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How to measure and verify the fulfilment of energy efficiency targets

A non-paper with FAQ:s and information on how to comply with Articles 4 and 5 of Commission proposal COM (2003) 739 final on energy end-use efficiency and energy services

1. Background: important points to remember

- Climate change and security of energy supply are growing problems.
- Improved energy efficiency can help a great deal to solve these problems.
- There is a documented cost-effective efficiency improvement potential of at least 20% of final energy consumption in the EU in the short to medium term (by 2010).
- Many measures have been introduced at EU level to improve energy efficiency, including energy labelling, energy performance in buildings, the promotion of CHP and minimum efficiency requirements in appliances and equipment.
- Some Member States have implemented measures more ambitiously than others and this has resulted in greater savings in these Member States.
- All Member States have initiated national energy efficiency improvement policies and measures, and some have initiated more and stronger ones than others.
- There are energy efficiency indicators at EU level (ODYSSEE), which are top-down/bottom-up (mixed) calculations[1], that point toward an average improvement in energy efficiency of around 0.8 % per year during the period 1990 -2001. However, since 1998, the average rate of improvement has fallen to less than 0.2% per year. According to these calculations, many Member States maintained acceptable rates of energy efficiency improvement for the period as a whole. (See **Annexes 3 and 4.**)

2. Why are targets and measurements necessary?

- We need to know if we really are accomplishing what we believe we are.
- We need to know which measures are most cost-effective and deliver the best results.
- We need to ensure that implementation of measures is as ambitious as possible.
- We need to ensure that all Member States contribute to improved energy efficiency in order to realize fully the existing potential.

3. What are we measuring?

- We are measuring the amount of energy saved that results from implementing measures that influence the choice and use of technologies and influence our energy consumption, while maintaining or improving the standard, satisfaction, utility or welfare level associated with the energy service being provided.

4. What are we not measuring?

- We are not measuring changes in energy consumption that result from such factors as changes in degree days, changes in occupancy levels, changed opening hours, changes in industrial structure, product mix, industrial output (plant throughput) and GDP, or changes in standards of living or comfort levels. Changes caused by these and similar

[1] ODYSSEE ODEX does contain a number of indicators based on bottom-up aggregations.

factors need to be removed or adjusted for before a true measure of the improvement in energy efficiency can be obtained.

5. How do we measure energy efficiency improvements?

- Broadly speaking, there are two methods to measure energy efficiency improvement. They are referred to as the "**top-down" method** and the "**bottom-up" method.**
- The "**top-down" method** uses more aggregated data, is simpler and less costly and is often referred to as "energy efficiency indicators" because it gives an indication--albeit a good indication-- of developments. It does not provide exact measurements at a detailed level. Most often, sectors of industries, groups of appliances and types of transport modes are used in the calculations. The amount of energy services derived per unit of energy is calculated. Adjustments on the annual data are then made for extraneous factors such as degree days, structural changes, product mix, etc. to derive a measure that gives a fair indication of energy efficiency improvement. (An example of what is mainly a top-down method is the database/modelling tool known as **ODYSSEE** Energy Efficiency Indicators. It does, however, include "bottom-up" calculations. The aggregated "ODEX index" for the EU contains many bottom-up components. ODYSSEE indicators are described in **Annex 1**.)
- The "**bottom-up" method** is the most accurate way to calculate energy savings from energy efficiency improvements. This is done by first estimating, calculating and/or metering energy consumption for a single end use--such as refrigerators-- over a defined period of time before an energy efficiency measure is implemented (the "baseline"[2]. Then this level of consumption is compared to the level of energy consumption (through estimation, calculation and/or measurement) for the same period after an energy efficiency measure has been implemented. The difference between the two calculations is a measure of improved energy efficiency. If this is done for many end-uses and the results added together, it will provide a rather exact measure of energy efficiency improvement. In carrying out the calculation, care must be taken even here to remove, adjust or otherwise correct for double-counting, extrinsic conditions and factors such as those listed in **point 5.** above. (An example of a measure database/simulation tool with a bottom-up character is **MURE,** which is described in **Annex 2**.)
- In Annex IV of the Commission proposal on energy end-use efficiency and energy services, guidelines for measurement and verification of energy savings are set forth. According to these, the measurement of energy savings should be estimated and/or measured before and after the implementation of the measure in question, while ensuring adjustment and normalisation for extrinsic conditions. In measuring the energy savings, a bottom-up model shall be used. This means that energy savings obtained through a specific measure or project, shall be measured and added together with energy savings results from other specific services, programmes, measures or projects. Double counting of energy saving that results from a combination of energy efficiency measures are to be avoided.

