3. The 'unexplained' change in emissions factor can then be taken as the impact of the ACEA agreement (which assumes, of course, that all other major factors have been identified and their impact accurately assessed).

2.3.2 Results

The overall results from the Tier 1, 2 and 3 analyses are shown in Table 2-3 (cumulative results for the period mentioned) and Table 2-4 (results for the years 2005 and 2007; the latter for the Tier 3 approach only).

Table 2-3 Cumulative impacts of Tier 1, Tier 2 and Tier 3 analysis over the period indicated

Group/Ms	Tier 1/2	Tier1 Freezing emission rates at earliest value (1995)	Tier 2 Removing the effect of dieselisation	Tier 3	Tier 3 actual vkm	Tier 3 constant 1996 vkm
	Policy impact period	(Mt CO ₂)	(Mt CO ₂)	Policy impact period	(Mt CO ₂)	(Mt CO ₂)
EU27	1995 to 2005			1996 to 2007	-135.8	-135.2
EU15	1996 to 2005	-119.9	-109.9	1997 to 2007	-114.9	-114.4
Germany	1997 to 2004	-25	-22.5	1998 to 2007	-24.8	-24.7
France	1998 to 2005	-14.8	-14.4	1999 to 2007	-24.2	-24.1
Spain	1999 to 2003	-4.3	-3.4	2000 to 2007	-3.5	-3.5
Italy	2000 to 2003	-11.2	-11.2	2001 to 2007	-19.0	-18.9
UK	2001 to 2003	-28.5	-30.4	2002 to 2007	-25.7	-25.6
Denmark	not possible			2003 to 2007	-2.5	-2.5
Austria	1995 to 2005	-1.1	-0.6	2004 to 2007	-0.6	-0.6
Netherlands	1996 to 2002	-3.8	-1.7	2005 to 2007	-4.5	-4.5
Poland	not possible			2006 to 2007	-3.5	-3.5
Czech Republic	not possible			2007 to 2007	-3.4	-3.4
Romania	not possible			2008 to 2007	-1.0	-1.0

Table 2-4 Annual impacts in the latest years (2005 and 2007)

	Tier1	Tier 2	Tier 3	Tier 3
	2005	2005	2005	2007
Group/MS	Freezing emission rates at earliest value (1995)	Removing the effect of dieselisation		
	(Mt CO ₂)	(Mt CO ₂)	(Mt CO ₂)	(Mt CO ₂)
EU27			-21.2	-30.2
EU15	-29.4	-26.4	-17.9	-25.4
Germany	-4.7	-4.1	-3.9	-5.7
France	-3.7	-3.3	-3.8	-5.3
Spain	-1.4	-1.4	-0.6	-0.8
Italy	-	-	-2.9	-4.0
UK	-8.1	-8.3	-4.0	-5.8
Denmark			-0.4	-0.5
Austria	-0.3	-0.1	-0.1	-0.1
Netherlands	-0.7	-0.6	-0.7	-1.0
Poland			-0.5	-0.8
Czech Republic			-0.5	-0.8
Romania			-0.2	-0.2

Results for case study Member States

The savings from the ACEA agreement for member states correspond approximately to the population and GDP, as the main drivers of car ownership of the states. However, some countries stand out. France has a relatively low effect compared to Germany and the UK. This is probably because of the exceptionally strong shift to dieselisation in France. Spain has a surprisingly small effect, given its size. This is due to the rapid increase in car ownership, especially of larger cars, and a certain increase in the km driven/year in Spain. The Czech Republic shows a surprisingly large impact. This is probably due to the rapid adoption of advanced engines, in comparison with other New Member States.

Results for EU-27

Overall, the impact of the ACEA agreement is assessed to have been considerable – a cumulative impact of the order of 135 Mt CO₂ for the EU 27 between 1996 and 2007. Based on the ASTRA model calculation in the year 2005 alone, the savings were around 18 Mt CO₂ per annum for the EU15 and 21 Mt CO₂ for the EU27.

Given the relative weakness of supporting policies (see below), this change can be attributed to the highly competitive nature of the automobile industry. While directive 1999/94/EC provides the basis for adoption of efficiency labelling of cars, TNO (2006) found no measurable effect of labelling policies in the assessment literature. While it cannot be plausibly argued that fuel efficiency is the main consideration of consumers' new car purchases, fuel efficiency figures are readily available and can be regarded as a point of competition between auto manufacturers. Therefore, the ACEA agreement can be seen to have reinforced this effect. However, the non-binding nature of the agreement is clearly demonstrated, in that the agreed ACEA targets have not been met.

2.3.3 Sensitivity analysis

The influence of the various factors was tested extensively in the Tier 3 analysis using the ASTRA model. The results are shown at Table 2-5.

Table 2-5: Sensitivity analysis, assessing the changes due to the different factors (based on the specific CO₂ emissions per km)

g CO ₂ /km	Historical development	Historical development ASTRA fuels prices	Const. diesel share	Const. size share	Const fuel tax	Const fuel price
1990	186.0	186.0	186.0	186.0	186.0	186.0
1992	188.0	188.0	188.0	188.0	188.0	188.0
1994	185.0	185.0	185.0	185.0	185.0	185.0
1996	183.0	183.0	183.0	183.0	183.0	183.0
1998	178.0	178.0	178.0	177.5	178.0	178.0
2000	169.0	169.0	169.3	169.7	168.9	169.0
2002	165.0	165.1	165.5	166.4	165.1	165.1
2004	161.0	161.4	161.6	162.5	161.3	161.3
2006	156.4	156.7	158.0	155.4	156.7	156.7
2007	152.9	153.0	154.3	150.1	153.1	153.0
2008	149.3	149.4	150.6	144.9	149.4	149.4

The factors assessed were:

- the impacts of changes in the shares of diesel vehicles;
- the impacts of the changes in the size share of vehicles;
- the impacts of fuel taxes, and;
- the impacts of fuel prices.

These were assessed by performing separate analyses, where these variables were kept fixed. The results were then compared to the historical data. As can be seen from the figure, the impact of all

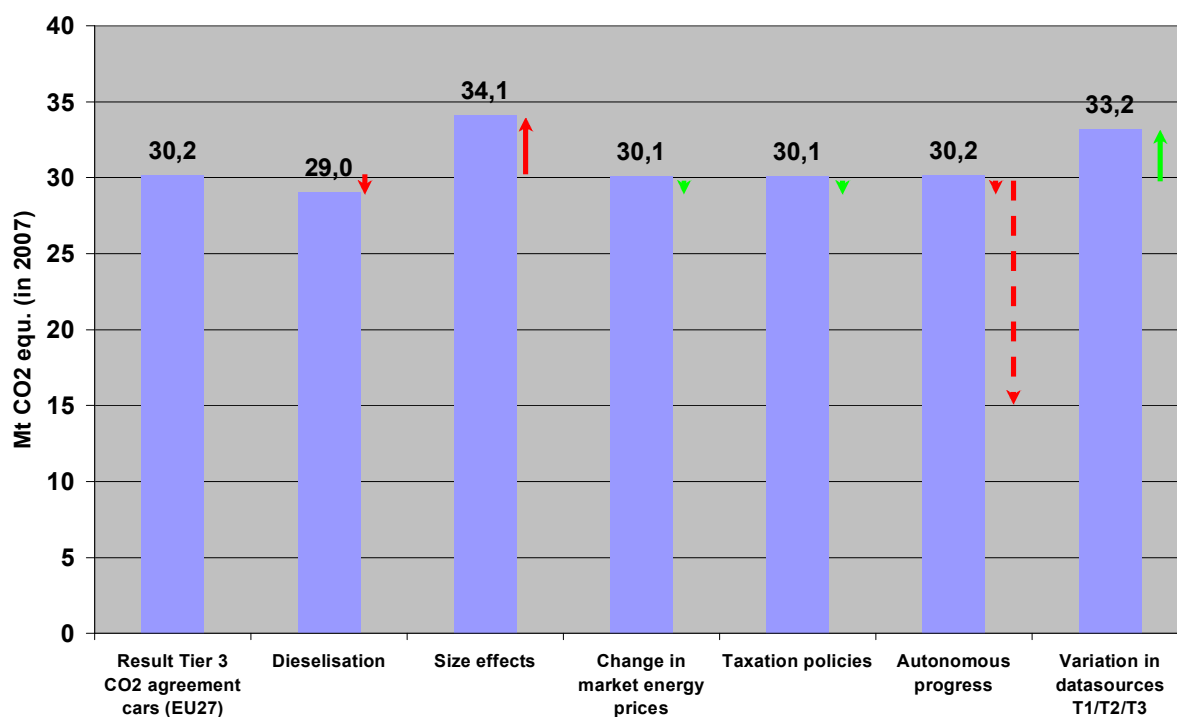
these variables was assessed to be very small. This is because these variables did not alter dramatically between 1990 and 2006. The period of very high oil prices, which did lead to a certain increase in fuel prices, came at the end of this period, too late to have a major effect on the data.

The sensitivity analysis indicated an apparent weakness in the policies supporting the ACEA agreement. While there have been a few interesting policy initiatives, such as company car taxation in the UK or the 'ecological tax' in Germany, as well as labelling initiatives following EU directive 1999/94/EC car labelling, these policies have had no noticeable impact on the fuel efficiency of the car fleet. The conclusion from this analysis is that improvements in performance have come from a combination of the autonomous technological improvement and the ACEA agreement itself.

A further critical element in the analysis is the estimate of the autonomous technological improvement. In the Tier 3 analysis, this trend was estimated as the average reduction in the period immediately before the agreement became effective, 1990-1996. It would be possible to estimate the trend over a longer time period. However, the estimated trend then contains more changes in other factors such as the oil price shock of 1973-74, or the swings in economic activity of the 1970s and 1980s, which are outside the scope of the Tier 3 analysis.

The different factors that have an impact on the Tier 3 results have also been examined in terms of their influence upon the overall change in emissions, and the results are shown in Figure 2-3. This shows the impact of using specific methodological assumptions, and the influence of data uncertainties, upon the overall results. The arrows show the relative variability in the results depending upon the particular assumptions that are used. The results represent the historic importance of the different factors. This does not necessarily mean that the factors will have the same importance in the future.

Figure 2-3 Sensitivity analysis of key parameters on the CO₂ savings from the voluntary agreement (impact on emission in 2007 for the EU27).



Note: Variations due to methodological choices are in red. Variations due to data issues are in green. Solid arrows represent an absolute assessment of the variation, as calculated in the current analysis. Dashed arrows show an estimate of the variation, but the absolute value is much more uncertain

2.4 Synthesis and interpretation of results

2.4.1 Comparison of results from the different methods

As can be seen in Table 2-3 the results from the Tier 1, 2 and 3 approaches are similar, on a cumulative basis, with a difference of around 2.5% between the Tier 1 and 2 and the Tier 3 approach. When assessed in terms of the annual savings in the most recent year the difference between the Tier 1/2 and Tier 3 approaches is greater, and can be explained by differences in the methodologies (e.g. the time period over which impacts were assessed, the treatment of the autonomous rate of technical progress). Differences in data sources between Tiers 1/2 and Tier 3 methodologies have also contributed to the discrepancy in the results.

The strength of the Tier 3 approach is that it allowed further sensitivity analysis to be carried out. This showed that, with the exception of autonomous progress, the influence of the other factors were generally small. If there had been more drastic changes in fuel prices or an earlier shift to larger cars, the differences in the results might have been far greater.

2.4.2 Comparison of impacts across Member States

The ACEA agreement was made at the EU level. Therefore, it could be assumed that it has been applied equally to all member states. Furthermore, the main differences between Member States which might impact on car purchases, taxation policy, fuel prices and consumers' behaviour are all taken into account at an individual member state level in the Tier 3 analysis using the ASTRA model. The differences between individual member states are partly due to differences in consumer preferences for new cars. Some states tend to purchase small cars, e.g. Italy, Spain and to some extent France, whereas others especially Germany and Sweden tend to purchase larger cars. Although there are differences in national policies to support the ACEA agreement, the relatively small changes of almost all policies means that the impact of these differences was not large.

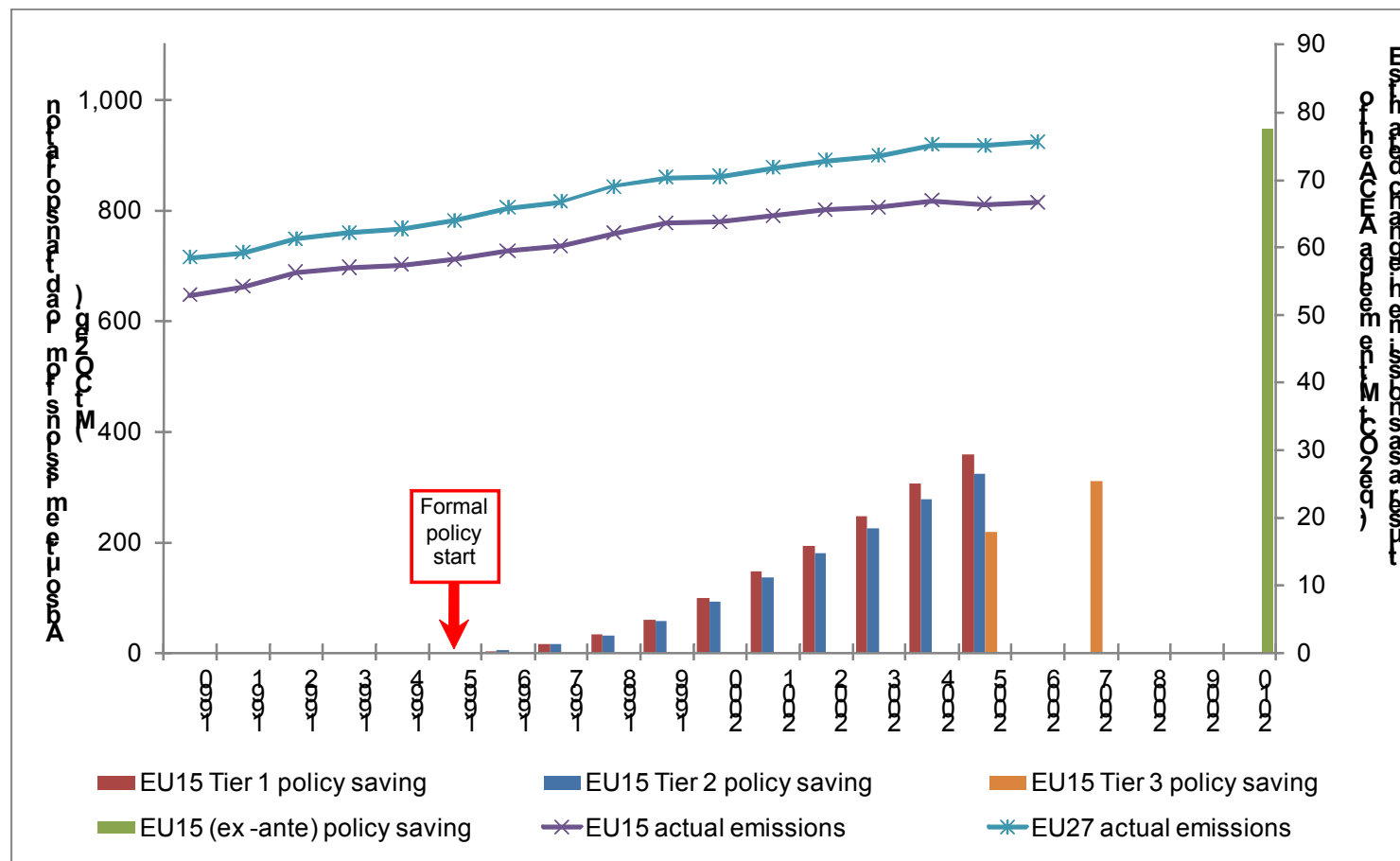
2.4.3 Comparison with alternative estimates and ex-ante results

The second ECCP progress report (EU 2002) estimated potential savings in the EU 15 in 2010 of 75-80 Mt CO₂ per annum. This estimate is compared with the results from the ex-post evaluation in the table below. Ex-post savings for the latest year (2005/2007) are considerably lower than the European Commission's ex-ante estimate of the policy savings in 2010. This is not surprising assuming that this estimate was based on the achievement of an average vehicle efficiency of 140g CO₂/km, which has not been achieved in reality.

Table 2-6 Comparison of ex-ante and ex-post results: ACEA Agreement

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
Voluntary agreements with car manufacturers	75 - 80	NE (EU27, 2005) 29.4 (EU15, 2005)	NE (EU27, 2005) 26.4 (EU15, 2005)	21.2/30.2 (EU27, 2005/2007) 17.9/25.4 (EU15, 2005/2007)
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations:				
MSsp: Member State specific starting year for the ex-post evaluation				
NE = not estimated				

The estimated impacts of the policy are put into context in Figure 2-4 below. The estimated (ex ante, and ex post) impacts are compared against the overall historical trend in emissions from road transport. This shows the relative influence of the agreement on the overall trend in emissions.

Figure 2-4: ACEA agreement: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above.

Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

2.4.4 Cost effectiveness

The costs due to the ACEA agreement can be assessed in two ways: The administrative and 'transaction' costs associated with the agreement and the R&D and investment costs to the industry of developing more fuel efficient cars. TNO (2006) assessed these social abatement costs as ranging from €233/tonne CO₂ at an oil price of €25/bbl to €132/tonne CO₂ at an oil price of €74/bbl. Hence the abatement cost of conventional motor cars is probably closer to the lower of these two figures. Besides, these costs are the technological costs linked to improving the fuel efficiency of a car, all characteristics being equal. They do not take into account possible downsizing or alternative marketing policies by manufacturers. They do not either reflect the fuel cost savings that consumers will enjoy after having purchased a more fuel-efficient car. However, these costs are independent of the particular policy, they are just the cost of the response. The cost of implementation of a voluntary agreement comes in the time and effort spent by the parties in reaching the agreement and the costs of monitoring the agreement. Such costs are small. The negotiations involve relatively small numbers of people, especially in the case of the ACEA and other manufacturers' associations who negotiate with the EU commission as a whole. The cost of monitoring the agreement is also small, because the necessary CO₂ emissions test figures were easily combined with the fuel test measurements. Therefore, the costs involved with implementing this policy are small. It is for this reason that voluntary agreements are popular, as well as being popular with manufacturers because they face no extra legislation. However, the scope of such agreements is limited. As has now been observed, the reduction to 140g CO₂/km by 2008 has not been achieved. If deeper cuts are to be made in vehicle CO₂ emissions, alternative policies are needed.

2.5 Conclusions

For the ACEA agreement, there is detailed data reported by Member States on the emissions performance and numbers of cars purchased. This enables a comprehensive ex-post analysis of the policy. The Tier 3 analysis provides the most robust estimate of the policy impacts. However, the Tier 1 and 2 analyses can also be used to provide a fair approximation of the policy impact.

The various sensitivity runs that were made with the ASTRA model have also demonstrated the (surprising) weakness of some of the factors which were considered to have a potential impact on technological development, such as fuel prices and taxation and the adoption of larger vehicles. The weakness of all these factors left only two drivers of the technological improvement – autonomous technical change (i.e. development carried out by the auto industry as part of the competitive strategies of manufacturers) and the effect of the voluntary agreement. The actual estimated savings attributed to the ACEA agreement are thus heavily dependent on the assumed level of autonomous technical change.

Overall, the analysis indicates that the policy has driven moderate levels of emissions improvement. However, the ACEA agreement will not lead to large scale adoption of alternative technologies such as electric vehicles or H₂ fuel cell vehicles. This reinforces the findings of the EU Strategy review (EU, 2007), which concluded that further legislative measures are necessary to achieve the target of 120g CO₂/km by 2012 for new cars and LDVs.

2.6 Recommendations

The ex-ante evaluation of future policies should include a realistic appreciation of the trends in consumer preferences and manufacturers' marketing policies. Factors leading to the adoption of new technologies and alternative modes of transport also need to be assessed, where possible.

In most cases, it is not sufficient to analyse a single policy in isolation. The effectiveness of a policy such as the ACEA is dependent on supporting measures such as fiscal incentives to buy more fuel efficient cars and information measures to ensure that information on fuel efficiency is readily available. Such an analysis may be carried out with transport models such as the ASTRA model used in this work in order to reflect well the interactions between different factors. However, the application of the methodology shows that the influence of these other factors is minor in this example.

2.7 References

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3 Case study: Biofuels Directive

Disclaimer: The analysis of the Biofuels Directive has been prepared by Fraunhofer ISI. The final presentation of the results from the Biofuels Directive does, however, not reflect the views of Fraunhofer ISI.

3.1 Introduction

3.1.1 Overview of policy

Biofuel production and consumption from renewable sources, mainly from biomass and agricultural feedstock, have increased considerably in the last few years. Biofuels started gaining interest in the 1990's in some Member States and more attention was given from 2000 onwards with legislative proposals such as the Biofuels Directive (2003/30/EC) that was adopted later in 2003.

Member States have been requested to set up national targets for introducing biofuels in their markets with the help of promotional measures triggered by the Biofuels Directive which is considered to have an important impact on these developments. The Directive required Member States to set up national indicative targets on the basis of energy content of all gasoline and diesel fuels consumption. For 2005 an interim 2 % biofuels target was agreed followed by the 5.75 % target for 2010. Until now all Member States have introduced policies to support the penetration of biofuels ranging from biofuel production quotas, blending obligations and tax exemptions in accordance with Article 16 of the Energy Taxation Directive (2003/96/EC). Up to now, these policies have been implemented on a national level with the aim to meet the national targets set in the Biofuels directive.

Since 2005, 13 Member States have received state aid approval for biofuels tax exemption while 8 Member States at least have plans or are implementing Biofuels blending obligations. However, the proposed 2005 targets were not met and it is likely that the 2010 targets will not be met according to the progress report on Biofuels (COM (2006) 845).

Biofuels diffusion into the markets have increased from 2001 onwards in Europe from 0.3 % of biofuels share in the transport fuels market to approximately 2.6 % at the end of 2007. Whilst initially this figure appears to be impressive, the progress made has been uneven across the different Member States. By the end of 2006, Germany and Sweden were the only two Member States that reached their targets. Altogether, the effectiveness of the present Biodiesel policy in most EU countries is limited.

In addition there are important challenges with respect to biofuels and food competition, expected increase in imports, and ensuring supplies meet sustainability criteria³. These issues may make the achievement of target more challenging.

The measure mapping of the measures potentially relevant for the promotion of Biofuels is provided in Table 3-1 below.

3.2 Emission trends and drivers

3.2.1 Impact upon greenhouse gas emissions

The Biofuels Directive has a direct impact on the emissions of the road transport sector since biofuels replace fossil transport fuels. Of course the Biofuels Directive is not the only policy to influence road transport sector emissions. Particularly relevant are also the ACEA agreements on CO₂ emissions (see separate Tier 3 report), the currently debated minimum standards for cars, the car labels and the modal shift policies. It is, however, easy to separate these policies from the biofuels policy so far, as the mutual influence was limited and the production of biofuels is recorded in own statistics. In future, however, through the introduction of biofuels in the CO₂ standards for cars and light duty vehicles, the interaction may increase.

³ In particular, the definition of a consensual way to determine and take into account emissions relating to expected land use changes.

Table 3-1: Measure mapping of the Biofuels Directive

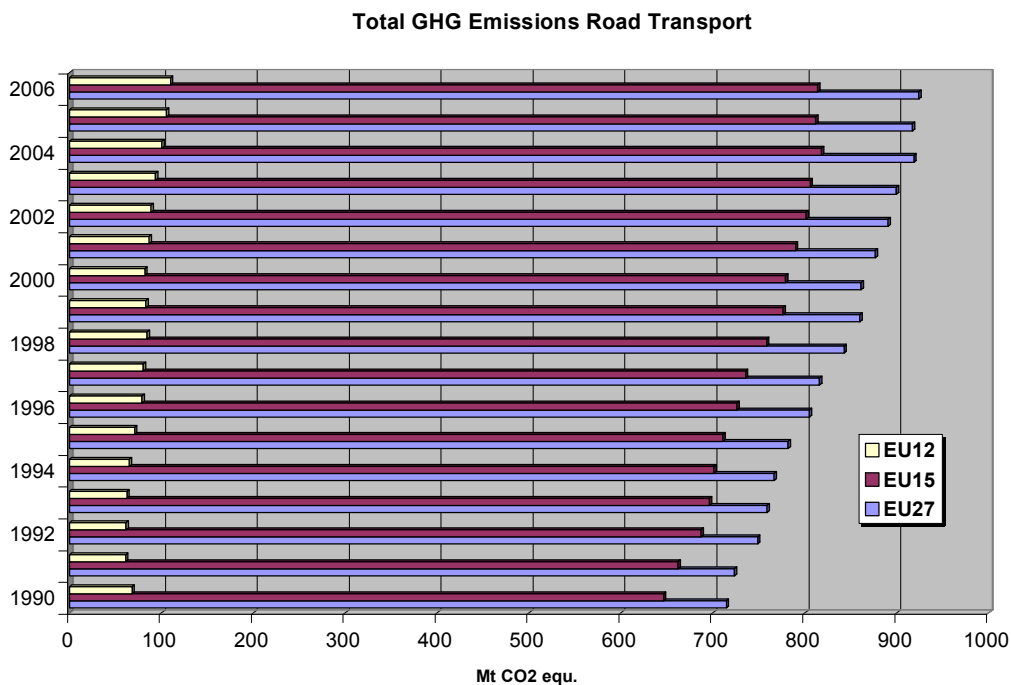
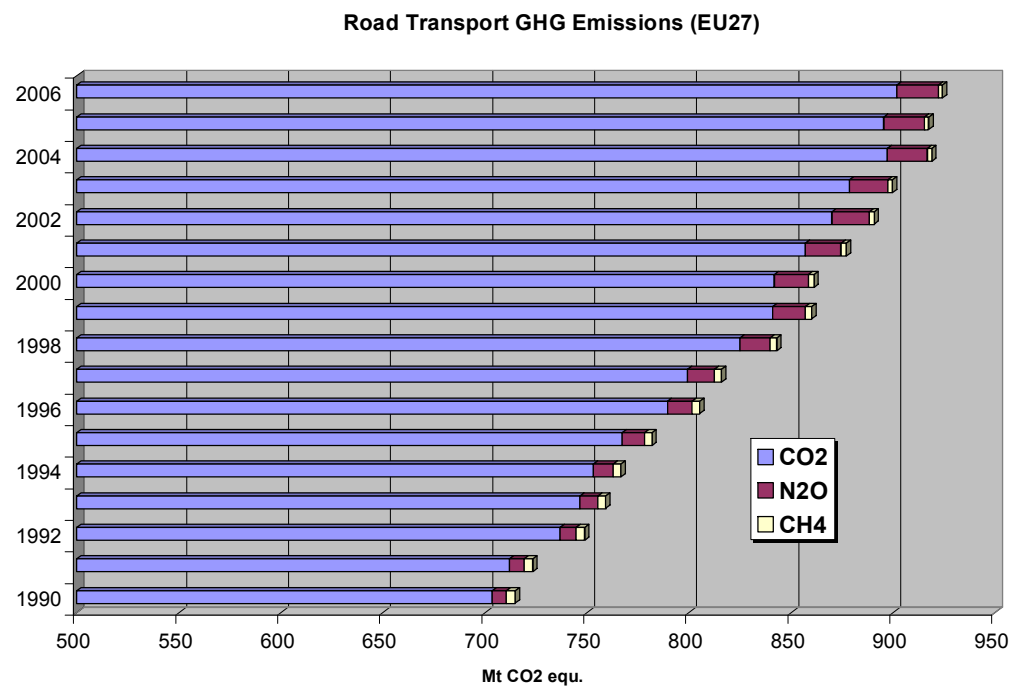
MEASURE	TARGET	GOAL FOR TOP-DOWN IMPACT
Support schemes for Biofuels		
Biofuel Directive	5.75 % Biofuels in 2010 – Proposal 10% in 2020 (discussion)	Increase share of renewable biofuels
National support schemes	Tax exemptions, quotas	Reaching national targets
Complementary financial measures		
Energy taxes	primary/final energy use	Incentive for production
Support for Agricultural Land (CAP Reform)	Subsidies for energy crops	Incentive for cultivation
Command and control		
Fuel standards (Fuel Standards for Biofuels)	Assure fuel quality. Basis for biofuel legal definition.	
Technology promotion		
R&D (1 st and 2 nd generation, BTL, Logistics, Sustainability)	Increase efficiency, technology diffusion	
Informational measures and voluntary demand		
Information and awareness campaigns and Industry and MS Governments/EU	Awareness raising, social acceptance, create markets	

3.2.2 Activity and emission trends

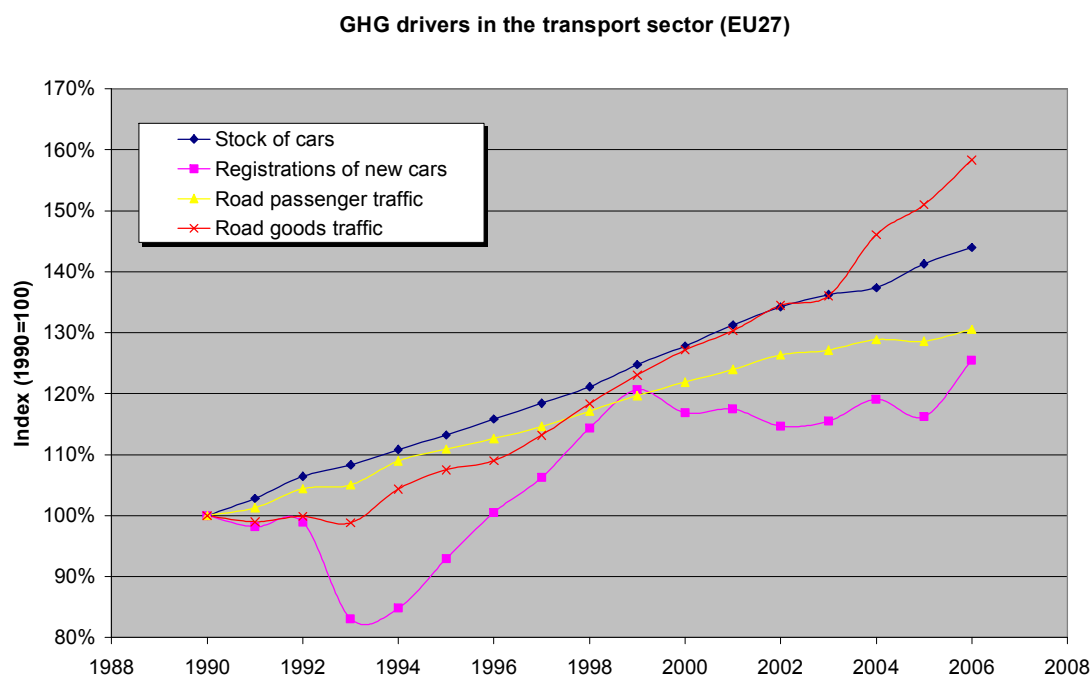
The GHG emissions from the road transport sector in the EU-27 are shown in Figure 3-1 based on the UNFCCC sector 1.A.3.B emissions. This is the most relevant category of GHG for the Biofuels Directive. It can be observed that emissions in the EU-27 countries the transport sector emissions increased 1990/2006 by about 29% to a level of over 900 Mt CO₂ equ. In recent years some saturation may appear which could be more marked in 2007 and 2008 due to the high transport fuel prices, but this will have to be confirmed when statistics are available. The EU-12 Member States showed a much stronger increase in the emissions of more than 60% since the beginning of the 1990s but in particular since 2000.

The increase in GHG emissions is directly correlated to the increase in the relevant transport drivers (see **Figure 3-2**), which shows the increase in car stocks, the new car registrations, as well as the increase in road passenger (pkm) and goods transport (tkm). Interestingly the new car registrations increase less rapidly than the car stock which indicates stock aging. Also the mobility in pkm is increasing less rapidly than the car stock which indicates less km driven per vehicle. The fastest growing driver is the goods traffic which increased nearly 60% since 1990 and in particular since 2002 since the new MS have been progressively integrated within the EU.

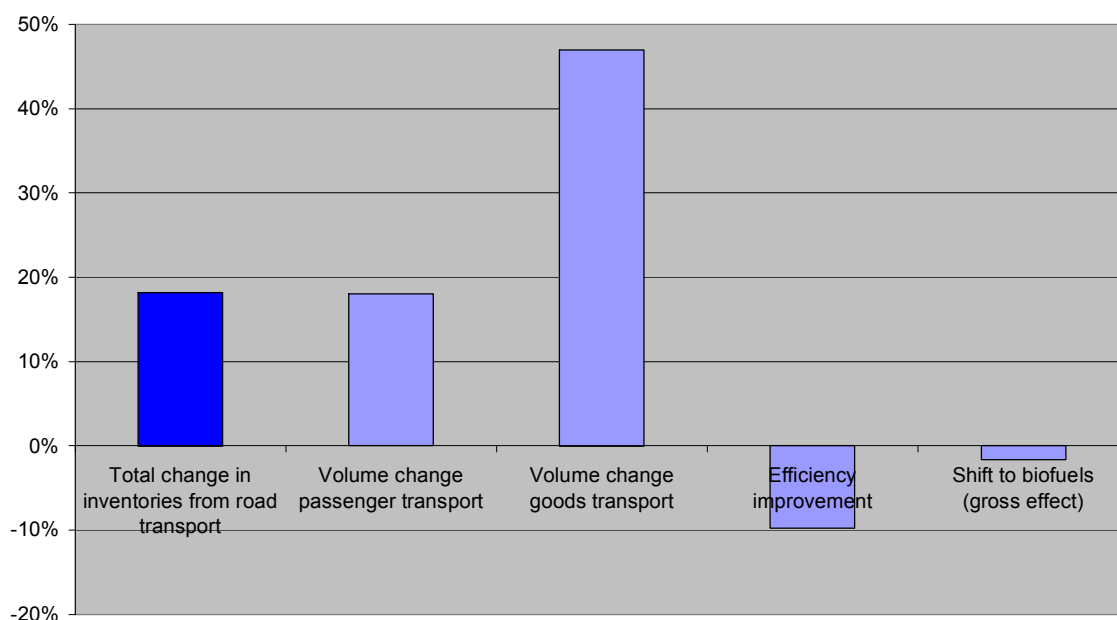
A factor analysis of the different contributions between 1995 and 2006 shows (Figure 3-3) that the volume changes of 18% (passenger transport) and 47% (goods transport), i.e. around 30% on average have been compensated by about 10% with efficiency improvement and around 1.7% by biofuels (the latter are the gross emissions for 2006 calculated in the Tier 3 report for biofuels. This is adequate here, as the LCA emissions occur in other sectors of the inventories). In total this results in an increase in the inventories of road transport of about 18% in 2006 compared to 1995.

Figure 3-1 Development of the GHG emissions of the road transport sector by type of GHG and for the EU-27/EU15/EU12

Source: EEA (2008)

Figure 3-2 Development of road transport activity levels in the EU-27

Source: Odyssee Database (2008) (www.odyssee-indicators.org)

Figure 3-3 Factor analysis of changes in the road transport sector emission inventories (2005 compared to 1995)

3.3 Impacts of the Biofuels Directive on emissions of GHGs

This section summarises the results from the application of the evaluation methodologies to the biofuels case study.

3.3.1 Overview of methodologies

Historical levels of biofuel production are available from statistics at an EU and Member State level in either tons or litres (and translated into energy units) and are used as an indicator of the effect of the transposition of the Directive in these Member States, taking into account the year in which the Directive has been applied. Biofuel production figures as an impact indicator are complemented with data on the biofuels consumed during the period before and after the Directive has been transposed to national law. Estimates on biofuels imports/exports have been carried out as they are not currently collected in EU or Member States statistics⁴.

Biofuel production across the EU before the time of adoption of the Directive into national law is initially accounted as autonomous development in combination with the identification of the national policies in place for biofuels. It is important to remark that most biofuels technologies (1st and 2nd generation) remain until now non-competitive without subsidies when compared to their fossil fuels counterparts, namely gasoline and diesel fuels. These options are capable of entering the markets only through political and economic support. The autonomous development therefore is assumed to be insignificant without the existence of the Directive in the ex-post perspective.

Delays in the implementation of the Directive into national law play a minor role in hindering the deployment of biofuels (from production, to distribution, trade and sale) in the markets. In view of the approval of the Directive, biofuels market actors across Member States started activities with the certainty that at national level policies to support the market (e.g. tax exemptions and quotas) would soon be put in place. On this basis, any delays in implementing the Directive are not considered to have a major effect on the biofuels development at Member State level.

The methodology proceeds with three levels of complexity (Tier 1, Tier 2, Tier 3) which are distinguished in the following manner:

- Tier 1 approach: calculates impacts based on the total biodiesel and bioethanol consumption and uses EU average default emission factors for each of the two main groups.
- Tier 2 approach: calculates impacts based on the total biodiesel and bioethanol consumption and uses MS average default emission factors for each of the two main groups.
- Tier 3 approach: calculates impacts based on specific feedstock/type of biofuel at MS level. However due to a lack of data on feedstocks for most of the MS (except for Germany) the refined calculation could not be carried out for a larger number of countries.

In the Tier 3 approach, the impact of the Biofuels directive on GHG emission reductions is analysed with the following accounting methods which are well established:

1. the direct CO₂ emission reductions achieved through the substitution of gasoline and diesel in energy terms (**gross impact**) and
2. CO₂ and GHG emission reductions achieved through biofuels consumption after the Directive entry into force taking into account emissions factors that reflect the complete life cycle emissions across the whole supply chain for biofuels (**net impact excluding land-use change**). This case presents the upper (net) impact limit assuming that no risk of direct or indirect land-use change occurring.

⁴ We are aware that data on biodiesel and ethanol imports may be available for certain EU sources. However, we were unable to access this data for use in this study. This issue therefore needs further investigations in follow-up studies to improve the methodology.

Table 3-2 Main differences between Tier 1, Tier 2 and Tier 3 methodologies with respect to the most important factors of influence on the results

Approach	Tier 1	Tier 2	Tier 3
Activity indicator	Volume of Biofuels	Volume of Biofuels	Volume of Biofuels
Emission factor (kg CO ₂ eq/GJ)	EU average / default IPCC emission factor	MS averages for bioethanol/ biodiesel	(1) Direct CO ₂ emission reduction (gross impact) (2) Life cycle EF based on MS feedstocks (net excl. LUC) (3) EF Elec prod. (co-generation uses) (4) Sensitivity analysis: life cycle EF incl. LUC (net imports)
Impact of biofuels imports/exports on emission factor	no	no	yes (type of feedstock; sensitivity analysis: iLUC)
Policy interaction with national biofuels policies ⁵	no	no	(yes) ⁶
Policy interaction with other national and EU-wide policies	Combined effect of biofuels and non-biofuels policies	Combined effect of national + EU policies. Combined effect of closely related national and EU policies.	Interaction of biofuel policy with non-biofuels agriculture and spatial policies (iLUC)
Autonomous progress ⁷	no	(yes)	(yes)
Geographic factors	no	no	(yes) ⁸
Timing issues / delay or announcement effects	no	no	MS specific

Note: Brackets indicate that the issue is considered in principle but was not considered relevant for the specific ex-post evaluation period investigated. iLUC = indirect land use change.

3.3.2 Results – Tier 1, Tier 2, Tier 3 approach

Results for case study Member States

For Europe, all three tiers result in positive GHG savings (excluding any impacts associated with land-use changes are excluded. The difference between the Tier 1, 2 and 3 results is explained by the assumed feedstock allocations used for Tier 3 and the use of average EU or MS well-to-wheel emission factors for Tier 1 and Tier 2.

⁵ Interaction with national biofuels policies (Tax exemptions/quotas, Energy taxes on Diesel/Gasoline, Support for Agricultural Land (CAP Reform):

⁶ All biofuels after transposition of Directive are supposed to be related to the introduction of the Biofuels Directive.

⁷ Profitable biofuels + previous national policies.

⁸ Normalisation to climatic conditions: annual ha yield.

Figure 3-4 and Figure 3-5 illustrate the net GHG emission savings for Tier 1, Tier 2 and Tier 3 for Europe and Germany respectively. The cumulative net GHG savings for Tier 1 and 2 amount to approximately 30 Mt CO₂-eq from 2004 until 2007 for Europe (EU-27). Allowing for the fact that indirect land use change has not been assessed, the results of the Tier 3 methodology are similar. For comparison, cumulative savings of are also reported in the figures. The German figures represent roughly half those values.

Figure 3-4 Net GHG Savings for all Biofuels for Europe – 2004-2007 and Total GHG Savings in Mt CO₂-eq – all accounting methods

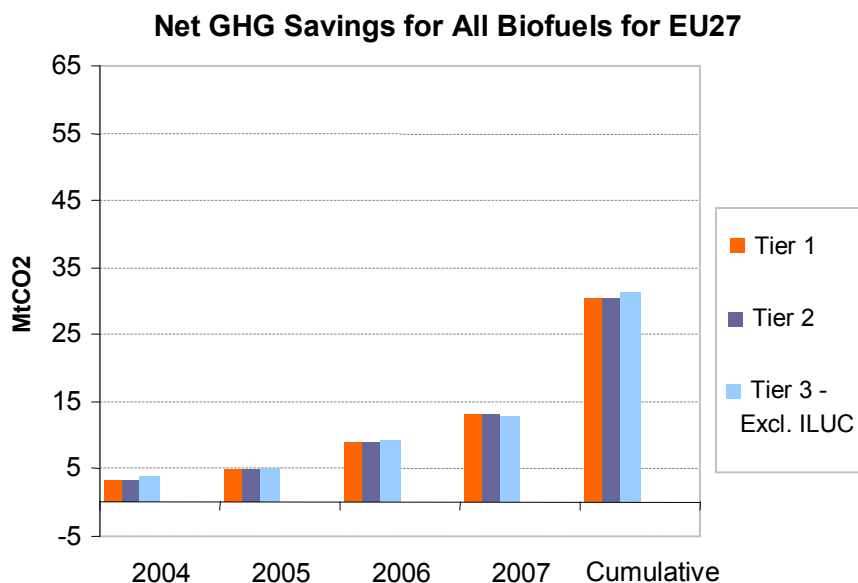
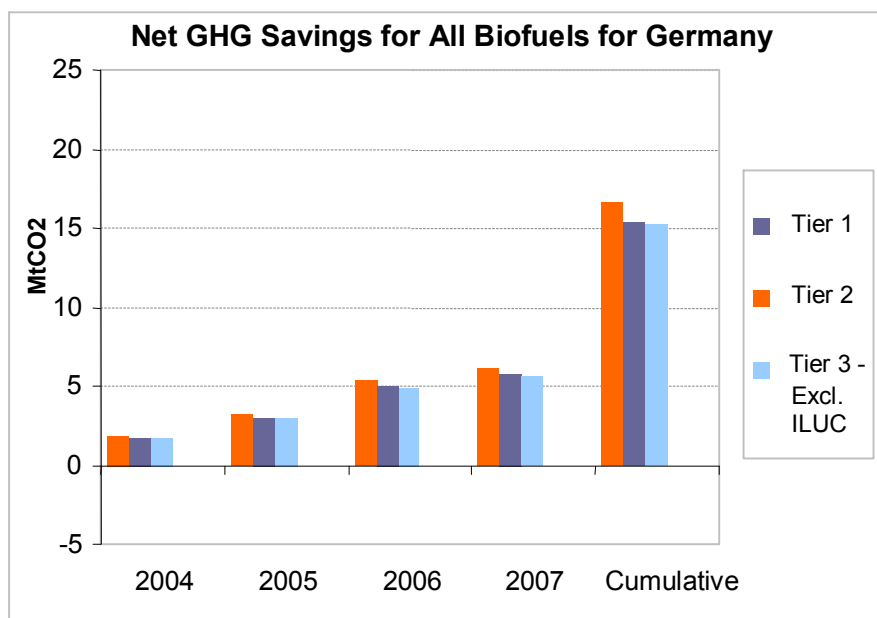


Figure 3-5 Net GHG Savings for all Biofuels for Germany – 2004-2007 and Total GHG Savings in Mt CO₂-eq – all accounting methods

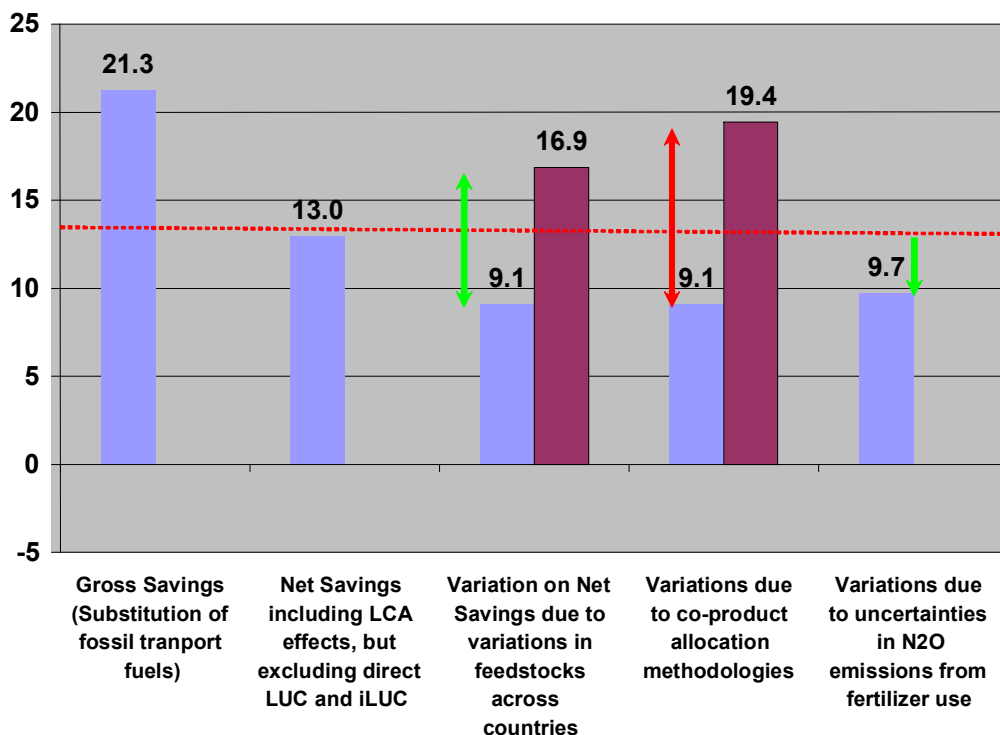


3.3.3 Sensitivity analysis

A range of different factors that have an impact on the Tier 3 results have been examined as part of a sensitivity analysis - the results are shown in Figure 3-6. This shows the impact of using specific methodological assumptions, and the influence of data uncertainties, upon the overall results. The arrows show the relative variability in the results depending upon the particular assumptions that are used. The results represent the historic importance of the

different factors. This does not necessarily mean that the factors will have the same importance in the future.

Figure 3-6 Biofuels Directive: sensitivity analysis for the different factors affecting the CO₂ savings (Mt CO₂ equ. in 2007 for the EU27)



Note: The dotted red line represents the result derived using EU average conditions. Variations due to methodological choices are in red. Variations due to data issues are in green. Solid arrows represent an absolute assessment of the variation, as calculated in the current analysis. Dashed arrows show an estimate of the variation, but the absolute value is much more uncertain

It can be seen that a number of data uncertainties may have substantial impact on the overall results. These are in particular:

- Uncertainties in country-wise feedstock composition and feedstock composition of imports;
- Uncertainties in N₂O emissions from the use of fertilisers;

Other factors are rather linked to methodological choices.

3.4 Synthesis and interpretation of results

3.4.1 Comparison of results from the different methods

The three different methods Tier 1, Tier 2, Tier 3 provide rather similar results because they are based on default emission factors established in LCA analysis. These factors may be subject to variations depending on scientific advances on individual parts of the biofuel production chain. This would, however, affect all three methods rather equally. An approach that includes a quantification of emissions from land use change may, depending on the methodology chosen and results found, deviate from the above results for each tier. Complex model calculations and detailed investigations will be required to develop a widely accepted evaluation methodology. Several academic works are going on worldwide trying to address the issue. The Renewable Energy Directive also requires the Commission to issue a report on the issue based on sound scientific evidence, by end 2010, and to provide a concrete methodology.

3.4.2 Comparison of impacts across Member States

The impact of the Biofuels Directive across Member States differs significantly (Table 3-3). If the share in biofuels production in 2007 is taken as a proxy for the share in impacts, Germany has the lead with more than half of the impacts, followed by France with around 19%. Other countries with substantial shares are Austria, Spain, UK, Sweden, Portugal and Italy (in total 22%). These differences are linked to the different promotion schemes introduced in the different countries for biofuels.

Table 3-3: Shares of different EU MS countries in biofuels production (2007)

Countries	Biofuels consumption (toe)	% of total
Germany	4.002.748	52%
France	1.434.214	19%
Austria	389.023	5%
Spain	373.220	5%
UK	348.690	5%
Sweden	281.251	4%
Portugal	158.853	2%
Italy	139.350	2%
Bulgaria	112.496	1%
Poland	100.680	1%
Belgium	91.260	1%
Greece	80.840	1%
Lithuania	52.600	1%
Luxembourg	34.963	0%
Czech Rep.	32.840	0%
Slovenia	13.787	0%
Slovakia	13.262	0%
Hungary	9.180	0%
The Netherlands	8.670	0%
Ireland	8.374	0%
Denmark	6.025	0%
Latvia	1.740	0%
Malta	0	0%
Finland	0	0%
Cyprus	0	0%
Estonia	0	0%
Romania	0	0%
Total EU	7.694.067	100%

Source: Observ'er

(http://www.energies-renouvelables.org/observ-er/stat_baro/comm/baro185.asp)⁹

3.4.3 Comparison with alternative estimates

There is already quite some experience with respect to the quantitative assessment of the impact of biofuels policies on the deployment of biofuels technologies as well as on GHG reductions in the future at EU level. In particular with respect to a prospective assessment of the future emission reductions of biomass including biofuels and renewable energy sources various studies exist, e.g. Ragwitz (2004), EEA (2006), REFUEL (2008), VIEWLS (2006). With respect to the current discussions on biofuels sustainability and certification, very few GHG balances and historic evaluations are found for biomass and biofuels besides the current discussion from IFEU (Jan. 2008).

With respect to the historic impact of the biofuels on GHG avoidance at EU level further evaluations have not been found besides the progress report for the Biofuel Directive from the EU Commission (Jan. 2007). In Germany various studies and analysis exist with respect to the analysis of climate

⁹ The Eurobarometer data are not official and probably not consolidated (some differences with Eurostat data). Therefore, in future evaluations reliance should be made on Eurostat data. Biofuel produced is also used for electricity and heat generation, i.e. not counting for the biofuels targets. With Eurostat data on 2007 are the most up-to-date available. Data on 2005 are also relevant for the assessment of the intermediate target.

change policies and measures at national level including analysis on prospective investments and expected CO₂ and GHG emissions such as the Integrated Energy and Climate Program (IEKP 2008) study as well as the Policy Scenarios IV and V from 2008 and the study on Investments for a Climate Friendly Germany (June 2008). In the framework of the discussions for the Sustainability Act for Biofuels, the study from IFEU in Dec. 2007 reviews the GHG Balances for the German Biofuels Quota Act as well as the Review on GHG savings calculations from the Renewables Fuel Agency in the UK from June 2008. These studies evaluated the emission reductions due to biofuels generation based on the LCA emissions of the biofuels from production to end use.

3.4.4 Comparison with ex-ante results

A recent ex-ante estimate for the EU is presented in RFA (2008). The savings resulting from the European Union 10% (by energy content) target are estimated to be approximately 54 – 68 million tonnes CO₂e. The following assumptions were made:

- The feedstock mix was based on the impact analysis carried out by the European Commission¹⁰ - details are provided in the table below.
- The GHG saving achieved by a biofuel chain was based on the best performing feedstock / origin default value from the UK Renewable Transport Fuel Obligation RTFO default values. The lower estimate assumes that there is no improvement over time in the GHG saving of first generation biofuels, while the higher estimate assumes that there will be a 20 percent improvement.

These ex-ante estimates scale rather well with the results found in this study when LCA factors were used (excluding land-use change) because those factors are already rather well established.

Table 3-4: Ex-ante GHG impact projections by E4tech (2008) for the 10 % biofuels target

Fuel chain	Quantity of biofuel	Low GHG saving	High GHG saving	Low GHG saving	High GHG saving
	Mtonne	kg CO ₂ e / GJ	kg CO ₂ e / GJ	Mt CO ₂ e	Mt CO ₂ e
Bioethanol from cassava	0.0	34.4	44.5	0	0
Bioethanol from wheat	12.4	25.6	37.4	8	12
Bioethanol from sugar beet	0.2	34.4	44.5	0	0
Bioethanol from sugar cane	2.0	60.0	64.9	3	3
Bioethanol from sorghum	0.0	60.0	64.9	0	0
Bioethanol from maize	4.5	35.6	45.4	4	6
Biodiesel from soya beans	3.4	38.8	48.3	5	6
Biodiesel from palm	0.6	39.6	48.9	1	1
Biodiesel from sunflower	1.3	41.2	50.2	2	2
Biodiesel from jatropha	0.0	39.6	48.9	0	0
Biodiesel from rapeseed oil	19.9	41.2	50.2	31	37
Lignocellulosic ethanol from bagasse	0.0	68.9	68.9	0	0
Lignocellulosic ethanol from wood residues	0.0	68.9	68.9	0	0
Lignocellulosic ethanol from agricultural residues	0.0	68.9	68.9	0	0
FT (or syn) diesel from bagasse	0.0	83.5	83.5	0	0
FT (or syn) diesel from wood residues	0.0	83.5	83.5	0	0
FT (or syn) diesel from Agricultural residues	0.0	83.5	83.5	0	0
TOTAL	44.3	-	-	54	68

Source: E4tech (2008)

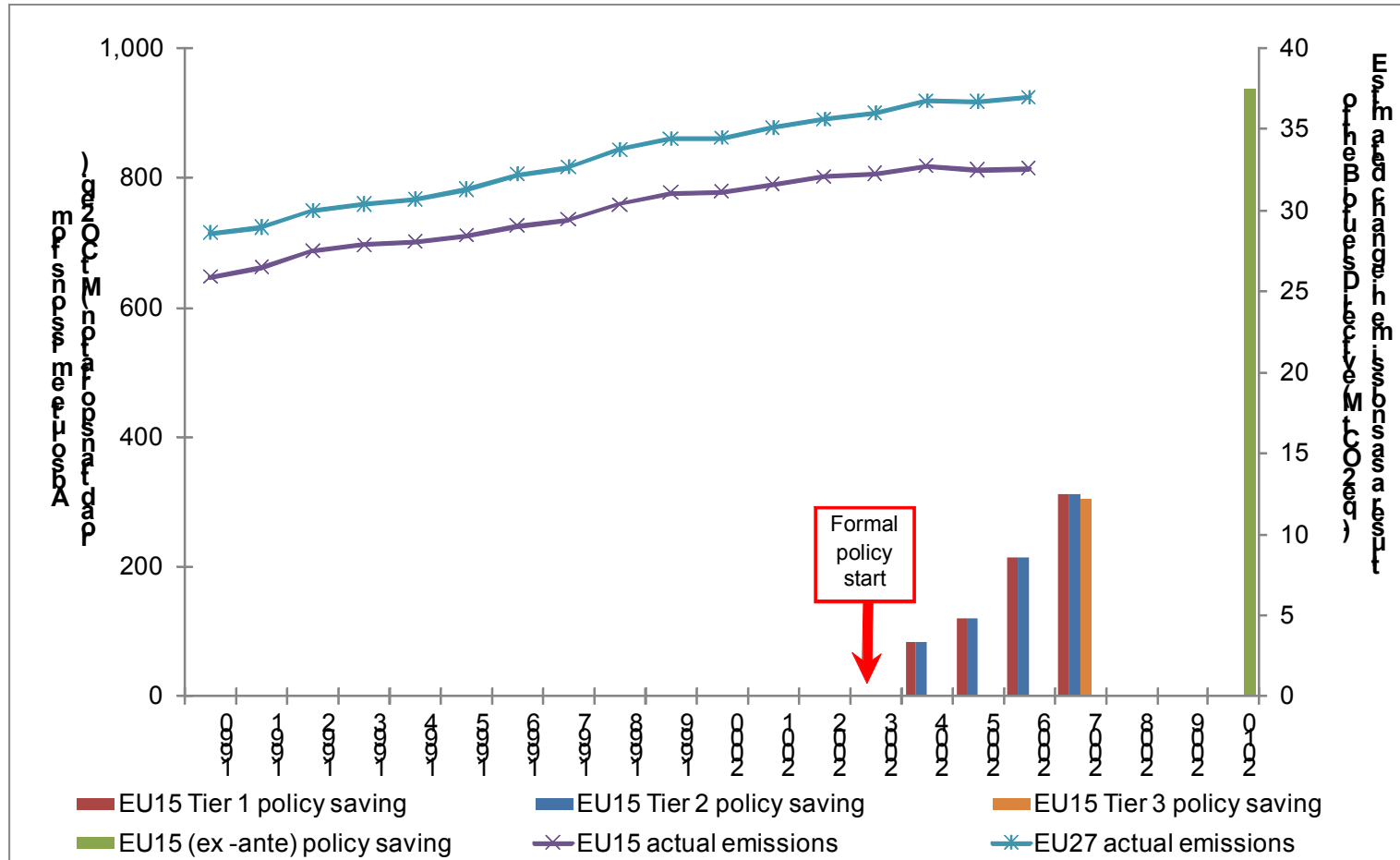
¹⁰ http://ec.europa.eu/agriculture/analysis/markets/biofuel/impact042007/text_en.pdf

The second ECCP progress report (EU, 2002) estimated potential savings in the EU 15 in 2010 of 35-40 Mt CO₂. This estimate is compared with the results from the ex-post evaluation in the table below. Ex-post savings for the latest year (2007) are considerably lower than those forecast by the European Commission for 2010 and are small in comparison to the challenge of sizeable and increasing road transport emissions in the EU.

Table 3-5 Comparison of ex-ante and ex-post results: Biofuels Directive

Comparison of ex-ante and ex-post results: Biofuels Directive				
Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)*		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
Biofuels Directive (Dir 2003/30/EC)	35 - 40	13.3 (EU27, 2007) 12.5 (EU15, 2007)	13.3 (EU27, 2007) 12.5 (EU15, 2007)	13.0 (EU27, 2007) 12.2 (EU15, 2007)
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations: MSsp: Member State specific starting year for the ex-post evaluation NE = not estimated				
Notes: * Excluding an assessment of the possible effects of indirect land-use change. Such effects, if taking place, may substantially reduce the impact calculated. Figures are, however, highly uncertain and require further investigation.				

The estimated impacts of the policy are put into context in Figure 3-7 below. The estimated (ex ante, and ex post) impacts are compared against the overall historical trend in emissions from road transport. This shows the relative influence of the agreement on the overall trend in emissions.

Figure 3-7 Biofuels Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above.

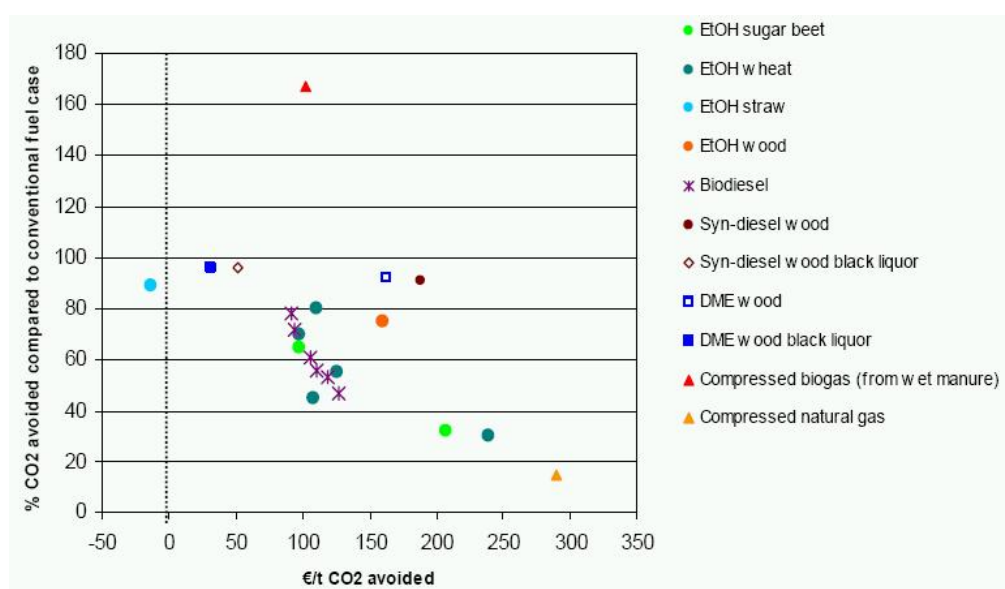
Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

3.4.5 Cost effectiveness

Generally, biofuels have caused additional costs as compared to conventional transport fuels since the Biofuels Directive was adopted. Therefore financial support schemes have had to be introduced at Member State level. In the Concawe/Eucar/JRC (2007) study costs of biofuels have been assessed. Even in the “high” oil price scenario of 50\$/bbl, few options are under the 100 €/t CO₂ mark, still much higher than the current value of CO₂ of 15-25 €/t (Figure 3-8), but in the range or lower than other alternatives for reducing GHG emission and oil dependency in the transport sector except for energy efficiency options on the vehicle technologies which in net terms generally lead to negative net costs.

According to the EU impact assessment of biofuels (2007) states that current estimates of costs show that second generation feedstock are 30% (second generation bioethanol) to 70% (BTL) more expensive than respective production of first generation fuels under present (2007) conditions and prices in the EU, but deliver higher GHG saving performances.

Figure 3-8 Biofuels: Cost vs. potential for CO₂ avoidance (Oil price scenario: 50€/bbl)



Source: Concawe/Eucar/JRC (2007)

3.5 Conclusions

The choice of emission factors for different biofuels is the most critical element in the evaluation. The LCA based approach delivers an upper limit to the impact of biofuels, which in 2007 was around 13 Mt CO₂ equ. mainly from biodiesel. Allowing for the fact that land-use change impacts have not been included in the assessment these impacts are relatively firm.

Methodological variations may be introduced by uncertainties in the LCA chain analysis (see the debate on N₂O emissions from fertilizing) and by methodological choices. With the possible growth of the share of biofuels of 2.6% in 2007 to the planned 5.75% in 2010 and the proposed 10% in 2020, more complications arise for the methodological aspects related to GHG impact quantification through the issue of land-use change. Depending on the size of such impacts, biofuels may have the potential to lead to increased emissions compared to the fossil reference system.

However, displacement effects are particularly difficult to establish. Therefore, careful analysis of such impacts is more necessary than in the past and dominates the current debate on biofuels.

3.6 Recommendations

The Gallagher Report (2008) reviews the uncertainties in the current methodologies to determine emission factors for biofuels. It points among other to the uncertainty in N₂O soil emissions on biofuel emissions and emissions from land use change.

Therefore, further analysis is needed on the following aspects:

- The well to tank GHG emissions of the biofuel (currently part of the emission factors and widely accepted, although individual parts of the LCA such as N₂O release from fertilisers are subject to a high variation);
- Emissions arising from land-use change may be large. The Commission is carrying out some modelling work aiming at a better understanding and quantification of the problem.

Such improvement of the methodology is vital for the evaluation of the GHG impact of biofuel policy. Advances on the methodology can be expected during the next 1-2 years, making the assessment more reliable.

3.7 Next steps

Further development of the methodologies for assessing the impact on emissions of biofuels policy, is necessary, in particular for the quantification of land use change. The European Commission is required by both the Fuel Quality Directive and the Renewable Energy Directive to prepare a report, and, if appropriate, proposals, on indirect land use change from biofuels. The most important next concrete steps to be carried out are:

- Understanding of the mechanisms causing indirect land use change;
- Define a methodology and appropriate tools to measure LUC due to biofuels policy.
- Determination of the scale of indirect land use change
- Determination of the scale of indirect land use change emissions

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4 Case study: RES-E Directive

4.1 Introduction

4.1.1 Overview of policy

Electricity generated from renewable energy sources (RES) in the EU has increased significantly in recent years, contributing not only to reductions in GHG emissions but also to enhanced energy security and employment. National promotion strategies triggered by the RES-E Directive (2001/77/EC) on renewable energy in the electricity sector are the major reason for this development.

The RES-E Directive entered into force in September 2001 and was transposed into national law by October 2003. The directive defines indicative targets for the share of renewable electricity in gross electricity consumption for all Member States. Furthermore it contains requirements on the implementation of national support schemes; it asks for a reduction of administrative and grid barriers and regulates the issuing of guarantees of origin for renewable electricity. According to the Directive *"Member States shall publish, for the first time not later than 27 October 2003 and thereafter every two years, a report which includes an analysis of success in meeting the national indicative targets taking account, in particular, of climatic factors likely to affect the achievement of those targets and which indicates to what extent the measures taken are consistent with the national climate change commitment."*

All EU Member States have introduced policies to support the market introduction of RES-E and most of them have started to improve the corresponding administrative framework conditions (e.g. planning procedures, grid connection). The market diffusion of new renewable energy sources has increased significantly since the RES-E Directive was adopted. The existing policies encompass feed-in tariffs, quota-based tradable green certificates (TGCs), investment grants, tender procedures and tax measures. Up to now, these policies have been implemented exclusively on a national level with the primary aim of meeting the national targets set in the RES-E directive. However, it is very likely that the RES-E targets will not be met based on the performance to date of the current policies (COM (2004) 366) and (COM (2006) 849). One important reason for this is that the RES-E support systems in most EU countries are still not designed in an appropriate way, see Ragwitz (2004). In some Member States, growth to date has only been moderate since investments in renewables are associated with high risks due to uncertainties associated with the policy instruments. Furthermore, certain identified barriers to enhanced RES-E deployment which are administrative, financial, and social in nature, as well as insufficient electricity grid capacity, are not being appropriately addressed by national authorities. Altogether, the effectiveness of the present RES-E policy environment in most EU countries is still limited and shows a rather uneven distribution across the EU.

The measure mapping of the measures potentially relevant for the promotion of RES-E is provided in Table 3-1.

4.2 Emission trends and drivers

4.2.1 Impact upon greenhouse gas emissions

The RES-E Directive has a direct impact on the emissions of the power sector. Since renewable energy sources replace conventional power plants the corresponding emissions of the conventional power plant will be avoided. Key parameters influencing the quantitative level of the impact are the amount of renewable electricity generated based on the policy and the emission coefficient of the replaced conventional power plant. The latter depends in particular on the fuel type and the efficiency of the replaced conventional plant.

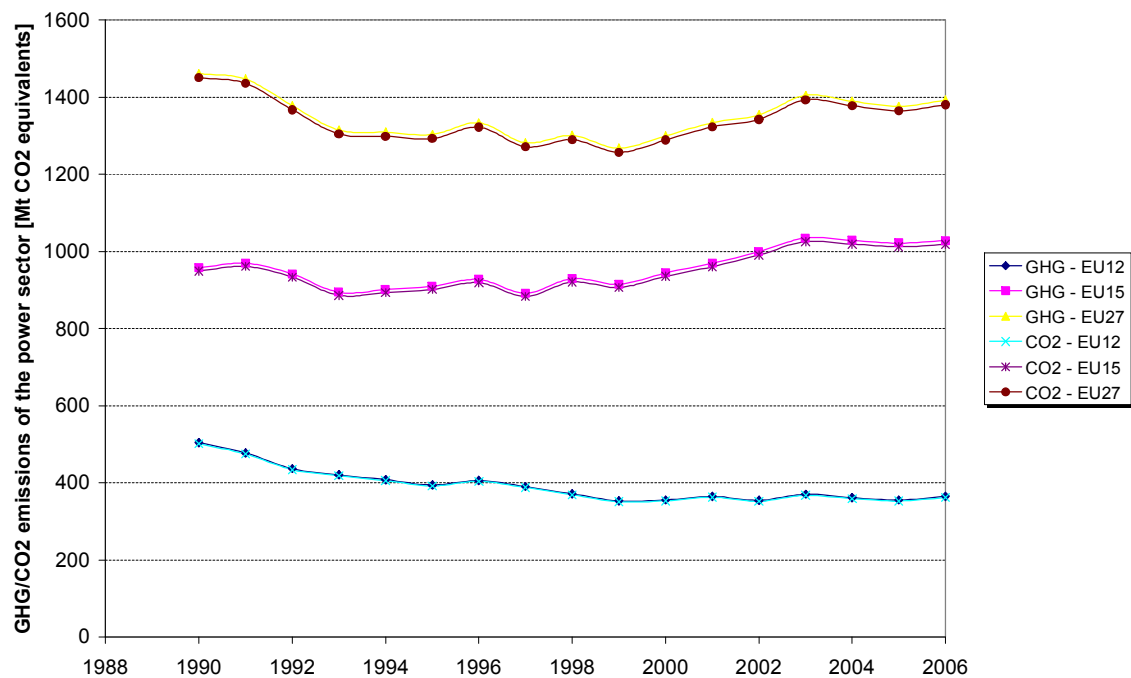
The RES-E Directive is not the only policy measure which has an impact on the emissions of the power sector. A second highly relevant measure is the EU Emission Trading Scheme. The impacts of this policy are discussed in a separate chapter. Other energy and environmental policies would also influence emissions from the electricity generation sectors. Therefore the development of the emissions of this sector cannot be understood by analysing the impact of the RES-E Directive alone.

Table 4-1: Measure mapping of the RES-E Directive

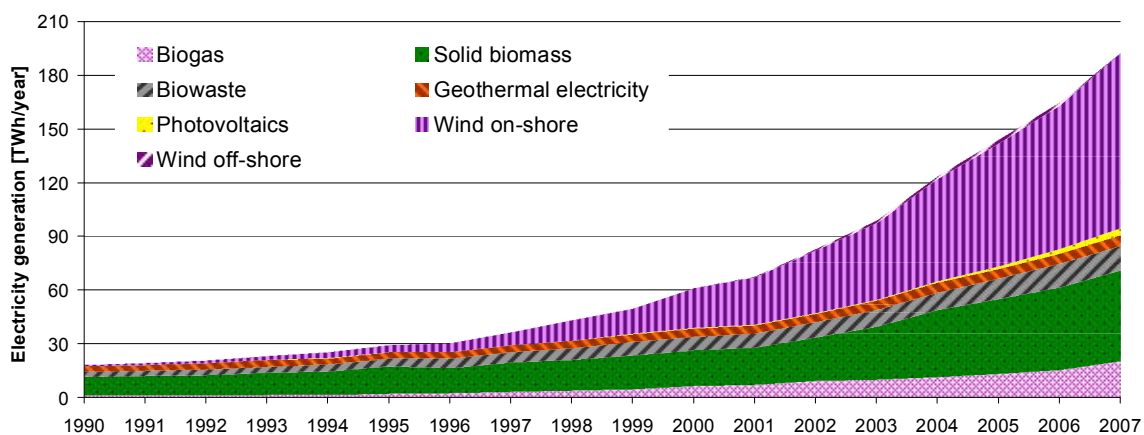
MEASURE	TARGET	GOAL FOR TOP-DOWN IMPACT
ECCP Support schemes for renewable electricity RES-E Directive National support schemes EU ETS Phase 1 (2005-2007) Phase 2 (2008-2012) Phase 3 (2013-2020) (proposed) Complementary financial measures Energy taxes Support schemes for CHP Command and control Technology standards Building codes Technology promotion R&D networks R&D subsidies Informational measures Labelling Subsidies for energy audits (SMEs) Information and awareness campaigns Voluntary demand for RES-E Industry association and national government/EU	Deployment of RES GHG emissions of large installations from energy and industry primary/final energy use deployment of CHP	21% RES-E by 2010 in EU national RES-E targets -21% compared to verified emissions in 2005 by 2020 (more ambitious if international Post Kyoto agreement can be achieved)

4.2.2 Activity and emission trends

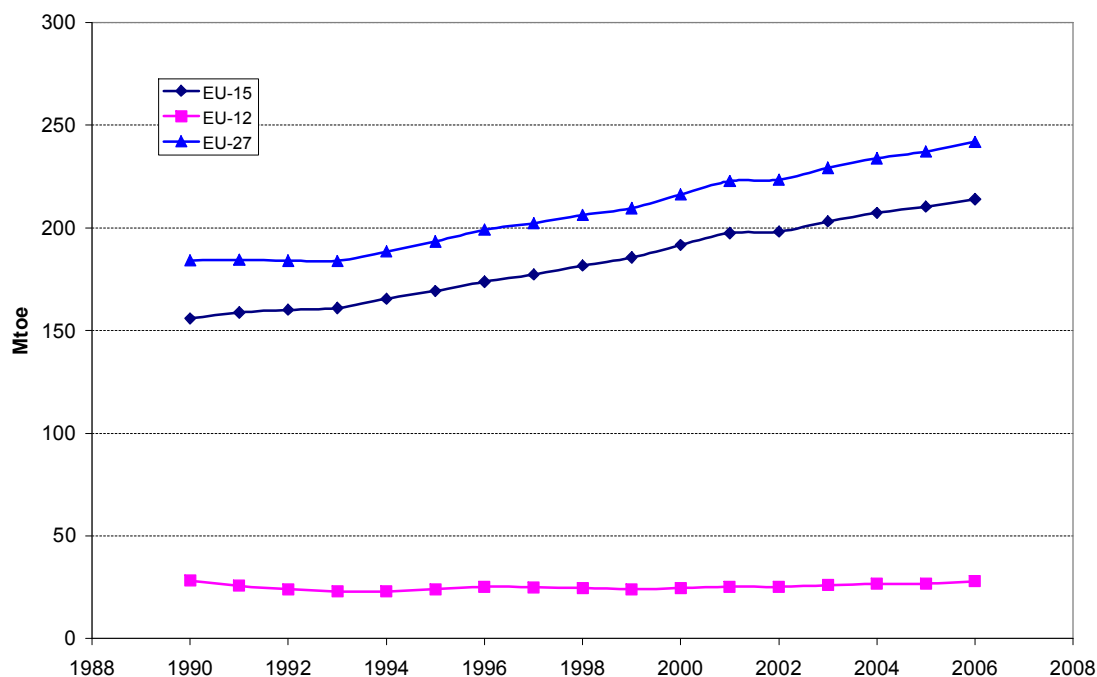
The CO₂ emissions from the power sector (electricity generation only) in the EU-27 are shown in Figure 4-1 based on the UNFCCC sector 1.AA.1.A emissions. It can be observed that emissions in the EU-15 countries increased during the last decade by about 7% whereas on the level of the EU27 emissions decreased. This latter trend can be explained by the economic decline in the EU-12 new Member States at the beginning of the 1990s. Therefore, the emission reductions that were associated with growth of renewable electricity during the time 1995-2005 (see Figure 4-2) which would have amounted to about 6% of total emissions of this sector during this period of time, has been overcompensated mainly by consumption growth, which amounted to about 23% (see Figure 4-3). At the same time a significant decrease of the emission coefficient of conventional power plants has been observed. This is due to both the shift to less CO₂-emitting fuels like natural gas, and efficiency improvements of the fossil power plants. The impact of these factors decreased emissions by about 12% (Figure 4-4).

Figure 4-1 Development of the GHG and CO₂ emissions of the power sector for the EU-27/EU15/EU12

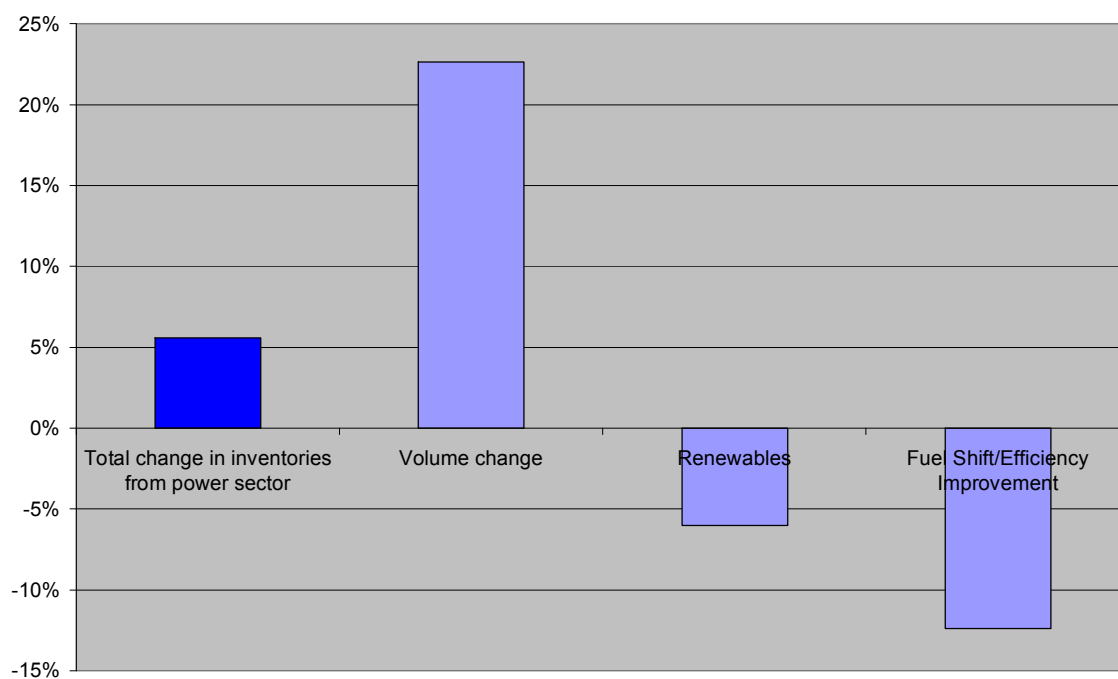
Source: EEA (2008)

Figure 4-2 Development of new renewables in the EU-27

Source: Eurostat, EurObserv'ER barometer for renewables, own calculations Fraunhofer ISI

Figure 4-3 Development of activity levels: Electricity consumption in the EU-27/EU15/EU12

Source: ENERDATA Global Stat.

Figure 4-4 Factor analysis of changes in the power sector emission inventories (2005 compared to 1995)

4.3 Impacts of the RES-E Directive on emissions of GHGs

This section summarises the results from the application of the methodologies to the RES-E case.

4.3.1 Overview of methodologies

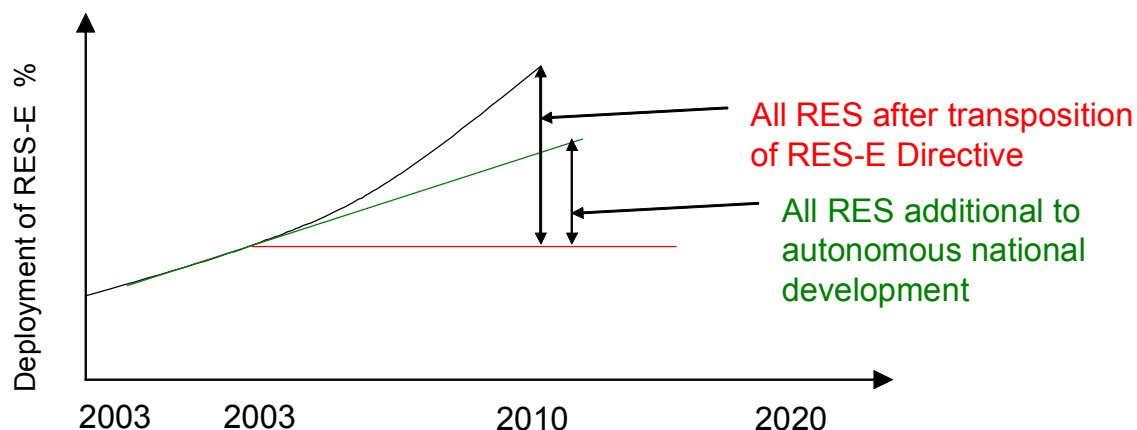
In order to evaluate the impacts of the RES-E Directive a number of methodological choices have to be made with respect to:

- approaches to account for the impact of the RES-E Directive as compared to pre-existing national policies
- approaches to calculate the avoided emissions based on different concepts of national emission coefficients

Three general methodological approaches can be pursued **to account for the impact of the RES-E Directive on the national renewable energy deployment**. These are:

- **Account for all new renewable energies installed after transposition of the Directive:** In this approach all new RES-E, which is installed after the date of the national transposition of the RES-E Directive and has received policy support, is assumed to be an outcome of the RES-E Directive (Figure 4-5). Therefore, any renewables that would have been cost-effective without any policy support (i.e. would have been installed anyway) are not assumed to be an outcome of the Directive.
- **Account for renewable implementation beyond the existing policy trend:** In this approach all new RES-E, which goes beyond the linear trend of the national RES-E development, after the date of the transposition of the Directive, is assumed to be an outcome of the RES-E Directive (Figure 4-5). Therefore, the short-run trend in RES-E deployment is assumed to continue in the absence of the Directive.
- **Expert judgement of the impact of the RES-E Directive on national measures:** In this approach one would specify, based on an expert judgement, whether a measure for the promotion of RES-E was introduced only for reasons of national policy priorities, e.g. security of supply, or whether the RES-E Directive was the main driver for the implementation of a national instrument.

Figure 4-5 Accounting methods for the impact of the RES-E Directive



For the actual calculations performed for this report the approach 1 "Accounting for all new renewable energies installed after transposition of the Directive" was chosen as the preferred option on the grounds of its simplicity and transparency.

Four general methodological approaches can be pursued **to account for different emission coefficients**. These are:

- **Average EU emission factor:** This approach assumes that renewable electricity production is replacing the average European fossil fuel mix of the EU-27 of public and auto producers¹¹.
- **Average national emission factor:** This approach assumes that renewable electricity production is replacing the average domestically applied fuel mix of public and auto producers¹¹.
- **Emission factors based on marginal power plant in terms of Short Term Marginal Costs (STMC):** This approach assumes that the marginal power plant along the merit order curve is replaced as reflected by the short term marginal generation cost of the plants. That means that the operation of the power system is optimised in a way that the most expensive fossil and nuclear plants are replaced by renewable electricity.
- **Emission factors based on marginal power plant in terms of Long Term Marginal Costs (LTMC):** This approach assumes that the marginal power plant along the merit order curve is replaced as reflected by the long term marginal generation cost of the plants. That means that the investments into the power system are optimised in a way that the most expensive fossil and nuclear plants are replaced by renewable electricity.

For the calculations applied in this project the approach no. 1 has been chosen for the Tier 1 calculations, the approach no. 2 for the Tier 2 calculations and the approach no. 3 for the tier 3 calculations.

The analysis proceeds for the Tier 3 approach along the following lines. Details on the methodologies can be found in the Tier 3 report.

- Step (i): Assess the electricity generation from renewables in the year of the transposition of the Directive and in the following years
- Step (ii): Assess the normalised electricity generation from renewables (normalisation possible for hydro, wind and solar) in the year of the transposition of the Directive and in the following years
- Step (iii): Assess the additional normalised electricity generation from renewables during the years after the transposition of the Directive
- Step (iv): Assessment of the additional normalised electricity generation from renewables during the years after the transposition of the Directive, which needed policy support
- Step (v): Determination of emission coefficient based on the average fossil fuel mix - accounting method I, or
- Step (vi): Determination of emission coefficient based on marginal power plant in terms of the short term marginal costs (STMC) of the power sector - accounting method II
- Step (vii): Determination of the total emission reductions

¹¹ Nuclear plants have been excluded because their operation was not influenced by renewables in the past.

Table 4-2 Main differences between Tier 1, Tier 2 and Tier 3 methodologies with respect to the most important factors of influence on the results

Methodology	Tier 1	Tier 2	Tier 3
Activity indicator	kWh produced	kWh produced	kWh produced
Emission factor (g CO ₂ /kWh)	EU average	MS average	MS average fossil park/ hourly short-term marginal
Policy interaction: + EU ETS + Other policies (e.g. taxation)	no no	no no	yes screened
Interaction national RES-E policies all RES-E after transposition of Directive RES-E after Directive beyond trend RES-E beyond trend (expert judgement)	No	no	yes (yes) (yes)
Autonomous RES-E (profitable RES-E) Large hydro Other profitable RES-E	yes no	yes no	yes (yes)
Impact of electricity imports/exports on emission factor	no	no	(yes)
Geographic factors (normalisation to climatic conditions for hydro, wind, solar)	no	no	yes
Timing issues / delay or announcement effects	no	no	no
Impact of other policies: + EU ETS + Other policies (e.g. taxation)	no no	no no	yes screened
Source data	EU official source data (Eurostat/inventory/registry)	EU official and unofficial data, MS data	Includes detailed bottom up statistics

Note: Brackets mean that the issue is considered in principle but was not considered relevant for the concrete ex-post evaluation period investigated.

4.3.2 Results – Tier 1, Tier 2, Tier 3 approach

Results for case study Member States

The results of the Tier 1, Tier 2 and Tier 3 approaches for each of the Member States are presented in

Table 4-3. In all cases the impact is shown without the contribution of large hydropower, as this technology can be typically classified as autonomous development, which would have taken place even without RES-E Directive.

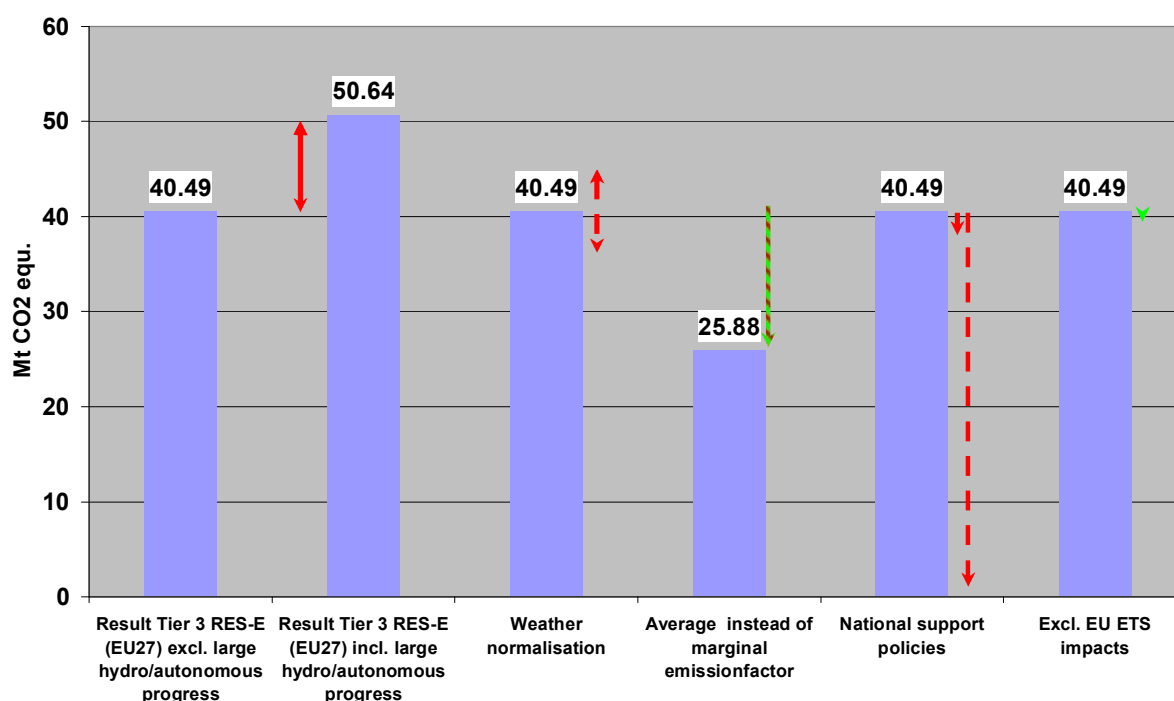
The different emission factors are shown for all countries covered in this analysis. It can be seen that emission factors differ significantly between the countries depending on the conventional power system in each country. In the Tier 1 approach the emission factor of the EU-27 is used for all Member States. The average EU emission factor is strongly influenced by the low coefficient in France, due to the high share of nuclear power in this country. Therefore the average EU-27 emission coefficient is lower for all countries compared to the national value, except for France. The highest emission reductions could be achieved in Germany followed by Spain, Italy and the United Kingdom. This relative order is the same for all three approaches although the absolute figures of emission reductions can differ significantly. In the Tier 3 approach the results for all countries represent the approximated short term marginal cost approach whereas for Germany the results are also shown for the calculation of the exact short term marginal cost approach. For the case of Germany it can be seen that the approximation of the short term marginal cost approach gives rather good approximation of the exact figures.

