How much will the Energy Service Directive contribute to the 20% EU energy savings goal?

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Abstract

The Energy Service directive (ESD) of the EU stipulates that member states realize 9% energy savings for the period 2008-2016. A harmonized calculation approach, consisting of a combination of top-down and bottom-up methods, will be developed to determine the savings of energy efficiency improvement measures. However, it is unclear which part of all realized energy savings is eligible in meeting the ESD target. One can argue that not all savings, especially the autonomous efficiency gains, should be accounted for, but only savings due to (new) policy. An analysis is made of the way the methods can be applied, how baseline choices define the savings and whether these represent policy induced savings. It is shown that the given target could be met with total energy savings that equal 1.0% of ESD energy use per year, hardly more than realized at present. With other choices the target is met with total savings of 1.6% per year. The savings found are made comparable with the 2.4% yearly savings derived from the 20% savings target for 2020 formulated by the EU. Given the large gap between ESD savings and the savings target, it is concluded that the methods and baselines used should be chosen such that the ESD target leads to realized savings after 2008 at the upper side of the margin.

Keywords: Energy Service directive; energy savings; top-down; bottom-up; autonomous savings; policy savings; baseline; Green Paper

1. Introduction

In April 2006, the European Union Directive on Energy End-use Efficiency and Energy Services came into force (Energy Service Directive or ESD [EC, 2006a]). The objectives of the directive are promoting cost-effective energy end-use efficiency and developing a market for energy services in EU countries. Achieving these objectives asks from MS adopting an energy savings target, stimulating energy companies to offer their customers energy services (instead of energy carriers), enhancing the exemplary role of the public sector, and providing financing arrangements and information.

The ESD should accomplish lower final, and thereby, lower primary energy consumption, thus contributing to improved security of supply and mitigation of CO_2 and other greenhouse gas (GHG) emissions. Moreover, more energy efficient technologies could boost innovativeness and competitiveness as underlined in the Lisbon strategy.

A non-obligatory target on improved energy end-use efficiency has been set for the period 2008-2016. The indicative target is equal to 9% of historic energy consumption and expressed in an absolute amount of energy to be saved. MS are encouraged to choose a higher target [EC, 2006a].

A harmonized calculation method, consisting of a combination of so-called top-down and bottom-up methods, should be used to determine the energy savings. However, only general instructions are given on how to calculate the savings. Therefore article 15.1 of the ESD requests further elaboration of the calculation method[1]. Proposals for refinement of the method have been developed in the Intelligent Energy - Europe (IEE) project Evaluation and Monitoring for the EU Directive on Energy end-use Efficiency and Energy Services [EMEEES, 2006]. According to article 16.2 of the ESD, a Committee of representatives of all MS must approve the method to be applied[2].

Given the present status of refined methods, Member States can calculate energy savings rather differently and it is not clear which energy savings are eligible in meeting the ESD target of 9%. For example, it is not explicitly mentioned in the Directive that the energy savings have to be additional to autonomous savings (see later discussion). Moreover, there is room for countries to use either top-down or bottom-up methods to calculate the savings. Finally, it is unclear to what extent countries can incorporate “early action” savings (i.e., savings achieved before 2008). This could lead to total realized energy savings that vary considerably while the same target of 9% is met. This difference is important, as it is not the 9% target, but the accompanying total savings that define how much this directive contributes to the EU savings goal.

The outcome of the ESD is of large interest for EU policy. The Green Paper on Energy Efficiency [EC, 2005] proposed extra efforts on energy savings that should lead to 20% lower primary energy consumption in Europe in 2020 compared to business-as-usual.

[1] “The values and calculation methods referred to in Annexes II to V shall be adapted to technical progress in accordance with the procedure referred to in article 16.2”

[2] Known as the Energy Demand Management Committee (EDMC)

This goal was part of the Energy Efficiency Action Plan of 2006, endorsed by the European Council. In 2007 other EU wide goals for 2020 have been formulated, for GHG emissions (-20% or -30% compared to the 1990 level) as well as renewable energy production (20% of final energy consumption). In [EC, 2008a] implementation proposals are formulated to reach these goals. The ESD savings contribute directly to the goal for energy savings and the emission reduction goals. The ESD will contribute indirectly to realizing the renewable target for 2020 as it lowers final energy consumption.

Section 2 provides an introduction into the evaluation issues used in the analysis, such as savings types, calculation methods and baselines. In the next section the calculation approach in the directive is analysed, with a focus on the uncertainty in total realized savings while meeting the ESD target. Section 4 presents historically realised savings and two variants for savings to be expected from the ESD. The relation between ESD savings and the 20% saving figure in the Green Paper is presented in section 5. Summary and conclusions on the way to realize an optimal contribution of ESD savings to EU policy goals follow in section 6.

2. Evaluation of energy savings

This section presents the concepts and analysis methods used later on in the analysis of ESD savings and the relation with the 20% savings goal. This regards the decomposition of changes in energy consumption, types of energy savings and methods to calculate savings. Then the concept of baselines and the relation with policy induced savings is dealt with.

Decomposition of changes in energy consumption

Figure 1 shows how an observed or projected change in energy use can be decomposed in three effects, namely:

- Volume effect
- Structure effect
- Energy savings.

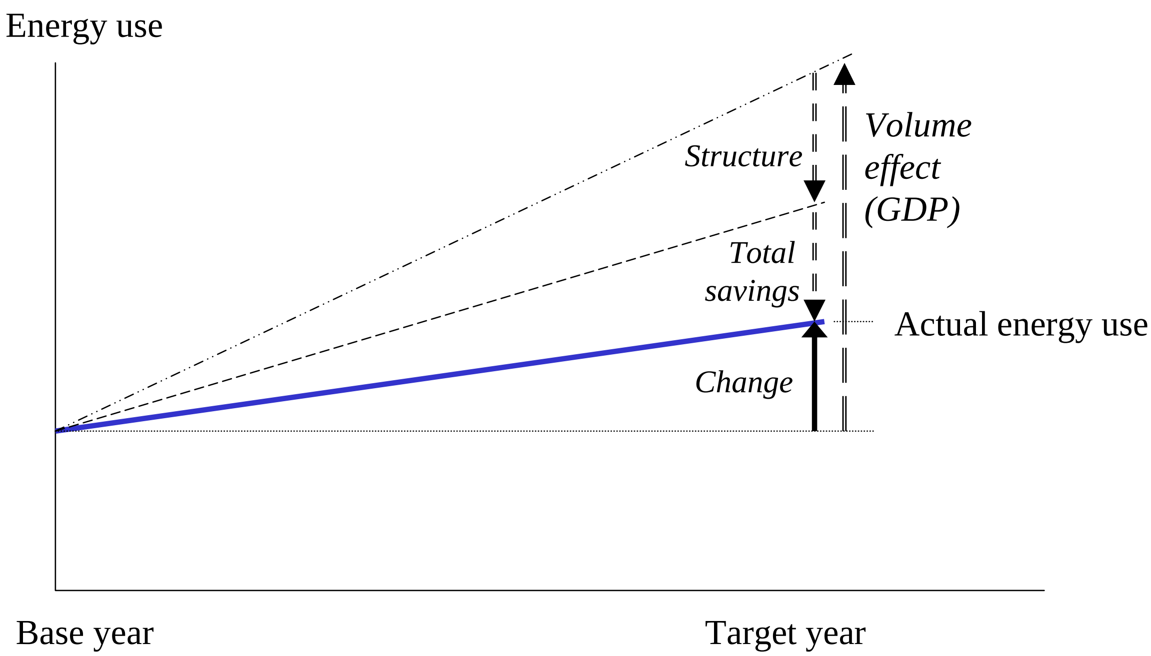

Figure 1: Energy use change decomposed into volume-, structure- and savings-effects

The **volume effect** regards a change in energy consumption due to the growth in energy using activities: more production of goods and services, more km traveled by car, more dwellings, more household appliances, etc. Often the volume effect is coupled to growth of GDP, which is thought to represent increased socio-economic activities. However, not all activities that need energy grow at the same pace as GDP. The Service sectors, which use relatively little energy, often show faster growth than energy intensive industrial sectors, such as steel or base chemicals. Therefore total energy consumption will increase less than GDP. On the other hand, some activities grow faster than GDP, e.g. the ICT

sector that uses a considerable amount of electricity. The **structure effect** accounts for all socio-economic changes that affect the demand for energy next to GDP growth. The structure effect can either increase or decrease energy use; in developed economies the structure effect normally mitigates the growth in energy use due to GDP growth. Finally, energy savings explain part of the change in energy consumption.
By definition, the **saving effect** mitigates energy consumption. The savings effect is defined as the percentage decrease for energy consumption without savings (the trend after volume- and structure effects).