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[2] In bottom-up calculations where it is not possible to measure consumption in the baseline beforehand, it is still possible to construct a baseline, using assumptions concerning the types and shares of technology, etc. that would have been used had the measure not been implemented.

Depending on the state of development of the measure, the impact may be measured or estimated. Several methods for collecting data to measure and estimate energy savings exist. At the time of the evaluation of a measure, it will not always be possible to obtain measurements. A distinction is therefore made between methods measuring energy savings and methods estimating energy savings.

Measured data may be obtained from bills from distribution companies or retailers reflecting estimated or metered consumption before and after the implementation of measures. Energy product sales data and the consumption of different energy products (e.g. petroleum, coal, wood, etc.) may be measured by comparing the sales data from the retailer or distributor obtained before the introduction of the energy efficiency measures with the sales data from the time after the measure.

Equipment and appliance sales data, together with performance specifications of equipment and appliances may be calculated on the basis of information obtained directly from the manufacturer. In some cases special surveys and measurements may also be carried out to obtain more precise data from the manufacturer or the retailer.

Calculations based on estimates, using data obtained from audits of industries, buildings, etc. may also be used to confirm energy savings. This can be done without using on-site data, but with assumptions based on equipment specifications, performance characteristics, operation profiles of measures installed and stipulations based on statistics. Verification is still necessary, however.

All the methods used may contain some degree of uncertainty, arising i.a. from errors due to instrumentation, modelling, sampling, etc. Member States are therefore encouraged to quantify uncertainty when reporting on the targets set out in the Directive, indicating accuracy and a confidence level, as well as the cost-effectiveness of decreasing uncertainty.

As far as possible, energy savings should be verified by a third party, such as a certified consultants, ESCOs or other market players decided by the appropriate Member State authority or agency.

Many sources of guidance for measurement and verification of energy savings are available from, e.g. . IEA, INDEEP database; IPMVP, Volume 1 (Version March 2002), which is the International Performance Measurement & Verification Protocol.

6. Is a top-down measurement such as that in ODYSSEE accurate enough to measure compliance with the 1% target or must we use a bottom-up calculation of MURE type?

- While it is preferable to use bottom-up calculations, top-down indicators such as ODYSSEE could be used as a **first approximation**. The use of the top-down method reduces the precision of the calculation of the energy efficiency improvement because it uses more aggregated data and, in addition, it is not always possible to correct completely for structural effects, plant throughput, etc when calculated at an aggregated level. Also, with indicators it is difficult to correlate individual energy efficiency improvements with the specific measures that caused them. *Top-down indicators could therefore in principle be used by Member States to check compliance. Member States would need also to provide the Commission with adequate* *information on measures taken, on their scope and probable impact, and the Commission could be prepared to assume responsibility for carrying out more exact bottom-up calculations for all the Member States, using a database tool of the MURE type.*

7. Do we need, in the bottom-up approach, to count every single incandescent light bulb that we replace with a compact fluorescent light and every single A++ refrigerator that is sold?

- No, it is not necessary to count every individual unit of energy-efficient technology that replaces less efficient technology or to count every house that is insulated by its owner. Accurate sales and market share statistics are available. Statistics covering square meters of useful space in buildings of different types as well as vehicles and person-km. are also available to use in top-down and bottom-up calculations. Extrapolations and interpolations can be carried out in cases where information is missing. This normally will not increase the margin of error significantly.