Table 4-3 Total emission reductions in Mt CO₂ due to renewable electricity installed after 2003

Tiers 3			AT	CZ	DE	DK	ES	FR	IT	NL	PL	RO	UK	EU-27	EU-15
emission factor approximated short term average		t/MWh	0.84	1.29	0.96	0.90	0.71	0.70	0.64	0.66	1.22	1.27	0.71	0.86	0.79
emission reduction (normalised)	2004	Mt	0.59	0.29	4.82	0.39	3.64	0.36	2.53	0.74	0.66	-0.09	1.26	20.55	17.80
emission reduction (normalised)	2005	Mt	1.44	0.41	12.09	0.71	5.88	0.96	3.44	1.25	2.01	-0.07	3.66	40.34	34.08
emission factor short term average		t/MWh			0.93										
emission reduction (normalised)	2004	Mt			4.68										
emission reduction (normalised)	2005	Mt			11.74										
Tiers 2			AT	CZ	DE	DK	ES	FR	IT	NL	PL	RO	UK	EU-27	EU-15
emission factor MS average		t/MWh	0.84	0.88	0.67	0.90	0.54	0.08	0.64	0.63	1.22	1.07	0.56	0.55	0.49
emission reduction (normalised)	2004	Mt	0.59	0.20	3.36	0.39	2.78	0.04	2.53	0.71	0.66	-0.07	0.99	13.13	11.05
emission reduction (normalised)	2005	Mt	1.44	0.28	8.42	0.71	4.48	0.12	3.44	1.20	2.01	-0.06	2.90	25.79	21.16
Tiers 1			AT	CZ	DE	DK	ES	FR	IT	NL	PL	RO	UK	EU-27	EU-15
emission factor EU average		t/MWh	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
emission reduction (normalised)	2004	Mt	0.39	0.12	2.77	0.24	2.83	0.28	2.18	0.62	0.30	-0.04	0.97	13.13	12.41
emission reduction (normalised)	2005	Mt	0.95	0.17	6.96	0.43	4.57	0.76	2.96	1.05	0.91	-0.03	2.83	25.79	23.75

Sensitivity analysis

The different factors that have an impact on the Tier 3 results have been examined as part of a sensitivity analysis, and the results are shown in Figure 4-6. This shows the impact of using specific methodological assumptions, and the influence of data uncertainties, upon the overall results. The arrows show the relative variability in the results depending upon the particular assumptions that are used. The results represent the historic importance of the different factors. This does not necessarily mean that the factors will have the same importance in the future.

Figure 4-6 Sensitivity analysis of the impacts of the RES-E Directive

Note: Variations due to methodological choices are in red. Variations due to data issues are in green. Solid arrows represent an absolute assessment of the variation, as calculated in the current analysis. Dashed arrows show an estimate of the variation, but the absolute value is much more uncertain.

It can be seen that normalisation according to the weather conditions (i.e. normalisation of the specific year under investigation to a long term average) can amount to about plus/minus 10% of the total emission savings calculated, depending of the specific RES-E portfolio of a country. The impact of using an average emission factor instead of a marginal one can be substantial. For the EU-27 this impact amounts to about one third of the total emissions. This is a very important factor which explains

the different results that are achieved from the different Tier methods. The extent to which the change in emissions is attributed to the RES-E Directive or to "independent" national policies can be crucial. In the extreme case where all of the emissions impacts from RES-E are attributed to the national policies the effect of the RES-E Directive would be zero. The impact of excluding the contribution of large hydropower - as a way to account for autonomous progress - is substantial and amounts to about 20% of the total emission reductions at EU-27 level. The EU ETS had in the past no impact on the emission reductions by the RES-E Directive since additional support had to be given in all countries in order to develop renewable electricity generation using specific support schemes.

4.4 Synthesis and interpretation of results

4.4.1 Comparison of results from the different methods

The results of the Tier 1, 2 and 3 approach show significant differences, but are in the same range. Due to the low emission factor of France, which is averaged over all EU countries in the Tier 1 approach, all EU countries, except France, show lower emission reductions in the Tier 1 approach. The Tier 3 approach leads to higher emission reductions for all countries, which have a contribution of nuclear power in their conventional generation portfolio.

4.4.2 Comparison of impacts across Member States

The impact of the RES-E Directive across Member States differs significantly and scales directly with the induced growth of renewable electricity in the Member States and with the carbon intensity of the power system. Countries, which have introduced successful instruments like Denmark, Germany, Spain, UK and have a coal based generation system at the same time show significant emission reductions due to the impact of the RES-E Directive. In some countries like Poland and the Czech Republic the very large value of the emission coefficient due to a high contribution of inefficient coal power plants is particularly significant.

4.4.3 Comparison with alternative estimates

There is significant experience with respect to the quantitative assessment of the impact of renewable electricity policies on the deployment of RES-E technologies as well as on GHG reductions. In particular with respect to a prospective assessment of the future emission reductions of renewable energy sources various studies exist, e.g. Ragwitz (2004), Ragwitz (2006). However, less evaluation exists with respect to the historic impact of renewable electricity on GHG avoidance on the EU level. Individual national studies exist in this respect, in particular in Germany substantial effort was made to quantify the impact of RES-E on the GHG balance. These studies evaluated the emission reductions due to renewable electricity generation based on the average or marginal emissions of the power system, see Lux (1999), Nitsch (2000), Klobasa (2005). Results of these studies are very similar to the ones derived in this study.

4.4.4 Comparison with ex-ante results

As stated above a wide literature of the assessment of ex-ante impacts of renewable energy policies exist. Within the framework of the ECCP ex-ante estimates were made for 2010 that were in the range of 100-125 Mt CO₂ reduction in 2010 in EU15 countries due to RES-E policies. This estimate is compared with the results from the ex-post evaluation in the table below. Ex-post savings for the latest year (2007) are considerably lower than those forecast by the European Commission for 2010 and are small in comparison to the challenge of sizeable and increasing road transport emissions in the EU.

The results for Tier 3 illustrate a close match between ex-post savings for the latest year (2008) and the European Commission's estimates for 2010 with a sharp increase in savings in recent years as additional capacity has been installed. This relative order of the emissions impact is the same for all three of the approaches although the absolute figures of emission reductions can differ significantly.

Table 4-4 Comparison of ex-ante and ex-post results: RES-E Directive

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)*		
		T1	T2	T3
CCPM	ECCP Review: annual savings in 2010 (EU-15)			
RES-E Directive (Dir 2001/77/EC)	100 - 125	25.8 (EU27, 2005) 23.8 (EU15, 2005)	25.8 (EU27, 2005) 21.1 (EU15, 2005)	40.3/139 (EU27, 2005/2008) 34.1/118 (EU15, 2005/2008)

The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:

Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices

Abbreviations:

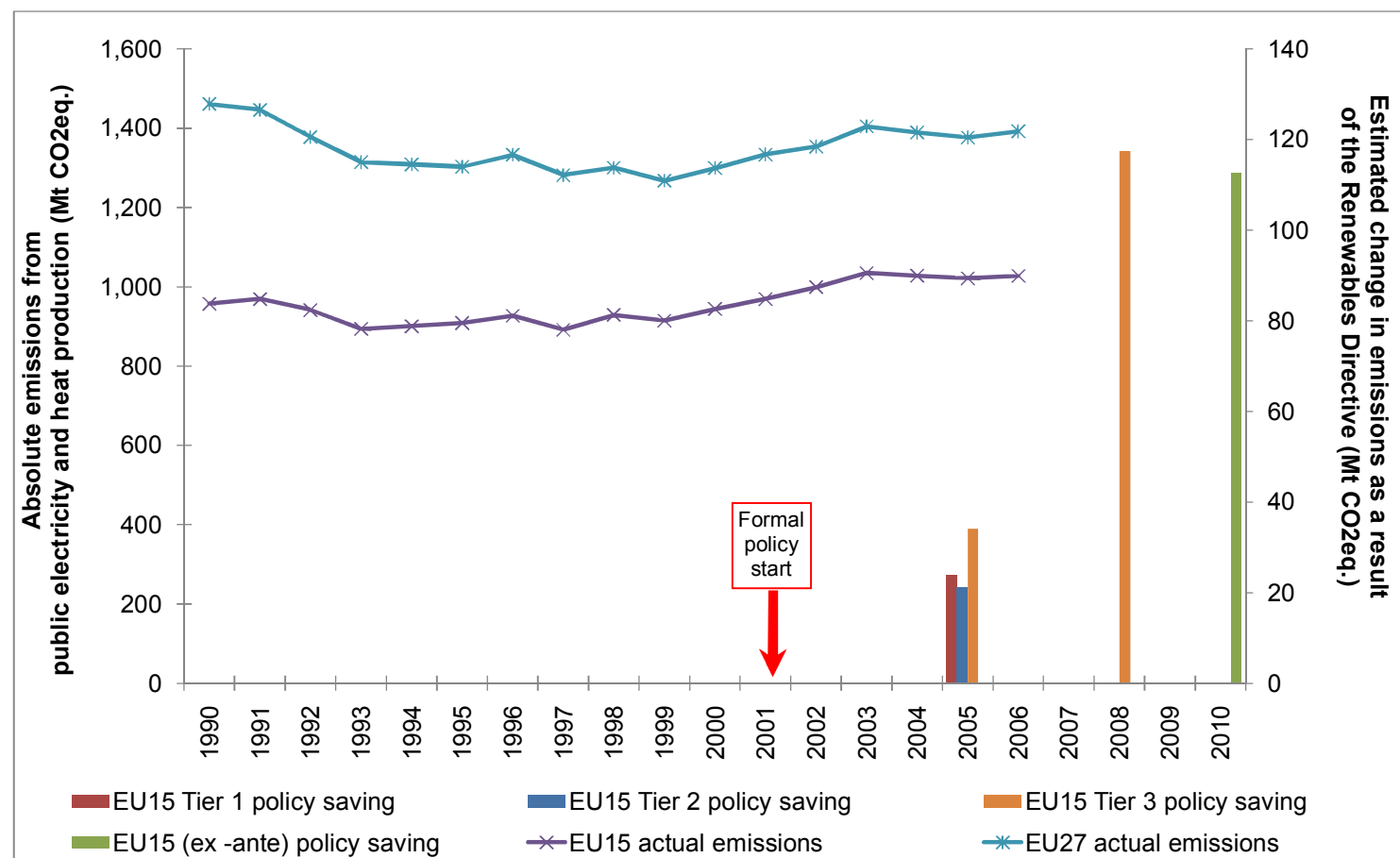
MSsp: Member State specific starting year for the ex-post evaluation
NE = not estimated

Notes:

* Excluding large hydro. 2008 estimate based on installed capacities in 2008 as compared to 2005 (minus the capacities already installed up to 2003).

For the year 2020 it was estimated in the "Renewable Energy Road Map Renewable energies in the 21st century: building a more sustainable future COM(2006)848" that 700 Mt of CO₂ will be saved based on the 20% target for renewable electricity. These figures are derived based on a bottom-up assessment of emission reductions by renewables in the electricity, heat and transport sector. One general difference between the ex-post and the ex-ante assessment is that ex-ante assessments should be based on the replacement of the marginal power plant with respect to long term marginal costs (LTMC), whereas for the ex-post assessment the marginal plant with respect to short term marginal costs (STMC) are relevant. Due to this important principal difference results of ex-ante and ex-post evaluations are not easily comparable.

The estimated impacts of the RES-E Directive are put into context in Figure 4-7 below. The estimated (ex ante, and ex post) impacts are compared against the overall historical trend in emissions from electricity and heat production. This shows the relative influence of the Directive on the overall trend in emissions.

Figure 4-7 RES-E Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above. The results in this figure exclude large hydro. 2008 results are extrapolation of 2005 results, taking into account actual capacities of wind and solar power installed in 2008.

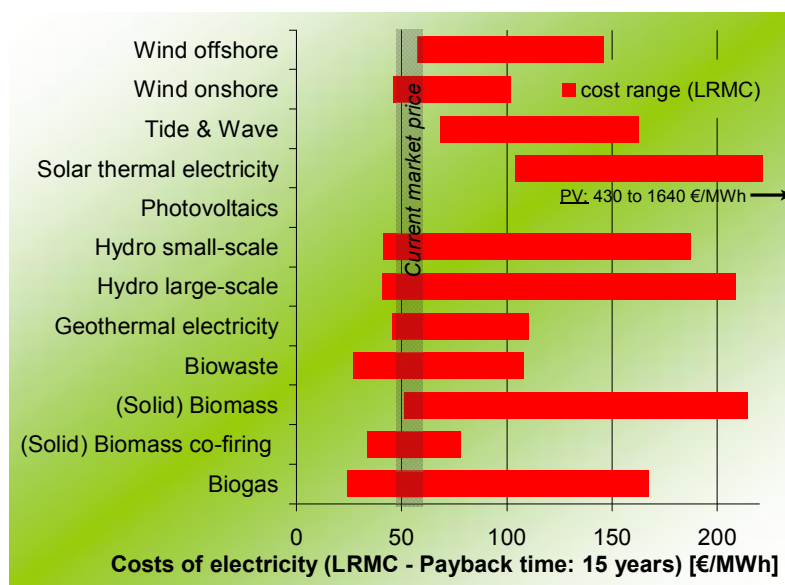
Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

4.4.5 Cost effectiveness

Generally, renewable energy sources are more expensive than conventional alternatives. Therefore financial support schemes had to be introduced at Member State level. These support schemes can now be evaluated regarding their policy costs. Such evaluations have been performed in different communications of the European Commission, e.g. SEC(2008)57, COM(2005)627. One general conclusion from these evaluations is that technology specific support schemes, which give long term price guarantees for investors, tend to be more cost effective than technology neutral instruments. Although this has not been an issue studied in this project, the additional generation costs of renewable energy sources triggered by the RES-E Directive can be estimated at the order of 1 billion € in 2005 for the EU-27. It has to be emphasised, however, that renewable energy sources also bring additional benefits such as increased security of supply.

A broad range of the total generation costs, due to several influences, for several RES technologies has to be assessed, when analysing the impact of renewable energies. Impacts as, variations in resource- (e.g. for photovoltaics or wind energy) or demand-specific conditions (e.g. full load hours in case of heating systems) within and between countries as well as variations in technological options such as plant sizes and/or conversion technologies have to be taken into account. Figure 4-8 depicts the typical current bandwidth of *long-run marginal generation costs*¹² per RES technology for the electricity sector in Europe.

Figure 4-8 Long-run marginal generation costs (for the year 2006) for various RES-E options in EU countries



4.5 Conclusions

The Tier 1 approach does not provide sufficiently detailed results in order to allow for an evaluation of the performance of the RES-E Directive at Member State level, since the emission coefficients differ largely among countries. However, the approach can easily be updated to a Tier 2 approach, using available statistics on the national electricity generation mix.

The Tier 2 is better since it gives a differentiation among Member States, but as the Tier 1 approach it may underestimate the emission reductions, since nuclear power is considered to be replaced by renewable energy. Overall, we consider that the Tier 2 approach provides a reasonable approximation of the policy impacts, without the need for a more complex model. Whilst the results are not without

¹² Long-run marginal costs are relevant for the economic decision whether to build a new plant or not.

uncertainties, we consider that these uncertainties are within a reasonable bound that the results can be used to provide an approximate estimate of the policy impact to date.

The Tier 3 approach provides further refinement of the approach, by taking into account the generation capacity that is replaced in a more sophisticated way. In this study it a Tier 3 approach, which models the avoided emissions based on the hourly dispatch of the power sector (using the PowerACE model), could be performed only for Germany. For all other Member States the approach to calculate the emission reductions based on marginal power plant with respect to the short term marginal costs had to be approximated. The case of Germany indicated that this approximation can be done with a reasonable level of agreement.

4.6 Recommendations

The RES-E Directive is more straightforward to evaluate than some of the other policies as the policy targets a single sector, data on the measures installed are readily available, and the impacts of autonomous development can be corrected for relatively easily. Therefore, the main recommendation for improving the methodology relates to the calculating of the generation capacity that is replaced by the renewable energy sources.

We recommend the further development of the Tier 3 methodology, to build upon the approach used in this study to evaluate the impacts in Germany (based on the hourly dispatch of the power sector). Although approximations to such a detailed calculation may result in reasonable estimates, as has been shown for Germany, the level of accuracy and the robustness of the results may increase significantly by using a detailed model of the power market. In this respect the evaluation requires the development of full European models representing on one hand the short-term dispatching induced by RES-E (which requires hourly resolution like in the PowerAce model for Germany and detailed information on the use and characteristics of power plants) and on the other hand the long-term investment effects in the power sector. Such a model may at the same time also be very useful to evaluate the impacts of the EU ETS.

4.7 Next steps

The most important next steps that should be carried out in this area are:

- The development of a European model to capture the short-term RES-E-induced changes (dispatching) in the power sector;
- Test the results of such a model against simplified approximation methods for more EU countries;
- Develop more sophisticated approximation methods to "imitate" detailed power market modelling by econometric approaches.

5 Case study: CHP

5.1 Introduction

5.1.1 Overview of policy

Directive 2004/8/EC “on the promotion of cogeneration based on a useful heat demand in the internal energy market” (hereafter referred to as CHP Directive or Directive) came into force in 2004. The purpose of this Directive is to increase energy efficiency and security of supply by creating a framework for promotion and development of high efficiency cogeneration. The directive obliges Member States to:

1. Set up a system for Guarantees of Origin (GOs) for high efficiency cogeneration
2. Establish an analysis of the national potential for high efficiency cogeneration including an analysis of barriers
3. Ensure that support for cogeneration is based on useful heat demand and primary energy savings
4. Evaluate the existing legislative and regulatory framework.

The CHP Directive does not set explicit targets for cogeneration or prescribes a minimum share for cogeneration in each Member State. As stated above the Directive aims to create a framework for promoting high efficiency cogeneration by forcing Member States to remove barriers, to redesign support schemes, to establish a system for GOs and to assess the national potential for high-efficient cogeneration. The impact of the CHP Directive will therefore differ country by country. The Directive will have impact when:

- Member States implement national policies to overcome administrative procedures, tariff issues and problems with grid access.
- GOs for high efficiency CHP get a market value.
- Member States set national cogeneration targets / focus areas based on the national potential study.
- Member States introduce a support scheme (need-based depending on market conditions) to yield the potential.

The Directive will have less or no impact when:

- Member States have already solved the main grid, tariff and administrative barriers before implementation of the Directive.
- Member States already have a (need-based) support scheme in place.
- GOs do not get a market value (but, e.g., are only used for the existing national support scheme).
- Member States do not show intentions to yield the national potential for high efficiency cogeneration.

Member States need to evaluate progress towards increasing the share of high-efficiency cogeneration every four years (first time not later than 21 February 2007) on request by the commission. In addition, Member States are required to submit annual statistics on national electricity and heat production from cogeneration as well as cogeneration capacities and fuels used. The Directive then requires the Commission to produce a report assessing Member State progress towards national targets every four years, starting in 2008.

5.1.2 Policy implementation

All Member States have implemented the Directive into national legislation. This does however not mean that the Directive is (currently) fully operational at Member State level¹³:

- The guidelines for calculating electricity from cogeneration are not yet published.¹⁴
- The systems for GOs for high-efficiency cogeneration are not yet operational (waiting for the Commission Decision on the calculation guidelines).
- Only a number of Member States have submitted their national potential studies and progress reports. The Commission has not yet evaluated the studies.
- Only a number of Member States have adapted their national support schemes (use of reference values, 10% primary energy threshold) but full adaptation is only possible when the calculation guidelines are ready.

The above means that the CHP Directive is unlikely to lead to a direct impact (over and above national policies) until at least 2009.

The CHP Directive is not the only Directive that promotes the use of cogeneration:

- The EPBD (Energy Performance of Buildings Directive) requires considering the feasibility of alternative options such as CHP in new buildings with a floor area over 1000 m².
- The RES-E (Renewable Energy Sources – Electricity) Directive (and the new RES Directive) promotes the use of bio-CHP.
- The Emission Trading Directive offers an incentive for low carbon options such as CHP.
- Large CHP (>50 MWth) is subject to emission limits under the LCPD (Large Combustion Plant Directive).
- CHP on industrial and agricultural sites will be subject to the requirements under the IPPCD (Integrated Pollution Prevention and Control Directive), such as the use of BAT (Best Available Techniques). However, CHP covered under the EU ETS is subject to derogations from the IPPC's emission limit values for greenhouse gases and energy efficiency requirements.

A range of national instruments is already in place including fiscal measures, investment subsidies, feed-in tariffs/premiums, obligations and tax exemptions. Most Member States already had CHP policies in place before the introduction of the Directive.

5.2 Emission trends and drivers

The use of CHP is linked to the demand for heat (and sometimes cooling) and is therefore not restricted to one sector. Typically, CHP can be found in the built environment (residential and tertiary), industry and refineries. Development of the heat demand in these sectors is driven by:

- Population size, size & number of buildings, number of occupants per building, building code (energy performance), improvement building shell existing buildings, global warming, behaviour - *residential sector*
- Economic growth, structural change, energy savings – *industry, refineries, tertiary sector*

Development of the CO₂ emission related to the heat demand is determined by the applied conversion technologies, their efficiencies and the fuel mix chosen. CHP is considered as an energy efficient conversion technology.

5.2.1 Impact upon greenhouse gas emissions

The following GHG Inventory categories will be affected by any policy impact from the CHP Directive:

- 1A1 Fuel Combustion Activities – Energy Industries (CO₂, N₂O, CH₄)
- 1A2 Fuel Combustion Activities - Manufacturing Industries and Construction (CO₂, N₂O, CH₄)

¹³ See also http://ec.europa.eu/energy/demand/legislation/chp_ms_reports_en.htm

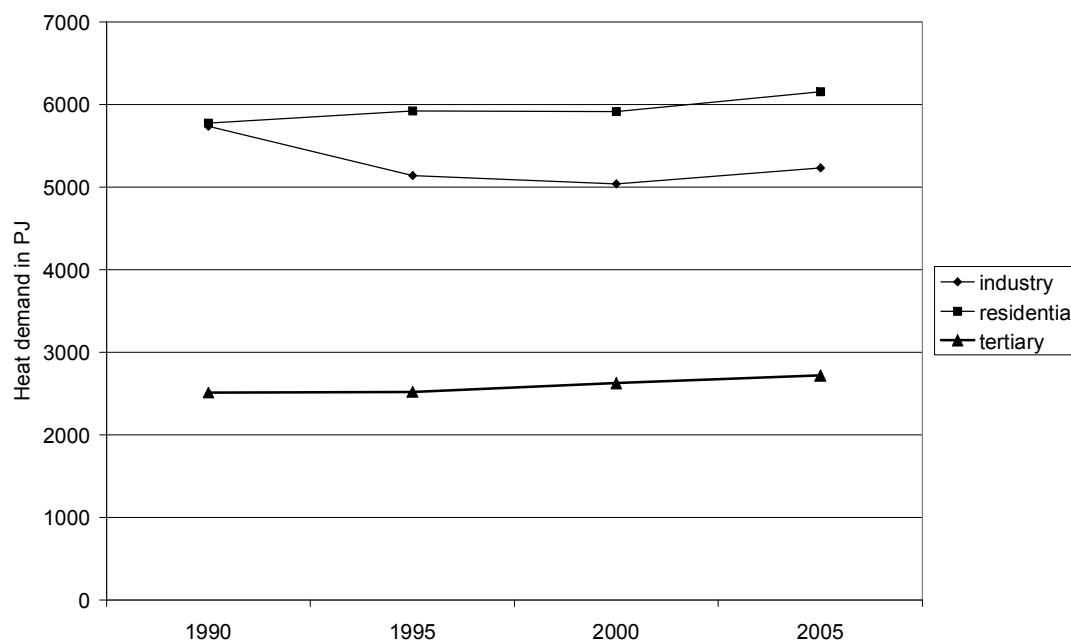
¹⁴ In October 2008 the 27 Member States have voted in favour of the calculation guidelines such as proposed by the Commission. Approval of the European Parliament and publication in the Official Journal of the European Commission is expected late 2008 or early 2009.

- 1A4 Fuel Combustion Activities – Other Sectors (CO₂, N₂O, CH₄)
- 1A5 Fuel Combustion Activities - Non-Specified (CO₂, N₂O, CH₄)

5.2.2 Activity and emission trends

The below figure shows the development of the heat demand in the period 1990-2005 for the residential, tertiary and industrial sectors (EU 25).

Figure 5-1 Development heat demand in EU25 (1990-2005) – source PRIMES



5.3 Impact of the Directive on GHG emissions

5.3.1 Overview of methodologies

The table below provides an overview of the main assumptions under each of the approaches relevant for CHP. In this case study only a Tier 1 analysis has been carried out to assess the impact of the CHP Directive. For Tier 2 and 3 an outlook for future assessments is given in section 5.4.2.

Table 5-1 Key methodological choices CHP Directive

Methodology	Tier 1	Tier 2 *	Tier 3 *
Activity indicator	CHP electricity	CHP electricity	CHP electricity
Emission factor (g CO ₂ /kWh)	EU average	MS average	MS average fossil park/ hourly short-term marginal
Autonomous CHP deployment	No	First order	yes
Policy interaction:			
+ Interaction with other ECCP policies (decomposition of European policy impact)	no	no	yes
+ Decomposition of European versus national policy impact	no	yes	yes
+ Quantify the impact of feed-in subsidies (operational support)	no	no	first order
Geographic factors (normalisation to climatic conditions for space heating)	No	yes	yes
Timing issues / delay / announcement effects	delay taken into account		
Source data	EU official source data (Eurostat)	EU official and unofficial data, MS data	
Other factors being relevant for CHP:			
+ Identify upcoming CHP technologies	no	yes	yes
+ Correction for base/target year deviations	no	first order	yes

* The Tier 2 and 3 approaches could not be further elaborated in the course of this study.

5.3.2 Tier 1 description

The Tier 1 methodology is composed of four steps¹⁵:

- For Tier 1 analysis 2004 is taken as the starting year, as this is the first year for which statistical data for cogeneration is available for all Member States from Eurostat¹⁶. This is due to the reporting requirements in the Directive, which prescribe a split in reporting of CHP and non-CHP electricity from 2003.¹⁷
- Secondly, when only total fuel (CHP fuel and non-CHP fuel) is available in the Eurostat CHP data from a Member State (this is currently the case for most Member States), in Tier 1 the amount of CHP fuel is estimated assuming a, relatively conservative, overall CHP efficiency of 75%¹⁸. Currently Eurostat only reports total fuel, but calculation guidelines from the Commission due to be adopted later in 2008 should mean that future statistics report this split.
- Thirdly, the emission factor for electricity and heat which is being replaced by CHP is determined. The Tier 1 approach assumes that CHP electricity production is replacing the average fuel mix of the EU-27 (fossil-fired public supply). The Tier 1 approach assumes that CHP heat is replacing the marginal factor associated with heat from a natural gas-fired boiler with an efficiency of 85%.
- Finally, in Tier 1 the additional CO₂ reduction from CHP is calculated by the following formula:

$$(CHP\ electricity\ (target\ year) \times reference\ emission\ factor\ electricity\ (target\ year) + CHP\ heat\ (target\ year) / 85\% \times 56.8\ kg\ CO_2/GJ - CHP\ fuel\ (target\ year) \times 56.8\ kg\ CO_2/GJ) - (CHP\ electricity\ (2004) \times reference\ emission\ factor\ electricity\ (2004) + CHP\ heat\ (2004) / 85\% \times 56.8\ kg\ CO_2/GJ - CHP\ fuel\ (2004) \times 56.8\ kg\ CO_2/GJ).$$

In the formula it has been assumed that is the average emission factor of CHP fuel (a mix of natural gas, coal, biomass and other fuels) is equal to the emission factor of natural gas-fired. This is a rather rough assumption. Figure 5-2 provides an overview of the different types of fuels (CHP and non-CHP

¹⁵ See also the CHP Guidelines within the Methodologies report for a more detailed description.

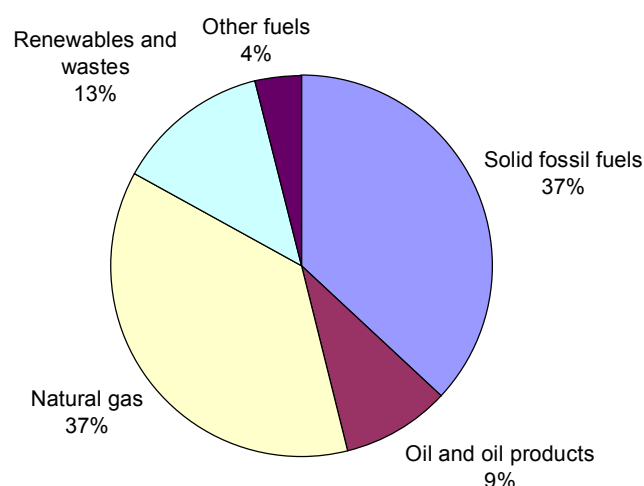
¹⁶ This differs from the general approach to evaluation where 1990 is taken as the starting year and the impact of a Directive is analysed relative to a continued trend from 1990 to the data of implementation of the Directive.

¹⁷ 2004 has been taken as starting year since 2003 data are not available within Eurostat.

¹⁸ Currently, only in the Eurostat statistics for the UK the fuel has been split in CHP fuel and non-CHP fuel. It can be easily determined whether statistical data on fuels includes all fuel or CHP fuel only. When only CHP fuel is included the overall efficiency (sum of heat and electricity divided by fuel) is between 75 and 85% (or even higher). In case all fuel is included the overall efficiency is (far) below 75%.

fuel) used in CHP plants in EU25. Solid fossil fuels (hard coal, lignite, peat) and natural gas are the dominant fuels, whereas the share of renewable energy sources and waste fuels is 13%. These statistics for CHP fuel include both the fuel consumption for CHP electricity and the non-CHP electricity. As mentioned, statistics for CHP fuel are not (yet) available. Roughly one could say that Figure 5-2 overestimates the share of solid fuels since these are dominantly used in steam condensing turbines. The dominant fuel for industrial CHP in all Member States is natural gas. The actual average CO₂ emission factor for CHP fuel will probably range between 60 and 70 kg CO₂/GJ. By using 56.8 kg/GJ the actual CO₂ savings from CHP are most likely slightly overestimated.

Figure 5-2 Fuel input CHP in EU25 (Eurostat 2006, 2004 data)



5.4 Results

5.4.1 Results – tier 1 approach

Before presenting and discussing the Tier 1 results it is first necessary to make clear what can and what cannot be expected from the Tier 1 impact assessment for CHP. The final aim of this project is to develop methodologies that allow the Commission and Member States to analyse the impact of the Directives and regulations of the European Climate Change Programme. The methodology for CHP should therefore provide a means to analyse the impact of the CHP Directive. As a requirement of the CHP Directive, Member States have started to collect CHP statistics on a structured and harmonised base. Currently, for the period 2004-2006 a comparable dataset is available for all EU-27 Member States. Prior to this, Member States used a different basis for the provision of statistics.

- There is therefore no current dataset that shows the historic trends well enough to be able to analyse whether the implementation of the Directive leads to a break in that trend.
- In addition, implementation of the CHP Directive has been delayed; the CHP Directive is unlikely to lead to a direct impact (over and above national policies) until at least 2009. Even with a complete data series, it would therefore be too early to see any impact. In 2011, 2009 statistics will be available which will add to the dataset and may show an impact but data completeness could still be an issue.

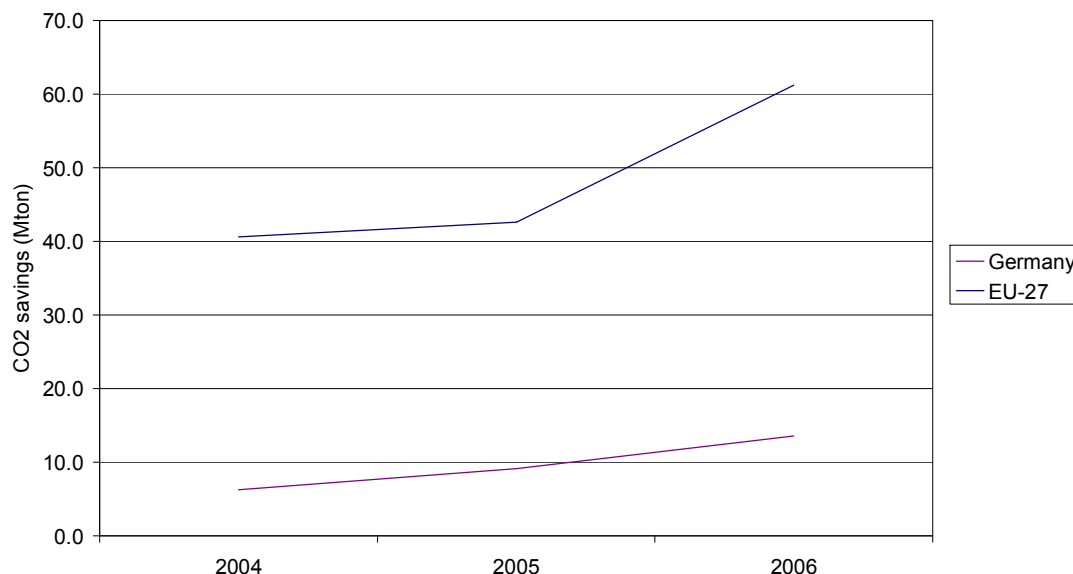
Overall, it can be argued that the **Tier 1 results should not be considered a policy impact assessment**. It is impossible, based on aggregated statistics only, to split any policy effect (whether national or European) from other effects such as autonomous development of CHP, changing economic activity from year to year in sectors that apply CHP, cold winters versus warm winters (relevant for district heating plants) etcetera. In addition, there is often a weak link between statistical data and policy objectives. For example, for the provisions of the CHP Directive which aim to remove administrative and other barriers to CHP, it is almost impossible to see the specific effect of these in the aggregate statistics. Furthermore, statistics are often less useful for identifying some specific developments (policy induced) such as the uptake of small scale bio-CHP and micro-CHP in the built environment. Although significant in that sector, the capacity added is usually small and not visible in statistics.

What Tier 1 does show us is the contribution of CHP to climate policy objectives regardless whether this contribution is policy induced or not. This information provides added value to the National GHG Inventories. The Inventories only show the trend of CO₂ emissions in a country but cannot explain the background of the trend development. The CO₂ savings by CHP, calculated in Tier 1, provide some of this background explanation. The contribution of policies to the achieved CO₂ savings is left to the more refined analyses in Tier 2 and, especially, Tier 3.

Figure 5-4 CHP savings in selected Member States (2004-2006)

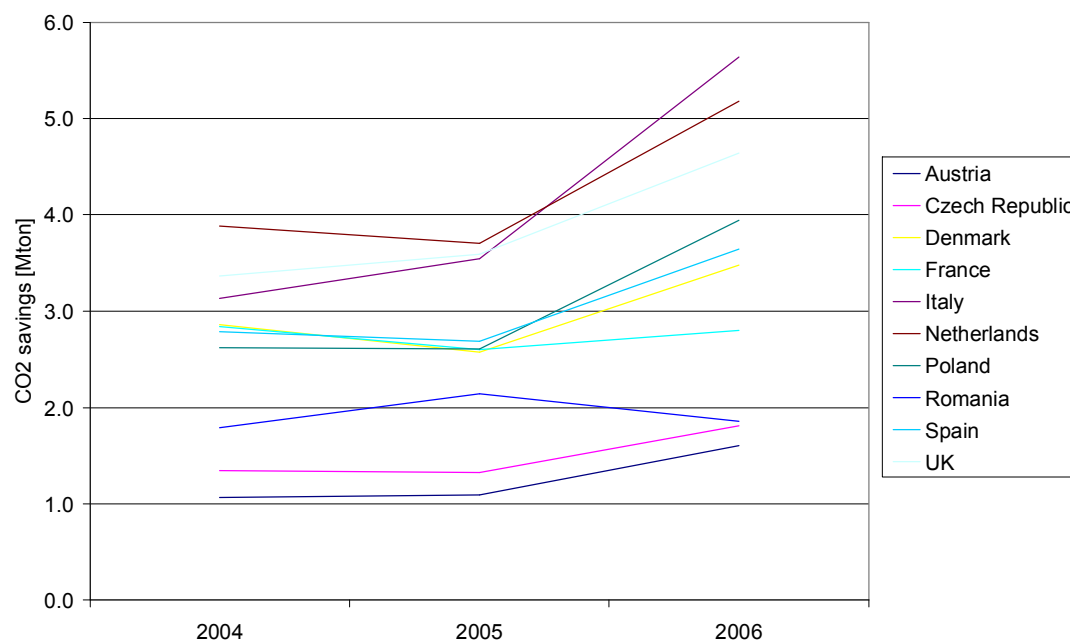
and Figure 5-4 show the CO₂ savings from CHP in the period 2004-2006.

Figure 5-3 CO₂ savings from CHP in EU-27 and Germany (2004-2006)¹⁹



¹⁹ In COM(2008) 771 final (Europe can save more energy by combined heat and power generation) 100 Mton CO₂ reduction from CHP are mentioned. As the Commission document does not provide insight in the assumptions used for calculating this figure (reference efficiencies and emission factors) these cannot be compared. As for the calculations in this project and the Commission's calculations Eurostat data have been used, it is most likely that differences in the reference situation explain the different outcomes (see also the sensitivity analysis later in this section).

Figure 5-4 CHP savings in selected Member States (2004-2006)



At the EU-27 level the CO₂ savings from CHP grew strongly (+44%) between 2005 and 2006. The selected Member States contribute about 80% of the EU total savings.²⁰ The growth in CHP savings is not due to increased electricity and heat production from CHP, see Figure 5-5, but can be fully explained by the increase of the EU average CO₂ emission factor for electricity between 2005-2006. This immediately shows how sensitive the calculation outcomes are for the reference situation.

Figure 5-5 CHP electricity and heat production in EU-27 (2004-2006)

²⁰ Finland and Sweden have e.g. also high shares in CHP.

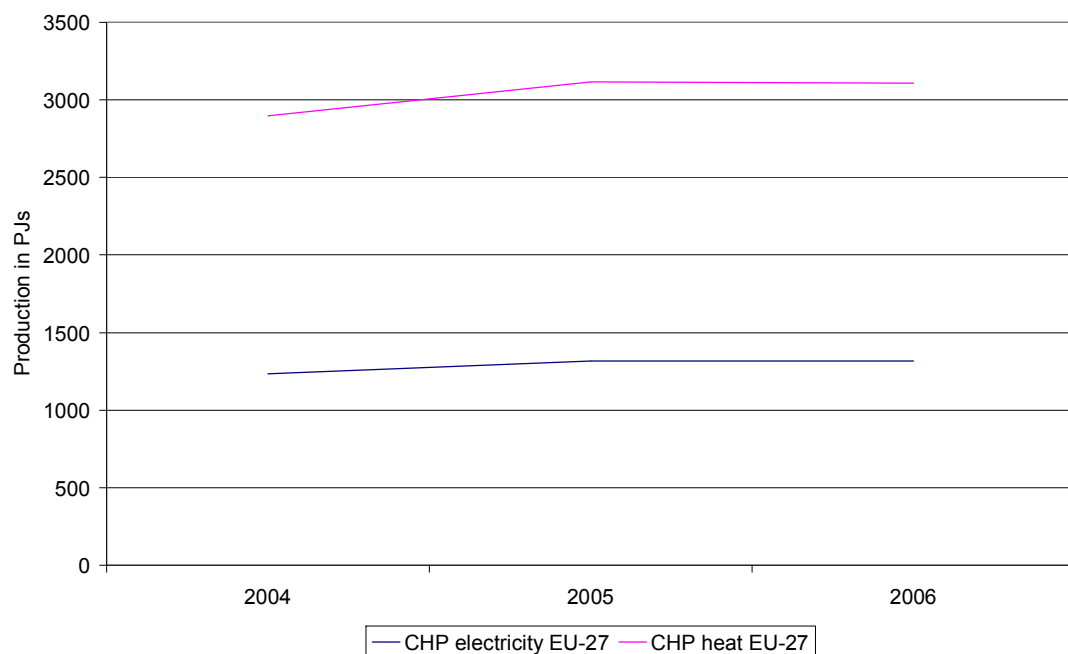
**Figure 5-6 and**

Figure 5-7 show the recent trend in electricity and heat production from CHP in the selected Member States. Electricity production from CHP is going down between 2004 and 2006 in many of these Member States: Czech Republic, Denmark, France, Netherlands, Poland, Romania and UK. In Germany (+41%) and Italy (+25%), however, the amount of CHP electricity grew strongly. For heat the situation is similar: less heat production in Czech Republic, Denmark, France, Poland, Romania and UK; and a considerable growth in Germany (+21%), Italy (+10%) and Spain (+11%). When comparing the trends in CHP production with the CO₂ savings from CHP in the different Member States (see

Figure 5-4 CHP savings in selected Member States (2004-2006)

and Figure 5-4), it can be concluded that increased CO₂ savings for most Member States can be explained by the higher EU average CO₂ emission factor for electricity in 2006. Only Germany and Italy also show increased CO₂ savings in the period 2004-2006 when correcting for the higher emission factor.

Figure 5-6 CHP electricity production in selected Member States (2004-2006)

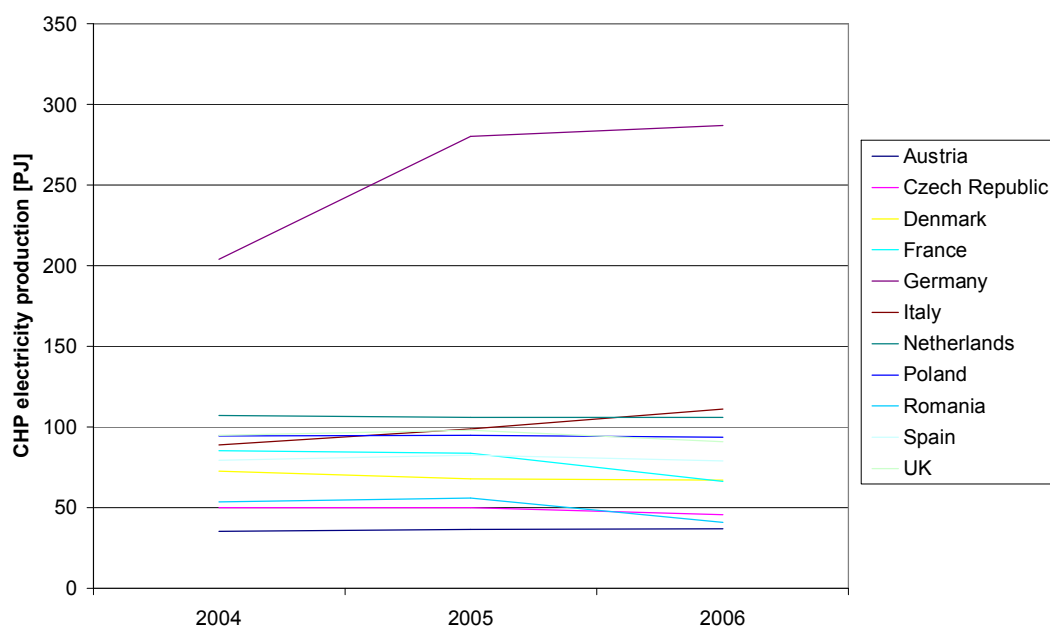
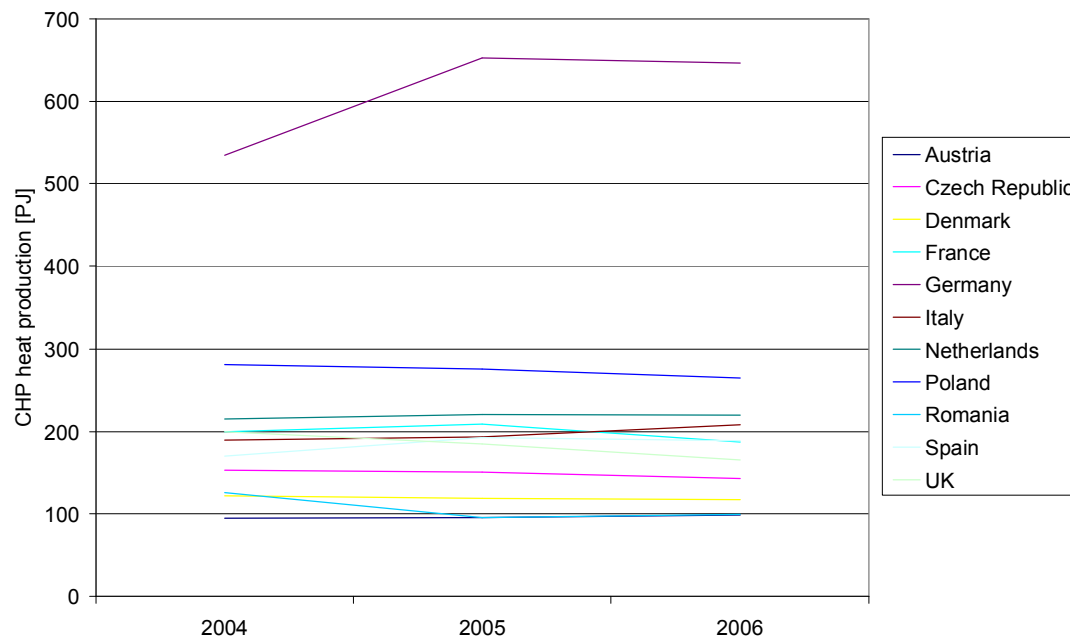


Figure 5-7 CHP heat production in selected Member States (2004-2006)

Sensitivity analysis

A sensitivity analysis has been carried out for:

Using a fixed (base year) EU average emission factor instead of a moving average emission factor.

Using national emission factors instead of an EU average emission factor.

1. Using a marginal approach instead of an average emission factor.
2. Using 85% overall CHP efficiency to calculate the CHP fuel instead of 75%.
3. Using 90% reference heat efficiency instead of 85%.
4. Using 70 kg CO₂ /GJ as fuel emission factor for CHP instead of 56.8 kg/GJ.

Ad 1.

In the Tier 1 calculation a moving average EU emission factor for electricity has been applied. It has already been mentioned that the observed development of CO₂ savings from CHP (see

Figure 5-4 CHP savings in selected Member States (2004-2006)

and Figure 5-4) are highly determined by the use of this moving average. If for the EU-27 a fixed emission factor is applied, the 2004 EU average emission factor, the CO₂ savings would have increased marginally to 44 Mton. This is because the average emission factor in 2004 was lower than in 2006. This means that the change in emission factor explains 85% of the observed impact at EU-27 level whereas only 15% can be addressed to increased CHP production. For individual Member States similar results can be obtained. The exact impact depends on the national increase of CHP production. For Germany e.g. 52% of the observed impact is due to the moving average emission factor and 48% can be explained by increased CHP production. For some Member States the change in emission factor will explain over 100% of the observed impact when CHP production has declined.

Ad 2.

Actually, the use of national emission factors is part of Tier 2 calculations. However, for interpreting Tier 1 analysis it makes sense to address the effect of the use of EU average emission factor instead of national factors. This primarily counts for countries for which national emission factors strongly

deviate from the European factor. Two clear examples are France with a very low emission factor (large share of nuclear) and Romania with a very high emission factor. For France CO₂ savings decline from +2.8 to -5.4 Mton (2006). For Romania the CO₂ savings increase from 1.9 to 19.0 Mton (2006).

Ad 3.

The impact of using a marginal approach instead of an EU average approach strongly depends on the choice of the marginal technology. A natural gas fired combined cycle (CCGT) is generally considered as an appropriate marginal reference for CHP. When we apply a CCGT reference with a CO₂ emission factor of 350 gr CO₂/kWh, the CO₂ savings from CHP decline from 61.2 Mton to 2.0 Mton for EU-27 (2006).

Ad 4.

The assumed 75% overall CHP efficiency is rather conservative provided that non-CHP production is taken out of the data. In full cogeneration mode most CHP plants will achieve higher overall efficiencies. Therefore, the effect of using 85% overall efficiency instead of 75% has been analysed. For EU-27 CO₂ savings from CHP increase strongly from 61.2 to 100.1 Mton (2006).

Ad 5.

The reference efficiency for heat is assumed to be 85%. In best practice plants (both district heating and industrial steam production) efficiencies up to 90% or even higher are possible. For EU-27 the effect of using 90% instead of 85% is a decrease in CO₂ savings from 61.2 to 49.9 Mton (2006).

Ad 6.

As mentioned, the CO₂ emission factor for CHP is a weighted average of the emission factors of the fuels used for CHP production. For the sensitivity analysis an average emission factor of 70 kg CO₂/GJ has been applied instead of the emission factor for natural gas (56.8 kg/GJ). For the EU-27 this means a decline of CO₂ savings from 61.2 to -20.6 Mton (2006). This is quite a strong impact. When using Member State emission factors for both the reference for electricity production and the CHP fuel mix the effect might be limited. Member States with much coal-based CHP do often also have their central power production primarily based on coal. The effect of an unfavourable CHP fuel emission factor will then be faded out by a high reference efficiency for electricity production.

Figure 5-8 and Figure 5-9 summarize the outcomes of the sensitivity analysis.

Figure 5-8 Sensitivity analysis at EU27 level

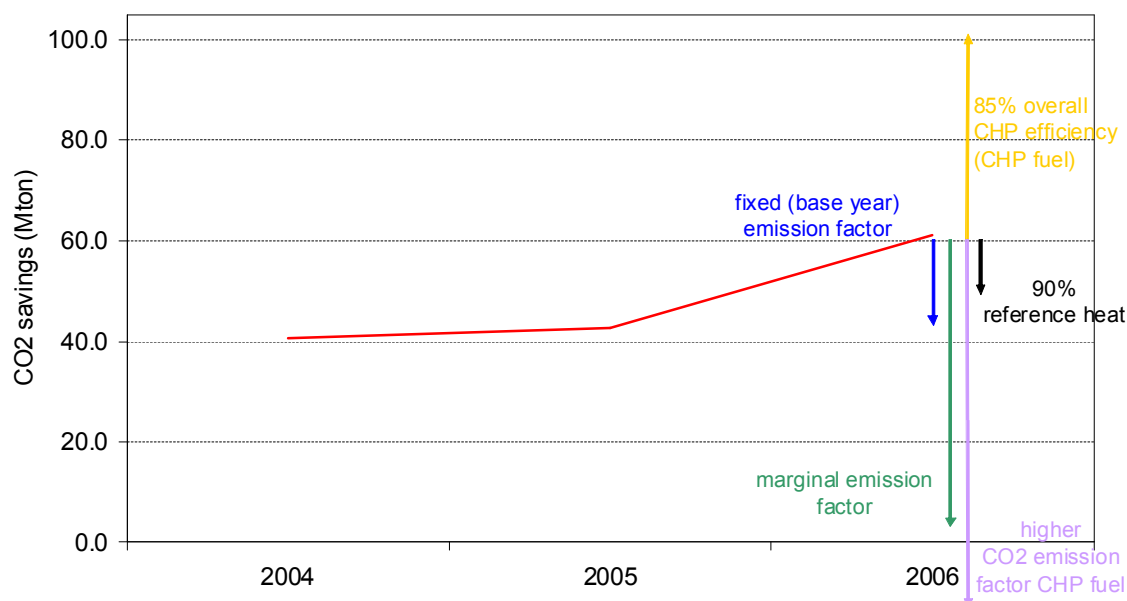
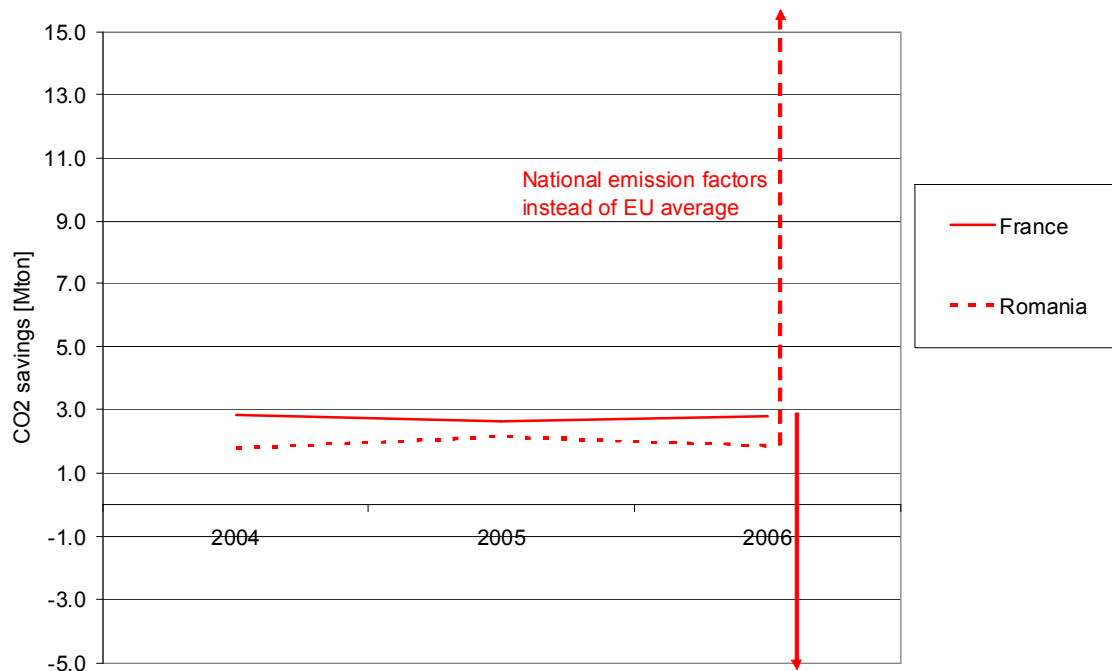


Figure 5-9 Impact of applying a national emission factor for electricity production instead of an EU average for France and Romania

5.4.2 Results Tier 2 & Tier 3 approach

Because of a lack of data, Tier 2 and 3 analyses can not currently be applied for CHP.

The Tier 2 approach should be a bridge between the simple Tier 1 approach and the complex and refined Tier 3 analysis. One way to do so is to increase the detail of the data which is used. Tier 1 uses aggregated Eurostat CHP statistics for CHP production and total fuel.

As an example, the Netherlands' national CHP statistics offer a great level of detail that is extremely useful to come to a more refined policy impact assessment:

1. All relevant CHP sectors in the country are listed:
 - Large scale district heating CHP (central power production)
 - Small scale district heating CHP (distribution companies)
 - Refineries & mining
 - Chemical industry
 - Paper industry
 - Food industry
 - Other industry
 - Agriculture
 - Health sector
 - Waste incineration
 - Other producers
2. For each sector production and input data is given for a number of CHP technologies
 - Combined cycle
 - Steam turbine
 - Gas turbine
 - Gas engine
 - Other technologies
3. For each type of technology the number of installations and the power capacity is given.
4. Fuel input is split into:

- Natural gas
- Fuel oil
- Coal
- Other fuels²¹

Ad 1.

The split in sectors is important to gain more insight in the trend development of CHP:

- When e.g. the chemical industry in a country shows strong growth figures during the evaluation period, the potential for CHP in that industry will grow along. When also the CHP statistics show an increase in CHP output in the evaluation period, part of it might be related to autonomous development.
- Another advantage of having a split in sectors is the possibility to check the base year and target year for discontinuities in the data. When e.g. the base year had an extremely cold winter and the target year was extremely warm, the observed trend for district heating CHP, CHP in agriculture and CHP in the health sector is distorted and should be corrected for.²²
- For industries it can be checked how the base year and the target year deviate in terms of economic activity/industrial output: an extreme good or bad base or target year can also distort the assessment results.
- A split in sectors also better allows explaining other discontinuities in the CHP statistics. When e.g. the biggest refinery in a country (with lots of CHP capacity) had its cyclical large scale maintenance in the base year or target year, this will certainly affect the CHP output for that sector.

Ad 2/3.

Insight in the development of the number of CHP installations of a specific technology and the power capacity gives a means to analyse the average full load operation time, fading out of specific technologies and switches to other technologies. A split in technologies also better allows analysing the quality of CHP such as required by the CHP Directive.

Ad 4.

A split of the fuel allows calculating an average emission factor for the CHP fuel which improves the robustness of the results.

Although the details of the Dutch CHP statistics allow better policy analysis²³, the link between statistics and policy impact is still rather weak. Statistics often fail to identify the introduction of new technologies that are policy induced. Examples regarding CHP are small scale bio-energy CHP, micro turbines in industry, microCHP in the built environment and, for the future, the introduction of fuel cell CHP. To identify the uptake of these technologies, Tier 2 analysis should rely on other official documents. The availability of such documents will probably differ country by country and will set the boundaries for Tier 2 analysis. For the Netherlands the following documents/sources should be used:

- For bio-energy an annual status document is published by the Dutch Energy Agency SenterNovem²⁴ which holds information on the development of small-scale bio-CHP.
- For microCHP an investment subsidy has become available from September 2008 on. SenterNovem is the responsible body for assessing the subsidy applications and granting the subsidy. This information could be well-used for estimating the CO2 impact of micro-CHP.
- CHP is eligible for the investment deduction scheme, a fiscal arrangement to promote increased use of CHP. Also for this scheme, SenterNovem is the responsible body. Information on awarded (and realized) projects (in the evaluation period) offers valuable insight in the possible impact from policies

The data sources for tier 2 assessment will not be a fixed list, but evolve in time. When e.g. the subsidy for micro-CHP is stopped and statistics still fail to identify the development of microCHP other data sources should be looked for.

²¹ Because of the split in sectors and technologies it is often clear what "other fuel" have been applied. E.g. other fuel in the large district heating plants is primarily co-fired bio-energy.

²² See e.g. Eurostat, Panorama of Energy, 2007 for temperature corrections at Member State level.

²³ It should however be noted that opposed to the Eurostat CHP Statistics the Netherlands' national CHP statistics do not distinguish CHP production and fuels from non-CHP. This means that in the Dutch statistics also non-CHP electricity is included. This hampers a policy impact assessment of the CHP Directive which goes even one step further: first distinguish CHP from non-CHP and then split CHP in high efficient CHP and other CHP.

²⁴ SenterNovem (2008) Status bio-energy in the Netherlands 2007.

Tier 2 analysis would allow a first order policy impact assessment. Tier 2 does e.g. not have the tool to assess free rider ship or to analyse the impact of feed-in subsidies for CHP. Where statistics show e.g. stable CHP output over the evaluation period, it might be the case that without feed-in subsidies CHP output would have declined. In order to analyse this more in-depth (tier 3) information is needed on the specific market conditions under which CHP has to operate in a country and the economic characteristics of the CHP installation itself. This type of information will probably only be available from Member States which have a history with feed-in subsidies for CHP.

Last step would be to decompose the determined policy impact into impact from national policies and impact from the CHP Directive (and possibly other directives, see section 5.1. This requires detailed knowledge of the CHP policies in a Member State and to what extent these policies were implemented or adjusted because of the European Directives. This is typically tier 3 analysis.

5.5 Synthesis

5.5.1 Comparison with alternative estimates

For the Netherlands an ex-post analysis analysing the CO₂ impact of CHP has been carried out for the period 1990-2000.²⁵ The additional CO₂ savings from CHP in this period range from 0.7-7.3 Mton, depending on the reference CO₂ emission factor for electricity production (367-625 gr/kWh). The estimated contribution from CHP policies to these additional savings range from 0.3-4.5 Mton.

These results can not be compared with the impact analysis for the Netherlands in this case study for several reasons:

- Limited data availability from Eurostat does not allow analyzing the pre-Directive period properly.
- The policy analysis carried out for the Netherlands is quite detailed and can be compared with a Tier 3 level analysis.
- The policy analysis carried out for the Netherlands focuses on the impact of CHP policies in general without the intention to split the policy impact in national and EU impact.²⁶

5.5.2 Comparison with ex-ante results

The second ECCP progress report (EU, 2002) estimated potential savings in the EU 15 in 2010 of 65 Mt CO₂ per annum. This estimate cannot be compared directly with the ex-post results, since the methodologies are inconsistent with the ex-post results capturing all CHP installation and not just those installed in response to the directive. In practice, the CHP Directive is unlikely to lead to a direct impact (over and above national policies) until at least 2009 i.e. the ex-post impacts to date are zero.

²⁵ ECN (2002) Effect van Energie- en Milieubeleid op Broeikasgasemissies in de Periode 1990-2000.

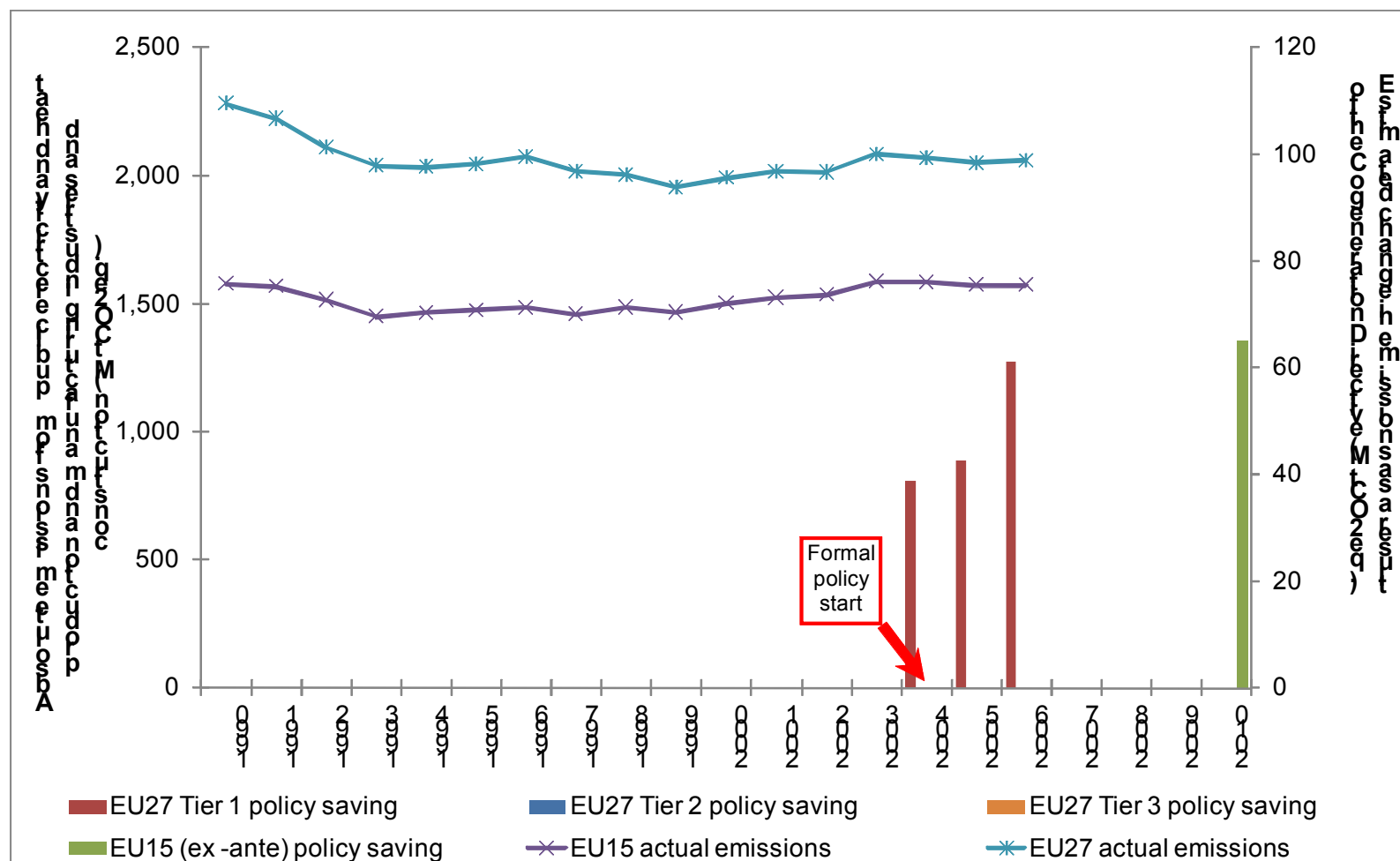
²⁶ As the evaluation period covers 1990-2000 only, no impact from EU policies can be expected since the Directive was not yet there.

Table 5-2 Comparison of ex-ante and ex-post results: CHP Directive

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1*	T2	T3
Promotion of cogeneration (Dir 2004/8/EC)	65	61.2 (EU27, 2006) NE (EU15, 2006)	NE	NE
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations: MSsp: Member State specific starting year for the ex-post evaluation NE = not estimated				
Notes: * Ex post CO ₂ savings based on primary energy savings. The Tier 1 approach assumes that CHP electricity production is replacing the average fuel mix of the EU-27 (fossil-fired public supply). It assumes further that CHP heat is replacing the marginal factor associated with heat from a natural gas-fired boiler with an efficiency of 85% Savings relative to 2004, attributing them to the Directive. However, the impact of the CHP Directive is still non-existing and only expected from 2009/2010 onwards. There is a contribution of CHP to climate policy objectives regardless whether this contribution is policy induced or not.				

At the EU-27 level the CO₂ savings from CHP grew strongly (+44%) between 2005 and 2006. In 2006 CHP contributed more than 60 Mt of CO₂ savings to the European climate change objectives as compared to 40 Mt in 2004. However, the increased CO₂ savings for most Member States can be explained by the higher EU average CO₂ emission factor for electricity in 2006. This highlights how sensitive the calculation outcomes are for the reference development.

The estimated impacts of the policy are put into context in Figure 5-10 below. The estimated (ex ante, and ex post) impacts are compared against the overall historical trend in emissions from electricity and heat production. This shows the relative influence of CHP on the overall trend in emissions.

Figure 5-10 CHP Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above. The CHP Directive may also influence the following inventory activities (but to less a degree that for the two sectors presented in the graph: 1.A.4 (Fuel Combustion Activities – other Sectors) and 1.A.5 (Fuel Combustion Activities - non-specified). Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

In 2005 the Energy research Centre of the Netherlands (ECN) developed a 2005-2020 business as usual scenario for the Dutch Ministries of Economic Affairs and Environment, being an update of the scenario for 2000-2010 developed in 2002.²⁷ These scenarios cover the full economy but provide ex-ante estimates of various climate policies, including the CHP policies:

- In 2002 it was estimated that the CO₂ impact from additional (i.e. after 2000) CHP policies would amount to 0.5 Mton in the period 2000-2010.
- In 2005 the figure was adjusted to 0.2 Mton being the result of deteriorated market conditions. The total CHP policy impact (including before 2000 policies) for the period 2000-2010 was ex-ante evaluated at 1.9 Mton.

It is not possible to compare these results with the results from the case study:

- In the case study it was not possible to determine a policy effect (the CHP Directive is not yet providing an impact and Tier 1 analysis does not allow determining a policy impact).
- It is unclear which reference values for electricity production have been used in the Dutch study.

5.5.3 Cost-effectiveness

The Energy research Centre of the Netherlands (ECN) has analysed the cost-effectiveness of the feed-in subsidy in the Netherlands.²⁸ Calculations show that cost-effectiveness is 25 euro/ton CO₂ saved. An earlier study of ECN included a full in-depth analysis of the costs for national CHP policies.²⁹ For the period 1990-2000 the cost-effectiveness of CHP policies amounted to 10 euro/ton CO₂ saved.

Ex-ante estimates of the cost-effectiveness of CHP are e.g. available from the Sectoral Objectives study which was carried out for DG-ENV.³⁰ Costs for CHP range from 12 to 227 euro/ton CO₂ based on a natural gas combined cycle as reference technology or -13 to 40 euro/ton CO₂ based on a 40% coal-fired power plant. The range in costs is due to the type and size of CHP. These costs figures are costs for technology and do not refer to policy costs.

5.6 Conclusions

- It is expected that the CHP Directive will not have an impact before 2009. This means that the impact of the CHP Directive can only be analysed from 2011 on when statistical data for 2009 becomes available.
- Tier 1 analysis for CHP should not be considered as a policy impact assessment as it is not possible to split policy effects from other effects such as autonomous development of CHP, level of economic activity and temperature fluctuations. Furthermore, the statistics used in Tier 1 are often less useful for identifying specific developments which may be induced by policy such as the uptake of small scale bio-CHP and micro-CHP in the built environment. Although this is significant in that sector and highly stimulated by policies, the contribution to overall statistics is small and not very visible.
- Tier 1 analysis nevertheless shows the contribution of CHP to climate policy objectives regardless whether this contribution is policy induced or not.
- Due to limited data availability CHP's additional contribution to CO₂ savings in the period 1990-2006 cannot be assessed.
- In 2006, CHP contributed more than 60 Mton of CO₂ savings to the European climate change objectives.
- It has been shown however that this result is rather sensitive to the reference CO₂ emission factor for electricity, the assumed overall efficiency for calculating CHP fuel from total fuel, the reference efficiency value for heat production and the assumed CO₂ emission factor for CHP fuel. Both the separate and combined effect of these indicators can either lead to savings of over 100 Mton or even negative savings.

²⁷ ECN (2005) referentieramingen energie en emissies 2005-2020.

²⁸ ECN (2004) Milieukosten energiematregelen 1990-2010. Overzicht kosten en mogelijke verbeteringen in de monitoring.

²⁹ ECN (2002) Besparingstrends 1990-2000. Besparing, instrumenten en effectiviteit.

³⁰ See http://ec.europa.eu/environment/enveco/climate_change/sectoral_objectives.htm.

5.7 Recommendations

- Current Eurostat CHP statistics do not split the total fuel in CHP and non-CHP. It is recommended that this split is implemented as it will improve the usefulness of the statistics. If CHP fuel is available in the statistics, no further assumption needs to be made on the overall CHP efficiency. This will improve the robustness of the calculation results as it has been shown that the outcomes are rather sensitive to this assumption.
- It is also recommended that CHP fuel per fuel category is reported to allow average CO₂ emission factors for the CHP fuel to be calculated.
- As the CHP Directive aims at promoting the use of high efficiency CHP (CHP that saves over 10% energy), it is recommended that high efficiency CHP and other CHP are reported separately. This should be done for both the electricity and heat production, and the fuel.
- The split between auto producers and public supply in the Eurostat statistics should include the fuel in addition to the CHP production. Furthermore, this split should also include the split in high-efficiency and other CHP.³¹
- Eurostat CHP statistics should report on sector level. This split in sectors should also include the split in high efficiency and other CHP.³¹
- Eurostat CHP statistics should report new CHP capacity.
- Eurostat CHP statistics should report on the number of CHP installations differentiated by type of technology (combined cycle, steam turbine, gas turbine, gas engine, other).
- National CHP statistics should be based on the same principles as the Eurostat statistics, i.e. split CHP production and fuel from non-CHP.

³¹ This would increase the quality of the Tier 1 assessment.

6 Case study: EU Emission Trading Scheme (EU ETS)

6.1 Introduction

This chapter describes the tiered approach developed for the evaluation of the European Emission Trading Schemes and discussed present limitations in the evaluation methodology.

The Tier 1 approach proposed for the evaluation of the EU ETS is based on emission intensity trends (derived from inventory statistics on emissions coupled with the value added of energy and the industry sectors as a whole). All values are EU wide values. At this level only a limited number of corrections can be introduced due to data limitations.

The Tier 2 approach is only briefly described in this chapter but not elaborated further. It is based on more detailed statistics by breaking especially the industrial sector further down on a subsectoral level.

The Tier 3 approach to the EU ETS described here proposes therefore two different methodologies:

- One for the **electricity sector** which represents the most relevant part of the energy transformation sector. This approach reposes on a detailed description of the power sector on a plant by plant level, as well as on a high time resolution (modelling on an hourly basis), so as to show the effects of the ETS on the dispatching of the fossil power plants, which are the most important **short term** effects and the most relevant ones for an ex-post analysis at the present level. For this purpose the PowerAce model was used which represents the renewables power generation units with an hourly resolution. At the longer **term, investment decisions** may be influenced by the EU ETS, however beyond the short historic time period 2005/2006 assessed here. For this purpose results from the Green-X model are provided. This issue is discussed further in this report.
- One for the **industry sector** based on an econometric approach. The econometric approach was chosen, because the industrial sector is far from having the same degree of detail concerning the different installations. Even from the emission registers only the CO₂ emissions are known by installation, neither the fuel mix nor the production levels. The econometric approach is therefore the most appropriate one for the **shorter term impacts**. Models tend to rely on assumed behaviour and the sector representation differs from the sectoral aggregation in the ETS. Hence, they cannot be directly linked to the information provided by the verified emissions tables. In contrast, econometric analyses are based on observed behaviour, and the econometric approach may be directly linked with emissions from the verified emissions tables.

6.1.1 Overview of policy

The European Emission Trading Scheme (EU ETS) is governed by the EU ETS Directive (CEC, 2003) and was launched in January 2005. The EU ETS covers around 11,000 large greenhouse gas emitting installations in the energy and industry sectors: combustion installations with a rated thermal input capacity of at least 20 Megawatts, as well as refineries, coke ovens, steel plants, and installations producing cement clinker, lime, bricks, glass, pulp and paper provided that they exceed the threshold production levels given in Annex 1 of the directive (CEC, 2003). The European Union Emissions Trading Scheme (EU ETS) is the world's largest emissions trading system and the first international trading system for CO₂ (Ellermann and Buchner, 2007). In total, the EU ETS covers about 50 % of Europe's CO₂ emissions and 40 % of its total greenhouse gas emissions. As the European Union's key climate policy instrument for the energy sector and the industrial sector, the EU ETS is expected to help the EU and the EU Member States reach their short- and long-term greenhouse gas emissions targets in a cost-efficient way (CEC, 2000). The EU ETS is made up of consecutive trading periods. The first trading period – often considered to be a “learning phase” – lasted from 2005 to 2007 (phase 1); the second trading period coincides with the Kyoto commitment period from 2008 to 2012 (phase 2). According to the recent proposal by the European Commission, the third trading period (phase 3) will last from 2013 to 2020 (CEC, 2008a). Also, the scope of the EU ETS will be extended to include

additional installations (air traffic) extending those already referred to in Annex 1 of the Directive (CEC, 2003). On the other hand, small emitters (with emissions of less than 25.000 t CO₂ in a reference period) may opt out from the system.

For phase 1 and phase 2 individual Member States developed country-specific National Allocation Plans (NAPs). At the macro level, these NAPs define the cap, i.e. the total quantity of allowances available in each period (ET-budget). Thus, the size of the ET-budget indicates whether the EU ETS is environmentally effective in terms of reducing CO₂-emissions. At the micro level, NAPs determine how these allowances are allocated to individual installations. By the end of a particular period, operators must surrender the number of allowances equivalent to the amount of emissions caused by their installations during that period. Otherwise sanctions have to be paid. Companies may emit more emissions than their initial allocation if they purchase extra allowances from others. In general, more stringent ET-budgets will lead to higher prices for European Union Allowances (EUAs) and thus greater incentives to improve carbon efficiency, *ceteris paribus*.

According to the Climate and Energy Package adopted by the EU in 2008 (CEC 2008a, 2009), after 2013 the ET-budgets and allocation rules will no longer be set by individual Member States, and the third trading period for the ETS will last from 2013 to 2020. The EU intends to reduce total greenhouse gas emissions by 20% compared to 1990 levels. In case other developed countries also decided to take on similar reduction targets within a Post-Kyoto framework, the EU would commit to a reduction of 30%. To achieve these targets the proposed size of the ET-budget corresponds to a reduction of 21% compared to 2005 emissions for the 20% target, and 38% compared to 2005 emissions for the 30% reduction target. The Climate and Energy Package also includes binding targets for renewables and energy efficiency. By 2020 the target share for renewables in final energy use is 20%. Finally, energy efficiency must be improved by 20% between 2005 and 2020 compared to the business as usual development.

6.2 Emission trends and drivers

6.2.1 Impact upon greenhouse gas emissions

Creating scarcity by limiting supply of allowances the EU ETS generates carbon costs, which first provides incentives to save emissions for installations directly covered by the EU ETS. Saving emissions through organizational measures or investment in carbon-saving technologies reduces the costs under the EU ETS since fewer allowances have to be surrendered. Short term measures include primarily organizational measures, fuel switch or dispatching (in power sector). Longer term investments for existing or new installations depend, in particular, on long expected future prices for EUA. Second, indirect effects result from the price effects of the EU ETS on product prices: higher product prices usually result in lower demand, lower production, and lead thus to lower emission levels. The EU ETS may result in an increase in power prices, the extent of which depends on the pass through of carbon costs to the customers (see e.g. Sijm et al. 2005, 2006). Direct and indirect carbon cost effects need to be taken into account, since these are the prime intended mechanisms translating the regulatory framework of the EU ETS in to real carbon savings. Currently only CO₂ emissions are included in the system but for the third period 2013-2020 also N₂O emissions from some installations in the industrial sector are to be included³².

6.2.2 Activity and emission trends

Under the rules governing the EU ETS, installations are required to submit their verified emissions data to Member State registries, which in turn forward it to the Community Independent Transaction Log (CITL). For 2007, this data became publicly available on the CITL on 2 April 2008. From 15 May onwards the CITL also shows information on whether installations complied with their obligation to surrender an amount of allowances equal to last year's verified emissions.

According to the information received by the CITL from national registries [1] the total amount of verified emissions from EU ETS installations in the EU-25 (excluding Malta) in 2007 was 2.050 billion tonnes of CO₂, 0.8% higher than the 2.034 billion tonnes recorded in 2006. However, when adjusted

³² Some installations with N₂O emissions have already opted in to the system. In the future perfluorocarbons from aluminium production will also be included.

for the entry and closure of installations since 2006, which led to a net addition of 581 installations to the system, the overall emissions increase last year was only 0.68%. This is well below the 2.8% growth in the EU's Gross Domestic Product recorded last year. Of the 11,186 installations participating in the scheme last year, 68 failed to surrender enough allowances to cover their 2007 emissions by the 1 May 2008 deadline. These installations are typically small and collectively account for less than 0.08% of allowances allocated.

Figure 6-1: Industrial installations under the EU ETS: Verified emissions 2005-2007 by Sector

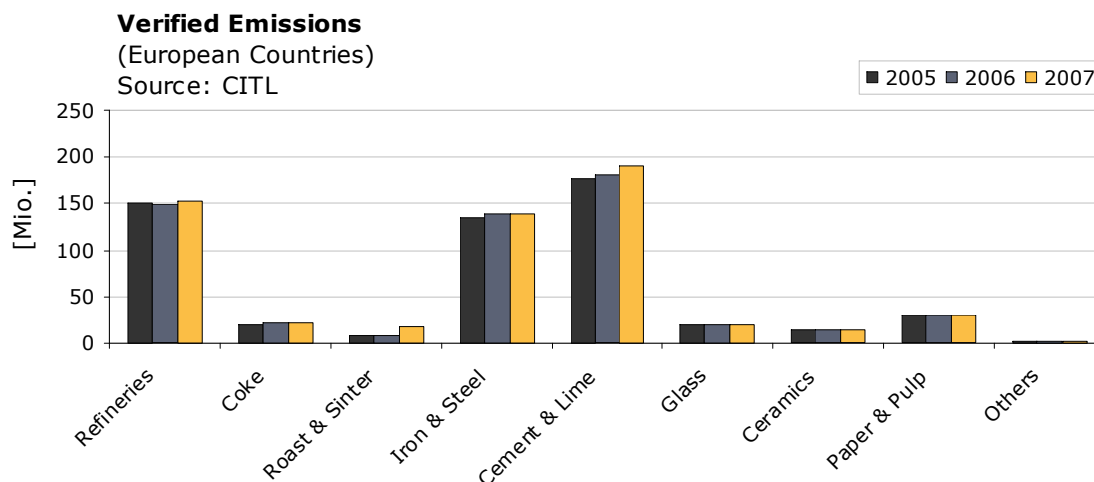


Figure 6-2: Verified emissions from the CITL for the first EU ETS trading period for combustion (energy sector and industrial combustion installations) and all activities

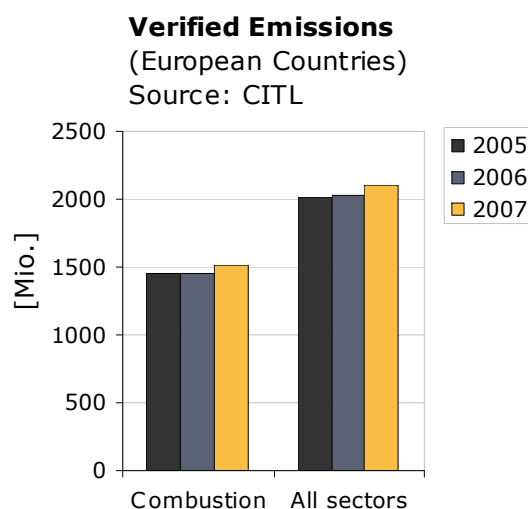


Figure 6-1 and Figure 6-2 display the annual verified emissions from the CITL for the first trading period of the EU ETS by industry sectors/activities (as defined in Annex I of the EU ETS Directive) and or all sectors/activities. As can be seen from Table 6-1, verified emissions of installations covered by the EU ETS have increased from 2005 to 2007. To the largest extent, this increase is due to higher emissions from combustion installations (ie. primarily the energy sector in 2007), but also from the production of cement and lime, and iron and steel.

It also must be kept in mind that the EU ETS sets a CAP on emissions for a given trading period. This allows for flexibility within the period, so emissions in individual years should not be looked at in isolation.

Table 6-1: Verified emissions in the EU ETS registry (CITL) 2005-2007

2005-2007 allocations, verified emissions and 2007 compliance in the EU ETS

excluding BU, RO and MT (1) (data from CITL, dated 8 May 2008)							
MS	Verified emissions (2)			Annual average allocation in 2005-2007 (3)	Number of installations		
	2.005	2.006	2.007		2005 (4)	2006 (5)	2007 (6)
AT	33.372.826	32.382.804	31.751.165	32.900.512	199	197	210
BE	55.363.223	54.775.314	52.795.318	62.114.734	309	309	309
CY	5.078.877	5.259.273	5.396.164	5.701.075	13	13	13
CZ	82.454.618	83.624.953	87.834.758	97.267.991	395	405	406
DE	474.990.760	478.016.581	487.004.055	498.390.019	1.842	1.851	1.915
DK	26.475.718	34.199.588	29.407.355	33.499.530	380	388	383
EE	12.621.817	12.109.278	15.329.931	18.953.000	43	47	47
ES	183.626.981	179.711.225	186.495.894	178.838.295	800	944	1.052
FI	33.099.625	44.621.411	42.541.327	45.499.284	578	589	607
FR	131.263.787	126.979.048	126.634.806	154.909.186	1.084	1.089	1.094
GR	71.267.736	69.965.145	72.717.006	74.400.198	140	152	153
HU	26.161.627	25.845.891	26.835.478	31.660.904	229	239	245
IE	22.441.000	21.705.328	21.246.117	22.320.000	109	114	113
IT	225.989.357	227.439.408	226.368.773	223.070.435	943	996	1.009
LT	6.603.869	6.516.911	5.998.744	12.265.395	93	99	101
LU	2.603.349	2.712.972	2.567.231	3.358.323	15	15	15
LV	2.854.481	2.940.680	2.849.203	4.560.191	93	101	93
NL	80.351.288	76.701.184	79.874.658	88.942.336	210	211	213
PL	203.149.562	209.616.285	209.601.993	237.838.568	817	817	869
PT	36.425.915	33.083.871	31.183.076	38.161.413	243	254	260
SE	19.381.623	19.884.147	15.348.209	23.209.832	705	730	755
SI	8.720.548	8.842.181	9.048.633	8.743.680	98	98	98
SK	25.231.767	25.543.239	24.516.830	30.489.902	175	173	169
UK	242.513.099	251.159.840	256.581.160	224.831.370	769	774	1.057
Total	2.012.043.453	2.033.636.557	2.049.927.884	2.151.926.173	10.282	10.605	11.186
(1) Bulgaria, Romania and Malta are not included in the table in order to allow for a proper comparison between the different years. Malta has yet to submit verified emissions for 2007, while Bulgaria and Romania only started participating in the EU ETS in 2007. Verified 2007 emissions in Romania were 69.604.599 tonnes, while no verified emissions data is yet available for Bulgaria							
(2) Verified emissions for all installations with open or closed accounts in CITL, as of 8 May 2008 (i.e. including new entrants and closed installations). As the CITL is constantly receiving information (including corrections of verified emissions data, new entrants and closures), aggregations carried out after 8 May 2008 might give a different result.							
(3) 2005-2007 annual average of allocation for installations with open or closed accounts plus annual average of allowances for auctioning and new entrants' reserve.							
(4) Number of installations with open or closed accounts in the CITL on 1 May 2006 (for MS without operating registries at this date, an underlined figure shows the number of installations which submitted 2005 verified emissions by 1 May 2007)							
(5) Number of installations with open or closed accounts in the CITL on 1 May 2007 (Malta's registry is operational, but has no open accounts yet)							
(6) Number of installations with open or closed accounts in the CITL on 8 May 2008							

Source: http://www.co2-handel.de/article185_8772.html (CITL)

Figure 6-3 and Figure 6-4 display the annual development of output in physical terms of the sectors covered by the ETS Directive. For comparisons it should be kept in mind, that the scope of the sectors is not the same as for the emissions displayed in Figure 6-1 and Figure 6-2 (CITL Data).