As a result of the three effects, Figure 1 shows an increasing total energy consumption. Presently, few European countries show decreasing energy consumption despite structural changes that mitigate energy use and the, sometimes substantial, energy savings.

Autonomous and "policy" savings

Evaluations of energy savings can regard total savings or "policy" savings. **"Policy" savings** are the result of deliberate efforts to stimulate the implementation of concrete energy saving measures, i.e. end-user actions[3]. Generally the government takes responsibility to stimulate or facilitate actions by energy users to save energy, e.g. by introducing taxes, subsidies, regulation, information or agreements with intermediate actors. However, here "policy" should be seen in a broader sense than government measures alone. It regards the result of all focused efforts to achieve energy savings, including provision of energy services and other voluntary initiatives of environmental groups, citizens and social responsible companies.
Total savings constitute both policy savings and autonomous savings (see figure 2). Autonomous savings are realized without a deliberate effort, neither from the users themselves nor by other actors, for the sake of energy savings alone. These savings originate from technological progress, e.g. for better steam engines for rail transport, steel production from iron ore or production of base chemicals. Often autonomous savings are driven by competitive pressure to save energy costs. Therefore autonomous savings will be partly dependent on high energy prices. However, even in periods with decreasing prices some autonomous savings occurred (see references in Appendix 1).

Total savings are important because they determine, together with the effects of economic growth and structural changes, how energy use will develop (see figure 1). **Policy savings** are important from the viewpoint of policy effectiveness, as they show what government supported actions and programmes actually accomplish. Therefore, evaluators want to split total savings into policy induced and autonomous savings.

[3] E.g., thermal insulation, energy management, or eco-driving. In order to avoid confusion with "measures", in the ESD, which can also mean policy measures these concrete energy-saving measures have been called end-user actions in the EMEEES project (EMEEES 2009)

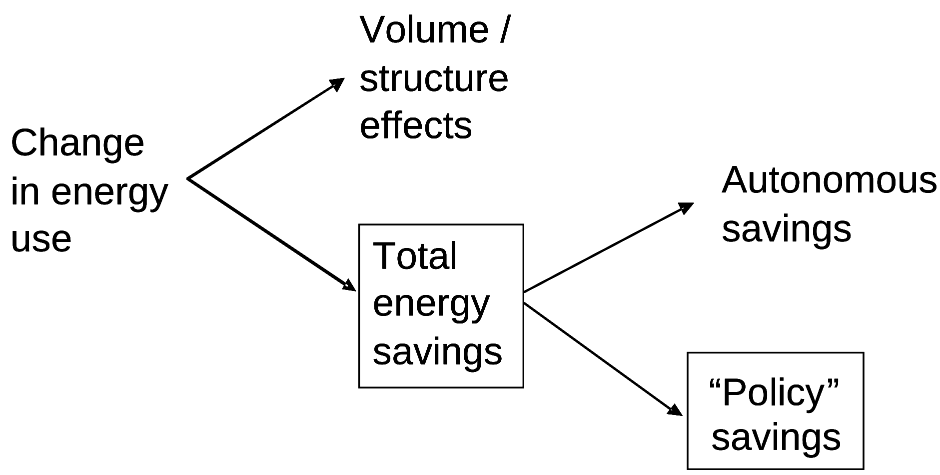

Figure 2: Decomposition of energy use change including types of energy savings

Since the eighties, many countries have already launched policies to save energy. Some saving effect of these policies will continue, even as policy measures disappear. With more and more past policy, the “autonomous” savings seen in energy consumption trends will now contain effects of earlier policy as well.

Energy savings calculated top-down and bottom-up

So-called top-down and bottom-up methods should be applied in the savings calculations for the ESD[4]. Total savings calculated with **top-down methods** are based on energy indicators, such as used in the Odyssee project (see [Odyssee, 2007]). For instance, a decreasing value for the indicator “average gas use for space heating in dwellings” is used as proxy for total energy savings for space heating. In practice, one has to correct for “normalization” factors, such as yearly changes in average temperature during the heating season. In some cases there is a need to correct for structure effects, such as larger homes and changing occupation rates. **Bottom-up methods** (see introduction [Vreuls, 2004]) can[5] be used to calculate the savings due to “policy”. These methods calculate savings for actions that are due to policy measures, or energy services provided by other actors. The savings are calculated from (1) the increased number of actions due to a policy measure and (2) the unitary savings per action (see [Vreuls et al, 2008]). An example is the number of high efficiency boilers, installed due to a subsidy scheme, times the energy savings per boiler. The savings have to be corrected for the same normalization factors as for top-down.

[4] See ESD for definition of top-down and bottom-up methods
[5] Bottom-up methods are not restricted to savings due to policy, see section on baselines

For the same energy use, and top-down indicators that are sufficiently corrected for structural effects, top-down savings will usually be higher than the bottom-up savings calculated.

Calculated policy savings in a scenario approach

Another method to calculate policy savings is the **scenario approach** using energy models. An example, in support of EU energy policy, is provided in [NTUA, 2006]. In this approach the overall policy effect can be derived from the difference in energy consumption between a business-as-usual scenario and a variant with a set of policy measures to enhance savings. In this way an analysis can be made of policy and saving measures needed for the extra 20% savings in 2020 [EC, 2005 / EC, 2006b].

Baseline and additional savings in bottom-up calculations

In bottom-up calculations for ESD savings, there is a need for a baseline that represents the situation in the absence of policy measure(s) or efforts of other actors. The baseline regards both the **number of end-user actions** as well as the **unitary savings per action**. In the boiler example, the baseline for the number is the “normal” penetration of high efficiency boilers. The baseline for unitary savings is the alternative boiler type chosen instead of the high efficiency boiler.
The “normal” boiler penetration trend could be set equal to the total number of high efficiency boilers installed, minus the subsidized number. But one has to take account of correction factors. The observed number of subsidized boilers must be corrected for free riders, i.e. energy users that would have bought the efficient boiler anyway but also have applied for the subsidy. On the other side, after the end of the subsidy scheme, the market may have been transformed in such way that high efficiency boilers have become the standard (the spill-over or multiplier effect). The higher number of high efficiency boilers after the end of the scheme will produce extra energy savings without further efforts. In cases with more than one policy measure, i.e. subsidies and higher energy taxes, account must be taken of double counting due to the overlap in both effects. The extra boilers due to the combination of policy measures will be lower than the extra boilers due to subsidies plus the extra boilers due to taxes. After all corrections are made the counted number of actions is found.

The baseline for the unitary savings of the high efficiency (HE) boiler is defined by the alternative system, chosen in case the subsidy scheme would be absent. In Figure 3 the following alternative systems are presented:

- the old boiler
- the least efficient boiler on the market
- the average-efficiency boiler on the market
- the next best boiler on the market.