8. Do energy efficiency targets work?

- There is good experience with targets in other areas, such as waste recycling and renewables electricity.
- There is also some experience with targets for energy efficiency at Member State level and indicative targets for energy intensity at EU level[3].
- Targets allow much subsidiarity, which increases their flexibility and effectiveness.
- Targets can be formulated in different ways, allowing the use of reference values, annual and/or accumulated targets, etc. They can be parts of voluntary agreements or linked to tax and "feebate" programmes. They can be well formulated indicative targets or mandatory targets.

9. Should Member States be encouraged to use their own models and methods to calculate their energy savings?

- Yes, Member States are free to carry out their own calculations if they so choose. Member States carrying out their own calculations will be encouraged to use more detailed bottom-up calculations because of their greater accuracy. If these are not available, or if they choose not to use them, top-down indicators or mixtures of top-down and bottom-up calculations could be used as **first approximations** and the results reported to the Commission**.** Member States will also be encouraged to continue to participate in both the ODYSSEE and MURE programmes since both of these can be used by the Commission to add up and verify the impacts of Member State policies and measures in order to calculate the total improvement in energy efficiency in Member States and in the EU.

10. How do we measure the impacts on energy savings of "horizontal" measures such as information campaigns and energy tax measures?

- In top-down measurement tools, these measures are combined with all other measures and are not analysed separately. For bottom-up calculations, methods of analysis are available to calculate both the degree and the length of the impact of information campaigns on behaviour. Regression analysis and similar econometric methods provide price elasticities at Member State level for calculating the effect on energy consumption of price changes caused by energy tax increases.

[3] Council Resolution of 7 December 1998 (OJ C 394, 17.12.1998, p.1.)

11. How do we avoid double-counting the effects of energy tax and similar measures when other measures are provided at the same time?

- In bottom-up calculations, it is difficult to eliminate completely all double-counting when two or more complementary measures are implemented during the same period. However, it is possible to set the boundaries of the field of consumption that is being impacted, estimate the total potential impact of all measures on the impacted area and divide the savings up, based on assumptions. The most important thing is to be certain that the sum of the savings ascribed to the measures does not exceed the available savings potential.(An example would be retrofitting of single-family owner-occupied houses, where retrofitting becomes economically more interesting due to the increased energy price resulting from an energy tax increase. If retrofitting increases simultaneously because of a campaign or third-party financing offer by an energy service company, a distinction needs to be made between the increase caused by the tax increase and that attributable to the energy service company. Dividing the effect between the two measures is possible.)

12. Is there a 100% accurate method for measuring improvements in energy efficiency?

- No, but fairly close. The tools and methods described above provide acceptable accuracy for their purposes. The acceptable size of the error depends on the size of the improvement in energy efficiency and on the size of the sample used in the calculation. With a 90% confidence interval and a total national annual savings target of 1%, a reasonable sample could result in a margin of error corresponding to ±10 %, or less than 0.1 % of energy consumption. This should be acceptable at the level of total consumption, allowing for larger degrees of uncertainty for smaller sectors with smaller samples. This would be decided by the level of savings and the cost-effectiveness of decreasing uncertainty. In bottom-up calculations carried out by the Commission, the acceptable margin of error could then be agreed by the Member States and harmonised.

13. How costly is it to measure improvements in energy efficiency?

- Measurement and verification of energy efficiency improvements do not need to be costly, even with bottom-up measurements. It is not necessary to carry out detailed measurements for each and every end-use in all sectors to obtain acceptable results[4]. The use of metered values and on-site visits can be kept to a minimum, being required only when it is necessary to establish a reference point upon which to extrapolate the consumption of larger groups of end-users. Sales and other available statistics may instead be used. Some Member States, such as the U.K and Italy, are today measuring improvements in energy efficiency on a broad front, using bottom-up calculations. Some, such as the Netherlands, use a mixture of bottom-up and top-down calculations. France has taken a decision to develop a fairly comprehensive system to use in its white certification system. In addition, there are many other Member States with voluntary agreements, performance contracts and similar arrangements that provide precise and detailed bottom-up information on actual energy savings attained. The results of these instruments are readily available. Evaluations at detailed levels of Member State energy efficiency programmes are also normally required by the financial authorities and can be made available. Routines for calculation, estimation

[4] It should be stressed that the cost of detailed bottom-up calculations should be limited by the value of the savings being calculated, remaining a reasonably small share of this savings.

and measurement are available in models and tools such as MURE, calibrated for individual Member States. These are easily adapted to changing national circumstances. (See **Annex 2**.)