Figure 6-3: Industrial installations under development of activity levels (physical units) (EU25)

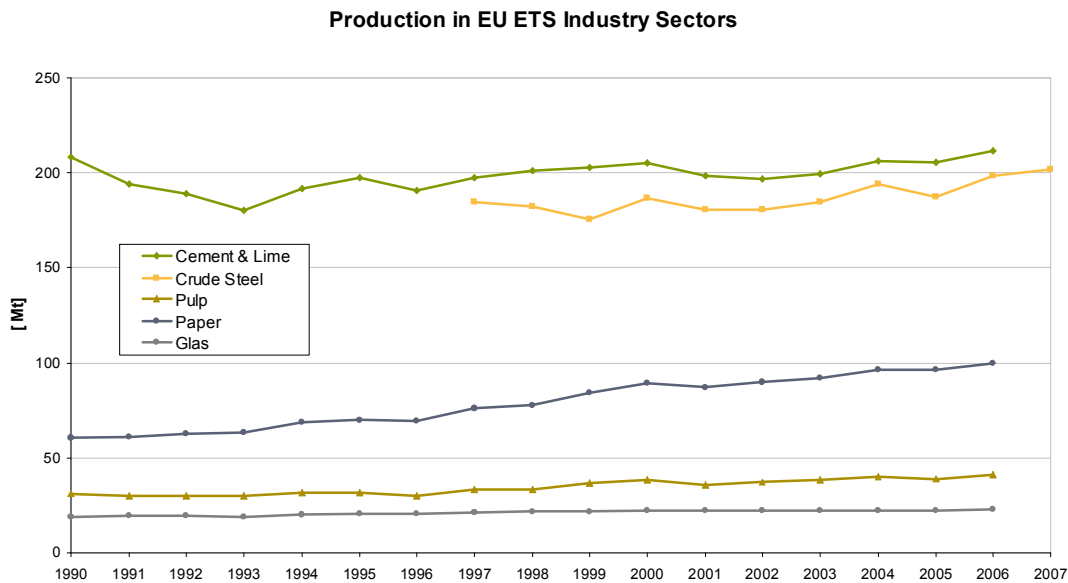
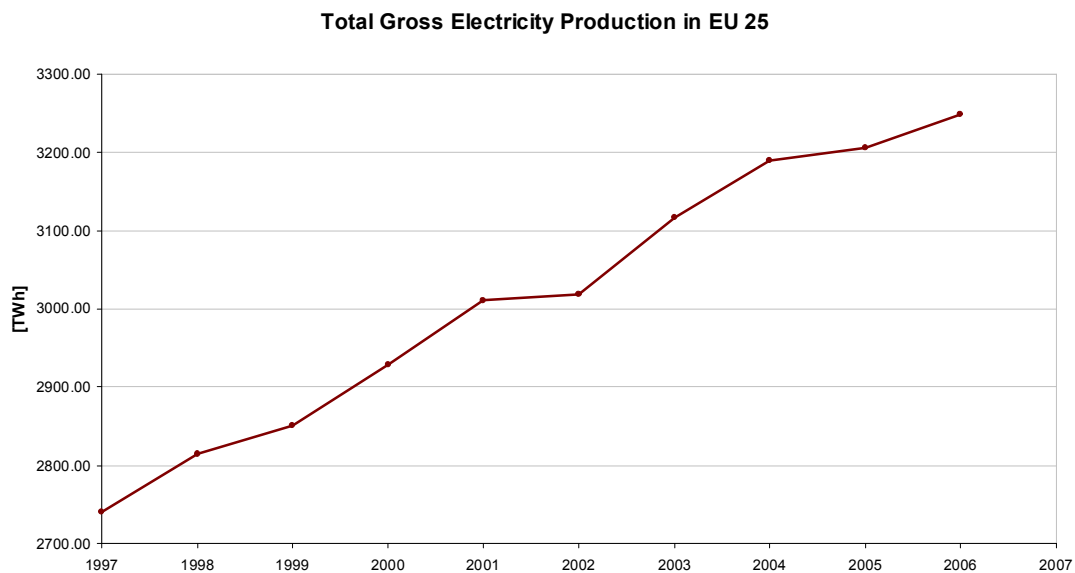


Figure 6-4: Activity levels (physical units) of the electricity sector in the EU25



6.3 Impacts of the Directive on emissions of GHGs

6.3.1 Overview of methodologies

Tier 1 and 2 methodologies

The Tier 1 approach proposed for the evaluation of the EU ETS is based on emission intensity trends (derived from inventory statistics on emissions coupled with the value added of energy and the industry sectors as a whole). All values are EU wide values. At this level only a limited number of corrections can be introduced due to data limitations:

- Firstly, the sector definition in the Value Added (VA) and emission statistics needs to be matched with the ETS participants. In Tier 1, the correction factors for adjusting the statistics sector definition to match the ETS system boundary (one for sectors, one for gases) are set at 0.
- Secondly, the historic trend in VA and emissions for the appropriate system boundary is determined for the 5 years preceding the implementation of the Directive.
- Thirdly, the historic annual development in emission intensity is assumed to continue in the baseline in absence of the ETS Directive and needs to be combined with the value added in the year of evaluation to determine the baseline emissions.
- Fourthly, the emissions from the baseline must be corrected for the impact of actual energy prices that are different than those occurring in the past. For Tier 1, the correction factor is assumed to be 0 due to data limitations. Such a correction factor could be derived in a future refinement of the methodology from the Tier 3 analysis and applied to the Tier 1/2 approaches
- Fifthly, the effect of the RES-E directive on emissions needs to be assessed (as described in the corresponding guideline). The baseline data need to be adjusted to reflect the effect of the RES-E directive, by adding the emissions associated with the additional renewable electricity production as determined under the previous step. At the level of Tier 1 it is assumed that all renewables can be associated with targeted RES-E policies. A further refined Tier 3 approach may derive in the future factors that could be applied to the Tier 1 approach to correct for impacts of the EU ETS on the deployment of renewables³³ (see the discussion in the Tier 3 report).
- Then, the effect of the ETS Directive is estimated by subtracting the actual verified emissions in the ETS sectors from the corrected baseline data determined in the previous step.
- Finally, the estimated effect of the Directive needs to be corrected for the JI projects hosted in the Member State, by adding the amount of emissions equivalent to the amount of ERUs generated within the Member States from the JI reserve. (Note: This refers to JI projects realised (=hosted) in the respective Member State, not to JI or CDM credits that a Member State purchases from projects realised abroad). Again, at the Tier 1/2 level due to data limitations this correction was not introduced.

The Tier 2 approach is similar to the Tier 1 approach, except for:

- Correcting the statistics sector definition with a country-specific correcting factor to match the ETS system boundaries.
- Work at a more disaggregated subsectoral statistical level (especially for the industrial sector)
- Assessing the effect of the RES-E Directive according to the Tier 2 approach for that Directive
- Correcting the effect for energy prices that are different from historic trends.

For the concrete Tier 1 calculations, the emissions were based on the emission inventories and the EU ETS was approximated as:

- Emissions from fuel combustion in the energy sector
- Emissions from fuel combustion in the manufacturing and construction sector
- Process emissions from cement production
- Process emissions from lime production
- Process emissions from limestone and dolomite use
- Process emissions from soda ash production

³³ Since the EU ETS and the RES-E Directive are essentially 'mutually reinforcing' then the disaggregation of impacts between the two instruments will always involve a degree of subjectivity. This can be avoided by considering the collective impact of the policy package. However, in practice, policy makers are interested in the impacts of individual policy instruments – hence some disaggregation is inevitable

- Process emissions from nitric acid production
- Process emissions from adipic acid production

The value added had to be approximated in a quite crude manner in the Tier 1 approach as:

- Energy, gas and water supply
- Mining and quarrying
- Manufacturing
- Construction

Tier 3 methodologies

Since the EU ETS differs in nature from the other measures under the ECCP it is considered worthwhile focussing on some methodological aspects for the evaluation of its impacts first. When developing a methodology to evaluate the EU ETS the following aspects have to be taken into account (see the detailed Methodologies report for an in-depth discussion of these factors).

- Carbon leakage
- Macro-economic effects
- Autonomous technological change
- Structural change
- Price-induced changes in emissions
- Policy-induced changes in emissions (policy interaction/policy mapping)
- Counterfactual climate policy
- Impact of trading allowances and using project-based credits
- Banking and Borrowing

Evaluation of the EU ETS based on the Tier 3 approach may be conducted using models or carrying out econometric analyses (possibly combined with expert judgements).

a) Evaluation based on models for the power sector

Models which allow for a sectoral disaggregation of the sectors covered by the EU ETS may be used for evaluation. This approach implicitly assumes that the models are able to capture the actual technological and economic environment, including agents' behaviour sufficiently well. Models suitable for the task include those capturing several sectors such as the PRIMES model or models for single sectors such as the PowerACE model (a model developed by Fraunhofer ISI for the power sector with an hourly presentation of the power sector). While the former allow for an analysis of the effects on all sectors in all countries combined (including interactions), sector-specific models with a high resolution in time tend to be better suited to capture technological and country-specific details including interactions with other policies. In principle, the evaluation consists of the subsequent steps:

Step (i): Run model with observed prices for EUAs in period t and include other economic variables as actually observed in period 1 (energy prices, sector growth, supply of renewables, policies, etc.) as much as possible (without compromising the logic and internal consistency of the model) (*Policy run*).

Step (ii): Run model from Step (i) but set price for EUAs at zero and – if possible – model counterfactual national climate policy (*Counterfactual*). The PowerACE and the Green-X models have for this purpose a detailed representation of targeted renewables policies.

Step (iii): Take the difference in emissions between Step (ii) and Step (i) and relate result (e.g. growth rate in emissions) to verified emissions (*Calibration*).

Due to the long lead times for the planning and construction of new power plants it can be safely assumed that the ETS had no impact on the structure of the power plant portfolio itself in the first period. **Therefore the central impact of ETS in the power sector in the first period is the change in plant dispatch caused by higher generation cost for CO₂-intensive generation technologies.** The PowerACE model is capable to simulate plant dispatch on hourly level for an entire year. It applies detailed data on power plants, renewable electricity generation, fuel prices and CO₂ prices to calculate plant dispatch, market prices and CO₂ emissions. As hourly plant dispatch is crucial for the calculation of emissions in the electricity sector the high detail level is necessary in order to obtain reliable results. In addition the model proceeds through a multi-agent simulation which allows

modelling the market behaviour of actors on the electricity markets. At present no models exist at that level of detail at the European level. This is why the impact evaluation with PowerACE is limited to Germany. Models currently used for the ex-ante impact assessment of the EU ETS such as PRIMES are only calculating at five-years intervals. In the longer term, investment decisions need to be included in the evaluation. In order to carry out such an integrated analysis it is advisable to combine several models: A plant dispatch model (e.g. PowerACE), a model for the diffusion of renewable electricity generation (e.g. PowerACE RESINVEST or GreenX) and a model the development of the conventional power plant portfolio (e.g. Balmorel, TIMES, MARKAL...). The combination of these model types could provide additional insights into the interaction of renewable support schemes and ETS in different time scales.

In principle, all policies and measures affecting supply and demand of the output produced by installations covered by the EU ETS interact with the EU ETS. The mutual influence appears as rather complex and not only of economic nature. See a more detailed discussion of this issue in the Tier 3 report.

At least to some extent, the impact of direct and indirect measures is taken into account when deciding on the size of the ET-budget (and on the size of the greenhouse gas budgets of the Non-ETS sectors). That is, for example the estimated impact of targeted support measures for renewable energy sources (such as feed-in tariffs) or demand-side energy efficiency measures which reduce supply from installations covered under the EU ETS would, in principle, have to be taken into account when deciding on the ET-budget. Once this cap is set, however, and these other measures turned out to be more effective than estimated when setting the cap, they would not lead to additional emission reductions because emissions replaced by carbon-free technologies beyond the assumed success would open more room for fossil emission, hence lead to a reduced price signal.

On the other hand, since the EU ETS results in an increase in power prices, rendering energy-efficient measures and technologies more profitable, the EU ETS complements the effectiveness of other measures. Similarly, by increasing the costs for carbon-intensive supply side technologies, carbon-free technologies become more profitable. The impact of the ETS can therefore be seen more complementary to other policies because it makes the continuation of those instruments easier as it reduces the need for direct subsidies. On the other hand, the ETS benefits from the presence of those instruments due to the volatility of prices for CO₂ allowances. Without the steady frame of the present promotion schemes for renewable energy sources far less renewables would be installed given the high uncertainties and high volatility around the carbon price. It has to be realised further that the cap once set, taking into account impacts of energy efficiency and renewables policies, any additional increase in the share of for example renewables or energy efficiency leads to a replacement of other options.

This interaction is exemplified with the policies for renewables: The REN target in EU Member States is reached by quantity based mechanisms (e.g. quotas) or price based mechanisms (e.g. fixed feed-in tariffs or feed-in premiums). Generally these systems should be designed to reach the REN target independently of the ETS price, which is clearly the case for a quota system and a fixed feed-in system. In the case of a premium system the level of the premium needs to be adjusted according to the ETS price. Impacts of these policies, taking into account carbon price, has been evaluated with the Green-X model.

The policy costs for the RES support will nevertheless depend on the ETS price (according to the impact assessment of the Climate package 45 €/MWh with ETS and 56 €/MWh without ETS) but the level of target achievement of the REN targets will not depend on the ETS price as these targets exist separately.

b) Econometric approach for the industry sector³⁴

Using econometric techniques, the EU ETS may be evaluated based on observed (rather than implied or imposed) behaviour. An econometric approach should only be used if sufficient data is available

³⁴ For the power sector, data requirements would be prohibitive. For example, VET data does not distinguish between particular power technologies. Likewise, it would be difficult to adequately reflect the impact of national policies, which are the main driver for the type of power generation in a country, based on time series analyses.

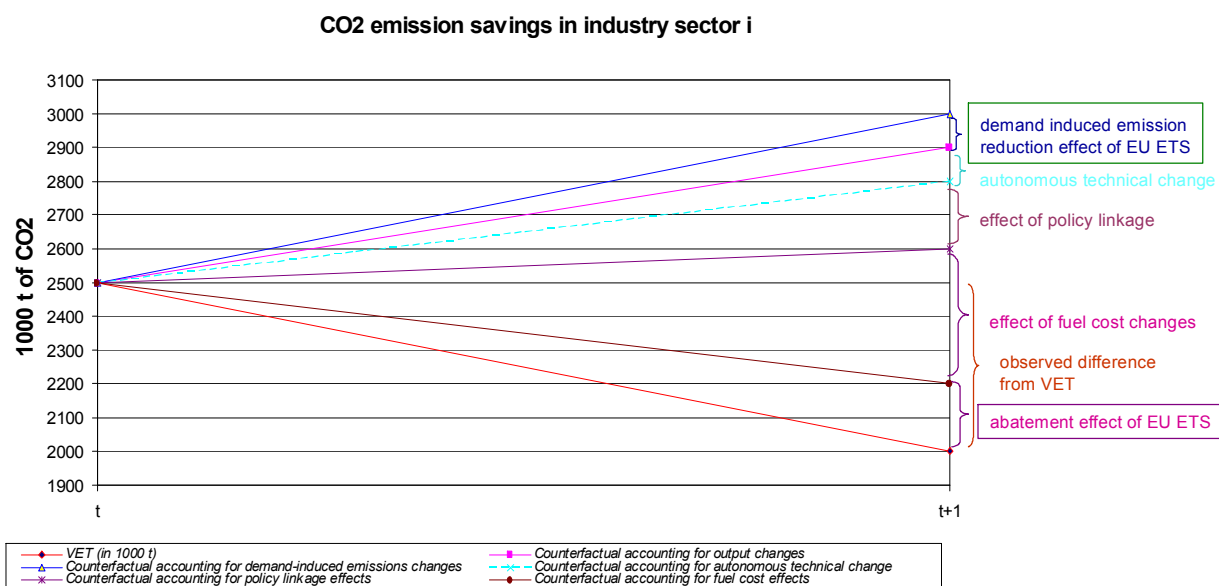
and if the regression equations are well specified. To estimate the savings in emissions associated with the EU ETS, the following adjustment would have to be carried out (for details see the Tier3 report on the EU ETS):

- (1) Step (i): adjust for growth rate in sector production (*output effect*)
- (2) Step (ii): adjust for demand reduction in response to increased output prices induced by EU ETS (*demand-induced emission reduction effect*). In order to improve the methodology in this working step, further work is certainly needed on demand elasticities that show the reaction of the demand for products due to the price of the allowances.
- (3) Step (iii): adjust for change in carbon intensity unrelated to policy or input price effects (*autonomous technical change effect*)
- (4) Step (iv): adjust for change in emissions resulting from other policies (*policy linkage effect*)
- (5) Step (v): adjust for change in carbon intensity induced by fuel costs (*fuel cost effect*)

The *direct effects* of the EU ETS in the year t may then be quantified by comparing the counterfactual with emissions in the VET. An estimate for the *indirect effects* of the EU ETS may be obtained by multiplying the change in demand from Step (ii) (in terms of the growth rate) with the *counterfactual*.³⁵ It should be pointed out again, when using the econometric approach, particular care needs to be given to the model specification. Findings need to be interpreted in the light of data availability and the quality of econometric results.

Further, since the proposed methodology calculates the direct effects of the EU ETS as a residual, it implicitly assumes that all other mechanism resulting in a reduction of greenhouse gases have been captured. Also, the approach primarily accounts for measures which quickly translate into greenhouse gas emission reductions, in particular fuel switch. The effect of abatement measures which – because of lead times – result in lower future emissions would then also show up as emission savings attributed to the EU ETS in the future.

³⁵ If reliable data was available, actual carbon intensity in t may be multiplied by the change in production induced by the demand effect to quantify the demand effect in terms of emissions.

Figure 6-5: General methodology for the econometric approach for the industry sector

6.3.2 Results: Tier 1/2 Approach

Given the complexity of the different factors intervening in the EU ETS, it is not astonishing, that simple approaches do not provide good estimates. The Tier 1/2 approach which is based on a projection of CO₂ intensities for the counterfactual, generally does not provide convincing results. The savings appear as too large or negative savings may appear (Table 6-2). The reason for this are mainly the fluctuations in the value added used for the projections which do not correlate well with the development of the part of the inventories that have been chosen to represent the EU ETS. This may be due to the fact that the total manufacturing sector was chosen as a proxy for the industrial part of the EU ETS. But even tests with the energy sector only, which is better matching one part of the EU ETS does not well capture the impacts. The aggregate value added simply contains too many factors of influence that are not well defined.

This advocates exploring more refined approaches at the Tier 3 level.

Table 6-2: Results from the Tier 1 Approach (Intensity Approach) and comparison with a direct impact evaluation from a projection of inventory data

Intensity approach			Direct projection of inventory data		
Tier 1		Mt CO ₂ eq.	Tier 1		Mt CO ₂ eq.
		2005			2005
Geographical entity	Germany	18,24	Geographical entity	Germany	13,56
	France	-0,62		France	-2,42
	Spain	-15,45		Spain	-7,63
	Italy	16,74		Italy	6,18
	UK	30,96		UK	-0,86
	Denmark	9,14		Denmark	7,14
	Austria	0,85		Austria	1,28
	Netherlands	-10,77		Netherlands	4,00
	Poland	41,02		Poland	1,34
	Czech	-11,61		Czech	-0,93

6.3.3 Results: Tier 3 Approach

Given the complexity of the EU ETS it was only possible to exemplify the results with the power sector and the cement sector in Germany. Procedure a) is exemplified by an analysis with the PowerACE model of the impact of dispatching in the German power sector as a consequence of the EU ETS price signals. Procedures b) and c) as outlined above will be exemplified for the German cement sector, respectively clinker production.

a) Evaluation based on the PowerACE model for the power sector in Germany (impact of dispatching)

Methodology:

- PowerACE Simulation platform
- Dispatch according to variable cost and start up cost
- CO₂ price is included into variable generation cost for all fuels
- Simulation with CO₂ price of zero and the actual daily spot CO₂ price taken from the European Energy Exchange for the years 2005 and 2006

Results of the PowerACE model for Germany:

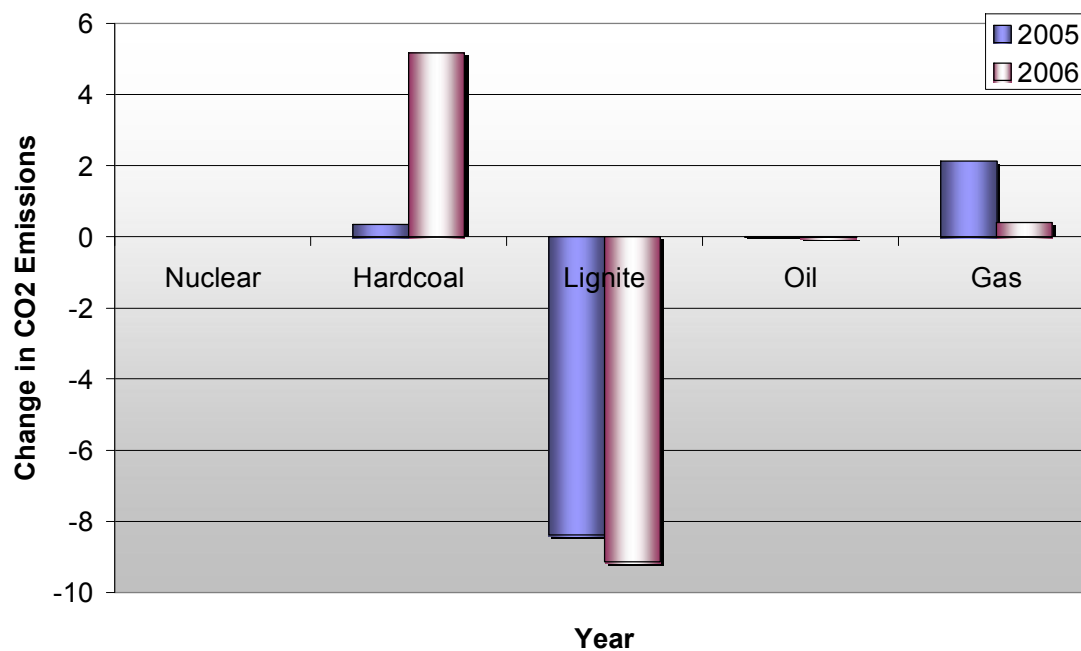
- Savings: 2005 max. 6.1 Mt
- Savings: 2006 max. 3.6 Mt

Analysis of the fuel switch:

- 2005: Mainly switch to gas

2006: Mainly switch lignite to hard coal (Reason: Increasing gas prices in 2006, slight decrease in decrease in hard coal prices in 2006, see

- Figure 6-6)

Figure 6-6: Change in CO₂ emissions from the power sector in Germany 2005 and 2006 due to the EU ETS (in Mt CO₂)

Source: Own calculations with PowerACE

b) Econometric approach for cement sector in Germany

The details of the application of the five methodological steps for the cement sector are described in the methodologies report report. **It should be underlined for this case study, that both the figures for the price elasticities and the assumptions on the cost pass through are highly uncertain due to a lack of empirical data. As the issue is highly sensitive (delocalisation of industrial companies from Europe; carbon leakage issues), the results need to be carefully debated and presented.**

Subtracting the *counterfactual accounting for fuel cost effects* from VET data for 2006, the implied direct savings from the ETS are calculated as 115 kt of CO₂ corresponding to 0.56 % (compared to counterfactual, see

Table 6-3).³⁶ The indirect effects are estimated to be 774 kt of CO₂ corresponding to 3.64 % of the counterfactual³⁷. Thus, the indirect effects of the EU ETS on carbon emissions in the cement sector are estimated to be substantially higher than the direct effects.

³⁶ It should be noted though that in principle, this approach may also lead to calculated negative direct emission reductions", in particular if the regression results imply large autonomous change or fuel price effects.

³⁷ To calculate this figure, the effects of autonomous technological change and of fuel costs were taken into account. Otherwise, the demand-induced emission reduction effect would be (slightly) overstated.

Table 6-3: Results for the impact of the EU ETS for the German clinker production

		2004	2005	2006
Step (i)	Emissions from Verified Emissions Tables	Unit		
	Observed growth rate in emissions	1000t	20066	20433
	Clinker production	%		1.83%
	Output growth rate	1000t	24315	24952
		%		2.62%
	Counterfactual accounting for output changes			20591
Step (ii)	Price elasticity of cement demand	%		-27.00%
	Increase in costs for cement (opportunity costs)	%		27.90%
	Change in demand (full pass through)	%		-7.53%
	"Realistic" pass through	%		50.00%
	Change in demand (realistic pass through)	%		-3.77%
	Counterfactual accounting for demand induced emission reduction	1000t		21367
Step (iii)	Autonomous technological change	%		-0.51%
	Counterfactual accounting for technical change	1000t		20485
Step (v)	Change in fuel intensity (fuel cost induced)	%		1.27%
	Change in carbon intensity (fuel cost induced)	%		0.31%
	Typical share of carbon costs to sum of fuel and carbon costs	%		
	Counterfactual			20548
Results	Implied savings from direct ETS effects	1000t		115
	as share of counterfactual	%		0.56%
	Implied savings from indirect ETS effects	1000t		774
	as share of counterfactual	%		3.64%

Note: Autonomous technological change was in this impact evaluation either determined by an econometric approach or derived from expert judgement.

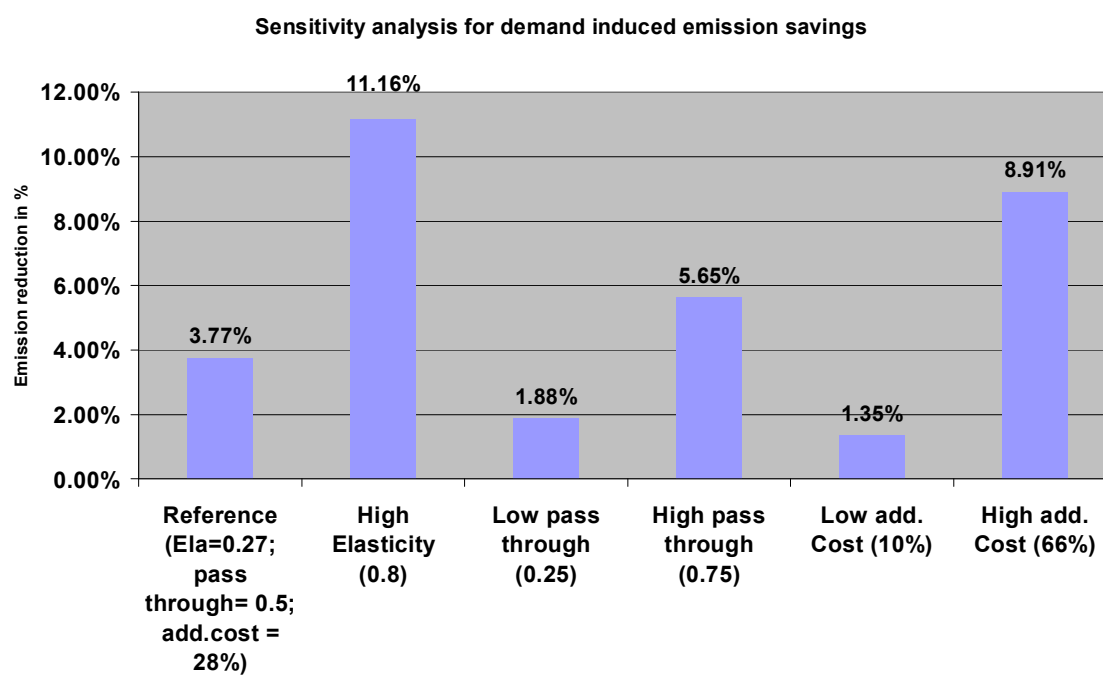
Sensitivity analysis

To illustrate the impact of the various blocks on indirect (i.e. demand-induced) and direct emission reductions, the values for the key parameters are varied.

Figure 6-7 shows the results compared to the reference case presented in

Table 6-3 and as the first column in

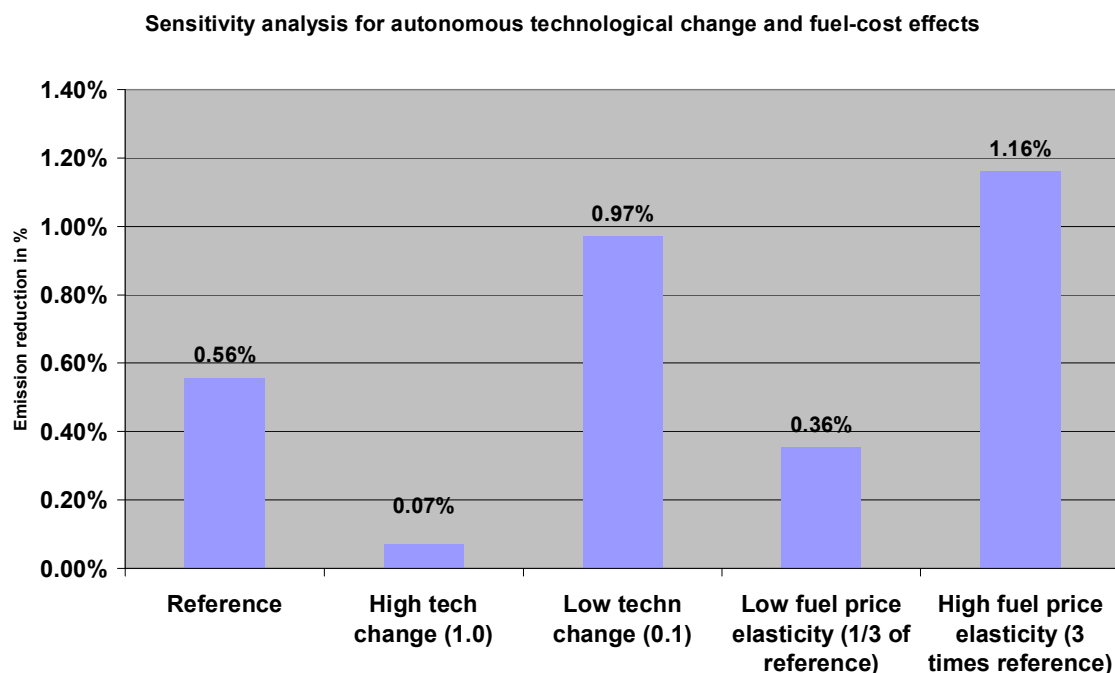
Figure 6-7, when the elasticity of demand is high (i.e. 0.8 rather than 0.27), when 25 percent or 75 percent of the additional (average) costs are passed on to consumers (rather than 50 percent), and when this cost increase is 10% and 66% (rather than 28%).

Figure 6-7: Sensitivity analyses for demand induced emissions savings in the German clinker production

In

Figure 6-8 results of selected sensitivity analyses are presented where autonomous technological change is high, i.e. fuel efficiency improves by 1.0% per year, or low (0.1%) rather than 0.5% as in the reference case. In addition the elasticity of fuel intensity with respect to coal price changes is assumed to be 1/3 and three times the value used in the reference case.³⁸

³⁸ Note that a higher coal price elasticity results in higher direct emissions savings because coal prices in 2006 were lower than in 2005.

Figure 6-8: Sensitivity analyses for direct effect of EU ETS on emissions savings in the German clinker production

6.4 Synthesis and interpretation of results

6.4.1 Comparison of results from the different methods

The Tier 1/2 approach as explored in this evaluation provides results which are not realistic. In general the impact estimates are far too high. This is due to the complexity of the EU ETS. Refinements may be possible on the Tier 1/2 approach but in order to achieve realistic results it is most likely that so many corrections have to be applied that need first to be derived from a Tier 3 approach.

The Tier 3 approach has delivered realistic results for the two examples chosen here: the dispatching in the power sector and the impacts in the cement sector in Germany. The calculations are, however, fairly complex and require substantial amount of additional data. Given the fact that the EU ETS is a major instrument within the ECCP, however, there is no way around developing such a more refined approach further. Current models, such as PRIMES are not well adapted to capture the multitude of effects. So more dedicated models need to be developed such as an hourly dispatching model for the European power sector exemplified here with the PowerAce model for Germany, as well as econometric approaches in the case of industrial sectors. These models need to be gauged to the CO₂ registries which provide more and more information over time. However, more investigations are still necessary to settle on interaction effects with other policies such as targeted renewables policies, energy efficiency policies as well as interactions with the Clean Development Mechanism CDM.

6.4.2 Comparison of impacts across Member States

The Tier 1/2 approach does not provide sufficiently reliable results in order to allow for a comparison. The Tier 3 approach could, for the moment being, only be exemplified for Germany concentrating on the power sector and the cement sector. Therefore a complete cross-country comparison is not possible at this stage.

6.4.3 Comparison with alternative estimates

For the first period (2005-2007), total emission allowances available to the EU ETS installations (emissions trading budget) exceeded verified emissions by about 3% (EEA 2007, EEA 2008). Since the emission level in the absence of the EU ETS cannot be determined (it is counterfactual), the real extent of possible over-allocation cannot be determined. Ellerman and Buchner (2006) tentatively suggest that a substantial part of the surplus may have resulted from abatement activities. As a consequence of the apparent surplus though, the price for EUA, which was relatively high in 2005 and for parts of 2006 (as long as information on actual emissions was not known), eventually dropped to almost zero towards the end of 2007. Hence, incentives to immediately reduce emissions (e.g. via fuel switch / dispatching) were only high in the beginning of the first period. However, since most measures to reduce emissions are long-term measures, it is rather the expected price for EU allowances (EUAs) than the current price which drives companies' investment behaviour.

6.4.4 Comparison with ex-ante results

The second ECCP progress report (EU, 2002) did not include an estimate of the potential savings from the EU ETS. Ex ante (and rather imperfect) estimates for the effect of the EU ETS in phase 2 may be obtained by comparing the size of the emissions trading budget for phase 2 with verified emissions in phase 1. Accordingly, for the EU-15 the EU ETS will provide a reduction in greenhouse gas emissions of approximately 139 Mt CO₂ (or 3.3%) (EEA 2008). For the EU-12 however, this method would result in a net increase of emissions by 12 Mt CO₂. Qualitatively, Schleich et al. (2008) come to a similar conclusion. Comparing projected emissions (by Member States) with the size of the emission trading budget, the estimated savings would be considerably larger.

Table 6-4 Comparison of ex-ante and ex-post results: EU ETS

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
EU ETS (Dir 2003/87/EC)	N/A	78.5 ^{1)/21.7 ²⁾ (EU-15, 2006)}	NE	4.5 (Germany, 2006) ³⁾

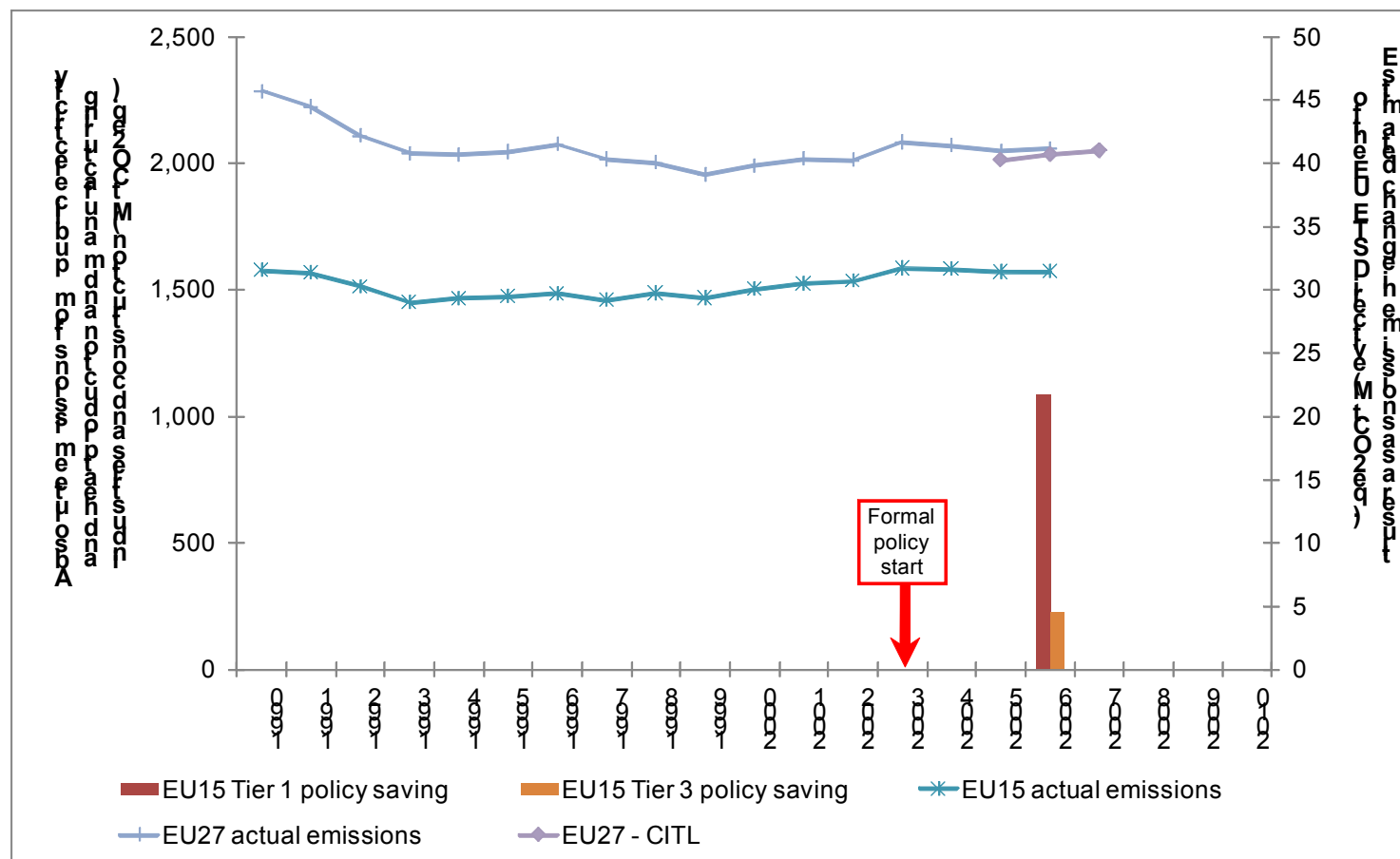
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:

Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices

Abbreviations:
MSsp: Member State specific starting year for the ex-post evaluation
NE = not estimated

Notes:
¹⁾ Intensity approach.
²⁾ Direct projection of inventory data.
³⁾ Includes only partial results for Germany and only the impacts in the power sector (dispatching effect only) and in the clinker production sector.

The estimated impacts of the policy are put into context in Figure 6-9 below. The estimated (ex ante, and ex post) impacts are compared against the overall historical trend in emissions from electricity and heat production. This shows the relative influence of the scheme, as estimated in this study, on the overall trend in emissions.

Figure 6-9: EU ETS Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above. The figure also includes data from the Community Independent Transaction Log CITL.

Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

6.4.5 Cost effectiveness

The arguments in favour of market-based instruments such as tradable allowances to generate a strong carbon price signal are well-known and need only be summarised here:

- They use market forces and all the information at the disposal of economic agents to improve the allocation of scarce resources;
- They can provide firms with flexibility to meet regulatory requirements;
- By allowing greater flexibility they ensure better efficiency through lower compliance costs;
- In the longer-term they encourage innovation and technological development

The Council of the European Union (2008)³⁹ concludes that market-based instruments, such as the EU ETS and environmental taxes, as well as more 'clean' technologies, should be the "centrepiece of Europe's efforts to reduce its greenhouse gas emissions". However, much depends on the design options of the system in order to provide the carbon signal to the energy consumer while keeping in mind competitiveness and carbon leakage issues.

6.5 Conclusions

The Tier 1 and Tier 2 approaches do not, currently, provide a sufficiently reliable estimate of the policy impacts. This means that a Tier 3 approach is required for this policy. It should, however, be investigated whether improvements are possible to the Tier 1 and Tier 2 methodologies, following experience from the further development and application of the Tier 3 methodology.

The Tier 3 approach could only be exemplified, in the current study, for two sectors (power sector and the cement sector) in Germany. The main uncertainties in the methodology are the assumed demand elasticities (which are used to characterise indirect effects) and the assumed cost pass-through behaviour of the energy sector and the industrial sector. Further work is required to advance the understanding of the factors further.

6.6 Recommendations

The EU ETS is a very complex and new instrument. For this reason we would like to highlight the explorative character of the methodology applied as part of this study and especially for the Tier 3 approach. The current approach seems to work for the German power sector and the German cement sector; produces "reasonable" results; however, the results depend crucially on some key parameters and assumptions about cost increases, pass through rates, and demand responses. These parameters need more empirical foundation than they have currently.

In considering the impacts on the power sector, future evaluations would benefit from the development of European models that represents:

- 1) short-term dispatching induced by the EU ETS (which requires hourly resolution and detailed information on the use and characteristics of power plants)
- 2) long-term investment effects in the power sector. This would, in particular, reflect the interlinkage between targeted renewables and energy policies and the ETS.

In considering the impacts on the industrial sector a full econometric analysis of the industrial activities as described in the Tier 3 report for the EU ETS is necessary. It is further necessary, to conduct misspecification tests to assess the appropriateness of the underlying econometric model from a statistical perspective. Although some regressions test have been carried out in this study, the results should be considered as exemplary and could be improved further when longer time periods are available in the future from the allowance registries.

The issue of CDM/JI projects interacting with the EU ETS needs to be further explored. In the current approach it is assumed that in the absence of JI projects, the corresponding emission reductions would not have taken place in the EU ETS. In part, however, the emission reduction measures

³⁹ Council of the European Union (2008): Report on the efficiency of economic instruments for energy and climate change. Brussels, 5 February 2008, 5850/08, ECOFIN 33, ENV 51. <http://register.consilium.europa.eu/pdf/en/08/st05/st05850.en08.pdf>

comprising the JI project could also be incentivised by the carbon price instituted by the EU allowance price. The extent to which this occurs will depend on the differential in the EU allowance price and the ERU price and the period over which that differential is (expected to be) maintained. This effect is not taken into account here. In the discussion process for the development of the methodology the argument was advanced that the impacts of CDM and JI should also be attributed to EU ETS, even if they take place elsewhere. In our view this is too far reaching. This view is supported by the fact that CDM may be used by countries that have no ETS. This clearly shows that the CDM is an instrument per se. The question would then be rather in how far the ETS by its presence enhances the uptake of CDM projects. Further discussion of the issue is certainly necessary.

In case further sectors and gases are added to the system (N₂O for some processes is already envisaged for some industrial processes), additional steps in the methodology may be needed, especially in terms of data sources and system boundaries (e.g. aviation or shipping).

When domestic offset projects become feasible within the scheme, additional steps in the methodology will be needed, adding the effects of domestic offset projects on emissions in non-ETS sectors to the estimated effect of the ETS Directive.

In terms of data, the quality of ex-post analyses of the EU ETS would be greatly enhanced if verified output data was available at installation level, similar to the emission data available in the verified emissions tables. Likewise, data quality could be improved, if data on installations covered by the EU ETS would be collected and displayed in a consistent way across Member States and would clearly allow identification of the types of installations (rather than conglomerates of various types of installations, as is often the case).

6.7 Next steps

The most important next steps are:

- The development of a European model to capture the short-term ETS-induced changes (dispatching) in the power sector;
- Develop further test applications of the econometric method developed for the industrial sector (for other years, for other Member States and for other sectors);
- Further analysis of the main uncertainties in the methodology (demand elasticities to characterise indirect effects and the cost pass-through behaviour of the energy sector and the industrial sector for the CO₂ signals).
- Further work on identifying pass through
- Further analytical work required to understand better the interaction between ETS and targeted policies for renewables and energy efficiency as well as CDM in order to settle on allocating possible impacts between those policies. At present there are still wide spreads in the allocation of impacts to either instrument.
- The outcome of the discussion process on the interlinkage of targeted policies with the ETS could be linked back to the Tier 1 and 2 approaches in the form of simplified correction factors.

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7 Case study: IPPC

7.1 Introduction

7.1.1 Overview of policy

Directive 2008/1/EC of the European Parliament and of the Council concerning integrated pollution prevention and control (hereinafter “IPPC”) codifies Council Directive 96/61/EC concerning integrated pollution prevention and control. The codified act includes all the previous amendments to the Directive 96/61/EC (for example concerning EU ETS) and introduces some linguistic changes and adaptations. However the substance of Directive 96/61/EC has not been changed.

Following the first IPPC review report the Commission adopted a Proposal for a Directive on industrial emissions. The Proposal recasts seven existing Directives⁴⁰ related to industrial emissions, including the IPPC Directive, into a single legislative instrument (COM(2007) 844 final).

7.1.2 Coverage and timescales

The IPPC Directive aims to prevent and control pollution arising from certain industrial activities⁴¹ including energy and mineral industries, production and processing of metals, chemical industries and waste management. The Directive sets out measures to prevent or reduce emissions into the air, water and land and defines the legal framework and environmental conditions for issuing permits to carry out the activities above-mentioned.

The Directive requires industrial installations concerned to obtain an environmental permit from the competent authorities in the member states. The permit should be based on 4 principals:

- Integrated approach – the permit must take into account the whole environmental performance of the plant including energy and waste efficiency
- Best Available Techniques (BAT) – operators are required to implement BAT to prevent and minimise impacts to the greatest extent possible. The Commission organises an exchange of information between experts from the member states, industry and environmental organisations to determine BAT.
- Flexibility – the Directive allows licensing authorities to take into account the technical characteristics of an installation, its geographical location and local environmental conditions when determining permit conditions.
- Public participation – the IPPC Directive ensures public participation in decision making by enabling access to permit applications, permits and results of monitoring of releases.

For all relevant pollutants, permits shall include Emission Limit Values (ELVs), based on BAT and not exceeding the ELVs of relevance set out in other community legislation.

Since 30th October 1999 new installations and existing installations subject to ‘substantial changes’ were required to meet IPPC requirements. Existing installations were required to be compliant by 30th

⁴⁰ Council Directive 78/176/EEC of 20 February 1978 on waste from the titanium dioxide industry, OJ L 54, 25.2.1978, p. 19

Council Directive 82/883/EEC of 3 December 1982 on procedures for the surveillance and monitoring of environments concerned by waste from the titanium dioxide industry, OJ L 378, 31.12.1982, p. 1

Council Directive 92/112/EEC of 15 December 1992 on procedures for harmonizing the programmes for the reduction and eventual elimination of pollution caused by waste from the titanium dioxide industry, OJ L 409, 31.12.1992, p. 11 (the last three being known collectively as: “TiO₂ Directives”).

Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (“IPPC Directive”), OJ L 257, 10.10.1996, p. 26, the subsequent amendments to the Directive are incorporated in the codified Directive 2008/1/EC.

Council Directive 1999/13/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations (“VOC Solvents Directive”), OJ L 85, 29.3.1999, p. 1

Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (“Waste Incineration Directive”), OJ L 332, 28.12.2000, p. 91

Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants (“LCP Directive”), OJ L 309, 27.11.2001, p. 1

⁴¹ The activities listed in Annex 1 of the Directive include energy activities, production and processing of ferrous metals, mineral industry, production of pulp from timber or other fibrous materials and, production of paper and board. Annex 1 details the specific activities and, capacity thresholds.

October 2007. It is estimated that about 52,000 installations are covered by the IPPC Directive across the EU-27 (European Commission, 2008).

Following an amendment of the IPPC Directive through the EU ETS Directive, a permit issued in compliance of the IPPC Directive shall not contain emission limit values for direct emissions of greenhouse gases if the IPPC installation is also covered by Annex 1 of the EU Emissions Trading Scheme Directive⁴². Given the first trading under the adoption of the EU ETS Directive in 2003 and the start of trading in 2005 it is difficult to distinguish between GHG emissions reduced as a result of IPPC and those achieved from 2005 as a result of the EU ETS. This issue is discussed further in Section 7.3.3

7.1.3 Reporting

Member States are required by the IPPC Directive to send the Commission every three years the available representative data on the limit values applied to specific category of activities covered by the Directive and, where appropriate, the BAT from which these values are derived. Member States also provide reports on the implementation of the Directive and its effectiveness based on a questionnaire prepared by the Commission for this purpose. This includes implementation of emission limit values for activities and legal instruments introduced by MS to implement the Directive. All reports submitted by MS are made available on the EEA's Central Data Repository and on the IRIS website (Industrial Emissions Reporting Information System)⁴³. Following submission of the MS reports, the Commission shall publish a Community report on implementation of the Directive.

At the same time, most IPPC installations are required to report annual total emissions of selected pollutants including the main greenhouse gases. Reporting was initially to the European Pollutant Emission Register (EPER)⁴⁴. EPER holds emission data for 2001 and 2004 and has been superseded by the European Pollutant Release and Transfer Register (EPRTTR). The EPRTTR implements the UNECE PRTR protocol in the European Community and will incorporate the EPER data for 2001 and 2004. The first reporting year for EPRTTR is 2007 (data provided in 2009) with subsequent reporting on an annual basis.

The EPER 2001 database contains data for about 9200 facilities in EU15 as well as Norway and Hungary. The 2004 database contains data for approximately 12000 facilities from EU25 and Norway. Compared to EPER, the EPRTTR extends the range of pollutants, the activities, releases to land, releases from diffuse sources and off-site transfers.

Development and dissemination of information on BAT is through information exchange and a consultative process organised by the European IPPC Bureau⁴⁵. The bureau produces and reviews BAT reference documents (BREF notes) to develop BAT for each IPPC activity.

7.2 Emissions trends and drivers

The ex-post impacts of the Directive on emissions of greenhouse gases can be defined in terms of the difference between the actual reported emissions and the emissions under the counter-factual scenario (i.e. the estimated level of emissions that would have arisen in the absence of the policy). This section describes the underlying trends in the actual reported emissions, and emission-causing activities. It is against this backdrop that the counter-factual scenario can be defined.

7.2.1 Impact upon greenhouse gas emissions

The IPPC Directive may affect GHG emissions through requirements to improve energy efficiency and measures taken to abate air emissions of polluting substances (e.g. sulphur dioxide, oxides of nitrogen, carbon monoxide), which may also influence GHG emissions. The IPPC Directive therefore has a potential influence on emissions from the following inventory sectors:

- 1A1. Fuel combustion by energy industries

⁴² As long as there is no local pollution effect associated with the GHG in question (carbon dioxide for the 2003 ETS Directive).

⁴³ <http://www.iris.eionet.europa.eu/>

⁴⁴ <http://cdr.eionet.europa.eu>

⁴⁵ <http://eippcb.jrc.es/>

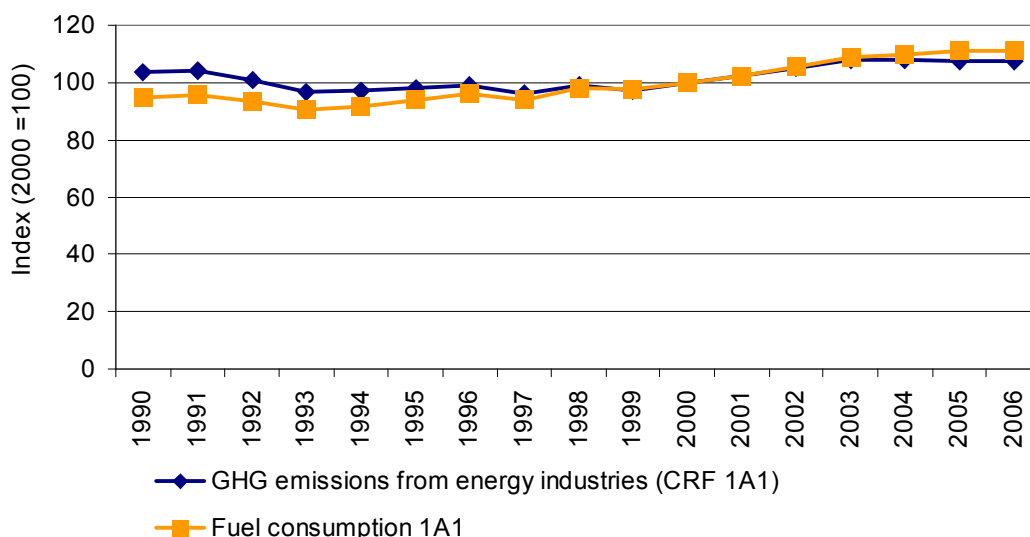
- 1A2. Fuel combustion by manufacturing industries and construction
- 2. Industrial processes

Activity and emission trends

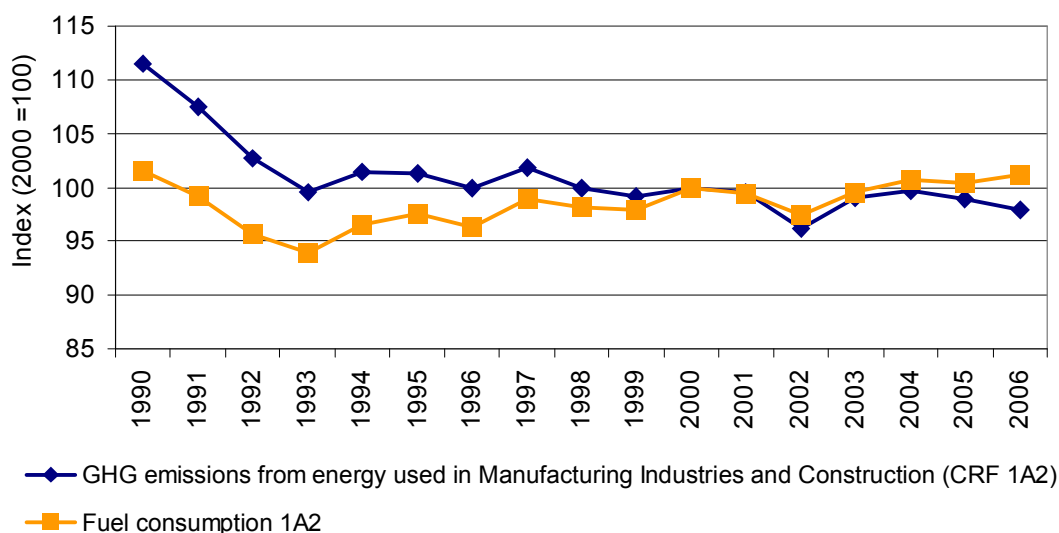
In the **energy industries**, total emissions have increased by about 4% since 1990 due to increased fuel consumption (see Figure 7-1). The trends in the fuel use and emissions indexes are not parallel and the increase in GHG emission since 1990 is less than the increase in fuel consumption indicating a reduction in carbon intensity in the fuel used. This arises because gas has displaced more carbon-intensive fuels such as coal and oil.

Furthermore, since 1990 substantial fossil fuel electricity generating capacity has been displaced by non-fossil generation and new gas-fired electricity generation capacity with higher efficiency has also been introduced (combined cycle gas turbines).

Figure 7-1 Greenhouse gas emissions and fuel consumption in energy sector, EU 15



The historical trends in GHG emissions and fuel consumption associated with **energy used in manufacturing industries** are shown in **Error! Reference source not found.** The trends are similar and, as with energy industries, a reduction in carbon intensity of the fuels used is apparent.

Figure 7-2: Greenhouse gas emissions and fuel consumption in energy used in manufacturing, EU 15

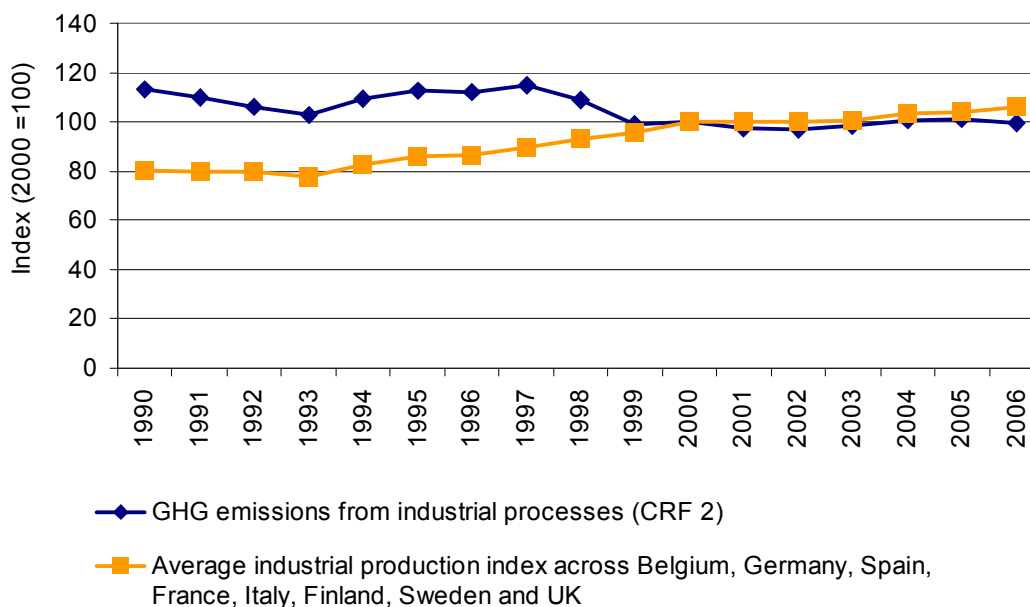
Whilst CO₂ emissions from fossil fuel combustion in manufacturing industries fell by 12 % between 1990 and 2006, industrial output from the sector increased (EEA, 2008). Whilst this can, in part, be explained by the reduction in carbon intensity of the fuel used - as described above - there are potentially other influencing factors. These may include:

- efficiency improvements
- structural change in Germany after reunification
- changes in the iron and steel production processes e.g. a 11% increase in share of steel production by electric arc furnaces instead of integrated steelworks

In addition wider use of cogeneration is also relevant.

Greenhouse gas emissions (non-energy related) from **industrial activity** accounted for 8 % of total EU-15 emissions of greenhouse gases in 2006 – that is 12 % below 1990 levels despite an increase in gross value added of about 30% in the sector between 1990 and 2006 (EEA, 2008). These emissions are mainly CO₂ emissions from cement production and from iron and steel production, N₂O emissions from nitric acid production, and HFC emissions from refrigeration and air conditioning equipment. Industrial process emissions stabilised between 2000 and 2006 and decreased for the first time since 2002 (-1 %) between 2005-6 (EEA, 2008).

The emissions trend includes reduced N₂O emissions from adipic acid production (mainly due to the retrofitting of installations with abatement technologies) but offset by increased N₂O emissions from nitric acid production due to increased activity in producer countries such as Netherlands and Germany and, increases in HFC emissions replacing banned chlorofluorocarbons (CFCs).

Figure 7-3 Greenhouse gas emissions and production index for industrial activities, EU 15

7.3 Impacts of the IPPC Directive on emissions of greenhouse gases

This section presents the initial estimates of the impacts of the IPPC Directive on emissions of greenhouse gases. The analysis has been performed in accordance with the tiered methodology that has been developed during this study, and is described in the accompanying evaluation guidance.

7.3.1 Overview of the methodologies

The **Tier 1** approach represents a high level assessment of the policy impacts. It is based upon existing EU wide statistics so that the methods can be easily repeated without additional data collection. It applies a number of simplifying assumptions to ease comparison between countries and policies, and consequently, may not adequately reflect the full complexity of the policy in question.

In contrast, the **Tier 3** approach involves a much more detailed assessment of the policy impacts, using a much higher resolution of data (which may require additional collection) and increasing complexity in the methods. As far as possible the Tier 3 approach aims to consider all of the main methodological issues, and isolate the impacts of the policy fully.

The **Tier 2** approach provides an intermediate level of analysis. It aims to address some of the most important methodological issues but it is still largely reliant upon existing established data sources. The extent to which the Tier 2 approach is able to isolate the policy impacts is therefore strongly reliant upon the availability and resolution of the data.

Within the scope of this current study it has only been possible to develop and implement a Tier 1 methodology for the IPPC Directive. However, some consideration has also been given to the issues that would need to be resolved as part of a more refined (Tier 3) approach. A comparison of the key methodological issues, and an illustration of the extent to which they may be addressed under each of the respective tiered approaches, is provided in the table below.

Table 7-1 Key methodological choices IPPC Directive

Approach	Tier 1	Tier 2*	Tier 3 *
Activity indicator	Industrial production index	Industrial production index	Installation or industry specific activity data.
Emission factor (g CO ₂ eq/unit of activity)	EU average	EU average	MS specific
Policy interaction (Policy overlaps with Large Combustion Plant Directive LCPD, Waste Incineration Directive WID, Landfill Directive, VOC, EU ETS.)	no	no	yes
Autonomous development (e.g. technological innovation)	no	yes	yes
Structural effects	no	no	yes (if data allows for corrections)
Geographic factors	no	no	no
Timing issues / delay or announcement effects	no	Consideration of MS implementation date and new vs existing installation effects.	
Source data	Eurostat/UNFCCC	Eurostat/UNFCCC	Installation or industry specific

* This study did not develop or apply a Tier 2 or Tier 3 methodology for IPPC.

Some important assumptions that underpin the Tier 1 analysis of the IPPC Directive are:

- The methodology uses GHG emissions inventory data and production activity data or indices to calculate changes in emissions intensity over time which may have been affected by the Directive.
- It is assumed that the Directive only affected the emissions intensity of production and did not influence the production volumes of the industry (activity level).
- In the absence of the Directive it is assumed that the emissions intensity is 'frozen' at the level in the year immediately prior to the implementation of the Directive.
- All changes in emissions intensity post implementation are attributed to the Directive i.e. the Directive is assumed to be the single driving influence on changes in the emissions intensity within the given sectors.
- The assumed year of implementation of the policy is 1999 for EU-15 Member States but varies for other MS depending on the year of accession to the EU: EU-12 MS (2004) and Romania/Bulgaria (2007).

It is important to note that the following corrections have **not** been possible within the current Tier 1 analysis, so the results provided below should be viewed with these limitations in mind:

- The aggregate statistics do not allow emissions and activities associated with installations covered IPPC to be isolated from non-IPPC installations and non IPPC activities.
- No adjustments have been made for the influence of other policies on the overall trend in emissions from the installations considered.
- No adjustments have been made for autonomous progress (i.e. the influence of on-going technological innovation on the trend in emissions)
- No adjustments have been made for structural changes in activity data (i.e. changes in production process, closure of facilities)
- No adjustments have been made for other exogenous factors such as energy prices.

Clearly, the Tier 1 analysis is an extremely simplified approach which significantly limits the accuracy of the overall results. In interpreting the results below some qualitative discussion is provided on the relative influence of the above factors, and therefore the accuracy of the Tier 1 results.

7.3.2 Quantitative results

Results from application of the Tier 1 methodology are presented in Table 7-2 below. Emissions savings are presented in CO₂ equivalents.

Table 7-2 Results from the application of the Tier 1 methodology

Group/MS	Period of impact	Cumulative savings (Mt)		Annual savings (Mt) in latest year	
		Industrial Processes	Energy	Industrial Processes	Energy
Austria	1999-2006	3	4	0	2
Czech Republic	2004-2006	-1	10	-1	5
Denmark	1999-2006	2	20	1	3
France	1999-2006	88	43	14	8
Germany	1999-2006	77	38	11	17
Italy	1999-2006	-27	32	-2	7
Netherlands	1999-2006	93	-2	14	1
Poland	2004-2006	-6	11	-3	7
Spain	1999-2006	12	50	2	18
UK	1999-2006	174	59	23	3

Error! Reference source not found. shows the total GHG savings indicated by the Tier 1 counterfactual as a percentage of the actual GHG emission over the period 1999-2006. The greatest improvements in emissions intensity relative to total emissions occurred in the Netherlands, the UK and France.

Table 7-3 Results from the application of the Tier 1 analysis, as a % of total emissions for the sectors concerned

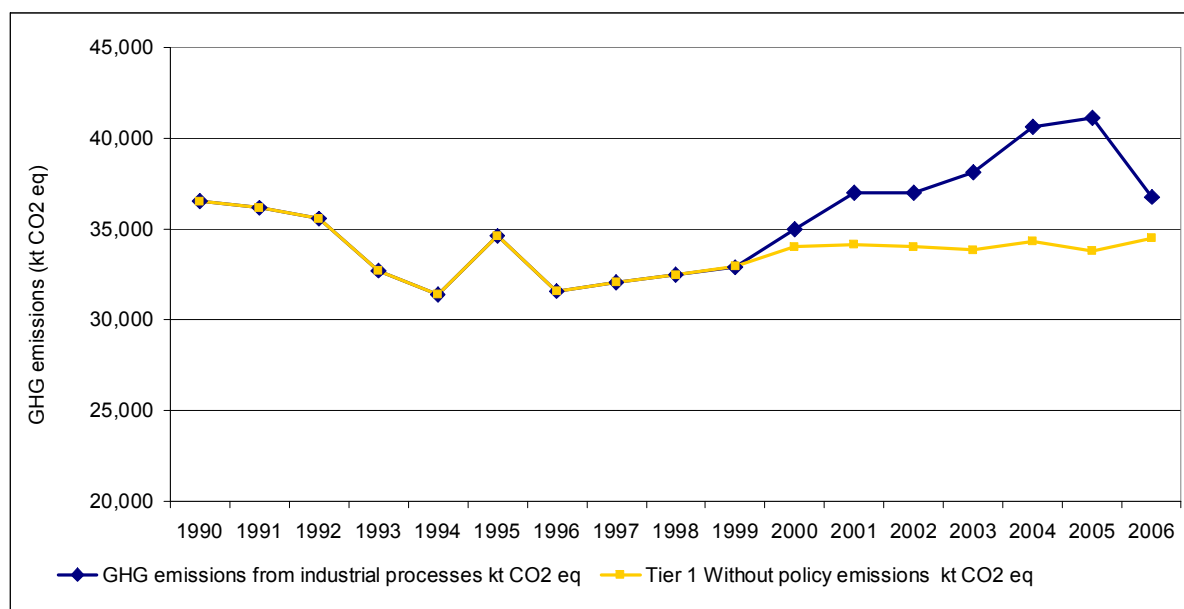
Group/MS	Period of impact	Estimated % emissions saved
Austria	1999-2006	2.1%
Czech Republic	2004-2006	3.0%
Denmark	1999-2006	7.4%
France	1999-2006	8.8%
Germany	1999-2006	2.5%
Italy	1999-2006	0.2%
Netherlands	1999-2006	10.2%
Poland	2004-2006	0.7%
Spain	1999-2006	3.7%
UK	1999-2006	9.0%
EU-15	1999-2006	4.9%
EU-27	1999-2006	3.9%

In aggregate terms the results for both the EU-15 and EU-27 show a reduction in emissions i.e. an emissions saving. However, there is a large variation in the estimates between Member States

For certain Member States the results suggest a 'negative saving'. This is the case where a country's emissions intensity has increased since implementation of the Directive, for example, as was the case of emissions from industrial processes in Italy (Figure 7-4).

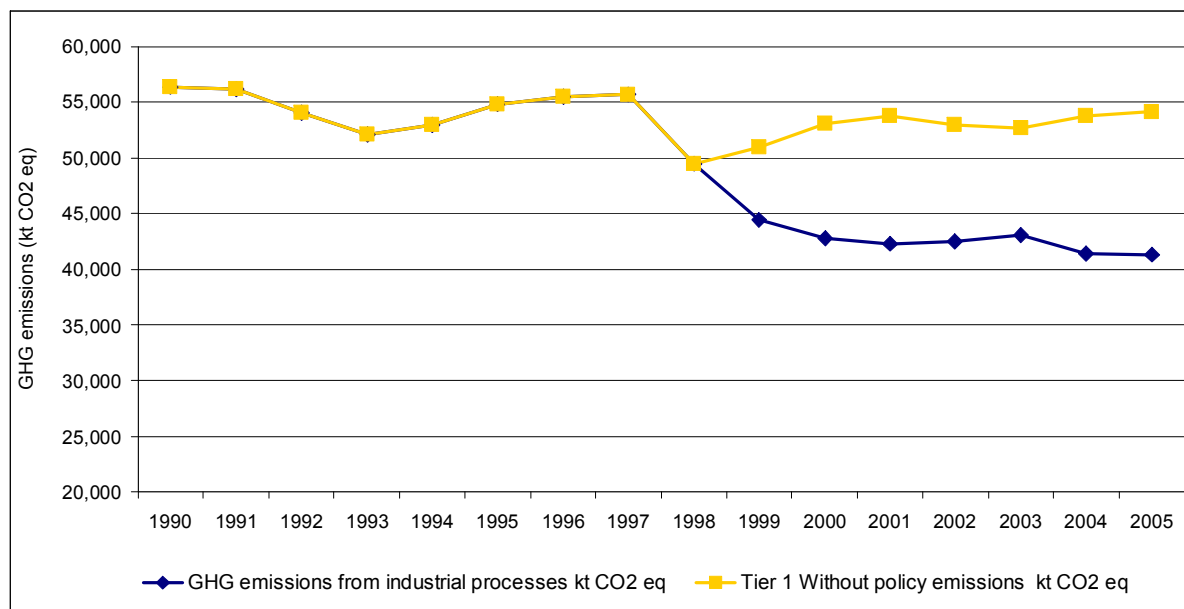
Italy's industrial process emission intensity was at its lowest (over the 1990-2006 period analysed) in 1999 and 1998 i.e. the year at which the Tier 1 methodology freezes the counterfactual emissions intensity. As a result, the increase in the process emissions intensity after 1999 results in an apparent 'negative saving' under the Tier 1 approach. This would imply that IPPC has caused an overall increase in emission. This is illustrated in Figure 7-4.

Figure 7-4 Application of the Tier 1 methodology, Italy



A contrasting result is found when the Tier 1 methodology is applied to France (see **Error! Reference source not found.**). In this example, the Tier 1 analysis suggests that the Directive has delivered a reduction in GHG emissions and a large policy impact.

Figure 7-5 Application of the Tier 1 methodology, France



Theoretically, if the implementation of IPPC did reduce GHG emissions from the installations, and the Directive was the single driver of changes in emissions intensity in the sector, then the Tier 1 without-policy emissions would be expected to be higher than the actual emissions. This is the result from the application of the Tier 1 methodology to France. However, the result for Italy suggest that this is not always the case.

One of the key assumptions that underpins the Tier 1 methodology is that the emissions intensity would be 'frozen' at pre-Directive levels. This is a major simplification. The variability of the emission intensity in both Italy and France in the years prior to the implementation of the Directive suggests that other factors have an important influence on this trend. These factors are discussed further below.

Therefore, on balance, taking into account the complexity of the sectors and the simplicity of the approach we suggest that **the results presented above should be treated with caution**. Whilst the

results are useful in showing the values that are achieved by implementing the Tier 1 approach, as it currently stands, **we do not consider the results sufficiently robust to recommend the use of a Tier 1 approach to quantify the impacts of the IPPC Directive.**

The Tier 1 results do provide an indication of the overall magnitude of the potential policy savings, but the results derived are likely to overestimate the true impacts of the policy. Further analysis, is required to isolate the policy impacts further, and identify the level of influence of the other influencing factors – and the overall level of accuracy of the results derived from a Tier 1 approach.

7.3.3 Influence of key parameters

As described above there are a range of factors that are not adequately isolated using a simplified 'top down' Tier 1 methodology. The importance of these factors will vary from one policy to the next. Some discussion of these issues for the IPPC Directive is provided below.

Activity indicator

The **Tier 1** approach makes use of sector wide emissions inventory data. This data does not match perfectly those installations that are covered by the IPPC Directive, including emissions from installations not covered in the scope of the IPPC Directive or under the threshold capacity or exempt due to EU ETS requirements. In addition, the Tier 1 approach uses Industrial production index data alongside emissions data to determine emissions intensity improvements. This data is available for only Belgium, Germany, Spain, France, Italy, Sweden and UK for the full time series 1990-2006, other countries report only for recent years. Furthermore, Industry Production Index annual data, taken from Eurostat, does not adequately reflect industrial activity in each sub-sector.

Ideally, the analysis would be carried out for just those installations that were covered by the Directive. This would require annual GHG emissions and production data for individual installations covered by IPPC. Some data on annual GHG emissions is available from the EPER (European Pollutant Emission Register, soon to be replaced by E-PRTR - European Pollutant Release and Transfer Register) database, which may, in the future, be used for such analyses. However there will be limitations. EPER data is available for 2001 and 2004 and E-PRTR data will be available for 2007, but only for installations where both capacity threshold *and* thresholds for each pollutant indicated in the E-PRTR Regulation (annex 1 and 2) are exceeded. This means that data may not be complete or comparable across years. In addition, some activities not covered by the IPPC Directive are covered by the E-PRTR Regulation ("new activities"), Nonetheless, annual reporting should cover around 30% of the larger IPPC emitters. In order to isolate the installations covered by the EU ETS, the Community Independent Transaction Log (CITL) verified emissions data for installations may be subtracted from total emissions. However, emissions from installations covered by neither EU ETS nor IPPC (falling below the threshold for inclusion in IPPC) would remain included.

Even with improved data on emissions from the installations, there is still a major data gap with respect to the data available on production or output from the installations. Since the Tier 1 methodology is based upon the change in emissions intensity then improved data on emissions is limited use if the data on production or output is still weak.

An alternative approach would be to utilise bottom up data on individual installations though this would very much comprise a **Tier 3** approach. In considering the effect of IPPC on individual installations, the Best Available Techniques (BAT) reference documents (BREFs) will be a useful source of information on the range of techniques that are considered as BAT and the cross media effects of such techniques including impacts on energy efficiency and CO₂ emissions. Where BREFs contain BAT Associated Emission Levels (BAT-AELs), the full range of AELs constitutes BAT. The Commission's Proposal for a Directive on industrial emissions provides a clear link between changes in BAT and the updating and reconsideration of permit conditions. Where a BREF is updated then the competent authority should reconsider and, if necessary, update the permit conditions for the installation concerned within four years of the publication of the new BREF to take into account changes in BAT. Given the present timing of updating of BREFs this would be expected to take place roughly every 8 years. However, competent authorities may take into account the local environment, geographical location and technical characteristics of the installation concerned when setting actual emission limit values and in making associated changes to the techniques employed by that

installation. Many of the BREFs reflect differences between new and existing installations, recognising that different emission reductions may be achievable depending on the age of the installation concerned.

However, as described in the box below even where bottom up data is available on the individual measures installed further research is required on the potential impacts of these measures on GHG emissions.

Bottom up analysis - technology level impacts

IPPC abatement technologies, in line with BAT reference guidance, address non-GHG emissions. Further research is required to determine the effect of these individual technologies on GHG emissions. In some cases, abatement technologies will increase GHG emissions through loss in energy efficiency of the process. However, this effect is thought to be very minor as supported by Larsson and Telle's (2005) review of the impact of BAT on GHG emissions is positive (see Table 14).

Table 7-4 Consequences of the IPPC Directive's BAT requirements for abatement costs and emissions

Table 3: Average emission reductions if all plants were technically or environmentally efficient. Figures are weighted with emissions. Percent

		All industries	Paper and Pulp	Inorganic Chemistry	Ferro Alloy	Primary Aluminum
Technical efficiency	Greenhouse gases	11	12	12	20	2
	Acids	16	6	11	25	1
Environmental efficiency	Greenhouse gases	36	37	42	64	10
	Acids	54	20	39	83	5

Source: Larsson and Telle (2005)

Policy implementation

Another key factor that needs to be taken into account in assessing the impacts is the influence of differences in policy implementation between Member States. In the **Tier 1** analysis it is implicitly assumed that the Directive is implemented in a consistent manner⁴⁶ in all member states. However, this is not necessarily the case.

In November 2005, the Commission adopted its first IPPC report⁴⁷, under Article 17 (3)⁴⁸, which included an IPPC Implementation Action Plan that aimed to help MS and monitor progress in meeting the October 2007 implementation deadline. The report acknowledged considerable delays in the implementation of the Directive. In particular, the report indicated that the majority of IPPC permits were issued towards the end of the period of IPPC implementation (between 2004 and October 2007). This suggests that the potential impacts of IPPC on emissions of GHG will not be realised until recently, and will only be reflected in the most recent statistics.

The report also commented on the considerable diversity in the approaches to implementation of the Directive throughout the EU. The diversity of implementation arises because some Member States have chosen to adapt existing national industrial pollution control regimes with varying degrees of compliance with IPPC; other Member States have had to introduce entirely new regulations. The diversity of progress and approaches at the MS level poses an obstacle to successful evaluation of the Directive's impact.

⁴⁶ although an adjustment is made for accession date of the 'new' member states

⁴⁷ http://ec.europa.eu/environment/air/pollutants/stationary/ippc/ippc_report.htm

⁴⁸ article 16(3) under Directive 96/61/EC

A more refined evaluation methodology would draw upon any available data on the implementation history of Member State permitting including, in particular, dates and phasing of implementation. In addition, any information on the stringency of conditions imposed in permits and the response of installations should be captured within the approach.

Autonomous development (technological innovation)

The **Tier 1** approach does not account for any autonomous technological innovation; it assumes all improvements in emissions intensity arise as a result the Directive. A more refined (i.e. **Tier 3**) approach, would attempt to address this in a more robust way.

However, the role of technological change and innovation is especially complex. There is a tension between the role of policy in incentivising research and development (and therefore improving technology) and the ‘natural’ (though irregular) progress of innovation on purely technical grounds. Distinguishing between, and measuring, these trajectories is extremely complex, but important for accurately evaluating the direct effect of PAMs on GHG emissions.

For certain policies that act upon specific technologies (e.g. appliances) it may be possible to extrapolate historical pre-policy trends in order to estimate the influence of autonomous technological improvements. However, for a policy such as IPPC which will influence a range of different technologies, across a range of sectors, this approach is less appropriate.

Policy interaction

Several national and EU policies interact closely with IPPC by addressing similar emission sources. This makes an evaluation of IPPC in isolation difficult. The **Tier 1** approach does not isolate any of these policies overlaps so the total impacts include the influence of these other policy drivers.

Large combustion Plant Directive

The revised LCP Directive (2001/80/EC) was published on 27th November 2001 and repealed the earlier Directive 88/609/EEC (as amended by Directive 94/66/EC). The revised LCP Directive tightened the Community requirements for air pollution control from new large combustion plants. In addition, new minimum emission limits for SO₂, NO_x and dust from ‘existing’ plants⁴⁹ were established and needed to be complied with⁵⁰ by 1/1/2008.

While LCPD sets emission limit values for SO₂, NO_x and dust from large combustion plant, reduction of CO₂ emissions and use of CHP to improve efficiency in fuel use is only mentioned in the introduction to the Directive. There are no direct references to carbon dioxide or greenhouse gases in the articles of the Directive. Efficiency is relevant to LCPD emission limit values for some gas turbines (less stringent emission limit values are applied for a gas turbine in a plant with a high overall efficiency).

The main greenhouse gas impact of the LCPD is through changes in efficiency of combustion plant. This may arise from additional abatement measures required to meet Emission Limit Values (ELVs), generally an efficiency penalty arising from a need to process exhaust gases, or, indirect improvement through replacement of plant with more efficient plant more capable of meeting LCPD emission limit values. However, other factors (not least fuel and technology costs and, efficiency) are very important when operators are considering replacement of an LCP. Energy efficiency gains under LCPD are hard to differentiate from those resulting from other EU regulation influencing the efficiency of combustion, such as the Directives on Combined Heat and Power, taxation, and commercial factors.

A more detailed (**Tier 3**) analysis would ideally calculate GHG savings achieved specifically by the LCPD. In doing so it would be especially important to consider trends in emission prior to the Directive’s implementation. The counterfactual will be heavily influenced by assumptions relating to fuel. The throughput of fuel, the fuel-type and fuel-mix used, market fuel prices and the efficiency of previous and available technologies are factors that have influenced emission levels in the absence of the Directive. Emission and fuel consumption data for LCP installations is made available to the Commission during LCPD triennial reporting and could be used for a **Tier 3** assessment of LCPD.

⁴⁹ Plants licensed before 1 July 1987

⁵⁰ Alternatively existing plant could choose to opt out which enabled them to continue operation for no more than 20,000 hours until 2015.

Waste incineration Directive (2000/76/EC)

The Waste Incineration Directive has applied to existing plants since December 2005 and to new plants since December 2002. This Directive has replaced Directives (89/369/EEC) and (89/429/EEC) on municipal waste incineration and (94/67/EC) on the incineration of hazardous waste. Many of the plants governed by the WID are also subject to IPPC controls (either as waste incineration activities or as energy, mineral or other activities co-incinerating waste). Distinguishing between the relative effects of each Directive at these plants is difficult, although it is important to note that the waste incineration Directive does not directly regulate emissions of GHG. Consequently the direct impacts of the Directive on GHG emissions are considered to be limited.

EU ETS

For IPPC installations that are also covered by the EU ETS, there is no requirement that CO₂ emission limit values be set in the IPPC permit. However, it is left to the Member States as to whether IPPC measures relating to energy efficiency are included for EU ETS participants.

Emission data from EU ETS installations cannot easily be removed from IPPC installation emissions data to reveal IPPC relevant emission trends. The **Tier 1** calculations presented in this report make use of sector wide emissions data which therefore includes both IPPC and non-IPPC installation emissions. A more refined analysis would be required to identify GHG emissions specifically related to IPPC installations.

Cogeneration Directive

All Member States have implemented the Directive into national legislation. However, at the time of writing, the Directive is not fully operational at Member State level⁵¹. Consequently, the CHP Directive is unlikely to lead to a direct impact (over and above national CHP policies) until at least 2009. However, in the future isolation of the impacts of the CHP Directive will be more important

National Policies

Entec (2007) found that approximately half of Member States had an integrated permitting procedure in place before the implementation of the IPPC Directive. Most of this legislation required integrated permits and at least partially satisfied the requirements of IPPC. However, some Member States' legislation did not cover all aspects such as BAT, cross media effects, energy use, odour and noise control. Those Member States with an integrated permitting procedure pre-IPPC include Austria, Belgium, Denmark, France, Germany, Hungary, Ireland, Luxembourg, the Netherlands, Sweden and the UK.

Additionally, there is diversity in transposition of the IPPC Directive into national legislation. For example, Member States can choose to allow case-by-case permitting or use of General Binding Rules covering whole industry sectors. It is therefore difficult to separate the effect of IPPC from pre-existing legislation and the **Tier 1** analysis assesses the combined effect of national and EU level policies.

A **Tier 3** analysis may be used to provide a more detailed review of policy developments in each Member State but disaggregation of the impacts of PAMs and other factors would require detailed knowledge of sectors, national measures and very much more data for sector analysis at, potentially, an installation-specific level.

Summary

The emissions data used in the **Tier 1** analysis include the effect of the LCPD, EU ETS, and a number of other policies and measures – at the EU and national level. Using more detailed installation level data disaggregated at source level, as outlined above, and reviewing MS implementation of each policy in detail would go some way to removing these overlaps. However, where this is not possible it may be necessary to evaluate the policies as a package.

In addition, it is important that any future policy evaluations recognize possible interactions between policies aimed at reducing GHG and those aimed at reducing other air pollutants since action taken to reduce one set of pollutants may have impacts on the other. Such links were considered in the Commission's modelling work underpinning its Proposal for a Directive on industrial emissions

⁵¹ See separate report chapter on the CHP Directive for more details.

(COM(2007) 844 final). It is important to ensure the continuation of this approach so that policies are not considered in isolation and the environmental integrity of policies is upheld.

Other exogenous factors

Some parameters such as the percentage changes in material and energy throughput in IPPC-controlled installations, fuel prices and technology changes will also have affected GHG trends since the Directive was implemented. These factors are not currently examined as part of the **Tier 1** approach, but are potentially very important on the overall level of emissions. Isolation of these factors would require a much more extensive approach, and the collection of large amounts of additional data. This is only possible as part of a Tier 3 analysis.

7.4 Comparison of results from the different methods

7.4.1 Ex-ante estimate on impacts of IPPC

A study performed for DG Environment on 'Energy Management and Optimisation in Industry', identified cost-effective savings of up to 60-70Mt CO₂eq/year for all manufacturing installations covered by IPPC, not including implementation of CHP⁵²

At a national level three MS have reported a projected saving associated with the IPPC Directive in the ECCP Database⁵³. However, estimates have been produced by only one of the Member States chosen for application of the methodology developed under this project – the Netherlands. The results from the application of the Tier 1 methodology in this study are much larger than the Netherlands' estimate (3.6 Mt reduction in 2010 from the policy "Low N₂O nitric acid production"). However, the Netherlands estimate relates to just the impacts on nitric acid production while the results from this project relate to the entire industrial process sector.

7.4.2 Comparison with ex-ante results

The second ECCP progress report (EU, 2002) identified potential savings from IPPC in two areas:

- **IPPC & non-CO₂ gases** - better control on non-CO₂ emissions in industrial sectors, under the IPPC Directive will be promoted through a periodic update of the BREFs and through the monitoring of Member States' implementation of the Directive.
- **IPPC: horizontal BREF on energy efficiency**

No final conclusions were drawn on the potential savings from these two activities. However, reference was made to DG Environment study on energy management described above

In the table below the estimated ex-ante savings from the DG Environment Study are compared with the ex-post results from this study. Overall, the results from the application of the Tier 1 methodology are more than double the results from the ex-ante appraisal. This is not surprising since the simplified Tier 1 methodology attributes all changes in emission to IPPC and does not isolate policy overlaps or other drivers.

Table 7-5 Comparison of ex-ante and ex-post results: IPPC

Mt CO ₂ eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
Integrated pollution prevention and control (Dir	60-70	176 (EU27, 2006) 156 (EU15, 2006)	NE	NE

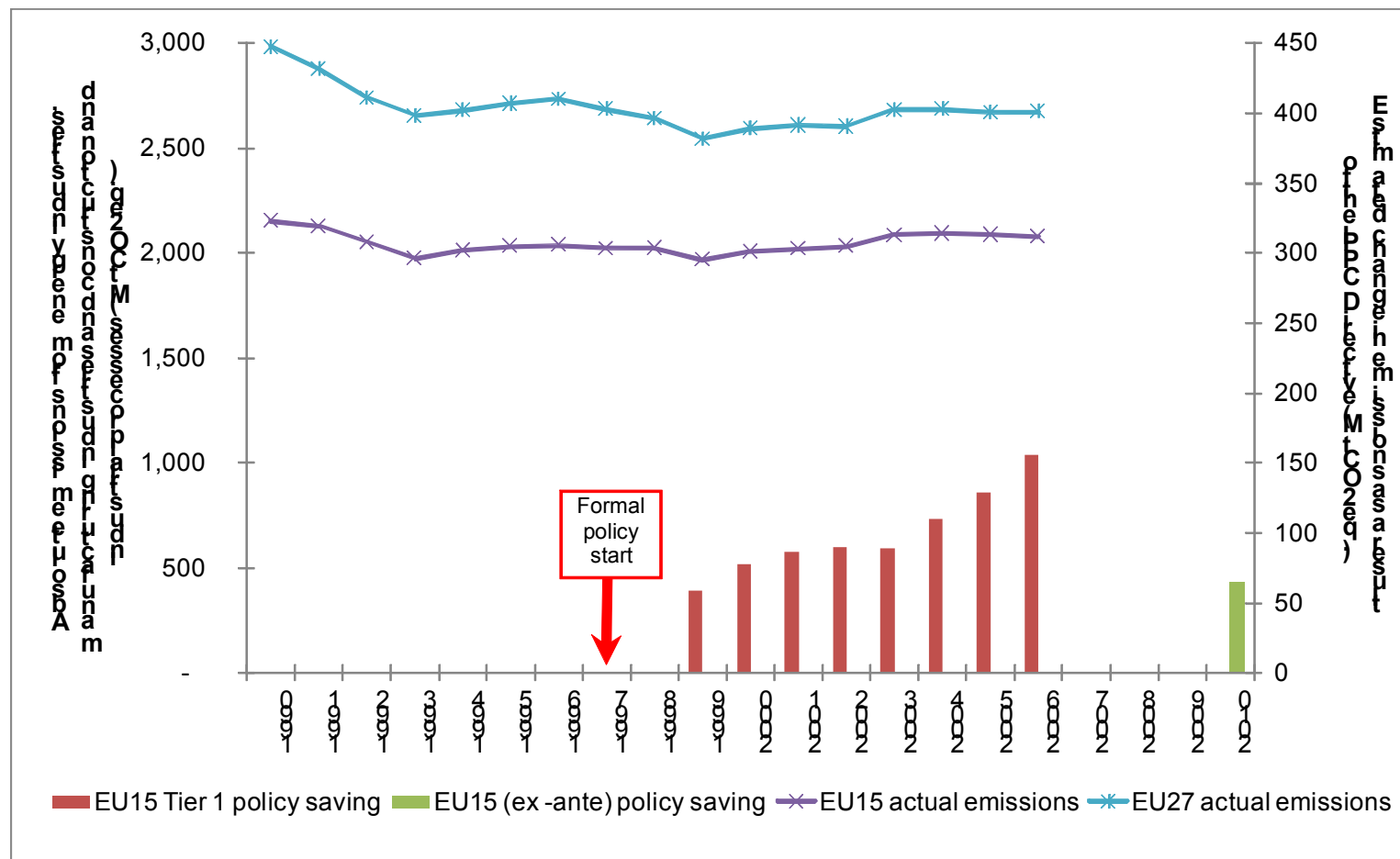
⁵² Source: Second ECCP progress report April 2003, http://www.climnet.org/pubs/second_eccp_report.pdf

⁵³ ECCP Policies and Measures database (October 2008)

96/61/EC)				
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations:				
MSsp: Member State specific starting year for the ex-post evaluation				
NE = not estimated				

The estimated impacts of the policy are put into context in below. The estimated (ex ante, and ex post) impacts are compared against the overall historical trend in emissions from energy industries, manufacturing and construction. This shows the relative influence of the scheme, as estimated in this study, on the overall trend in emissions.

Figure 7-6: IPPC Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development



Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. See **Error! Reference source not found.** for further details. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above.

Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2007 GHG inventory (EEA, 2008).

7.5 Conclusions

The development and testing of a Tier 1 methodology for IPPC has proved to be challenging. The results have highlighted several methodological difficulties which require more in-depth analyses at Member State, sector and installation level to resolve. Further data collection would be required to enable such analyses.

The Tier 1 methodology that has been developed identifies, and can help to explain, the trends in emission intensity in the sectors concerned. However, application of the methodology has highlighted limitations of using such an aggregated top-down method to assess the impact of the IPPC Directive.

Therefore, on balance, taking into account the complexity of the sectors and the simplicity of the approach **we do not consider the results sufficiently robust to recommend the use of a Tier 1 approach to quantify the impacts of the IPPC Directive.** A more sophisticated, Tier 3, methodology would need to be developed in order to move towards a more accurate estimate the policy impact.

A Tier 3 approach will require new data to be collected, and existing data to be analysed in much greater detail. Consideration should be given to the usefulness of collecting detailed data sets for the purposes of evaluating the GHG impact of IPPC given that the policy is not directly aimed at reducing GHG emissions and since other policies such as EU ETS are directly addressing GHG emissions from similar groups of installations. In addition, even if industry level GHG emission and activity data were to become available in future, methodological issues (such as overlaps with pre-IPPC permitting policies and uncertainty over which factors – commercial or policy – drive emissions) would likely remain, meaning that a policy impact assessment may still be unsatisfactory.