In the first case, the old boiler itself is the baseline and therefore all savings compared to the old boiler count as unitary savings (A). In the second case the least efficient boiler is assumed to be more efficient than the old one, thus counted unitary savings (A) are less than total unitary savings. In the third case, the average boiler has a higher efficiency than the least efficient one, leading to even lower counted savings. The last case regards the next best alternative to the HE boiler, leading to few counted unitary savings. The cases show that the choice of the baseline has a large effect on the counted unitary savings of the HE boiler. The savings that are not counted are called baseline (B) savings.

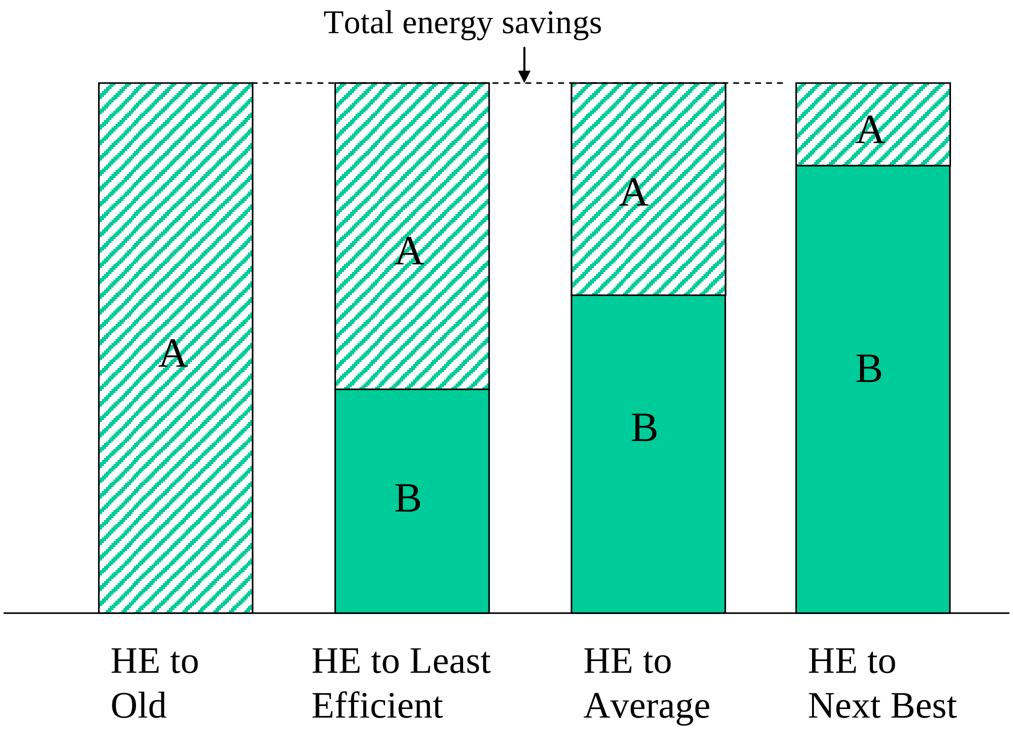

Figure 3: Counted unitary savings (A) of High Efficiency (HE) boilers, and baseline (B) savings, for various baseline choices

Other baseline cases are also possible, such as the stock average boiler in a chosen year. Due to improving efficiencies the stock average will be worse than the market average, thereby providing more savings to be counted for the HE boiler. If the old boiler is not replaced by a HE boiler but by a less efficient one, negative savings could result, e.g. in the last case with the next best to HE boiler as alternative.

The counted number of actions and the counted unitary savings found result in **total additional savings** with regard to the chosen baseline.

Baseline and additional savings in scenario calculations

In the **scenario approach** the business-as-usual scenario acts as baseline for calculating the additional saving effect of (extra) policy measures. The energy systems and end-user actions already present in the business-as-usual scenario define the baseline for the further penetration of end-user actions due to policy, and the baseline for their unitary savings. Therefore, in the simulation models applied no explicit choices on baselines have to be made (as was the case in the bottom-up example for boilers). If the energy models can cope with multiple policy types and their interaction, the correction factors mentioned earlier are automatically taken into account.

For **top-down calculations,** used to calculate total savings, no baselines are applicable in this paper as no distinction is made here between policy savings and autonomous savings[6].

Relation between policy/autonomous and additional/baseline savings bottom-up

On the one hand, policy and autonomous savings are used as analytical quantities in discussions on the contribution of (EU) savings policy to total savings. On the other hand, the additional and baseline savings are the result of concrete bottom-up savings calculations with specific baseline choices. The question is how the calculated additional/baseline savings relate to the policy/autonomous savings.

For **bottom-up calculations,** the additional savings are defined by the choice of the baseline. Therefore, the answer to the question lies in the relation between baseline and policy measure(s) applied. For the high efficiency (HE) boiler example this can be illustrated for the baseline cases in Figure 3. The baseline case to the right represents a stringent European minimum efficiency standard for new boilers that forces energy users to buy at least the next best alternative. Here national policy for buying the most efficient boiler results in relatively few calculated additional savings. However, the savings due to the EU Energy using Products regulation can also be counted as policy-induced savings. In that case the third baseline case (HE to Average in Figure 3) could provide the correct baseline for calculating policy savings. However, the market average not only represents autonomous savings but also some existing policy that has stimulated new efficient boilers, thereby raising the market average efficiency and thus limiting the additional savings. The second baseline case (HE to Least Efficient in Figure 3) may better represent the situation that would have materialised without any policy, i.e. with some autonomous savings for boilers only.
From these examples it can be concluded that the match between policy measures and accompanying baseline choice is not always clear. A choice that delivers the policy induced savings is not easily made. This holds in particular for defining a baseline that excludes the effect of existing policy, in order that the baseline only reflects autonomous energy savings. Therefore, there is room for different baseline choices with given policy.. Only if the baseline is carefully justified, the calculated additional savings represent the savings due to policy.

Policy/autonomous versus additional/baseline savings in scenario calculations

For **scenario calculations** the relation between policy/autonomous savings and additional / baseline savings is illustrated in Figure 4. The baseline is the business-as-usual (BAU) scenario, containing all factors that already lead to energy savings; not only technological

[6] They could be adapted to calculate additional savings, by correcting the indicators for autonomous and energy price related effects (see [EMEEES, 2009]). However, this is restricted due to data constraints.

development and energy prices that define autonomous savings, but also existing policy that results in some policy savings. The newly introduced policy measures in the scenario variant cause additional savings that come on top of the baseline savings. It is shown that policy savings provide part of the baseline savings as well as all additional savings. Only in absence of existing policy, the baseline savings are equal to autonomous savings and additional savings are equal to policy savings.
In practice one can use a simulation model to calculate separately the autonomous savings (simulation without any policy measure), the savings due to existing policy (second simulation and taking the difference with the case without policy) and the savings due to new policy (third simulation and taking the difference with the case with existing policy).