14. How do we take account of the technical lifetimes, the persistence and the attenuation rates of measures? That is, how long will measures last and have an impact?

- Default values for the lifetimes of measures could be proposed by the Commission and agreed by the Member States. Some Member States have already developed tables of measures and their lifetimes, such as the UK and Italy. France is now preparing such tables.

15. How can we add together the impacts of these measurements to show that we are fulfilling the 1% and 1.5% targets?

- MURE and ODYSSEE and similar tools can be adapted to the 1.5% public sector target by agreeing common definitions of public sector energy and energy efficiency expenditures**.** Some additional statistics will be required. The 1.5% target is a sub-target of the 1% overall target and thus uses the same methods of calculation.

16. Is a clear target worthwhile even without a perfect method to measure compliance?

- Yes, most certainly, because we have acceptable measuring tools. A fixed target provides a clear and quantifiable objective. The alternative would be no target at all or a poorly defined target. We would then miss a unique opportunity to develop a simple, equitable, manageable yet strong tool for improved energy efficiency.

17. Why is a mandatory target better than an indicative target or reference values?

- The advantage of mandatory targets is that they are regarded as more “fixed” than other types of targets such as reference values and indicative targets. In the case of reference values or indicative targets, there is more room for the target to “glide”, increasing the margin of error. With reference values, Member State resources are also expended unnecessarily on calculating and explaining deviations from the reference values rather than on reaching the targets. With a 6% target for the six-year period, where a margin of error of 0.05%/year is considered acceptable and feasible, introducing indicative targets or reference values for the whole period would likely increase this margin of error significantly, even at total level and much more so at sectoral level.

- An acceptable solution might be that the 1% and 1.5% **annual** targets could become interim results to measure progress toward the 6% target for the **six-year period**, and the 9% accumulated target for the same period for the public sector. The annual targets could then become secondary reference values, used by Member States to report annual progress to the Commission toward the accumulated targets for the six-year period. **The accumulated targets for the six-year period would then become the primary target.**

ANNEX 1

ODYSSEE Energy Efficiency Indicators

The aim of the project has been to develop a common methodology for calculating energy efficiency indicators for all EU countries, based on national data, which, harmonised to a common format, are stored in one database 'ODYSSEE'. This database provides a permanent structure among participating organisations for continuously reviewing national achievements in the field of sectoral energy efficiency and CO_2 emissions.

The ODYSSEE project was initiated in 1992, with support from the SAVE programme of the European Commission, Ademe and 15 national Efficiency Agencies within the European network of energy efficiency agencies (« EnR »). To reach this objective, the project relies on:

- a common database on energy efficiency indicators called ODYSSEE,
- regular workshops to compare national experiences and to harmonise the interpretations drawn from the indicators,
- annual reports on energy efficiency evaluation.

ODYSSEE indicators are macro-indicators, defined at the level of the economy a whole, of a sector, or of an end-use. Six types of indicators are considered to monitor energy efficiency trends or to compare energy efficiency performances:

-energy intensities relating an energy consumption to a macro-economic variable;
-unit consumption or specific consumption relating energy consumption to a physical indicator of activity;
- "bottom-up" energy efficiency index, to provide a synthesis of energy efficiency trends, assessed at a disaggregated level, including the ODEX index.
- adjusted indicators to make cross-country comparisons, that attempt, as far as possible, to adjust for structural differences between countries (climatic, economic or technical).
- diffusions indicators for monitoring the diffusion of energy efficient equipment and practices;
- target indicators to set up, for each country target or benchmark in comparison to countries with better performance.
- CO_2 indicators complement the energy efficiency indicators. All previous types of indicators are also expressed in terms of CO_2.

