Evaluation of policies and measures in the residential sector of the EU-15

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Keywords

energy efficiency, measure evaluation, measure simulation, backcasting, forecasting, impact analysis

Abstract

This paper provides an in-depth analysis of the impact of EU-15 Policies and Measures (P&M's) for energy efficiency and renewables in the residential sector (both national and at EU-level). Two types of impact analysis have been carried out. The first concerns a simulation exercise with the MURE simulation model: for each country, the savings corresponding to the application of the P&Ms were evaluated by measuring the impact of a given "Policy scenario" with respect to a "Reference". This simulation was carried out for two periods: 1990-2000 (Backcasting) and 2000-2025 (Forecasting). The backcasting simulation, carried out to better understand the P&M's future effectiveness, regards the comparison and evaluation of the gap between the hypothetic energy savings, due to the application of the P&Ms enforced during the backcasting period, and the real trend of the observed data. The results (energy saved, CO_2 avoided) broken down by main measure categories are discussed at European level. An example of the way the energy saving measures have been analysed and evaluated at country level is presented for France. The results of the forecasting impact analysis demonstrate that the EU residential sector is far from the Kyoto target for 2010 but also far from the objective of the planned EU Directive on Energy Efficiency and Energy Service (1% savings per year). For this reason a second type of impact analysis explores the possible achievable energy savings up to 2025 considering all economic savings possibilities.

Introduction: Quantitative Evaluation of Policies and Measures in the Residential Sector

In the future, increasing requirements can be expected with regard to the quantitative monitoring and evaluation of the impacts of energy policies and measures. There are quantitative targets for the improvement of energy efficiency, renewables, combined heat and power generation (CHP) and the reduction of greenhouse gases, with the corresponding obligations to report on the progress of actions carried out or the results achieved, e.g. in

- The proposed Energy Service Directive (reporting on energy efficiency progress achieved using indicators);
- National and EU Monitoring Reports under the EU Monitoring scheme (Council Decision 280/2004/EC for a monitoring mechanism on CO_2 and other greenhouse gas emissions);
- The European Climate Change Programme, proposing detailed policies and measures to cope with the EU Kyoto target of –8%;
- National reporting of Member States on climate change measures under the EU burden sharing and for national targets; and
- National Communications to the UNFCCC (EU and Member States).

A recent study (ADEME/ENERDATA/FRAUNHOFER ISI/ISIS, 2005) carried out in the Odyssee-MURE project, established the quantitative impacts of policy measures implemented between 1990 and 2000 ("backcasting evaluation") in the residential sector for a set of EU-Member States which represent more than 90% of the EU-15 energy consumption. It also made a study of measures, implemented or in preparation between 2000 and 2004, as well as of potential economic energy efficiency measures up to 2025 ("forecasting"). This paper presents the general methodology used for the selection of measures from the MURE database and the quantitative estimates for the residential sector in the bottom-up analysis with the MURE simulation tool. Backcasting and forecasting cases are followed by the results of the Economic Potential Scenario. The MURE database and simulation tool are briefly described in the following.

A short description of the MURE database and simulation tool

The details on the measures analysed in this paper have been drawn from the MURE database. The MURE (Mesures d'Utilisation Rationnelle de l'Energie) database and simulation tool[1] provide comprehensive, up-to-date information on energy efficiency policy measures in the EU-15 Member States. The MURE database and simulation tool has been developed within the SAVE programme by a team of European organisations, currently composed of ISIS (Italy), Fraunhofer ISI (Germany) and Enerdata (France). Previously Inestene (France) and the March Consulting Group (UK) contributed to the development. The database as well as the quantitative data for the simulation tool are updated by the European Energy Agencies participating in the MURE-Odyssee projects. The coverage has been constantly improved over the years thanks to an on-line management section, which allows prompt and continuous upgrading by the project partners involved. The database allows the user to select among over 850 measures for each of the four demand sectors (Household, Transport, Industry, Services) and for one (or more) of the EU-15 countries plus Norway. The measures can be retrieved according to various criteria (e. g. type of measure, enforcement year, target audience, technologies affected, etc.). By clicking on a link, a concise synthetic description of the measure can be viewed where succinct information is provided on the legal framework, the year of enforcement, the measure type, actors involved, and more.