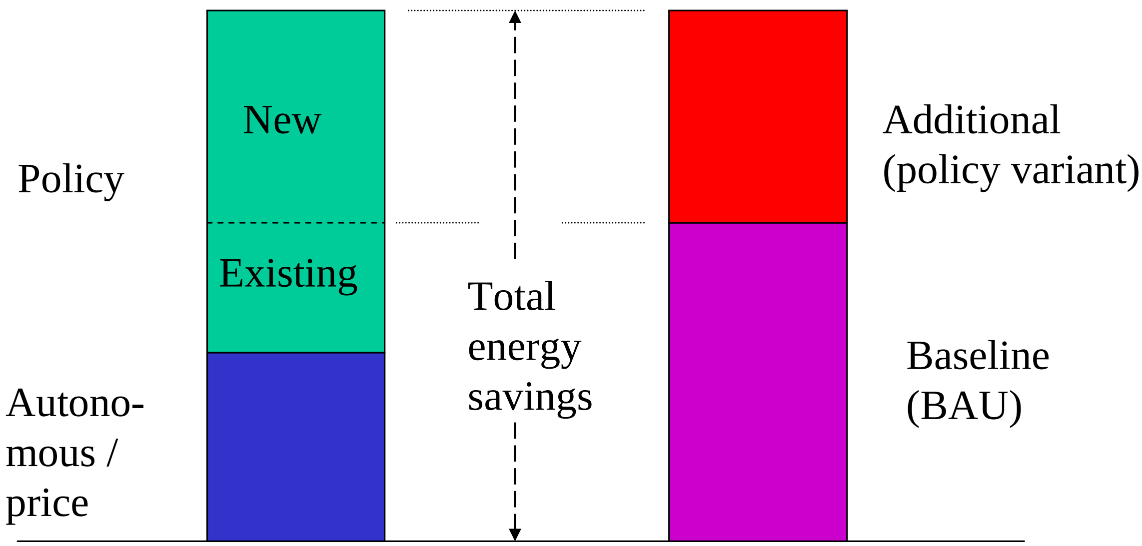

Figure 4: Policy/autonomous versus additional/baseline savings in scenario calculations

It must be remarked that additional and baseline savings in scenario calculations can be defined differently from that in bottom-up calculations, due to the problems mentioned earlier.

3. Total energy savings and calculated ESD savings

In section 2 it has been shown how different types of savings can be calculated with top-down or bottom-up methods. In this section it is analysed which part of total savings could be eligible for the ESD target of 9%.

Additional savings and baselines in the ESD

The term "additional" is not used in the ESD in direct relation to the calculation of energy savings. Also no explicit statements on baselines are given in the ESD. Implicitly baselines are introduced in the section on measurement, where it is stated "Energy savings shall be determined by measuring or estimating consumption **before** and **after** implementation of the measure".

Mix of top-down and bottom-up methods

According to the ESD, the bottom-up methods should cover at least 20-30% of ESD energy consumption. In the ESD Committee[2] it has been proposed to focus the bottom-up methods on energy consumption in buildings. Countries may choose to prove the remaining part of ESD savings with top-down methods or with bottom-up methods. In the last case all ESD savings are calculated bottom-up[7].

Refined top-down and bottom-up methods

The methods on savings calculations should be elaborated on, and approved by the ESD Committee (see section 1). In the EMEEES project, the set-up of a calculation system has been explored, and a number of top-down and bottom-up methods have been developed [EMEEES, 2009]. Following this exercise, the EC has proposed concrete top-down and bottom-up methods to experts and representatives of the member states. Currently, this process is still not finished. However, enough information is available to analyse the possible savings due to the ESD. These results are thought to be independent of final adaptations to the ESD calculation formulas.

The top-down methods will be based on the Odyssee energy indicators (see previous section) and regard total[8] savings. If limited data are available, member states can choose indicators at an aggregated level. With more data, they can apply more detailed indicators. In general, the more detailed indicators will provide more reliable saving results, because aggregated indicators incorporate the structural) effects mentioned earlier. E.g. the trend for the indicator "total energy use per household" incorporates the effect of more appliances per household. At a lower aggregation level, a correction can be made for increased ownership. The set of top-down indicators for the different end-use sectors covers almost all ESD energy use.

[7] EMEEES has found that it is possible to calculate (almost) all savings by bottom-up methods.
[8] Some indicators show no savings or even increasing specific energy consumption, i.e., negative "total" savings. That is why the results have been called "apparent total" savings (EMEEES (2009).

As mentioned earlier bottom-up harmonized methods have been proposed for energy savings in buildings. As to the baselines, a distinction is made between three different cases:

- retrofit (refurbishment) of buildings
- replacement of equipment,
- new systems (equipment or buildings).

Calculation rules differ per measure but in general the following applies. For **retrofit** the original building including earlier retrofits (stock average) is the baseline. For **replacement** of old systems, the baseline can be the stock average for the historic year or a more recent reference year. But countries can also apply the market average baseline which will be more efficient than the stock average[9]. For **new equipment** the baseline is the market average. For **new buildings** no physical reference exists; here the baseline is coupled to the first performance standard or to later, more stringent, versions. The baseline can also vary depending on the year the measure is implemented. In practice, the amount of eligible savings found will differ per bottom-up method, per country and per period.

Early action savings

The ESD offers the opportunity that the savings target can also be met by so-called early action savings in the period from 1995 on. In this way forerunner countries, which are assumed to have only more expensive saving possibilities left, are not “punished” for having acted fast. The ESD gives specific rules for the calculation of early action savings[10]. These rules define that early action savings can be calculated with bottom-up methods only.

Uncertainty on the constitution of ESD savings

The following uncertainties are valid as to the constitution of calculated ESD savings:

- if **top-down** methods are applied in the way discussed in the ESD Committee, the results regard total savings[8]; if bottom-up methods are applied, they often regard additional/policy savings. The mix of top-down and bottom-up methods could diverge per country, leading to ESD savings that are either composed of mainly additional/policy savings (for 100% bottom-up coverage), or constitute for a large part total savings (for 20-30% bottom-up coverage).
- in some top-down cases indicators will show negative savings in one country and positive savings in another country. If indicators with negative savings are not used, this will lead to a different coverage and less comparable saving figures..
- in case of **top-down**, indicators at different aggregation levels can be applied, resulting in higher or lower total savings.

[9] According to EMEEES findings, savings for the stock approach will more resemble total savings while the market approach result resembles more the additional/policy savings, see [EMEEES, 2009].

[10] Annex I (point 3) states: “Measures of a technological nature should either have been updated to take account of technological progress, or be assessed in relation to the benchmark for such measures.”

- in the case of **bottom-up** methods, harmonized methods are proposed for buildings but national methods can be applied in other sectors. As energy use patterns, climate and policy focus define where most savings are found, some countries have to prove their savings more with harmonized methods than others. If harmonized methods are more stringent, this can affect the eligible fraction of total savings.
- in case of **bottom-up** some methods may calculate total savings (e.g. if the old system is chosen as baseline), while other methods calculate additional savings due to the latest adaptation of a policy measure (e.g. previous standard as baseline for new dwellings according to the more stringent standard). If most applied methods regard the last case, with relatively small eligible savings, the total eligible savings will be lower than for the first mentioned methods. The same holds for applicability and eligible savings of methods for the cases replacement, retrofit and new systems[11].
- if countries include savings from **early actions** in their ESD savings, without raising their savings target above 9%, they have to realize fewer savings in the period 2008-2016 than other countries.

Possible results for total savings

The calculated ESD savings will always (have to) meet the target of 9%. However, given the uncertainties mentioned, the underlying total savings for 2008-2016 could diverge because different fractions of total savings are eligible for the ESD target. Two extreme cases are shown in Figure 5, where the green area depicts the ESD savings to be realized.

In the **minimum eligible fraction** case substantial total savings are needed because they only partly count as eligible savings. Only bottom-up (BU) methods are applied. Due to stringent baselines for the methods that can be applied, less than half of all savings are counted as additional savings that are eligible for the ESD target (see partly green surface in Figure 5). No early action savings are regarded, so the target is met solely by savings in the period 2008-2016.
In the **maximum eligible fraction** case fewer total savings are needed because they almost all count as eligible savings. Top-down (TD) methods are applied as much as possible, covering 70% of ESD use, and their total savings are fully eligible. This is not the case for the BU methods, but here the baselines of applicable methods are chosen less stringent, and a relatively high fraction of total savings counts as well. Also, early action (EA) savings in the period before 2008 contribute to meeting the target, further limiting the need to save energy in the period 2008-2016..
Both cases meet the ESD target of 9% but in the case with maximum eligible fraction much lower total savings for the period 2008-2016 are needed than in the minimum fraction case.