Energy intensities are defined as a ratio between an energy consumption (measured in energy units: toe, Joule) and an indicator of activity measured in monetary units (Gross Domestic Product, value added). Energy intensities are the only indicators that can be used each time energy efficiency is assessed at a high level of aggregation, where it is not possible to characterise the activity with a technical or physical indicator, i.e. at the level of the whole economy or of a sector. Intensities are also calculated at constant structure to leave out the influence of structural changes in the economy and provide a better indicator of overall efficiency. An example is total final energy intensity at constant structure.

Unit consumption (or specific consumption) is defined at a more disaggregated level (sub-sector, end-uses) by relating an energy consumption to an indicator of activity measured in physical terms (tons of steel, number of vehicle-km, etc) or to a consumption unit (vehicle, dwelling, etc.). They can either be calculated from existing statistics (unit consumption) or are available as such from surveys (specific consumption). Examples are unit consumption of crude steel, unit consumption of industry (EU average), unit consumption of road transport per equivalent car, specific consumption of new cars (test values), unit consumption per dwelling for space heating, unit consumption per employee, and unit consumption per m2.

Bottom-up energy efficiency indices provide an overall assessment of the energy efficiency trends of a sector or an economy. They are calculated as weighted averages of detailed sub-sectoral indicators (by end-use, transport mode, etc.). A decrease in the index means an energy efficiency improvement. Such indices are better for grasping the reality of energy efficiency changes than energy intensities. They are still not as detailed as most true bottom-up calculations. Such ODYSSEE indices use toe/dwelling, kWh/appliance, toe/capita, etc. The reference year is 1990. The "ODEX" index for the EU is based on 25 indices weighted together (7 in transport, 8 for households, 10 for industry). ODEX is being extended to include 30 indices weighted together.

Adjusted energy efficiency indicators account for differences existing among countries in the climate, in economic structures or in technologies. Comparisons of energy efficiency performance across countries are meaningful only if they are based on such indicators. Examples are energy intensity of industry adjusted to EU average structure and unit consumption of dwellings, scaled to European average climate

Diffusion indicators have been introduced to complement the existing energy efficiency indicators, as they are easier to monitor, often with a more rapid updating. They aim at improving the interpretation of trends observed in the energy efficiency indicators. The objective is to centralise in the ODYSSEE database data that are collected in other studies, in particular in other SAVE projects. In other words, the objective is to rely on "international sources" that cover all countries at the same time. Three types of diffusion indicators are considered:
-Market penetration of renewables (number of solar water heaters, % of wood boilers for heating, etc.)
- Market penetration of efficient technologies: number of efficient lamps sold, % of label A in new sales of electrical appliance, etc.
- Diffusion of energy efficient practices, such as percentage of passenger transport by public modes, by non motorised modes; percentage of transport of goods by rail by combined rail-road transport, and percentage of efficient processes in industry. Examples are diffusion of label A in the EU and diffusion of low emission glazing.

Target indicators aim at providing reference values to show possible targets of energy efficiency improvements or energy efficiency potentials for a given country. They are somehow similar to benchmark values but defined at a macro level, which implies a careful interpretation of differences. Two types of target indicators are considered, according to the source of improvement:
- Indicators of technical progress
- Indicators with potential for technical efficiency ("technical potential") and higher penetration of "more efficient practices ("non technical potential")

Target values are based on comparable indicators, adjusted to account for national circumstances such as climate, country size, lifestyles, size of dwellings, appliance ownerships), and other quantifiable differences not targeted by energy efficiency policy.

ANNEX 2

General methodology to analyse the impact of the energy saving measures issued by a given Member State, using the MURE database as an example

Introduction

The MURE database is used to collect and analyse the basic information to calculate the impact of energy efficiency policies, programmes and measures for a given Member State. The quantitative outputs of the energy impact calculations are provided by the MURE simulation tool in the form of energy savings attributable to policies and measures. To this end the MURE simulation tool, on the basis of the information provided by the energy saving measures analysis, the statistical and technical and cost data stored in its databases, and the reference starting simulation year, calculates and draws up **two** levels of energy consumption covering a selected period of time:

The baseline calculation that, starting from the reference year and continuing through the target period, modifies the natural energy consumption demand trend provided by the main energy consumption drivers (mainly the population, households growth rate, disposable income, autonomous improvement, etc. according to the impact on consumption of the technology and energy saving measures in place before the starting reference year

The measurements calculation, that modifies the baseline curve according to the impact provided by each of the energy saving measures, individually and together, that are implemented after the starting reference year.