For more exhaustive information about the measure, the user can download the complete measure description file: this document provides an in-depth description of the measure and its main features (specific actions provided for by the enforced law, actors and target audience involved, subsectors and technologies affected, methods of enforcement, etc.). Moreover, an impact evaluation section (when available) enables the user to quickly appraise the actual outcome of the measure. Methods used for the evaluation and related results are provided, as well as real/estimated energy savings (fuels and electricity) and carbon dioxide emission reductions achieved over a given time frame. If no quantitative evaluation is available, a qualitative expert judgement is reported, namely an assessment of the measure impact (high/medium/low) in terms of energy (fuel/electricity) and CO_2 savings.

The MURE simulation tool, is a bottom-up analysis tool in which selected energy efficiency measures can be parameterised and evaluated (see the following paragraphs).

Bottom-up Modelling of the Impact of Policies and Measures in the Residential Sector

METHODOLOGICAL APPROACH

The simulation scenarios

The evaluation of the impact of policies and measures (P&Ms) for EU-15 is the result of simulations carried out for 10 countries[2]. For each country, the savings corresponding to the application of the P&Ms were evaluated by calculating the impact of a "Policy scenario" with respect to a "Reference" case. Two different simulations were carried out: the first "backcasting" evaluation refers to the past decade (1990-2000) and the second "forecasting" one covers the period 2000-2025.

The "Reference" is defined as a simulation in which the energy demand trend was calculated by taking into account the main energy consumption drivers (e.g. the demography and social drivers as measured by the number of households). It includes possible saturation trends in the drivers, and the (residual) impact of energy saving measures implemented before a certain base year (the year from which the impact simulation exercise starts: 1990 in the case of backcasting and 2000 in the case of forecasting). The "Policy scenario" refers to a simulation where the energy demand development takes into account additional energy saving measures implemented (or even planned) after the respective base years.

The backcasting simulation consists of comparing and evaluating the gap between the hypothetical energy savings, due to the application of the P&Ms enforced during the backcasting period, and the real trend of the observed data[3]. This comparison shows what would have been the energy demand trend if all the envisaged policies and measures had been applied as intended by the policy makers, and what really happened. It provides a view of the real energy demand drivers that enables to improve the analysis of future effectiveness of P&Ms (e.g. influence of increased room temperatures, of heated surfaces and of annual heating periods which all slow down the impact of the various building regulations introduced over time

The simulation of energy saving measures

The energy saving measures implemented by each country were first sorted by issuing date in order to separate the measures enforced during the past decade from those commencing in the year 2000 (or later on). To simulate the

1. For more information: www.mure2.com
2. Only the following 10 countries have been analysed due to a lack of significant datasets in the other five: Austria, Denmark, France, Germany, Greece, Italy, Spain, Sweden, the Netherlands and the UK.
3. climate-corrected to avoid the influence of variations in the annual external temperature.

Table 1. Energy efficiency measures active in France.

Measures issued 1990-1999 (and still active)		Measures issued from 2000 onward	
1	Tax credit (1990)*	6	Building insulation standard (2001)
2	Boiler directive (1994)	7	Promotion of solar energy (2000)
3	Labels for electric appliances (1995)	8	Local information centres (2000)
4	VAT reduction (1999)	9	Minimum efficiency standards for refrigerators and freezers (2004)
5	Grants for audits (1999)		

* Year when measure became active in brackets.

P&Ms impacts in both the backcasting and the forecasting exercise, each measure was then parameterised. The measure parameterisation consists of setting the following simulation criteria and figures:

- selecting the type of intervention foreseen by the measure (building shell insulation, boiler substitution, maintenance of heating systems, introduction of renewable energies, etc),
- evaluating the penetration rate in the dwelling stock affected per type of intervention (exogenous data for MURE,
- setting the relative gain per type of intervention (internally calculated by MURE).