[11] In the EMEEES project clear rules have been formulated which baselines to take for total/policy savings.

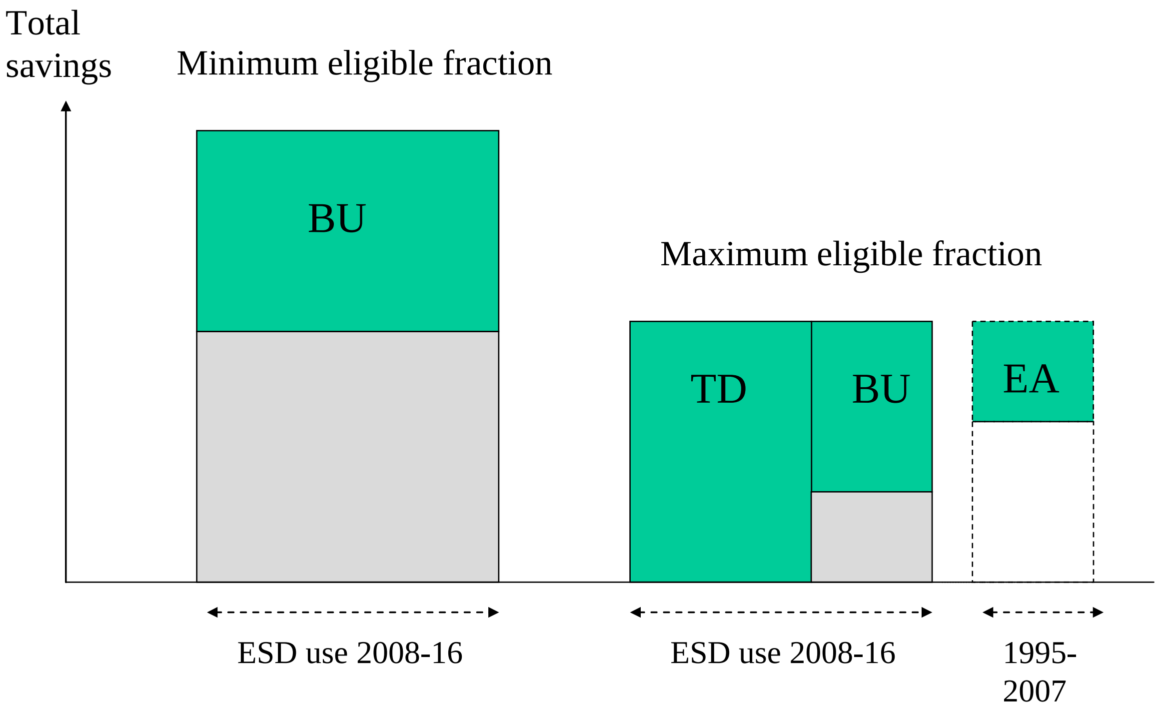

Figure 5: Extreme cases for 9% ESD eligible savings (green) as part of total savings

4. Savings historically and due to ESD

The ESD savings to be expected should be compared with historic savings, both autonomous and policy related. So, first an overview is given of these realized energy savings in EU countries.

Realized total energy savings historically

The historic saving figures presented here have been calculated based on the results from the EU-sponsored Odyssee project during many years. In this project, so-called energy indicators are determined for EU countries. These indicators concern parts of energy end-use, e.g. space heating for households, steel production in industry or car use in transport. The indicators relate total energy use to a suitable driver or explaining quantity, e.g. the number of dwellings in relation to total energy use for space heating (see [Odyssee, 2007]).
When calculating the indicator values, energy use is corrected for yearly differences in climate. For instance, gas use for space heating is corrected for the difference between actual and average number of heating degree days in the heating season. If possible, indicators incorporate corrections for structural changes, e.g. the observed shift in industry from energy-intensive to energy-extensive sectors.

In total 26 indicators are calculated for all end-use sectors, for the EU member states and Norway. These indicators are aggregated to so-called ODEX-indicators, three for end-use sectors and one overall (see figure 6).

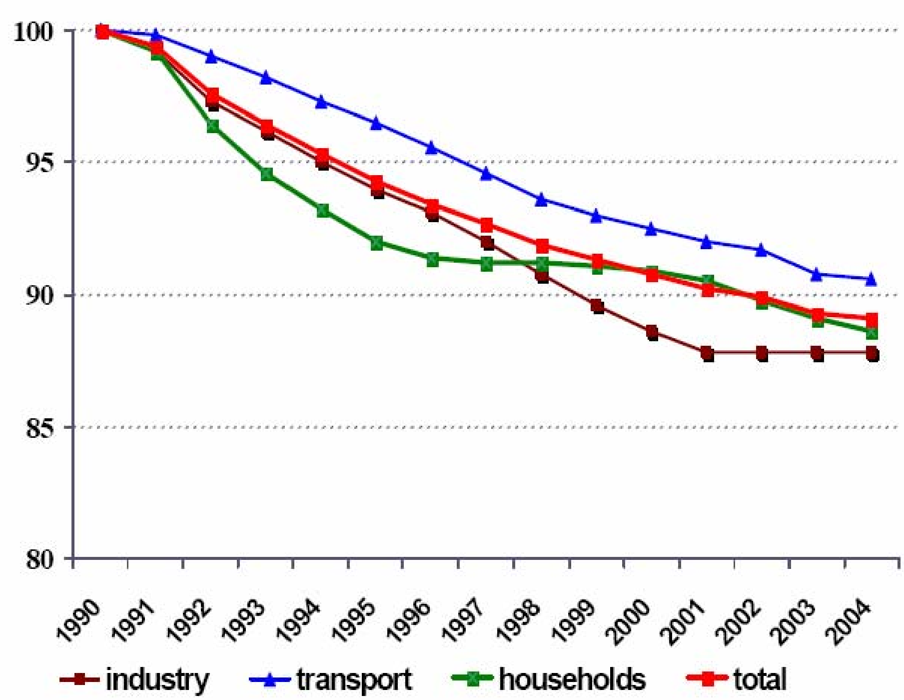

Figure 6: ODEX-indicators on energy end-use sectors for EU countries [source Odyssee, 2007]

The aggregated ODEX-indicators are presented as indices, where a value below 100 means that an efficiency gain has been realized. The change in index values is only a proxy for realized total savings. Due to limited data availability it is not possible to remove all structural effects from energy trends; therefore the indicators do not fully represent “true“ savings. However, it is assumed that, due to compensating mechanisms, the aggregated ODEX represents actual saving trends reasonably fair.

According to figure 6 derived from [Odyssee, 2007] the increase in total end-use efficiency[12] for EU-15 countries amounts to 11%, or 0.9% per year for the period 1990-2004. It must be stressed that this regards the sum of autonomous and policy savings.

Realized policy savings historically

Few studies exist on systematic ex-post monitoring and evaluation of realized policy savings in EU countries. Available studies only focus on the effects of selected policy measures, effects over a limited period or effects in specific countries (e.g. [Verbruggen et al, 2001]]). Especially for the new member states hardly any policy evaluation study is available. Therefore, EU policy savings have been estimated, using a combination of country specific figures and information on the amount of policy impact in EU countries (see Annex 1).

Given total energy savings for EU countries of 0.9% per year, policy savings are rated at about 0.3% and thus autonomous savings at about 0.6%. Many new member states applied less saving measures in the nineties and fewer policy measures were present until recent years. Therefore, the estimates for total savings and policy savings are set at 0.8% and 0.2% per year respectively for these countries. But due to the limited weight of new member states in overall energy consumption of the EU, this does hardly influence overall EU figures.

ESD savings to be expected

It is assumed that historic trends for autonomous savings will continue but the trend for policy savings, and total savings, changes as a result of ESD implementation. In section 3 two cases were analysed as to total savings in relation to eligible ESD savings, both meeting the target. Based on these extreme cases, an ESD-policy case and an ESD-total case are defined for ESD savings to be expected.