7.6 References

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8 Case study: F-Gas Regulation

8.1 Emission trends and drivers

Regulation (EC) No 842/2006 of the European Parliament and of the Council on certain fluorinated greenhouse gases (the F-Gas Regulation) aims at reducing emissions of the fluorinated greenhouse gases covered by the Kyoto Protocol (Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) Sulphur hexafluoride (SF₆)).

8.1.1 Impact upon greenhouse gasses

The regulation aims at reducing F-gas emissions by addressing the

- (1) containment, use, recovery and destruction of those gases,
- (2) labelling and disposal of products and equipment containing F-gases,
- (3) reporting of information on those gases,
- (4) control of use,
- (5) the placing on the market prohibitions of some products and equipment,
- (6) training and certification of maintenance-personnel and companies handling F-gases.

Moreover the regulation introduces the prohibitions to commercialize on some products and equipment.

The containment and recovery articles in the Regulation will mainly have an impact on the stationary refrigeration, air-conditioning and heat pump sectors and in the fire protection sector. The Regulation also affects the personnel involved in the installation, servicing and recovery of F-gases from these systems as well as from equipment containing fluorinated greenhouse gas based solvents, high voltage switchgear, fire extinguishers and mobile air-conditioning.. For operators of relevant systems the Regulation introduces a range of obligations including prompt leakage repair, leakage checking and record keeping and ensuring that appropriately qualified and certified personnel is employed.

Reporting obligations

The Regulation obliges operators in particular sectors (refrigeration, air-conditioning, heat pumps and fire protection systems) to maintain records indicating quantity and type of product in use, quantities added when necessary, and quantities recovered during servicing, maintenance and final disposal.

In particular, producers, exporters and importers of F-gases are required to submit formatted data to the Commission on an annual basis, copying their submissions to the responsible authority in their MS. The first round of these reports was due by 31st March 2008, while following reports are due every year thereafter.

Status of implementation

The Regulation entered into force on the 4 July 2006 and applied as of 4 July 2007, with the exception of the marketing prohibitions which applied from 4 July 2006. The Regulation includes prohibitions for various products and equipment, which vary by date, as indicated in the Regulation and its Annex. Table 1 shows the different use bans according to Article 9 of the Regulation.

Table 8-1 Placing on the market prohibitions in accordance with Article 9**Overlaps with other Directives**

There is no overlap between this regulation and other EU climate policy directives. However Regulation (EC) No 2037/2000 on substances that deplete the ozone layer has a certain impact on the use of fluorinated greenhouse gases, as many of the F-Gases used are substitutes for ozone depleting substances.

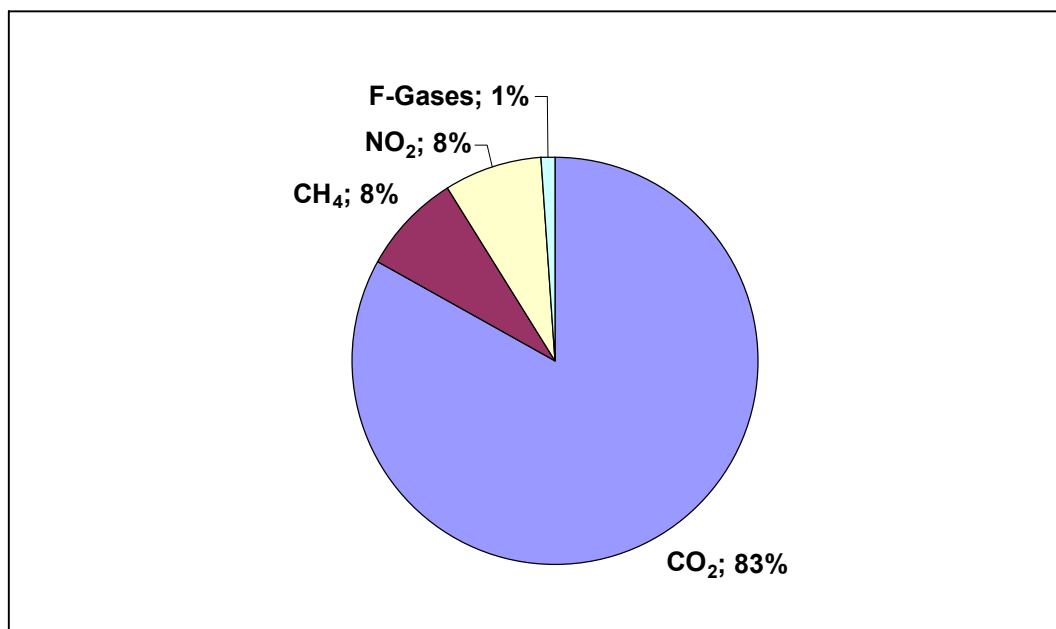
Before the introduction of the Regulation some Member States had already introduced national policies to stimulate the reduction of F-gases (i.e. policy to restrict the use of F-gas in certain applications, policy instruments to address containment including taxation of fluids). Table 2 shows the different national policies that are in place.

Table 8-2 Other National policies in place

Country	Type of policy	In place since:
Austria	Restrictions on the use of F-gases (<i>Industriegas-V, BGBl. II Nr. 447/2002</i>)	1 July 2003
Denmark	GWP weighted taxation for CO ₂ emissions from refrigerants containing HFCs	1 March 2001
Denmark	HFC use ban for the refrigeration sector with refrigerant charges above 10 kg	1 January 2007

8.1.2 Activity and emission trends

Figure 8-1 shows the share of greenhouse gas emissions in the EU-27 in 2006. As highlighted in the graph, F-Gases contribute to a small extend to overall European greenhouse gas emissions (approx. 1 %).

Figure 8-1 Share of GHG emissions by gas in the EU-27 in 2006 [EEA, 2008]

Due to the high Global Warming Potential (GWP) of F-gases, even small emissions reductions can lead to a relatively high emission reduction in terms of CO₂ equivalent. Therefore abatement costs for measures that reduce F-Gas emissions tend to be comparatively low, per ton of CO₂ emission avoided.

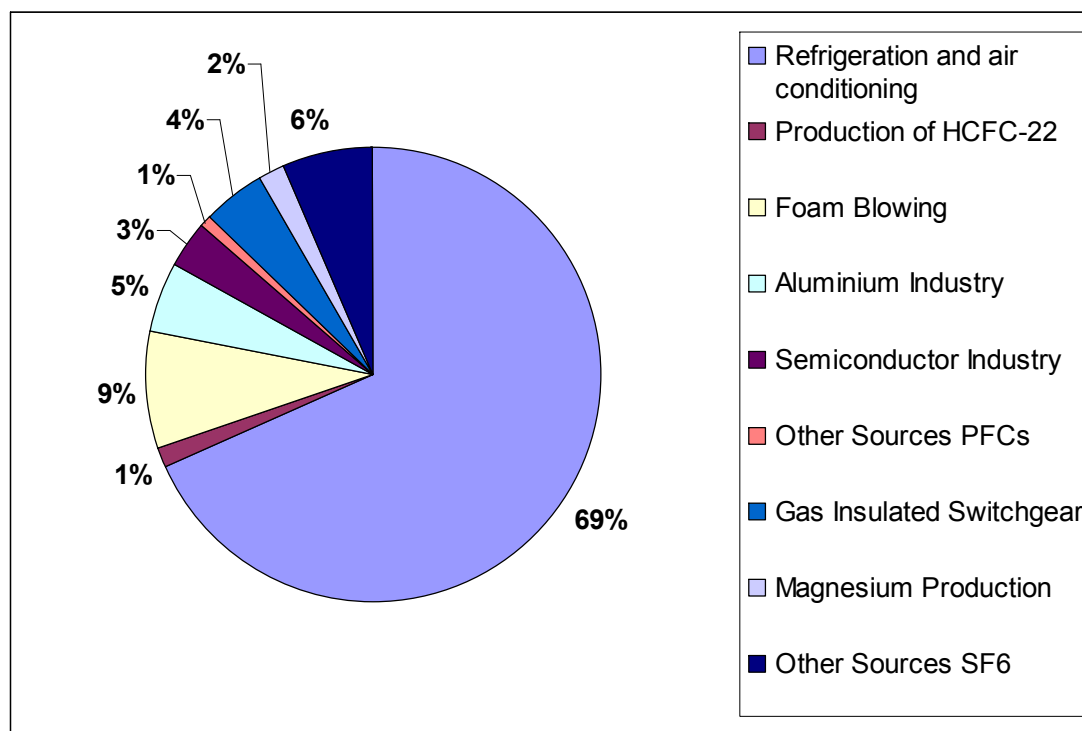
It is estimated that in absence of the F-Gas Regulation the use and emissions of F-Gases would increase in the future, as economic growth typically leads to an increasing use of equipment that uses F-gasses. Moreover, as F-gasses are potential HCFCs substitutes, a further increase would be stimulated by the phasing out of HCFCs, mandated by Regulation (EC) No 2037/2000 on substances that deplete the ozone layer.

The Refrigeration and Air conditioning sector can be seen as a key category for most of the countries. It accounts to approximately 65 % of the total F-Gas emissions of the EU-27 (see

Figure 8-2). However this is a very heterogeneous sector as it consists of several different subsectors such as domestic refrigeration, commercial refrigeration, transport refrigeration, industrial refrigeration, stationary and mobile air conditioning. Therefore an assessment of this sector especially in terms of the impact of the Regulation with a simple top-down approach is rather not possible (see chapter 1.3.3).

Other relevant emission sources are the aluminium industry, emissions from foam blowing and emissions from the use of gas insulated switchgear (see

Figure 8-2).

Figure 8-2 Share of F-Gas Emissions by source in the EU-27 in 2005 [own calculations based on national Inventory data for 2005]

8.2 Impacts of the directive on emission of GHG

8.2.1 Overview of methodologies

A Tier 1 approach relies upon the availability of basic aggregated activity data at the sector level, such as annual chemical consumption data, used in combination with emission factors (emission-factor approach) or data on equipment sales (mass-balance approach). Main data source are the national inventory submissions to the UNFCCC.

The tier 1 approach is based on the assumptions that basic aggregated activity data and respective emission factors are available and allow for the quantification of F-gas emissions over time. For simplicity reasons and due to lack of sufficient data, a tier 1 approach is also based on a counterfactual scenario in which: (1) activity data are not affected by the regulation and in which (2) per activity, leakage rates of F-gasses would remain constant in absence of the regulation. Based on these assumptions the central calculation algorithm for F gasses is the following:

$$PI_{i,t} = \sum_{j=1}^n A_{j,t} * GWP_j * \Delta F_{j,i,t}$$

- $PI_{i,t}$: policy impact of F-Gas policies (ktonnes of CO₂-eq) in year t compared to the year F-Gas policies were introduced (i)
- $A_{j,t}$ activity data pertaining gas j in future year t
- $\Delta F_{j,i,t}$ changes in the emission factor (leakage rate) for gas j, associated to activity A in year t compared to the base year (i)
- GWP_j – Global Warming Potential of gas j
- Starting year is 2006 when the Regulation was implemented

A calculation algorithm similar to the one described above is also central for tier 2. However, rather than using sector level data, tier 2 makes use of activity data at the level of equipment or product type (sub-application). Moreover tier 2 assumes that activity data change over time in conjunction with GDP changes.

Although able to provide an indication of the changes occurring to target variable, tier 1 and 2 are limited in the extent to which they describe the mechanisms by which policy is affecting emissions in F gasses and to evaluate the impact of policy in such changes.

Due to the heterogeneity of sub-applications and to the different market and technological dynamics taking place with different sub-applications, a more detailed Tier 3 approach would be most suitable at determining the impact of the F-gas regulation for the EU-27. A Tier 3 approach would define typical activity data and equipment lifetime per sub-application. Emissions would be calculated by applying specific emission factors per sub-application during operation, at servicing and at end-of-life. Tier 3 would also consider the potential interaction with the Montreal Protocol.

Tier 3 requires more data inputs than Tier 1 and 2 and thus requires a more sophisticated data collection process. To assemble all relevant input data the Tier 3 approach requires therefore a close cooperation between policy makers, industry and relevant associations. Table 3 summarizes the main methodological choices for the evaluation of the F-gas Regulation.

Table 8-3 The tiered methodology

Methodology	Tier 1	Tier 2	Tier 3
Activity indicator	Where available: Aggregated activity data in National Inventory Submissions to UNFCCC Annual chemical consumption data and stock data (banks) derived from annual consumption data	Where available: Disaggregated Inventory consumption and stock data on sub-application level.	Detailed consumption and stock data disaggregated on each sub-application reported to the MS.
Emission factor	Emission factors (e.g. leakage rate) from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.	Emission factors (e.g. leakage rate) from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.	Country specific emission factors per sub application.
Autonomous development	Current formula assumes activity data are not affected by the regulation and that per activity, leakage rates of F-gasses would remain constant in absence of the regulation	In absence of the F-Gas regulation activity data would increase proportionate to GDP growth of the member states. Leakage rates are assumed to remain constant.	In absence of the Regulation Activity data would increase. Main drivers are GDP growth and the phase out of ozone depleting substances due to Regulation (EC) No 2037/2000
Timing Issue	A policy delay of at least 2 years is assumed for all member states.	A policy delay of 2 years for EU-15 member states is assumed and a delay of at least 5 years for new member states.	A policy delay of 2 years for EU-15 member states is assumed and a delay of at least 5 years for new member states.
Reference values	GWP factors from IPCC 2006	GWP factors from IPCC 2006	GWP factors from IPCC 2006
Uncertainties	Main uncertainty in the tier 1 approach arises from the heterogeneity of the affected sectors. Generally, disaggregated methods (Tier 2/Tier 3) have less uncertainty than Tier 1 methods because of the heterogeneous nature of the sub-applications. Uncertainties are also related to restricted availability of activity data and emissions factors on application level	Uncertainties are related to restricted availability of activity data and emissions factors on application level	Uncertainties are related to restricted availability of activity data and emissions factors on application level

8.3 Results

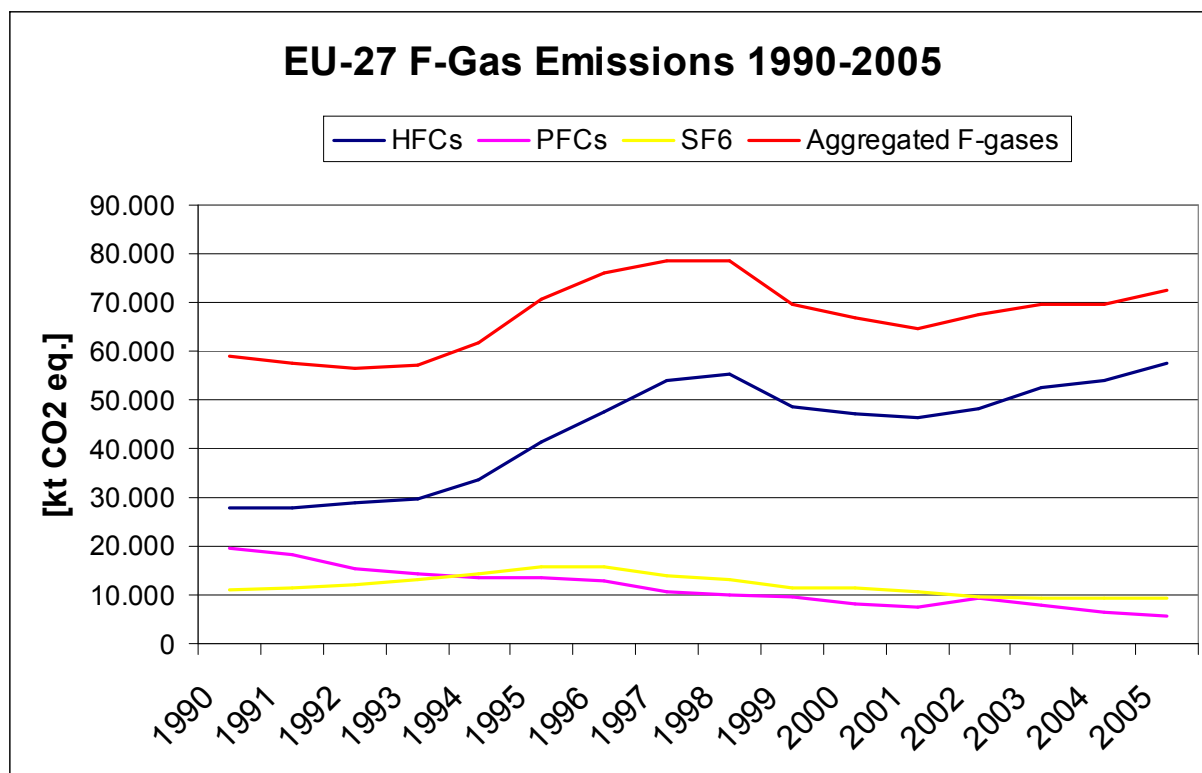
No quantifications of the impact of F-gas regulation were undertaken as part of this project, as the regulation entered into force in July 2006, most of its provisions became mandatory in July 2007 but there is some delay (estimated in at least 2 years) before the provisions will produce an impact. Moreover, as already mentioned above, several key data are current lacking and this limits the applicability of both tier 1 and more complex evaluation methods. Thus, the sections below illustrate the type of results that may be obtained, once relevant data become available and analyses are undertaken.

8.3.1 Results – Tier 1 approach

Currently, aggregated activity data is only available for very few member states. An assessment might be possible for single member states, such as Germany, United Kingdom or Austria.

For many countries the only data available is the highly aggregated data submitted to the UNFCCC. Such data may provide a rough picture of the F-gas emission trend over the last years, as shown in Figure 8-3, which depicts the F-Gas emissions development in EU-27 from 1990 to 2005.

Figure 8-3 EU-27 F-Gas emissions 1990-2005 [UNFCCC inventory data]



This data, is not fully suitable for the quantification of the impact of the F-gas regulation, because many Member States still do not have an F-Gas inventory and several emission sources are not reported, and therefore not included, in this data.

When deploying inventory data to establish a counterfactual and measure emissions, to perform tier 1 estimates, one should be aware of these limitations. Furthermore, due to the heterogeneity of the sectors and of their various sub-applications, which lead to different response to the F-gas policy, the application of a Tier 1 approach would mostly provide an indication of the changes in the target variable, rather than providing insight on the actual EU-wide impact of the regulation. Only for the following sectors the Tier 1 approach would lead to a realistic result of the regulation's impact:

- 2.F.2 – Foam Blowing
- 2.F.4 – Aerosols/ MDIs
- 2.C.4.2 Magnesium Foundries

Additionally very small installations of the refrigeration and air conditioning sector, such as domestic appliances and plug in chest freezers, could be assessed through Tier 1. Also small fire extinguishers are possible for a Tier 1 assessment.

8.3.2 Results - Tier 2 approach

A Tier 2 approach would clearly rely on the availability of disaggregated activity data at the sub-application level. In this the tier 2 approach is not very different from the Tier 3 approach. Due to the complexity of sub-applications, however, the Tier 2 does not rely on specific emission factors, as tier 3 does. In a Tier 2 approach, default emission factors are instead taken from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

E.g. in the refrigeration sector, one would need the amount of refrigerant charged in the numerous different appliances and systems used per subsector. By then applying the default emission factors of the 2006 IPCC Guidelines for national greenhouse gas inventories the emissions can be calculated.

Thus Tier 2 would allow a good estimate of activity data and F-gas use by sub application. As default emission factors are used, its main limitation is that changes in emission factors achieved through the regulation would not be captured.

Currently disaggregated activity data isn't available for most of the sectors and member states. This data gap will need to be filled before a tier 2 approach can be used to evaluate the impacts of the regulations.

8.3.3 Results - Tier 3 approach

The clearest view of the impact on emissions of the F-Gas regulation can only be achieved through a detailed bottom-up approach on sub-application level. Due to the large heterogeneity of applications and emission sources a tier 3 approach would entail a variety of sub-modules for quantification, with individual counterfactuals, activity data and emission factors. The sections below describe the Tier 3 approach for the refrigeration and air-conditioning sector, which is the major emission source for fluorinated greenhouse gases.

The refrigeration and air-conditioning sector (UNFCCC category 2.F.1) consists of 6 different major sub categories. Table 4 gives an overview of the sub categories of the refrigeration and air conditioning-sector.

Figure 8-4 UNFCCC Category 2.F.1

Refrigeration and air-conditioning (UNFCCC Category 2.F.1)
2.F.1.1 Domestic refrigeration
2.F.1.2 Commercial refrigeration
2.F.1.3 Transport refrigeration
2.F.1.4 Industrial refrigeration
2.F.1.5 Stationary air-conditioning
2.F.1.6 Mobile air-conditioning

For each of the sub categories a large number of different substances are used, many different appliances exist, refrigerant charges vary from several grams up to one tonne, and emission (leakage) rates differ from 1% to 100%.

A detailed bottom-up analysis for every single sub-sector would therefore constitute the tier 3 assessment for the impact of the F-gas regulation in the refrigeration sector. The impact would be calculated by looking at annual emissions per appliance. Activity data is the initial refrigerant charge of an appliance. Specific emission factors can be calculated through the amount refilled during service and maintenance. The counterfactual scenario can be estimated for individual appliance-types, considering their specific characteristics and technologies. Some simplifications may be possible for some categories. For example, as pointed out above, the impact assessment for domestic appliances and plug in chest freezers might be assessable through simpler, approaches. For these appliances a tier 3 approach may be similar to tier 1 using the total number of appliances and average refrigerant charges as key inputs. As these appliances are relatively leak tight, emission factors are rather small and a default emission factor such as given in the UNFCCC Guidelines can be applied.

Tier 3 requires a significant amount of data to be applied. The F-Gas regulation obliges system operators of refrigeration and air-conditioning appliances with refrigerant charges above 3 kg to

maintain records on the quantity and type of fluorinated greenhouse gases installed, any quantities added and the quantity recovered during servicing, maintenance and final disposal. This data is the key for a detailed, tier 3, impact assessment and should therefore be collected by member states. Unfortunately this could result in an enormous and expensive effort for each member state, as an adequate way to assemble all this data has yet to be developed. The articulation of suitable data collection processes is therefore a critical precondition for the application of a tier 3 approach to evaluate the impact of the F-gas regulation.

8.3.4 Ex-ante projections

Ex ante estimates of the potential savings from the F Gas regulations have EU level by the European commission. The second ECCP progress report (EU, 2002) estimated potential savings in the EU 15 in 2010 of 23 Mt CO₂ per annum. No ex-post estimates are available to compare the results with. However, the ex-ante projections provide an indication of the potential magnitude of the results.

Table 8-4 Comparison of ex-ante and ex-post results: F-gas regulations

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
F-Gases (Regulation EC No 842/2006)	23	NE	NE	NE
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations:				
MSsp: Member State specific starting year for the ex-post evaluation				
NE = not estimated				

8.4 Synthesis and interpretation of results

Due to the enormous heterogeneity and complexity of the affected sectors a simple top-down assessment would not lead to a realistic assessment of the impact of this policy. Such approach could only be applied to a small number of 'simpler' sectors. A Tier 3 approach, applied at sub-category level, appears the most appropriate to capture the interactions between the policy and F-Gas emissions. Undertaking such assessment, however, would require a significant amount of data that are currently not available. Therefore no adequate results could be calculated in the scope of this study.

As the policy also mandates the collection of some critical data, the required review of the regulation by July 2011 will offer the opportunity to undertake a more detailed assessment of the impact of the regulation.

8.5 Conclusions

Regulation (EC) No. 842/2006 aims at reducing emissions of the fluorinated greenhouse gases covered by the Kyoto Protocol by addressing various different sectors and appliances that use fluorinated greenhouse gases.

Due to the heterogeneity of the affected sectors and its sub-appliances a simple top-down assessment, such as described under Tier 1, would not clearly show the impact of the regulation in the most important sectors affected by the Regulation.

Also a Tier 2 approach, as illustrated above, would suffer several limitations when assessing the de facto impact of the regulation.

Only a detailed bottom-up analysis would effectively show the real impact of the F-Gas regulation on overall F-gas emissions in Europe.

The required data for both a Tier 2 and Tier 3 approach is currently not available, neither at member state level, nor at EU-27 level. Collecting such data will therefore be a critical factor for the evaluation of the policy. To assemble all relevant data for a future impact assessment such as required through article 10 of the regulation, a close cooperation between policy makers, industry and relevant associations is clearly needed in the future.

8.6 Recommendations

To gain an overview of the F-gas regulation's impact on total emission reductions member states and the European Commission should focus on the creation of an adequate and cost effective way to assemble required data on sub-application level. Through reporting obligations for system operators of refrigeration, air conditioning and heat pump equipment, as well as fire protection systems containing 3 kg or more of fluorinated greenhouse gases detailed data will be available for each appliance. This data should be made available for the impact assessment. How this could work has yet to be assessed and will be a key question for the review of the regulation according to article 10.

8.7 References

EEA, (2008) European Environment Agency: Greenhouse gas emission trends and projections in Europe 2008, EEA Report 5/2008, Copenhagen 2008

9 Case study: European Directive for the Energy Performance of Buildings (EPBD)

9.1 Introduction

9.1.1 Overview of policy

The Directive on the Energy Performance of Building⁵⁴ (EPBD) aims to ‘promote the improvement of the energy performance of buildings within the EU, taking into account outdoor climatic and local conditions as well as indoor climate requirements and cost effectiveness. The Directive has the long term objective of transformation the market practices of the building sector and represents a first step towards a European wide harmonised legislation for thermal regulation in buildings. However, it is important to underline that the approach adopted by the EPBD is fully in line with the subsidiary principle; therefore its dispositions are laying down a general framework of principles and procedures leaving to the individual responsibility of Member States (MS) its practical definitions and application. The following paragraphs present the main elements of the EPBD together with an overview of the transposition measures adopted indicating the opportunities and the challenges for an overall evaluation and for an assessment of their impacts.

Art.1 of the EPBD lists the main elements covered by the Directive and which are analysed in the following paragraphs:

- A. Setting of a general framework of calculating the integrated energy performance of buildings.
- B. Application of minimum requirements on the energy performance of new buildings and, to a certain extend, to existing buildings when subjected to major renovation.
- C. Creation of certification schemes for new and existing buildings on the basis of the above standards and the imposition of an obligation of public display of the energy performance certificates in public buildings and buildings frequented by the public.
- D. Establishment of regular inspection of boilers and heating/cooling systems and the imposition of an obligation of assessment of the heating installation for boilers which are older than 15 years.

At present, the current EPBD policy approach is under discussion: the European Commission has recently opened a ‘public consultation for the recasting of the EPBD⁵⁵’. The recast is based on the reasoning that there are still many unexploited cost-efficient energy efficiency measures available in the building sector that could be promoted through the legislative re-formulation of the Directive. The issues that have been included in the recast are highlighting the short comings of the first years of implementation of the EPBD. The recast is addressing the following aspects:

- the simplification and clarification of the wording of some dispositions;
- the review of the EPBD thresholds which cover the appropriate proportion of buildings and installations. In particular, the one set in Art.6 that limits the introduction of specific energy efficiency requirements to newly constructed buildings and to those with a floor area of above 1000m² which undergo to major renovation;
- the strengthening of certain requirements;
- the enhancement of the public buildings leading role.

Moreover, with respect to certification, it is considered to include the ‘payback time’ as mandatory information. It is finally under discussion to regulate in detail the inspection of boiler and air conditioning systems (indicating specifications, requirements and objectives). In order to allow for the comparison of energy performance and to improve transparency, the creation of a benchmarking system has been proposed.

⁵⁴ Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the Energy Performance of Buildings
Official Journal L 001 , 04/01/2003

⁵⁵ http://ec.europa.eu/energy/demand/consultations/buildings_dir_en.htm

9.1.2 The transposition of the EPBD into the national legislation

The EPBD, published on the 04/01/2003, sets 4 January 2006 as the deadline for the implementation of the first two provisions⁵⁶ mentioned above while allowing a further transition period of up to three years (i.e. until 4 January 2009) for the last two⁵⁷ - due to the challenges faced by the Member States as regards training and accreditation of experts to carry out the certification and inspection. When evaluating the impact of the Directive, one has to take into account that the transposition of the Directive has been more or less substantially delayed by most of the MS. In April 2008, the Commission had sent 'reasoned opinions', as the second step in infringement procedures, to several Member States for failure either of notifying the national measures requested in the EPBD or for having adopted inadequate transposing norms⁵⁸. Out of these countries, Belgium, the United Kingdom and Greece have been already referred to the European Court of Justice, and against Greece the ECJ has ruled in favour of the Commission. DG TREN reports the following table regarding infringement procedures opened for the non-communication national measures⁵⁹:

Table 9-1: Infringement procedures opened for the EPBD Directive (as of 16/10/2008)

AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HU	
X	X							X		X	X	X	
IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
			X								X		X

Two observations shall be made regarding the partial implementation of the EPBD in MS:

As mentioned above, the EPBD contains a wide range of legislative measures and, in some cases, countries have failed to transpose all four mentioned elements of the Directive. The full transposition of the EPBD requires MS to adopt highly technical initiatives involving the review of national calculation methods as well as administrative measures aiming at the creation of new structures and professional curriculae. In addition, the responsibility to adopt the adequate legislation is shared in many countries between nation and regional authorities, and, as a consequence, 'fragmented implementation' has occurred in more than one country where some regions have fully enforced the EPBD while others are lagging behind. As example, we consider the case of Belgium: The Flemish Region has effectively transposed the Directive. The Walloon Region has not specified energy performance requirements for buildings and has not determined inspection procedures for boilers and air conditioning systems. The Capital Region of Brussels has failed to define the methodology to calculate the energy performance of non-residential buildings and the complete specification of minimum energy performance requirements for existing buildings which undergo major renovations. A similar case of partial implementation can be observed in the case of the UK with regard to the implementation of the Directive in Gibraltar as well as provisions related to energy performance certificates and to the inspection of boilers and air conditioning systems in Northern Ireland.

Table 9-2 maps the different policies that may interact with the EPBD. Even if it is still not possible to provide an ex-post impact analysis of the interaction of these measures with the EPBD or to design a counterfactual scenario, it is conceivable to anticipate some possible interactions and synergies (see Table 9-3).

Table 9-2: EPBD Measure interaction map

56 A) Establishment of a general framework methodology for the calculation of the integrated energy performance of buildings, B) Application of minimum requirements on the energy performance of new buildings and to a certain extent also to existing buildings when they are renovated.

57 C) Certification schemes for new and existing buildings on the basis of the above standards and public display of energy performance certificates, recommended indoor temperatures and other relevant climatic factors in public buildings and buildings frequented by the public, D) Regular inspection and assessment of boilers and heating/cooling installations, the latter for boilers older than 15 years.

58 <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/863&format=HTML&aged=0&language=,>
[http://www.eeb.org/061106-Briefing-Buildings-Directive.pdf,](http://www.eeb.org/061106-Briefing-Buildings-Directive.pdf)
http://ec.europa.eu/energy/demand/consultations/doc/2008_public_consultation_buildings_background_en.pdf

59 http://ec.europa.eu/dgs/energy_transport/infringements/energy_directives_en.htm

MEASURE	TARGET	GOAL FOR TOP-DOWN IMPACT
ECCP Directive on the Energy Performance of Buildings (EPBD) EuPs Standards (heating equipment)	Final energy, GHG emissions Final energy, GHG emissions	20% improvement in energy efficiency 20% improvement in CO2 emissions
Complementary national measures Independent building regulation issuing at national level Support schemes for renovation works and heating equipment replacement White Certificates (heating equipment and insulation) Information and awareness campaigns		

For the measure where screening is relevant the following remarks can be made:

- The main national measures interacting with the EPBD directive are (and will be) the national support measures, mainly subsidies and incentives. In practice the building certificates and the support measures are expected to mutually and virtuously interact but only the future experience will show if this will really happen.
- The national regulatory EE standards for new and existing buildings are de facto part of the EPBD itself
- White Certificate schemes are relevant so far only for the UK, France and Italy. Most impact was observed in the UK. The mechanism was however similar to subsidy schemes, and hence is included in the evaluation of national support schemes to the EPBD directive.

Table 9-3: Interactions and synergies of the national policies with the EPBD

MEASURES	ASSUMPTION ON THE POSSIBLE INTERACTIONS
Independent and parallel building regulation (those issued in the years 2004 – 2007)	• These regulatory measures have been generally issued in the framework of the Building Directive and thus are, in some way, part of it. • Some regulations can go beyond the Directive purposes because of national policies and culture. For example the Dutch or French national targets are notably more ambitious than the simple targets achievable by the Directive: ○ For the Netherlands, new houses target: 85 kWh/m² in 2006, 60 kWh/m² in 2011, 40 kWh/m² in 2015 ○ For France: (1) In 2010, 50 kWh/m².year for all public and tertiary buildings (2) In 2012, 50 kWh/m².year for all buildings (adjusted to the geography and latitude) (3) In 2020, all new buildings should be passive buildings (< 15 kWh/m².year) or positive energy buildings
Incentives and Subsidies	• Only applicable to existing buildings (except for incentives to new buildings to go beyond the prevailing thermal regulation) • In theory these measures should not interfere with existing buildings because they are only given beyond building regulation requirements. • The data available for existing buildings would generally not separate impacts of the incentives and of the EPBD. Issue of free riders, but difficult to catch
White Certificates and EuP standards	• White Certificates: mechanisms in principle similar to subsidy schemes. Impact evaluation requires knowledge of technologies promoted (e.g. evaluation of the Energy Efficiency Commitment EEC in the UK) • The EuP standards should modify the heating equipment market independently from the Building Directive but, in the medium term, this should allow to better achieve the Minimum Performance Requirements

MS facilitating measures

The regulatory and facilitating measures issued by the MS to enhance the EE in the building sector cover a wide range of instruments varying from subsidies and incentives to EE standards and norms:

- Energy efficiency standards and building codes are the most effective instruments to enhance the building energy performance but the compliance factors have to be monitored with care and their application to existing building is still difficult mainly due to the investment barrier and other important obstacles like the conflict of interest between landlords and tenants (the latter should be more and more tackled by the certification scheme foreseen in the EPBD).
- Direct subsidies for energy efficiency investments remain popular. As they have often been considered as costly and questionable, they are now better targeted. Subsidies are viewed as a temporary measure to mobilize consumers, to prepare for new regulations, or to promote energy efficient technologies by creating a larger market than would exist otherwise, with the objective of a cost reduction for the subsidized energy efficient technologies.
- Fiscal incentives, such as tax credits, tax reductions and accelerated depreciation, are usually considered cheaper than direct subsidies, especially to households, as they have lower transaction costs. They can work well if the tax collection rate is sufficiently high: such measures usually perform poorly in an economy in recession or in transition.

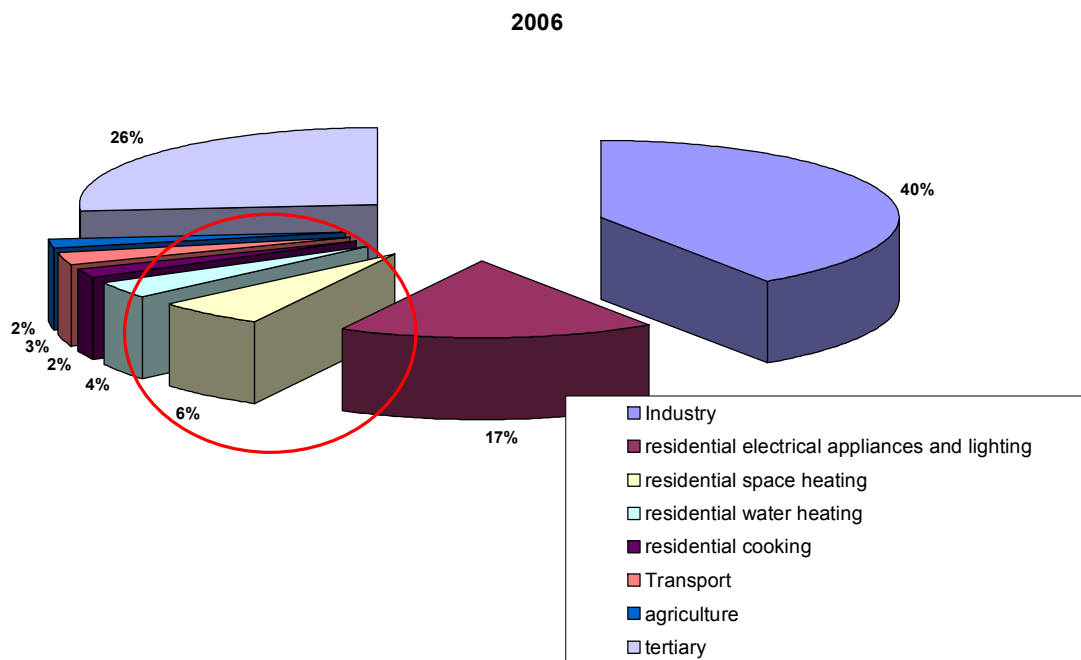
Apart from the cost barrier, another obstacle that hinders the penetration of the energy efficiency works in the buildings is the lack of information to consumers about what they can do. To address this issue, a large range of tools has been designed from the general information campaign, dwellings rating their energy performance, audits, local information centres, comparative information etc.

The Tier 3 report provides a rather deep insight of these instruments for some important MS. The wide range of facilitating measures enforced well reflects the different challenges and difficulties faced by the Member States to foster the EE practices in the existing buildings as well in implementing the EPBD Directive and which have justified rooting the Directive in the subsidiary principle.

9.2 Emission trends and drivers**9.2.1 Impact upon greenhouse gas emissions**

The EPBD addresses the two inventory sections 1.A.4.A. Commercial/Institutional and 1.A.4.B. Residential, which contain the direct emissions from fossil fuel uses for heating, hot water preparation and cooking. However, the space heating relevant parts of these sections represent a major share of these sections. The EPBD addresses also electric heating which is part of the power sector emissions. The emissions of this sector are reported in the chapter concerning the RES-E Directive. However, this is a fairly large category. Electric space heating represents roughly 6% of the total final electricity consumption (

Figure 9-1). They are also smaller space heating parts concerned by the EPBD in the industrial sector emissions. They represent on average, however, also less than 10% of the energy-related emissions from industry. We will therefore concentrate in this paragraph on the two sections 1.A.4.A. and 1.A.4.B. which are largely influenced by the EPBD. They represented in 2006 in the EU27 about 13% of all GHG emissions and 16% of energy-related GHG emissions.

Figure 9-1 Share of electric space heating in total electricity consumption of the EU27 and hence in the CO₂ emissions from the electricity sector

9.2.2 Activity and emission trends

In the **residential sector** there two main activity drivers for the GHG emissions from space heating:

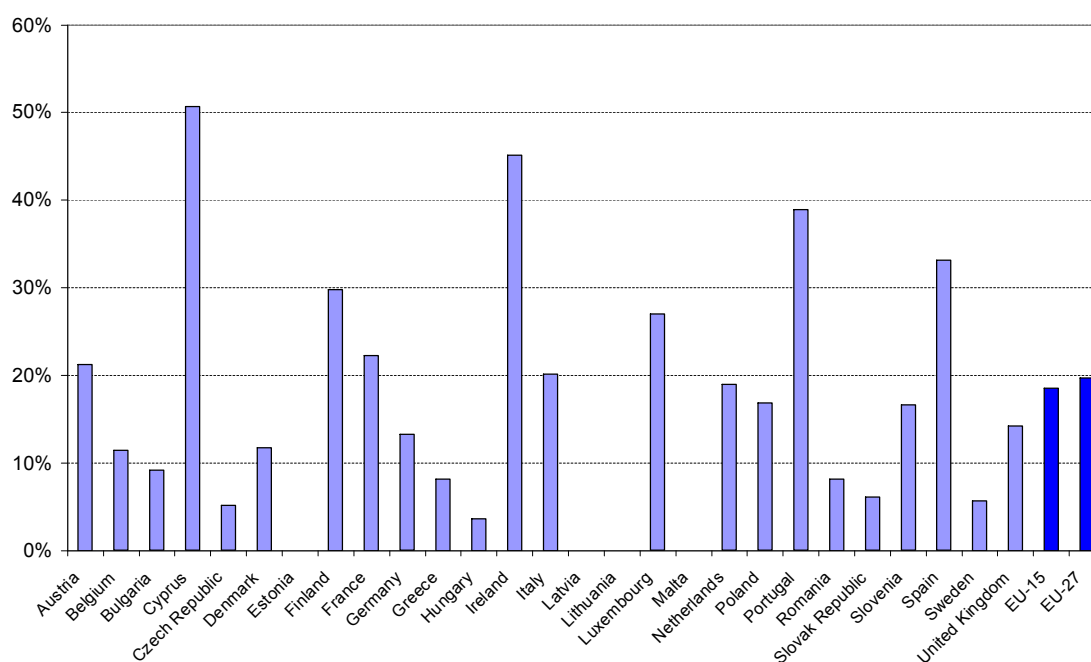
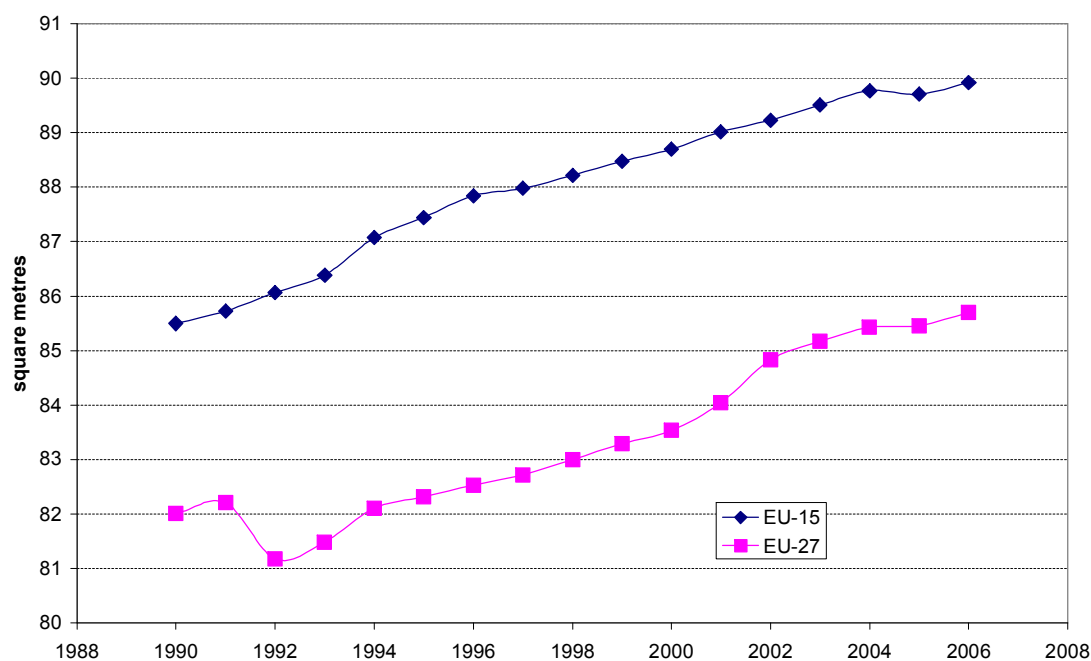
- One is the increase in the number of households themselves (Figure 9-2) due to socio-economic changes in the society (decreasing number of persons per household, aging society, increasing mobility etc.) and rising incomes. In total the number of households has risen by roughly 20% in the period 2006/1990.
- The second is the increase in the size of the households (Figure 9-3). On average for the EU15/EU27 this has increased by 4-5% on average over the period 2006/1990.

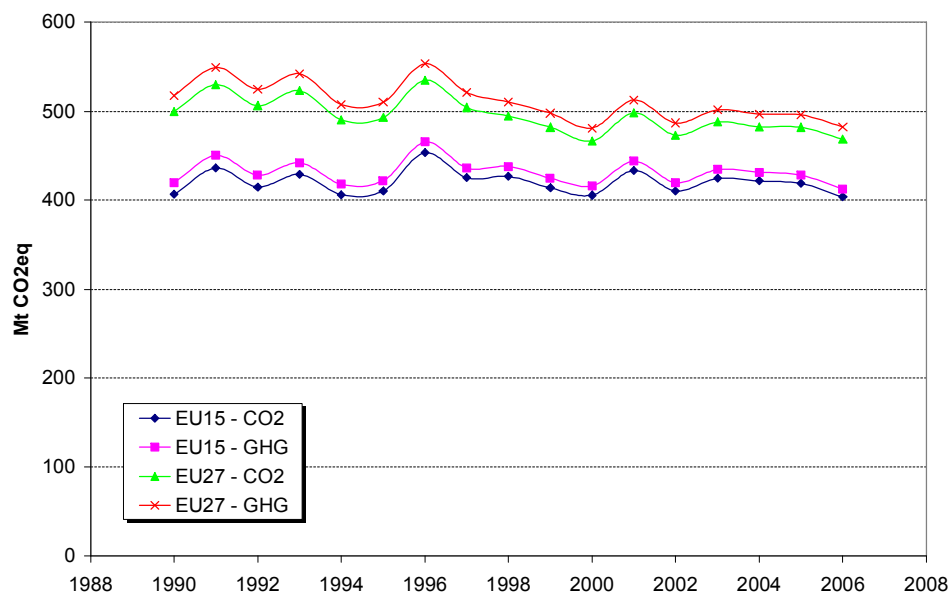
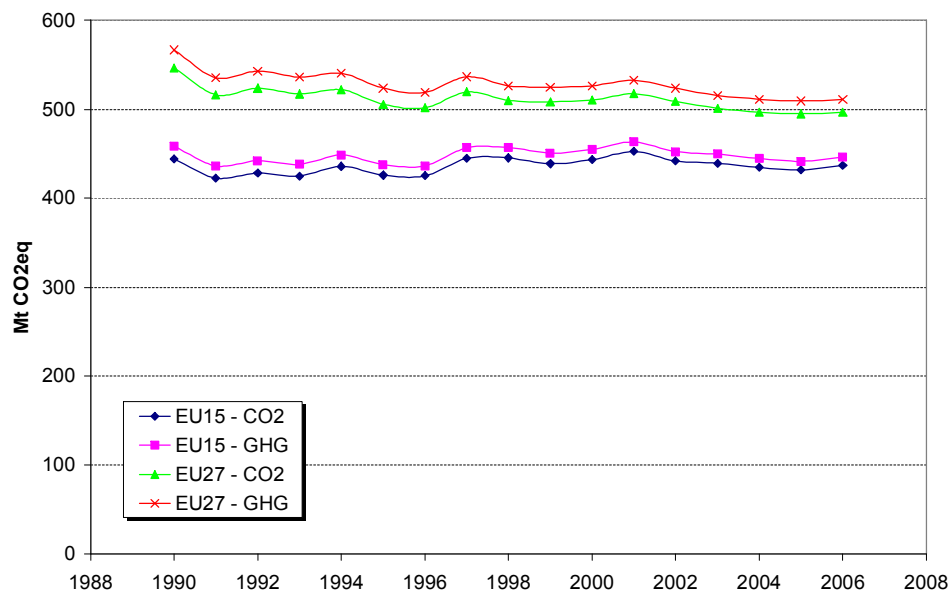
As a sum, the direct GHG emissions of residential buildings due to these drivers would have increased by a total of about 25% (Figure 9-5). In fact, however, the emissions from the section 1.A.4.B. Residential remained fairly stable (Figure 9-4) and the increase was compensated by the increase in efficiency⁶⁰ due to the building regulation active in the period 1990-2006 and by the shift towards less carbon intensive fuels.

Space heating is largely influenced by annual climate variations. In order to see better the long-term trends it is therefore necessary to carry out a climatic correction by normalising to an average heating year.

The GHG emissions are essentially CO₂ emissions from fuel combustion.

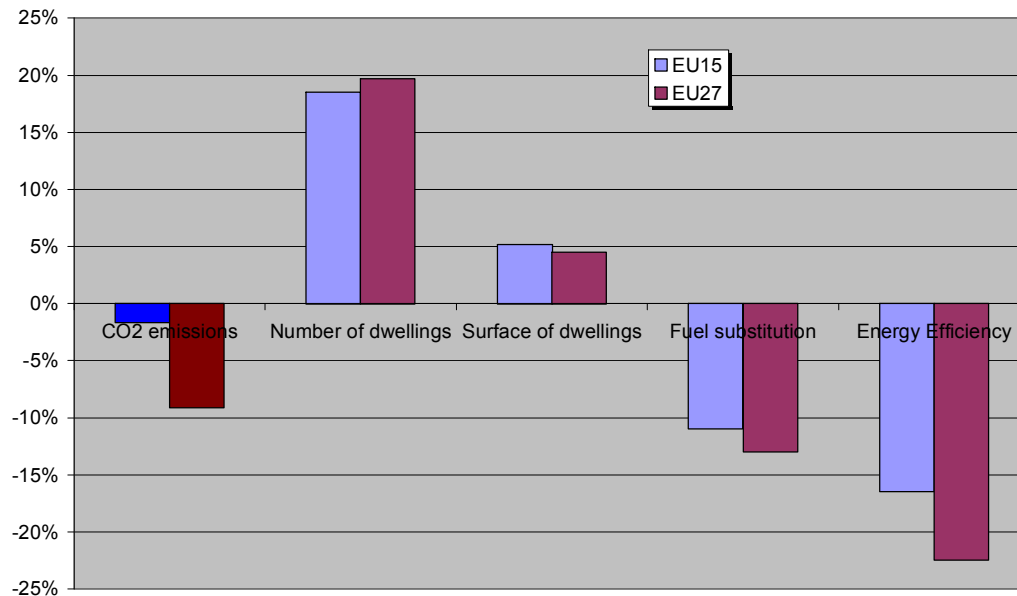
⁶⁰ This contains also the effect that efficiency is improved when switching for example from oil or coal-fired boilers to gas-fired boilers. The effect of the lower carbon-content of itself, however, is compressed in the column fuel substitution in Figure 9-5.

Figure 9-2 Development in the number of households 2006/1990 (EU27).Source: Odyssee Database 2008 (www.odyssee-indicators.org)**Figure 9-3 Increase in the average surface of residential buildings 1990-2006**Source: Odyssee Database 2008 (www.odyssee-indicators.org)**Figure 9-4: Development of GHG and CO2 emissions from the residential sector (EU15/27) (uncorrected and correct for annual climate variations)**

1.A.4.B. Residential (not climate corrected)**1.A.4.B. Residential (climate corrected)**

Source: EEA 2008

Figure 9-5: Factor analysis of changes in the emission inventories (CO₂) from the residential sector (Inventory sector 1.A.4.B.) (2006 compared to 1990)



In the **commercial/institutional sector** few countries have statistics about the buildings in this sector. It is therefore necessary to look at alternative activity levels, even if they are less well correlated to the GHG emissions from space heating activities:

- One activity indicator is the increase in value added in the service sector. However, this is not very closely correlated with space heating uses and is also difficult for the institutional part of the service sector which generates not value added properly spoken. This activity is then evaluated economically by comparison.
- The most readily available indicator are the employees. Since 1993 the employees have increased by 27-28% (Figure 9-6). In the EU15 since 1990 they increased by 40%.
- The square metres are also available for sum countries and the EU15. They have also increased by about the same percentage in that period than the employees.

As a sum, the direct GHG emissions of commercial/institutional buildings due to these drivers would have increased by a total of about 28% between 1993 and 2006 and by 40% between 1990 and 2006 (estimate). In fact, however, the emissions from the section 1.A.4.A. Commercial/Institutional increased more slowly between 1993 and 1990 and have even decreased if one takes the early period 1990-1993 also into account (Figure 9-7). The emissions were to some degree compensated by the increase in efficiency⁶¹ and by the shift towards less carbon intensive fuels (Figure 9-8). The early period from 1990-1993 was a period of rapid fuel change and energy efficiency improvement, especially in Eastern Germany. However, especially in the new Eastern European Members, the data on this period are scarcer.

Figure 9-6: Activity indicators inventory sector 1.A.4.A. Commercial/Institutional

⁶¹ This contains also the effect that efficiency is improved when switching from oil or coal-fired boilers to gas-fired boilers. The effect of the lower carbon-content of itself, however, is compressed in the column fuel substitution in Figure 9-5.

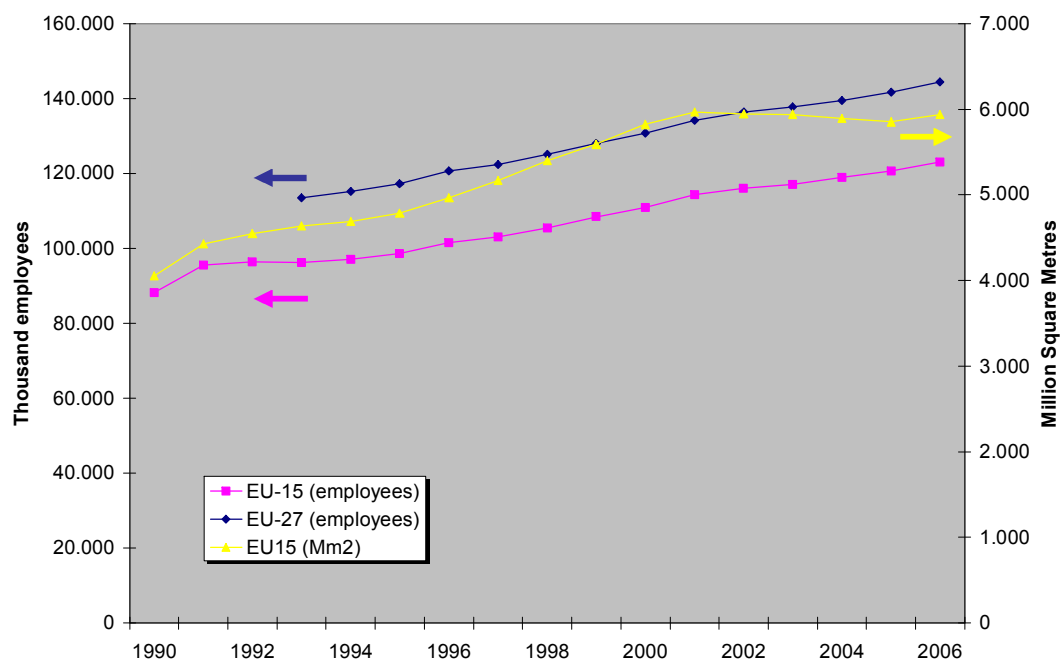
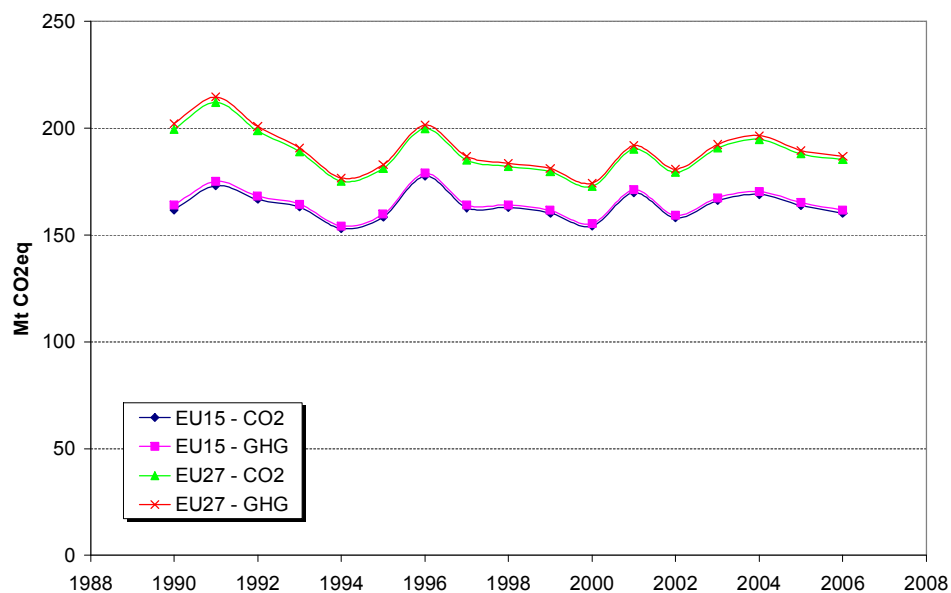


Figure 9-7: Development of GHG and CO₂ emissions from the commercial/institutional sector (EU15/27) (uncorrected and correct for annual climate variations)

1.A.4.A. Commercial/Institutional (not climate corrected)



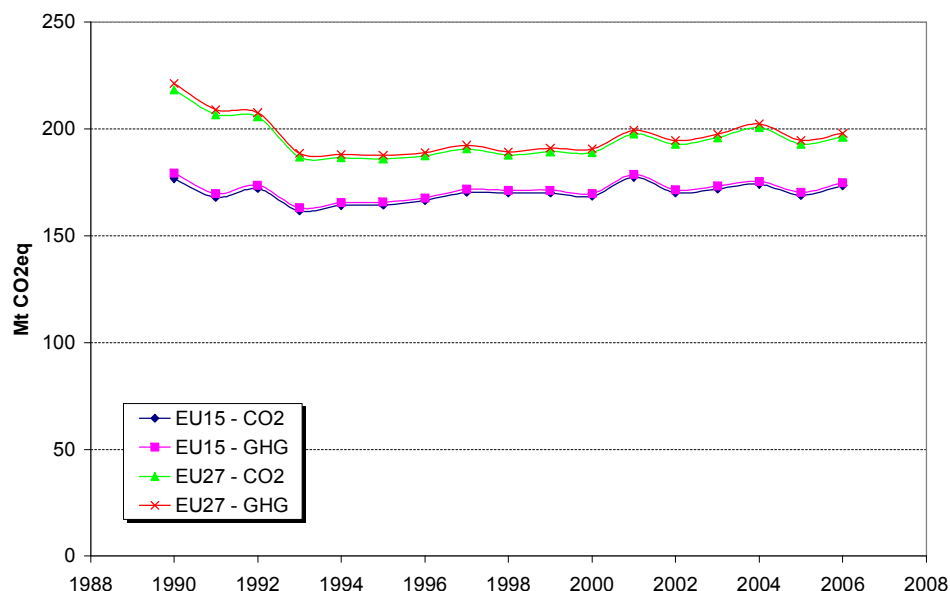
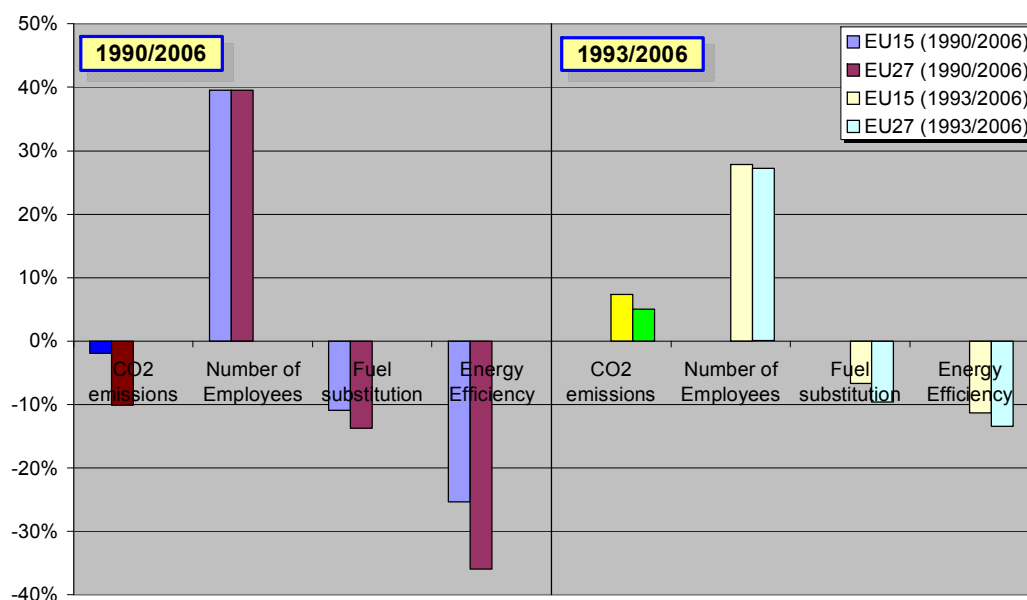
1.A.4.A. Commercial/Institutional (climate corrected)

Figure 9-8: Factor analysis of changes in the emission inventories (CO2) from the commercial/institutional sector (Inventory sector 1.A.4.A.) (1990/2006 and 1993/2006)



9.3 Impacts of the EPBD on emissions of GHGs

This section summarises the results from the application of the methodologies to the EPBD case.

9.3.1 Overview of methodologies

The methodologies are described in detail in GHG-PAM (2008) Guidelines for the Ex-post impact assessment of ECCP Measures on the Member State level: Energy Performance Directive for Buildings EPBD and in the Tier 3 report. They are summarised here.

Table 2-2 shows the main differences between Tier 1, Tier 2 and Tier 3 methodologies.

Before entering into the details of the methodology description, it is important to underline that, given the fact that the application of this Directive is very recent and/or, in some parts, it is not yet implemented, it has been objectively impossible to carry out a real ex-post evaluation (according to the information provided in the Tier 3 report, the first implementing measures started, for few countries, in the years 2005-2006 and only concern new buildings). Further, the impact of any building regulation on the total building stock is not immediate, but can only be detected in the energy consumption statistics some years after its issuing. Actually, the most recent Odyssee energy efficiency indicators (www.odyssee-indicators.org) based on statistical information, are available to the year 2006/7 and it is thus not possible to detect from these data any kind of substantial impact of the EPBD. **We have therefore opted at Tier 1, 2 and 3 level for simulation exercises in order to illustrate the ex-post evaluation methods.** The Tier 1 and 2 simulation exercises assume that impact of the EPBD, which has been issued in 2002 was immediate and that all impact observed after 2002 was triggered by the EPBD. This is clearly an overestimate although the EPBD has certainly had an influence on the development of national building regulation issued between 2002 and 2006. For the Tier 3 exercise we tried to **develop an ex-post Tier 3 methodology by simulating the impacts of the EPBD during 2004-2020 with the MURE building model. This simulation exercise is useful to derive data requirements for the Tier3 guidelines.** The most important hypothesis for the simulation exercise is that the newest national building regulation put in place after introduction of the EPBD is strongly influenced by the EU Directive.

Table 9-4 Main differences between Tier 1, Tier 2 and Tier 3 methodologies with respect to the main factors of influence on the results

Methodology	Tier 1	Tier 2	Tier 3
Activity indicator	Number of households (Inventory sector 1.A.4.B.). Number of employees (Inventory sector 1.A.4.A.). Estimate of space heating shares.	Number of households and development of square metres. Estimate of space heating shares.	As Tier 2 but including data on building stocks and technical characteristics of existing, new and refurbished buildings. Use of the MURE simulation model
Emission factor	Fuel specific emission factors. Aggregate average EU emission factors for electric space heating	Fuel specific emission factors. Emissions for electric space heating based upon aggregate data reported by Member States to UNFCCC	Fuel specific emission factors. Short-term marginal emission factor (hourly model or approximation by fossil fuel plants)
Autonomous development and previous policies	Correction for autonomous progress/previous policies included in a very approximate manner by assuming a fixed rate based on the stock renewal and the period 1990-2002 previous to the EPBD.	Correction for autonomous progress/previous policies included in a very approximate manner by assuming a fixed rate based on the stock renewal and the period 1990-2002 previous to the EPBD.	Autonomous progress/previous policies simulated by the penetration of the building regulation before the introduction of the EPBD.
Structural effects	No adjustment for structural changes in the activity data	Adjustment for the increase in household size.	Adjustment for the increase in household size, for the shift in multi/single family houses, change in age structure,...No adjustment for increase in internal temperatures and length of heating period.
Timing issues	Calculates policy impacts from implementation date at EU level, no adjustment for implementation delays or announcement effect.	Calculates policy impacts from implementation date within each MS, no adjustment for implementation delays or announcement effect.	Calculates policy impacts from implementation date within each MS. Adjustment for implementation delays or announcement effect.
Policy interaction	Combined effect of closely related national and EU policies.	Combined effect of closely related national and EU policies.	Separation of national promotion schemes by explicit simulation of potentially overlapping policies.
Geographic factors	Adjustment for climatic influence	Adjustment for climatic influence	Adjustment for climatic influence
Other exogenous factors	Non-compliance with building regulation implicit in statistical data	Non-compliance with building regulation implicit in statistical data	Non-compliance with building regulation explicitly modelled
	No further adjustment for exogenous factors	No further adjustment for exogenous factors	Adjustment for impacts of commodity prices for heating on the autonomous uptake of insulation measures.

Tier 1 – EU level

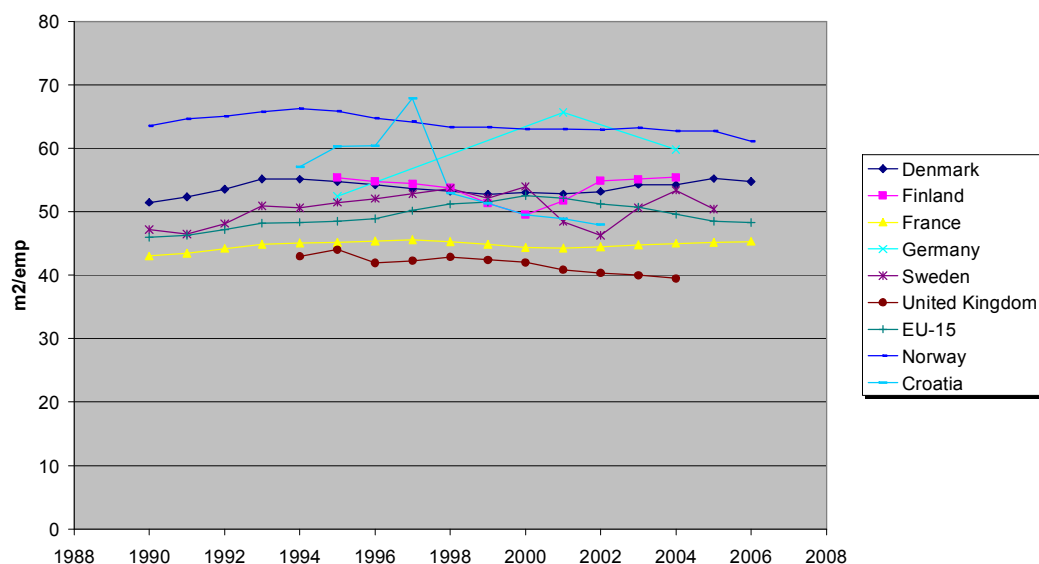
The assessment of the policy impact at Tier 1 level is based on Eurostat data (number of households as the activity indicators and overall consumption for households). Energy use for space heating is separated by making use of Eurostat shares for heating for each fuel. The methodology projects the indicator residential energy consumption for space heating per dwelling from the period 1990-2002 up to 2006 and compares this baseline development with the actually observed development. Hence the EPBD is assumed to have an immediate impact in 2002 the year of its introduction at the EU level. The unit consumption of energy use per dwelling for space heating is typically decreasing over the period considered although in some Member States this figure is also increasing. For the Commercial/Institutional sector employees as used as the activity level. Corrections are made for climate impacts on the energy use in both the residential and the commercial/institutional sector.

Emissions from electricity saved are evaluated with an average EU emission coefficient including nuclear power plants.

Tier 2 – MS level

This approach is based on national data collected in the Odyssee Database (www.odyssee-indicators.org) in the frame of the Intelligent Energy for Europe Programme of the EU. These are unofficial statistics. Energy use for space heating is separated by making use of national shares for heating for each fuel. For the residential sector, in addition to the number of dwellings it allows to take into account the development of the number of square metres per dwelling. Similar corrections as for Tier 1 are made for autonomous progress. The savings are larger than with the Tier 1 approach because the number of square metres was increasing in the past, compensating for part of the technical savings achieved by building regulation. No correction is made for the increase in internal temperatures over time because this is not covered by statistical data. For the Commercial/Institutional sector a Tier 2 methodology is designed based on square metres. However, statistical data on the square metres are scarce in many countries. For this sector, however, the improvement with this approach seems more limited given the fact that the m² per employee seem to have been fairly stable over the past decade with a trend, nevertheless, to decrease, probably due to the spread of open offices which allow to place staff in a more compact manner. Corrections are made for climate impacts on the energy use in both the residential and the commercial/institutional sector. Emission factors are based on average MS emission from the power sector.

Figure 9-9: Square metres per employee in the Commercial/Institutional sector



Source: Odyssee Database 2008

Tier 3 – Detailed calculations using the MURE simulation model

Overall, the methodology for an ex-post analysis is as follows (for more details including on the MURE simulation model used, see EPBD case study report on Tier 3 methodology):

1. The **energy impact** of the EPBD has been calculated by using the *MURE simulation model*. Main data for the residential sector is information on the building stock characteristics in the EU27 (split single/multi-family, split by age classes, split by fuels, distinction by countries and climatic zones) and on the technical characteristics of existing, new and refurbished buildings which penetrate the stock as well as on compliance with building regulation.

2. The **main data sources for the modelling inputs** where the following (Table 9-5).

Table 9-5: Main input variables used by the MURE model and corresponding data sources

Input variables	Data sources
Drivers: Trends in number of households	Primes database
Drivers: Trends in square metres	Wuppertal Institute and other specialised sources (see below)
Structural data for buildings	Odyssee database
Building EE standards	Wuppertal Institute and other specialised sources (see below) Odyssee database for calibration
Building EE penetration rates	Wuppertal Institute and other specialised sources (see below)
Heating technologies diffusion - reference year	EuP preparatory studies, LOT 1
Heating technologies diffusion - forecast	ISIS – FhG/ISI assumptions

The most important sources of data used to set up the input variables set have been:

- *The Odyssee* database that provides a detailed energy efficiency data and indicators for the EU-27 members and Norway as associated country to the EU. Among others, the database provides important information on the construction of dwellings, single and multi-family dwellings (new and existing) and detailed information about the average square metres for new/existing single/multi-family dwellings. The time period covers the years 1990 to 2006/7 (as of 2008).
- Statistical publications such as “Housing Statistics in the European Union 2004” from *Boverkert and MMR*⁶² (2005) that give a detailed overview of the housing development and living conditions in the European Union. It is the 10th edition and, for the first time, it covers the whole EU-25. The database for the quality of the housing stock is of special interest. It concentrates on the average living area and the age of the EU-building stock as well as on the distribution of building types such as single and multi-family buildings. The last update of the Housing Statistics, by the *Italian Ministry of Infrastructure and Italian Housing Federation* (MIIR) has been used to refresh these data.
- The PRIMES model that gives an overview of the projections of household numbers for each country of the European Union by 2030. Also, detailed values of the current and future energy use and CO₂ emission trends to 2030 are given.
- The study “Cost-effective Climate Protection in the EU-Building Stock” carried out by *ECOFYS* for *EURIMA*⁶³ (2005) that analyses the energy saving potential of the building stock in the analysed countries and which could be realised by further tightening the requirements of the *Energy Performance of Buildings Directive (EPBD)*. Additionally, the last study *U-values – For better energy performance of buildings*, from November 2007, was used to refresh data.
- The EuP study on Central Heating Boilers, LOT 1 V.H Kemna and others.

3. The following are the main *settings applied to the “ex-post evaluation” simulation exercise*:

- The time frame of this evaluation is 2004 – 2020
- The simulation has been carried out by applying to each country either the building regulation recently adopted or under discussion (*Art. 5&6*). These standards are applied to both existing and new buildings.
- No very strict building regulation like those required for passive houses, have been applied because out of the scope of the Directive.
- For the achievement of the Minimum Performance Standards (*Art 7*) a moderate but steady improvement of the heating systems has been considered by simulating the shift to high efficient gas boilers, heat pumps and renewables.
- The regular inspections (*Art. 8*) has been taken into account by simulating the spread of a regular maintenance practice for heating devices

⁶² Boverkert = National Board of Housing, Building and Planning, Sweden; MMR = Ministry for Regional Development of the Czech Republic.

⁶³ European Insulation Manufacturers Association (EURIMA).

The evaluation provides:

- the final energy trends and savings and the corresponding CO₂ emissions for the household heating uses. For the household sector the evaluation was carried out in two steps: first of all we evaluated the useful energy trends by estimating the penetration of the EPBD EE standards in the building stock of the different MS. Then we calculated the final energy consumption trends by estimating the impact of the Directive on the heating technologies.
- the useful energy trends and savings for the service sector. For the non-residential buildings the evaluation has been limited to the useful energy due to the lack of reliable data on the diffusion of heating technologies in the service sector.

The settings for the useful energy evaluation have been the following:

- Main energy consumption drivers: growth of the households stock and the dwelling size in m².
- **Baseline:** Unit energy consumption for both new and existing buildings frozen at 2004 but the new EE standards existing in 2004 anyway penetrate and therefore the new buildings apply the most recent national building regulation valid before the introduction of the EPBD (**this designs a possible counterfactual scenario if seen from the ex-post perspective of the year 2020**).
- **EPBD** penetration:
 - *Existing buildings:* The EPBD modifies the real estate market, obliging the building owners to reduce the building renewal interval from 40 to 30 years or less and to carry out insulation interventions together with standard rehabilitation measures for building maintenance. In figures this implies:
 - 25% of refurbished buildings by 2020 for the moderate climate/western countries (At, De, DK, Fr, NI, UK); 20% of refurbished buildings for warm climate/western countries (Es, It); 16% of refurbished buildings for moderate climate/eastern countries (Cz, Pl).
 - *New buildings:* new standards implemented at national level in accordance with the requirements of the EPBD, that is:
 - strong penetration of the EPBD EE standards starting from the year 2010. Moderate penetration of further tighter EE standards initiated by the EPBD from 2015. The EE standards penetration is fine-tuned for the different country groups according to historic observations.
- Similar criteria are adopted for the non-residential buildings, in particular, for the *existing stock*:
 - 30% of refurbished buildings by 2020 for the moderate climate/western countries, 25% of refurbished buildings for warm climate/western countries, 18% of refurbished buildings for moderate climate/eastern countries.

In the calculation of the useful energy trends we considered the fact that only part of the target group to which the Directive is addressed will comply with its requirements. This has led to apply a set of **Compliance Factors**⁶⁴ in accordance with the following criteria:

- Different compliance factors for existing and new buildings
- Compliance factors differentiated by country groups:
 - Western/moderate climate countries: 55% existing, 70% new (only 55% and 70% respectively comply with the regulation)
 - Western/warm climate countries: 50% existing, 70% new
 - New EU Members/moderate to cold climate: 45%, 70% new

The Compliance Factors reduce notably the expected savings and a sensitivity analysis has been carried out to evaluate this barrier. **It is worth adding that the certification mechanisms envisaged by the EPBD should reduce this barrier but ex-post controls of the quality of the certification are highly required.** In any ex-post evaluation data on non-compliance are important for the quality of the evaluation.

MURE breaks down the existing and new building stock by the building standards described in Table 9-6 for existing and new buildings. For the model evaluation their penetration needs to be assumed. In

⁶⁴ Source: Wuppertal Institute based on Hjorth and Warren (2008), ESD Potential Study for DG TREN (to be published). The compliance factors are based on historic observations of non-compliance. However, there are no good statistical databases for most countries that cover non-compliance issues.

an ex-post evaluation these penetration ratios have to be established statistically. The existing building EE standards Ref 1, 2 and 3 are equal to the new standards New 1, 2 and 3.

Table 9-6: Breakdown of the existing and new building stock by type of building standard

Existing buildings (by the time of the base year 2004 for the simulation)	MURE code
Buildings without refurbishment	W. Ref
Buildings refurbished with old (1980-2000) building regulation	Ref0
Buildings refurbished with recent building regulation (after 2000 but before the introduction of the EPBD)	Ref1
Buildings that will be refurbished with EPBD building regulation (new building regulation initiated/inspired <u>currently</u> by the EPBD)	Ref2
Buildings that will be refurbished with more stringent building regulation (more stringent building regulation initiated/inspired in the future by the EPBD, e.g. low energy consumption houses)	Ref3
New buildings (built starting from the base year 2004)	
Buildings that will be built applying recent building regulation (after 2000 but before the introduction of the EPBD)	New1
Buildings that will be built applying EPBD building regulation (new building regulation initiated/inspired <u>currently</u> by the EPBD)	New2
Buildings that will be built applying more stringent building regulation (more stringent building regulation initiated/inspired in the future by the EPBD, e.g. low energy consumption houses)	New3

The settings of the final energy evaluation have been the following:

- **Baseline:** the heating technologies share for both existing and new buildings is frozen in 2004. There is an energy efficiency increase for heating technologies independent from the EPBD due to the implementation of the EuP (Energy-using-products) standards currently set up at EU level. It is important to note that in this way the impact of the EuP standards are not attributed to the EPBD; however they may be part of the ECCP and have to be evaluated separately. **Again this baseline constitutes an *anticipated* counterfactual scenario.**
- **EPBD scenario:** the heating technologies energy efficiency increase is the same as in the baseline (except for the impact of the equipment maintenance required by the EPBD) and therefore the EE increment is only due to fuel shift, mainly:
 - Moderate shift to natural gas systems (from oil and coal-fired units)
 - Moderate penetration of renewable heating systems (especially in the southern countries)
 - Moderate penetration of heat-pumps (also caused by other measures such as White Certificate Schemes at national level)
 - For biomass and district heating systems the market share is frozen to the year 2004 for the existing stock (this may be a conservative assumption)

4. Conversion of energy savings to CO₂ savings

The CO₂ emissions have been calculated from the energy savings according the following procedure:

- The fuel, district heating and electricity coefficients have been averaged on the basis of the heating technology mixes by country (sources for the base year: EuP studies, Odyssee database).
- For electricity, like in the study on the appliances directive, we have assumed the average fossil fuel emission coefficient of the power sector of the selected countries (as a proxy for hourly simulations of the emission coefficient); see Table 9-7.
- For district heating we have assumed the fuel mix coefficients according to the data available in the MURE database.

Table 9-7: Average emission coefficient of the power sector of selected EU countries (including all fossil plants) according to PRIMES

	AT	CZ	DE	DK	ES	FR	IT	NL	PL	RO	UK	EU-27	EU-15
t/MWh	0.84	1.29	0.96	0.90	0.71	0.70	0.64	0.66	1.22	1.27	0.71	0.86	0.79

By multiplying the total energy savings presented in the previous section with the emission coefficients calculated for each country in accordance with the method outlined above, the total emission reductions can be calculated.

5. Assess the importance of specific factors. These are:

- independent national measures aiming at the same target;
- autonomous progress;
- the impact of energy price variations

The issue of autonomous progress has been discussed in the entrance by settling the methodology on a starting building efficiency frozen in the base year. The heating equipment efficiency is, on the contrary not fixed at the reference year because its improvement will mainly depend on the incoming new EuP eco-design standards. A variant to this approach may be to determine the autonomous progress from the development of the building sector consumption per m² before the entrance of the directive (approach taken at the Tier 2 level). A risk with this procedure is to overlap the impact of the Directive with that provided by the application of the national building codes that, as already outlined, for many countries have been issued envisaging the, or in parallel with, the Directive itself. At the end the impact of the Directive would be determined only by the accelerated ratio of the existing building energy efficiency (this ratio should be frozen in the autonomous progress scenario) and the renewal of the heating equipment.

For what concerns these last points, the following issues have to be considered with care to try to understand the impact of the Directive with respect to the other measures:

- if the building certificates alone, that is without incentives and subsidies, are able to convince the EPBD target audience to improve the EE of the existing building;
- if, in presence of the building certificates, it is still possible to speak of free riders effect.
- if, or to which extent, the White Certificate mechanisms will interfere (in positive terms) with the heating and cooling system control and the building energy performance itself.

The increase of energy prices was limited during the past 10 years, except for the last two years, and moreover there was not a clear correlation between the building energy consumption and the MS purchasing power (contrary to what happened in the case of the electric appliances, see the report on the Labelling Directives for Large Appliances) due to the obvious influence of the climate on this type of consumption. However the energy prices for heating have been increasing due the increased fuel input prices and, once, hopefully, solved the present serious economic crisis, the energy price are expected to follow their growing trend. This should obviously favour the diffusion of EE investments and practices but the balance between the energy price and the disposable family income is also an issue. Mechanisms like the White Certificates and Third Party Financing could help achieving the EPBD targets. This is illustrated by the fact that for example White Certificates schemes in France, Italy or the UK promote insulation measures in buildings as one of the important targets. White Certificates are also mentioned in the Energy Service Directive, as a potentially useful instrument to be further investigated.

9.3.2 Results – Tier 1, Tier 2, Tier 3 approach

Results for case study Member States

Table 9-8 illustrates the CO₂ emission⁶⁵ savings for Tier 1 and 2 for the selected MS and the EU15/EU27 respectively (period 2002-2006). The table documents also Tier 3 results (2004-2020). Overall results differ quite substantially for all three methods. Results from Tier 1/2 methodologies indicate savings per year in the range of 16-31 Mt CO₂ in the residential sector with the higher results for the Tier 2 methodology. The Tier 3 results are not directly comparable with Tier 1/2 results because this methodology is looking at a different time period and into the future. With full compliance with the regulation, the residential sector savings may reach 74 Mt CO₂ by 2020.

Table 9-8 (Direct and indirect) CO₂ Savings for the EPBD in Tier 1/2 methodologies for the residential and the Commercial/Institutional sectors (2002-2006) and in Tier 3 methodologies (2004-2020)

Tier 1 Analysis (Based on average member state fuel mix; EU emission factors)								
Savings per year MtCO ₂						Cumulative	Average annual	
Residential Sector	2002	2003	2004	2005	2006			
EU-27	3,9	14,0	20,4	21,9	17,4	77,6	15,5	
EU-15	-0,4	2,0	8,6	9,2	9,3	28,8	5,8	
Service Sector						Cumulative	Average annual	
Residential Sector	2002	2003	2004	2005	2006			
EU-27	2,7	-3,0	-0,7	2,8	4,4	6,2	1,2	
EU-15	2,2	-4,0	1,2	1,8	3,5	4,7	0,9	
Tier 2 Analysis (Based on average member state fuel mix; MS emission factors)								
Savings per year MtCO ₂						Cumulative	Average annual	
Residential Sector	2002	2003	2004	2005	2006			
EU-27	11,3	31,6	37,6	40,3	35,8	156,5	31,3	
EU-15	4,3	16,9	22,0	25,3	19,2	87,8	17,6	
Service Sector						Cumulative	Average annual	
Residential Sector	2002	2003	2004	2005	2006			
EU-27	-	-	-	-	-	0,0	-	
EU-15	0,2	-10,2	-7,5	-12,6	-13,6	-43,6	-8,7	
Tier 3 Analysis (Based on detailed simulation of building stocks)								
Savings per year MtCO ₂								
Mt CO ₂	CO ₂ emissions with Compliance Factors (partial compliance with regulation)				CO ₂ emissions without Compliance Factors (full compliance with regulation)			
	2004	2010	2015	2020	2004	2010	2015	2020
Residential Sector	2004	2010	2015	2020	2004	2010	2015	2020
Total 10 countries investigated	0,0	17,7	28,1	38,7	0,0	32,1	47,2	59,7
EU-27	0,0	22,0	34,9	48,0	0,0	39,8	58,5	74,0
Service Sector	2004	2010	2015	2020	2004	2010	2015	2020
Total 10 countries investigated *	0,0	2,0	3,9	5,6	-	-	-	-
EU-27 (useful energy only)*	0,0	2,4	4,8	6,9	-	-	-	-
EU-27 (estimate with heating systems included)*	0,0	7,3	11,6	16,0	0,0	13,3	19,5	24,7

* only from savings on the building envelope (useful energy). Data on heating systems are not included due to data gaps.

In useful energy terms service sector savings present 33% of residential savings on useful energy. Hence they may also present 33% of the residential sector emissions including savings on the heating systems if one assumes similar heating efficiencies for the service sector.

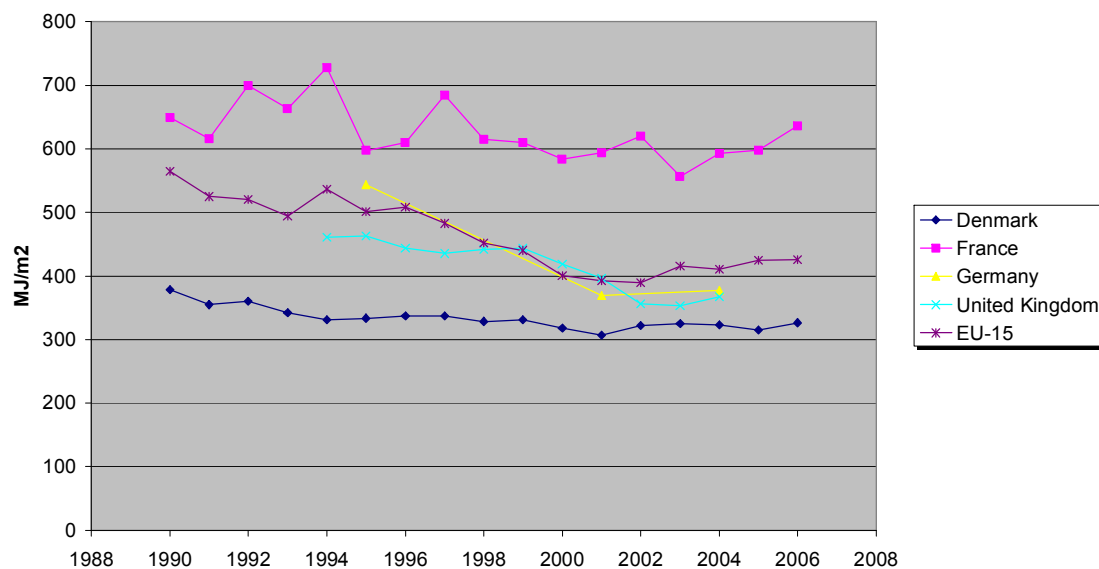
Note: Negative values represent in theory “dis-savings”. In practice they imply structural changes which are not separated. In the Tier 1 methodology this is for example the increase in the size of residential buildings.

The results for the Commercial/Institutional sector are not very significant given the size of the savings obtained (roughly 1 Mt CO₂ at EU27-level in Tier 1 methodology, see Table 9-8). The resolution of the data for this sector is generally poor, and the use of aggregate data does not allow the separation of structural changes. For example, it is difficult to explain why surfaces are saturating in the EU15 in the Commercial/Institutional sector, while energy use for space heating is still increasing. This leads to specific energy consumption per m² which is increasing (Figure 9-10). The surfaces used in this approach are much more uncertain than employees. Also the space heating shares in this sector are in many countries not very well known, and based on samples and estimates. This is also the reason why the results obtained with the Tier 2 methodology do not indicate any savings at all.

⁶⁵ Other GHG have been neglected in this analysis but may be considered in future evaluations. However, their contribution is small.

In the Tier 3 approach, due to a lack of information on heating systems in the Commercial/Institutional sector only useful energy savings could be calculated. The total savings on useful energy achievable by the non-residential buildings in the 10 countries investigated reach 2,743 ktoe by 2020 (assuming partial compliance with the building regulation) corresponding to 33% of the useful energy savings achievable in the household sector (8,320 ktoe). Thus, if savings on heating systems are similar than for the residential boilers, CO₂ savings in the service sector in 2020 may be around 25 Mt CO₂ at EU27-level assuming full compliance with the regulation.

Figure 9-10: Space heating consumption Commercial/Institutional sector (climate corrected)



Source: Odyssee Database 2008

Differences in the results between Tier 1, 2 and 3 results are explained by:

- Assumptions on the start of the EPBD: Tier 1 and Tier 2 methodologies assume that the EPBD had already an influence at the national level right from its enforcement at EU level in 2002, despite the fact that even today formally in many countries part of the EPBD is still in the phase of being transposed to national law. Tier 3 does not make this assumption and introduces the regulation when they became valid or can be expected to be valid in the future, i.e. after 2006 as the earliest year.
- Structural factors taken into account: The Tier 1 methodology does not separate the trend towards larger heated surfaces in residential buildings. It delivers therefore smaller savings because technical savings are compensated by increasing comfort.
- The treatment of autonomous progress and pre-EPBD policies: The Tier 3 methodology models explicitly the penetration of pre-EPBD thermal regulations, while Tier 1 and 2 methodologies handle this in a progress factor derived from the period 1990-2002. However, for the moment, the impact of high energy prices on changes in autonomous insulation measures is not included but must be considered in a high-price environment as during the last two years.
- Corrections of climatic variations: in principle this is a well-established method; however, it has its limitations: given the fact that in Tier 1 and 2 methodologies the savings are established as a relatively small difference between the counterfactual and the policy scenario, especially in the earlier years when the penetration of the EPBD impacts is still small, imperfect corrections of climatic variations may induce quite large fluctuations in the savings. These may be reduced by taking averages over several years. In Table 9-8 we have therefore calculated the averages over several years. The reason why the correction of climatic variations is imperfect is that when a year is colder, the behaviour changes and people tend to be more careful to avoid drought for example. On the contrary, if a winter is warmer, windows and doors are opened less carefully. Also rooms may be more easily overheated. This leads to the fact that energy consumption for space heating does not change fully linear with degree day changes.