To this end the following key data are generally required (and provided by the MURE database):

- Issuing and ending year of the measures.
- Scope (boundaries) and mechanisms of the measures.
- The description of the stock to which the measure is addressed (with quantitative information).
- Available ex post evaluations of the impact of the measures and of similar measures.
- Costs of the measures (to calculate pay-back and cost effectiveness).

Impact simulation methodology

The following is an example of the methodology applied to simulate the impact of the energy saving measures in the household sector (set up within the ongoing MURE-ODYSSEE project).

1) Categories of the measures in the following six categories:
   a Financial measures for the improvement of, e.g., the heating system, cooling system, building shell, etc.
   b Informative, educational measures
   c Fiscal, tariff measures
   d Technical ordinances (e.g. building codes)
   e Measures enhancing appliance energy efficiency
2) Sorting of the measures by issuing date
3) Setting of the simulation criteria
   a The impact of the financial and informative measures are estimated using data on the insulation, maintenance frequency and impact and boiler substitution interventions. The impact of the regulative measures (ordinances, labelling, etc.) are estimated

applying the technical parameters stated by the measures themselves (e.g. in the building codes, u-values or energy efficiency indexes). The fiscal/tariff measures will modify (increase) the penetration rates of the financial measures, using i.a., elasticities.

b The impacts of the financial and informative measures are calculated as follows:

- for insulation we take into consideration the parameters suggested by the technical ordinances, or similar regulating laws;
- for maintenance, which is intended to mean an intervention on, e.g. the heating system, including burner substitution, device controls, individual accounting, etc., we apply a percentage gain in combustion and transformation efficiency based on statistical averages for peak performance unless this is better specified in the measures; for boiler substitution we assume that the fiscal (but also the fiscal and tariffs) measures contribute to accelerating the renewal rate of the boilers;
- the gain for boiler substitution is provided by the ratio between the new and the old boiler energy efficiency; we normally assume that this gain does not change during the simulation period.

c The penetration rates of these measures are evaluated case by case in accordance with their aim and their nature.