In the “**ESD-policy**” case only savings from existing and new policy count, resembling the minimum eligible fraction case. These policy savings must meet the target of 9%, thus should rate on average 1.0% per year[13]. Given 0.3% savings per year from already existing policy, the directive should lead to 0.7% extra policy savings. Together with the 0.6% autonomous yearly savings, the total savings rate at 1.6% per year (see Table 1).

[12] The Odyssee figure does not incorporate savings due to own co-generation at the site of the end-user. Up to now it is unclear whether the ESD fully incorporates CHP-savings. Therefore CHP savings are left aside.
[13] For assumption made when converting the 9% for 2008-2016 to 1.0%/year see chapter 5.

In the "**ESD-total**" case almost all savings, be it due to policy or autonomous, count. Moreover, early action savings outside the ESD period 2008-2016 could be counted as well. This resembles the maximum eligible fraction case. These total savings should meet the target of 1.0% yearly. The autonomous savings already provide total savings of 0.6% per year. Now only 0.4%-point policy savings are needed to meet the target, or only 0.1%-point extra due to new policy measures (see Table 1). But if these 0.1 % extra savings are due to early action savings, no further effort is needed.

Table 1: Expected energy savings for two different ESD cases (%/year)

	ESD Total	**ESD Policy**
Present savings		
- autonomous	0,6	0,6
- existing policy	0,3	0,3
- total	0,9	0,9
Extra policy savings	0,1	0,7
Total savings	1,0	1,6
(of which)		
Policy contribution	0,4	1,0

Given these possible developments, the total savings for the period 2008-2016 could lie between 1.0% and 1.6% per year. The difference is due to whether total or only "policy"-induced savings are counted as ESD savings (see section 3).

5. ESD savings and Green Paper / EEAP target:

EU policy on Energy Efficiency

The Green Paper on Energy Efficiency [EC, 2005] formulates the policy on energy savings of the European Commission. In the Action Plan on Energy Efficiency {EC, 2006b] possibilities for extra savings are explored. However, most of this policy has not been officially endorsed by the European Council and Parliament in the form of directives.

According to the Green Paper and EEAP, EU primary energy consumption should be lowered by 20% compared to baseline projections for 2020 (see Annex I of [EC, 2005]). In [Lechtenböhmer, 2005] a scenario is described that shows how this target could be reached with a set of policy measures. In [Atkins & ECN, 2006] an assessment is made of the energy saving possibilities in the Action Plan on Energy Efficiency of the EU. But neither in the Green Paper nor in these studies there is an explicit reference to a specific baseline projection. However, in other EU policy documents, such as [EC, 2005], [EC, 2006b] and [EC, 2008b], energy scenarios calculated with the PRIMES model are used. Normally policy documents use the most recent scenarios available. For the Green Paper and Action Plan, published in 2006, the baseline should have been based on the PRIMES scenarios for EU-15 countries, developed in 2005 [NTUA, 2006]. It is also assumed that the most recent year with actual data at that time, namely 2005, has acted as base year.

According to the PRIMES baseline scenario, GDP grows with 2.3% per year in the period 2005-2020 and total primary energy consumption (TPEC) increases with only 0.5% (see Table 2). This results in a decreasing energy intensity at a rate of 1.8%/year. The decrease in energy intensity is partly accomplished by structural changes in the economy. The stronger growth in non-energy intensive sectors provides economic growth with relatively low growth in energy consumption. The other cause for lower energy intensity is more efficient energy use.

Table 2: Economic and energy trends in the scenario for the Green Paper / EEAP

		2005	2020	Yearly change 2005-2020
GDP	Mld Euro	9716	13656	2,3%
TPEC	Mtoe	1744	1885	0,5%
E-intensity	ktoe/Meuro	0,18	0,14	-1,8%
TPEC -20%	Mtoe		1508	
Extra savings	Mtoe		377	-1,5%
E-intensity	ktoe/Meuro	0,18	0,11	-3,2%

If energy consumption in 2020 has to be lowered further by 20%, the energy intensity in 2020 should decrease from 0.14 to 0.11 ktoe/MEuro. Compared to the level in the base year (0.18 ktoe/MEuro) this boils down to an intensity change of -3.2% per year. The difference with the original intensity decrease (-1.8% per year) must be realized with extra energy savings. Assuming the same yearly amount of extra savings up to 2020, this demands **extra** savings of 1.5%/year.

Differences between ESD and Green Paper

According to [Boonekamp, 2006a] the Green Paper and the ESD differ as to:
- scope
- period
- definition of target
- definition of eligible savings

The **scope** of the Green Paper is total (i.e. primary) energy consumption, including energy users that participate in the Emission Trading system (ETS). In order to avoid overlap in policy instruments these, often large, energy users in industry and energy supply sectors are excluded from the ESD scope (see figure 7). The relevant **period** for ESD is 2008-2016, while the Green Paper regards the longer period 2005-2020. However, ESD savings may encompass earlier savings from 1995 on, while Green Paper savings only count from 2005 on.

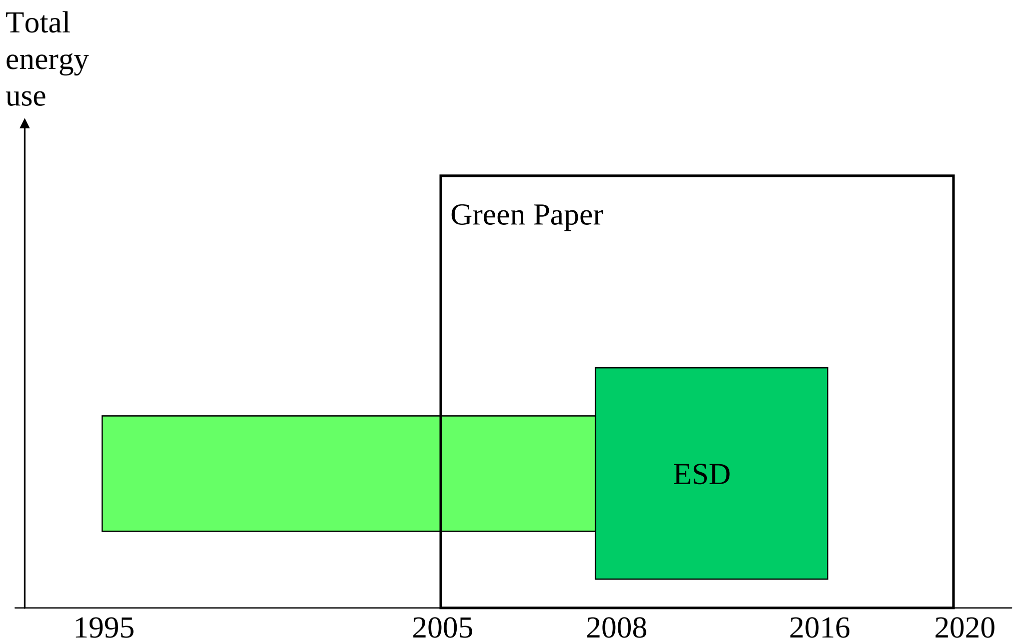

Figure 7: Scope and time frame for ESD and Green Paper

Green Paper and ESD also differ as to the **definition of the target** for energy savings. The 9% from ESD is a fraction of known historical energy use. If energy consumption increases, ESD savings will end up at less than 9% of 2016 energy consumption. The Green Paper target is a fraction (20%) of primary energy use for 2020. The expected absolute energy savings figures presented in Table 2 are valid for the chosen scenario. However, if BAU energy consumption increases faster, more Mtoe have to be saved in order to realize the 20% target.