- Differences in the emission factors used: EU-wide versus national emission factors (mainly an issue for electric heating and district heating). See the debate on this issue in the section on appliance labelling.
- The treatment of overlapping EU policies and national promotion policies for the thermal improvement of buildings: in Tier 1 and 2 methodologies they cannot be separated from the impacts of the EPBD, while in Tier 3 they can be modelled separately (such as for example the impact of the Energy-using-Product EuP Directive, another ECCP policy, on heating and cooling appliances). National subsidy schemes for the insulation of existing buildings or for new low-energy buildings/passive houses are in principle not overlapping if there are no free-rider effects and the subsidy goes only to insulation exceeding the regulation. In practice, however, there will be an overlap and free-rider effects need to be determined separately.

Sensitivity analysis

In

the

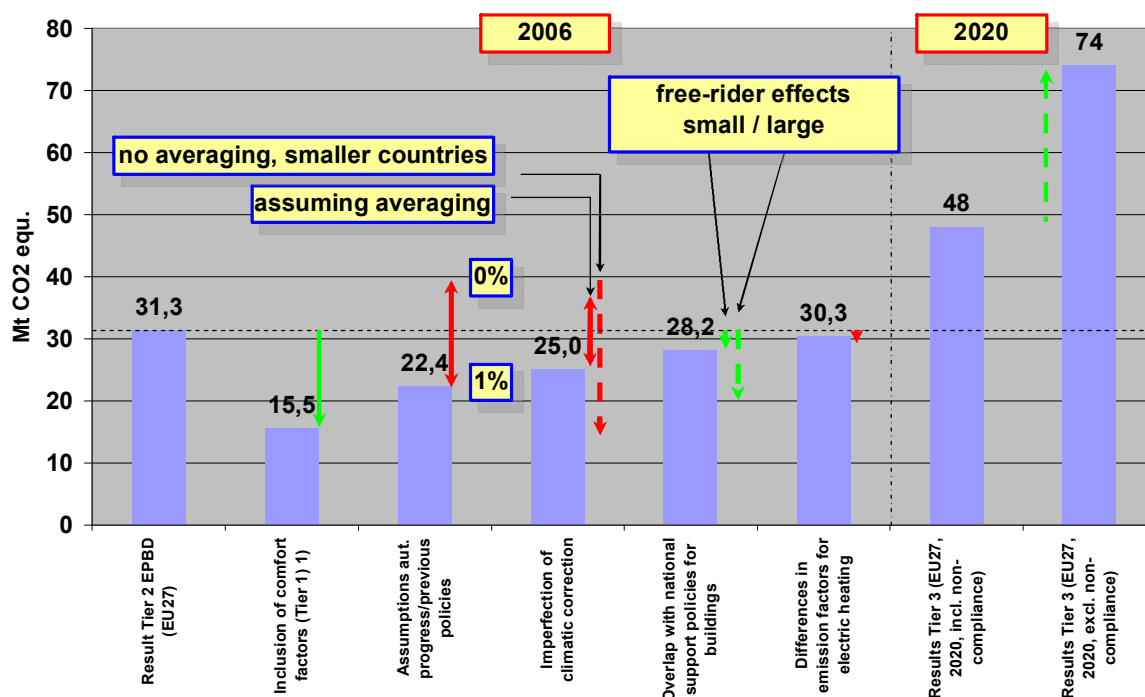
Figure 9-11 the results of the sensitivity analysis are shown. This shows the impact of using specific methodological assumptions, and the influence of data uncertainties, upon the overall results. The arrows show the relative variability in the results depending upon the particular assumptions that are used. The results represent the historic importance of the different factors. This does not necessarily mean that the factors will have the same importance in the future.

It can be seen that a variety of factors may have substantial impacts mainly linked to data uncertainties. These are in particular:

- Inclusion of comfort factors such as increased square metres per building (Tier 1 approach), in difference to Tier 2 and 3 approaches which make the comfort increase explicit and do not include them into the impact estimate.
- Overlap with national support policies for buildings: small in case free-rider effects can be well controlled
- Non-compliance issues are included automatically in Tier 1 and 2 approaches while non-compliance with building regulation is made explicit in the Tier 3 approach.

Other factors are rather linked to methodological choices. These are in particular:

- Assumptions on autonomous progress/previous policies: In the Tier 3 approach autonomous progress/previous policies is modelled explicitly by considering the penetration of buildings obeying to the previous building regulation. For Tier 1 or 2 approaches this is included by assuming a progress factor. For the residential sector for example 0.5% annual improvement was chosen in agreement with the period 1990-2002.
- Assumptions on the start of the policy impacts: while Tier 1 and 2 approaches assume an immediate start of the impacts in 2002, the year when the EPBD has been accepted (there are some arguments for this: the EPBD as an important EU policy had some effects on national legislation before it was translated in all MS to national regulation). The Tier 3 approach looks on the contrary on the implementation delays and thus models the EPBD impacts only in the period 2004-2020, assuming that the main impacts of the EPBD are still in the future.
- Imperfection of climatic correction: In the Tier 1 and 2 approach, given that this is a statistical approach, without averaging over several years, for smaller countries and in early stages, when savings are still small, the fluctuations in the impact results may reach quite considerable levels.
- Differences in emission factors for electric heating: only important for countries with high shares of electric space heating or high shares of district heating

Figure 9-11 Sensitivity analysis of the impacts of the EPBD

Note: Variations due to methodological choices are in red. Variations due to data issues are in green. Solid arrows represent an absolute assessment of the variation, as calculated in the current analysis. Dashed arrows show an estimate of the variation, but the absolute value is much more uncertain. ¹⁾ e.g. increase m2/dwelling included

9.4 Synthesis and interpretation of results

9.4.1 Comparison of results from the different methods

The three different methods Tier 1, Tier 2, Tier 3 provide results which are diverging for the various reasons mentioned above. Tier 1 and 2 diverge for the residential sector due to the fact that Tier 2 disaggregates further comfort factors such as the increase in m² per dwelling. For the Commercial/Institutional sector the savings calculated are not significant. The Tier 3 methodology based on the detailed modelling of the building stock used as inputs for the MURE simulation model, which was investigated in the form of a simulation for an ex-post impact evaluation in the period 2004-2020, is more precise and less subject to annual fluctuations as for example the Tier 1 or 2 approaches due to the imperfect climatic corrections in those approaches which are amplified by considering the difference between the counterfactual and the actual development. With the Tier 3 methodology and the MURE simulation model approach there is nevertheless a rather good evaluation scheme in place, at least for the residential sector, with the main weak point of the assessment being insufficient data on the compliance with building regulation. In order to improve the quality of the evaluation in the future such information must be provided by sampling. For the Commercial/Institutional sector, there is still a lack of basic data, especially on heated surfaces and the types of heating systems in order to carry out a reliable Tier 3 evaluation.

9.4.2 Comparison of impacts across Member States

The impact of the EPB Directive across Member States differs significantly in the different methods. Generally, In Tier 1 and 2 methodologies the impact of imperfect correction of climatic variations becomes larger, the smaller the geographic region, given the slow path with which more efficient buildings are penetrating to building stock. Averaging the results over several years in order to smooth out the fluctuations becomes the more important. Only after 10-15 years, when the cumulated impacts become larger, Tier 1 and 2 methodologies will be less influenced by the fluctuations.

Table 9-9 CO2 Savings in Tier 1 methodologies for the EPBD (2002-2006)**Tier 1 Analysis (Based on average member state fuel mix; EU emission factors)**

Residential Sector	Savings per year MtCO2					Cumu- lative	Average annual
	2002	2003	2004	2005	2006		
EU-27	3,9	14,0	20,4	21,9	17,4	77,6	15,5
EU-15	-0,4	2,0	8,6	9,2	9,3	28,8	5,8
Austria	-0,18	-0,40	0,59	0,32	0,53	0,9	0,2
Czech Republic	0,61	0,59	0,73	1,75	-0,37	3,3	0,7
Denmark	-0,05	0,11	0,24	0,35	0,43	1,1	0,2
France	-2,66	-0,32	0,28	2,54	0,50	0,3	0,1
Germany	-0,54	3,49	9,11	7,36	0,26	19,7	3,9
Italy	1,45	5,48	3,73	6,87	8,15	25,7	5,1
Netherlands	0,35	0,70	1,13	1,24	1,16	4,6	0,9
Poland	1,24	3,87	3,78	1,35	-1,49	8,8	1,8
Romania	-0,60	-0,77	-1,03	-0,92	-0,96	-4,3	-0,9
Spain	-0,44	-0,72	-0,50	-0,80	-1,13	-3,6	-0,7
UK	-0,48	-1,10	-1,83	1,17	2,85	0,6	0,1
Service Sector							
EU-27	2,7	-3,0	-0,7	2,8	4,4	6,2	1,2
EU-15	2,2	-4,0	1,2	1,8	3,5	4,7	0,9
Austria	-0,30	-0,85	0,42	0,67	0,55	0,49	0,03
Czech Republic	-0,01	-0,68	-0,81	0,02	0,56	-0,92	-0,05
Denmark	-0,02	-0,07	-0,07	-0,05	-0,07	-0,29	-0,02
France	0,88	-1,65	-0,35	-0,35	0,49	-0,98	-0,06
Germany	1,61	0,62	1,68	2,96	1,79	8,66	0,51
Italy	0,56	-1,23	0,25	-1,12	-2,88	-4,41	-0,26
Netherlands	-0,35	-0,68	-0,25	0,89	-0,33	-0,71	-0,04
Poland	-1,80	-2,36	-2,07	-1,44	-1,19	-8,86	-0,52
Romania	0,46	0,13	-0,45	-0,40	-1,22	-1,47	-0,09
Spain	-0,08	0,94	1,24	0,94	1,91	4,95	0,29
UK	0,64	1,23	0,43	1,08	1,46	4,84	0,28

Note: Negative values represent in theory "dis-savings". In practice they imply structural changes which are not separated. In the Tier 1 methodology this is for example the increase in the size of residential buildings.

Table 9-10 CO₂ Savings in Tier 2 methodologies for the EPBD (2002-2006)

Tier 2 Analysis (Based on average member state fuel mix; MS emission factors)							
	Savings per year MtCO₂					Cumu-	Average
Residential Sector	2002	2003	2004	2005	2006	lative	annual
EU-27	11,3	31,6	37,6	40,3	35,8	156,5	31,3
EU-15	4,3	16,9	22,0	25,3	19,2	87,8	17,6
Austria	0,18	0,59	1,76	1,57	1,88	6,0	1,2
Czech Republic	1,14	2,13	3,12	4,41	3,12	13,9	2,8
Denmark	-0,29	0,07	0,29	0,59	0,61	1,3	0,3
France	0,96	3,66	4,77	6,23	8,76	24,4	4,9
Germany	0,63	11,18	17,08	15,76	8,54	53,2	10,6
Italy	0,93	1,26	2,18	-0,38	-1,79	2,2	0,4
Netherlands	0,34	1,19	1,41	1,78	2,06	6,8	1,4
Poland	7,07	12,36	12,75	9,70	5,81	47,7	9,5
Romania	0,41	1,12	1,89	2,27	2,28	8,0	1,6
Spain	-	-	-	-	-	0,0	-
UK	5,14	3,25	1,05	7,25	11,17	27,9	5,6
Service Sector							
EU-27	-	-	-	-	-	0,0	-
EU-15	0,2	-10,2	-7,5	-12,6	-13,6	-43,6	-8,7
Austria	-	-	-	-	-	0,0	-
Czech Republic	-	-	-	-	-	0,0	-
Denmark	-0,10	-0,10	-0,09	-0,01	-0,10	-0,4	-0,1
France	-1,32	2,24	0,94	0,46	-1,40	0,9	0,2
Germany	-	-	-0,23	-	-	-0,2	-0,2
Italy	-	-	-	-	-	0,0	-
Netherlands	-	-	-	-	-	0,0	-
Poland	-	-	-	-	-	0,0	-
Romania	-	-	-	-	-	0,0	-
Spain	-	-	-	-	-	0,0	-
UK	2,37	2,48	1,76	-	-	6,6	2,2

Note: Negative values represent in theory "dis-savings". In practice they imply structural changes which are not separated. In the Tier 2 methodology this is for example the increase in internal room temperature and the length of the heating period due to comfort increase.

Table 9-11 (Direct and indirect) CO₂ Savings in Tier 3 methodologies for the EPBD (2004-2020; only residential sector)

Tier 3 Analysis (Based on detailed simulation of building stocks)								
Savings per year MtCO ₂								
Mt CO ₂	CO ₂ emissions with Compliance Factors (partial compliance with regulation)				CO ₂ emissions without Compliance Factors (full compliance with regulation)			
Residential Sector	2004	2010	2015	2020	2004	2010	2015	2020
AT	0,0	0,2	0,5	0,8	0,0	0,6	1,0	1,3
CZ	0,0	0,8	1,0	1,2	0,0	1,4	2,0	2,4
DE	0,0	7,4	11,0	14,4	0,0	11,8	16,3	19,8
DK	0,0	0,2	0,3	0,4	0,0	0,3	0,5	0,6
ES	0,0	1,0	1,5	1,9	0,0	1,7	2,4	2,9
FR	0,0	2,4	4,4	6,9	0,0	4,6	7,2	10,0
IT	0,0	2,0	3,2	4,2	0,0	4,2	6,4	8,0
NL	0,0	0,2	0,6	0,9	0,0	0,7	1,2	1,5
PL	0,0	1,3	2,1	3,0	0,0	2,8	4,4	5,8
UK	0,0	2,1	3,6	4,9	0,0	4,1	6,0	7,6
Total 10 countries investigated	0,0	17,7	28,1	38,7	0,0	32,1	47,2	59,7
EU-27	0,0	22,0	34,9	48,0	0,0	39,8	58,5	74,0
Service Sector	2004	2010	2015	2020	2004	2010	2015	2020
AT	0,0	0,1	0,1	0,2	-	-	-	-
CZ	0,0	0,1	0,2	0,2	-	-	-	-
DE	0,0	0,6	1,1	1,6	-	-	-	-
DK	0,0	0,0	0,1	0,1	-	-	-	-
ES	0,0	0,2	0,3	0,4	-	-	-	-
FR	0,0	0,2	0,5	0,8	-	-	-	-
IT	0,0	0,4	0,6	0,8	-	-	-	-
NL	0,0	0,1	0,2	0,2	-	-	-	-
PL	0,0	0,2	0,4	0,6	-	-	-	-
UK	0,0	0,2	0,5	0,8	-	-	-	-
Total 10 countries investigated *	0,0	2,0	3,9	5,6	-	-	-	-
EU-27 (useful energy only)*	0,0	2,4	4,8	6,9	-	-	-	-
EU-27 (estimate with heating systems included)*	0,0	7,3	11,6	16,0	0,0	13,3	19,5	24,7

* only from savings on the building envelope (useful energy). Data on heating systems are not included due to data gaps. In useful energy terms service sector savings present 33% of residential savings on useful energy. Hence they may also present 33% of the residential sector emissions including savings on the heating systems if one assumes similar heating efficiencies for the service sector.

9.4.3 Comparison with alternative estimates

ADEME (2005) estimates in an ex-post analysis for the period 1990-2000 in the EU15 that around 22 Mt CO₂ had been saved in the residential buildings. In an ex-ante analysis they estimate that the savings may reach 55 Mt in the EU15 by 2020 which is in a comparable range with the partial compliance results presented for the Tier 3 approach.

Also at the national level impact studies exist. For example in Germany various studies and analyses exist with respect to the analysis of climate change policies and measures at national level such as the Policy Scenarios IV⁶⁶ from 2008. These studies evaluated the emission reductions due to national building regulation, which are considered, however, mainly from the national perspective. For Germany for 2020 savings of 4.8 Mt CO₂ from national building regulation including certification were estimated assuming no further tightening of the regulation. If the regulation were further tightened and compliance were further improved to realise larger potentials an additional 12 Mt appear feasible by 2030. These results appear more modest compared to the maximum estimates obtained in the Tier 3 projections which may be estimated at around 25 Mt for 2020 (including residential and service sector buildings). In order to better understand the differences it is, however, necessary to compare carefully assumptions and the delimitation of the measures.

⁶⁶ www.umweltdaten.de/publikationen/fpdf-l/3361.pdf

9.4.4 Comparison with ex-ante results

The second ECCP progress report (EC 2003), based on the results of the ECCP Working Group on 'Energy efficiency and end-use equipment and industrial processes', estimates for the EPBD in the EU15 an impact of 35 – 45 Mt of CO₂ savings. These results are comparable with the estimates derived from applying the Tier 1 and Tier 2 methods. However, as described above the Tier 1 and Tier 2 estimates use incorrect assumptions with respect to the implementation of the EPBD in Member States. A more realistic estimate is provided by the Tier 3 approach, which estimates more limited progress in delivering emissions reductions.

Table 9-12 Comparison of ex-ante and ex-post results: Energy Performance of Buildings Directive

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
Energy Performance of Buildings (Dir 2002/91/EC)*	35 - 45	83.8 (EU27, 2006) 33.5 (EU15, 2006)	156.5 (EU27, 2006) 44.2 (EU15, 2006)	0.0/31.7 (EU27, 2004/2010) 0.0/26.9 (EU15, 2004/2010)

The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:

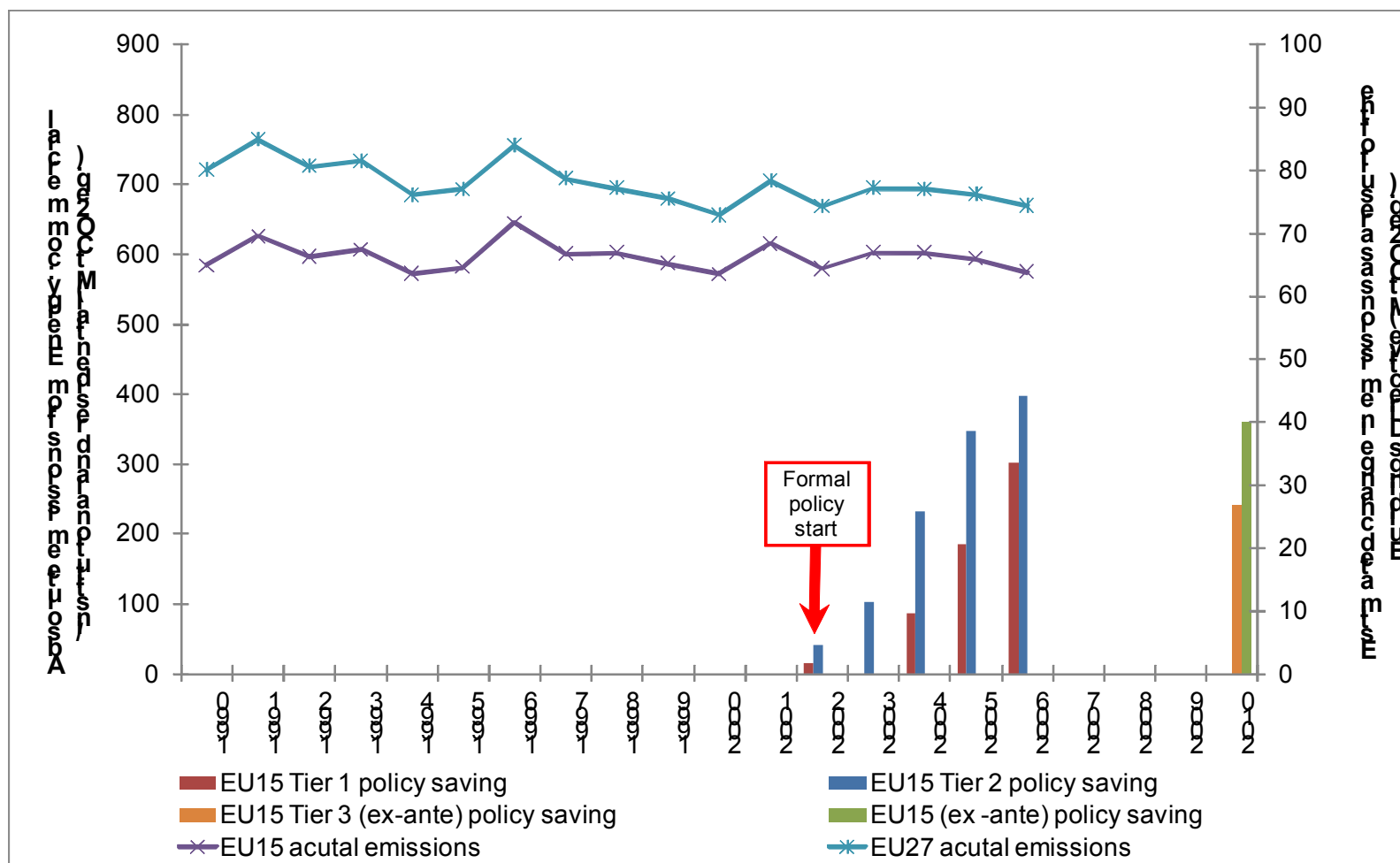
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices

Abbreviations:

MSsp: Member State specific starting year for the ex-post evaluation
NE = not estimated

Notes:

* T1/T2 results under the assumption that the EPBD has already produced impacts starting 2002. T3 makes the more realistic assumption that impacts will only start in 2008 taking into account delays in the implementation of the EPBD.

Figure 9-12: Energy Performance Directive for Buildings EPBD: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

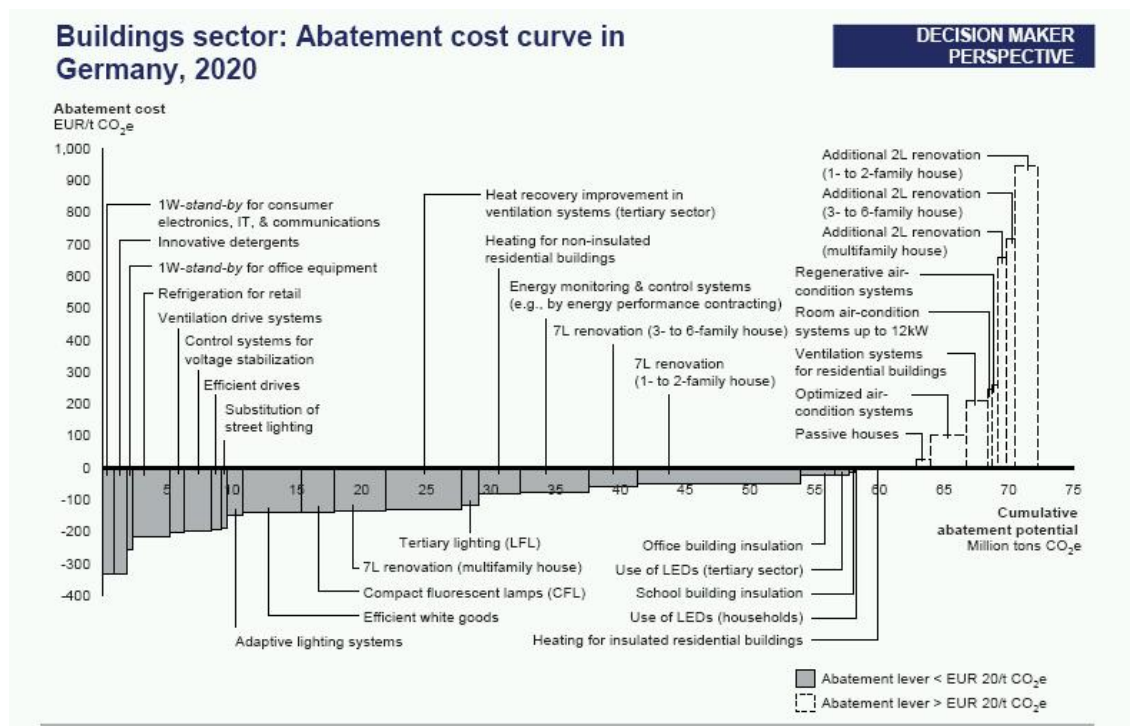
Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above.

Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

9.4.5 Cost effectiveness

Generally savings on buildings envelopes belong to the most cost effective options to avoid CO₂ emissions, although very performing buildings may still come at a positive cost. As an example we illustrate this with a study published by McKinsey in 2007 for Germany (Figure 9-13). Similar results have been obtained in studies by Fraunhofer ISI⁶⁷.

Figure 9-13: Abatement costs for the building sector in Germany for 2020.



Source: McKinsey (2007), <http://www.mckinsey.com/client-service/ccsi/costcurves.asp>

Learning curves

Learning curves, also known as experience curves, depict experience-driven cost reductions over production levels for the future. This aspect is important in order to judge about the improvement in cost effectiveness over time. A study by Jakob and Madlener (2002) analysed the development of refurbishment costs in Switzerland over 25 years, from 1975 until 2000 (

⁶⁷ <http://www.kliminvest.net/download/endbericht.pdf>
<http://www.umweltdaten.de/publikationen/fpdf-l/3517.pdf>
<http://www.isi.fhg.de/n/e-projekte/e-ikep-makro.html>

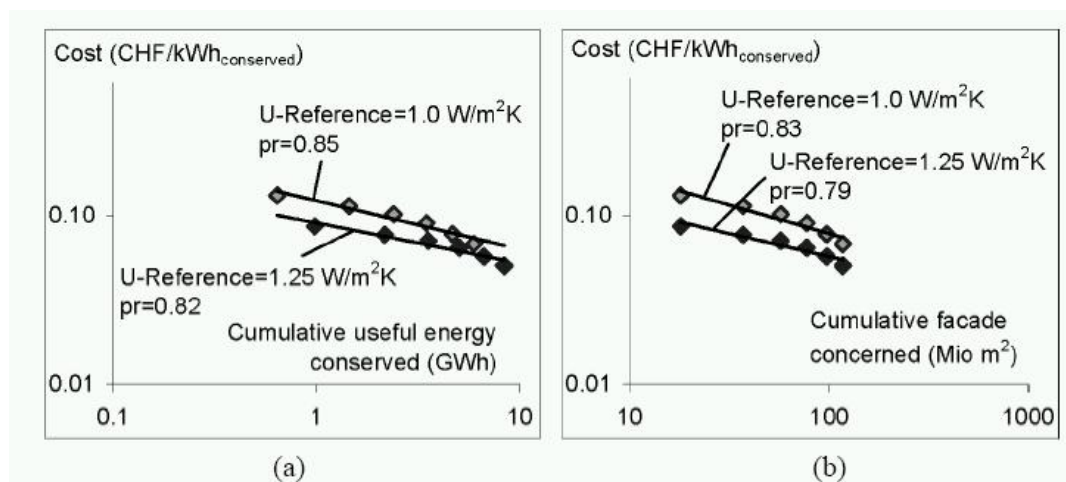
Figure 9-14 and Figure 9-15) and found out, that experience-curves are in fact not used efficiently in public policy respectively have seldom influence on it, in order to determine performances of energy-efficient technologies in the market.

Figure 9-14: Cost of window manufacturing in 1970 and in 2000, nominal and real (U-value 1970 approx. 2.5-3.0 W/m²K; 2000 approx. 1.3 W/m²K), expressed in CHF/m² standard window.

	Glass	Material, coating	Window manufacturing	Assembly incl. transport	Calculated contribution margin	Total
1970						
nominal	150	70	120	60	80	480
real ¹	202 ²	94 ²	135 ³	80 ²	90 ³	601
2000	100	100	80	80	90	450

¹Real 2000 prices;
²Adjusted with the Swiss producer price index for the manufacturing industry;
³Adjusted with the average price index for the construction of residential buildings.
Source: [3], data obtained from an interview with a representative of SZFF (Schweizerische Zentralstelle für Fenster- und Fassadenbau), Dietikon/ZH.

Source: M. Jakob (2004)

Figure 9-15: Experience curves for facades, using different output categories: (a) cumulative useful energy conserved, (b) cumulative area of facades insulation applied 8in logarithmic scales)

Note on Progress ratio: cost decrease in case of doubling of cumulative output

$$pr = c \cdot (2Y_{cum})^b / c \cdot Y_{cum}^b = 2^b$$

Source: M. Jakob (2004)

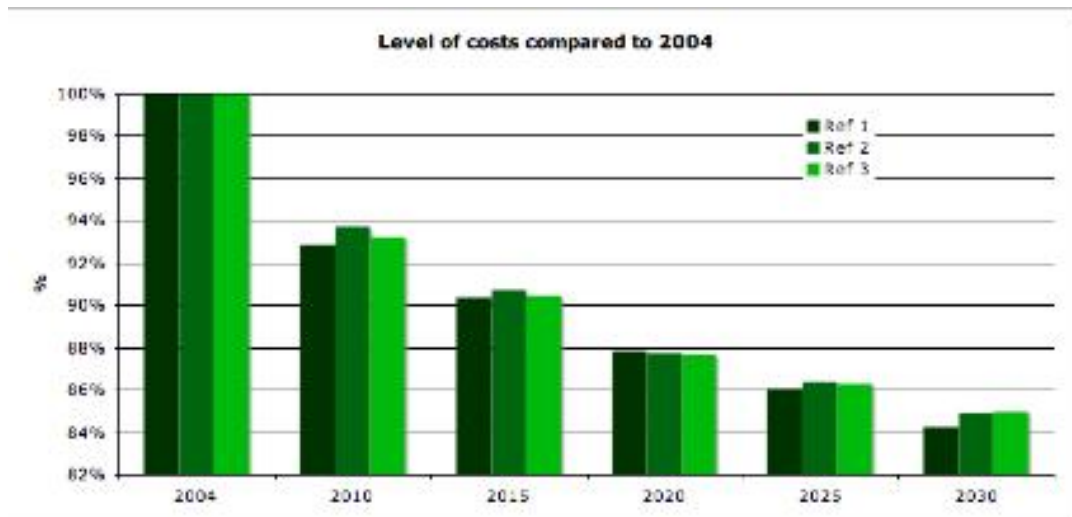
It is important to know that such curves are not easy to determine precisely because each specific region uses different materials to refurbish buildings and its transfer from one country to another is limited. This limit exists, because of different climate conditions and different performance of building codes and standards in each country or region. The results of the study which has been conducted by Jakob and Madlener can be applied in a similar way to other countries.

Why can we expect reduced costs in the future despite increasing U-values for surface components and better insulation standards? This result is based on the economies of scale and scope. They originate from a reduction of costs because of increasing production levels; fixed costs are lower per unit of produced products. Therefore, learning curves are relating to decreasing production costs. Furthermore, these curves are referring to the fact that skilled workers are better educated and the larger production volumes reduce the time to convert work habits and enhance speed. Especially in

the construction sector cost degradation in energy efficiency measures results from the use of pre-fabricated components and other progress.

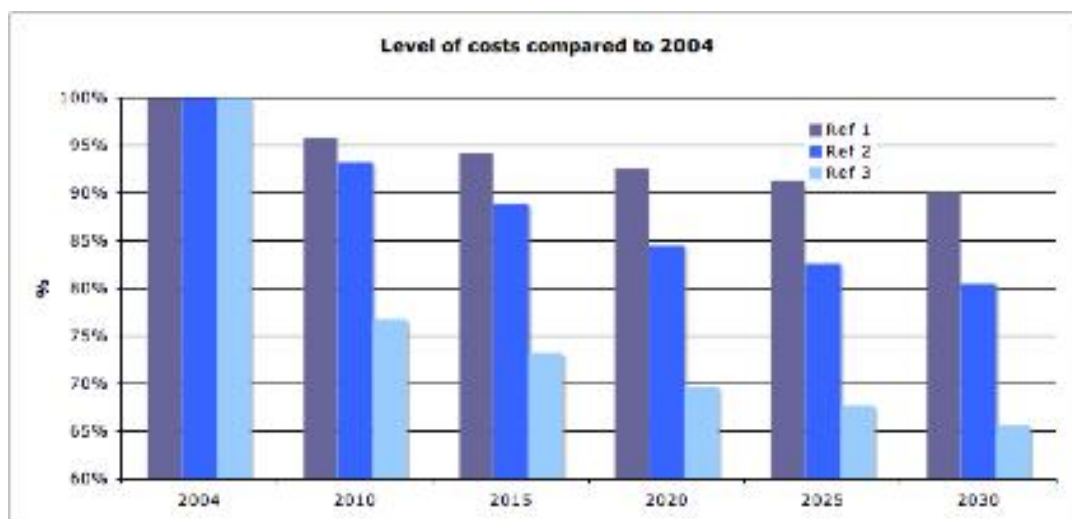
Figure 9-16 to Figure 9-17 give an overview of expected learning curves for roofs, facades and floors respectively windows from 2004 to 2030 according to experiences from Jakob and Madlener's study (ESD Potential Study 2009).

Figure 9-16: Learning curves for roof, façade and floor insulation



Source: WI calculations in ESD Potential Study (2009) based on Jakob et al. (2002)

Figure 9-17: Learning curves for efficient windows



Source: WI calculations in ESD Potential Study (2009) based on Jakob et al. (2002)

It highlights the fact that learning effects by skilled workers and technical development of better insulation materials could reduce costs for the insulation of facades, roofs and floors as well as for windows. In the case of windows it was observed that the price of double glazing windows decreased by more than a factor of two, despite technical progress and a reduction of the U-value. For example, costs for the refurbishment of roofs as well as of facades and floors are reduced by 16 % by 2030 for the energetic standard of Ref 1 and 15 % for Ref 2 and 3.

As already mentioned, the effect of learning curves is even more noticeable in the production of windows. Jakob and Madlener highlighted that over 25 years the costs of the most effective window have been reduced by 34 %. Taking into account that from 2004 until 2030 26 years will pass by, it is suggested that low-emission triple glazing, which are used for passive and low-energy houses and are comparable with the energetic standard of Ref 3 and New 3/4, will be even more cost-effective in the future and reduce their costs by 34 %. There are already existing vacuum insulation-glass windows

with this high energetic standard. Figure 9-17 shows the reduction of costs for Ref 1 and Ref 2 in the coloured columns.

9.5 Conclusions

The different tiered methodologies discussed in this chapter deliver results for the sum of the residential and service sector in the EU27 which differ substantially among each other. These differences are explained by methodological differences and data issues:

- Assumptions on the start of the policy impacts: Tier 1 and 2 approaches assume an immediate start of the impacts in 2002, the year when the EPBD was accepted. (There are some arguments in support of this: the EPBD is an important EU policy and had some effect on national legislation before it was translated into all MS to national regulation). The Tier 3 approach takes into account the implementation delays and thus models the EPBD impacts only in the period 2004-2020, assuming that the main impacts of the EPBD are still in the future.
- Inclusion of comfort factors: Factors such as increased square metres per building (Tier 1 approach), compared to Tier 2 and 3 approaches which make the comfort increase explicit and do not include them into the impact estimate.
- Overlap with national support policies for buildings
- Non-compliance issues: These are included automatically in Tier 1 and 2 approaches while non-compliance with building regulation is made explicit in the Tier 3 approach.
- Assumptions on autonomous progress/previous policies: In the Tier 3 approach autonomous progress/previous policies are modelled explicitly by considering the penetration of buildings complying with the previous building regulation. For Tier 1 or 2 approaches this is included by assuming a progress factor. For the residential sector an annual improvement of 0.5% was chosen for the period 1990-2002.
- Imperfection of climatic correction: Tier 1 and 2 use a statistical approach that doesn't use averaging over several years. Therefore for smaller countries and in early stages of implementation when savings are still small, the fluctuations in the impact results may be considerable.
- Differences in emission factors for electric heating: This factor is only important for countries with a high proportion of electric space heating or a high proportion of district heating.

The size of the possible CO₂ savings indicates that by 2020 the EPBD could be one of the largest impacts to ECCP policies if its implementation is enforced.

9.6 Recommendations

The evaluation has shown three important points for discussion for further evaluations:

- 1 Decisions have to be made whether **comfort increasing factors** such as m² per dwelling are to be included in the impact evaluation result (as in Tier 1) or excluded from the results (as in Tier 2 or 3). We believe that it is more appropriate to exclude them from the result but to explain them separately. However, a variety of comfort factors such as increasing internal room temperatures are difficult to separate due to lacking data.
- 2 **The supposed start of the impacts due to the EPBD** has a large influence on the final results. Tier 1 and 2 approaches suppose an immediate impact even if the regulation is formally delayed in many MS, at least in some aspects such as the implementation of certification schemes. Tier 3 assumes that the observed delays are important for the final impacts. Both approaches have arguments for them (see **Error! Reference source not found.**).
- 3 **Non compliance** is a critical factor for the results and it should be considered how knowledge on this factor can be improved and how the important non-compliance in many MS (as can be judged from the scarce data available) can be reduced in further tightening of the EPBD.

9.7 Next steps

The most important next concrete steps to be carried out in order to improve on the evaluation methodologies for the EPBD are:

- The **data basis which is available for the evaluation of the Directive** in the service sector is bad in many countries of the EU27. Approaches to improve this situation exist, mainly in the form of suitable surveys of buildings in this sector. In Germany for example, such an approach is followed every 3 years in combination with private market research institutes like GfK. The lack of data hampers especially the more detailed Tier 3 approach.
- **Non-compliance with building regulation** has a large impact on the evaluation results but is largely unknown for both the residential and the service sector. This issue deserves to be investigated more carefully in field studies to improve knowledge.
- The issue of **data averaging for the Tier 1 and 2 approaches** which is necessary due to imperfect corrections for climatic variations must be further investigated.

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10 Case study: Labelling Directive for Electric Appliances

10.1 Introduction

10.1.1 Overview of policy

The EU Directives on appliance labelling

Council Directive 92/75/EEC of 22 September 1992⁶⁸ on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances aimed to harmonise national measures on the labelling and product information regarding the consumption of energy in order to allow consumers to choose the most energy efficient appliances. From 1992 up to today 8 implementing Directives⁶⁹ have been adopted (Table 10-1) which regulate the labelling specifications for each product types and some of which have been updated during these years. The Directives are applied to the following types of products:

- refrigerators, freezers and their combinations
- washing machines, dryers and their combinations
- dishwashers
- ovens
- water heaters and hot water storage appliances
- lighting sources
- air conditioning appliances

Strictly related to the label legislations are the two Directives establishing minimum efficiency requirements for ballasts for fluorescent lighting and for household electric refrigerators, freezers and combination⁷⁰. Through an amendment these Directives have become the first implementing measures of the recently adopted Directive Eco-design of Energy Using Products (EuPs)⁷¹ that provides a coherent EU-wide rules for eco-design. The Eco Design Directive does not introduce directly binding requirements for specific products, but establishes a framework of condition and criteria that need to be respected by the implementing measures (to be issued) for the setting of eco-design requirements for energy-using products. Since 2007, The Commission has established a working plan in order to set out for the following three years an indicative list of product groups which will be considered as priorities for the adoption of implementing measures.

The transposition of the EU Labelling Directives into the national legislation

As shown in Table 10-1, all the 27 MS have transposed either partially or completely the EU Directives related to labelling and to energy efficiency minimum requirements into their national legislations. The Table refers to the year when the Directives have been firstly transposed into national legislation and does not show the transposition of the amendments afterward issued for some of them⁷².

68 Council Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances Official Journal L 297 of 13.10.1992

69 Energy Labelling of Household Electric Refrigerators, Freezers and their Combinations (Directive 2003/66/EC amending Directive 94/2/EC), Energy Labelling of Household Washing Machines (95/12/EC amended 96/89/EC), Energy Labelling of Household Electric Tumble Driers (95/13/EC), Energy Labelling of Combined Washer Driers (96/60/EC), Energy Labelling of Household Dishwashers (97/17/EC amended 99/9/EC), Energy Labelling of Household Lamps (98/11/EC), Energy Labelling of Household Air-conditioners (2002/31/EC), Energy Labelling of Household Electric Ovens (2002/40/EC).

70 Fluorescent lighting Directive 2000/55/EC and Household electric refrigerators, freezers and combinations Directive 96/57/EC

71 Directive 2005/32/EC of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council - Official Journal L 191 , 22/07/2005

72 Source: Mure Database

Table 10-1 points out that the first wave of implementing measures of the Directive 92/75/EEC related to large appliances (i.e. refrigerators, freezers and their combination, washing machines, electric tumble driers) has been adopted during the timeframe 1995-1997 and transposed in the old Member States (EU15) either at the end of the period 1994-1996 or the beginning of the period 1997-2000. During the 2001-2004 timeframe most of the new European Members States (EU12) have transposed the 'package of European Labels Directives' which by then included as well the implementing Directives regarding Dishwashers, Air conditioners, Electric ovens adopted at European level between the 1999 and the 2002. These last directives have been implemented by the old Member States during the same time span (2001-2004). The two appliance groups of freezers, refrigerators and their combinations, and of the lighting system have been regulated in more stringent way by both the Labelling Directive and the minimum efficiency requirements Directives. Overall it is possible to point out that the deadlines for transposition of the Labels Directive have been respected by most of the EU Member States and as the full implementation of the Directives in the 27 MS took place mainly during in the period of 2001-2004.

Member States are required to communicate to the Commission about the main provisions of domestic law which they adopt in the field covered by this Directive. Otherwise, there are no particular requirements for EU Member States to report in the implementation of the Labelling Directive nor are there regular statistical investigations on the shift in the labelling classes triggered by the Directive.

Table 10-1: Countries that have implemented the EU Directives by yearly intervals⁷³

	1994- 1996		1997- 2000		2001-2004		2005-2008	
	Number of countries	Countries	Number of countries	Countries	Number of countries	Countries	Number of countries	Countries
Refrigerators, Freezers and their Combinations (94/2/EC)	11	AT, DK,FR,NL,RO,SP, SE, BE, EL,PT, UK	2	IT, DE	8	CY, CZ,EE, HU, LV,MT,SK,SI	2	BG, PL
Washing Machines (95/12/EC)	1	FR	11	AU, BE, DK, DE, EL,IT, NL, PT, SP, UK, CZ	8	CY,EE, HU, MT, RO, SK, SI, LV	2	BG, PO
Electric Tumble Driers (95/13/EC)	9	AU, DK,FR, DE, EL, NL, PT, SP, SE	2	BE, IT	10	CY,CZ,EE,HU, LV, MA,PL,RO,SK,SI,	1	BG
Washer Driers (96/60/EC)	3	AU,FR, NL	9	BE,DK,DE,EL,IT, PT,SP,SE,UK	11	CY, CZ, EE, HU, LV, LT, MT, PO, RO, SK, SI	1	BG
Dishwashers (97/17/EC)	1	FR	8	AU, BE, FI, DE, IT, NL, PT, SP	10	CY, CZ, EE, HU, LV, MT, PL, RO, SK, SI	1	BG
Air-conditioners (2002/31/EC)					22	AU, BE, CY, CZ, DK, EE, FI, DE, EL; HU, IT, LV, LU, MT, NL, PT, RO, SK, SI, SP, SE, UK	2	BG, PL
Energy Labelling of Household Electric Ovens (2002/40/EC)					22	AU, BE, CY, CZ, DK, EE, DE, EL; HU, IT, LV, LU, MT, NL,PL, PT, RO, SK, SI, SP, SE, UK	1	BG
Minimum standards for Refrigerators, Freezers (Directive 96/57)			15	AU, BG, CZ, DK, FI, FR, AL, IE, LT, NL, PT, RO, SP, SE, UK,	7	CY, EE, HU, MA, PT, SK, SL		
Energy Labelling of Household Lamps (98/11/EC)			6	AU, BE, FR, DE, SP, UK	11	CY, CZ; EE, HU, LV, NL, PL, PT, RO, SK, SL	1	BG
Energy efficiency requirements for ballasts for fluorescent lighting (00/55/EC)					20	AU, BE, CY, CZ, EE, FR, DE, EL, HU, IE, IT, LT, MT, NL, PT, RO, SK, SL, SP, SE	2	BG, PL
	Number of countries	Countries	Number of countries	Countries	Number of countries	Countries	Number of countries	Countries
	1994- 1996		1997- 2000		2001-2004		2005-2008	

- The main national measures interacting with the labelling directives were national support measures, mainly subsidies.
- The (indirect) interaction between demand side measures and the EU ETS is discussed in a separate case study on the EU ETS
- White certificate schemes are relevant so far only for the UK, France and Italy. Most impact was observed in the UK. The mechanism was however similar to subsidy schemes, and hence is included in the evaluation of national support schemes to the labelling directive.
- Electricity taxes as for example in Germany have had little impact on consumer choices so far, given the low tax rates applied.

⁷³ Information regarding Finland Luxembourg, Lithuania was not available and information regarding Greece, Ireland, United Kingdom, Sweden and Denmark is not complete.

Table 10-2 maps the different policies that may interact with the Labelling Directives. However, a variety of them can be excluded by a screening process:

- The main national measures interacting with the labelling directives were national support measures, mainly subsidies
- The (indirect) interaction between demand side measures and the EU ETS is discussed in a separate case study on the EU ETS
- White certificate schemes are relevant so far only for the UK, France and Italy. Most impact was observed in the UK. The mechanism was however similar to subsidy schemes, and hence is included in the evaluation of national support schemes to the labelling directive.
- Electricity taxes as for example in Germany have had little impact on consumer choices so far, given the low tax rates applied.

Table 10-2: Measure mapping of the Appliance Labelling Directive

MEASURE	TARGET	GOAL FOR TOP-DOWN IMPACT
ECCP1 Labelling Directives + Minimum Efficiency Standards Implementing labelling directives for various appliances Minimum standards for appliances	(Indirect) GHG emissions of large electric appliances	20% improvement in energy efficiency
EU ETS Phase 1 (2005-2007) Phase 2 (2008-2012) Phase 3 (2013-2020) (proposed)	GHG emissions of large installations from energy and industry	20% improvement in CO ₂ emissions
Complementary national measures Mainly support schemes for efficient appliances (see below) White certificate trading schemes (including obligations on energy suppliers/distributors) Electricity taxes Information and awareness campaigns	Final energy Final energy Final energy Final energy	

MS facilitating measures

The most important interacting measures are accompanying or facilitating measures. Along with the transposition of the Labelling Directives, 11 countries have decided to reinforce the market transformation effect of these directives with the establishment of 'accompanying or facilitating measures'.

For most cases, these measures consist in subsidies or rebates granted to citizens and directed to foster the renewal of old appliances and to support the purchase of highly efficient appliances labelled A/A+ or compact fluorescent lamps.

Table 10-3 shows for each of the MS that have issued this type of measures the titles of the measures itself, the issuing year and the instruments chosen for their implementation.

Table 10-3: Facilitating Measures for the EU Labelling Directive at national level

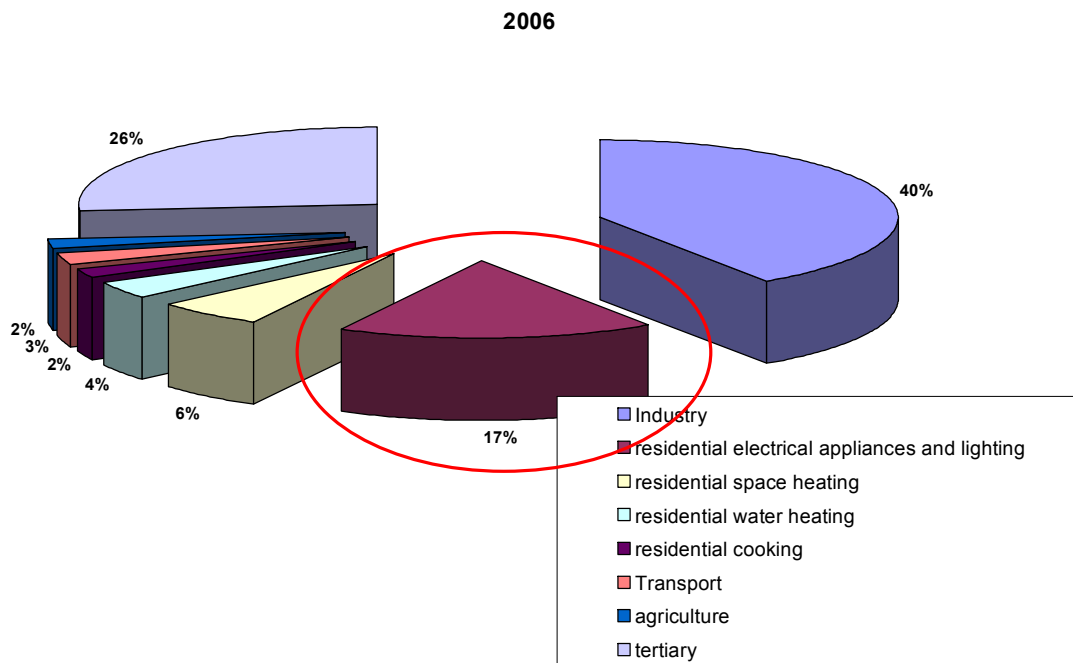
	Facilitating Measures: Main Instruments
Cyprus	Scheme for subsidising CFL lamps (2007): free distribution of CFLs lamps to the households (up to 6 lamps/household)
Denmark	Electricity Saving Trust (1997 - 2008): Information, Issuing of consumers guidelines
Germany	Program for introducing new, highly efficient household appliances to the market: Subsidies to very efficient household on the basis of the "Top Runner Strategy" (Measure proposed)
Italy	Financing Laws 2007 & 2008: Tax Subsidies for the purchase of A+ (or better) models.
Malta	Rebates on investments in energy efficiency by domestic consumers (2007): subsidies for the purchase of A (or better) models (rebate on the purchase price)
The Netherlands	The energy premiums scheme (1999 - 2003): subsidies for the purchase of A (or better) models
Romania	The promotion of the use of energy-efficient household electrical appliances (proposed): subsidies for the purchase of an appliance with an A/A+ label.
Spain	Action Plan 2005 - 2007 and 2008 - 2012: subsidies to the households to replace the "D" appliances with the A (or better) ones.
Slovenia	Stimulation of the investments in energy efficiency measures in households: subsidies for the purchase of CFLs (1996) and efficient appliances (2008)
UK	Energy Efficiency Commitment: mainly addressed to energy suppliers that are required to achieve targets for the promotion of energy efficiency improvements in the household sector. Tax rebates are also foreseen for low income households

10.2 Emission trends and drivers

10.2.1 Impact upon greenhouse gas emissions

Since electric appliances use electricity the related emissions are part of the power sector emissions. The emissions of this sector are reported in the chapter concerning the RES-E Directive. However, this is a fairly large category. Electric household appliances and lighting represents roughly 17% of the total final electricity consumption (

Figure 9-1). In the share of electric appliances roughly a good half of the electricity consumption can be attributed to the larger electric appliances which are subject to labelling, the other half to smaller appliances. This implies that only about 9% of the associated emission inventory categories are concerned by the Directive.

Figure 10-1 Share of electric appliances in total electricity consumption of the EU27 and hence in the CO₂ emissions from the electricity sector

10.2.2 Activity and emission trends

There two main drivers for the CO₂ emissions from electric appliances:

- One is the increase in the equipment rates of households (

Figure 10-2). For most appliances this has increased by 6-9% on average over the period 2006/1995, except for dishwashers which have increased by 50%

- The second is the increase in the number of households themselves (Figure 9-2) due to socio-economic changes in the society and rising incomes (Figure 9-3). In total the number of households has risen by 12% in the period 2006/1995.

As a sum, the consumption of electric appliances due to these drivers would have increased by a total of about 20% or nearly 1.5% annually on average (Figure 9-5). In fact, however, the consumption for large appliances and hence the CO₂ emissions remained fairly stable (Figure 9-4) and was largely compensated by the increase in efficiency.

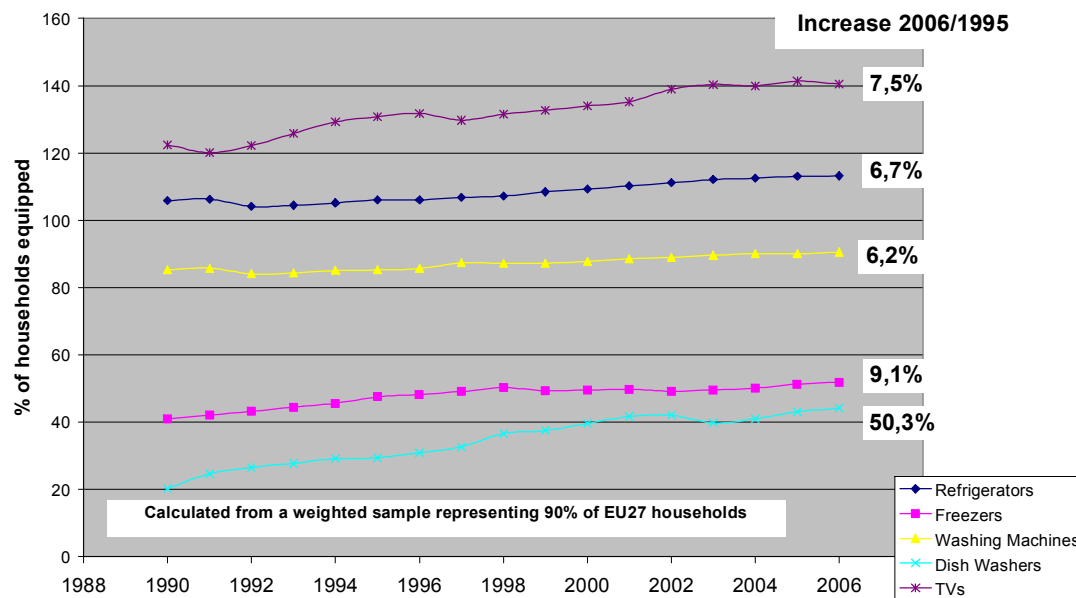
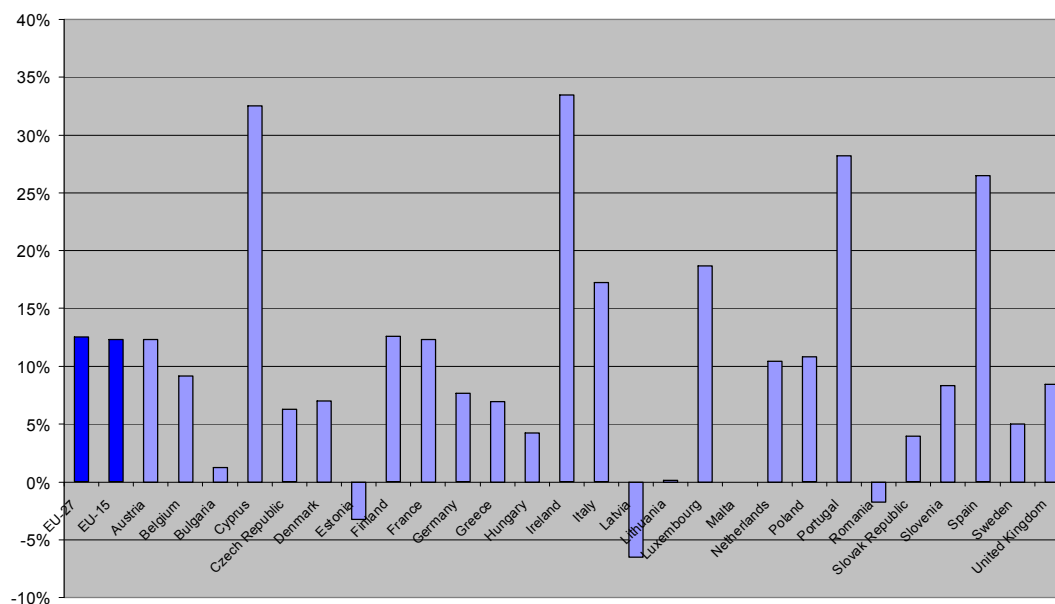
Figure 10-2 Development in equipment rates with electric appliances for the EU27).Source: Odyssee Database 2008 (www.odyssee-indicators.org)**Figure 10-3 Development in the number of households 2006/1995 (EU27).**Source: Odyssee Database 2008 (www.odyssee-indicators.org)

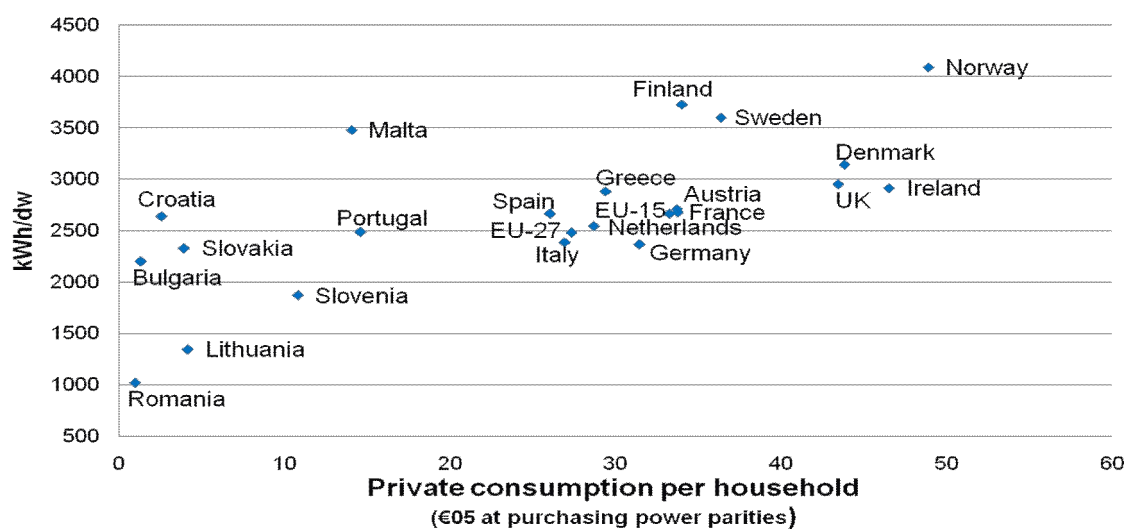
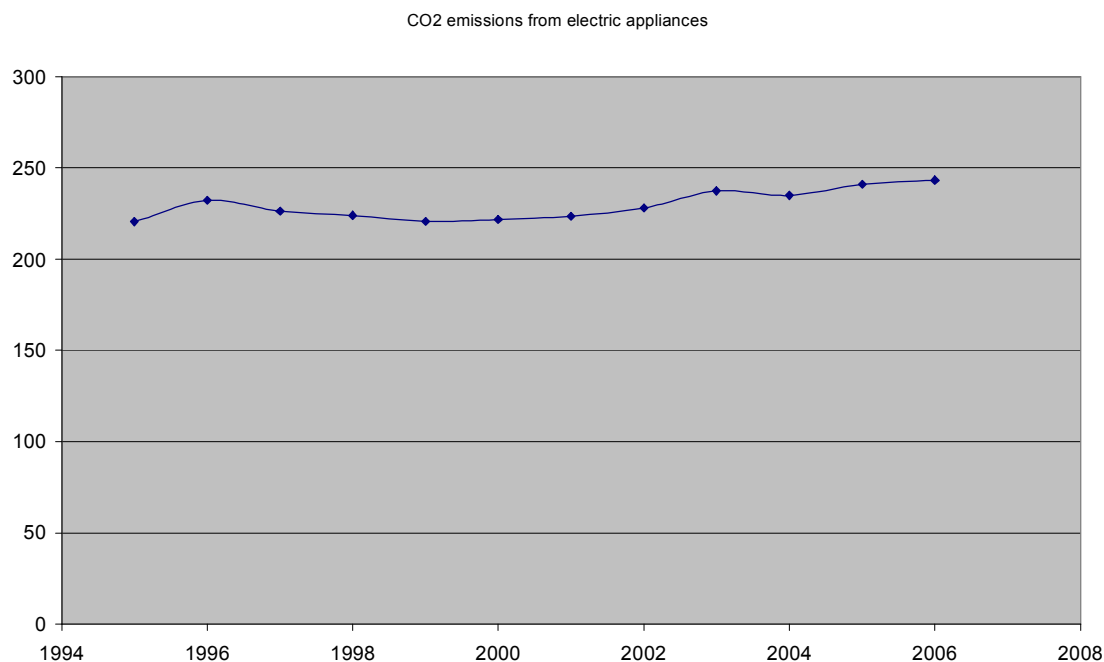
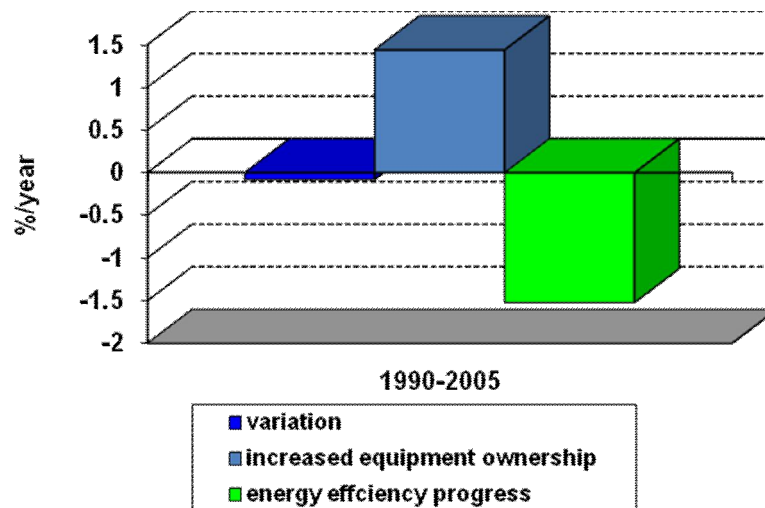
Figure 10-4 Electricity consumption of electrical appliances per dwelling and private consumption per households (2006)Source: Odyssee Database 2008 (www.odyssee-indicators.org)**Figure 10-5: Development of CO2 emissions from electric appliances (EU27)**Source: Odyssee Database 2008 (www.odyssee-indicators.org)

Figure 10-6: Variation of the consumption per dwelling for large appliances (EU27)

10.3 Impacts of the Labelling Directive on emissions of GHGs

This section summarises the results from the application of the methodologies to the appliance labelling case.

10.3.1 Overview of methodologies

The methodologies are described in detail in GHG-PAM (2008) Guidelines for the Ex-post impact assessment of ECCP Measures on the Member State level: Labelling of household appliances and in the Tier 3 report. They are summarised here. Table 10-4 shows the main differences between Tier 1, Tier 2 and Tier 3 methodologies with respect to the main factors of influence on the results of the impact evaluation.

Table 10-4 Key methodological choices Appliance Labelling Directive

Approach	Tier 1	Tier 2	Tier 3
Activity indicator	Number of households. ⁷⁴	Number of households and appliance ownership.	Number of appliances. ⁷⁵
Emission factor (g CO ₂ eq/kWh saved)	EU average	MS average	MS average fossil park/ hourly short-term marginal
Policy interaction (in particular synergy with national promotion schemes)	no	no	yes
Autonomous development (i.e. improvement of appliances in the pre-Directive period))	yes (at aggregated level)	yes (at appliance level)	yes (at appliance level)
Structural effects (e.g. adjustment for structural changes due to changes in ownership)	no	yes (if data allows for corrections)	yes (if data allows for corrections)
Geographic factors (e.g. adjustment for climatic variation for electric heating)	no	yes	yes
Timing issues / delay or announcement effects	Same start date	MS specific	MS specific
Other exogenous factors: impacts of commodity prices (electricity prices) but impact small	no	no	yes

Tier 1 – EU level

The assessment of the policy impact at Tier 1 level is based on Eurostat data (number of households as the activity indicators and overall electricity consumption for households). This approach does not separate individual appliances, nor does it split off electricity uses not concerned by the Labelling Directive (e.g. for electric heating, for electric water heating and small electric appliances). The methodology projects the indicator residential electricity consumption per dwelling from the period 1990-1995 up to 2006 and compares this baseline development with the actually observed development. The unit consumption of electricity per dwelling is typically increasing over the period considered although in some Member States this figure is also decreasing. No corrections are made for climate impacts on electric heating because data does not allow separation. Emissions from electricity saved are evaluated with an average EU emission coefficient including nuclear power plants.

Tier 2 – MS level

This approach is based on national data collected in the Odyssee Database (www.odyssee-indicators.org) in the frame of the Intelligent Energy for Europe Programme of the EU. These are unofficial statistics. It separates the main large appliances (appliance ownership data and unit consumption in terms of kWh/appliance/year) but does not make use of sales data or labelling classes.

No correction was made for autonomous progress. In principle this is possible by using data for the period before the introduction of the Labelling Directive, however, in reality for a variety of countries the time series are not long enough.

Emission factors are based on average MS emission from the power sector.

⁷⁴ Appliances not treated individually. No separation of appliances not subject to labelling.

⁷⁵ As Tier 2 but including sales data per appliance and data on split by efficiency class. Use of a stock model.

Tier 3 – Detailed calculations using the MURE stock model

Overall, the methodology for an ex-post analysis is as follows (for more details including on the stock model used, see Labelling Directive case study report on Tier 3 methodology):

1. The *energy impact* of the EU Directives concerning the cold and wash appliances has been calculated by using the *MURE appliance stock model*. Main data is the split in sales data by labelling class for the different appliances
2. We evaluate the impact of the EU Labelling Directives on the energy consumption a backcasting analysis was carried out starting in 1990 up to the year 2004. Within this period two different scenarios have been set up:
 - The *baseline scenario* that provides the energy consumption trends in the hypothesis that nor Labelling Directives neither other type of energy efficiency measures would have been implemented in the reference period.
 - The *Directives scenario* that furnishes the estimation of the energy consumption trends in accordance with the real appliances sales mix as provided by the GfK market panels.

It is obvious that, in this exercise, the main and critical role is plaid by the baseline scenario, being the Directive scenario rather straightforward. In this framework our choice has been to freeze the unitary energy consumption of the analysed appliances at the value they had achieved in the year 1990, in accordance with the estimations provided for this year by a CECED study⁷⁶. In principle a correction for autonomous progress is possible at the level of the Tier 2 approach (no split by labelling classes is available before the introduction of the Labelling Directive)

3. Convert electricity savings with emission factors based on marginal power plant in terms of Short Term Marginal Costs (STMC)

This approach assumes that the marginal conventional power plant along the merit order curve is replaced regarding to the short term marginal generation costs of the plants. That means that the operation of the power system is optimised in a way that the most expensive fossil and nuclear plants are replaced by electricity savings. This is the approach chosen here. The marginal emission coefficients can be calculated with an hourly model (PowerAce model discussed in the section on the EU ETS and the RES-E Directive).

However, there are also limitations in what is known in terms of load patterns of the more efficient appliances. Therefore, in order to cover all countries, a more simplified approach was developed by using either the average fossil fuel mix or an existing typical gas-fired power plant with a relatively low efficiency⁷⁷ of 40% (around 500 g/kWh) depending whether the appliances is mainly or to a large degree used during peak-time (e.g. driers) or has a regular pattern over day and night (e.g. refrigerators) (accounting method I) as compared to the hourly approach (method II). In the absence of precise load patterns for efficient appliances they were classified as follows into two categories (Table 10-5).

Table 10-5 Classification of efficient appliances according to load patterns

Appliances with load patterns mainly or frequently during peak hours	Appliances with load patterns mainly off-peak and during base load time
Washing machine Driers Dishwashers Air conditioners	Refrigerators Fridge-Freezers Freezers Lighting
Short term marginal emission coefficient: average gas-fired plant	Short term marginal emission coefficient: average fossil-fuel-fired plant

This approach is simplified in that it uses a rather crude classification. Surely a variety of the appliances cited on the left side have off-peak users. Similar, part of the right-hand devices occurs during peak time or near peak-time. However there is no statistical information on the usage patterns

⁷⁶ R. Stamminger, R. Kemna *Report on Energy Consumption of Domestic Appliances in European Household* - CECED

⁷⁷ This can be justified by the fact that many gas-fired plants in the EU are still fairly old and in peak load not used in an optimal range.

4. Assess the importance of specific factors. These are:

- Assessing the impact of national support schemes to enhance the impact of the labels by comparison of the countries concerned with the achievement of countries without such additional national support schemes.
- Impact of electricity prices (impact small in the time period considered)

5. The 'unexplained' change in emissions factor can then be taken as the *impact of the Labelling Directive* (which assumes, of course, that all other major factors have been identified and their impact accurately assessed).

The following table provides the list of the main input variables used by our stock model and the corresponding sources:

Table 10-6 Main data inputs for the Tier 3 methodology

Input variables	Sources
Appliances Lifetime	CECED study
Lifetime standard deviation (i.e. +- 3 years)	
Ownership rate	
Energy labelling shares of the yearly sales	GfK (CECED for the years before the 1995)
Specific energy consumption by energy labelling category	CECED databases
Household number	Census data

The yearly energy labelling shares are the only scenario drivers. For the rest, the lifetime variables and the stand-by energy consumption values has been kept constant during the considered period while the ownership rates and the specific energy consumption by energy labelling category (but only for refrigerators and freezers) varies along the scenarios steps.

10.3.2 Results – Tier 1, Tier 2, Tier 3 approach

Results for case study Member States

Figure 3-4 illustrates the CO₂ emission⁷⁸ savings for Tier 1, Tier 2 and Tier 3 for Europe and Germany respectively. The overall results are in about the same range for all three methods, especially if taking into account that the geographic delimitation is not always the same. Results indicate savings in the range of 13-21 Mt CO₂ for the period 1995-2004/6 with somewhat higher results for the Tier 1 methodology. Differences may, however, arise for individual countries or individual appliances.

Differences between Tier 1, 2 and 3 results are explained by:

- the degree of disaggregation: while the Tier 1 methodology does not distinguish between the different electricity appliances, especially those concerned by the Labelling Directive and those not concerned, the Tier 2 and 3 methodologies do. The Tier 2 methodology is limited by the number of countries in the Odyssee Database for which information on individual appliances is available. Tier 3 methodology is limited by the detailed labelling information available for the sales of the different appliances in the different EU countries
- the treatment of autonomous progress
- differences in the emission factors used
- the treatment of national promotion policies for the appliance labels

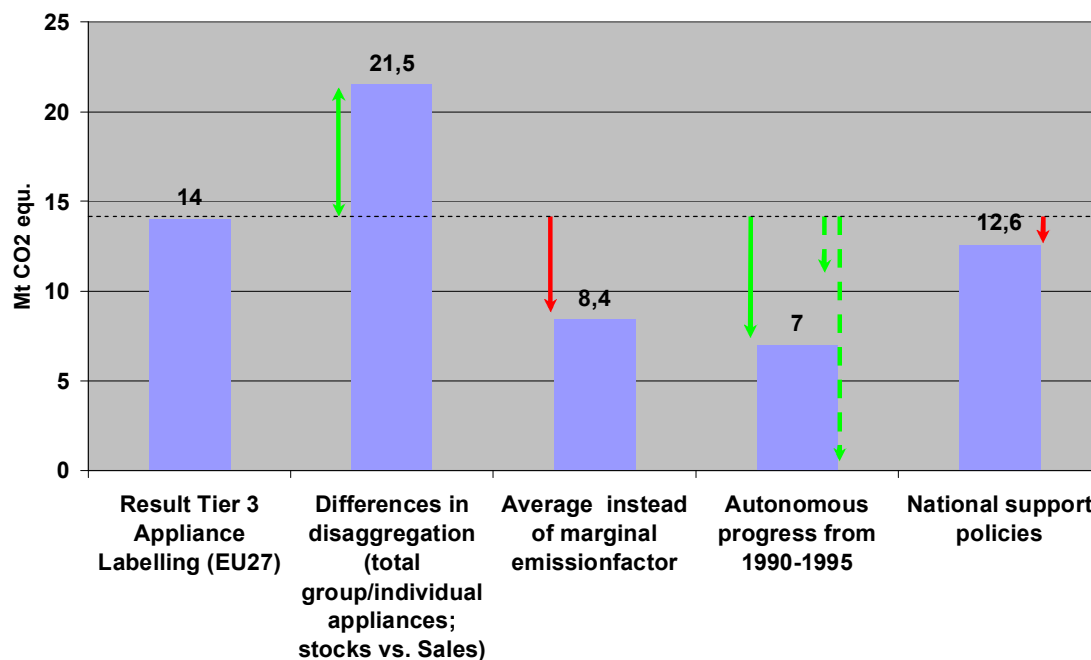
⁷⁸ N₂O emissions have been neglected in this analysis but may be considered in future evaluations.

Table 10-7 CO2 Savings in Tier 1/2/3 methodologies for the Labelling Directive for Europe (1995-2004/6)

kt CO2	Tier 1		Tier 2		Tier 3
	2005	2006	2005	2006	2004
Total: refrigerators, freezers, washing machines, dishwashers, driers (Tier 2 only)					
EU-27	-15302	-21485	-	-	-13290
Sum of countries investigated	-9206	-12169	-6258	-7356	-11999
Austria	-340	0	-80	-100	-259
Czech Republic	-5580	-5972	-	-	-485
Denmark	-1446	-1525	-187	-215	-213
France	0	0	-302	-372	-2574
Germany	-327	-1890	-3512	-4171	-2822
Italy	-1131	-1640	-439	-463	-1782
Netherlands	-383	-366	-56	-61	-805
Poland	0	0	-	-	-654
Spain	0	0	-	-	-1101
UK	0	-777	-1682	-1973	-1304
Refrigerators	-	-	-1724	-2058	-6255
Freezers	-	-	-2031	-2336	-2084
Washing machines	-	-	-880	-1000	-2807
Dish washers	-	-	-833	-991	-853
Driers	-	-	-790	-970	-

Sensitivity analysis

Figure 10-7 shows the impact of using specific methodological assumptions, and the influence of data uncertainties, upon the overall results. The arrows show the relative variability in the results depending upon the particular assumptions that are used. The results represent the historic importance of the different factors. This does not necessarily mean that the factors will have the same importance in the future.

Figure 10-7 Sensitivity analysis of the impacts of the Labelling Directive

Note: Variations due to methodological choices are in red. Variations due to data issues are in green. Solid arrows represent an absolute assessment of the variation, as calculated in the current analysis. Dashed arrows show an estimate of the variation, but the absolute value is much more uncertain.

It can be seen that a variety of factors may have substantial impacts mainly linked to data uncertainties. These are in particular:

- The differentiation between individual electric appliances in the residential sector subject or not subject to the Directive
- The differentiation of sales and stocks
- The differentiation of labelling classes.
- Data necessary to correct for autonomous progress. For the Tier 3 approach no detailed data on labelling classes are available prior to the Directive. A correction may therefore at best occur with the same procedures as at the level of Tier 2 but which is only available for some countries and some appliances unless more detailed figures are available with the manufacturers or GfK.

Other factors are rather linked to methodological choices. These are in particular:

- Choices in the emission factor (average EU/MS or MS marginal)
- Taking or not into account corrections for national support policies.

10.4 Synthesis and interpretation of results

10.4.1 Comparison of results from the different methods

The three different methods Tier 1, Tier 2, Tier 3 provide results which are reasonably close together. Nevertheless the methodology based on the detailed sales data by efficiency classes used as inputs for the MURE stock model is much more precise and less subject to annual fluctuations as for example the Tier 1 approach which also contains electric heating (not covered by the Labelling Directive) and which cannot be corrected for annual climatic variations (this is only explanation for the rather large increase in impacts from 2005 to 2005 in

Figure 3-4). This approach needs to be extended to cover further appliances and to integrate more recent observations on the split by labelling classes. With the Tier 3 methodology and the stock model approach there is nevertheless a rather good evaluation scheme in place with the main weak point of the assessment of the autonomous progress before the start of the Labelling Directive.

10.4.2 Comparison of impacts across Member States

The impact of the Labelling Directive across Member States differs significantly (Table 10-8), depending also on the type of appliance and the ownership rates. Refrigerators/freezers account for the largest amount of savings because this was the earliest implementing Directive to the Labelling Directive (from 1994) hence the market has been most completely transformed. Also the penetration of households with refrigerators is much larger than the penetration of households with dishwasher, although the latter use has been growing considerably over time.

Table 10-8 Total emission reductions in Mt CO₂ due electricity savings from the Labelling Directives up to 2004

CZ	Refrigerators	Freezers	Washing machines	Dishwashers	4 appliances
AT	149	48	42	21	259
CZ	392	58	34	2	485
DE	1557	588	458	218	2822
DK	86	67	42	20	213
ES	271	217	504	110	1101
FR	1409	419	536	211	2574
IT	991	188	482	120	1782
NL	373	143	225	64	805
PL	429	124	98	3	654
UK	597	232	389	87	1304
Total 10 countries	6255	2084	2807	853	11999
Estimate scaled to EU27*	7256	2418	3256	990	13920

*scaled with private consumption. The 10 countries represent 86% of EU27

Note: emission factor based on average fossil fuel mix or average gas-fired plant

10.4.3 Comparison with alternative estimates

Paul Waide estimated in IEA (2003) that in European IEA Members, existing measures for appliance Labelling and Minimum Efficiency Performanc Standards for appliances (MEPS) have saved 7.6 Mt CO₂ in 2000, generating net economic benefits of 224 Euro for each tonne of CO₂ avoided (see also

Table 10-10 in the following section).

Bosseboeuf et al. (2005) estimate electricity savings of 14 TWh from 1994 to 2000 for the EU15, which fits well with the 21 TWh estimated here for the EU27 in 2004.

Also at the national level impact studies exist. For example in Germany various studies and analysis exist with respect to the analysis of climate change policies and measures at national level such as the Policy Scenarios IV from 2008. These studies evaluated the emission reductions due to labelling policies. Differences between study occur in the treatment of autonomous savings, which may substantially influence the outcome of the studies. For Germany for 2004 savings of 2.2 TWh from Labelling policies and MEPS were estimated, somewhat less than the 3.6 TWh estimated in this study.

10.4.4 Comparison with ex-ante results

Annex I of the ECCP progress report (EC 2003), based on the results of the ECCP Working Group on 'Energy efficiency and end-use equipment and industrial processes', estimates for white goods a CO₂ reduction of 26 Mt CO₂ in the 2010 baseline with respect of 1990, despite the increased demand for e.g. dishwashers and tumble dryers. Industry analysis shows that this is mainly as a consequence of energy labelling and the related measures by Member States. Partitioning one third of the saving to restrictive measures at the lower end of the market (minimum standards, voluntary agreements), the CO₂ savings from Commission Directives issued before 1999 amount to 17 MtCO₂. Taking out the negative effect of an increased market penetration of dishwashers and tumble driers, the contribution of existing energy labels is estimated at 20Mt CO₂eq. This ex-ante estimate is mostly in line with the estimates presented here which estimate 12 Mt for the EU 15 in 2004 and 13 Mt CO₂ reduction for the EU27. This is not astonishing given that these estimates are calculated based on the same basic data for appliance sales by labelling class.

Table 10-9 Comparison of ex-ante and ex-post results: Appliance labelling directive

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3*
Labelling Directive for electric appliances (Directive 92/75/EEC) *)	26	21.5 (EU27, 2006) NE (EU15, 2006)	NE NE	13.3 (EU27, 2004) 12.1 (EU15, 2004)

The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:

Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices

Abbreviations:
MSsp: Member State specific starting year for the ex-post evaluation
NE = not estimated

Notes:
* Including existing labels which are estimated ex-ante to be around 20 Mt CO₂-eq.
** Tier 3 results are based upon a more refined approach, however, data at a more refined level is only available to 2004.

Another ex-ante estimate for the OECD Europe is presented in IEA (2003). The savings resulting from OECD Europe appliances labelling and MEPS policies are estimated to 7.6 Mt CO₂ in 2000, 16.9 Mt in 2005

Table 10-10). These results cope well with the results reported here in this evaluation. In the projections, these impacts may further increase to nearly the triple in 2030, due to the market transformation initiated.

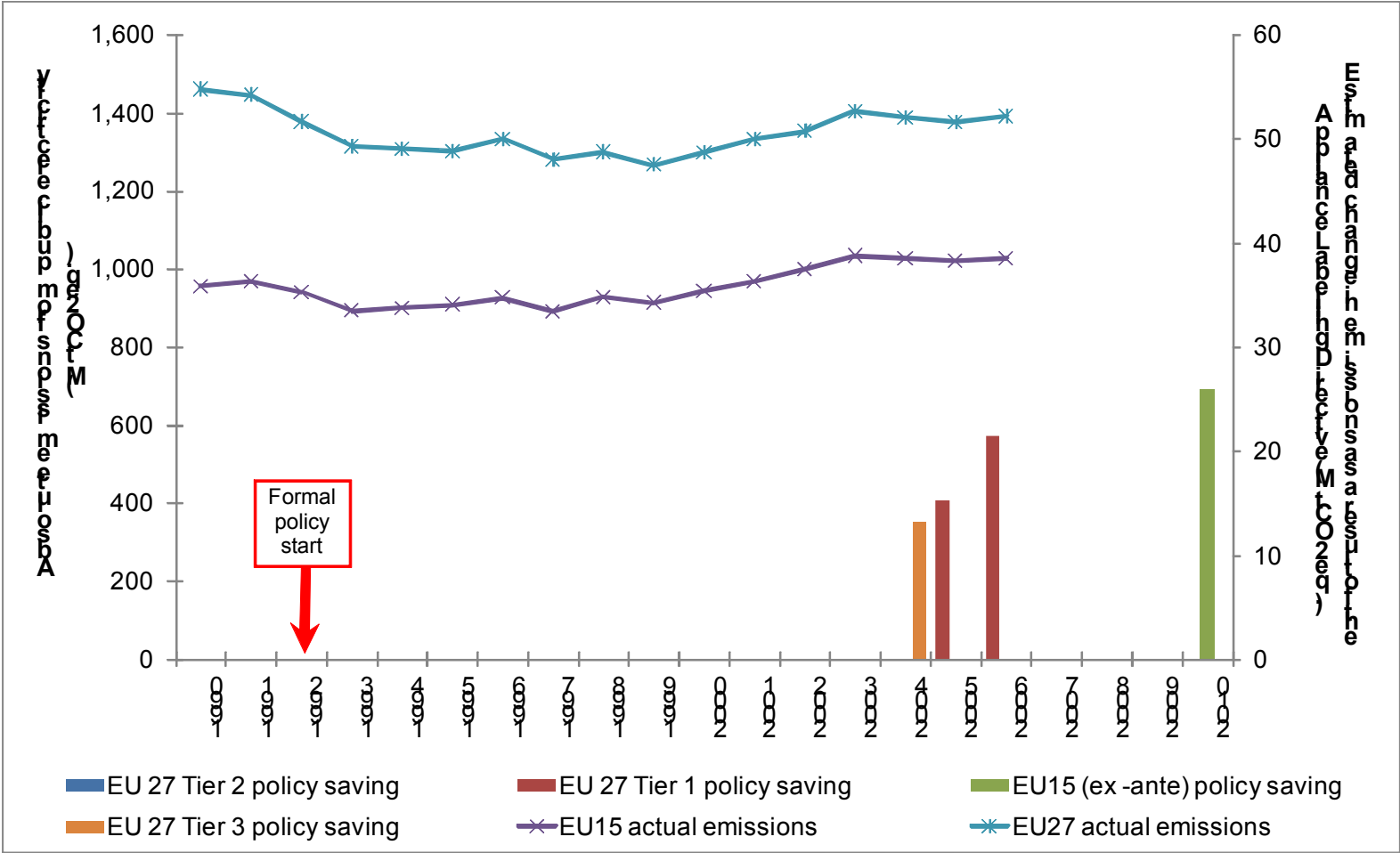
Table 10-10: Ex-ante and ex-post CO₂ impact projections by IEA (2003) for the OECD Europe Labelling and MEPS policies

Year	Energy cost saving (billion €)		Equipment purchase cost increase (billion €)		Net cost saving (billion €)		Carbon dioxide reduction		
	Annual savings	Cumulative savings from 1990	Annual increase	Cumulative increase from 1990	Annual savings	Cumulative savings from 1990	Annual (Mt-CO ₂)	Share of residential total in 1990 (%)	Cumulative (Mt-CO ₂)
1995	0.4	0.8	0.0	0.0	0.4	0.8	1.4	0%	2.9
2000	2.4	8.2	0.8	2.4	1.7	5.8	7.6	3%	26.0
2005	5.4	29.4	1.5	7.9	4.0	21.5	16.9	5%	92.1
2010	9.1	67.5	2.0	16.8	7.1	50.7	28.4	8%	210.7
2015	11.1	119.2	2.5	28.6	8.5	90.6	34.7	10%	372.5
2020	12.5	179.1	2.7	41.8	9.8	137.3	39.3	10%	560.3
2025	13.7	245.4	3.0	56.3	10.6	189.1	43.2	11%	769.1
2030	14.5	316.4	3.4	72.6	11.1	243.8	46.0	11%	993.6

Source: IEA (2003)

In Figure 10-8 the results of the evaluation can be put in context by comparing the estimated emission reductions with the overall historical trend in emissions from electricity and heat production.

Figure 10-8 Appliance Labelling Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development



Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above.

Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

10.4.5 Cost effectiveness

Generally electricity savings on electric appliances belong to the most cost effective options to avoid CO₂ emissions. In addition, due to the relatively small difference between the most efficient appliances and the average of the market, as well as due to the fact that with market penetration a rapid decrease in the differential costs occurred in the past, the consumers face less important investment barriers to energy efficiency than in other sectors.

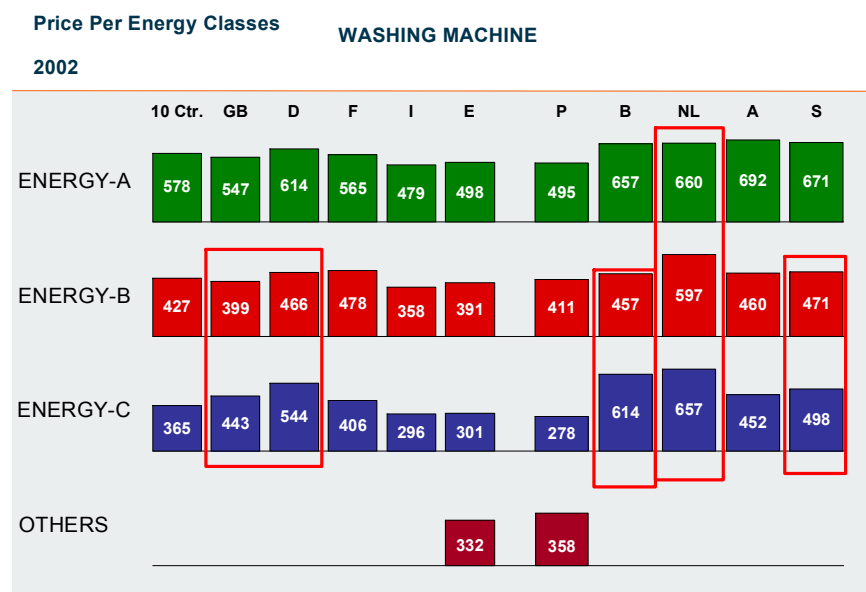
The IEA (2003) estimates that “savings can be achieved at negative cost to society, since the extra costs of improving energy efficiency are more than offset by savings in running costs over the appliance’s life. In the US, each tonne of CO₂ avoided in this way in 2020 will save consumers \$65; while in Europe, each tonne of CO₂ avoided will save consumers €169 (reflecting higher electricity costs and currently lower efficiency standards in Europe).” See also more details on cost savings in the previous section in

Table 10-10.