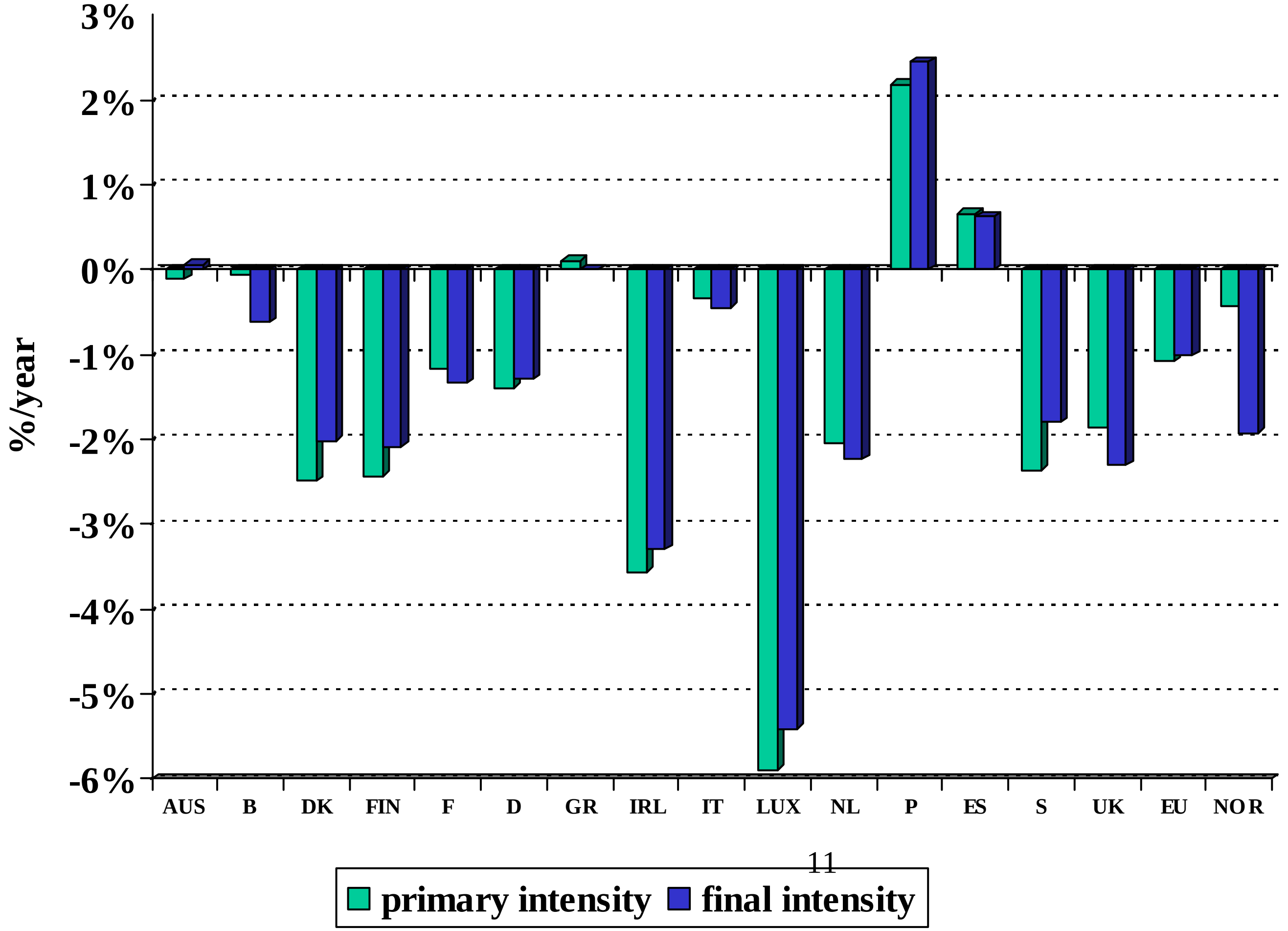
d The gain of the building codes for the new dwellings is provided by the ratio between the new U values and the U values of the reference new building stock (the stock of buildings that ranges from the year of the first building code up to the reference year). The involved stock is obviously the number of new constructed houses in the analysed period.

e The gain and penetration rates of the measures concerning the appliances labelling measures (for the cold and washing machines) are evaluated on the basis of the findings of studies such as Cool Labels, the E-GRIDS project (a project carried out in collaboration with CECED, GfK, and ENEA), etc.

This simulation model is an example. It, like other available models, can be further refined by calibrating it with more detailed investment cost data, recent studies on the effects of measures, etc. Data on energy prices and costs and macro data such as population, disposable income, etc. are provided exogenously by the PRIMES model (using EUROSTAT data), which is the main energy scenario model for the Commission. Other models, including Enerdata`s Medea also provide input.

The MURE simulation tool is harmonised with the ODYSSEE database. Working groups from Member State energy agencies work actively to update MURE and ODYSSEE. ODYSSEE is now up to date. Some additional work is required to update, strengthen and expand MURE to the EU 25 level.

Annex 3. Energy intensities in Member States; average percentage change/year 1990-2001 **Source: ODYSSEE INDICATORS 2004. Sector and end-use group intensities corrected for climate, structural, etc. and aggregated up to total levels.(Partial top-down/bottom-up indicator calculations.)**



Annex 4. Energy efficiency improvement since 1990

Total 10%; industry 18%; transport 5%; households 6%.

Source: ODYSSEE INDICATORS 2004. Sector and end-use group intensities corrected for climate, structural, etc. and aggregated up to total levels. (Partial top-down/bottom-up indicator calculations.)