As mentioned earlier, the **definition of eligible savings** in the ESD is not clear, although the ESD Committee took some decisions on this topics. In the previous section two options were described: policy savings only, or total savings (policy plus autonomous savings). The Green Paper is clear about this issue; the 20% lower energy consumption has to come from additional energy savings on top of the baseline development which already incorporates autonomous savings and savings due to existing policy measures. Thus, extra policy efforts should provide 1.5% additional yearly savings. Given present savings of 0.9% per year the Green Paper/ EEAP target translates into 2.4% overall yearly savings.

Comparison of saving figures for ESD and Green Paper

Table 3 provides figures on energy trends and savings for the two ESD cases and the Green Paper/PRIMES case. To be able to compare ESD and Green Paper developments, the figures have been made comparable in the following way:

- **scope**: the figures for the Green Paper scenario [NTUA,2006] regard the overall energy system, including energy supply and large industrial end-users that fall outside the scope of ESD. Here it has been assumed that the savings figures at national system level are also valid for the ESD part. In this way all figures regard the ESD scope and can be compared with each other[14]
- **period**: the ESD target of 9% regards the period 2008-2016 while the Green Paper target of 20% is defined for 2020. Both figures have been converted into average yearly figures, enabling a comparison for the common period 2008-2016
- **target**: the ESD target, i.e. 9% of fixed historic energy use, has been set equal to 1% per year of current energy consumption. This is acceptable as overall EU energy use is expected to grow hardly (see Table 2 and [NTUA, 2006])
- **background trends**: in all cases the same assumptions are used as to economic growth, structural changes (affecting energy use), autonomous savings and saving effects of existing policy (see upper part of Table 3). Structural changes make energy demand growing less than the economy (GDP); the effect has been set at -0.5%, slightly higher than the level in the period 1993-2000 with comparable economic growth (see [Odyssee, 2007]).

Given these assumptions and conversions the following can be observed from Table 3. Total energy savings for the ESD cases, taken from Table 1, are 1.0% or 1.6% per year. For the Green Paper, the 0.9% savings from autonomous and existing policy and the

[14] The Green Paper saving figures are defined on total primary energy consumption, while ESD figures are defined on the largest part of final energy consumption. The difference constitutes industrial end-use under the emission trading scheme and the conversion losses in refineries and power production. Applying the Green Paper figure to the ESD part means implicitly that this figure is also valid for the other energy use.

1.5% extra savings lead to total savings of 2.4% per year. In the ESD-policy case the savings provide two-thirds of the Green Paper savings (1.6% versus 2.4%). In the ESD-total case they are less than half the Green Paper figure (1.0% versus 2.4%).

The ratio between GDP growth and actual energy use, the energy intensity, decreases in all cases. The slowest decrease, -1.5 for ESD-total, is equal to the world average for 1990-2006 [WEC, 2007]. The fastest decrease, -2.9[15] for the Green Paper case, is about twice as high; this decrease is substantially higher than that for the 25% best performing countries in the world [WEC, 2007]. This decrease in energy-intensity is such high that energy consumption itself falls by 0.6% per year. In the ESD cases even the best performing ESD-policy case does not reach stabilization of energy consumption.

Table 3: ESD energy use and savings for ESD and Green Paper cases (%/year)

	ESD Total	**ESD Policy**	**Green Paper**
GDP-growth	2.3	2.3	2.3
Structure	- 0.5	- 0.5	- 0.5
Energy excl.savings	1.8	1.8	1.8
Present savings			
- autonomous	0.6	0.6	0.6
- existing policy	0.3	0.3	0.3
- total	0.9	0.9	0.9
Extra policy savings	0.1	0.7	1.5
Total savings	1.0	1.6	2.4
Actual energy use	0.8	0.2	- 0.6
E-intensity	- 1.5	- 2.1	- 2.9

Case for higher energy prices

Since 2004 oil prices have risen considerably, and reached all time high values in 2008 [BP-oil prices]. If these high prices should be valid, ESD and Green Paper figures could change because high prices will increase autonomous savings. It has been assumed for analysis purpose that high prices are valid up to 2020. Tentatively, a 50% increase in autonomous savings has been assumed[16]. For high energy prices, the assumed autonomous savings increase from 0.6% to 0.9% per year (see Table 4).

[15] The 2.9% differs slightly from that in table 2 due to differences for structure and actual energy use
[16] Keeping in mind a 5-7 fold increase in oil prices in $ from the nineties, the appreciation of Euro against $, the often high energy taxes that mitigate the relative rise in % of end-user prices, and overall price elasticity values in the order of 0.2 (see [EIA, 2005], [Haas, 1998] and [Dahl, 1993]).

Table 4: ESD and Green Paper results for high energy prices (%/year)

	ESD Total	ESD Policy	Green Paper
GDP-growth	2.3	2.3	2.3
Structure	- 0.5	- 0.5	- 0.5
Energy excl.savings	1.8	1.8	1.8
Present savings			
- autonomous	0.9	0.9	0.9
- existing policy	0.1	0.3	0.3
- total	1.0	1.2	1.2
Extra policy savings	0.0	0.7	1.5
Total savings	1.0	1.9	2.7
Actual energy use	0.8	- 0.1	- 0.9
E-intensity	- 1.5	-2.4	-3.2

In the ESD-policy case the yearly policy savings will remain at 1.0% but the autonomous savings rise from 0.6 to 0.9%, thus total savings of 1.9%. In the ESD-total case the increase in autonomous savings is assumed to lead to an equal decrease in policy savings, because total savings still meet the target. Finally, for the Green Paper the total savings increase from 2.4% to 2.7% per year. Here the extra savings of 1.5% cannot be traded against more autonomous savings. Now the ESD-policy case provides more than two-thirds of the Green Paper savings (1.9% versus 2.7%). In the ESD-total case the total savings are much less than that for the Green Paper (1.0% versus 2.7%).

6. Summary and conclusions

Energy Service directive
One goal of the directive on Energy End-use Efficiency and Energy Services (ESD) is the promotion of cost-effective energy end-use efficiency, enabling lower primary energy consumption that contributes to improved security of supply and mitigation of CO_2 emissions. An indicative target of 9% energy savings for the period 2008-2016 has been set (excluding fuel use as part the emission trading system and based on historic energy consumption). For the calculation of realized savings a harmonized and combined set of so-called top-down and bottom-up methods should be used. Further work should be done on these methods before the first intermediate evaluation in 2011.

Energy saving types and calculation methods
Generally, evaluations of energy savings focus either on savings due to “policy” (policy measures or actions of other actors), or on total savings that include autonomous and price-induced savings as well (see Figure 2). Total savings are important because they define, together with volume (economic growth) and structure effects, the trend for total energy consumption. “Policy” savings are important because they show the effect of efforts by government or other actors.
In practice, many Member States wish to calculate total savings using so-called top-down indicator methods. E.g. the decrease in the indicator “average fuel use per dwelling” is used as a proxy for energy savings for space heating. Policy savings can be calculated with so-called bottom-up methods that focus on the effect of deliberate actions, often stimulated by policy. E.g. for a subsidy scheme, the savings are set equal to the number of subsidized high efficiency boilers times the savings per boiler.
Bottom-up calculation methods use baselines that lead to so-called additional savings above the savings already present in the baseline situation. For instance, the savings of a high efficiency boiler are calculated using the market average boiler as baseline (see Figure 3). When another baseline is used, e.g. the next best alternative, lower calculated savings are found. If the choice of the baseline can be coupled to policy measures, the policy induced savings could be calculated. However, in practice it is often difficult to match the policy savings to the additional savings calculated bottom-up.
This is not the case for scenario analysis for EU energy policy formulation, such as the Green Paper on Energy Efficiency. Here a business-a-usual trend including existing policy provides the baseline trend. The 20% additional savings of the Green Paper are directly connected to extra policy measures (see Figure 4).