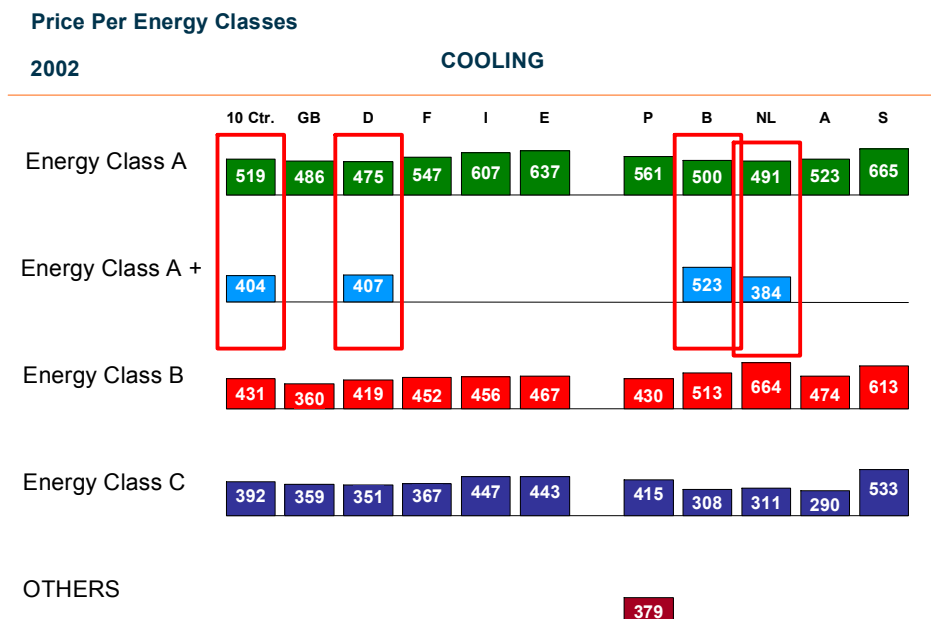
Also many other investigations have shown that there is not a correlation between the price of more efficient appliances and its performance (Figure 10-9 and

Figure 10-10). This has led to the fact that while the energy efficiency performance of appliances have drastically improved in a decade, the prices for the devices have dropped in Europe and over the world (Figure 10-11 and

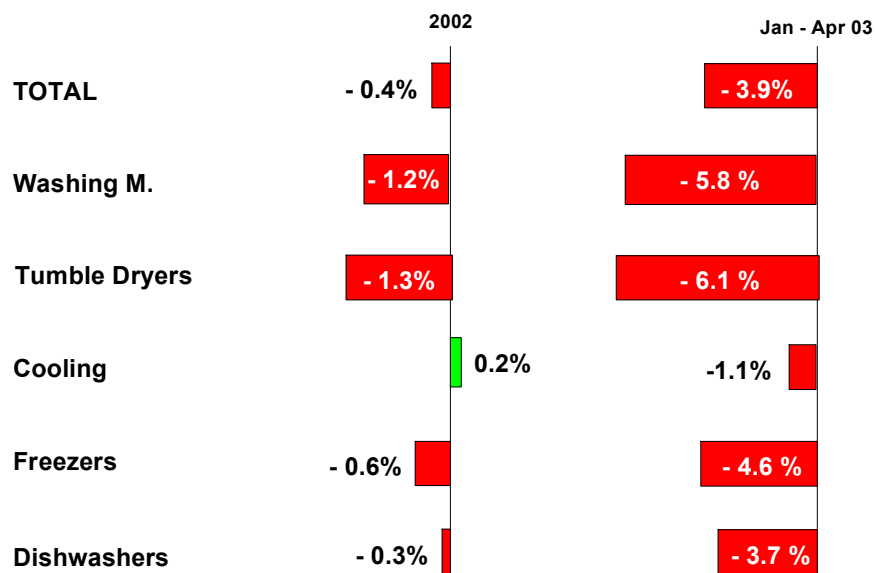
Figure 10-12).

Figure 10-9: Do energy efficient washing machines really cost more?

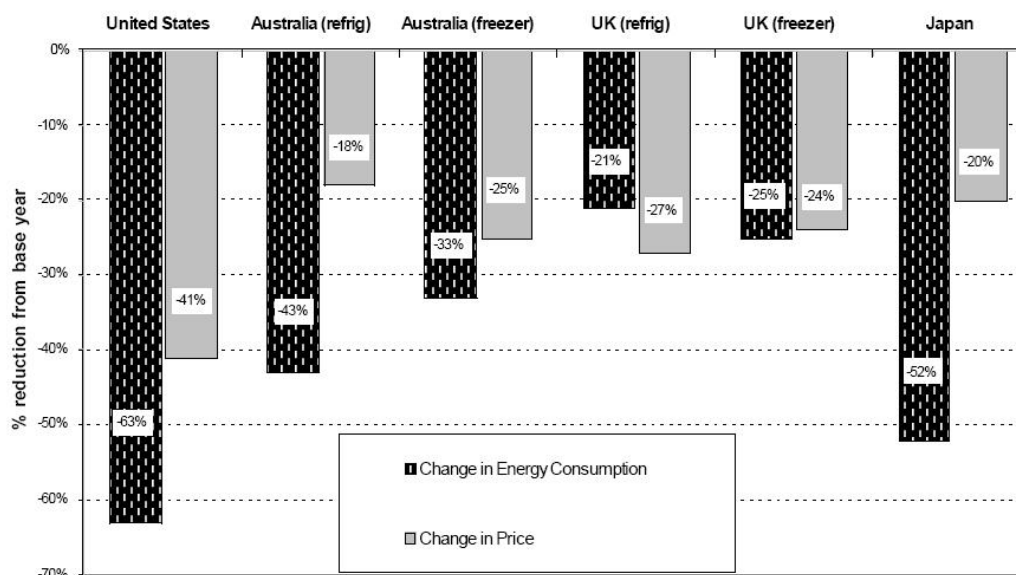
Source: GfK (2005)

Figure 10-10: Do energy efficient cooling appliances really cost more?

Source: GfK (2005)

Figure 10-11: Changes in the average price for electric appliances are not really linked to the penetration of labelling classes...

Source: GfK (2005)

Figure 10-12: Efficiency and real price trends for cold appliances (varying time scales)

Source: M. Ellis et al. (2007)

10.5 Conclusions

The different tiered methodologies discussed in this chapter deliver results which are comparable. If autonomous progress is not corrected for then they deliver an upper limit for the quantitative impact estimate. However, it is difficult to project autonomous progress from the pre-Directive period for two reasons. Firstly, data on the efficiency of appliances before 1994 (the start of the first implementing Directives) is relatively scarce and secondly, because the progress in this earlier period might have been easier to achieve – so many not be representative of progress that is achievable more recently. On this basis we consider that correction for autonomous progress should be done with caution. If long run-trends in efficiency are simply extrapolated then there is a danger that policy impacts will be calculated as close to zero.

The size of the CO₂ savings indicates that the Labelling Directive has a “medium size impact” compared to, for example the RES-E. Nevertheless, as the projections show (IEA 2003) this impact has the potential to almost triple by 2030 with the existing policies in place. Furthermore, the labelling schemes and MEPS may be enhanced and expanded to other appliances, especially through the Eco-design Directive, increasing the overall impacts.

Another methodological correction that has been examined is policy overlaps. The separation of impacts from national support policies seems feasible by comparing countries or sets of countries with and without supporting policies.

10.6 Recommendations

The evaluation has shown two important points for discussion in further evaluations:

- The **data basis which is available for the evaluation of the Directive** in the Tier 3 methodology is not a public one, but belongs to private actors such as GfK and the appliance association CECED. Care should therefore be taken to clarify how, on a regular basis, evaluations of the labelling schemes can be carried out. The most recent exercise of this type is just being finished (Fraunhofer ISI/GfK/BSR Sustainability 2008) and the results could be integrated in an evaluation of the Labelling Directive to a more recent date. The data used for the Tier 1 and 2 methodologies are public but are either relatively aggregate and include appliances not covered by the Labelling Directive, or are not available for all appliances and all countries

- The issue of correction for autonomous progress has been discussed and improvements to the methodology for corrections should be sought through discussions with experts from the appliance producers or by identifying more detailed time series data before 1994.

10.7 Next steps

In addition to the further development of the methodology for calculating emission factors for electricity savings, the most important next steps to be carried out are:

- Increase the number of appliances covered in the Tier 3 approach, in particular labels for air conditioning and lighting.
- Discuss with GfK and manufacturers whether more detailed data sets may be obtained to improve the issue of autonomous progress, or try to clarify the issue through further expert consultations.
- Integrate the most recent study results to improve on the time period covered (Fraunhofer ISI/GfK/BSR Sustainability 2008). These results became available too late to integrate them into the present study.
- Clarify the availability of private data sets for regular evaluations of the Labelling Directive.

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11 Case study: Landfill Directive (1999/31/EC)

11.1 Introduction

11.1.1 Overview of policy

The Landfill Directive sets out operational and technical requirements on waste and landfills; and provides for measures to prevent and reduce possible negative effects of waste on the environment, including the greenhouse effect. The Directive also sets targets to progressively reduce the landfilling of biodegradable waste by 25% (2006), 50% (2009), 65% (2016) compared to 1995 levels.

The deadline for implementation of the Landfill Directive (Directive 1999/31/EC) in the Member States (MS) was 16.07.2001. Its objective is to prevent or reduce as far as possible negative effects on the environment from the landfilling of waste, by introducing stringent technical requirements for waste and landfills. The Directive aims to achieve these objectives by inter alia: encouraging a reduction in the amount of municipal solid waste being landfilled through diversion to alternative processing techniques; and, encouraging recovery of gases produced at landfill sites.

Article 5(2) of the Directive requires the reduction of biodegradable waste going to landfill by:

- 25% by 16th July 2006
- 50% by 16th July 2009, and
- 65% by 16th July 2016,

against the total amount of biodegradable municipal waste produced in 1995 or the latest year before 1995 for which standardised Eurostat data is available.

MS that landfilled more than 80% of their municipal waste in 1995 may postpone each of the targets by a maximum of four years.

MS were required to set up a national strategy for the implementation of the reduction of biodegradable waste going to landfills by not later than July 2003.

The Directive requires MS to report on the implementation in respect of their national strategies every three years. The Commission is then required to publish a Community report within 9 months of receiving the MS reports.

11.1.2 Policy implementation

In its report of March 2005⁷⁹, the European Commission states that by January 2004 it had received strategies from Austria, Denmark, France, Germany, Italy, Greece, Luxembourg, the Netherlands, Portugal, Sweden, the UK, Belgium and Finland. Ireland and Spain had not submitted reports. In addition the ten new MS had to submit their national strategies after accession.

Austria, the Flemish Region of Belgium, Denmark and the Netherlands had all achieved the most stringent target by the 2005 report. Germany was expecting to meet that target by 2005. On the other hand, Greece and the UK made use of the possibility to postpone the attainments of the targets by four years.

In 2006, achievement of the landfill targets was more widespread with Austria, Sweden and Luxembourg additionally meeting their 2016 targets (Table 11-1).

Table 11-1: Conformity against Landfill targets for EU MS (source: European Commission figures)

⁷⁹ European Commission, COM(2005) 105, Report from the Commission to the Council and the European Parliament on the national strategies for the reduction of biodegradable waste going to landfills pursuant to article 5(1) of Directive 1999/31/EC on the landfill of waste.

	Total biodegradable municipal waste in 1995 (Ton)	Total biodegradable municipal waste going to landfills in 2006 (Ton)	Achieved reduction	Comments
Austria	2,675,300	12,264	100%	Target accomplished
Belgium (Brussels)	-----	-----	n/a	No landfills available
Belgium (Flemish)	3,397,080	7,202	100%	Target accomplished
Belgium (Wallonia)	1,126,692	705,822	37%	Target accomplished
Germany	----	----	n/a	Target accomplished. By Law since 1 June 2005, no biodegradable waste is allowed in landfills
Denmark	Not available yet	Not available yet	Not available yet	Initiating infringement proceedings is envisaged
Spain	11,934,142	7,768,229	35%	Target accomplished
Finland	2,100,000	1,047,800	50%	Target accomplished
France	18,615,000	7,432,000	60%	Target accomplished
Hungary	2,340,000	1,538,000	34%	Target accomplished
Slovenia	445	312	30%	Target accomplished
Italy	16,757,000	Not available yet	Not available yet	An additional letter of reminder will be sent to the national authorities
Luxembourg	142,166	233	100%	Target accomplished
The Netherlands	2,406,000	Not available yet	Not available yet	An additional letter of reminder will be sent to the national authorities
Portugal	2,252,720	Not available yet	Not available yet	An additional letter of reminder will be sent to the national authorities
Sweden	2,242,000	30,586	99%	Target accomplished

11.2 Emission trends and drivers

The ex-post impacts of the Directive on emissions of GHGs can be defined in terms of the difference between the actual reported emissions and the emissions under the counter-factual scenario (i.e. the estimated level of emissions that would have arisen in the absence of the policy). This section describes the underlying trends in the actual reported emissions, and emission-causing activities. It is against this backdrop that the counter-factual scenario can be defined.

11.2.1 Impact upon greenhouse gas emissions

The disposal of municipal solid waste (MSW) to landfills gives rise to large amounts of methane (CH₄), carbon dioxide (CO₂) as well as smaller amounts of nitrous oxide (N₂O) through the decomposition of degradable material in the waste. These emissions are recorded in UNFCCC emissions inventories under category 6A - solid waste disposal on land. Through its aims to encourage a reduction in the amount of municipal solid waste being landfilled and recovery of gases produced at landfill sites, the Landfill Directive therefore directly impacts on these emissions.

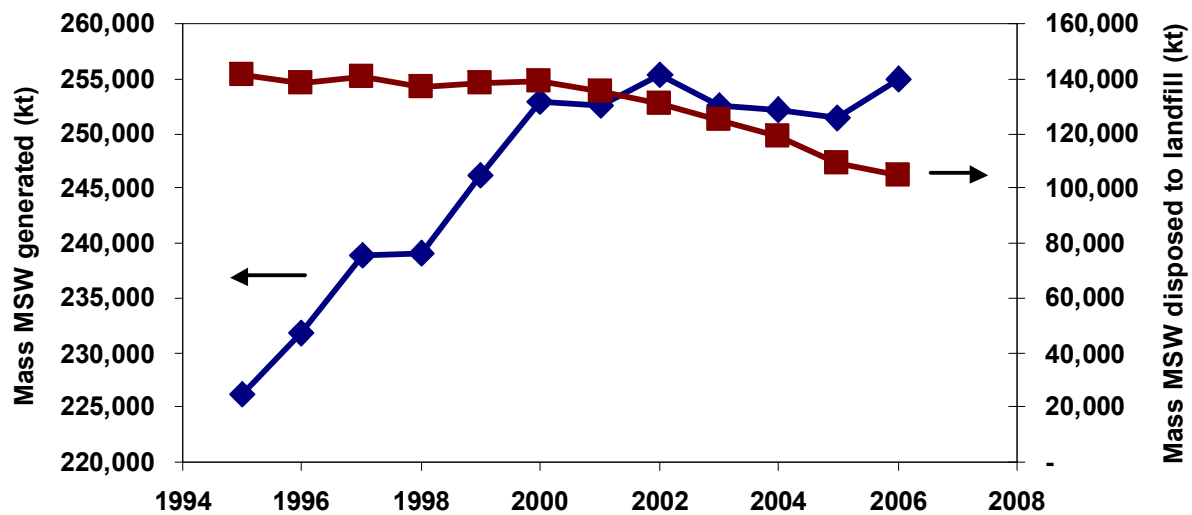
11.2.2 Activity and emission trends

Emissions from MSW disposal to landfill sites are dependent on the quantity of biodegradable MSW disposed to landfill. This is in turn determined primarily by the total mass of MSW disposed to landfill.

In the recent past, the total mass of MSW generated in the EU 27 has steadily increased, although since 2002, that trend has stabilised. In this context it is interesting that the mass of MSW disposed to landfill has gradually decline from 141,000 kt in 1995 to 105,000 kt in 2006.

The gradual decline in disposal of MSW to landfill commences prior to the implementation of the Landfill Directive. The change can therefore be attributed to policies that were put in place by various early moving MS. As discussed in section 11.1.2, 4 MS have already achieved the most stringent target of the Directive.

Figure 11-1: Annual mass of MSW generated and disposed to landfill in the EU 27 (source: Eurostat, accessed September 2008)



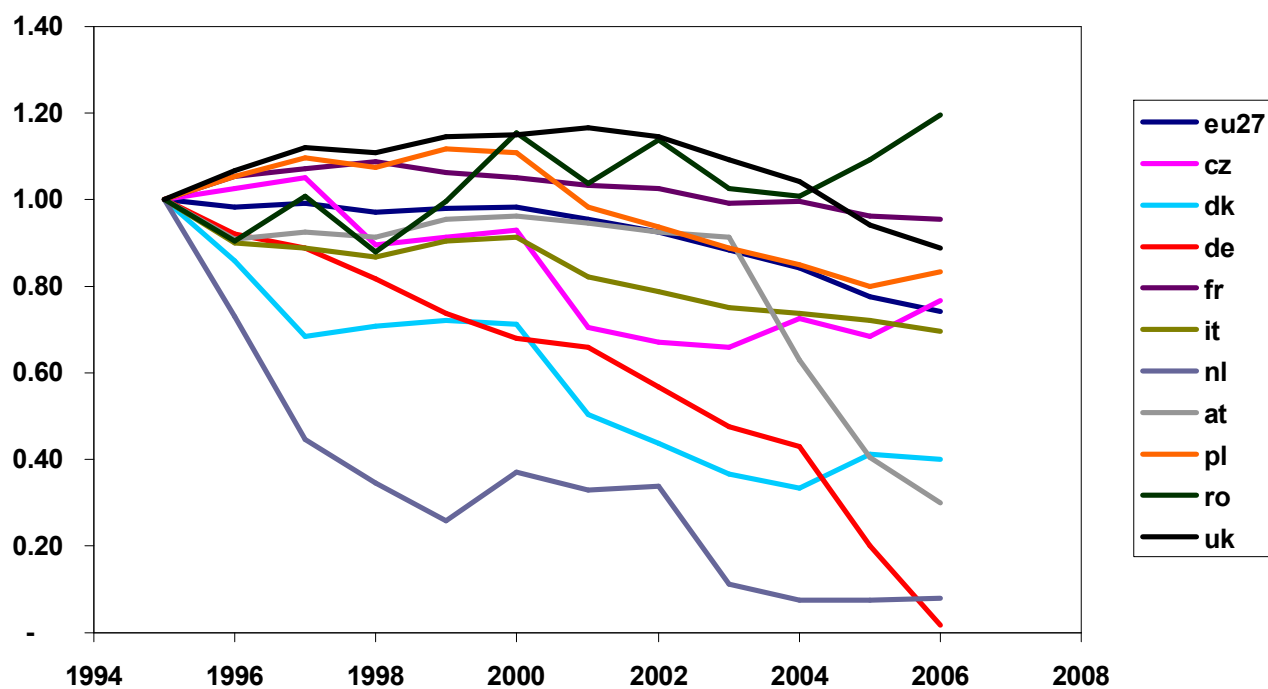
For example Austria, one of those MS already achieving the target, put in place Ordinance in 1993 and 1995 for separate collection of packaging waste and biodegradable waste. Only waste less than 5% total organic content can be disposed to landfill. Relative to that in 1995, the mass of MSW disposed to landfill in Austria has declined steadily to 2003 and then accelerated. In 2006, the mass of MSW to landfill in Austria was 30% of that in 1995 (

Figure 11-2).

In Germany, MSW to landfill has declined almost linearly since 1995 and in 2006 represented less than 10% of the 1995 value (

Figure 11-2). Separate collection and recovery of biodegradable waste from households, gardens and parks, as well as paper and packaging waste has reduced landfilling significantly. Mechanical biological treatment of waste, which separates the high calorific value fraction of waste from residual waste, is widespread in Germany. The carbon content of the residual waste going to landfill may not exceed 18% and the biodegradable content is estimated at 10%.

Figure 11-2: Index for evolution of the mass of MSW disposed to landfill, for the study MS (1995 = 1)
(source: Eurostat, accessed September 2008)



On the whole, the mass of MSW disposed to landfill has been decreasing in the EU 27. Of the case study MS selected for this study, only Romania has shown an increase since 1995 in the mass of MSW disposed to landfill (

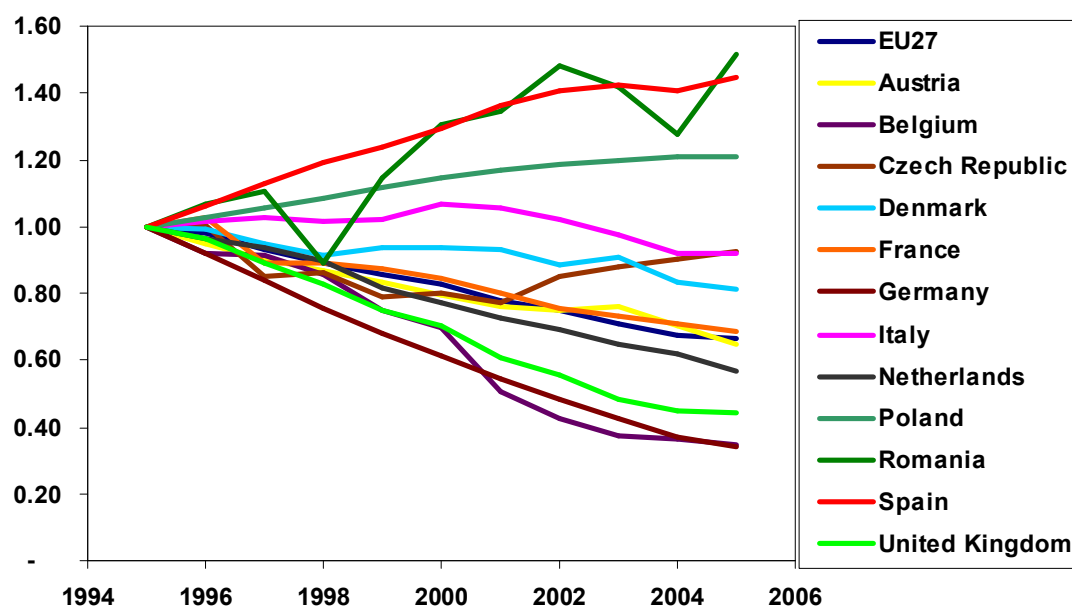
Figure 11-2),

Reported greenhouse gas emissions from landfills (UNFCCC category 6.A - Solid waste disposal on land) tend to reflect this underlying trend of declining landfill waste activity (

Figure 11-3). For most MS, emissions have declined since 1995. However, for Poland, Spain and Romania, emissions have steadily increased, reflecting the increase in waste disposed to landfill. It is important to note in considering these emissions that the decomposition of waste in landfills is slow, and so a unit of waste disposed to landfill can generate emissions of greenhouse gases for many decades after its introduction to the site. The recent UNFCCC guideline reporting methodologies take this into account. Therefore, a component of the emissions shown in

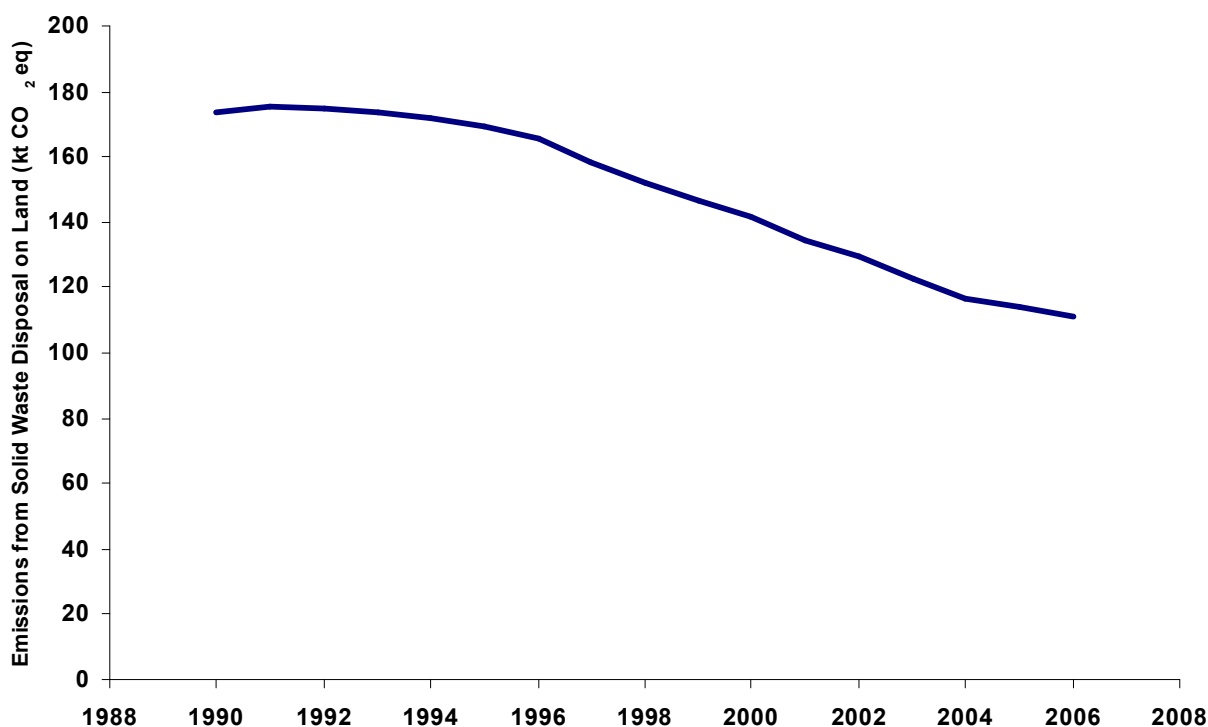
Figure 11-3 arises from waste placed in the landfill prior to the waste disposal shown in

Figure 11-2.

Figure 11-3: Indexed emissions from solid waste disposal on land (UNFCCC 6.A, 1995 = 1). (source: EEA GHG dataviewer)

In summary, the overall picture is one of declining landfill emissions in Europe. Over the period 1990 to 2006, total emissions of GHGs from the solid waste disposal on land fell by 39% for the EU 15. Emissions from the EU 27 waste sector also fell by 32% (

Figure 11-4).

Figure 11-4: Greenhouse gas emissions from solid waste disposal on land in the EU 27 (Source: EEA, 2008a)

11.3 Impacts of the Directive on emissions of GHGs

This section presents the initial estimates of the impacts of the Landfill Directive on emissions of greenhouse gases. The analysis follows the tiered methodological approach developed throughout the study and described in detail in the accompanying evaluation guidelines.

Results are presented for each of the 11 Member States selected for detailed consideration. These are: Germany, France, Spain, Italy, UK, Denmark, Austria, Netherlands, Poland, Czech Republic, Romania. Results are presented for each of the Tiered methodologies, respectively, and then the overall results are compared with each other and some overall conclusions are drawn. In each case the limitations with the approach and key methodological assumptions are highlighted.

11.3.1 Overview of methodologies

The Tier 1 approach represents a high level assessment of the impacts. It is based upon existing EU wide statistics so that the methods can be easily repeated without additional data collection. It applies a number of simplifying assumptions to ease comparison between countries and policies, but may not adequately reflect the full complexity of the policy in question.

In contrast the Tier 3 approach involves a much more detailed assessment of the policy impacts, using a much higher resolution of data (which may require additional collection) and increasing complexity in the methods. As far as possible the Tier 3 approach aims to consider all on the main methodological issues.

The Tier 2 approach provides an intermediate level of analysis. It aims to address some of the most important methodological issues but it is still largely reliant upon existing established data sources.

The overall scope of each of these approaches and the assumptions that have been used in defining the policy impacts under each approach is summarised in table below.

The methodology applied in this case study follows closely the suggested methodology for use in calculating National GHG inventories⁸⁰. Data on the total mass of MSW disposed of to landfill in the EU is used to drive the first order decay model of organic waste decomposition in landfills. This method describes the decomposition of organic matter in any year as a function (an exponential function) of the mass of organic matter in the landfill at the start of the year.

As mentioned previously, the decay of waste in landfills can take many decades. The landfill directive acts to reduce waste disposed to landfill. Therefore one of the fundamental impacts of the Directive on emissions of greenhouse gases is calculated as the emissions that would have occurred from the waste that would otherwise have been disposed to landfill if the Directive had not been brought into force. Since that waste would decay over many decades, the total impact of the Directive is the cumulative emissions over its lifetime in the landfill. For each year of the analysis then, one of the impacts of the Directive is the lifetime emissions of the waste that would have been disposed to landfill if the Directive had not been implemented.

A detailed description of the approach adopted is described in the Guidelines for the Landfill Directive. The following points cover some of the fundamental components of the analysis:

- Eurostat data on the mass of MSW disposed of to landfill is used to describe the activity for this policy. This source was chosen to align best with the Commission's definition of landfill sites under the Landfill Directive.
- The key assumptions made for the construction of counterfactuals focussed on the total amount of waste disposed of to landfill and on the rate of recovery of landfill gas.

⁸⁰ IPCC, 2006, Guidelines for National Greenhouse Gas Inventories, Volume 5 Waste, Chapter 3: Solid Waste Disposal

Table 11-2: Summary of the Tiered methodology for analysis of the Landfill Directive

Methodology	Tier 1	Tier 2	Tier 3
Activity indicator	- MSW disposed to landfill (Eurostat) - Fraction of MSW generated that is disposed to landfill; Composition of MSW (EEA, 2008b) - Default parameters for first order decay (IPCC, 2006)	Building on the methodology of Tier 1: - Landfill gas recovery rates; Incineration of MSW (EEA, 2008a) - MS specific parameters for first order decay: decay constants, methane correction factor	Includes detailed bottom up statistics.
Autonomous development + structural change	Does NOT consider autonomous development or structural change. The fraction of MSW disposed to landfill is assumed to remain at 2001 values in the absence of the Directive.	Autonomous change is considered by extrapolating the linear trend (from 1995 to 2000) in MSW disposed to landfill forward to the present as a counterfactual.	Correction(s) of autonomous development and structural change.
Timing issues	Calculates policy impacts from same start date, no adjustment for implementation delays or announcement effect	The Landfill Directive is still assumed to be implemented in 1999	
Policy interaction	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.	Some effect of pre-existing policies removed from the estimation	Estimates effect of specific EU policy.
Exogenous factors	No adjustment for exogenous factors	No adjustment for exogenous factors	Adjustment for impacts of: profitability of landfill gas recovery; profitability of incineration

11.3.2 Results – Tier 1 approach

The Tier 1 approach to quantifying the greenhouse gas impact of the Landfill Directive assumes that all changes in mass of MSW disposed to landfill since 2001 are the result of the Directive. This assumption implies that there were no policies in place prior to the Landfill Directive and also that there have been no other drivers of changes to the activity. The assumption is implemented by freezing the proportion of total MSW disposed to landfill at pre-Directive levels.

As introduced in 11.3.1 above, the methodology makes use of the IPCC recommended first order decay model. The model is driven by the mass of degradable organic waste disposed to landfill for each MS. Under tier 1, the composition of the MSW is taken as the EU average waste composition derived from IPCC guidance values.

Based on these assumptions, the Tier 1 analysis gives rise to savings for all the case study MS and for the EU 27 (Table 11-3). For data availability reasons, the EU 27 calculation only covers the time period 2001 – 2004, whereas for all MS other than Poland, Czech Republic and Romania, the assessment time period is 2001 – 2005. This follows the requirement for the Directive to be implemented by mid-2001. For the accession countries Poland and Czech Republic, the assessment starts in 2004, the year of accession. For Romania, which acceded at the beginning of 2007, there is insufficient data to complete an analysis.

**Table 11-3: Estimated GHG savings from the Landfill Directive calculated using the Tier 1 methodology
(Tg CO₂ eq.)**

Type of results		Ex-post evaluation - annual savings							Ex-post evaluation results - cumulative savings inclusive of years presented	
Period		2001	2002	2003	2004	2005	2006	2007	2008	
Geographic Entity	EU-27	-	18.11	33.34	51.32	79.64	99.96			2001 - 2006 282.37
	Germany	-	6.54	9.75	11.73	24.98	36.71			2001 - 2006 89.70
	France	-	0.91	2.74	3.61	5.15	6.69			2001 - 2006 19.11
	Spain	-	- 0.29	- 0.22	3.71	5.27	4.69			2001 - 2006 13.16
	Italy	-	3.72	6.86	10.15	12.81	15.70			2001 - 2006 49.23
	UK	-	2.92	6.78	12.50	17.61	22.78			2001 - 2006 62.59
	Denmark	-	0.11	0.24	0.32	0.25	0.27			2001 - 2006 1.20
	Austria	-	0.40	0.50	2.08	3.30	3.86			2001 - 2006 10.14
	Netherlands	-	- 0.02	1.69	2.07	2.07	2.03			2001 - 2006 7.84
	Poland	-	- 0.17	- 0.22	0.54	1.08	1.50			2004 - 2006 2.74
	Czech Republic	-	0.45	0.60	- 0.13	0.57	- 0.06			2004 - 2006 1.43
	Romania	-	-	-	-	-	-			- -

Although there is variability in the results by MS, the values make qualitative sense. Large, populous MS such as Germany, France, UK and Italy have seen the greatest savings as a result of the Directive. Considering the result for Spain in more detail, it might appear surprising that the Directive appears to have caused a greenhouse gas saving despite the fact that the total mass of MSW disposed to Landfill increased post 2001 and then decreased to below pre-Directive levels. However, the proportion of MSW disposed to landfill since 2001 has fallen. So the 'frozen' pre-Directive proportion, which is assumed here would have been the case in the absence of the Directive, suggests more waste would have been disposed to landfill in the absence of the Directive than that reported.

For the Germany, section 11.2.2 described the measures in place in Germany to reduce waste disposal to landfill and the significant impact they have had. This taken in conjunction with its large population and therefore substantial total mass of MSW generation supports the finding that it has received the largest absolute reduction in emissions,

Due to the handling of lifetime emissions in the analysis (see section 11.3.1), it is important to note that comparison of the cumulative savings to current total emissions from solid waste disposal on land is not meaningful and therefore not presented here.

Policy implementation

As discussed in section 11.1.2, of the case study MS considered in this study, only Spain had not submitted a National Strategy to the Commission by January 2004. However, Real Decreto 1481/2001, on regulation for eliminating waste disposal to landfill, requires that all regional authorities must produce a waste strategy to this end.

The UK chose to defer the targets of the landfill directive for four years. However, by 2001 it had put in place measures to reduce the mass of biodegradable MSW disposed to landfill, for example under the packing Regulations, businesses had obligations to recover 52% of packaging waste in 2001 and recycle at least half of that. Newspaper publishers in England committed to using 60% recycled content by 2001, followed by 65% by 2003 and 70% by 2006.

Therefore, the choice of 2001 for the start date of the policy, in all but the accession countries, seems reasonable and appropriate for the analysis of the Landfill Directive.

Autonomous development

The assumption that a 'frozen' proportion of the total MSW generated is disposed to landfill does not reflect longer term trends in reduction of MSW disposed to landfill, which were brought out in section 11.2.2. Since 1995, landfilling of MSW has been gradually declining, even as the total mass of waste generated has increased. Therefore, the assumption of a 'frozen' proportion gives rise to a upper bound to the estimate of the impact of the Landfill Directive. Autonomous developments including preceeding national policies or improving economic situation for other forms of waste disposal could have had an impact on the amount of waste disposed to landfill.

Structural changes

Taking the EU average composition of MSW does not reflect regional differences in the characteristics of the waste disposed to landfill, which affect the emissions arising from it. However, additionally, assuming a constant composition does not reflect any changes in the composition over time as a result of end-user choices or regulations to affect the supply chain.

Policy interaction

The Tier 1 approach assumes that the landfill Directive is primarily responsible for any change in the mass of MSW disposed to landfill. However, other waste policies as well as economic pressure will influence this activity metric.

The most significant overlaps occur with:

- The Framework Directive on Waste (75/442/EEC), which provides for the establishment of proper waste control regimes, and requires that designated national competent authorities draw up a waste management plan identifying:
 - Wastes to be recovered or disposed of
 - Technical requirements for recovery or disposal
 - Special arrangements for specific types of waste
 - Suitable disposal sites or installations
- The Packaging Directive (94/62/EC), which aims to harmonise national measures in order to prevent or reduce the impact of packaging and packaging waste on the environment and contains provisions for the prevention of packaging waste, on the re-use of packaging and on the recovery and recycling of packaging waste.
- The Directive on Integrated Pollution Prevention and Control (96/61/EC), which has the objective prevent and control of air, water and land pollution arising from certain industrial activities including landfill sites. IPPC uses a permit system based on emission limit values for sites. However, the permits also incorporate general principles such as specifying best levels of energy efficiency.

These policies have given rise to many national level policies but there will also be independent national policies that would have had an impact on emissions from disposal of waste in landfills in the absence of the Landfill Directive.

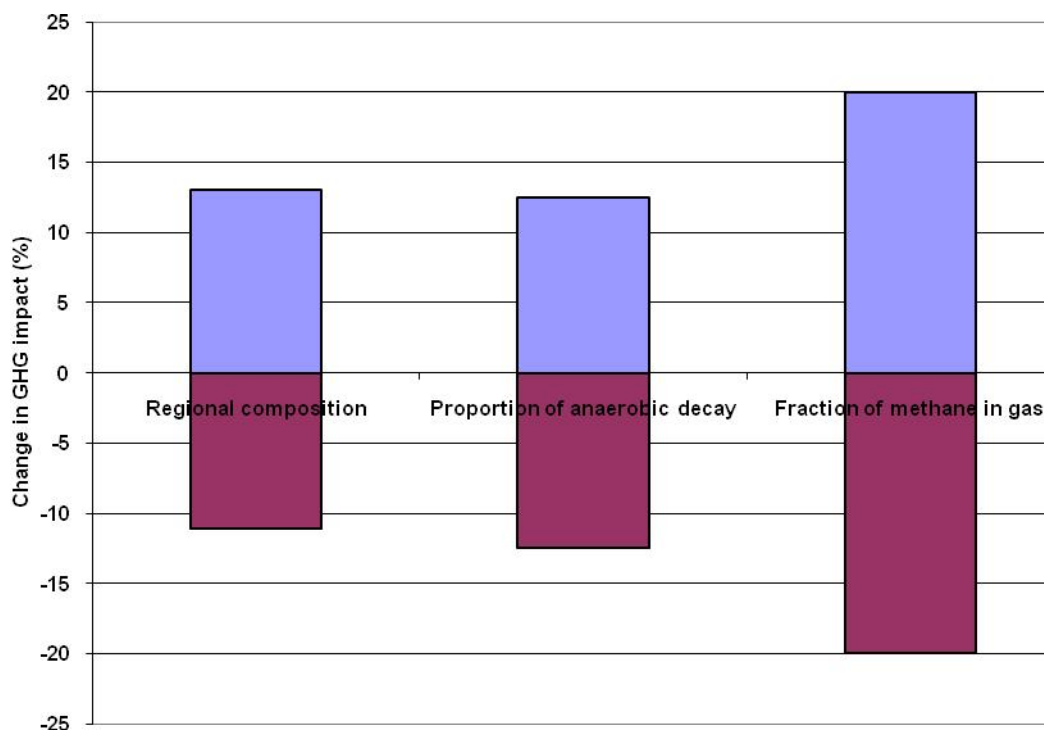
The issue of pre-existing policies and measures is linked to that of autonomous development discussed above. In the absence of the Landfill Directive these measures would have delivered emissions savings, which the assumption of a 'frozen' proportion of MSW disposed to landfill does not take into account. Attributing some of the savings calculated here for the Tier 1 analysis to other polices is important to take into account.

Sensitivity analysis

The main assumptions of the Tier 1 analysis were tested for their sensitivity (Figure 11-5). Firstly, the impact of changing the composition to be representative of the region to which each MS belonged resulted in changes to the cumulative impact of +13% to -11%, compared to the standard methodology where the EU27 composition is assumed for all MS.

The first order decay model requires an assumption about the proportion of the waste in landfill sites that will decay anaerobically, and therefore generate methane. Additionally, the model needs the fraction of methane in the landfill gas generated. For each of these assumptions, the standard Tier 1 methodology uses the IPCC default values. Sensitivity to these assumptions is 1:1 proportional, so an increase in the proportion of waste decaying anaerobically of $1/8^{\text{th}}$ leads to an increased in the emissions from that landfill of $1/8^{\text{th}}$.

Figure 11-5: The maximum and minimum sensitivities across the case study MS of the Landfill Directive's impact on GHGs calculated using the Tier 1 methodology



11.3.3 Results - Tier 2 approach

The Tier 2 assessment builds on the proposed Tier 1 approach discussed above. For the Tier 2 assessment, established data sources are still used but the approach aims to take into account further complexities of waste disposal to landfills and more country specific issues. Two issues in particular are considered in more detail under the Tier 2 methodology.

Lifecycle emissions

One of the objectives of the Landfill Directive is to reduce the amount of biodegradable waste being disposed in landfills. A result of this is that more waste will be processed through other waste handling streams. Therefore in order to build a more realistic picture of the impact of the Directive, it is important to take into account the change in emissions from these other waste processing streams: incineration, recycling and biological treatment. The Tier 2 analysis incorporates the emissions produced by these processes for the waste that is diverted from landfill. Additionally, the Tier 2 approach takes into account the emissions associated with energy displaced by heat and electricity generated when the waste diverted from landfill is incinerated with energy recovery.

Emission factors for incineration and recycling of MSW are taken from the European Environment Agency's 2008 report on municipal waste management and greenhouse gases. Emissions from the biological treatment were calculated using default emission factors from the IPCC 2006 report on solid waste management.

Autonomous developments

As discussed above the Tier 1 approach fails to take into account autonomous developments that would have impacted on emissions from MSW disposal to landfills in the absence of the Directive. In the Tier 2 methodology an attempt has been made to take this into account by considering the historic trend in mass of MSW disposed to landfill. By extrapolating this trend forward, the assumption is made that in the absence of the Directive the rate of change of the mass of MSW disposed landfill would be the same as that over which the trend analysis was made.

As was the case for the Tier 1 analysis, the results generated using the Tier 2 approach show substantial variation across the case study MS (Table 11-4). Again, the more populous MS demonstrate largest savings.

Table 11-4: Estimated GHG savings from the Landfill Directive calculated using the Tier 2 methodology (Tg CO₂ eq.)

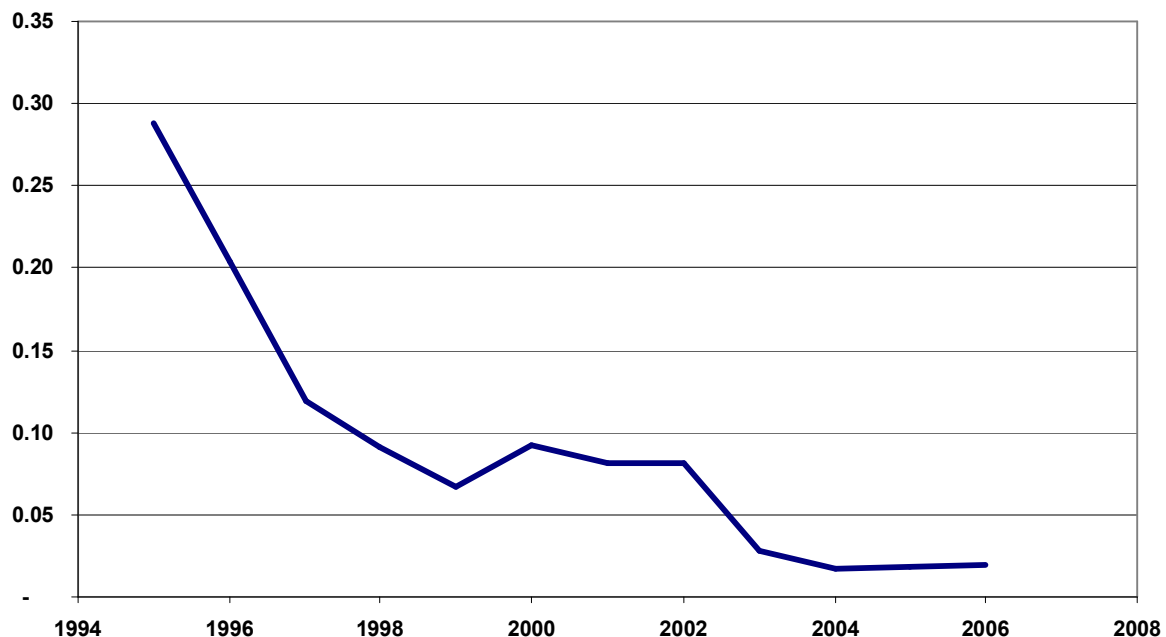
Type of results		Ex-post evaluation - annual savings								Ex-post evaluation results - cumulative savings inclusive of years presented	
Period		2001	2002	2003	2004	2005	2006	2007	2008		
Geographic Entity	EU-27	0.30	6.17	11.76	17.74	25.64	30.54			2001 - 2006	92.16
	Germany	0.88	0.06	0.41	0.39	3.07	5.34			2001 - 2006	8.39
	France	0.65	1.24	2.11	2.54	3.21	3.84			2001 - 2006	13.59
	Spain	1.09	1.28	1.19	0.35	0.64	0.62			2001 - 2006	1.95
	Italy	2.34	3.34	4.21	5.45	5.38	6.38			2001 - 2006	27.09
	UK	0.24	2.27	5.11	8.09	10.08	11.70			2001 - 2006	37.48
	Denmark	0.27	0.25	0.22	0.16	0.14	0.32			2001 - 2006	0.43
	Austria	0.06	0.04	0.11	0.32	0.66	0.80			2001 - 2006	1.58
	Netherlands	0.55	1.34	1.06	1.71	2.50	3.30			2001 - 2006	10.46
	Poland	-	-	-	0.02	0.10	0.19			2004 - 2006	0.31
	Czech Republic	0.05	0.08	0.04	0.31	0.20	0.85			2004 - 2006	1.19
	Romania	-	-	-	-	-	-			-	-

Note that the Tier 2 analysis produces a negative saving, equivalent to a rise in emissions, for a number of MS in one or other year. For the Spain, the Netherlands and the Czech Republic negative cumulative savings are recorded. The negative saving is a result of the counterfactual assumed for the Tier 2 methodology; extrapolation of the 1995 to 2000 trend in proportion of total mass of MSW disposed to landfill. Clearly, where a negative saving arises, the counterfactual suggests that more MSW would have disposed to landfill than in the absence of the Directive.

When extrapolating an historic trend forward it is important to consider what was happening in the period upon which the trend is based and most importantly, is that period representative for the period for which it is extrapolated. For some MS, for example Austria and the Netherlands, the period used to develop the historic trend coincided with a period of implementation of measure to reduce landfilling of waste. The rate of reduction in MSW disposed to landfill has continued and in fact accelerated for these MS since 2001, therefore the approach proposed here yields GHG savings as a result of the Directive. Over time however, it may become increasingly difficult to reduce the mass of MSW disposed to landfills. When this point is reached, the actual rate of reduction of MSW disposed to landfill will slow and the trend calculated over the 1995 – 2000 period may no longer provide a representative counterfactual. This situation can be seen in Figure 11-6, which shows the time variation of the proportion of total MSW generated in the Netherlands that is disposed to landfill. Over the period 1995

to 1999, the proportion falls from near 30% down to less than 10%. From then on the proportion has been reasonably stable, rising in 2000 to around 9% then falling to 2% through into 2006.

Figure 11-6: Proportion of total MSW generated in the Netherlands that is disposed to landfill



For this reason, it is important that in the future a Tier 3 methodology is developed based on the variables that determine the mass of MSW generated and disposed to landfill. This is discussed further in section 11.3.4.

The treatment of autonomous development here is strongly influenced by national policies that were in place prior to the Landfill Directive. It is assumed that the influence of these policies continues following the Directive's implementation and that influence is removed from the policy impact estimate attributed to the Directive. There is an argument to be made that from the EU perspective, the Directive should be attributed the impact of national policies from the time subsequent to implementation. Therefore, it should be recognised that there is scope for debate around the treatment of autonomous development in the Tier 2 estimation of the impact of the Landfill Directive.

Policy interaction

The choice of extrapolating the historic trend in mass of MSW disposed to landfill should incorporate much of the policy overlap outlined in section 11.3.2 into the counterfactual and therefore remove that component from the attribution of GHG savings to the Landfill Directive. This is clearly only true for the policies that were implemented during the 1995 to 2000 period over which the trend analysis was performed.

Sensitivity analysis

One of the main assumptions in the Tier 2 approach concerns the amount of waste processed by recycling and biological treatment. Data on the split of MSW disposed to landfill compared to the mass incinerated is available. However, there is no information on how the remaining waste is processed. Therefore in the standard methodology it is assumed that the ratio of waste processed by recycling is equal to that processed by biological treatment. For most MS the cumulative GHG impacts of the Landfill Directive are relatively insensitive to a shift in this ratio:

- increasing by around 15% for a shift in the ratio to twice as much biological treatment as recycling; and,
- decreasing by around 15% for a shift to double the amount of recycling compared to biological treatment.

However, the results for Spain are particularly sensitive to this ratio, since only around 60% of the total mass of MSW generated is disposed by landfilling or incineration. The GHG impacts of the Landfill Directive calculated for Spain using the Tier 2 approach are relatively small. Changes in the ratio of recycling to biological treatment are therefore more important relative to the total impact than for other MS.

Considering other Tier 2 assumptions, changes to the proportion of landfill waste decaying anaerobically of $\pm 1/8^{\text{th}}$ gives rise to increases and decreases of +5% and –20% and vice versa, respectively.

11.3.4 Results - Tier 3 approach

It has not been possible to perform a detailed Tier 3 analysis as part of this study. However as described in the previous section, the results from the Tier 1 and Tier 2 analysis are subject to certain uncertainties, that ideally would be resolved or addressed further. This section provides some further examination of the relative importance of the issues, and suggests some potential ways in which these issues could be addressed in future evaluations.

The principal development for a Tier 3 analysis would be to refine the counterfactual for waste disposed through the various processing streams in the absence of the Directive.

The EEA have recently carried out a modelling exercise for projecting greenhouse emissions arising from the waste sector in Europe⁸¹. As a part of this exercise, they calculated models for total MSW generation, however, the fraction of this waste disposed to landfill was based on best estimates. It would be beneficial to consider if a model for mass of waste disposed to landfill could be developed based on data on landfill rates over the period prior to the implementation of the Landfill Directive.

Issues to be considered for future evaluations:

- Reported recovery rates of landfill gas from landfill sites are under debate. Some MS report near or complete recovery. However, the recent IPCC guidance takes issue with this level of recovery and recommends that for reporting an upper limit of 20% is used. For the current assessment the reported recovery rates are used, however, this should be reviewed for any further assessment.
- The definition of MSW varies between MS. To inform the evaluation of the impact of the Landfill Directive, reporting on the sources of waste would be useful.

11.4 Synthesis and interpretation of results

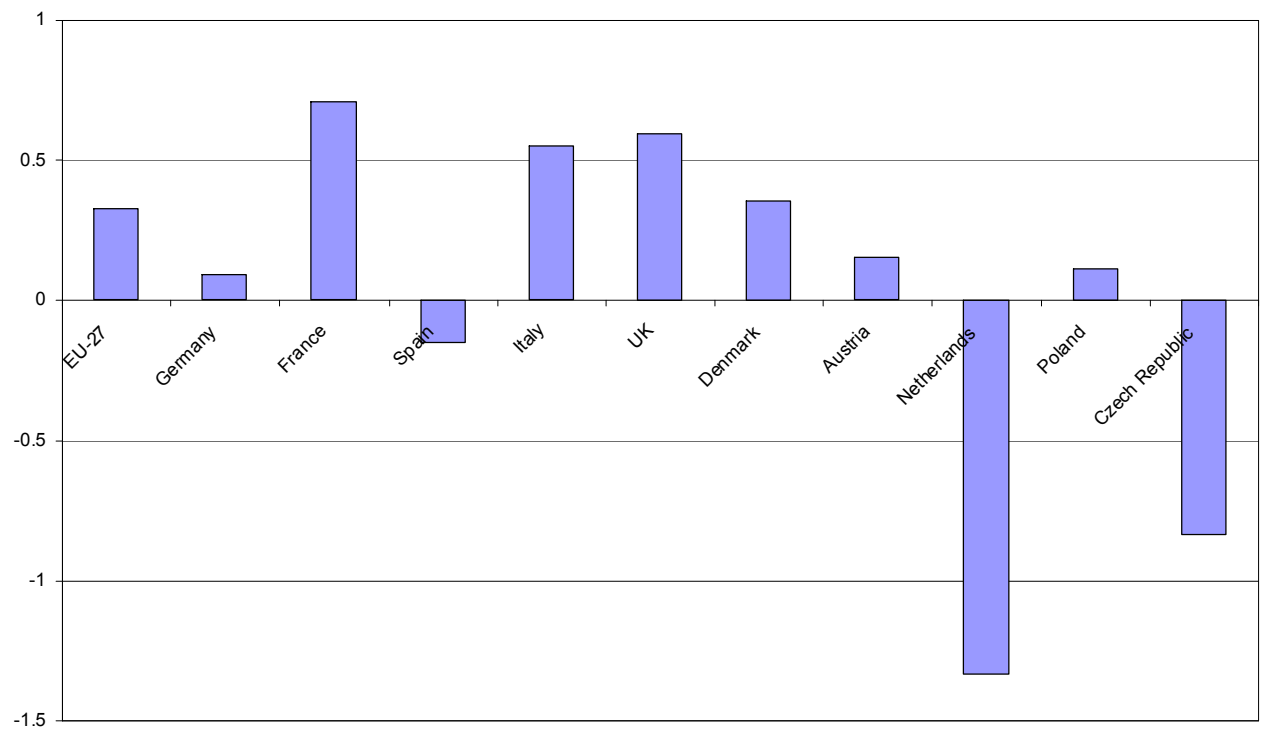
The tiered approaches presented above should add increasing levels of refinement to the quantification of the impact of the Landfill Directive on GHGs. Here we compare the results calculated under the two tiers proposed here and discuss the results in the context of other estimates of the impact of the Landfill Directive on GHGs.

11.4.1 Comparison of results from the different methods

On comparing the Tier 1 and Tier 2 results, the clearest difference is the magnitude of the savings attributed to the Landfill Directive. For the EU 27, the savings calculated using the Tier 1 approach are three times larger than those calculated using the Tier 2 approach (Figure 11-7). For Germany and Austria, the tier 2 results are up to a 10-fold smaller than for tier 1. Additionally, for the Tier 2 approach, three member states show negative results (see section 11.3.3 for a discussion of the reasons for these changes). These differences are largely the result of our inclusion and treatment of autonomous progress.

Figure 11-7: Tier 2 cumulative GHG impacts as a fraction of the Tier 1 results

⁸¹ EEA (European Topic Centre on Resources and Waste Management), Working Paper 2001/1, Municipal waste management and greenhouse gases, 31st January 2008.

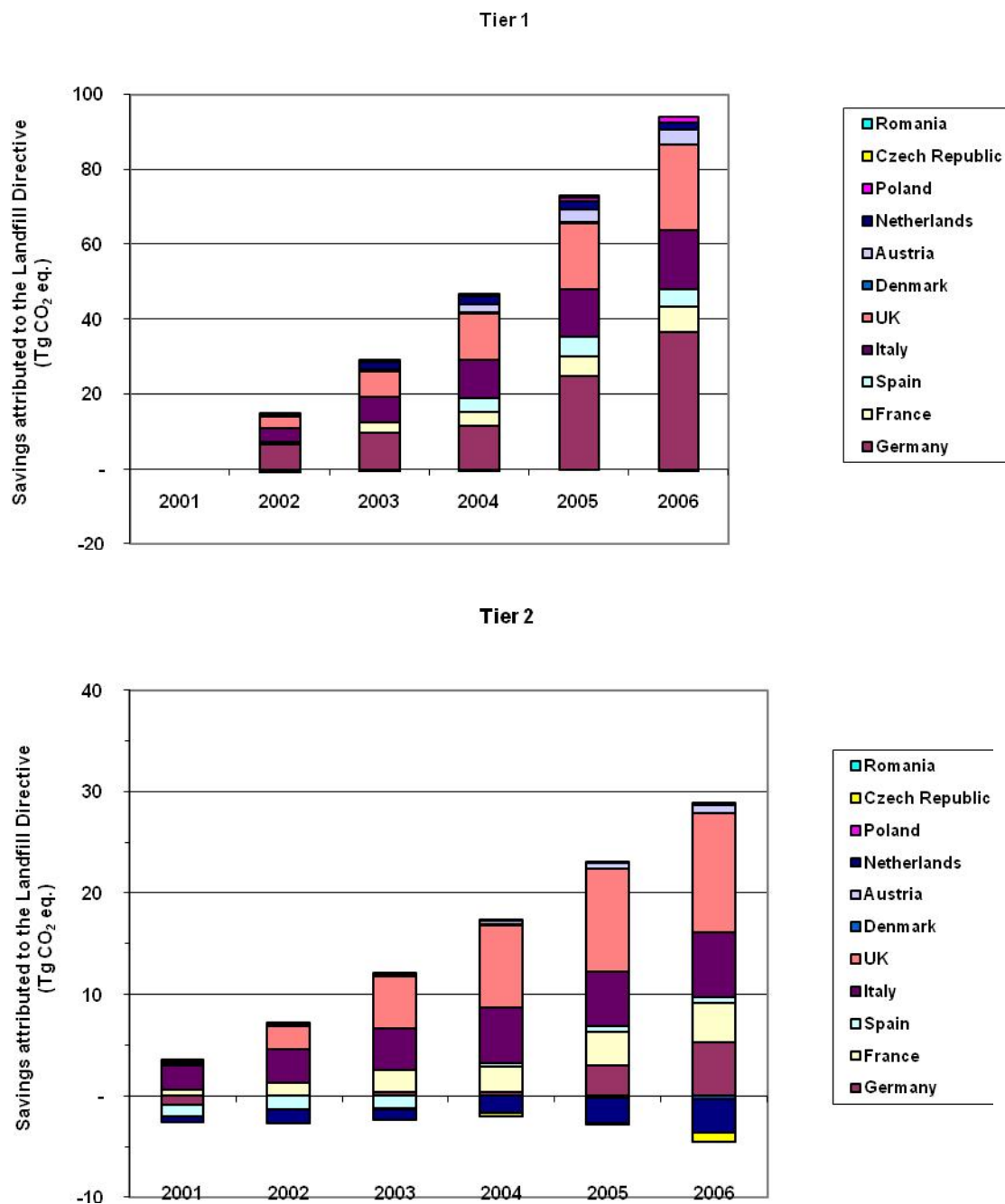


11.4.2 Comparison of impacts across Member States

The presentation of results under the 2 tiers of analysis (sections 11.3.2 and 11.3.3), has already introduced some of the general differences across the MS.

In both the Tier 1 and Tier 2 analyses shown in, Figure 11-8 the majority of the savings across the case study MS arise from Germany, France, Italy and the United Kingdom, which are the largest producers of MSW from our case study MS. One anomaly to this is Spain, which although lower than those MS listed above, generates much larger amounts of MSW than any other case study MS. However, the savings attributed to the Landfill Directive in Spain are small by comparison to the large MSW generators, and this is true for the results generated using both the tier 1 and 2 approaches. The reason behind this is that the fraction of all MSW that is disposed to landfill has fallen only slightly in Spain from 1995 to 2006 and much of that decline happened prior to 2001, when the Landfill Directive was officially implemented. Therefore, neither calculation leads to the conclusion that the Directive has had a substantial impact on GHGs in Spain.

Finally, as has also been introduced earlier, for Austria, Denmark and the Netherlands, where measures to reduce the fraction of MSW disposed to landfill were in place prior to the implementation of the Landfill Directive, only small savings have been attributed to the Directive. This is a reasonable outcome since levels of MSW disposal to landfill were low prior to the Directive and could therefore not decline significantly. Since landfill gas production is not as great in these MS, due to lower implied levels of landfilling, improvements in landfill gas recovery that may be attributed to the Directive also have a less significant impact.

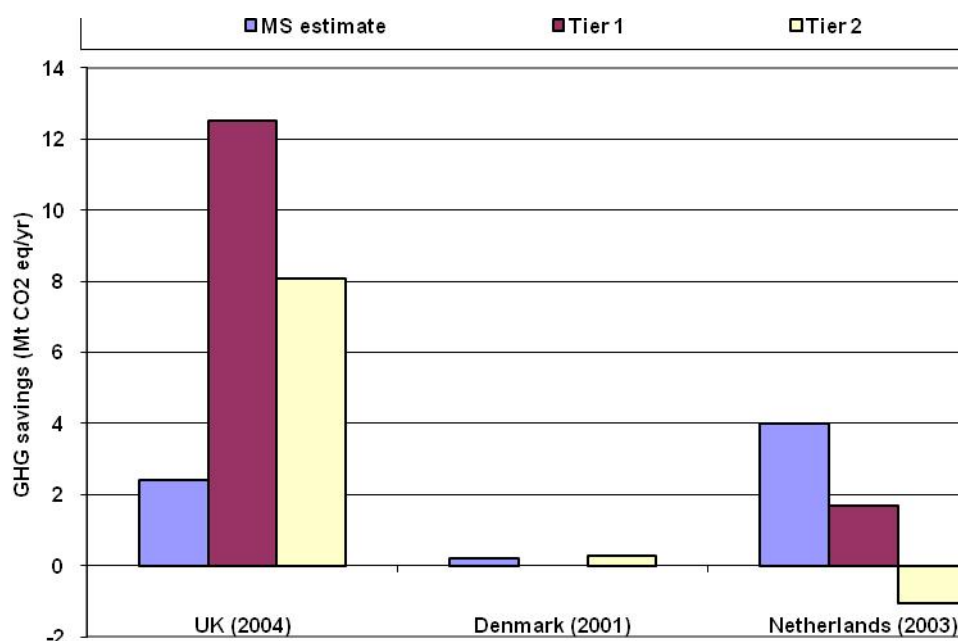
Figure 11-8: Time series of the GHG savings attributed to the Landfill Directive in the case study MS (note the difference in scale between the tier 1 and tier 2 analyses)

11.4.3 Comparison with alternative estimates

There have been a handful of estimates of the impact of the Landfill Directive made by MS. Comparing those estimates with the results from the Tier 1 and Tier 2 approaches proposed here, there are some differences, particularly in the case of the UK and the Netherlands. For Denmark on the other hand, the Tier 2 estimated GHG savings are similar to the MS estimate, lying 1/3 greater than that value.

In the UK particularly, the Tier 1 results show nearly a six-fold greater impact than the MS estimate. The Tier 2 estimate moves closer but remains over three times larger. Conversely for the Netherlands, the Tier 1 approach suggests a smaller impact than the MS estimate, and for Tier 2, as has been previously details (section 11.3.3), the result is negative. This divergence may in a large part relate to difference in the scope of the evaluation (e.g. inclusion/exclusion) of national policies.

Figure 11-9: Comparison of GHG savings estimated by MS and by the tier 1 and tier 2 approaches proposed here

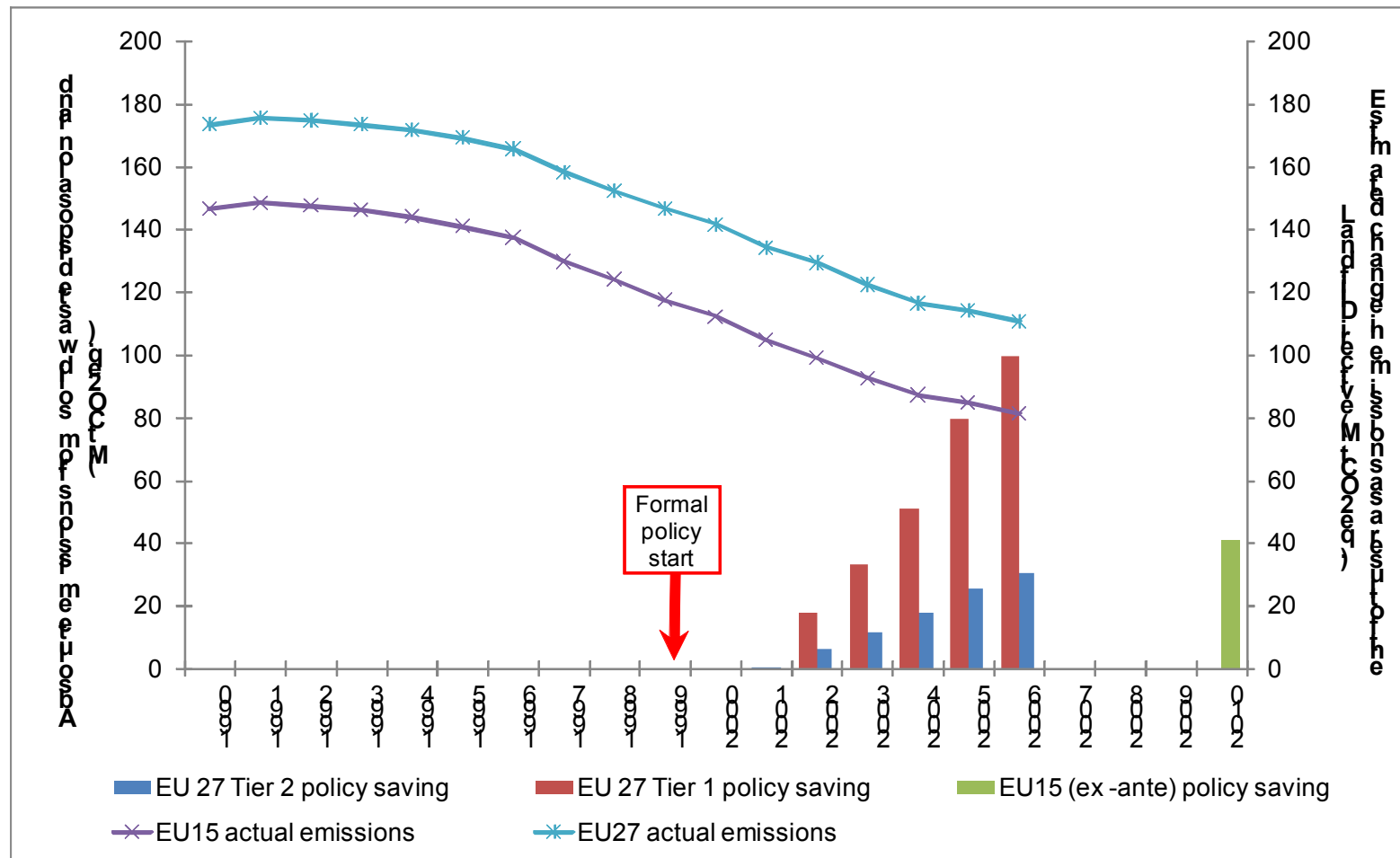


Within the framework of the ECCP an ex-ante estimate was made for the impacts of the Landfill Directive in 2010, of 41 Mt CO₂ eq. in the EU 15. This estimate is compared with the results from the ex-post evaluation in the table below. Ex-post savings for the latest year (2006), based upon the Tier 2 approach, are a reasonable proportion of the ex-ante estimate, although the latter is based upon the EU-15 and the former the EU-27. This suggests that the Directive has made some good progress in delivering emissions reductions to date.

Table 11-5: Comparison of ex-ante and ex-post results: Landfill Directive

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
Landfill Directive (Dir 1999/31/EC)	41	100.0 (EU27, 2006) NE (EU15, 2006)	30.5 (EU27, 2006) NE (EU15, 2006)	NE
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations:				
MSsp: Member State specific starting year for the ex-post evaluation				
NE = not estimated				

In Figure 11-10 the results of the evaluation can be put in context by comparing the estimated emission reductions with the overall historical trend in emissions from solid waste disposal. The estimated savings are significant in relation to the overall sector emissions.

Figure 11-10: Landfill Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above.

Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

11.4.4 Cost effectiveness

Article 10 of the EU Landfill Directive requires the operator of a landfill site (whether private or public and for the disposal of any type of waste) to charge a price covering all of the costs involved in the setting up and operating of a landfill site as well as the estimated costs of a closure and after-care of the site for a period of at least 30 years.

The ex-post cost effectiveness of the EU Landfill Directive was conducted by Golder Europe. The report, which was submitted to the European Commission (EC) in October 2005, used a governmental questionnaire and an individual landfill site operator interview in each Member State.

Though the authors admit that the implementation of this methodology provided major challenges as to a lack of robust data from the various representatives of government and industry within the Member States they came up with some major results. The estimated costs for the disposal of waste (excluding any landfill tax if relevant) for each member state is shown in the following table⁸².

Country	Latest date	Cost range for hazardous waste (€/tonne)	% change	Cost range for non hazardous waste (largely municipal solid waste) (€/tonne)	% change	Cost range for inert waste (€/tonne)	% change
Austria	1999	No data	unknown	50 - 150	unknown	No data	unknown
Belgium-Flemish	2003	102	2 (after 2 years)	116	5 (after 2 years)	28	58 (after 2 years)
Belgium-Walloon	2003	58	unknown	No data	unknown	10	unknown
Denmark	2004	900	592 (after 17 years)	110	57 to 340 (after 17 years)	60	362 (after 17 years)
Finland	2003	42 - 189	unknown	30 - 121	unknown	No data	unknown
France	No date	60 - 150	unknown	No data	unknown	5 to 10	unknown
Germany	2005	No data	unknown	123 (average from 12 sites)	unknown	No data	unknown
Greece	2005	No data	unknown	8 to 35	75 (after 6 years)	No data	unknown
Ireland	2005	No data	unknown	120 - 240	52 (after 4 years)	No data	unknown
Italy	2003	No data	unknown	90 - 110	unknown	No data	unknown
Luxembourg	2003 and 1970 for inert	75	unknown	50	unknown	4	unknown
Netherlands	2002	128	38 (after 4 years)	58	- 8 (after 4 years)		unknown
Portugal	2004	No data	unknown	26	unknown	No data	unknown
Spain	2004	No data	unknown	12	unknown	No data	unknown
Sweden	2004	100-160	unknown	70 - 90	unknown	40 - 60	unknown
UK	2003	65 - 185	unknown	21	unknown	4	unknown

The implementation of the EU Landfill Directive was generally followed by a cost increase of waste disposal in every EU member state.

While this result corresponds to what is to be expected in reaction to the implementation of the EU Landfill Directive there are several potential limitations:

- The costs are only approximations as actual costs are often due to the exact type of waste to be disposed of, the location of the facility in respect of local competition and internal business processes of the operating organisation.
- A cross country comparison of costs, i.e. an assessment of whether the cost per tonne of waste disposal converge across countries, is difficult to impossible as to the following reasons

⁸² Golder Europe, submitted to the European Commission "Markets" Team DG ENV.F.2 (BU-5 00/120), Report on implementation of the Landfill Directive in the 15 member states of the European Union, 2005

- There is a large variation in the costs per tonne of waste disposal across countries.
- There are a large variations in the cost changes, which probably correspond to the very different observed time periods across countries
- Several data are unknown or not available. The poor data result from the fact that it is often difficult to obtain representative costs, as government representatives may not be aware of the operational details at landfills. Also, organisations operating landfills are reticent about revealing their disposal charges since they regard this as commercially sensitive information.

In addition to the limitations above one has to take the following country-specific features into account:

- **Germany, Belgium** and the **Netherlands**, took action in the mid 1990s (or earlier) to reduce the amount of municipal waste being disposed to landfill enabling them to fulfil their requirements and divert biodegradable municipal waste from landfill. This may be a reason why the costs to dispose waste in these countries did not change much within the observed years.
- In the **UK** the cost of landfilling had been artificially depressed since the implementation of the Landfill Directive, as certain landfills tried to fill their void space before a permit is required (due to the large number of landfills involved, permits are being phased in gradually). Nevertheless, gate prices had increased in the **UK** over the observed years and thus better reflected the higher costs of construction and operation required for the Landfill Directive.
- In the **Netherlands**, between 1985 and 1995 the gate fees at landfills had increased as a result of more stringent environmental emission-thresholds. From 1995 to 2005, prices had increased as a consequence of higher taxes on the landfilling of waste, together with a prevention policy of waste going to landfills.
- The existence of “illegal landfill” in several countries may also be likely to distort the real cost per tonne of waste disposal. Ten member states reported zero illegal landfill sites, namely **Austria, Belgium-Flemish, Denmark, Finland, Germany, Luxembourg, Netherlands** and the **UK**. This probably reflects the longer tradition in these countries to run an effective waste management. The other six member states reported a significant number of illegal landfills, namely **Belgium-Walloon** (963 illegal landfills), **France** (1042), **Greece** (1453), **Ireland** (>9), **Italy** (1763) and **Portugal** (6). It should be noted, however, that the definition of “landfill” in the Landfill Directive is not always directly reflected in the definition contained within the legislation of each Member State. In some cases the definition of a landfill is given in relation to the issuing of a permit to construct and operate a landfill. This definition does not allow for the existence of a non-permitted (i.e. “illegal”) landfill.

11.5 Conclusions

Two approaches have been developed to estimate the impact on GHGs of the Landfill Directive. The approaches are based on the IPCC recommended methodology for quantifying GHG emissions from solid waste disposal on land.

In general, the Tier 1 approach estimates the impacts to be more substantial than the Tier 2 approach. Much of this difference in magnitude of impacts can be attributed to the counterfactual of MSW disposed to landfill in the absence of the Directive. The Tier 1 approach should be treated as an upper bound to the impact of the Directive on GHGs.

The Tier 2 approach incorporates a number of refinements over Tier 1 and the impacts attributed to the Directive are considerably reduced.

Overall, the Directive has the most impact for MS generating large quantities of MSW and that also incinerate a reasonable fraction of that waste. As is to be expected, those MS that had reduced landfilling of MSW prior to the implementation of the Directive, give rise to a lower impact.

These approaches are a useful first attempt to calculate an ex-post assessment of the impacts of the Landfill Directive on GHGs in the EU and a selection of case study MS.

11.6 Recommendations

The methodologies proposed for quantifying the impacts on GHGs of the Landfill Directive should be applied carefully. The Tier 1 approach should be considered as an estimate of the upper bound of the impact. The analysis would benefit from the refinements introduced in Tier 2. However, it is important to understand the reasons for the refinements and how representative they are for a specific MS. The assumption that the counterfactual mass of MSW disposed to landfill would evolve following the extrapolated trend calculated from the period 1995 to 2000 needs to be carefully considered. In particular, where policies were in place prior to the Directive then using an extrapolated trend suggests the impact of national policies would have continued at the same rate in the absence of the Directive.

In addition, where the data is available the approaches should be tailored to be as specific as possible to the MS to which the analysis is applied.

11.7 References

European Commission, COM(2005) 105, Report from the Commission to the Council and the European Parliament on the national strategies for the reduction of biodegradable waste going to landfills pursuant to article 5(1) of Directive 1999/31/EC on the landfill of waste.

EEA (European Topic Centre on Resources and Waste Management), Working Paper 2001/1, Municipal waste management and greenhouse gases, 31st January 2008.

Golder Europe, submitted to the European Commission "Markets" Team DG ENV.F.2 (BU-5 00/120), Report on implementation of the Landfill Directive in the 15 member states of the European Union, 2005

IPCC, 2006, Guidelines for National Greenhouse Gas Inventories, Volume 5 Waste, Chapter 3: Solid Waste Disposal

IPCC, 2006, Guidelines for National Greenhouse Gas Inventories, Volume 5 Waste, Chapter 4: Biological Treatment of Solid Waste

Statistical Office of the European Communities, EUROSTAT

12 Case study: Waste Incineration Directive (2000/76/EC)

12.1 Introduction

12.1.1 Overview of policy

The Waste Incineration Directive (WID) aims to regulate the incineration of waste in order to prevent excessive pollution to air, water and soil. Incineration and co-incineration plants must be authorized, comply with emission limit values for air and water pollutants, implement measurement and monitoring systems and recover any heat generated. Under the Directive:

- Emission limit values are established for air pollutants such as: Dust, HCl, HF, SO₂, NO_x, heavy metals and dioxins.
- Heat generated by the incineration process must be recovered and put to good use as far as practicable.

The Waste Incineration Directive has applied to existing plants since December 2005 and to new plants since December 2002. This Directive replaces Directives (89/369/EEC) and (89/429/EEC) on municipal waste incineration and (94/67/EC) on the incineration of hazardous waste.

Commission Decision 2006/329/EC of 20th February 2006 detailed a questionnaire that is to be used for Member States (MS) to report their implementation of the Directive. The first round of reporting under this decision will be due in September 2009.

The Directive on Integrated Pollution Prevention and Control (IPPC) also covers waste incineration plants that meet specific capacity thresholds⁸³. The WID sets more explicit requirements for the recovery of energy than the IPPC Directive. Therefore, WID is considered separately from the IPPC Directive.

Although WID does not directly set out to reduce emissions of greenhouse gases from waste, it does have indirect influences on these emissions, through improved energy recovery from the incineration process and potentially through its requirement for application of air pollutant abatement measures that may impact on greenhouse gas emissions. These impacts are discussed in more detail in section 12.2.1.

12.2 Emission trends and drivers

The ex-post impacts of the Directive on emissions of GHGs can be defined in terms of the difference between the actual reported emissions and the emissions under the counter-factual scenario (i.e. the estimated level of emissions that would have arisen in the absence of the policy). This section describes the underlying trends in the actual reported emissions, and emission-causing activities. It is against this backdrop that the counter-factual scenario can be defined.

12.2.1 Impact upon greenhouse gas emissions

WID does not set out to directly influence the emissions of greenhouse gases from waste incineration. However, it is possible that the technology required by incineration and co-incineration sites in order to meet the emission limit values set out in the Directive will influence greenhouse gases as well. Technology to reduce air pollutant emissions is most likely to influence emissions of greenhouse gases in the case of efforts to limit emissions of nitrogen oxides. Abatement techniques for NO_x at MSW incineration sites have previously involved injection of urea or ammonia into exhaust gases.

⁸³ Installations for the incineration of municipal waste with a capacity exceeding 3 tonnes per hour and installations for the incineration of hazardous waste with a capacity exceeding 10 tonnes per day

However, this selective non-catalytic reduction technique generates N_2O , a strong greenhouse gas⁸⁴. More modern selective catalytic reduction systems for removing oxides of nitrogen cause negligible emissions of N_2O ⁸⁵. In this study we have therefore not considered the direct impacts of NOx abatement techniques for N_2O emissions at the Tier1 or Tier 2 level. We do however make discussion of this area in our thoughts for Tier 3 analysis (Section 12.3.4).

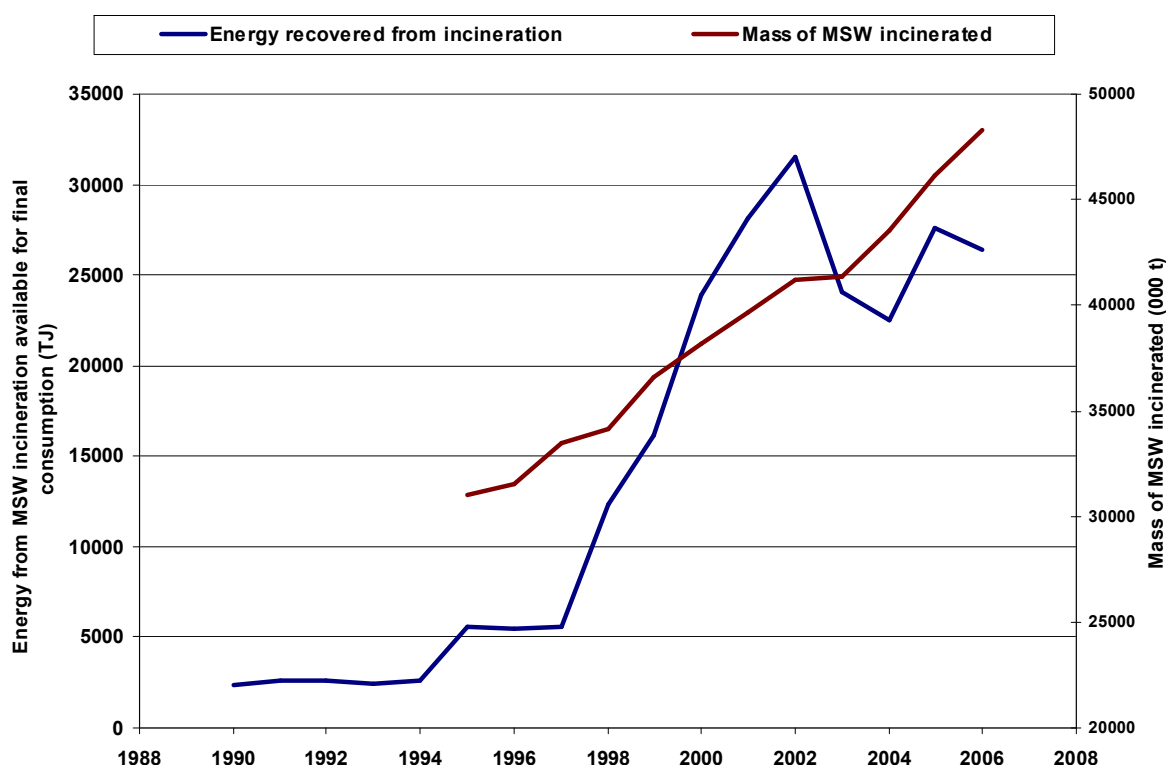
Through its requirements for energy recovery from incineration processes, WID does impact on greenhouse gas emissions by displacing energy that would otherwise have been generated from other sources. Energy generated from fossil fuel sources in large combustion plant (LCP) would give rise to greenhouse gas emissions. Abatement measures tend to consume energy, therefore the stringent ELVs laid down by the WID will result in lower energy yield per unit of waste incinerated. The LCP Directive set much less stringent ELVs and combined with the fact that incinerators produce lower temperature and pressure steam than a LCP, the energetic value of waste incinerated does not replace the same value of fossil fuels.

12.2.2 Activity and emission trends

Over the period 1995 to 2005, there has been a near linear increase in the mass of MSW disposed of through incineration in the EU 27 (Figure 12-1). Over the same time period, the energy from MSW incineration available for final consumption has also increased considerably, rising from around 5,000 kt in 1995 to over 30,000 kt in 2002 before oscillating around 25,000 over the next four years.

The increasing mass of MSW incinerated and the increases in energy available from that process is likely to be the result of efforts under Framework Directive on Waste.

Figure 12-1: Changes over time in the mass of MSW incinerated and the energy recovered from incineration for the EU27

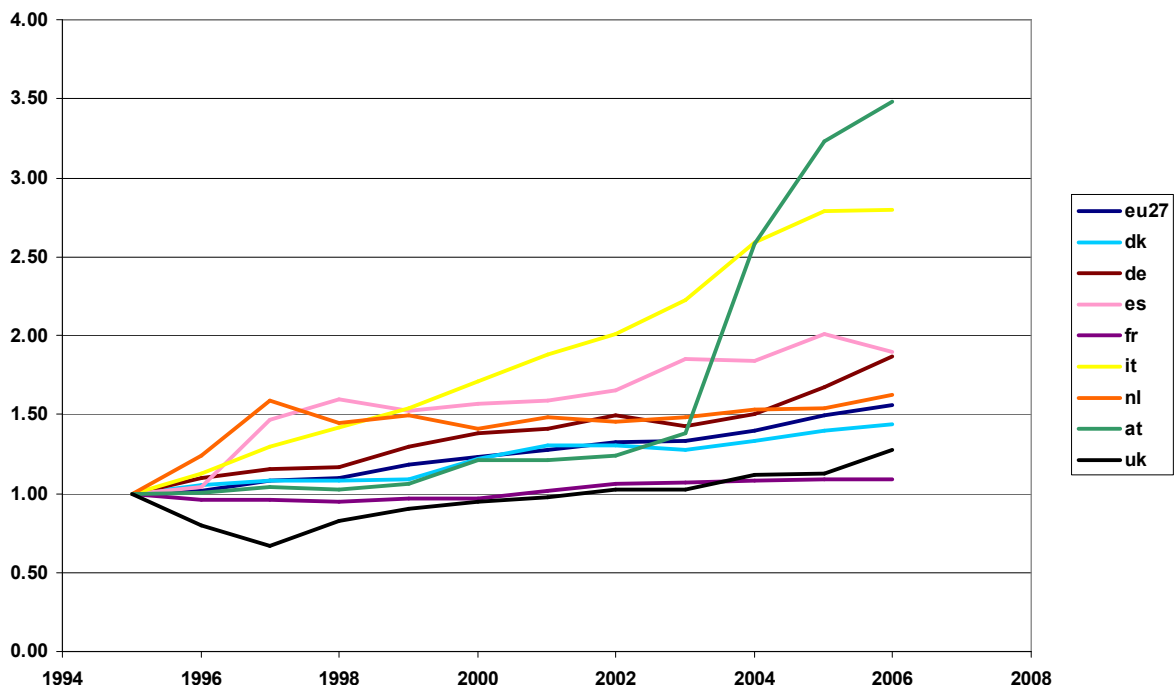


⁸⁴ Yuji, T., W. Nobuhisa, I. Saburo, Effect of reductive NOx abatement techniques on N2O emission at municipal solid waste incineration plants, *Annual report of Osaka City Institute of Public Health and Environmental Sciences*, No. 61, 22 – 25, 1999.

⁸⁵ Gutierrez, M., D. Baxter, C. Hunter, K. Svoboda, Nitrous oxide (n2O) emissions from waste and biomass to energy plants, *Waste Management & Research*, vol. 23, No. 2, 133 – 147, 2005.

Considering the change in the mass of MSW incinerated for the case study MS in this project it is clear that from 1995 to 2006 incineration has grown for all MS where data is available (Figure 12-2). For Italy and Austria in particular, relative to 1995 levels, incineration has increased substantially to 2006. Rising by 180% in the case of Italy and by 250% in Austria. In Italy, there has been a gradual increase in the proportion of total MSW incinerated, whereas in Austria there has been a sudden increase since 2003.

Figure 12-2: Index of the mass of MSW disposed by incineration in the case study member states for which data is available (1995 = 1)



Emissions from waste incineration are split in UNFCCC reporting between category 6.C for waste oil, incineration of corpses and hospital waste, and category 1.A for MSW incineration. There currently no data on the emissions arising from MSW incineration under category 1.A therefore it is not possible to demonstrate the changes in emissions from this sector over the last decade.

12.3 Impacts of the Directive on emissions of GHGs

This section presents the initial estimates of the impacts of the Waste Incineration Directive on emissions of greenhouse gases. The analysis is structured on the tiered methodological approach developed throughout the study and described in detail in the accompanying evaluation guidelines.

Results are presented for each of the 11 Member States selected for detailed consideration. These are: Germany, France, Spain, Italy, UK, Denmark, Austria, Netherlands, Poland, Czech Republic, Romania. Results are presented for each of the Tiered methodologies, respectively, and then the overall results are compared with each other and some overall conclusion are drawn. In each case the limitations with the approach and key methodological assumptions are highlighted.

12.3.1 Overview of methodologies

The Tier 1 approach represents a high level assessment of the impacts. It is based upon existing EU wide statistics so that the methods can be easily repeated without additional data collection. It applies a number of simplifying assumptions to ease comparison between countries and policies, but may not adequately reflect the full complexity of the policy in question.

In contrast the Tier 3 approach involves a much more detailed assessment of the policy impacts, using a much higher resolution of data (which may require additional collection) and increasing complexity in the methods. As far as possible the Tier 3 approach aims to consider all on the main methodological issues.

The Tier 2 approach provides an intermediate level of analysis. It aims to address some of the most important methodological issues but it is still largely reliant upon existing established data sources. The overall scope of each of these approaches and the assumptions that have been used in defining the policy impacts under each approach is summarised in table below.

A detailed description of the approach adopted is described in the Guidelines for estimation of ex-post impact of WID. However some important assumptions in the analysis are:

- Following the discussion of the impacts of WID on emissions of greenhouse gases (section 12.2.1), the approach proposed here considers only the effect of the Directive on recovery of energy from incineration and subsequent displacement of energy from other sources.
- The assumption is made that WID in itself does not affect the mass of MSW disposed through the incineration stream.

Table 12-1: Summary of the Tiered methodology for analysis of the Waste Incineration Directive

Methodology	Tier 1	Tier 2	Tier 3
Source data	EU 27 values for: • mass of MSW disposed through incineration (Eurostat) • energy from incineration available for final consumption (Eurostat) • Energy from waste as heat and electricity (CEWEP country reports) • Large scale electricity and production (Eurostat) • Primary fuel consumed in electricity production (Eurostat) And, • Emission factors for combustion of fossil fuels (IPCC)	As for tier 1 except MS specific values where available.	Includes detailed bottom up statistics.
Autonomous development + structural change	Does NOT consider autonomous development or structural change. The energy available per unit mass of MSW incinerated is assumed to remain at 2005 values in the absence of the Directive.	Autonomous change is considered by extrapolating the linear trend (from 1995 to 2004) in energy available for final consumption per unit mass MSW incinerated forward to the present as a counterfactual.	Correction(s) of autonomous development and structural change.
Policy start date	Calculates policy impacts from same start date, no adjustment for implementation delays or announcement effect	As for tier 1	
Policy interaction	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.	Some effect of pre-existing policies removed from the estimation	Estimates effect of specific EU policy.
Exogenous factors	No adjustment for exogenous factors	No adjustment for exogenous factors	Adjustment for impacts of profitability of waste incineration.