Possible energy savings from ESD calculations
The formulation and endorsement of top-down and bottom-up methods for the ESD has not been finalized yet. In line with current proposals it has been assumed that top-down methods, based on Odyssee indicators, are used to calculate total savings[8]. These total savings would then count fully to the ESD target. Harmonised bottom-up methods are proposed for energy savings in buildings. For these methods, baselines are defined per method, making a distinction between the cases replacement, retrofit and new systems. The baselines define the savings that are eligible as to the ESD target.

The fraction of total savings that is eligible for the ESD target can vary, given the room for countries to choose different methods and baselines. Countries have to cover at least 20-30% of ESD energy consumption with bottom-up methods for buildings. The remaining ESD savings can be proved by either top-down or bottom-up methods (if chosen by national methods). Some countries also wish to incorporate savings from early actions, from 1995 on, in their ESD target. Given the choices mentioned, the ESD target of 9% can be met with largely varying total savings (see figure 5).

Savings historically and due to ESD

Historically, total savings of 0.9% per year have been realized in EU countries. From literature it is estimated that about 0.3% is due to saving policy, leaving 0.6% for autonomous savings.

For savings to be expected from the ESD two cases were defined, based on the analysis of varying total savings. In the ESD-total case almost all realized savings contribute to the ESD target of 1% per year. Therefore, only 0.1% extra savings are needed on top of the currently already realized savings. Moreover, these 0.1 % extra savings could be taken from early action savings, if these were included. In the ESD-policy case only savings due to policy count for the 1% target. These savings are calculated with bottom-up methods with stringent baselines. Therefore, only a part of all realized savings counts to the target. The policy savings have to be raised from the historic 0.3% to 1.0%, to be in line with the ESD target. Together with the autonomous savings, total savings of 1.6% per year result.

ESD savings and Green Paper target

The Green Paper on Energy Efficiency formulates EU policy on energy savings that should lead to 20% lower primary energy consumption compared to baseline projections for 2020. Together with the savings that are already part of the baseline this comes down at 2.4% total savings per year.

A comparison of ESD and Green Paper savings shows that the ESD-policy case provides two-thirds of the Green Paper savings (1.6% versus 2.4%) while the ESD-total case provides less than half (1.0%). Even in the best performing ESD case the savings rate has to be raised by 50% to meet the Green Paper target. This demands a further strengthening of savings policy compared to most existing ESD Action Plans. In the other ESD case energy savings remain more or less at historic levels.

With sustained high energy prices autonomous savings could increase from 0.6% to 0.9%. The same increase is valid for total savings in the ESD-policy case (1.9%) and the Green Paper (2.7%). However, in the ESD-total case the increase in total savings could be zero, as higher autonomous savings are traded for lower policy savings.

Conclusions

- In meeting the same ESD target of 9%, largely varying total savings can be found due to the choice for top-down or bottom-up methods, counting early action savings or not, and differences in baseline choices and eligible savings for the methods applied in the specific situation of countries.
- If all savings, including those of early actions, are eligible, hardly any extra (policy) savings, compared to historic levels, are needed to reach the ESD target.

- If only additional savings from actions, stimulated by policy or executed by other actors, are eligible much higher total savings result. But still these high savings have to increase further by 50% to meet the Green Paper target.
- Sustained high energy prices lead to more autonomous savings and higher total savings. But if all savings count, the extra autonomous savings are traded with policy savings and total savings remain at a low level.
- As the Green Paper goal is regarded as essential to meet the target for greenhouse gas emissions in 2020 [EP, 2008], it is of importance that total savings due to the ESD reach the highest level possible. In line with the Green Paper approach, the eligible savings for meeting the ESD target should represent “policy” savings only. A practical way to realize this is the definition of stringent baselines, to be decided by the Committee that supervises the ESD calculation, and to restrict the eligible savings to realized savings for the period 2008-2016. In that case more saving measures have to be implemented to reach the given ESD target and higher total savings are realised.
- In time, yearly savings could be raised further to the Green Paper level by using even more rigorous baselines in the methods used. Also the use of top-down methods could be limited, as already foreseen in the ESD, because they often provide an easier way to reach the ESD target than bottom-up methods. An alternative could be reformulating the ESD target in case of the application of top-down methods. In this way a correction is made for the autonomous amount of savings.

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Annex 1: Estimation of autonomous and policy related savings for EU countries

For the Netherlands the contribution of policy to realized total savings has been analysed in the following studies:

- Outcome of the Long-Term Agreements on Industrial Energy Efficiency [Rietbergen et al, 2002]
- Indicators on domestic efforts to reduce CO_2-emissions [Boonekamp, 2005]
- Interaction between policy measures for household energy savings [Boonekamp, 2006b].

In [Rietbergen et al, 2002] the results of Voluntary Agreements in Dutch industry were analysed. It was concluded that between a quarter and a half of the 2% yearly savings were due to the agreements or other supporting policy measures. Thus at least 1% of the savings can be regarded as autonomous or price induced. From the figures in [Boonekamp, 2005] on emission reduction due to total savings (table 2.4) respectively policy savings (table 2.6) it can be estimated that about 40% of total savings over the period 1990-2003 probably are due to policy. It regards all sectors, including energy supply. Section 6 of [Boonekamp, 2006b] provides saving results based on ex-post simulations with a detailed bottom-up model on household energy use. It appears that about 50% of fuel savings and 15% of electricity savings in households for 1990-2000 are the result of three main policy measures (taxes, regulation and subsidies). On basis of these results it has been assumed that for the Netherlands total energy savings of 1.0% per year consist of 0.7% autonomous savings and 0.3% policy induced savings (see also page 7 in [EZ, 2006]).

An EU-wide source of information is provided by the MURE-database on policy measures [MURE, 2007]. The results for EU-15 countries show that they apply already policy measures for years, although to a strongly varying degree. Also qualitative impact values are available for many of the policy measures. The savings figures for the Netherlands are transferred to the EU-15 level by comparing the number and impact of policy measures for the Netherlands with that of EU-15 countries. From this comparison, for all end-use sectors, it follows that the impact of policy measures is relatively less for the EU-15. Therefore it is assumed that not 40%, but about 30%, of total savings are related to policy. Given earlier mentioned total energy savings for EU-15 countries of 0.9% per year, policy savings amount to about 0.3% and autonomous savings to about 0.6%. Many new Member States (NMS) applied less saving measures in the nineties and almost no policy measures were present up to recent years. Therefore for NMS the overall estimate of total savings is 0.8% and policy savings are about 0.2% per year. Because the weight of NMS in EU-25 energy use is limited the EU-15 values are also valid for EU-25.

Other sources regarding autonomous savings state the following about autonomous energy savings. In [Adams & Begley, 2004] a model for the Australian energy system is described that uses 0.5% a year for autonomous energy savings in end-use sectors. In [Wing, 2006] the declining energy intensity for US industry is analysed. For the period 1980-2000 part of the lower energy intensity is due to sectoral changes, but the 17%

decrease in energy efficiency also contributes substantially. In [IPCC, 2001] assumptions are made for worldwide industrial energy trends for the IPCC scenarios. It is stated in section 3: “Autonomous energy efficiency improvement is assumed to lead to a reduction of specific energy use by 0.5%–1.0% per year (assumption for the average: 0.75%)”. In [Stern, 2003] the energy efficiency trends for the US are discussed. Until 1982 negative efficiency trends are found, but after 1982 substantial autonomous efficiency increase is detected. In [BRD, 2005] it is estimated that Households will reduce CO_2 emissions by 5.3 Mton between 2008 and 2011. Of this reduction, 1.4 Mton should be autonomous and/or price induced. In [Newell et al, 1999] trends for consumer durables are analysed as to energy use trends. It is concluded that “a sizable portion of efficiency improvements were autonomous”.