12.3.2 Results - tier 1 approach

The tier 1 approach to quantifying the greenhouse gas impact of WID assumes that if WID had not come into force in 2005 for all incineration plant, the energy recovered per unit mass of waste

incinerated would have remained 'frozen' at 2005 levels. At least some level of energy recovery has always been practiced and the WID may have led to some increase in energy recovery, and corresponding introduction of technical measures, during the period to 2005. We recognise that it is critical to the analysis to choose an appropriate reference year from which to construct the 'frozen' baseline. However, prior to 2005 decisions regarding energy recovery were not made under the obligations of the WID for all waste incineration sites. For 2005 and onwards, all decisions are made in the context of the regulations laid out in the WID, therefore, we can have certainty that WID was influential rather than other important drivers such as economics. For this reason, the year 2005 has been taken here as the reference year for energy recovery per unit mass of waste incinerated.

The energy recovered from waste incineration subsequent to 2005 is therefore assumed to displace heat and electricity from other sources. The ratio of heat energy to electrical energy output from MSW incineration is based on the country reports of CEWEP (Confederation of European Waste-to-Energy Plants).

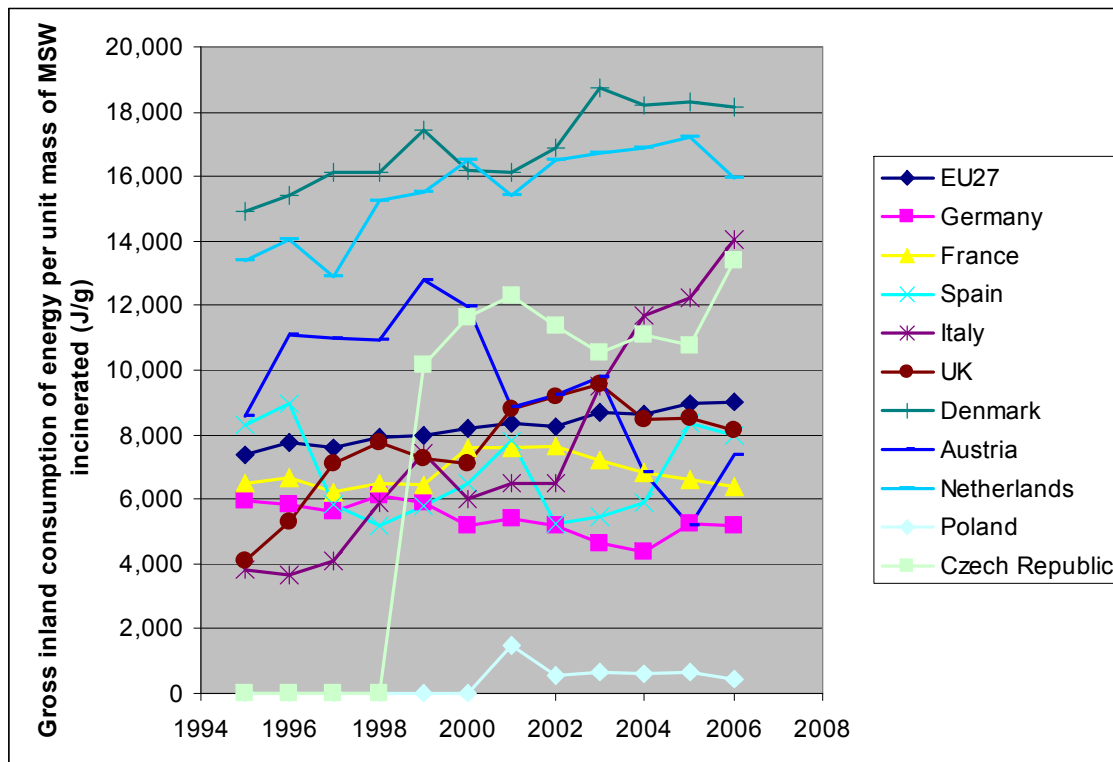
Table 12-2: Ex-post impacts on GHGs of the Waste Incineration Directive estimated using the tier 1 approach (ktCO₂ eq)

Type of results						Ex-post evaluation results - cumulative savings inclusive of years presented	
Period		2005	2006	2007	2008		
Tier		Tier 1					
Geographic Entity	EU-27	0.00	767.27			2005 - 2006	767.27
	Germany	0.00	-152.99			2005 - 2006	-152.99
	France	0.00	-589.66			2005 - 2006	-589.66
	Spain	0.00	-163.60			2005 - 2006	-163.60
	Italy	0.00	1571.72			2005 - 2006	1571.72
	UK	0.00	-266.32			2005 - 2006	-266.32
	Denmark	0.00	-70.53			2005 - 2006	-70.53
	Austria	0.00	760.86			2005 - 2006	760.86
	Netherlands	0.00	-1016.89			2005 - 2006	-1016.89
	Poland	0.00	-2.18			2005 - 2006	-2.18
	Czech Republic	0.00	176.08			2005 - 2006	176.08
	Romania	0.00	0.00			2005 - 2006	0.00

The ex-post impacts estimated using this tier 1 approach are shown in Table 12-2. There is considerable variation across the case study MS and the EU 27. Italy and Austria, which were highlighted for the growth in incineration (section 12.2.2) show the largest savings as a result of the Directive. However, what is perhaps most striking about the results is the 6 MS for which this analysis suggests WID did not produce a saving but may in fact have resulted in an emission increase.

The reason for the negative savings attributed to the Directive in 6 of the case study MS is down to the trend in energy recovery per unit mass of MSW incinerated (Figure 12-3). Those MS showing a negative savings estimate have a relative energy recovery rate in 2006 that is lower than that in 2005, the counterfactual for tier 1. Therefore, the actual energy recovered in this counterfactual is less than actually occurred. So, the savings attributed to the Directive are negative. Why the energy recovery rate in 2006 should fall for a number of MS is unclear. The first report on implementation of WID may help to answer this query.

Figure 12-3: Time evolution of energy recovery rates from MSW incineration for case study MS



Autonomous development

It can be clearly seen that for all MS there is considerable variability of the energy recovered from MSW incineration. The assumption of 'frozen' energy recovery value in the absence of the Directive does not reflect the real situation prior to the Directive coming into force for all incineration plant. The treatment of autonomous development is discussed further in section 12.5.

Policy implementation

As mentioned in section 12.1.1, WID came into force for all incineration plants in 2005. However, reporting on the implementation of the Directive has not yet been made at the time of writing. Following this report, the implementation of the Directive can be updated within the methodology

Policy interaction

The Tier 1 approach assumes that WID has been primarily responsible for any changes in the energy recovered from MSW incineration. However there are a number of policies and measures that may have influenced this metric:

- Framework Directive on Waste (75/442/EEC) requires national competent authorities to draw up a waste management plan. One element of the plan encourages recovery of waste including for its use as a source of energy;
- The Combined Heat and Power (CHP) Directive (not yet implemented) aims to indirectly support the advancement of CHP which is commonly used to capture the energy generated through the incineration of MSW.
- National policies on waste incineration will also interact with WID.

In the absence of the Waste Incineration Directive it is likely that these measures would have delivered emissions savings, by encouraging energy recovery. On this basis the assumption that a 'frozen' proportion of MSW is disposed to landfill, does not take these policy interactions into account. It is therefore important to attributing some of the savings calculated here for the Tier 1 analysis to the other policies.

12.3.3 Results - Tier 2 approach

The Tier 2 methodology builds on the proposed tier 1 approach discussed above. At the tier 2 level, established data sources are still taken into account but the approach introduces the following refinements:

- The methodology attempts to take into account autonomous development in the recovery rate for specific MS and some of the policy interactions that were not included in the tier 1 approach;
- MS specific data (where available) for calculating energy recovery rate, emission factors for heat and electricity.

The results are provided below.

Table 12-3: Ex-post impacts of the Waste Incineration Directive on GHG emissions , calculated using the tier 2 approach (kt CO₂ eq)

Type of results						Ex-post evaluation results - cumulative savings inclusive of years presented
Period		2005	2006	2007	2008	
Tier		Tier 2				
Geographic Entity	EU-27	0.00	-760.86			2005 - 2006 -760.86
	Germany	0.00	45.20			2005 - 2006 45.20
	France	0.00	-228.24			2005 - 2006 -228.24
	Spain	0.00	-100.93			2005 - 2006 -100.93
	Italy	0.00	737.57			2005 - 2006 737.57
	UK	0.00	-564.85			2005 - 2006 -564.85
	Denmark	0.00	-323.93			2005 - 2006 -323.93
	Austria	0.00	967.10			2005 - 2006 967.10
	Netherlands	0.00	-1371.48			2005 - 2006 -1371.48
	Poland	0.00	-6.93			2005 - 2006 -6.93
	Czech Republic	0.00	215.20			2005 - 2006 215.20
	Romania	0.00	0.00			2005 - 2006 0.00

EU 27 heat to power ratio of energy generated used to calculate the emission factor for electricity & EU 27 emission factor for heat is applied

EU 27 heat to power ratio of energy generated used to calculated emission factor for electricity

For a number of MS, data availability required that EU 27 averages were used in place of country specific values, Table 12-3 indicates where this is the case. Emissions from public thermal power stations to heat or electricity have been assigned according to the ratio of energy produced in each form. Where this split is not available, the EU 27 ratio has been used. Additionally, for a number of MS, data availability prevented the calculation of a MS emission factor for large-scale generation of heat. In, this situation, the EU 27 emission factor has been taken.

The results generated following the tier 2 approach show substantial variation across the case study MS with savings ranging from -1371 to 738 kt CO₂ eq. In addition to the EU 27, there are five MS for which the approach suggests negative savings can be associated with the implementation of WID, these are: France, Spain, UK, Denmark and Netherlands. For Denmark, UK and the Netherlands, each MS has seen a trend of increasing energy recovery from waste incineration over the period 1995 to 2004. However, in the year 2006, energy recovery per unit waste incinerated fell. For France, energy recovery remained relatively stable over the 1995 – 2002 period, after which point recovery rates have fallen gradually. Energy recovery in Spain has varied substantially over since 1995 but the long-term trend has been relatively stable. In the year 2005 to 2006 however recovery rates fell. For those MS that experienced a fall in recovery rates in the analysis year 2006, the counterfactual

extrapolated from the historic trend suggests that in the absence of WID energy recovery rates would have been higher. Therefore, negative emissions savings are attributed to WID.

The previous discussion raises the point that it is important to consider if the counterfactual chosen for this analysis is appropriate. Extrapolating the historic trend in energy recovered per unit of waste incinerated seems reasonable, providing that the underlying economic and political drivers continue to exert an equivalent level of influence. However, this is not certain and more information is required on the implementation of WID and on the details of how waste incineration has developed within each case study MS. See section 12.5 for further discussion of the drawbacks of this approach.

12.3.4 Results - Tier 3 approach

It has not been possible to perform a detailed Tier 3 analysis as part of this study. However as described in the previous section, the results from the Tier 1 and Tier 2 analysis are subject to a considerable uncertainty surrounding the counterfactual for energy recovery from waste. This issue would ideally be dealt with in a Tier 3 approach.

Importantly, the autonomous changes in energy recovery are likely to be influenced by economics and the relative price of energy generated from other sources. As energy prices have risen it has become increasingly worthwhile to recover as much energy as possible from the waste incineration process. Therefore a potentially useful counterfactual would take the correlation of energy recovery rate against energy prices prior to the Waste Incineration Directive and then use energy prices after the implementation WID to set a baseline for what recovery efficiency may have been achieved had the Directive not been implemented.

In addition to advancing the analysis of greenhouse gases displaced by energy recovered from the waste incineration process, it is important at the Tier 3 stage to also consider the implication of NO_x reduction technologies for reducing emissions of N₂O. In order to achieve this analysis, further information must be obtained on the technologies applied in Waste Incineration plant. This therefore points towards a model that might consider individual waste incineration plant and the technologies and actions that each takes.

12.4 Synthesis and interpretation of results

The following sections bring together the results from the different tiers of analysis discussed in sections 12.3.2 and 12.3.3 above.

12.4.1 Comparison of results from the different methods across the member states

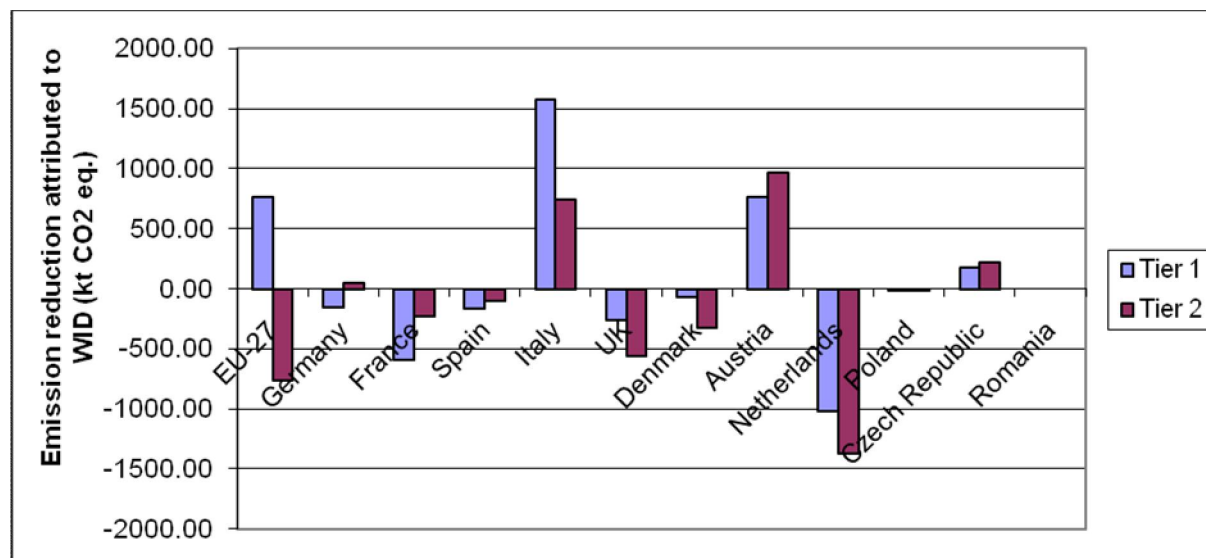
The ex-post impacts estimated using the tier 1 approach generally include autonomous progress and the impact of other policies. For this reason the tier 1 estimates would be expected to be substantially larger than those derived using the tier 2 estimate, which takes some autonomous progress and policy interaction into account (Figure 12-1). However, for 4 MS, the tier 2 results are greater than for tier 1.

It is worth reiterating here the primary focus of the analysis of WID is the energy recovered per unit mass of MSW incinerated. Therefore, the differences can be primarily explained by the time series of energy recovery for each MS and the counterfactual assumptions made. For France, the UK, Denmark and the Netherlands, the trend over the period 1995 to 2004 was of increasing energy recovery from MSW incineration. However, as previously noted, in 2006 the energy recovery rate fell in all these MS. As a result, the tier 1 counterfactual of a 'frozen' 2005 recovery rate leads to a smaller difference from the actual energy recovery rate than the tier 2 counterfactual, which extrapolated the 1995 – 2004 trend forward. Accordingly, the tier 1 estimates are lower than for tier 2.

For the EU 27 as a whole, the tier 1 and tier 2 results are similar in magnitude but of different sign. For the tier 1 analysis, the 'frozen' 2005 energy recovery rate leads to a positive saving estimate attributable to WID. However, when the long-term trend of increasing energy recovery from incineration is extrapolated forward as the tier 2 counterfactual the resulting recovery efficiencies are higher than the actual rates in the period since the implementation of WID. Therefore, the sign of the

saving shifts to negative. The converse is true in Germany, where the long-term trend in energy recovery rates is negative. Against the frozen 2005 rate, the 2006 recovery efficiency is lower. However, once the long-term trend is taken as the counterfactual the savings impact becomes positive.

Figure 12-4: Comparison of tier 1 and tier 2 results for the EU 27 and the case study MS



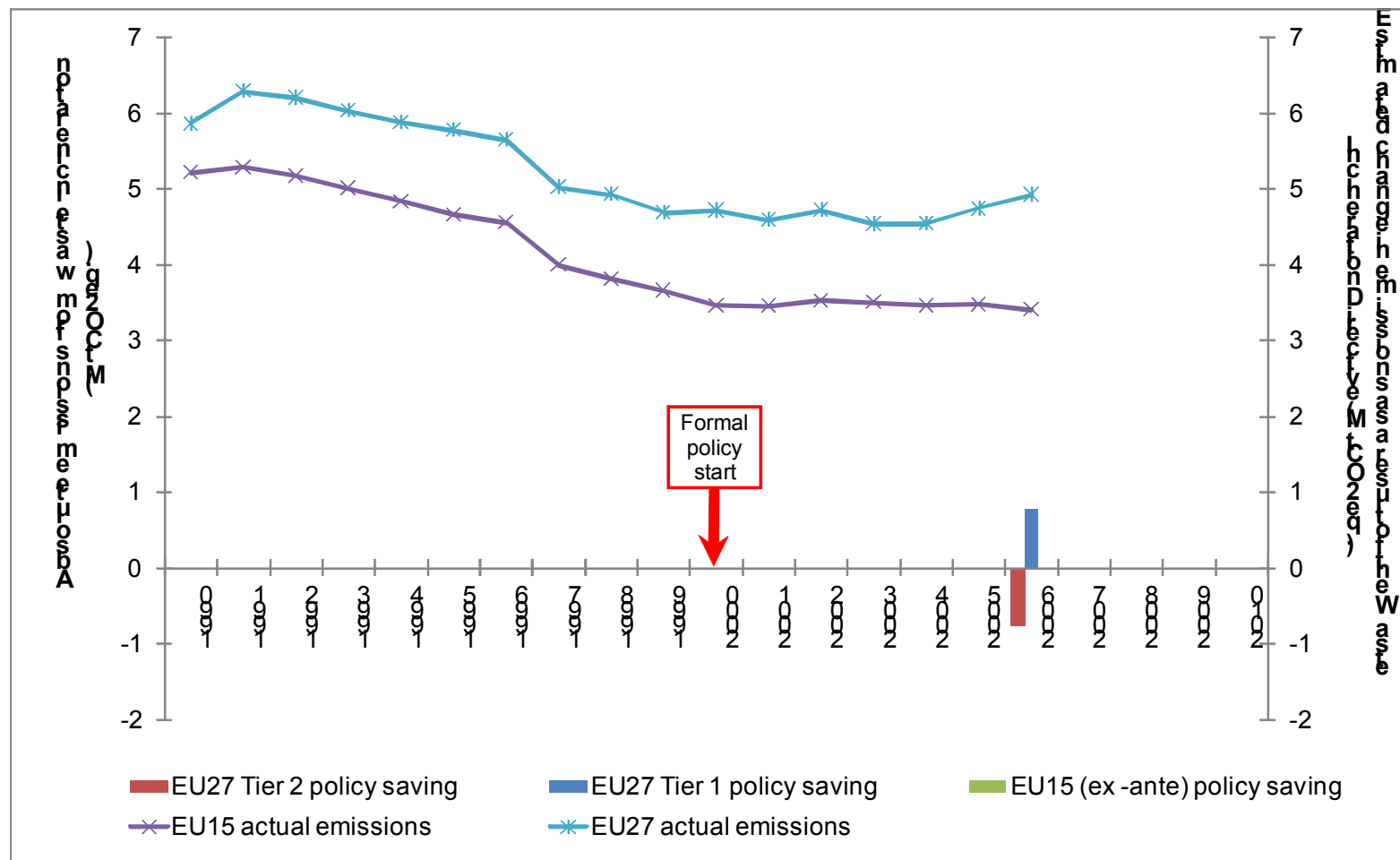
12.4.2 Ex ante projections

No quantitative ex-ante estimates of the impacts of the Waste Incineration Directive upon GHG emissions within the European Union have been identified. The results from the ex-post evaluation are presented in the table below. This is a consistent reporting format as used for the other policies.

Table 12-4: Comparison of ex-ante and ex-post results: Waste Incineration Directive

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
Waste Incineration Directive (Dir 2000/76/EC)	NE	0.8 (EU27, 2006) NE (EU15, 2006)	- 0.8 (EU27, 2006) NE (EU15, 2006)	NE
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations:				
MSsp: Member State specific starting year for the ex-post evaluation				
NE = not estimated				

In Figure 12-5 the results of the evaluation can be put in context by comparing the estimated emission reductions with the overall historical trend in emissions from waste incineration. The estimated savings are potentially significant in relation to the overall sector emissions. However, the potential range in the impacts is larger, reflecting limitations in the methodology – as described above.

Figure 12-5: Waste Incineration Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above. Emissions from waste incineration are split in UNFCCC reporting between category 6.C for waste oil, incineration of corpses and hospital waste, and category 1.A for MSW incineration. There is currently no data on the emissions arising from MSW incineration under category 1.A.

12.5 Conclusions

Two methodologies are proposed for investigating the impact on GHG emissions of the Waste Incineration Directive. Both methodologies are based on the impact of the Directive on energy recovered per unit mass of MSW incinerated.

The Tier 1 estimate attributes autonomous changes and other policy impacts to WID. Therefore it should be treated as a first order assessment. The Tier 2 approach attempts to take some account of autonomous developments and policy interactions. However, further refinement of the approach (i.e. a Tier 3 approach) is necessary for a robust estimate of the policy impacts. Perhaps the principal conclusion is that the analysis of WID is not fully suited to a Tier 1/2 indicator based approach.

Additionally, for the EU 27 as a whole and a number of individual MS, 2006 saw an anomalous fall in energy recovery from MSW incineration set in the context of a trend towards increasing recovery. For this reason negative savings associated with WID have been calculated here.

It could be argued that the treatment of autonomous development applied here; linearly extrapolating the historic trend, is not a reasonable estimate of what may have happened in the absence of the WID. Primary this is because of the large variability in the time series of energy recovery rates and the lack of a strong trend over the 1995 - 2004 period for some MS. The analysis could be better served by considering autonomous development in this manner as a sensitivity analysis.

12.6 Recommendations

The Tier 1 and 2 methodologies proposed here could be built upon using more detailed MS knowledge to start investigating the ex-post impact of WID on GHG emissions. It is recommended that MS knowledge is applied where possible to refine the methodologies, taking into account specific issues, and to generate a representative counterfactual. Particular attention should be paid to what would have happened in the year 2006 in the absence of WID since, as can be seen from this analysis, the anomalous decrease in relative energy recovery from MSW incineration in some MS suggests negative savings attributable to WID.

Further investigation should be made into the impacts of NO_x abatement technology on emissions of N₂O from waste incineration processes.

Once further data becomes available, it will be instructive to also consider if there has been an early mover policy effect, where waste incinerators have implemented NO_x abatement and energy recovery practices prior to the policy start date.

13 Case study: 2003 CAP Reform

13.1 Introduction

This case study presents the analysis, results and recommendations that relate to the evaluation of the impacts to date of the 2003 reforms to the Common Agricultural Policy, on emissions of greenhouse gases with the European Union. Given the significant overlap, these results should be considered in conjunction with those presented for the Nitrates Directive.

The chapter provides an overview of the overall instrument and its impacts upon emissions of greenhouse gases. This is then followed by a more detailed examination of some of the individual elements of the 2003 reform, specifically the sheep and beef sectors⁸⁶. Since the outcomes of the 2003 reforms will only be reflected within emissions data from 2005 at the earliest, the extent to which the policy can be evaluated to date is limited. Therefore, the focus of the chapter is upon the applicability of the methods to future evaluations of the policy.

The analysis has been performed in accordance with the tiered methodology that has been developed during this study, and is described in the accompanying evaluation guidance. In particular, the report examines the extent to which a simple top-down methodology can be used to quantify the impacts of the CAP regulations on emissions of greenhouse gases.

13.1.1 Overview of policy

The Common Agricultural Policy is the catch-all title for a number of different policies which have operated in the European Union since 1962 governing agricultural production in the region. Originally designed to increase levels of agricultural efficiency and production, recent reforms of the policy have sought to encourage EU farm businesses to become more market focussed, as well as introducing a greater number of environmental regulations governing farming.

The 2008 CAP 'Health Check' built upon the reforms of 2003 which involved a radical rethink of the way that the EU should support agricultural production. One of the major elements of the 2003 reform was decoupling, which meant that for the first time farm businesses would receive payments largely based on their acreage rather than on what they produced. This meant that farmers could produce what the market wanted, rather than what the CAP was paying them to produce.

The introduction of the single farm payment, which replaced a number of the different support schemes operating previously, was another major element of the reforms. Different Member States have adopted different mechanisms to manage the transition from varying payments to farmers in different regions and involved in different enterprises but the main focus has been to make payments according to area managed (reflecting to a greater or lesser extent historical payments) rather than number and type of crops grown and livestock raised.

Cross compliance was another major element of the CAP reform in 2003. This was the process whereby direct payments are dependant on maintaining all land in good agricultural and environmental condition (GAEC) and complying with (largely existing) legislation affecting agricultural management. These pieces of legislation are known as statutory management requirements (SMRs) and must be complied with if relevant to the situation and enterprises of that specific farm. In this way the 2003 CAP reform Council Regulation 1782/2003 created a direct link with existing environmental, food safety and animal and plant health legislation.

Alongside agricultural CAP measures there is a strong emphasis on rural development in Member States, partly funded by money diverted from the CAP budget through what is known as modulation. Additional funding is provided by the European Agricultural Fund for Rural Development (EAFRD) to

⁸⁶ Whilst the testing of the methodology on the sheep and beef sector will cover certain aspects of the CAP reform on emissions of greenhouse gases, specifically emissions from livestock, it is important to note that there are other impacts associated with the 2003 CAP reforms that will not be captured within this analysis. This includes, for example, the impacts of set aside on carbon sequestration.

assist with implementation of Council Regulation (EC) No 1698/2005 on support for rural development. Rural Development measures are focussed on three axes:

1. Improving the competitiveness of agriculture and forestry by supporting restructuring, development and innovation;
2. Improving the environment and the countryside by supporting land management;
3. Improving the quality of life in rural areas and encouraging diversification of economic activity.

These objectives are to be achieved through the funding of projects and schemes under each of the three axes. These include, under axis 2, voluntary agri-environment schemes under which farmers are paid for environmental management which goes beyond the legal requirements – so called baseline – covered by GAEC and SMRs as well as additional minimum requirements on use of fertilisers and plant protection products. There is a range of other rural development policies which may affect farm management which include less favoured area (LFA) payments for farms in more marginal areas such as uplands. Rural development measures also include schemes associated with water use and protection and forestry and woodland.

The CAP itself comprises a number of elements directly governing agricultural production in the EU which are aspects of Regulation 1782/2003 rather than separate legislation as listed above. These include the beef and cow premiums, milk quota, set aside and sheep quotas and premiums although a number of other policies and measures remain part of the CAP at the current time. The application and adoption of all such CAP measures will be influenced by the measure and the CAP itself, as well as GAEC and SMR rules, rural development schemes and other non-agricultural policy issues.

13.1.2 Impact upon greenhouse gas emissions

The CAP reform has the potential to influence emissions of GHG across all farm sectors within the European Union in the following ways:

- Change in livestock numbers (e.g. reduced intensity because payments are no longer linked to production)
- Change in inputs including fertilisers (e.g. maximising profit & efficiency of inputs rather than volume of outputs, especially in the light of increasing costs)
- Improved environmental practices (because of cross-compliance: statutory management requirements (SMRs) and GAEC)
- Maintenance of grassland and semi-natural area (because of set-aside and obligation on Member States to retain certain permanent pasture).

As a result, the CAP reforms will potentially impact upon all of the main activities/emissions associated with the agricultural sector. These include the emissions inventory CRF classifications:

- 4A - Enteric fermentation
- 4B - Manure management
- 4D - Emission from soils
- 5B - Cropland – sequestration in soils and vegetation
- 5C - Grassland – sequestration in soils and vegetation
- 1A4c - Emissions from energy use in agriculture/forestry/fisheries

It is important to consider the methodologies, and their relative uncertainties, that are used to estimate emissions from the sector. For example, using the Tier 1 IPCC methodology to estimate emissions from the sector, only the impacts of changes to livestock numbers and amounts of N fertilisers applied can be accounted for; the impacts of more subtle changes, such as improved manure management, would go un-noticed.

In addition, the impacts of the CAP reforms can potentially extend beyond the boundary of the emission inventories that are prepared by EU Member States. Since the production and trade of agricultural commodities takes place within a global market, of which the EU is a major player, changes to the CAP can potentially impact upon production on a global basis. This in turn, may have an impact upon the emissions of greenhouse gases from agricultural production outside of the EU (for example through land use change). This is a complex issue, and is largely beyond the scope of this analysis. The focus of this chapter is therefore upon the impacts of the CAP reform on direct emissions within the EU.

The impacts of the CAP reform will extend to all farm sectors within the European Union, and may include the range of impacts described above. To make the evaluation of the 2003 CAP reform more manageable it is useful to consider the individual elements of the CAP and their status before and after the 2003 reform (Council Regulation 1782/2003), rather than all elements of the reform together. Consequently two elements of the coupled Common Agricultural Policy are considered within this chapter: the sheep and goat meat regime and the beef sector premia. Specifically, the change in livestock numbers arising from the reform in these sectors.

In practice, the impacts of the CAP reform on greenhouse emissions from the sector are far more wide-ranging than these two elements, so the analysis presented here represents a sub-set of the total potential impacts of the reform.

13.2 Sheep and Goat meat regime

13.2.1 Background

The sheep and goat meat common market organisation (CMO) or regime was first introduced in 1980 to establish a common organisation of the market, to stabilise the market, and to ensure a fair standard of living for sheep and goat farmers. Measures contained within the regime included the payment of an annual ewe premium, the setting of a basic price for meat and the use of intervention measures including Private Storage Aid (where meat is taken off the market and put into storage for a period of between three and seven months), or, in the case of some Member States, the payment of an additional variable premium paid on sheep. Trade measures were also imposed which effectively prevented imported products reaching the market at prices below those operating in the Community.

The major reform to the sheep and goat meat regime that was included within the 2003 CAP reform was the partial decoupling of support payments from agricultural production. Effectively, this meant that a maximum of only 50% of sheep and goat premia could be production-linked, with the rest incorporated into the Single Farm Payment.

The expectation was that by decoupling payment, production levels would adjust downwards, to reflect the underlying profitability of alternative enterprises⁸⁷. The net effect of the reforms would therefore be a decline in the total number of sheep. In addition, structural change are also anticipated, since the incentive to maintain the breeding herd is reduced when the ewe premia are decoupled (FAPRI, 2003)⁸⁸.

13.2.2 Implementation

The implementation of the 2003 reforms within the sheep and goat sector has varied from one Member State to the next as the option was given to allow partial coupling to remain. The main rationale for this was to discourage the abandonment of otherwise unproductive land. Effectively, what this meant was that in Member States that retained the maximum proportion of coupled payments the livestock sectors would have seen little change from the previous reforms in 1999. However, for those Member States that did decouple there are likely to be more considerable changes to these sectors.

According to European Commission⁸⁹ the following Member States implemented partial decoupling in the sheep and goat sector (equivalent to 50% of the sheep and goat premia): Denmark, Spain, France, Portugal, Finland and Slovenia. For Belgium, Germany, Ireland Luxembourg, Malta, Netherlands, Austria, Sweden and the UK payments are fully decoupled. Greece and Italy included a percentage of the ceiling for the sheep and goat sector as part of its Article 69 application for targeted support.

⁸⁷ However, some have argued that the disassociating payments with units of production may in itself not be sufficient to totally break the link between payment and production levels. See for example, Analysis of the Impact of Decoupling on Agriculture in NI <http://www.qub.ac.uk/afe/fapri/decouplingNI.pdf>

⁸⁸ Analysis of the 2003 CAP Reform Agreement September 2003. FAPRI Staff Report 2-03

⁸⁹ http://ec.europa.eu/agriculture/healthcheck/guide_en.pdf

13.3 Emission trends

The aim of the ex-post evaluation methodologies is to describe the impact of the individual policies and measures upon greenhouse gas emissions from the targets/sectors influenced by the respective policies. The impact of the policies is measured in terms of the difference between the actual emissions and the emissions under the counter-factual scenario (i.e. the estimated level of emissions that would have arisen in the absence of the policy). This section describes the underlying trends in emissions, and emission-causing activities against which the counter-factual scenario can be defined.

13.3.1 Impact upon greenhouse gas emissions

Sheep enterprises are associated with emissions of methane, nitrous oxide and carbon dioxide. Methane is produced in sheep as by-product of enteric fermentation. It is also emitted during the management of animal manures. Emissions of nitrous oxide can arise from animal manure management systems, and from agricultural soils due to use of manure as fertiliser and from the application of mineral-N fertilisers. Carbon dioxide is associated with energy consumption on the farm. In global warming terms, methane and nitrous oxide are much more important greenhouse gases.

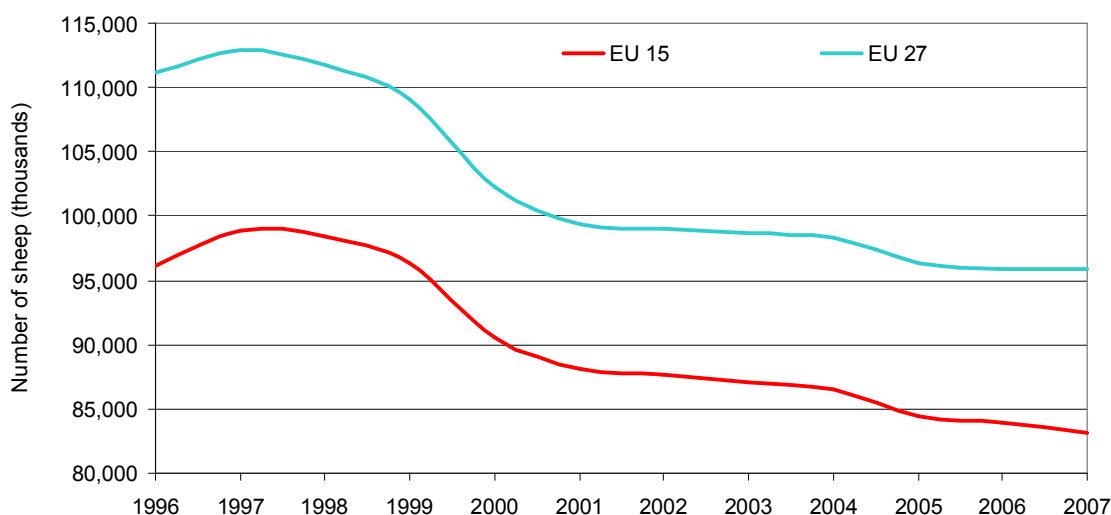
By influencing the number of sheep, specifically ewes, the reforms described above are also expected to influence the greenhouse emissions associated with sheep rearing.

13.3.2 Activity and emission trends

Greenhouse gas emissions associated with the raising of sheep and goats are reported by Member States to the UNFCCC under category 4.A. Also emissions arising from the management of manures and application of manures to land are captured under reporting category 4.B – Manure management and 4.D.1.2 – Animal Manure Applied to Soils. In parallel with reporting emissions, the underlying activity data (i.e. number of animals) is also captured in the submission to the UNFCCC. A further source of statistics is Eurostat, who collect statistics on the sheep population within the European Union. The Eurostat statistics are similar but not always identical to the UNFCCC activity data. Eurostat data is presented below up to the year for which statistics are available (2007).

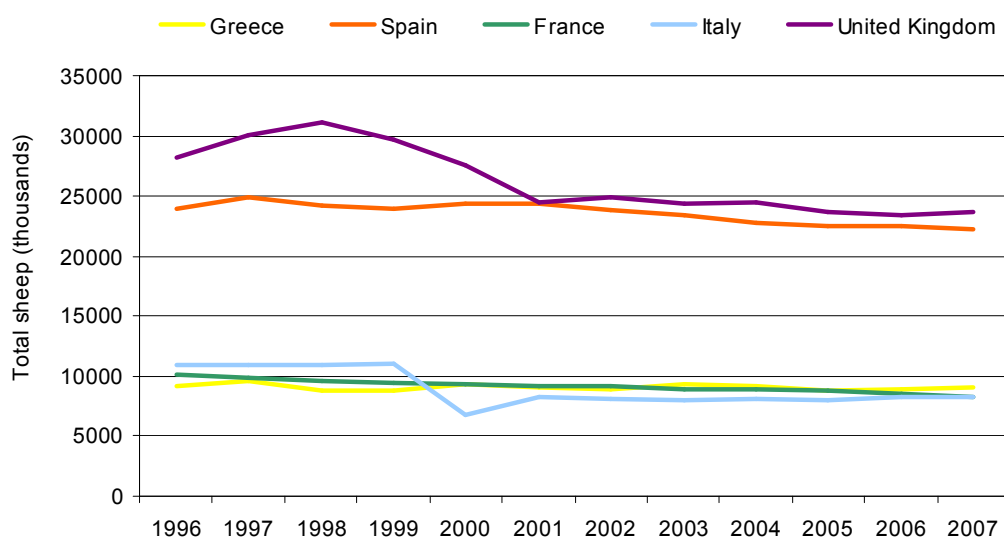
Activity

The chart below shows the trend in total sheep numbers within the EU 15 and EU 27 since 1996. Total sheep numbers showed a steep decline between 1999 and 2001 (which can to a large extent be explained by the foot and mouth outbreak in the UK, and selected other Member States) and a more gradual decline thereafter. Between 2004 and 2005 the decline in sheep numbers appears to be greater than the trend for the previous three years, which may indicate the potential impact of the 2003 reforms on sheep numbers.

Figure 13-1 Sheep population within the European Union (1996 – 2007)

Source: Eurostat

Total sheep numbers are dominated by activities in a small number of Member States. Collectively, sheep numbers in United Kingdom, Spain, France, Italy and Greece were responsible for 86% of the EU-15 number in 2007. Trends within these Member States are shown further in Figure 13-2 below.

Figure 13-2 Sheep population within selected Member States (1996 – 2007)

Source: Eurostat

Of particular significance is the steep reduction in sheep numbers within the UK and Italy. The main cause of the decline in the UK was the outbreak of foot and mouth disease (FMD), which severely disrupted the livestock sector in 2001 with large losses⁹⁰ and obstacles to trade. Since the UK is the large producer of sheep within the EU, this had a significant impact upon overall sheep numbers within the EU during this period. In Italy, the population decline can be partly explained by a Bluetongue outbreak that took place in Italy during the summer and autumn of 2000. These incidents clearly highlight the significant influence that other factors, unrelated to the policy in question, can have upon the underlying activity statistics.

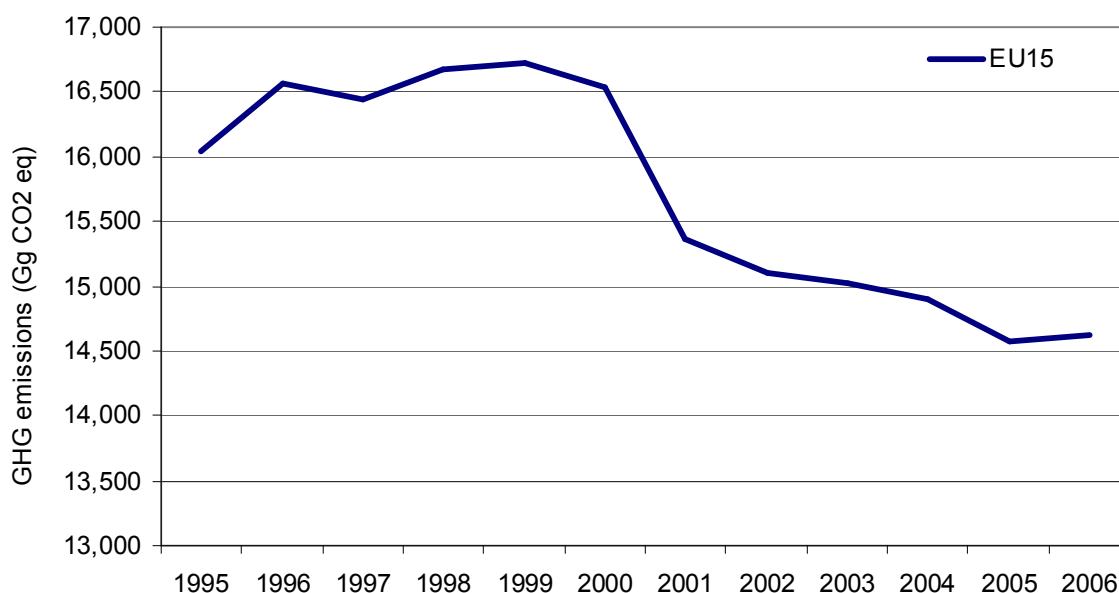
⁹⁰ It is estimated that around 3.5 million sheep have been killed and destroyed in the framework of the FMD containment and another 1.5 million have been destroyed within the Livestock Welfare disposal Scheme in the UK (Canali, 2005)

Emissions

Emissions associated with sheep production in the EU 15 are shown in the figure below. Emissions data is only available from the UNFCCC up to 2006. An important consideration in analysing the emissions data is the potential difference in methodology that have been applied by different Member States in calculating their emissions. For example, the UNFCCC data suggest that emissions per head are much greater for raising sheep in Denmark than the EU average, and also lower in the UK than the average. Since the UK is a major contributor to total EU15 sheep numbers then this reduces the average emissions per head from the EU15. Whilst these methodological differences are not considered further here, it is important to recognise these alternative approaches since they may influence the apparent effectiveness of the policy within different Member States⁹¹.

Where a more advanced methodology is employed then it can explain variations better.

Figure 13-3 GHG emissions from the sheep sector in the EU15



Source: UNFCCC and Eurostat

The trend in emission follows the trend in animal numbers, although not perfectly. This discrepancy may in part relate to differences between the activity data reported to UNFCCC and to Eurostat on sheep populations, but also the methodologies used to calculate emissions from the sector (as discussed above).

Summary

For most Member States the 2003 CAP Reforms will only be realised in terms of its influence upon sheep numbers and associated emissions by 2005 at the earliest. However, it is clear that since 1995 there have been a number of significant changes in the activity and associated emissions of the sector. In particular, the influence of the foot and mouth disease outbreaks in 1999 have had a significant impacts upon overall emissions. More recently, the trend from the sector has been a gradual decline in sheep number, and associated emissions.

⁹¹ It can also influence the apparent effectiveness between years. For example, in the UK total emissions from the sheep sector increased between 2005 and 2006 whilst the number of sheep actually declined.

13.4 Impacts of the sheep and goat meat reforms on emissions of greenhouse gases

As described above the impacts of the 2003 reforms on greenhouse emissions are only likely to be reflected within the emissions data reported by Member States from 2005 onwards. This limits the extent to which the impacts of the policy to date can be evaluated. Nevertheless it is still useful to implement the guidance that has been developed, as far as possible, as this provides a useful insight into the limitation of the guidance and the areas for improvement.

13.4.1 Overview of methodologies

As with all policies a tiered approach has been developed for the evaluation of the 2003 CAP reforms, whereby a Tier 1 approach represents a high level assessment of the impacts based upon existing EU wide statistics, whereas in a Tier 3 approach a more detailed assessment of the policy impacts is attempted using bottom up data.

Ideally, all of the policies would be evaluated using the most detailed (Tier 3) approach, since this will provide the most comprehensive understanding of the policy impacts. However, in developing the guidelines we have been conscious that resources are not always available to perform detailed analysis, so we have sought to develop a flexible approach where attempts have been made to evaluate policies on the basis of current statistics. Indeed one of the aims of this report is to investigate how accurately the policy impacts can be quantified using current statistics (Tier 1). This is discussed further in the next section.

Within the scope of this study it has not been possible to implement a Tier 3 analysis of the policies within the agricultural sector. However, attempts have been made to define what a Tier 3 assessment may entail for this policy.

The main assumptions that have been used in defining the counter-factual under each of the approaches is summarised in the Table below.

T

Table 13-1 Summary of methodological choices

Methodology	Tier 1	Tier 2	Tier 3
Activity indicator	Number of animals (Eurostat/UNFCCC); GHG emissions from enteric fermentation and manure management (MS submissions to UNFCCC)	Number of animals (Eurostat/UNFCCC); GHG emissions from enteric fermentation and manure management (MS submissions to UNFCCC)	Number of animals (Eurostat/UNFCCC); GHG emissions from enteric fermentation and manure management (MS submissions to UNFCCC)
Emission factor	Emissions based upon aggregate data reported by Member States to UNFCCC	Emissions based upon aggregate data reported by Member States to UNFCCC	Emissions based upon aggregate data reported by Member States to UNFCCC. Supplemented by bottom up or more refined statistics
Autonomous development	No correction(s) made for any autonomous development (i.e. number of animals fixed at pre policy levels)	No correction(s) made for any autonomous development (i.e. number of animals fixed at pre policy levels) Issue tested as a sensitivity analysis	Correction(s) of autonomous development where data allows.
Structural effects	No adjustment for structural changes in the activity data	No adjustment for structural changes in the activity data	Analysis of, and correction for, main structural changes where data allows
Timing issues	Calculates policy impacts from same start date, no adjustment for implementation delays or announcement effect	Calculates policy impacts from implementation date within each MS, no adjustment for implementation delays or announcement effect	Calculates policy impacts from implementation date within each MS, no adjustment for implementation delays or announcement effect
Policy interaction	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.
Geographic factors	No adjustment for geographic factors on e.g. local markets for certain products.	No adjustment for geographic factors on e.g. local markets for certain products.	No adjustment for geographic factors on e.g. local markets for certain products.
Other exogenous factors	No adjustment for exogenous factors	No adjustment for exogenous factors	Adjustment for impacts of commodity prices

13.4.2 Results

In the **Tier 1** approach it is assumed that all changes in the number of sheep, and all associated GHG emissions, can be attributed directly to the decoupling of the sheep premia. This assumes that the number of sheep, and the emissions per head, would remain at the pre-reform levels in the absence of the policy.

This assumes that no other policies are in place to influence the number of animals, and that the 2003 CAP reform is the single most important driver of sheep numbers in the sector. Clearly, this is a highly simplified approach, and does not adequately reflect the full complexity of the market drivers for sheep production. However, it does provide an indication of the overall magnitude of emissions that can potentially be influenced by the policy.

Under this approach the impacts of the reform have been assessed in terms of the change in the number of sheep from the pre-reform levels. Since the impacts of the 2003 reforms are unlikely to be implemented until 2005 then this is the first year when the impacts will be realised. The Tier 1 approach also assumes that the Directive implemented consistently within all Member States.

No account is taken of the influence of any autonomous developments on the emissions from the sector, and the Tier 1 approach assumes that the implementation date and scale of implementation would be consistent across all member states. Likewise, no corrections are made for the influence of and structural changes in the sector e.g. changes in the number of breeding ewes etc.

In the **Tier 2** only one further adjustment is made – the correction for the actual start date of the policy within the respective Member States. However, as a sensitivity analysis, the impact of autonomous development in sector is analysed. Specifically, The linear trend in animal numbers for the period prior to the 2003 reform (see

Figure 13-1) is assumed to continue to the present i.e. account is taken for any underlying trends in production that will not be captured within a ‘frozen efficiency’ counter-factual of Tier 1.

All further adjustments to the policy are likely to require more extensive analysis that will only be feasible as part of a **Tier 3** approach.

The results from applying the Tier 1 approach are provided below. As described previously, a few Member States dominate sheep farming in the EU. Therefore, results are presented for only the most important Member States⁹².

Table 13-2 Change in emissions in the sheep sector resulting from the 2003 CAP reform (Mt CO₂eq)

		Tier 1		Tier 2	
Emissions in 2006		Change in 2006 emissions	% of 2006 emissions	Change in 2006 emissions	% of 2006 emissions
France	1.6	0.0	3%	0.0	1%
Germany	0.5	0.0	3%	0.0	2%
Greece	1.4	-0.1	4%	0.0	1%
Ireland	0.8	-0.1	10%	-0.1	10%
Italy	1.4	0.0	1%	0.0	2%
Portugal	0.7	0.0	3%	0.0	4%
Spain	4.2	-0.1	1%	0.1	2%
United Kingdom	3.6	-0.1	3%	-0.1	3%
EU-15	14.6	-0.3	2%	-0.2	1%

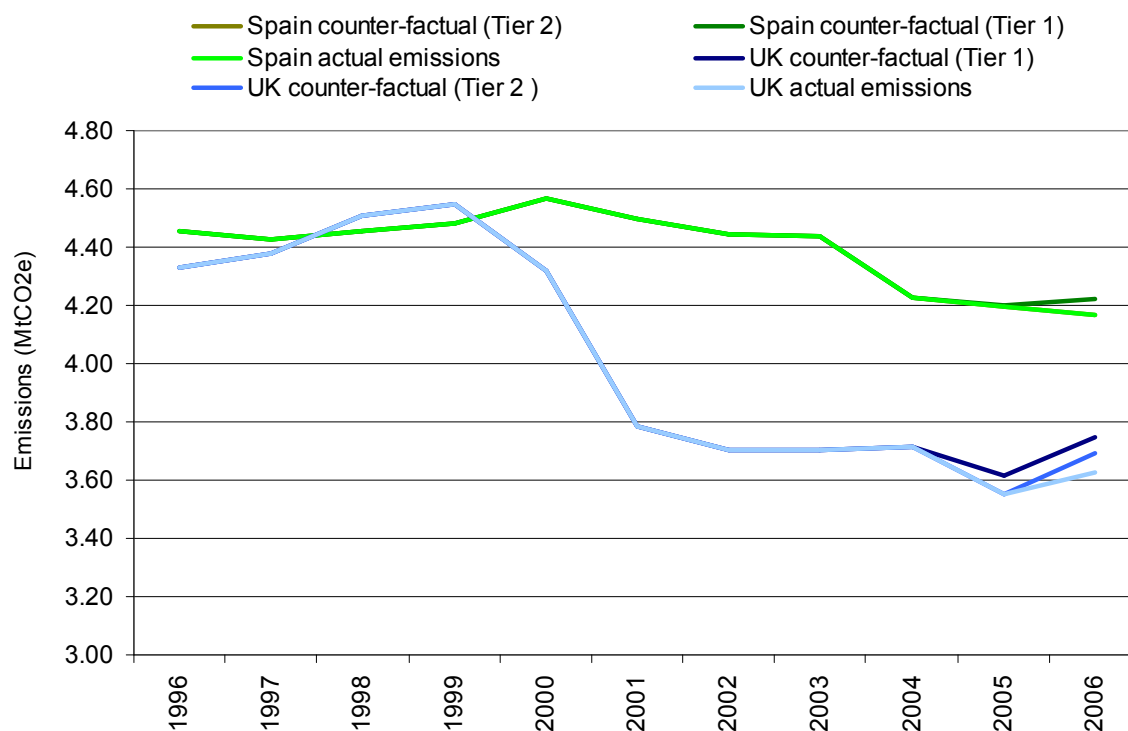
Notes: minus number reflect a reduction in emissions as a result of the reform.

The results show a large variation in the results between Member States. The largest change in emissions (relative to the counter-factual) is in Ireland with a reduction in emissions equivalent to 10% of the actual emissions in 2006. For the EU-15 as a whole the reduction in emissions is equivalent to 2% of the 2006 levels. Two Member States (Italy and Portugal) showed an apparent increase in emissions relative to the counter-factual, suggesting that the 2003 CAP reform actually increased emissions from the sector.

Since not all Member States implemented the reforms in the same way, uniform savings are not expected across all Member States. Specifically, for those Member States that fully decoupled payments, it would be expected that the impacts of the reform would be more significant than for those that only partially decoupled their payments. Of the countries listed, Germany, Ireland and the United Kingdom had fully decoupled payments. They also showed some of the larger changes in emissions.

For illustration, the trends in the emissions from two Member States with the largest sheep populations are shown in the chart below. The actual emissions, are compared to the derived counter-factual (i.e. the estimated emissions in the absence of the policy), with the difference between the 2 lines demonstrating the change in emissions arising from the policy.

⁹² Those with an absolute emission in 2007 >0.5 MtCO₂eq

Figure 13-4 Estimating impacts of the 2003 CAP reform on emissions from the sheep sector in Spain and the UK (MtCO₂eq)

As shown in the chart the apparent savings arising from the CAP reform in both Spain and the UK are small in comparison to the other changes in emissions that occurred within the respective sectors over the last 10 years. Whilst this is not justification for not attempting to evaluate the policy impacts, it does put into perspective the scale of the savings, and the relative importance of other variables that are not captured within the Tier 1 and the current Tier 2 methodologies. A related issue is that the emissions data is only available, currently, up to 2006. Therefore, it is limited in the extent to which it can describe the policy impacts. Once data for future years is available the overall impact may be more significant.

Furthermore, the Tier 1 and Tier 2 methodologies do not take into account any uncertainties inherent within the underlying emissions data. This relates to both uncertainties in the calculation of the emissions from sheep and differences in the methodologies employed by Member States to compile the results presented in their inventories. A further uncertainty relates to how well the activity indicators reflect the impacts of sheep enterprises on emissions on greenhouse gases. Specifically, the above activity data does not take into account the emissions arising from the application of manures to soils, or emissions arising from manure deposits to pastures. This is because the aggregate inventories don't differentiate by type of manure. An allocation of emissions from these source categories can be made with more detailed descriptive statistics, which may be available at Member State level, but not collated centrally by an EU wide statistical agency.

13.4.3 Sensitivity analysis

Ideally, as part of a Tier 3 approach a correction will be made for the possible extent of any autonomous development. This may include, for example, the impacts of previous CAP reforms⁹³ or other underlying trends in agricultural productivity arising from technological innovation.

⁹³ For the sheep sector the introduction of a simplified regime for the sector in 2001, the main element of which was fixing the ewe premium at a flat rate rather than the 'variable deficiency' payment, was one potentially important reform. The reform aimed to enable producers to respond

Whilst, for the reasons described below, it is difficult to estimate an appropriate level of autonomous development for this sector it is still useful to examine trends in emissions from the sector prior to the implementation of the 2003 reforms. This gives an indication the potential error in the Tier 1 estimates. The results are interesting. For the three years proceeding the impacts of the 2003 reform (2002-2004) sheep number have declined at approximately 550 thousand sheep per annum for the EU15⁹⁴. Assuming this represented a long run trend that would continue in the absence of the 2003 reforms, this would reduce the 'savings' attributed to the 2003 reforms, when compared to a 'frozen efficiency' approach. At an EU15 level this would reduce the savings to 0.1 Mt CO₂ (or 1% of 2006 levels). Whilst this is clearly a very simplistic analysis it does provide a useful check for the results described above.

13.5 Cattle and Suckler cows

13.5.1 Background

Prior to the 2003 CAP reform the measures used to support the beef sector comprised intervention support – when beef prices fell below a specific point beef would be purchased into intervention at a fixed price. In July 2002 this was replaced with private storage aid used to support storage of beef until prices climbed. The other measures in place were direct payments to farmers, designed to:

- compensate for the reductions in the intervention price (slaughtering premium and the special beef premium);
- support incomes to producers who are specialised in beef production (suckler cow premium);
- encourage producers towards extensive farming (extensification payment);
- assist producers in less favoured areas or in Member States highly specialised on beef production (additional suckler cow premium);
- balance the market throughout the year (deseasonalisation premium);
- permit Member States to support specific production systems (national envelopes).

The 2003 reform gave the option to Member States of retaining up to 100% of the suckler cow premium and 40% of the slaughter premium *or* retaining *either* up to 100% of the slaughter premium *or* alternatively up to 75% of the special male premium (sometimes referred to as the special beef premium).

The premium rates for bovine animals are as follows:

- suckler cow premium €200 per head
- additional national suckler cow premium up to €50 per head
- slaughter premium (adult bovine animals) €80 per head
- slaughter premium (calves) €50 per head
- Male bovine premium (steer/bull) €150 or 210 per head).

These premiums are largely unchanged from those that were available under the previous (Agenda 2000) reform. Therefore, where full decoupling has occurred the impacts of the 2003 CAP reform should be evident and distinguishable from those of previous reforms. On the other hand, where only partial decoupling has occurred, establishing what this has meant for the industry in general may be harder to discern.

Policy implementation

The changes introduced under the 2003 CAP reform varied from one Member State to the next in terms of their impact on these sectors, largely because the option was given to allow partial coupling to remain.

more readily to market signals, so may explain some of the trends in animal numbers from 2002 (when it was implemented) to 2005 when the 2003 CAP reform came in.

⁹⁴ Although the year-to-year variation has been large (from 310,000 to 780, 000)

According to European Commission⁹⁵ nine Member States of the EU-15 have adopted coupled payments in the beef sector. These are shown in Table 13-3 below. France, Portugal and Spain have 100 per cent coupling for all listed beef payments in their outer regions. The only countries to have discontinued all coupled payments are: Germany (from 2009), Ireland, Luxembourg, and United Kingdom (England, Wales and Northern Ireland only). Greece and Italy included the beef sector as part of its Article 69 application for targeted support.

Table 13-3 Beef sector coupled payments by Member State

Beef sector coupled payment option	Beef sector coupled payment and coupling rate	Member State	Start date
1 and 2a	Slaughter premium calves (100%) Suckler cow premium (100%) Slaughter premium bovine adults (40%)	Austria	2005
		Belgium	2005
		France	2006
		Portugal	2005
		Spain	2006
1 and 2b	Slaughter premium calves (100%) Slaughter premium bovine adults (100%)	Netherlands	2006
2c	Male beef special premium (75%)	Denmark	2005
		Finland	2006
		Sweden	2005

Source: adapted from European Commission, February 2007

New Member States did have the option to make complementary national direct payments (CNDPs) to farmers during a transitional period following entry into the CAP, inter alia alongside SAPS payments or SPS. These come from their own funds or may be co-financed via the rural development budget within ceilings set at EU level.

13.6 Emission trends and drivers

The ex-post impacts of the Directive on emissions of GHGs can be defined in terms of the difference between the actual reported emissions and the emissions under the counter-factual scenario (i.e. the estimated level of emissions that would have arisen in the absence of the policy). This section describes the underlying trends in the actual reported emissions, and emission-causing activities. It is against this backdrop that the counter-factual scenario can be defined.

13.6.1 Impact upon greenhouse gas emissions

Beef enterprises, similar to sheep, are associated with emissions of methane, nitrous oxide and carbon dioxide. Emissions arise from enteric fermentation, from manure management and application of manures and mineral-N fertilisers to soils. By influencing the number of animals, the reforms described above are also expected to influence the greenhouse emissions associated with beef production.

13.6.2 Activity and emission trends

Greenhouse gas emissions associated with the raising of cattle are reported by Member States to the UNFCCC under category 4.A. Also emission arising from the management of manures, and application of manures to land are captured under reporting category 4.B – Manure management and 4.D.1.2 - Animal Manure Applied to Soils. In parallel with reporting emissions, the underlying activity

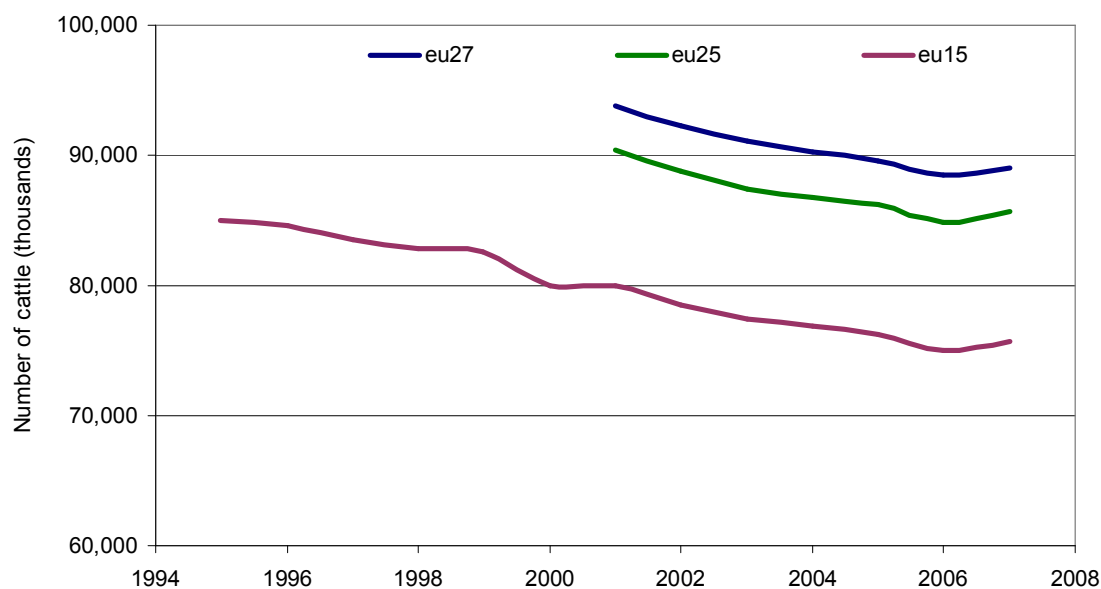
⁹⁵ http://ec.europa.eu/agriculture/healthcheck/guide_en.pdf

data (i.e. number of animals) is also captured in the submission to the UNFCCC. Likewise, Eurostat collect statistics on the cattle populations within the European Union. The Eurostat data is repeated below as it has statistics up to 2007.

13.6.3 Activity and emission trends

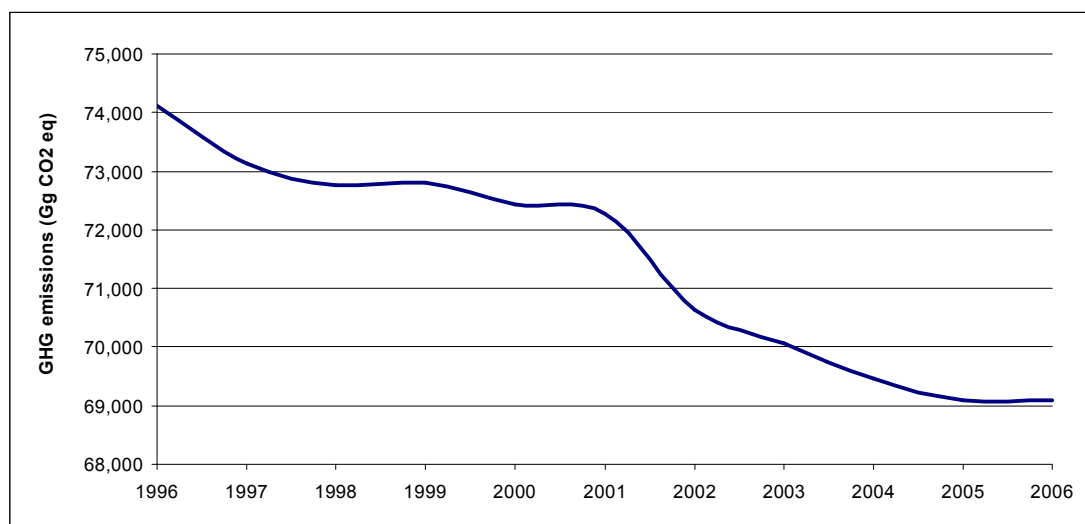
The chart below shows the trend in total cattle numbers within the EU 15, EU 25 and EU 27. Emissions in the EU 15 are described from 1995, and for the EU 25/27 from 2001. Total cattle numbers have followed a declining trend in almost all years since 1995.

Figure 13-5 Cattle population within the European Union (1996 – 2007)



Source: Eurostat, December Survey

Emissions associated with cattle in the EU 15 are shown in the figure below. Emissions data are available from the UNFCCC up to 2006.

Figure 13-6 Emissions associated with cattle in the EU-15 (1996 – 2006)

Source: UNFCCC

Emissions from the EU 15 have largely tracked the decline in animal numbers, as you would expect.

13.7 Impacts of the 2003 reforms to the beef sector on emissions of greenhouse gases

As for the sheep and goat sector, the impacts of the 2003 reforms on greenhouse emissions are only likely to be reflected within the emissions data reported by Member States from 2005 onwards.

13.7.1 Overview of methodologies

A comparative approach has been applied to that described above for the sheep and goat sector, since the nature of the reform are very similar. For completeness the main assumptions that have been used in defining the counter-factual under each of the approaches is summarised in the Table below.

Methodology	Tier 1	Tier 2	Tier 3
Activity indicator	Number of animals (Eurostat/UNFCCC); GHG emissions from enteric fermentation and manure management (MS submissions to UNFCCC)	Number of animals (Eurostat/UNFCCC); GHG emissions from enteric fermentation and manure management (MS submissions to UNFCCC)	Number of animals (Eurostat/UNFCCC); GHG emissions from enteric fermentation and manure management (MS submissions to UNFCCC)
Emission factor	Emissions based upon aggregate data reported by Member States to UNFCCC	Emissions based upon aggregate data reported by Member States to UNFCCC	Emissions based upon aggregate data reported by Member States to UNFCCC. Supplemented by bottom up or more refined statistics
Autonomous development	No correction(s) made for any autonomous development (i.e. number of animals fixed at pre policy levels)	No correction(s) made for any autonomous development (i.e. number of animals fixed at pre policy levels) Issue tested as a sensitivity analysis	Correction(s) of autonomous development where data allows.
Structural effects	No adjustment for structural changes in the activity data	No adjustment for structural changes in the activity data	Analysis of, and correction for, main structural changes where data allows
Timing issues	Calculates policy impacts from same start date, no adjustment for implementation delays or announcement effect	Calculates policy impacts from implementation date within each MS, no adjustment for implementation delays or announcement effect	Calculates policy impacts from implementation date within each MS, no adjustment for implementation delays or announcement effect
Policy interaction	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.
Geographic factors	No adjustment for geographic factors on e.g. local markets for certain products.	No adjustment for geographic factors on e.g. local markets for certain products.	No adjustment for geographic factors on e.g. local markets for certain products.
Other exogenous factors	No adjustment for exogenous factors	No adjustment for exogenous factors	Adjustment for impacts of commodity prices

13.8 Results

The results from applying the Tier 1 and Tier 2 approach are provided below. The results are presented for only the most important Member States⁹⁶.

⁹⁶ Those with an absolute emission in 2007 >2.0 MtCO₂eq. No data was available for the Netherlands or Finland.

Figure 13-7 Change in emissions in the non-dairy cattle sector resulting from the 2003 CAP reform (Mt CO₂eq)

		Tier 1		Tier 2	
Emissions in 2006		Change in 2006 emissions	% of 2006 emissions	Change in 2006 emissions	% of 2006 emissions
Austria	2.0	0.0	3%	0.0	3%
Belgium	2.5	0.0	2%	0.0	2%
France	23.7	0.4	1%	0.4	1%
Germany	8.3	-0.1	1%	-0.1	1%
Ireland	7.0	0.0	0%	0.0	0%
Italy	4.7	-0.2	4%	-0.2	4%
Spain	6.2	-0.2	3%	-0.2	3%
United Kingdom	8.4	-0.1	1%	-0.1	1%
EU-15	69.1	-0.5	1%	-0.5	1%

Notes: minus number reflect a reduction in emissions as a result of the reform.

Overall, the savings derived from the Tier 1 methodology represent only a small proportion of the total emissions from the sector in 2006, for the EU15. Larger savings are shown for Austria and Italy (as a percentage of 2006 emissions). For several countries the methodology shows an increase in emissions arising as a result of the CAP reform. The impact of market factors, including an increase in demand and the associated market price for beef from 2004 to 2006, can potentially explain this result. However, the Tier 1 methodology does not attempt to isolate this impact. Results for the Tier 2 approach are almost identical for those arising from Tier 1. This is unsurprising given the only methodological adjustment is the Member State specific implementation date, and for most Member States this was 2005 as assumed in the Tier 1 approach.

13.8.1 Sensitivity analysis

Ideally, as part of a Tier 3 approach a correction will be made for the possible extent of any autonomous development. Whilst, for the reasons described below, it is difficult to estimate an appropriate level of autonomous development for this sector it is still useful to examine trends in emissions from the sector prior to the implementation of the 2003 reforms. This gives an indication the potential error in the Tier 1 and Tier 2 estimates. The results are interesting. For the three years proceeding the impacts of the 2003 reform (2002-2004) cattle number have declined at approximately 675⁹⁷ thousand cattle per annum for the EU15. Assuming this represented the underlying trend that would continue in the absence of the 2003 reforms, this would reduce the 'savings' attributed to the 2003 reforms, relative to a 'frozen efficiency' counter-factual. In fact, at the EU15 level this would actually lead to an apparent increase in emissions by 1.1 MtCO₂, which reflects the fact that animal numbers, and the associated emissions have levelled off since 2005. Whilst this is clearly a very simplistic analysis it does provide a useful check for the results described above.

13.8.2 Overall results and conclusions

A number of other factors will affect the size and structure, and thus environmental impact, of the livestock sectors in Member States, alongside the CAP and other legislation, and these must all be taken into consideration when developing a counterfactual. These additional variables are not isolated and corrected for within the current Tier 1 or the Tier 2 approaches.

On this basis we consider that **the results presented above should be treated with caution**. Whilst the results are useful in showing the values that are achieved by implementing the Tier 1 approach, as it currently stands, **we do not consider the results sufficiently robust to recommend the use of a Tier 1 or Tier 2 approach to quantify the impacts of the CAP Reform**. This statement is supported by the views of the stakeholders who commented on the draft guidance for the policy.

⁹⁷ With a range of 650 - 700

However, the Tier 1 approach does show the overall magnitude of the change in emissions in the sector that could be in part driven by the policy, but the results derived are likely to overestimate the true impacts of the policy. Further analysis, is required to isolated the policy impacts further, and identify the level of influence of the other influencing factors – and the overall level of accuracy of the results derived from a Tier 1 approach. These issues are discussed further below.

Autonomous development

The most important factor that is not sufficiently considered within the **Tier 1** approach is the influence of the market prices upon production levels i.e. the autonomous behaviour of farmers in response to the costs faced and returns achieved by livestock producers. This, in turn, is strongly influenced by exogenous variables such as commodity prices. For example, the profitability of certain livestock enterprises is extremely sensitive to feed prices. Similarly, international trade, taking into account import/export duties and tariffs will all have affected the profitability of the EU livestock sector.

The Common Agricultural Policy, by its very design, interacts closely with the market for agricultural commodities. Therefore, by failing to isolate the influence of the overall market conditions upon production levels the Tier 1 approach is significantly limited. However, such is the complexity of the market, with a large number of interacting variables, that only by means of a **Tier 3** approach can these issues be adequately addressed. Furthermore, even using econometric relationships and detailed information on the supply and demand characteristics of the market, there is still likely to be significant uncertainty in the results of such analysis. Faced with such uncertainty, the Tier 1 approach at least provides a transparent, if oversimplified, assessment of the impacts

A further complication is that agricultural markets are not homogenous, so the impacts of these markets upon production levels, and the influence of the reforms to the CAP, may vary from sector to sector and one Member state to the next. In particular, the 12 countries which have joined the EU since 2004 will have faced substantial changes in the way that their livestock sectors operate as a result of joining the CAP, irrespective of the 2003 reform. However, for EU-15 MSs changes are likely to have been less marked and economic drivers will have had as much if not more impact on the development of the sector, even in the absence of reform.

For example, the nature of the production and supply (including retail) chain and the structure of the industry in different Member States may all influence policy outcomes. At one end of the scale small-scale production of sheep or goat meat in LFA upland areas, where the animals are sold at market for processing at local slaughtering facilities and sale at local retail outlets will contrast sharply with large-scale lowland sheep production for export or for processing in a distant slaughterhouse and sale through a multinational retailer.

Likewise, beef production on systems where for part of the year animals are housed will require cereal-, soy- or silage based rations, all of which will require inputs (costs of which have been rising) for their production. Yet more intensive indoor or yarded beef production, where cattle (or calves, in the case of veal) are kept indoors or in external yards or feedlots year-round will be more vulnerable to changes in input costs than less intensive beef production where grazing constitutes a significant element of the diet⁹⁸.

The nature of local market will also have an impact upon the outcomes from the reforms within different Member States. For example, returns to the sheep sector in southern regions of the EU are boosted by sheep-milk production. Consequently, direct payments are a lower proportion of returns to sheep in these regions. You would therefore expect the that 2003 CAP Reforms would have a greater impact upon producers in Northern Europe than in Southern Europe.

Often the subtlety of these national or local circumstances is not reflecting in the high level statistics data, which makes it difficult to consider these issues within a high level (**Tier1/2**) methodology designed to be applicable to all Member States (in the broadest terms all sectors). Only through a detailed analysis (**Tier 3**) can these national and local market dynamics be adequately reflected.

⁹⁸ This issue is also relevant to other environmental outcomes in addition to emissions of greenhouse gases, for example biodiversity and landscape impacts. Whilst these issues are not relevant to this study, in considering the impacts and drivers associated with CAP it is important to recognise that there are a range of environmental, economic and social objectives.

Autonomous technological developments include improvements to the efficiency of agricultural production, or reduction in associated emissions that arise from technological innovation. For example, developments in nutrition and grassland management will also affect the viability of dairy systems, although such improvements may play a greater role in larger, more intensive herds found in MS such as the UK and the Netherlands, rather than in smaller herds in other MSs.

An important methodological issue related to how savings from technological or management practices are quantified – and how this relates to the emissions reported by Member States in their emissions inventories. For example, under a regime of fixed quotas the numbers of dairy cattle have tended to decrease as milk yield per cow has increased. Hence if emission estimates are made on the basis of an emission factor per animal, then emissions from dairy production will appear to have decreased. However, in order to achieve these increases in milk yield dairy cows have been put onto a higher plane of nutrition, increasing N intake in feed and N in excretion, and hence potentially increasing emissions of NO₃, NH₃ and N₂O per cow. The converse is true, in some countries at least, for pigs and poultry, where increased use of phase feeding and the incorporation of synthetic amino acids into feeds has reduced N intake in feeds and N excretion. These factors may now be taken into account where emission inventories are based on a mass flow approach, as is increasingly the case for national inventories of ammonia (see Reidy et al., 2007). However, current IPCC methodology will not capture the impact of these changes on emissions of N₂O.

It is even more difficult to isolate these autonomous developments from the policy impacts – especially since the policy may in this case had strong influence over the developments⁹⁹. A key consideration for a future Tier 3 analysis is therefore how to quantify these impacts, and ensure that the savings can be compared/calibrated with the data reported in national emissions inventories.

Other exogenous factors

Livestock disease is another factor that is unrelated to the CAP, but has influenced emissions from the sector. Disease outbreaks in recent years have included bluetongue, foot and mouth and BSE. The nature and length of the impact of disease outbreaks varies between Member States depending on a range of factors from structure of the domestic industry, whether they are a net importer or exporter of meat, attitude and capability of government to tackle animal disease and so on. A good example of this later point is the different attitudes of European governments towards bovine tuberculosis. The control policies implemented by the Irish government are in stark contrast to the attitude shown by the government in Britain, where the disease incidence continues to increase.

It may be possible within a **Tier 3** approach to correct for the impacts of these factors by either looking at historical trends prior to the outbreak, or alternatively drawing upon survey (bottom up) data on e.g. numbers of animals affected to make an adjustment of the policy impacts.

Policy implementation

As described above the nature in which the reform have been implemented within different Member States may have a significant impact upon the overall outcomes. Specifically, the extent to which payment have been decoupled is likely to have an important bearing on the results within different member states. The timing of implementation may also have an influence on the overall impacts at a given point in time, although the variation in implementation date is less marked than for certain other policies.

The **Tier 1** approach provides some insights into the extent to which decoupling has influenced the overall level of savings, by allowing the comparison of results between different Member States.

It is possible within a **Tier 2** approach to correct for the implementation date to reduce the error associated with this factor. What are less easy to correct for are changes associated with long term policy developments such as the CAP. For example CSL (2006) reporting on the initial impacts on the 2003 CAP reforms in England suggest that beef and sheep producers are already beginning to make system changes in response to the expected change in support between now and 2012.

⁹⁹ For example, the milk quotas have seen a large increase in the productivity from the dairy sector much of which has been influenced by innovation in the sector.

Policy overlaps

When considering the appearance of the counterfactual, further complications arise due to the interrelationships between elements within the CAP, as well as interaction with other policies. This includes, for example, interaction with the Nitrates Directive. Under cross compliance direct payments to farmers is dependant on maintaining all land in good agricultural and environmental condition (GAEC) and, , complying with (largely existing) legislation affecting agricultural management (SMRs). Therefore failure to comply with this existing legislation - which includes the Nitrates Directive – would lead to reduced direct payments. On this basis it can be argued that CAP has had a role in encouraging Member States to implement the Nitrates Directive, and in communicating to farmers their obligations under the Directive.

However, what is much more difficult to determine is the extent, in quantitative terms, to which the CAP has delivered additional savings (i.e. reductions on N₂O from soils) than would have occurred anyway without the requirement for compulsory cross compliance as part of the 2003 reforms. Isolation of policy impacts in this way is particularly challenging when aggregate statistics are used as the basis for the policy assessment, such as in the Tier 1 and Tier 2 approach. In such circumstances, a practical approach is to consider the impacts of the other pieces of legislation as part of a broader package. In this example, Nitrates and CAP would be seen as a package. It may be possible to determine indicative estimates of isolated elements (see for example the case study report on the Nitrates Directive), however, overall we suggest that it is more appropriate to present the policies as a package, if the overall impacts cannot be adequately isolated.

Structural changes

The overall aggregate number presented above may not describe the full changes in the structural changes associated with the CAP Reforms.

For example, as reported by CSL (2006), at an aggregate national level farm statistics show little change in sheep numbers in England between 2003 and 2005. However, a more detailed investigation of upland holdings shows that while the total number of sheep and lambs has remained stable (+1%), there are indications that the structure of the flock is beginning to change. The most notable change is a reduction in breeding ewe replacements (-14%). In the Beef sector CSL (2006) note that while the beef herd increased by 3 per cent there was a marked decline in the number of suckler herd replacements compared to a year earlier.

From an emissions standpoint, these structural changes, whilst not necessarily changing the overall numbers of animals, can change the average emissions per head, and the emission overall.

Other factors affecting the industry

There are a range of factors, many of which interact with one another, which are likely to affect the size and structure of the dairy industry above and beyond the effects of changes in the dairy regime.

These include changes relating to management, housing, feed and feed practice, milking and breeding. For instance, robotic milking systems and developments in milking parlour design can speed up the milking process and reduce labour requirements, and therefore cost. However, such developments require significant capital investment and their adoption is likely to vary from farm to farm and MS to MS.

13.9 Synthesis and interpretation of results

This section provides a synthesis of the results from the different approach and makes some conclusions with respect to the overall impact of the policies.

13.9.1 Comparison of results from alternative estimates

The impacts of the 2003 CAP reform have been examined by a number of other studies, in many cases, in much more detail than was possible for this study. A notable study was that led by IEEP¹⁰⁰ (2007) for DG Agriculture of the European Commission, which examined the environmental impacts of CAP measures related to the beef and veal sector and the milk sector. The study followed a two-step approach. Firstly, it analysed the causal chain, leading from the measures to likely impacts at farm level, including impacts on farm structures and management practices. Secondly it considered the effects these are likely to have had on the environment. The study was largely qualitative in nature, but did draw upon quantitative evidence to support the overall conclusions. The analysis is particularly useful for this study since the approach followed is closer to what might be considered a Tier 3 approach, within our methodological framework. Since we have not been able to carry out a Tier 3 study ourselves, then the results from the IEEP analysis, provides some valuable insights into some of the conclusions that we have drawn at a Tier 1 and Tier 2 level.

One of the case studies the IEEP study examined was the coupled payments after the 2003 reform in the Beef and Dairy sector. The study examined the impacts of the reform by considering, and then testing, a number of hypotheses relating to the impacts of the reforms on the sector. In particular, the study explicitly considered the economic factors influencing production, including impacts on farm income, and the associated impacts upon farm production and farm management. The authors drew the following tentative conclusions, from the analysis:

- **Scale of production:** Coupled beef payments appear to have contributed to the maintenance of beef cattle numbers, particularly where the coupled suckler cow premium has been implemented. The coupled dairy premium appears to have had little or no impact on dairy production.
- **Intensity of production:** There is no evidence to suggest that either coupled beef or dairy payments have contributed to any particular intensification or extensification trend.
- **Regional distribution:** Coupled suckler cow premiums appear to be contributing to the maintenance of suckler cows and suckler cow production in implementing Member States (for example, France, Austria), including LFAs in these countries. The impacts of other coupled payments are less clear.
- **Specialisation:** There is no evidence to suggest that coupled payments have influenced specialisation to any great degree. The exception is that some CNDPs may have contributed to, and others slowed, an ongoing process of restructuring, including specialization

With respect to GHG emissions the study drew the following conclusions:

The maintenance of cattle numbers arising from beef coupled payments is likely to sustain greenhouse gas emissions at a higher rate than might be expected under the main and, to a lesser extent, secondary counterfactual, thereby contributing to climate change.

The results of this study therefore support our primary assertion that the decoupling of payments under the CAP reform will lead to a decline in animal numbers, and an associated reduction in greenhouse gas emissions. The IEEP report also supports our assessment that the drivers of production are complex suggesting that disaggregating “*the effects of coupled payments from market changes, structural changes, technological development and other support is difficult. The relative impact of the coupled element of the single farm payment, compared to the decoupled element, is also likely to vary both at the level of the Member State and the individual.*”

Ex ante estimates

The second ECCP progress report (EU 2002) estimated a reduction potential of 2.9% of agricultural emissions, totalling 12Mt CO₂eq. in the EU 15 by 2010. The bulk of these savings related to reductions in N₂O from soils (10 Mt CO₂eq) with the Nitrates Directive expected to play an important role in delivering these savings. Reduction in emissions from enteric fermentation (0.3 Mt CO₂eq) and from

¹⁰⁰ Evaluation Of The Environmental Impacts Of CAP (Common Agricultural Policy) Measures Related To The Beef And Veal Sector And The Milk Sector

anaerobic digestion (1.7 Mt CO₂eq) made up the remaining abatement potential. The reduction in livestock numbers that was predicted to result from measures introduced by the CAP reform proposals was highlighted as important factor in delivering these emissions savings.

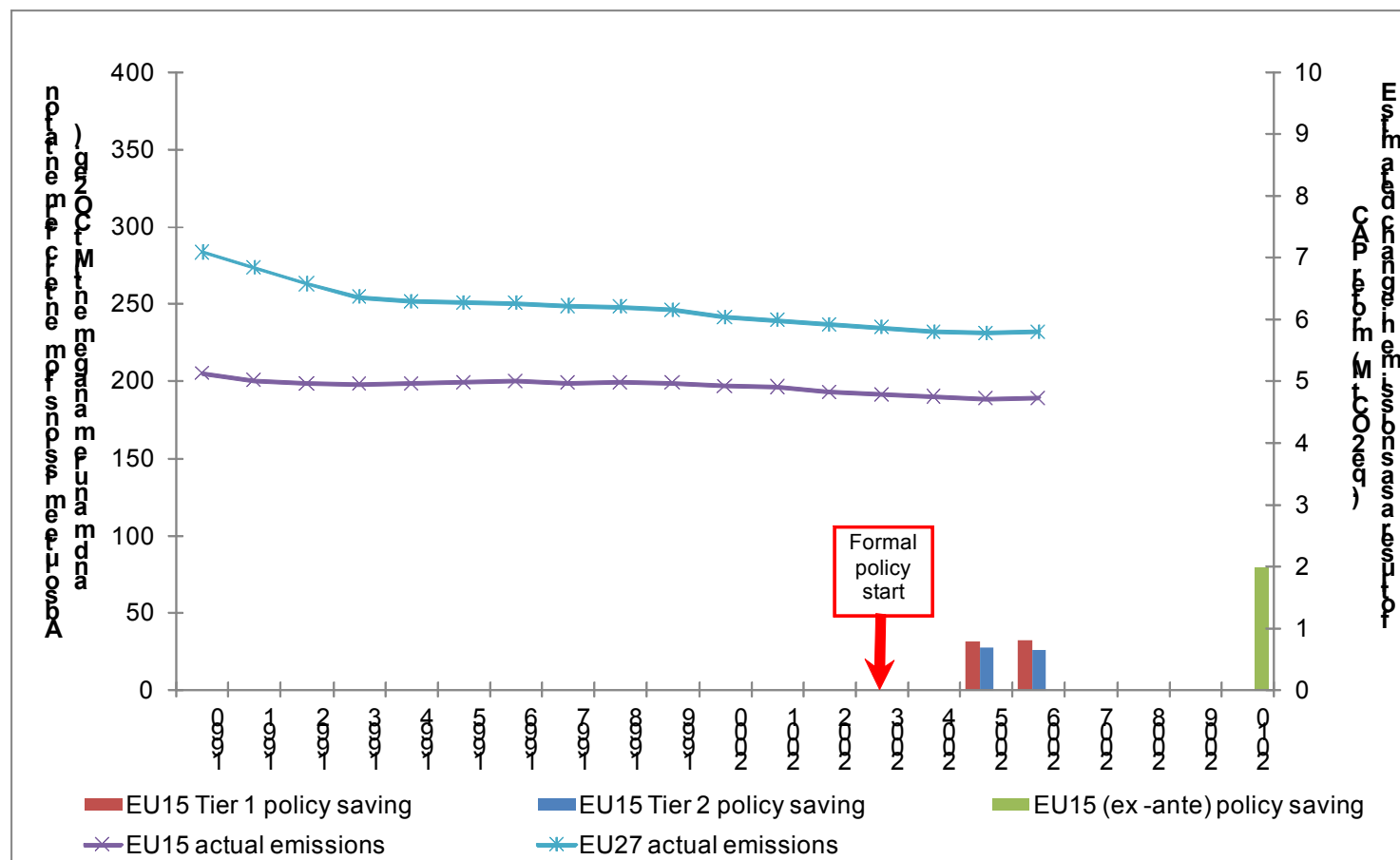
These ante projections are compared to the results from the ex-post analysis in Table 13-4 below. Since emissions of N₂O from soil have largely been considered in the chapter on the Nitrates Directive, the savings from enteric fermentation and anaerobic digestion are used here.

The comparison should be treated with caution. As described previously, the ex-post results in this chapter represent a subset of the potential impacts of the CAP reform by focussing on just two individual elements of the 2003 reform, specifically the sheep and beef sectors. Likewise the CAP reform will have wider impacts on emission beyond enteric fermentation and anaerobic digestion (e.g. on emissions of N₂O soils, and also wider impacts on carbon sequestration). These limitations are over and above the uncertainties in the evaluation results themselves.

Table 13-4: Comparison of ex-ante and ex-post results: 2003 CAP Reform

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
Common Agricultural Policy (Regulation EC No 1782/2003) ¹⁾	2.0	NE (EU27, 2006) 0.8 (EU15, 2006)	NE (EU27, 2006) 0.7 (EU15, 2006)	NE
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations:				
MSsp: Member State specific starting year for the ex-post evaluation				
NE = not estimated				
Notes:				
1) The analysis has focussed two individual elements of the 2003 CAP reform only: the sheep and goat meat regime and the beef sector premia. Specifically, the change in livestock numbers arising from the reform in these sectors. Other important components have not been investigated within this study and would benefit from further investigation. In particular, the methodologies need to be extended to include impacts on carbon within soils and the broader impacts of land use change. Impacts in N ₂ O emissions from soils and nitrate use are included in the impacts of the Nitrate Directive.				

The estimated impacts of the policy are put into context in Figure 13-8 below. The estimated (ex ante, and ex post) impacts are compared against the overall historical trend in emissions from enteric fermentation and manure management. The estimated savings are extremely small in comparison to the overall emissions from the sector.

Figure 13-8: Common Agricultural Policy CAP: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008).

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above. Only 4A/B category emissions investigated. In general, the following categories are relevant: 4A - Enteric fermentation, 4B - Manure management, 4D - Emission from soils (see Nitrate Directive), 5B - Cropland – sequestration in soils and vegetation, 5C - Grassland – sequestration in soils and vegetation, 1A4c - Emissions from energy use in agriculture/forestry/fisheries

13.10 Conclusions

The reforms of the Common Agricultural Policy can potentially have a large scope of influence upon GHG emissions from the agricultural sector. This includes direct emission from livestock, but also emissions associated with manure management, nutrient applications to land and land use change.

In order to test the methodologies developed during the study, the analysis presented within this chapter has focussed two individual elements of the 2003 CAP reform: the sheep and goat meat regime and the beef sector premia. Specifically, the change in livestock numbers arising from the reform in these sectors. Other important components have not been investigated within this study and would benefit from further investigation. In particular, the methodologies need to be extended to include impacts on carbon within soils and the broader impacts of land use change.

The Tier 1 and Tier 2 approaches have drawn upon aggregated statistical data, and associated activity data, for the main emissions categories influenced by the 2003 CAP reform. This provides the overall context in terms of the changes in emissions of GHG emissions from the agricultural sector. However, the main methodological challenge is understanding the role that the CAP reform has had upon the overall emission trends, together with the role of the other key variables.

A particular challenge in understanding how market factors impact upon agricultural production under the CAP reform. Since the reforms effectively aim to influence the sensitivity of production to market conditions, then the impacts associated with CAP and impacts associated with market conditions (e.g. commodity prices) are fundamentally linked.

Policy overlaps have not been considered in detail with the analysis. However, through the cross compliance mechanism the regulations have been specifically designed to have consideration for the influence of other policies. In this way it is extremely difficult to isolate the influence of the individual policy element. Therefore, whilst it is possible to derive an estimate for the impacts of the Nitrates Directive¹⁰¹, due to the significant overlap with the CAP regulations, it is recommended that the policies are evaluated as a package of measures.

Overall, we do not consider the results of the Tier 1 and Tier 2 approach sufficiently robust to recommend the use of a Tier 1 approach to quantify the impacts of the CAP Reform. This relates to a number of factors, a large number of potential actors to influence, a range of market and non-market variables and a complex set of decision factors. This makes it extremely difficult to evaluate the impacts using a simple indicator. Instead it is likely that a range of indicators and performance monitors may be required to identify, in a more meaningful way, the true policy impacts.

However, such is the complexity of the sector, with a large number of deterministic variable influencing agricultural activities and associated emissions, then even the more detailed models are likely to be subject to a moderate to high level of uncertainty. In this instance the top down methodology provides an over simplistic, but easy to apply approach.

A further limitation relates to the available emissions data that is limited in the extent to which it can describe the impacts of the 2003 CAP Reforms. Since the 2003 Reforms will not have an impact until 2005, the impacts are only just beginning to show in the latest emission inventory data.

13.11 Recommendations

- Assess the feasibility of using existing economic models e.g. CAPRI (Common Agricultural Policy Regional Impact) to perform a Tier 3 approach on an EU27 wide basis. Use the outputs from this analysis to assess the robustness of the Tier 1 / Tier 2 approach and identify suitable correction factors to improve the reliability of this approach.
- The priority should be an assessment of the impacts of the reforms on livestock numbers, or nutrient applications.

¹⁰¹ See separate chapter on Nitrates Directive

- Since most Member States apply the IPCC Tier 1 methodology for the quantification of emissions, then isolation of the impacts of the CAP reform upon animal numbers from the other drivers is the main methodological uncertainty.

13.12 References

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14 Case study: Nitrates Directive

14.1 Introduction

This case study presents the analysis, results and recommendations that relate to the evaluation of the impacts to date of the Nitrates Directive, on emissions of greenhouse gases with the European Union. Given the significant overlap, these results should be considered in conjunction with those presented for the Common Agricultural Policy (CAP).

The analysis has been performed in accordance with the tiered methodology that has been developed during this study, and is described in the accompanying evaluation guidance. It has only been possible, within the scope of the resources available to this project, to implement a Tier 1 and Tier 2 level assessment for the Nitrates Directive. The results, therefore, are less comprehensive than those presented for certain other policies, where a Tier 3 level analysis has been implemented.

14.1.1 Overview of policy

The Nitrates Directive was adopted in Europe in 1991. The aim of the Directive is to reduce water pollution by nitrates from agricultural sources, and to prevent future pollution. Member States are required to:

- designate as Nitrate Vulnerable Zones (NVZs) all land draining to waters that are affected by or at risk for nitrate pollution.
- establish a code of good agricultural practice to be compulsory followed by farmers in NVZ and followed on voluntary base by farmers outside of the NVZ.
- establish an Action Programme of obligatory measures for the purposes of tackling nitrate loss from agriculture. The Action Programme should be applied either within NVZs or throughout the whole country.
- review the extent of their NVZs and the effectiveness of their Action Programmes at least every four years and to make amendments if necessary (Defra, 2008).

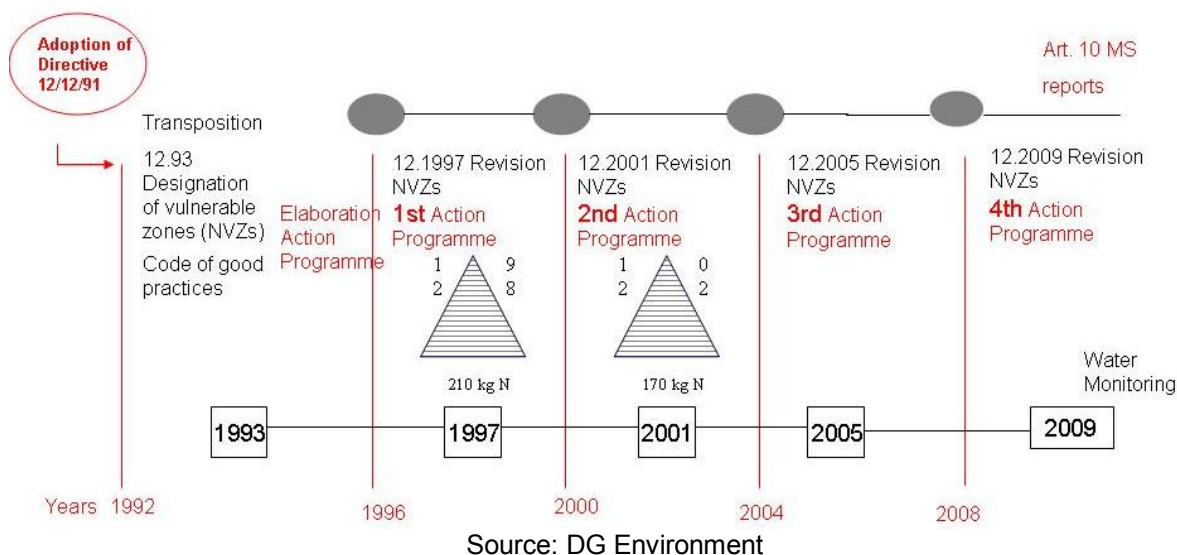
The Directive was introduced in response to the significantly increased use of both inorganic Nitrogen and Phosphorus fertilisers as agriculture underwent post-war intensification under the Common Agricultural Policy (CAP). Whilst the Nitrates Directive was not specifically designed as greenhouse gas mitigation policy, by improved nitrogen management, it has the potential to reduce emissions of N₂O from soils.

Key elements of the Directive include monitoring and reviewing: National monitoring is required in MS every 4 years on both NO₃ concentrations and eutrophication which is used to assess the impact of action programmes. This monitoring is to be accompanied by reviews and revisions of NVZs and action programmes if necessary.

14.1.2 Policy implementation

The implementation schedule for the Nitrates Directive is described in the Figure below. Following the adoption of the Directive in December 1991, Member States were required to introduce a raft of measures within two years and review these measures, and to monitor nitrate levels, on an ongoing basis.

By 2000, all Member States had transposed the Directive, set up comprehensive monitoring networks, established a code of good practice, and designated their nitrate vulnerable zones (except Ireland) (European Commission, 2002). However, there has been significant variability in how the Directive has been implemented within different Member States. This is discussed further in section 14.3.1 below.



In order to limit the losses linked to agricultural activities, the main types of actions that the Nitrates directive promotes (in annexes II-codes of good practice, and III-actions programmes) simultaneously concern¹⁰²:

- Crop rotations, soil winter cover, catch crops, in order to limit leaching during the wet seasons.
- Use of fertilisers and manure, with a balance between crop needs, N inputs and soil supply, frequent manure and soil analysis, mandatory fertilisation plans and general limitations per crop for both mineral and organic N fertilisation.
- Appropriate N spreading calendars and sufficient manure storage, for availability only when the crop needs nutrients, and good spreading practices.
- “Buffer” effect of non-fertilised grass strips and hedges along watercourses and ditches.
- Good management and restrictions of cultivation on steeply sloping soils, and of irrigation

The measures implemented are relatively broad in scope, including both technical measures e.g. manure storage, but also wider farm management actions. The measures are also applicable to a large number of individual farming installations, which may be very diverse in character. This variability in the target sector is a key challenge for the evaluation of the effectiveness of the Directive.

14.2 Emission trends and drivers

The ex-post impacts of the Directive on emissions of greenhouse gases can be defined in terms of the difference between the actual reported emissions and the emissions under the counter-factual scenario (i.e. the estimated level of emissions that would have arisen in the absence of the policy). This section describes the underlying trends in the actual reported emissions, and emission-causing activities. It is against this backdrop that the counter-factual scenario can be defined.

14.2.1 Impact upon greenhouse gas emissions

The main goal is reduce water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution. However, there is a close link between N₂O emissions from agricultural soils and nitrate losses resulting in water pollution. Therefore, measures aimed at reducing nitrate content in water also result in declining N₂O emissions to the atmosphere.

However, it is important to recognise that the Directive has not been designed with its primary objective of abating GHG emissions. Consequently, the type of measures implemented under the Directive, and the manner in which the Directive has been implemented within different Member States, has been driven by the requirement to reduce nitrogen loading of water bodies, rather than to

¹⁰² Based upon European Commission (2002)

maximise the GHG mitigation potential. This is reflected in the monitoring that is required under the Directive, with the focus on monitoring of water quality.

In addition to impact of the Directive on emissions of N_2O , the policy also has the potential to impact upon soil carbon, which may result in the release of sequestered carbon. This issue was examined as part of the European Commission funded ClimSoil project (Alterra, 2008). This study found that whilst conventional wisdom may suggest that limiting the addition of N fertiliser may play a role in reducing soil C contents, this effect may be negligible. Recent studies suggest that N fertiliser may also lead to increased mineralization of Soil Organic Matter, hence reducing fertiliser-N inputs, to avoid excess N fertilization, may also preserve Soil Organic Carbon. The impacts of Nitrates Directive on soil carbon have not been considered further in this report.

14.2.2 Activity and emission trends

Emissions of N_2O arise from the application of nitrogen-containing fertilisers to soils. The release of nitrous oxide from the soil is a naturally occurring process, but is exacerbated by the application of additional nitrogen to the soil.

In soil, nitrous oxide (N_2O) is produced predominantly by two microbial processes: nitrification, i.e. the oxidation of ammonium (NH_4) to nitrate (NO_3) and denitrification, i.e. the reduction of NO_3 to gaseous forms of N, ultimately N_2 . N_2O production is an intermediary by-product of both processes. The magnitude of N_2O emissions relates to the rate of fertiliser applied, which is itself related to the crop type to which the fertiliser is applied, and the soil temperature and soil moisture content (EMEP/CORINAIR, 2006). While some studies have indicated the form of N fertiliser used may influence N_2O emissions, at the present stage of knowledge, IPCC consider too few data are available to derive emission factors for different fertilisers or soil types from existing data. Therefore, the IPCC method (IPCC/OECD, 1997) currently defines one single method for all types of N input and all crops.

N_2O is also emitted indirectly from the denitrification of leached NO_3 in slow moving waters. Thus reducing the amounts of NO_3 leached will reduce these indirect emissions also. N_2O emissions are also released from manure processing techniques based on denitrification. These techniques are applied in the more intensive livestock regions in the EU.

From an emissions inventory perspective the impacts of the Nitrates Directive on the emissions of N_2O would be expected to be reflected in the following CFR categories:

- 4.D.1 – Direct Soil Emissions, specifically;
 - 4.D.1.1 – Synthetic fertilisers
 - 4.D.1.2 – Animal manures applied to the soil
- 4.D.2 - Pasture, range and paddock manure
- 4.D.3 – Indirect Soil Emissions, specifically;
 - 4.D.3.2 - Nitrogen Leaching and Run Off

The impacts of the Directive may also be reflected in other emission reporting categories, for example, the requirement for manure storage may impacts upon 4.B Manure management. However, it is more difficult to isolate the activities associated with this impact category that relate to the Nitrates Directive, from those manure management activities that are unrelated to the Directive. On this basis the emissions from this impact category have not been included in the analysis; this may lead to an underestimate of the total impacts.

Whilst Member States emissions inventories provide a comprehensive and quality checked source of data, prepared in accordance with a consistent set of guidelines, they do have some limitations when used for assessing policy impacts.

Three methods for evaluating N₂O emissions from cultivated soils treated with N fertiliser are specified in IPCC (2006). These methods are referred to as the Tier 1, Tier 2 and Tier 3 approaches¹⁰³. The Tier 1 approach is the simplest in which a single relationship between soil N₂O emissions and N fertiliser application rates is proposed as means for deriving national GHG emissions inventories. Because of its simplicity, it was adopted initially by most countries which ratified the Kyoto Protocol to the UNFCCC. However, it is recognised that actual soil N₂O emissions depend on a number of specific factors including soil and crop type, and past and present climate, land use and cultivation practices. In other words, soil N₂O emissions are location specific and can be expected to vary from country to country (indeed, even within countries). In an attempt to accommodate this in an approximate manner, the Tier 2 approach allows location specific values to be incorporated into the simple relationship between soil N₂O emissions and the N fertiliser application rate adopted in the Tier 2 approach. Further sophistication is achieved in the Tier 3 approach through the use of actual measurements and models for estimating soil N₂O emissions.

Most analysts recognise the simplicity of the Tier 1 approach which enables every country to use the same relationship and, in effect, a universal set of data with actual national N fertiliser application rates to produce results for national GHG emissions inventories. However, there is a growing acceptance that a single, simple relationship with universal data, as reflected in the Tier 1 approach, is no longer valid as a means of estimating soil N₂O emissions. However, for the time being the Tier 1 approach is being used until agreed results are produced from developed and validated estimates of soil N₂O emissions from the Tier 2 and Tier 3 approaches.

From a policy evaluation perspective, the simpler (Tier 1) inventories are not sufficiently detailed to take account of all factors that may influence emissions. Inventories are unlikely to give the most accurate answer if they cannot represent the variations in management and/or environment that exist nationally within a given source category. Importantly, it is often impossible to represent the implementation of mitigation methods within Tier 1 methodology. With the increasing level of detail, Tier 2 and Tier 3 methodologies have the potential to yield more accurate estimates and the ability to reflect changing practices and the implementation of mitigation methods. However, the requirement for input parameters (e.g. characterisation of livestock feed, liveweight gains) is greater for these methodologies and, in many cases, these data may not exist at a national level. These limitations in inventory approaches, or in the collection of relevant activity data, may mean that the actual change in emissions arising from a policy is not reflected in the inventory.

As an example, in recent years, management of animal feeds (i.e. improving the efficiency of dietary N utilisation) has received increasing attention as a tool to help control environmental pollution¹⁰⁴. If successfully implemented, the feed management will result in a reduction in the emissions of NH₃ and N₂O regardless of any change in livestock numbers. However, if Member States adopt default factors for the emissions per animal, this change will not be reflected in the emissions inventories.

N fertiliser application

The Nitrates Directive, by requiring farmers not to exceed crop requirement for the quantity of fertiliser nitrogen applied to each field each year, is expected to result in a reduction in the overall application rates for N fertilisers.

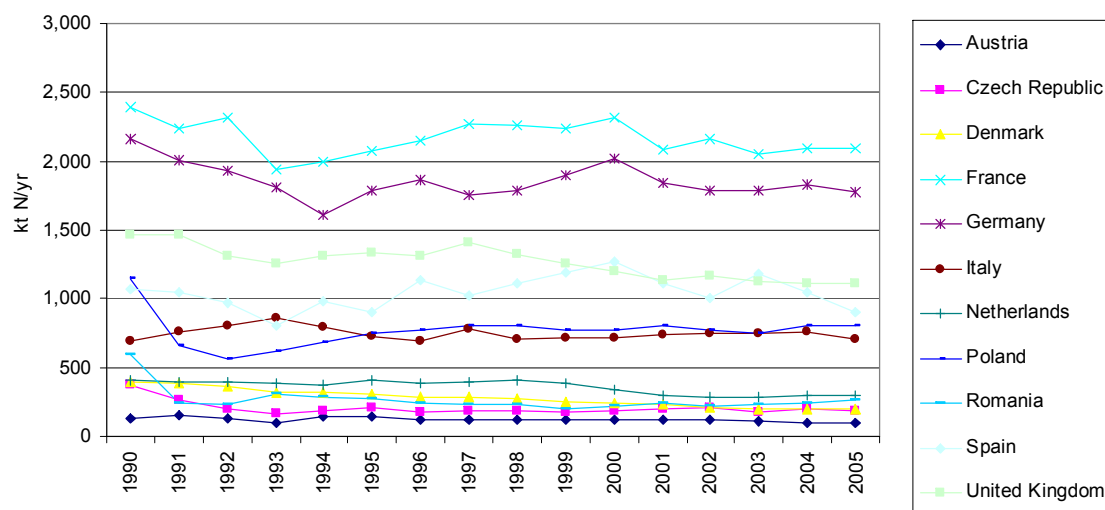
Figure 14-1 below shows the trends in synthetic N fertiliser application rates since 1990 in each of the Member States that have been selected for detailed consideration. This is followed by Figure 14-2 which shows the application rates for organic fertiliser (such as farmyard manure (FYM) and slurry) over the same period. In both cases the application rates have been taken from the emissions inventories submitted by Member States to the UNFCCC in accordance with their reporting

¹⁰³ Not to be confused with Tier 1, Tier 2 and Tier 3 evaluation methodologies that have been developed and applied in this study. The concept of increasing refinement from Tier 1 to Tier 3 is consistent between the IPCC emission factors and the evaluation methodologies applied here. However, the Tier 1/2/3 evaluation approach does not necessarily imply the use of the respective Tier 1/2/3 emission factors. In practice, the Tier 1 evaluation approach uses data reported by Member States to the UNFCCC, so could conceivably include emissions estimated using the full range of IPCC emission factors.

¹⁰⁴ For cattle and sheep, the greatest potential for improving feed N utilisation appears to be associated with improvements in the supply of energy to rumen micro-organisms by increasing use of high-sugar grasses or forage maize (as maize silage). Less reliance on grass feeds of the type used currently could lead to both a decrease in N intake, more efficient use of carbohydrate and reduced N excretion hence reducing subsequent emissions of all N compounds. Synthetic amino acids are increasingly being used in pig and poultry rations, and their inclusion results in significant improvements in N utilization at an animal level because essential amino acid supply can be more closely matched to requirements. Other strategies, such as phase feeding allow further matching of dietary amino acid supply with requirements, resulting in reductions in overall dietary N concentration and N excretion.

requirement. The activity data is therefore consistent with reported Member State emissions of N₂O under CRF category 4.D.1.1, and 4.D.1.2, respectively.

Figure 14-1 Application rates of synthetic nitrogenous fertiliser to the soil

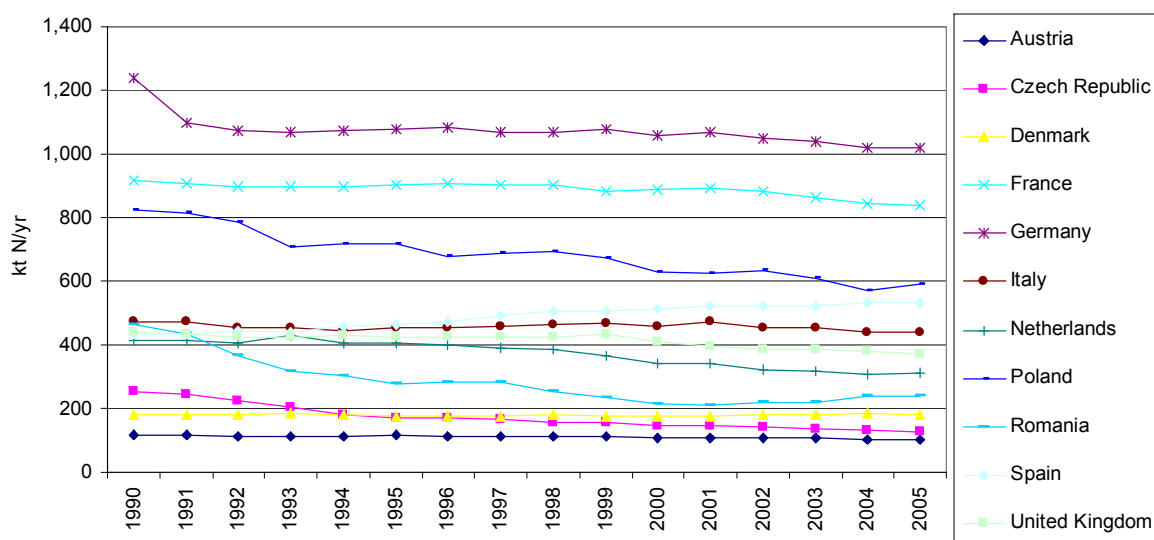


Source: UNFCCC

Application rates for synthetic nitrogen fertilisers have fallen between 1990 and 2005 in each of the countries examined, with the exception of Italy, which has seen a slight increase in usage. For the EU-15 application rates have declined by an average of 19% over the period.

A comparable trend is apparent for application rates from animal manures to soil. For the EU-15 as a whole application rates in 2005 are 9% lower than in 1990, with application rates falling in 9 of the 11 Member States examined. This is shown in Figure 14-2 below.

Figure 14-2 Application rates of animal manure applied to soil



Source: UNFCCC

So

Composition of animal manure varies considerably according to a range of factors and in most countries a reduction in total numbers of livestock since 1990 has resulted in a slight reduction in the amount of manure to be disposed of (EC, 2005). This can partially be explained by the changes in agricultural policy, notably the 2003 CAP reform, that has contributed to stabilising or reducing cattle,

sheep and goat numbers¹⁰⁵. For some of the Eastern European countries the decreases in the early to mid 90's were largely in consequence of the transition to a more market-based economy.

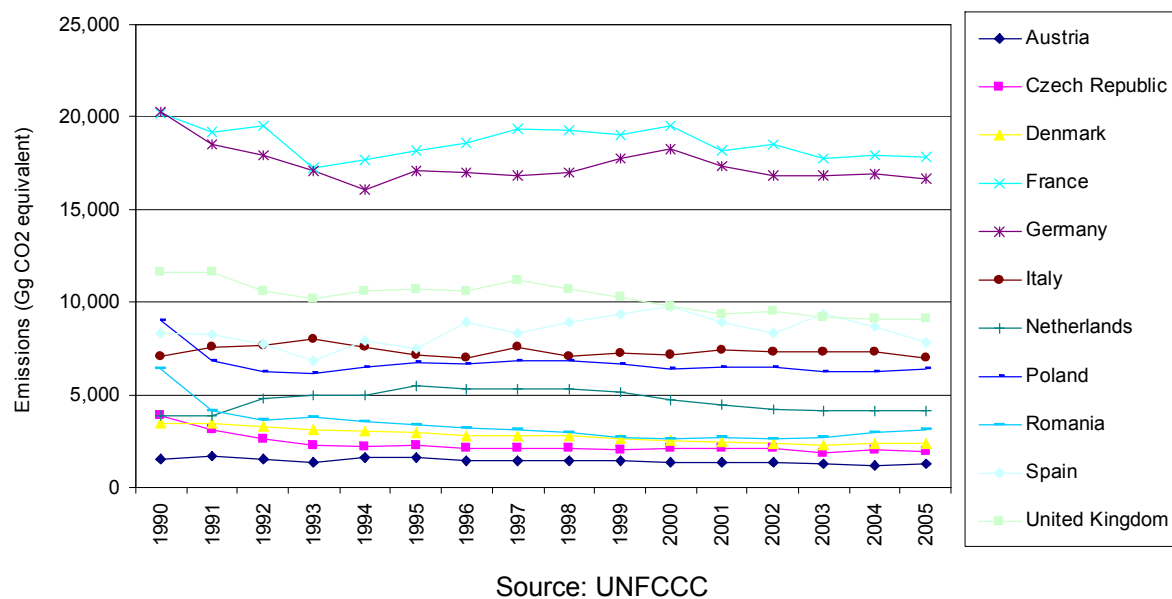
Emissions

The reductions in fertiliser application rates described above can help to explain the change in emissions of greenhouse gases (largely N₂O) arising from this activity. Figure 14-3 below shows the trend in total greenhouse gas emissions from the application of synthetic and mineral fertiliser to soil. This information is repeated in

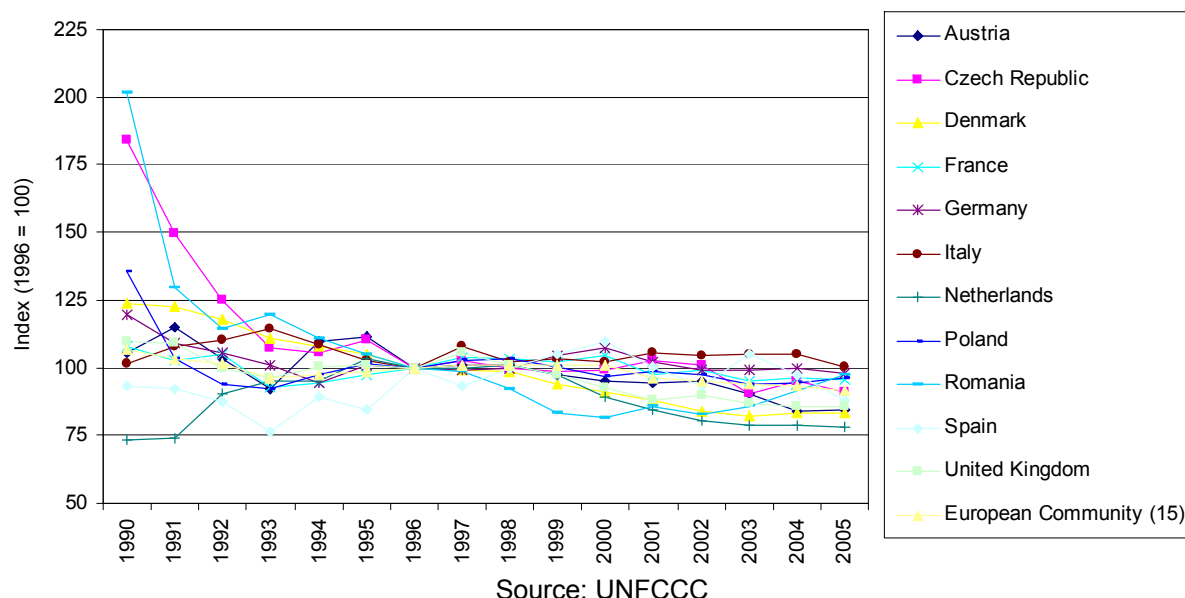
¹⁰⁵ See associated report for the 2003 CAP reform.

Figure 14-4, but presented as an index to emissions in 1996 to show trends prior to, and following, the implementation of the Directive in the EU-15¹⁰⁶.

Figure 14-3 Emissions of GHGs from soils arising from the application of nitrogen fertilisers



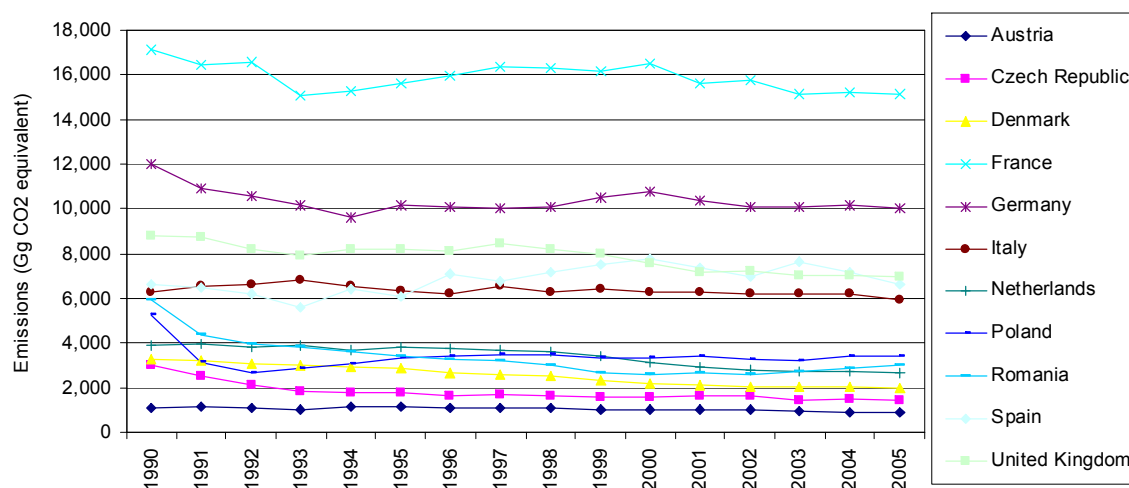
¹⁰⁶ Although as described later, the actual implementation date for Member States was in some cases much later than this date.

Figure 14-4 Trend in emissions of GHGs from soils arising from the application of nitrogen fertilisers

As shown in Figure 14-4, emissions arising from the application of nitrogen fertilisers have followed a declining trend for most of the Member States considered since 1990. The Directive came into force in 1991. For almost all Member States emissions have declined since 1996 (i.e. when the first action programmes of Nitrates Directive came into force for the EU15 MS). However, emissions also had a high degree of variability prior to the implementation of the Directive, with certain Member States showing a large decline in emission between 1990 and 1996 (mainly those whose economies were in transition) but other showing an increase. This suggests that other factors have an important influence on emission over this period. Conversely, the fact that emissions from Member States have followed a much more consistent trend since 1996 may indicate the influence of the Directive on the overall emissions.

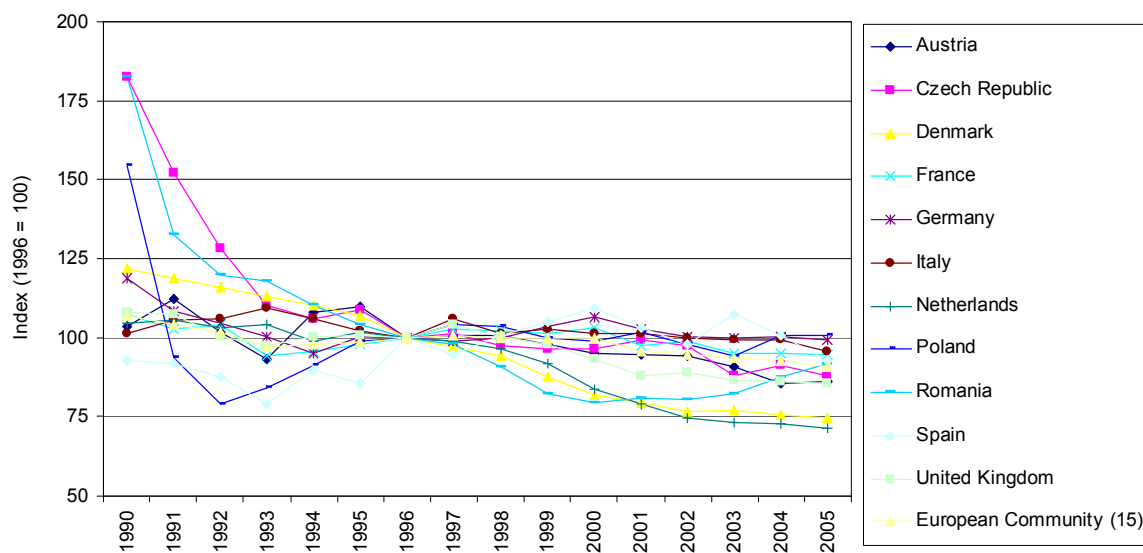
As described previously, in addition to the N_2O releases associated with the application of fertilisers and manures to soils, N_2O is also emitted indirectly from the denitrification of leached NO_3 in slow moving waters. Thus the reductions in leached NO_3 resulting from the Directive, will also reduce emissions of N_2O from this source. In fact, since the emission category is directly related to the primary aim of the Directive - reducing nitrate loading of water bodies - then you would expect a close correlation between the effectiveness of the Directive in reducing emissions of GHGs and the effectiveness of the Directive overall.

The trends in emissions from this source category are described in the table below. Again, the data is based upon the inventories submitted by Member States to the UNFCCC and is therefore consistent with reported Member State emissions of N_2O under CRF category 4.D.3.2.

Figure 14-5 Trend in emissions of GHGs from soils arising from nitrate leaching

Source: UNFCCC

As with the previous emissions reporting categories it is interesting to view the emissions as an index to emissions in 1996 to show trends prior to, and following, the implementation of the Directive in the EU-15. A similar declining trend is shown in most Member States to that shown previously from direct emissions from soils. In the EU15, emissions declined by an average of 9% between 1996 and 2005. However, declines were also shown in those Member States who were not at the time implementing the requirements of the Directive

Figure 14-6 Trend in emissions of GHGs from soils arising from nitrate leaching

Source: UNFCCC

Summary

Over the period that the Nitrates Directive has been in force the application rates of both synthetic and mineral nitrogen fertiliser have declined in most Member States. This, in turn, has contributed to an overall reduction in the emissions of N₂O from soils. The key question for this study is to what extent this change in application rates (and associated emissions) has resulted from the implementation of the Nitrates Directive, and to what extent it is a result of other influencing factors. This is discussed further in the following sections.

14.3 Impacts of the Nitrates Directive on emissions of GHGs from soils

This section presents an initial estimate of the impact of the Nitrates Directive on emissions of greenhouse gases. The analysis has been performed in accordance with the tiered methodology that has been developed during this study, and is described in the accompanying evaluation guidance.

Results are presented for each of the 11 Member States selected for detailed consideration. These are: Germany, France, Spain, Italy, UK, Denmark, Austria, Netherlands, Poland, Czech Republic, Romania. Results are presented for each of the Tiered methodologies, respectively, and then the overall results are compared with each other and some overall conclusions are drawn. In each case the limitations with the approach and key methodological assumptions are highlighted.

14.3.1 Overview of methodologies

The Tier 1 approach represents a high level assessment of the impacts. It is based upon existing EU wide statistics so that the methods can be easily repeated without additional data collection. It applies a number of simplifying assumptions to ease comparison between countries and policies, and consequently, may not adequately reflect the full complexity of the policy in question. Therefore, whilst the Tier 1 approach is a useful first step in the policy evaluation process, it may not, for all policies, provide a sufficient level of accuracy to be considered a policy impacts assessment.

In contrast, the Tier 3 approach involves a much more detailed assessment of the policy impacts, using a much higher resolution of data (which may require additional collection) and increasing complexity in the methods. As far as possible the Tier 3 approach aims to consider all on the main methodological issues, and isolate the impacts of the policy fully.

The Tier 2 approach provides an intermediate level of analysis. It aims to address some of the most important methodological issues but it is still largely reliant upon existing established data sources. The extent to which the Tier 2 approach is able to isolate the policy impacts is therefore strongly reliant upon the availability and resolution of the data.

The overall scope of each of these approaches and the assumptions that have been used in defining the policy impacts for the Nitrates Directive, under each approach, is summarised in the table below.

Methodology	Tier 1	Tier 2	Tier 3
Activity indicator	Agricultural land area (FAO); N ₂ O emissions from soils (MS submissions to UNFCCC)	Agricultural land area (FAO); N ₂ O emissions from soils by Member State (MS submission to UNFCCC)	Agricultural land area (FAO) MS data on land use and crop type; Emissions from soils (MS submission to UNFCCC). Includes detailed bottom up statistics e.g. fertiliser application rates
Emission factor	Emissions based upon aggregate data reported by Member States to UNFCCC, and associated IPCC emission factors.	Emissions based upon aggregate data reported by Member States to UNFCCC, and associated IPCC emission factors.	Emissions based upon aggregate data reported by Member States to UNFCCC, and associated IPCC emission factors.
Autonomous development	No correction(s) made for any autonomous development (i.e. counter-factual emissions per unit of land area frozen at pre-Directive levels)	No correction(s) made for any autonomous development (i.e. counter-factual emissions per unit of land area frozen at pre-Directive levels)	Correction(s) for autonomous development, where considered important.
Structural effects	No adjustment for structural changes in the activity data	No adjustment for structural changes in the activity data	Correction of structural changes in activity where data allows

Timing issues	Calculates policy impacts from same start date, no adjustment for implementation delays or announcement effect	Calculates policy impacts from implementation date within each MS, no adjustment for implementation delays or announcement effect	Calculates policy impacts from implementation date within each MS, no adjustment for implementation delays or announcement effect
Policy interaction	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.	Combined effect of national and EU policies. Combined effect of closely related national and EU policies.	Estimates effect of specific EU policy.
Geographic factors	No adjustment for soil type or moisture, or any annual variation in fertiliser application rates due to weather variability.	No adjustment for soil type or moisture. Correction for annual variation in fertiliser application rates due to weather variability.	No adjustment for soil type or moisture. Correction for any annual variation in fertiliser application rates due to weather variability.
Other exogenous factors	No adjustment for exogenous factors	No adjustment for exogenous factors	Adjustment for impacts of fertiliser prices and commodity prices. Adjustment for availability of animal manures

Within the scope of this study it has not been possible to implement a Tier 3 analysis of the Nitrates Directive. The results presented below are therefore restricted to the Tier 1 and Tier 2 methods. However, as part of the analysis a number of methodological improvements have been identified that could be considered in the future as part of a Tier 3 approach.

It is important to note that the following corrections have **not** been possible within the current Tier 1 and Tier 2 analysis, so the results provided below should take this into account:

- No adjustments have been made for the coverage of NVZs (i.e. accounting for the fact that certain Member States have applied the NVZs to specific areas, rather than the whole territory)
- No adjustments have been made for autonomous progress (i.e. the influence of previous national policies, or technological developments on the trend in emissions)
- No adjustments have been made for structural changes in activity data (i.e. changes in mix of crop types)
- No adjustments have been made for other exogenous factors such as commodity prices.

On this basis the Tier 1 and Tier 2 results should be considered a partial analysis. These issues would, ideally, be addressed as part of a Tier 3 approach.

14.3.2 Results

Tier 1 approach

In the Tier 1 approach the principal assumption is that the Nitrates Directive has not influenced the total area of agricultural land, but through the action programme measures implemented, has caused a reduction in the N₂O emissions arising. Therefore any change in the emissions of N₂O per unit of agricultural land is assumed to be a result of the Nitrates Directive. This assumes that no other policies are in place to influence N application rates from agricultural land, and that the Directive is the single most important driver of emissions in the sector. This is recognised as a major simplification, and as a result the Tier 1 approach may not adequately reflect the other important influencing factors on N application rates. However, it does allow an indicative estimate of the overall magnitude of emissions that can potentially be influenced by the policy.

Under this approach the impacts of the Directive have been assessed in terms of the change in emissions of N₂O from soils¹⁰⁷ per unit area of agricultural land, relative to 1996 levels – the date by which Member States were required to implement the main components of the Directive. This utilises

¹⁰⁷ The indicator is defined as N₂O emissions reported under CRF category 4.D Agricultural Soils minus emissions reported under sub category 4.D.3.1 Nitrogen Deposition, since emissions from N deposition are not influenced by the Directive.

existing aggregate statistics from the FAO on agricultural land area within each of the Member States, and also data reported by Member States to the UNFCCC on emissions of N₂O from soils.

No differentiation is made between different land use, fertiliser, crop or soil types in the Tier 1 approach. Likewise, no corrections are made for the influence of climatic factors on e.g. fertiliser application rates. Furthermore, by assessing impacts on the basis of total agricultural land area no differentiation is made between emissions from soils within NVZs and those outside of NVZs. Therefore, in the Tier 1 approach no adjustments are made to reflect the significant variations in the coverage of action programme measures (e.g. proportions of land areas classified as an NVZ) between Member States (see Table 2-1)

The analysis assumes the emission rate of N₂O from soils per unit area of agricultural land is 'frozen' at the pre-Directive rates (i.e. in the absence of the Nitrates Directive the emission rate would remain at this level), and it is assumed that the Directive is implemented consistently within all Member States even if at the time they were not yet member of the EU.

Tier 2 approach

The Tier 2 approach aims to build upon the methodology proposed for Tier 1. The Tier 2 approach is again based upon established statistical sources, and therefore can be applied without additional data collection, but aims to correct for some of the methodological issues that were not adequately addressed within Tier 1.

Two specific issues are considered in more detail as part of the Tier 2 methodology for the Nitrates Directive. These are an adjustment for the start date of the policy, to reflect the fact that not all Member States implemented the Directive within the original timescales required by the Directive, or were not required to implement the Directive until a later date (for the new Member States). The second adjustment takes into account the sensitivity of using a single year, to determine the pre-Directive efficiency, which may not adequately reflect the influence of climatic variations on fertiliser application rates. Consequently, the Tier 2 approach defines the 'frozen efficiency' as the average application rate in the 3 years prior to the implementation of the Directive.

Quantitative results

Table 14-2 show the estimated saving from applying the Tier 1 and Tier 2 approach to the Member States that were selected as case studies to test the methodologies. In

Table 14-1 the results are presented for those case study Member States that were part of the European Union when the Directive was implemented, so would be expected to show an impact within the timescales of the reported data. In

Table 14-2, the results for the new Member States are shown.

Table 14-1 Estimated emission savings from applying Tier 1 and Tier 2 methodologies (Mt CO₂eq)

		Tier 1		Tier 2	
	N ₂ O from soils in 2005	Change in 2005 emissions	% of 2005 emissions	Change in 2005 emissions	% of 2005 emissions
Austria	2.7	-0.2	8%	-0.4	15%
Denmark	5.3	-0.9	17%	-0.9	17%
France	45.9	-2.4	5%	-1.7	4%
Germany	35.4	+0.4	1%	+0.9	3%
Italy	16.5	-0.1	1%	-0.1	1%
Netherlands	8.1	-2.5	31%	-2.5	30%
Spain	18.2	-0.5	3%	-0.7	4%
UK	23.5	-2.9	12%	-3.1	13%
EU-15	183.4	-10.7	6%	-8.2	4%

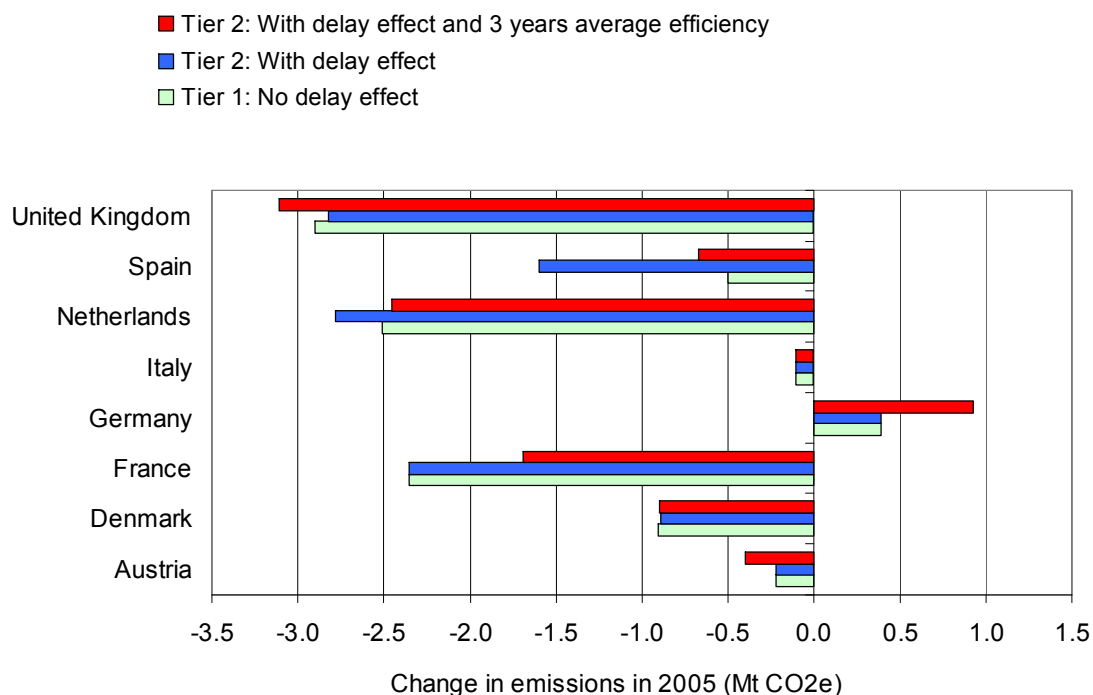
On the basis of the results derived from applying the Tier 1 and Tier 2 approach, the Nitrates Directive has a large variation in effectiveness between Member States. For the certain Member States the estimated savings are large, with savings of over 30% against the pre-Directive level of emissions per ha of land, recorded for the Netherlands. Large emission savings are also recorded for Denmark (17%) and the United Kingdom (12%). In contrast, the results for three Member States (Spain, Germany and Italy) show only a modest change in emissions as a percentage of 2005 levels.

For Germany in particular the result is significant as it represent a net increase in emissions relative to the frozen efficiency baseline – suggesting (under the assumptions of the Tier 1 and Tier 2 approaches) that the Nitrates Directive resulted in a net increase in emissions. One possible explanation for this result is that the agricultural sector in Germany was going through significant structural changes over the period following reunification, which involved the return of abandoned agricultural land back into use in the Eastern part of Germany. It has not been possible to isolate these structural changes in the Tier 1 and Tier 2 approaches, and this remains an important weakness of the current methods.

In absolute terms the largest savings are estimated to be delivered in the UK, Netherlands and France. For the EU15 as a whole the reduction in emissions, as estimated using the Tier 1 approach are, 10.7 MtCO₂ eq in 2005. When a Tier 2 approach is applied, the emission savings estimate is lower at 8.2 MtCO₂ eq in 2005, for the EU15.

For several Member States, applying a Tier 2 approach (i.e. correcting for the policy start date and climatic factors) does not yield a large change in emissions – in percentages terms. Notable exceptions are Austria, Germany and Spain, where the Tier 2 approach yields savings that are almost double those achieved from applying a Tier 1 approach. This suggests, at least for certain Member States, that the adjustments of these methodological assumptions can influence the results by a factor of 2. The influence of these methodological adjustments on the results in each of the Member States is shown in

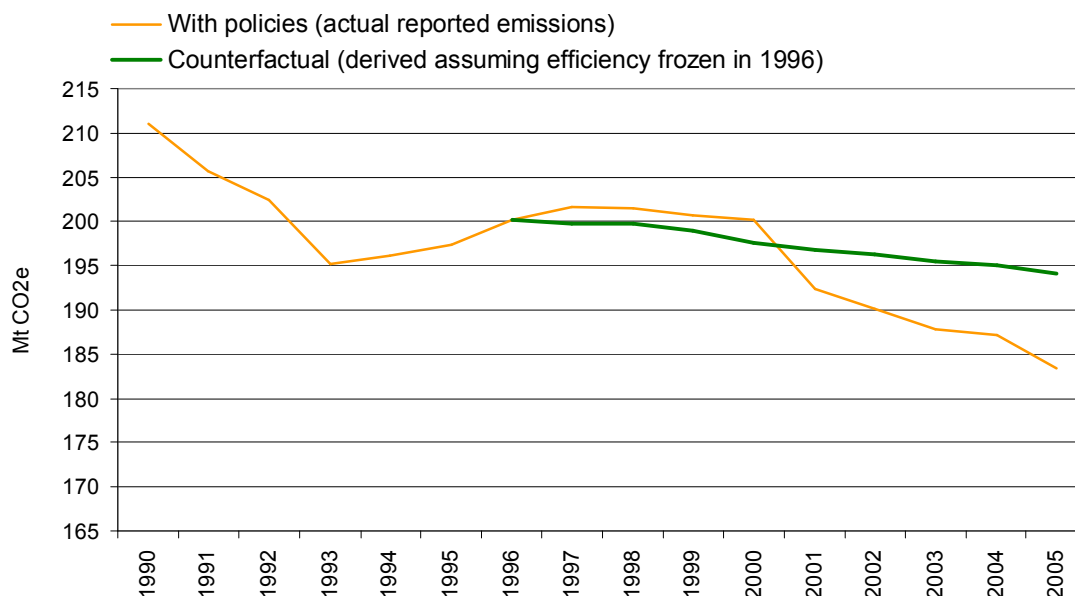
Figure 14-7 below.

Figure 14-7 Influence of key methodological assumptions on Tier1/2 results

For Austria, France and Germany, the variation in the results between Tier 1 and Tier 2 can be fully explained by taking a 3-year average efficiency, rather than a single year average efficiency. For most Member States the correcting for the implementation date is less significant, with the exception of Spain, where the change in this assumption more than doubles the estimated savings.

The trend in emissions in the EU-15 is examined further in the chart below. The actual emissions from the sector have been compared to a derived counter-factual, which represents the estimated emissions (in accordance with the Tier 1 approach) that would have occurred in the absence of the Directive. The savings are represented as the difference between the with-policies trend and the counter-factual trend¹⁰⁸.

¹⁰⁸ The decline is the counterfactual emission over time results from a decrease in the overall agricultural land area in the EU-15 over the period examined.

Figure 14-8 Counter-factual EU-15 emissions assumed under the Tier 1 approach

The chart shows, under the assumptions applied within the Tier 1 approach, a net reduction in greenhouse gas emissions associated with the Directive between 2001 and 2005. However, between 1996 and 2001 the counter-factual is actually lower than the actual emissions, which implies that the Directive actually resulted in an increase in emissions during this period. Clearly, this is counter to the overall expectations for the Directive (similarly for the results from Germany shown in the table above), and puts into doubt the reliability of the Tier 1 approach. As described above, structural changes in the agricultural sector over this period, and to a lesser extent delays in policy implementation, are important factors not reflected in the Tier 1 approach. Likewise, by calculating emissions on the basis of the total land area, the current approach does not reflect the different coverage of NVZ between Member States.

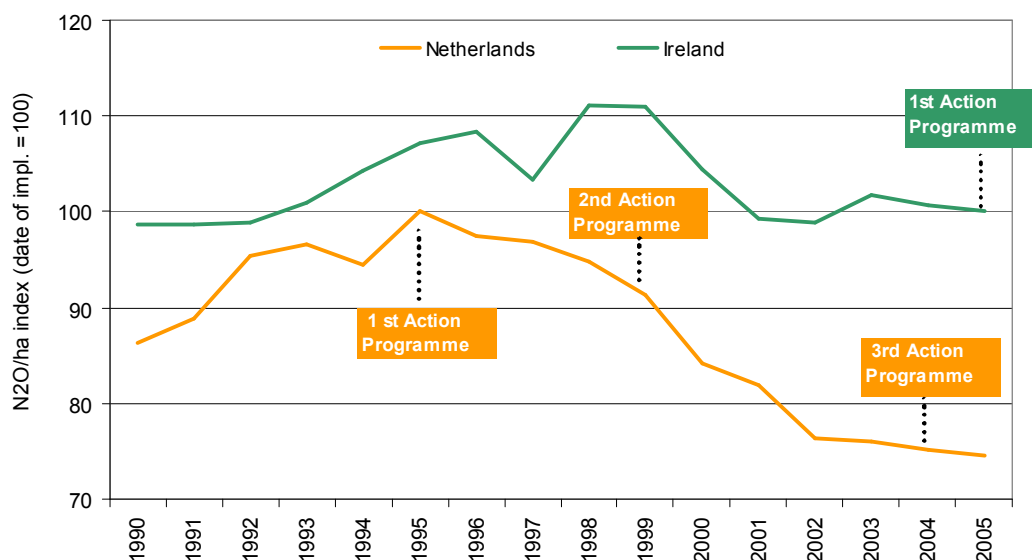
A further test of the reliability of the Tier1 approach is its application to those Member States that have not implemented the Directive, at least within the timescales of the reported data. The results for those cases study Member States that have recently joined the EU are provided below. In addition, results are presented for Ireland as this provides a useful control. Ireland is not going through the same transitional adjustments in its economy as the new Member States, but it also did not implement an Action Programme until 2006, so in theory, the impacts of the Nitrates Directive will not be realised within Ireland until after this date.

Table 14-2 Estimated emission savings from applying Tier 1 and Tier 2 methodologies (Mt CO₂eq)

	N ₂ O from soils in 2005	Tier 1		Tier 2	
		Change in emissions in 2005 as a result policy	% of 2005 total emissions	Change in emissions in 2005 as a result policy	% of 2005 total emissions
Czech Republic	4	- 0.4	10%	0	0%
Poland	16	1.6	10%	0	0%
Romania	10	- 0.4	4%	0	0%
Ireland	6	- 0.5	8%	0	0%

The results are interesting. For Poland the results show an increase in emissions between 1996 and 2005, however, for the three other Member States a reduction in emissions (similar to those experienced by the EU-15) are estimated. Whilst it could be argued that some reductions in emissions within these Member States may have resulted from measures implemented in preparation for the Directive, an alternative argument is that other important factors (in addition to the Nitrates Directive) are influencing the trends in emissions. In the case of Poland, for example, the NVZ covered only 2% of the land area so the influence of the measures introduced under the Nitrates Directive will only cover a small proportion of the total activities.

In Figure 14-9 below the trends in the Tier 1 indicator for two Member States, the Netherlands and Ireland, are examined in more detail. These are interesting case studies as the Netherlands showed the largest savings (in % terms) under the Tier 1 approach, and Ireland showed savings despite not implementing an action programme within the timescales of the available emissions data.

Figure 14-9 Historical trend in emissions indicator for Netherlands and Ireland

The Netherlands implemented action programmes in response to the Directive as early as 1995 and has seen a clear decline in N₂O emissions per ha of agricultural land. In contrast, Ireland did not implement an action programme until 2006 and has seen a much more fluctuating trend in the emissions rate over this period. This does suggest, at least for the Netherlands, a causal relationship between the action programme measures and the reduction in emissions. Under the Tier 1 approach all of this change in the emissions rate is attributed to the Nitrates Directive.

The results in Figure 14-9, and also closer examination of the trends in other Member States, demonstrate the large variability in trends between Member States. Some of this variability is likely to relate to the different approaches taken by Member States to implement the Directive. However, the

underlying structure of the agricultural sectors within the Member States, and its changes over time, is likely to be of equal if not greater importance. The methodologies described allow some investigation of these issues, and can be performed easily using existing established data sources.

However, on balance, taking into account the complexity of the sectors and the simplicity of the approach we suggest that **the results presented above should be treated with caution**. Whilst the results are useful in showing the values that are achieved by implementing the Tier 1 approach, as it currently stands, **we do not consider the results sufficiently robust to recommend the use of a Tier 1 approach to quantify the impacts of the Nitrates Directive**. This statement is supported by the views of the stakeholders who commented on the draft guidance for the policy.

Furthermore, whilst the Tier 2 approach represents an improvement on the analysis that was performed for Tier 1, a number of potentially important methodological issues remain unresolved. This partially reflects the resolution of the data that is available, but more importantly the complexity of this particular policy.

As a result, **we consider that the Tier 2 results should not be considered an accurate representation of the greenhouse gas impacts that can be attributed to the Nitrates Directive**. The results do provide an indication of the overall magnitude of the potential policy savings, but the results derived are likely to overestimate the true impacts of the policy. Further analysis, is required to isolate the policy impacts further, and identify the level of influence of the other influencing factors – and the overall level of accuracy of the results derived from a Tier 1 or Tier 2 approach. These issues are discussed further below.

Policy implementation

The **Tier 1 approach** assumes that the Directive is implemented on a consistent basis across all Member States. However, this has not been the case. There has been significant variation both in terms of the coverage (e.g. proportions of land areas classified as an NVZ) but also the timing of implementation of the Directive.

This is highlighted in Table 14-3 below, where the proportion of the total land area designated as a NVZ in each of the EU-15 states is described. There is a significant variation in the NVZ coverage between Member States. This ranges from 100% coverage for Denmark, Germany, Luxembourg, Netherlands, Austria and Finland – to less than 5% coverage for Italy, Portugal and the UK. At the time the summary table was published by the European Commission, Ireland had yet to designate any of its area as an NVZ¹⁰⁹.

¹⁰⁹ But has subsequently applied a whole territory approach.

Table 14-3 Implementation of the Nitrates Directive within the EU-15

Member State	NVZ area ('000s km ²)	Proportion of total area %	EC potential NVZ area ('000s km ²)	Combined series ('000s km ²)
Belgium	3	9	16	16
Denmark	43	100		43
Germany	356	100		356
Greece	14	11	9	14
Spain	32	6	71	71
France	241	48	37	241
Ireland	0	0	7	7
Italy	6	2	89	89
Luxembourg	3	100		3
Netherlands	37	100		
Austria	84	100		84
Portugal	0.9	1	12	12
Finland	334	100		334
Sweden	41	9	44	44
UK	8	3	19	19
EU15	1202	38		1332

Source: European Commission, Implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources: Synthesis from year 2000 Member States reports

The Tier 1 approach draws upon aggregate statistics that are currently collected and compiled for each of the EU Member States on a consistent basis. Aggregate statistics on N₂O emissions from soils are only reported at a national level, whereas, for certain Member States, the impact of the Directive is only applicable to a subset of the land area, i.e. the area of land covered by the action programme measures. For this reason the currently available aggregate statistics may not reflect adequately the land area that is affected by the Directive.

Furthermore, as indicated above, the timing of implementation of the Directive has also varied significantly between Member States. This variation is not accounted for in the Tier 1 approach.

In the **Tier 2 approach**, a correction has been made to reflect the fact that the implementation of the Directive has not been uniform across all Member States. The policy implementation data has been assessed, for each Member State, as the date at which the first action programme under the Directive was fully implemented. This has been estimated based upon the synthesis reports prepared by the Commission of the monitoring reports submitted by Member States, and other secondary sources.

Identifying the correct policy implementation date for each Member States has not been straightforward. For certain Member States, notably Denmark and France certain control measures were put in place prior to the deadline required by the Directive, which it could be argued were a direct result of the Directive. For other Member States, the date of implementation of their first action programmes is not readily available in the summary reports prepared by the Commission, so has been estimated.

For Austria, France and Germany the assumed policy implementation date is 1996 based upon data reported in COM 16 (1998). For the UK, the policy impacts have been quantified from 1998 (based upon ADAS, 2007), and for the Netherlands from 1995 (based upon Zwart, 2008). For Spain and Italy a policy start date of 1999 has been assumed in the absence of better data. For the new member states, the implementation timescales for the Nitrates directive were agreed as part of the commitments taken in the negotiation for accession.

In addition to the uncertainties with respect to the policy implementation date described above, it has not been possible to make any adjustments for other variations in implementation between Member

States within the Tier 2 approach e.g. definition of NVZs. The current resolution of the data does not enable an assessment of the emissions reductions in areas that are covered by NVZs versus those that are not covered by the action programmes introduced under the Directive. This is a significant limitation of the current data set.

As part of a **Tier 3 approach** the issue of policy implementation could be addressed, on a very crude basis, by looking at the emission reductions that have occurred within Member states that applied the NVZ to the whole territory, as compared to those that have applied it to specific regions. In making this comparison, it will be important to select Member States that are similar in characteristics e.g. similar level of pre-Directive N surplus, similar mix of agricultural activities.

An alternative would be to utilise bottom up data and statistics that may be available. For example, a report by ADAS (2007) on the implementation of the Nitrates Directive in the UK made some comparisons, using the British Fertiliser Practice Survey (BSFP), of fertiliser-N use within and without NVZs. The results suggested that applications within NVZs were less than those outside, although not by a lot.

This suggests that this issue may be less important than certain other factors, although this finding should be treated with caution. For example, N fertiliser recommendations for wheat differ according to soil type, being less on sandy soils than on other soil types. Since sandy soils are more prone to leaching it is possible that areas within NVZs have a greater proportion of sandy soils than areas outside. However, even this is uncertain, since NVZ designations are greatly influenced by over-winter rainfall. Increasing over-winter rainfall will tend to increase the amount of nitrate leached, but by less than the amount by which drainage water increases. Hence the overall effect of increasing over-winter rainfall tends to be to dilute the nitrate concentration. Hence there is no simple correlation between soil type and NVZ designation.

Autonomous development

Autonomous development can potentially describe a range of inter-related factors that influence the counter-factual trend in emissions. However, for the purposes of this analysis we focus upon the influence of autonomous technological development (i.e. innovation in technology) and autonomous policy development (i.e. the impacts of previous policies). By assuming that the emissions per ha of land are 'frozen' at pre-Directive levels, the **Tier 1 and Tier 2 approaches** may not adequately reflect the long running trends in N fertiliser consumption within Europe that results from these autonomous developments.

Technological innovation can directly influence the use of fertilisers within the sector. Historical innovation include advances in precision application of fertilisers through increased use of soil sampling and greater understanding of crop nutritional requirements, together with technological developments in application machinery. More recent developments include the use of GPS and light reflecting sensor technology, which combined, can identify specific areas within individual fields that require additional inputs.

It could be argued that the innovation in these techniques has been, at least partially, influenced by the requirements of the Directive. It could also be argued that certain development would have occurred anyway. For example, the price of agricultural commodities and fertiliser prices may provide a sufficient economic stimulus for the take up of such technologies anyway.

For certain other policies the influence of autonomous technological progress may be identified by looking at historical trends in technological efficiency, but this is less straightforward for fertiliser application rates. Specifically, it is difficult to relate application rates to specific technologies or management measures, and even if this were possible, data is generally lacking on the uptake of the specific technologies/measures.

Whilst the empirical data is limited, we consider that overall the impacts of autonomous technological progress are less important in driving the counter-factual emissions than other variables. This could be examined further as part of a **Tier 3 analysis**, but is not considered a priority.

Autonomous policy development relates to the influence of closely related national policies that may have been in place prior to the Nitrates Directive. According the European Environment Agency¹¹⁰, of the EU-15, four Member States reported having national policies and measures in place prior to the Nitrates Directive, which were linked to it. These were Austria, Germany, Netherlands and Sweden. In addition, France and Denmark are known to have closely related national policies in place prior to the Directive. In the absence of the Nitrates Directive these national policies may potentially have delivered additional reductions in the N₂O emissions from soils than would be assumed under the 'frozen' efficiency assumption.

In the Tier 1 and Tier 2 analysis it is assumed that the full impacts of these national policies have already been realised prior to the implementation of the Nitrates Directive, and that no autonomous policy development would continue once the Nitrates Directive was implemented. For those policies that set limits or controls, which were then replaced by the (more stringent) requirements of the Directive, then this is probably a reasonable assumption.

A related issue is the extent to which national policies set up by Member States prior to the implementation of the Directive were done so in response to the Directive – so should be included within the overall savings. This can only be addressed by looking at the individual policies within Member States in more detail, which could form part of a **Tier 3 analysis**.

A third and potentially more important area that may be captured as part of the underlying autonomous development is autonomous behaviour. This includes the behaviour of the key actors in response to market factors (so is strongly related to exogenous factors such as prices), but also wider social or environmental behaviours (e.g. demand for organic produce).

Structural changes

Structural changes can be described in terms of the activity data that is used to estimate the emissions from the sector. Changes in the structure of this activity data may be result in changes in the associated emissions, however, these structural changes may be effectively 'hidden' in the overall aggregate statistics – so the impacts of these changes are not isolated from the other factors driving emissions.

For example, the use of *total land area* to assess the average rate of emissions from soils may not take into account changes in the agricultural land use type over time. The level of nitrogen fertiliser applications within a country (and the associated emissions) will vary according whether the land is arable or grazed, intensively farmed or natural/semi-natural vegetation. The current **Tier 1 approach** does not currently reflect changes in the N₂O emissions per ha of land that results from these structural changes in land use.

Whilst certain statistical data is available that could potentially be used in the future, as part of a **Tier 2 or Tier 3 analysis**, to help resolves structural changes¹¹¹, it was not possible to include these corrections with the current Tier 2 approach.

For example, it may be possible to isolate these structural changes by examining the changes in agricultural land use type over time, and the associated impacts on emissions. Specifically, by examining trends in land use and crop type, and using EU or Member State average data on fertiliser application rates by land use/crop type, it may be able to isolate the influence of these changes in the underlying activity from the overall trend in emissions. Ideally, the assessment would be carried out using consistent emission factors as those used for the compilation of the emissions inventory, taking into account national circumstances and variations in application rates by land use type.

Policy interaction

The **Tier 1 and Tier 2 approaches** assumes that the Nitrates Directive is the primary policy instrument influencing N fertiliser consumption. However, other agricultural and environmental policies will influence the level of N fertiliser that is available and applied to land.

¹¹⁰ EEA, Greenhouse gas emission trends and projections in Europe 2007; Tracking progress towards Kyoto targets.

¹¹¹ Such as the disaggregation of agricultural land area into land use types, and data on changes in crop production over time.

The most significant overlap is with the Common Agricultural Policy, which provides an overarching framework that influences the range of agricultural activities with the EU. It could be argued that in the past the CAP and the Nitrates Directive have sometimes contradicted one another as traditionally the CAP was designed to stimulate production while the Nitrates Directive was aimed at reducing pollution by improved nutrient management. However, following the 2003 CAP reform, European agriculture is not only more market focussed¹¹² but also includes an instrument known as cross compliance.

Under cross compliance direct payments to farmers are dependant on maintaining all land in good agricultural and environmental condition (GAEC) and, where relevant, complying with (largely existing) legislation affecting agricultural management. Failure to comply with this existing legislation - which includes the Nitrates Directive – would lead to reduced CAP payments. On this basis it can be argued that CAP has played an important role in encouraging Member States to implement the Nitrates Directive, and in communicating to farmers their obligations under the Directive.

Another major element of the 2003 CAP reform was decoupling, which meant that for the first time, farm businesses would receive payments largely based on their acreage rather than on what they produced. This meant that farmers could produce what the market wanted, rather than what the CAP was paying them to produce. These reforms were expected to lead to a reduction in agricultural production, and the associated use of inputs, as farmers became more sensitive to market conditions¹¹³. The reduction in animal numbers induced by the CAP reforms would reduce the availability of manures (and importantly reduce surplus manures) which would then make it easier for farmers to comply with the requirements of the Nitrates Directive. In addition, the focus on farm efficiency provided an additional incentive to reduce over-application of synthetic N fertiliser.

In addition to CAP reform there have been other changes in legislation such as the Integrated Pollution Prevention and Control Directive (IPPC, 2000) which sets standards for manure management on large pig and poultry holdings; and the introduction of a number of environmental schemes. Some of these changes will tend to reduce nitrate losses. Many target other objectives, for example, wildlife, or minimising pollution other than nitrate, and their impact on nitrate is therefore expected to be minor.

Further policy interaction occurs with the range of rural development actions, including agri-environmental measures, that can further contribute to mitigation. This includes, for example, aid to modernise farms (e.g. via energy efficient equipment and buildings), training and advisory services, and support for biogas. Some of these actions e.g. training, will support the delivery of Nitrates Directive directly, for example by encouraging more efficient use of resources. Other actions, will impact indirectly, for example support for biogas will help to deal with surplus manures.

A further area of interactions relates to the National Emissions Ceiling (NEC) Directive. The NEC requires Member State to draft ammonia action plans to reduce emissions of ammonia. The measures introduced (e.g. manure management) will also impact upon emissions of greenhouse gases.

The impacts of other policies on the indicator *emissions per unit of land area*, were not adequately isolated in the Tier 1 and Tier 2 methodologies. However, the influence of these policies is potentially significant. Of particular important is the influence of the CAP reforms on the availability of animal manures and the changes in land use type. It may be that isolation of these impacts is too difficult, even within a **Tier 3 approach**, in which case it may be better to consider the influence of the Nitrates Directive as part of a wider package of policies targeting the agricultural sector.

Other exogenous factors

There is a range of other factors that may potentially influence the application rates of Nitrogen fertilisers, and the associated emissions, but have not been explicitly considered within the analysis. The importance of such factors may vary from year to year or from one Member State to the next, and

¹¹² This is expected to lead to a reduction in agricultural production, and the associated use of inputs, as farmers are more sensitive to market conditions. However, the recent CAP reforms, by making the agricultural sector more responsive to the market, might also lead to an increase in emissions if market prices increase sufficiently to justify increased production and inputs.

¹¹³ See related case study report on CAP Reforms for further details

may also vary in terms of their significance. The following factors have not been considered within the Tier 1 analysis but are potentially important:

Annual or seasonal variations in **weather conditions** can influence the fertiliser requirements and associated application rates. For example¹¹⁴:

- A very wet (or very dry) autumn might delay the establishment of winter sown crops, or alter the ratio of winter to spring sown crops, with their different fertiliser requirements.
- Prolonged wet weather can increase leached losses of some nutrients, particularly nitrogen and sulphur. Weather conditions also affect other aspects of soil chemistry and nutrient availability.
- Adverse weather conditions can disrupt planned activities, such as fertiliser spreading.
- Growing conditions determine plant growth and hence affect nutrient requirements.

In the **Tier 1 approach** no adjustments are made. Therefore, by taking a frozen efficiency based upon a single year may not adequately reflect the variation in application rates induced by these climatic variations.

It may be possible to use statistical relationships to isolate the influence of key climatic variables and application rates. However, such an analysis is beyond the scope of the Tier 2 approach. A more simplified approach for adjusting for this sensitivity would be to base the frozen efficiency upon the average level over the three years prior to the implementation of the Directive rather than taking a single year value. This has been the approach used in **Tier 2**.

Another important driver is **economic factors**. The price of inputs and the value of agricultural outputs are influenced not just by factors within the EU but also global commodity prices. IFA (2008) cite research by Bel et al (2004) which found that fertiliser demand was more sensitive to agricultural output demand than its own price. Specifically, that prices of agricultural commodities have a greater influence – as much as 25 times higher – on farmers' decisions. The rationale for this finding is that since farmers generally buy fertilisers on credit that is repaid only when their harvests are sold, investing in fertilisers to increase yield and crop quality carries some risk. Therefore, the price that farmers expect to receive for their output influences their initial decisions to invest in fertilisers.

Consideration of these economic factors would require a more detailed modelling of the relationships (elasticities) between agricultural inputs and outputs and the associated price of the factors of production. An econometric analysis of this kind is beyond the scope of a **Tier 1 or 2 approach** and only possible as part of a **Tier 3 approach**.

Other factors

Prior to the implementation of the Directive there was a large variation in the nitrogen surplus for agriculture within different Member States. Consequently you might expect large variation in the level of emissions reductions between Member States due to variation in capacity to make savings.

As discussed in 14.2.2 uncertainties in emissions factors, and the use of default factors in emissions inventories is another major area of uncertainty. Whilst this does not represent a methodological issue, per se, the use of different methodologies for the calculation of N₂O emissions will result in the non-comparability of results between Member States.

¹¹⁴ taken from the British survey of Fertiliser Practice fertiliser use on farm crops for crop year 2007. ISBN 978-0-95525-693-6
<http://www.defra.gov.uk/farm/environment/land-manage/nutrient/pdf/bsfp2007.pdf>

14.4 Comparison of results with estimates from the different sources

14.4.1 Ex post estimates

Since the primary aim of the Nitrates Directive is to reduce nitrate loading of water bodies then the focus of existing evaluations is the effectiveness of the Directive in delivering this outcome. No ex-post evaluations have been identified that have quantified the impact of the Directive on emissions of N₂O.

However, some evaluations have been performed on the effectiveness of the Directive which can be used to cross check the results from this study. For example, ADAS (2007) reviewed the impacts of the measures within the 2002 Nitrate Vulnerable Zone Action Programme on nitrate leaching in England. This considered an assessment of the NVZ measures at field level, comparing practices under the NVZ to those from a pre-NVZ baseline survey. The survey data suggested that the adjustment of fertiliser inputs to take account of manure N supply had improved. Likewise, the survey indicated that the number of farmers receiving manure not produced on their own farm; and the quantities of manure moved between farms, have approximately doubled since the last survey. This reflects the need to find additional land for compliance with the manure loading limitations.

In the Netherlands Zwart *et al* (2008) provided a detailed examination of agricultural practice and water quality in the Netherlands in the 1992-2006 period, with a particular focus on the effectiveness of the nitrates Directive. Whilst the evaluation did not consider the impact of the Directive on N₂O emissions, it did consider the effectiveness of the Directive more broadly. The authors found that, as a result of the European Nitrate Directive, the nitrogen surplus in Dutch agriculture decreased by almost 40 percent between 1992 and 2007.

14.4.2 Ex ante estimates

The first ECCP quantified the potential savings from N₂O emission from soils in the EU-15 at 10 MtCO₂eq, by 2010. Whilst the savings were not allocated to a particular policy, and without examining the methodological assumptions to derive this estimate, the ex-post savings identified above compare favourably to this ex-ante estimate. As set out in Table 14-4, for the EU15 as a whole the reduction in emissions, as estimated applying the Tier 1 approach, is 10.7 MtCO₂ eq. in 2005. For the Tier 2 approach the savings were estimated to be 8.2 MtCO₂ eq. This suggests that good progress has been made against the target set out in the original ECCP. In addition, since the ex-ante estimate was not assigned to a particular policy, then the limitations of the Tier 1 approach in not considering policy overlaps are not relevant for this comparison.

The second ECCP (2006)¹¹⁵ included a review of the first ECCP. The review concluded that fall in N₂O emissions, between 1990 and 2003 was mainly due to a decrease in the use of nitrogen mineral and organic fertilisers; this can be assumed to be to a large extent a consequence of both the reforms of the CAP and the implementation of the nitrates directive. The review did not attempt to isolate the impacts of the Nitrates Directive from those associated with CAP as both policies were seen as mutually supportive.

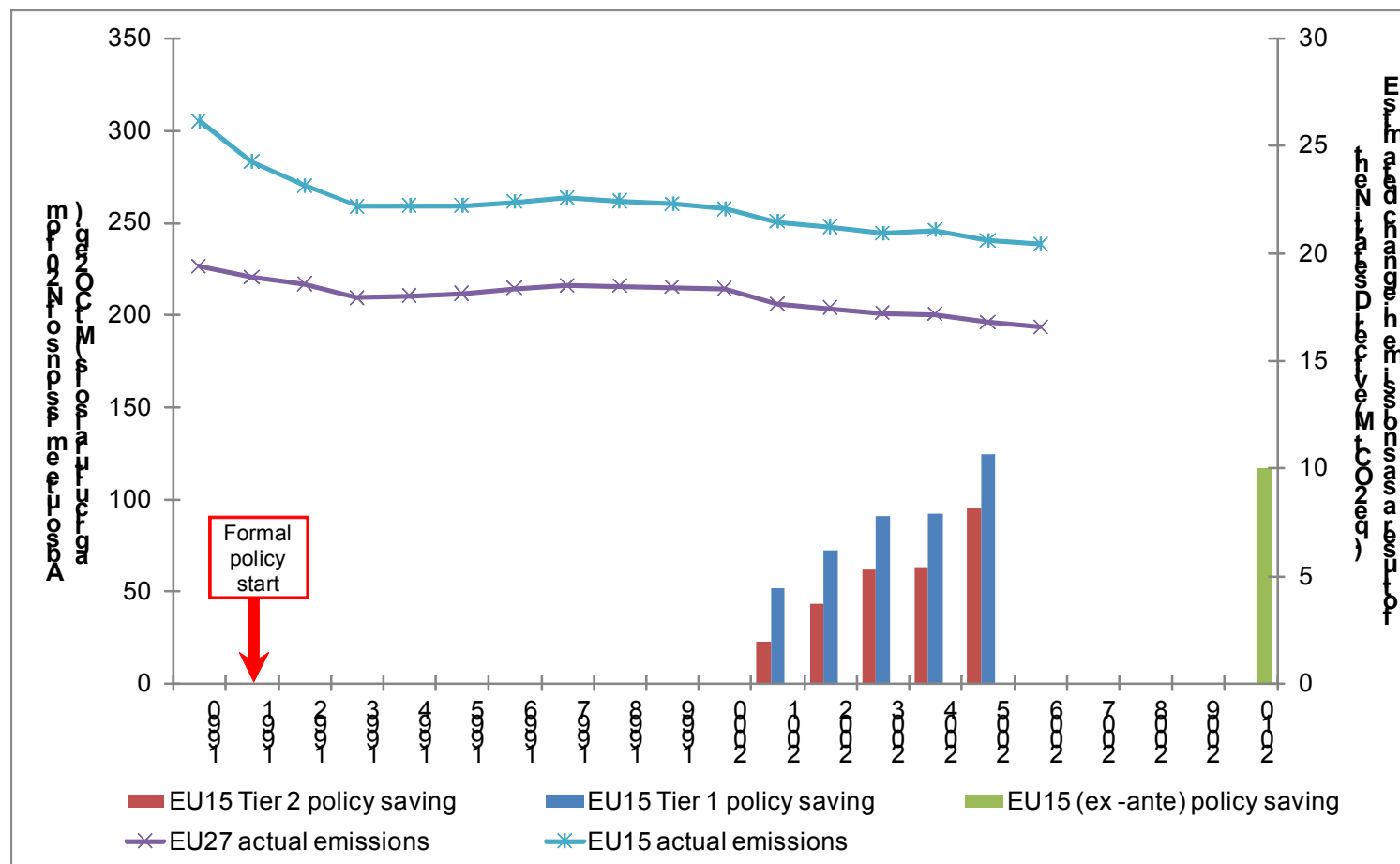
¹¹⁵ http://ec.europa.eu/environment/climat/pdf/eccp/review_agriculture.pdf

Table 14-4 Comparison of ex-ante and ex-post results: Nitrates Directive

Mt CO2 eq.	Ex-ante estimates	Ex-post estimates (annual saving in latest year)		
CCPM	ECCP Review: annual savings in 2010 (EU-15)	T1	T2	T3
Nitrates Directive (Dir 91/676/EEC)	10	NE (EU27, 2005) 10.7 (EU15, 2005)	NE (EU27, 2005) 8.2 (EU15, 2005)	NE NE
The colours in the fields for the Tier 1, 2, 3 approaches have the following meaning:				
Red colour:	The approach provides only a rather approximate estimate of impacts and should not be considered a robust assessment of the policy impacts			
Orange colour:	The approach provides a fair approximation to the impact assessment. However the approach may need to be worked out further.			
Green colour:	The results can be considered as a good estimate of the policy impact. However, frequently, still methodological choices have to be made, for example with respect to the emission factors. The data basis is, however, satisfactory to make these choices			
Abbreviations:				
MSsp: Member State specific starting year for the ex-post evaluation				
NE = not estimated				

A further benchmark is provided in a study performed by Alterra (2007) on 'Integrated measures in agriculture to reduce ammonia emissions'. The study modelled 'ex-ante' the potential impacts of various policies and measures aiming at reducing the impact of N losses from agriculture. This included an examination of the impact of the Nitrates Directive. In accordance with the 'full implementation' scenario, Alterra projected that the Directive would deliver additional reductions in N₂O emissions from the EU-27 by 4% by 2020, from year 2000 levels. However, these results are not directly comparable to those presented elsewhere as the year 2000 emissions level already includes the impacts of the 'partial' implementation of the Directive.

The estimated impacts of the policy are put into context in Figure 14-10 below. The estimated (ex ante, and ex post) impacts are compared against the overall historical trend in N₂O emissions from agricultural soils.

Figure 14-10: Nitrate Directive: Key results of the ex-post analysis in comparison with ex-ante estimates and inventory development

Notes: Emission trends are shown on the primary axis while estimated policy savings are shown on the secondary axis. The final year for which ex-post estimates are available varies between policies. The geographical coverage of ex-post policy savings varies due to data constraints and is detailed in the legend above.

Sources: Policy savings for 2010 are European Commission ex-ante estimates while savings for historic years are ex-post estimates generated under this study. The source for absolute emissions is the 2006 GHG inventory (EEA, 2008)

14.4.3 Cost effectiveness

Whilst the focus of this chapter has been upon the effectiveness of the Nitrates Directive, it is important to also consider as part of an ex-post evaluation the efficiency of the policy, specifically the cost efficiency of delivering the emissions reductions. It is not within the scope of this project to derive primary estimates of the ex-post costs of the case study policies. However, it is useful to draw upon existing estimates, where available, to examine the cost-effectiveness of the policy.

A study by Kuik (2006) for DG Environment of the European Commission provided an analysis of the difference in ex ante and ex post estimates of the costs to farmers of the implementation of the Nitrates Directives. The study was one of several case studies comparing ex-post and ex-ante estimates of the costs of environmental policies.

The case study reviewed national estimates from seven EU Member States and Candidate countries: Croatia, Denmark, France, Italy, Lithuania, Netherlands, Finland, and the United Kingdom. However, a comparison between ex-ante and ex-post estimates could only be made for Denmark and the Netherlands. The cost estimates were expressed as either € per hectare affected or € per kg N. No assessment was performed of the impact (or cost) of the Directive on greenhouse gas emissions.

The study found that the (ex-ante) costs of the Nitrates Directive differ across Member States. The costs range from € 6 to € 236 per hectare affected, and from € 0.4 to € 3.5 per kg N. The authors identified a number of factors that influenced the range in estimates, including differences in industry structure, livestock intensity, historical rates of fertiliser application, and the vulnerability of soils to nitrate leaching. Different assumptions and methodological differences were also identified as important factors in explaining the variation. Overall, the authors stated it is impossible to relate the cost differences to differences in the application of more or less efficient policy instruments across Member States.

For the two Member States (Denmark and the Netherlands) where it was possible to compare ex ante and ex-post cost estimates, the authors found that the ex-ante estimate is at least as large as the ex-post estimate and usually larger. When expressed as cost-per-kgN, the ex-ante estimates were found to be between 1.2 and 1.9 times as large as the ex-post estimate (Kuik 2006). For Denmark, the major reasons for this difference were that the stricter requirements on the utilisation of the N content of animal manure turned out to be much cheaper than expected at the time of the ex-ante estimate. For the Netherlands, the major difference was that the expected costs for dairy farms to dispose of their surplus manure were much smaller than expected, largely because of a more rational management of fertilisers at these farms. Both for Denmark and the Netherlands, the costs of nitrate measures at the farm level were lower than expected because of improved fertiliser management.

14.5 Conclusions

The primary objective of the Nitrates Directive is to reduce water pollution by nitrates from agricultural sources, and to prevent future pollution. There is a close link between N₂O emissions from agricultural soils and nitrate losses resulting in groundwater pollution. Therefore, measures aimed at reducing the nitrate content in water also result in declining N₂O emissions to the atmosphere.

However, the Directive has not been designed specifically as a GHG mitigation policy. This has an important bearing on the amount and type of monitoring data that is currently collected, and available for the ex-post evaluation of the impacts of the Directive on GHG emissions.

In accordance with the tiered methodology that has been developed during this study, and is described in the accompanying evaluation guidance, an initial estimate has been made of the impacts of the Nitrates Directive to date, on emissions of greenhouse gases within the European Union.

Two approaches have been employed to evaluate the impacts of the policy:

- The Tier 1 approach represents a high level assessment of the impacts. It is based upon existing EU wide statistics so that the methods can be easily repeated without additional data

collection. It applies a number of simplifying assumptions to ease comparison between countries and policies, and consequently, may not adequately reflect the full complexity of the policy in question.

- The Tier 2 approach provides a more refined analysis. It aims to address some of the most important methodological issues but it is still largely reliant upon existing established data sources. The extent to which the Tier 2 approach is able to isolate the policy impacts is therefore strongly reliant upon the availability and resolution of the data.

It has not been possible within the scope of the resources available to this project to implement a Tier 3 approach, which would enable to inclusion of bottom up statistic and allow a more detailed approach. Therefore the results are less comprehensive than those presented for certain other policies.

Application of the Tier 1 and Tier 2 methodologies enables an initial assessment of the potential GHG savings that may have been delivered by the Nitrates Directive. The analysis, using a top-down indicator of emissions per unit of agricultural land, does show a decline in emissions of N₂O from soils, as would be expected under the Nitrates Directive. For the EU15 as a whole the reduction in emissions, as estimated by applying the Tier 1 approach, is 11.5 MtCO₂ eq in 2005. For the Tier 2 approach the savings were estimated to be 8.2 MtCO₂ eq. These estimates compares favourably to the projected savings of 10 MtCO₂ eq. in 2010 estimated in the first ECCP for savings from N₂O emission from soils.

However, whilst these results are encouraging, similar reductions in emissions are shown in those Member States that have not implemented the Directive. This suggests other important factors are influencing the estimated savings in addition to the Directive. Therefore assuming that all of the reduction in emissions can be attributed to the Nitrates Directive is likely to overestimate the true policy impacts.

Overall, taking into account the complexity of the sectors and the overall uncertainties we consider that the Tier 1 and Tier 2 results should not be considered an accurate representation of the greenhouse gas impacts that can be attributed to the Nitrates Directive. The results do provide an indication of the overall magnitude of the potential policy savings, and the savings from N₂O emission from soils more generally. However, further analysis is required to isolated the true policy impacts, and identify the level of influence of the other main drivers of emissions.

A number of key uncertainties remain unresolved in the Tier 1 and Tier 2 approach. One of the most important uncertainties relates to the issue of policy overlap. Specifically, the overlap between the Nitrates Directive and the Common Agricultural Policy. The cross compliance requirements that were part of the 2003 reform provide an explicit linkage with the Directive, however, the influence of earlier reforms on the overall agricultural sector within Europe will have an indirect impact upon the effectiveness of the Nitrates Directive. In order to account for the synergies between the CAP Reform and the Nitrates Directive it might be more appropriate in future evaluations to consider the policies as a package, rather than in isolation.

A second area of uncertainty is the influence of other exogenous factors on the application of nitrogenous fertiliser. Specifically, the influence of changes in commodity prices on the behaviour of farmers has not been considered within the evaluation. Using econometric techniques these impacts can potentially be isolated, however, this is beyond the scope of a Tier 1 and Tier 2 analysis.

The third major area of uncertainty is the issue of structural changes, which relates to the resolution of the data used in the analysis. The current indicator does not differentiate between changes in N₂O emissions that arise as a result of reduced N application rates, from those associated with changes in the farming or land use type.

Further uncertainties surround the emissions and emissions factors themselves for this sector. For the purpose of this analysis we have used, for consistency, the data reported by Member States to the UNFCCC. However, there is large uncertainty in both the activity data and the emissions factors themselves. These uncertainties raise wider questions about the extent to which the emission inventories can adequately reflect the changes in emissions arising from the Directive. Whilst the inventories are the best current source of data available to inform the policy impact assessment, they are not without limitations.

To some extent, the uncertainties with respect to the emissions inventories help put the other methodological uncertainties into perspective. Whilst a number of methodological issues remain unresolved in the Tier 1 and Tier 2 approaches, even if they were resolved, the limitations in the emissions data would mean that there would still be large uncertainties in the overall policy impact results.

14.6 Recommendations

The resolution of the data available within current aggregate statistics is not sufficient to isolate structural changes, policy overlaps or autonomous progress. Whilst some of this data is available at a Member State level, the data is not collated centrally to enable this analysis easily. This includes:

- Fertiliser application rate within and outside NVZs;
- Crop type by area;
- Fertiliser type and price data.

DG Agriculture is currently making efforts to establish better data on farming practices in the context of the Farm Structural survey. This may provide a good opportunity to compile an improved dataset to enable the most robust quantification of the impacts of the Nitrates Directive (as well as other agri-environmental measures) on greenhouse gas emissions.

The scope of a potential Tier 3 approach has been described in more details in the section above. We suggest that future work focuses on the following methodological improvements:

- Integration of econometric analysis of input and commodity prices on N fertiliser application rates;
- Calibration of bottom up data on farm management measures implemented within Action Programmes;
- Correction for impacts on climatic variation on fertiliser application rates;
- Correction for changes in crop type and fertiliser type on fertiliser application rates.

These recommendations need to be balanced against the additional costs of collecting and verifying the data. The characteristics of the agricultural sector (a large number of individual actors and the variability in activities) present significant challenges for the collection of robust data. Current methods typically rely upon surveys of agricultural holdings, which may be costly. However, the surveys are typically used for a number of purposes (for example, collection of economic, social as well as environmental information) so the marginal cost of the additional data collection should be used when considering the requirements for a proportional analysis.

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