Even if the settings applied in these simulation exercises vary by measure and country, some general rules can be highlighted:

- For building shell insulation, the parameters suggested by the regulating laws (in particular thermal buildings codes), were considered. The gain was calculated by considering the ratio between the new energy performance standards (generally in kWh/m^2) and the average performance standards of the buildings built under the previous code.
- For boiler substitution, the following renewal rate was applied: 8 years for boilers serving more than three dwellings and 15 years for other boilers.
- For generic interventions in the heating system, including burner substitution, device controls, individual heat metering in multi-family buildings, etc., an average gain of 10% was applied unless specified otherwise in the measures. This choice was motivated by in-depth evaluations of such types of measures at the national level.
- Fiscal and tariff-type policy measures were assumed to accelerate the penetration rates of financial and other similar energy saving measures.
- The gain and penetration rates of appliance labelling measures (for cold appliances and washing machines) were simulated based on the findings of other SAVE and EU projects, mainly the E-GRIDS project[4].

Based on these settings, the impact of each measure was simulated in each country. The results were then summed up in order to arrive at the final impact at European level[5].

The following section shows this procedure for the example of France.

Impact evaluation case study for France

Over the period 1990-2004, nine main measures were issued in France in the household sector, five of which during the 1990s.

As an example, the parameterisation and simulation of the tax credit and VAT reduction were carried out as shown in Table 1.

The two measures were merged into one measure as they have a similar implementation scheme and the same type of impact. The stock involved was estimated starting from the fact that 4% of French households carried out energy efficiency measures in 2000 (i. e. using VAT reduction) and 7% in 2002. As these measures are valid until the year 2005, it was estimated that, by this year, the building stock affected by these measures should not exceed 10%. This stock was further subdivided according to the type of work undertaken as a consequence of these measures: 39% of households have improved the heating systems, 39% window insulation, and 22% the insulation of walls and other building components (based on information from ADEME-SOFRES). Applying the energy saving interventions provided by MURE (i.e. insulation, control devices, maintenance) to these shares, the efficiency gain can be calculated (the overall final gain resulting from this mix of interventions amounts to 22%).

Figure 1 shows the energy savings in the year 2025 by each of the measures described above, compared to a "with-

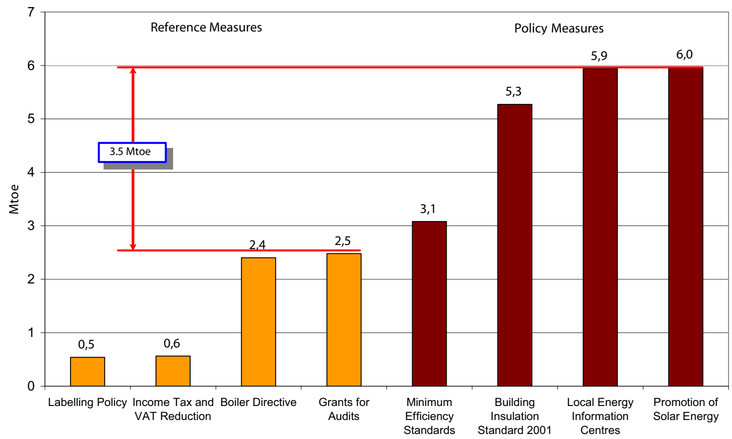

Figure 1. *Cumulative Impact of 1990-2004 energy efficiency measures for France in 2025.*

4. E-GRIDS (Enhancing the Goverment Regulatory Energy Measures Impact and Diffusion Speed Appraisal Method) is a project carried out within the 5th Framework Programme by ISIS (project leader) Enerdata, ENEA and Gfk (project number: NNE5-2001-00147)
5. The total energy consumption of the 10 countries analysed in this project represents about 90% of total EU-15 energy consumption.

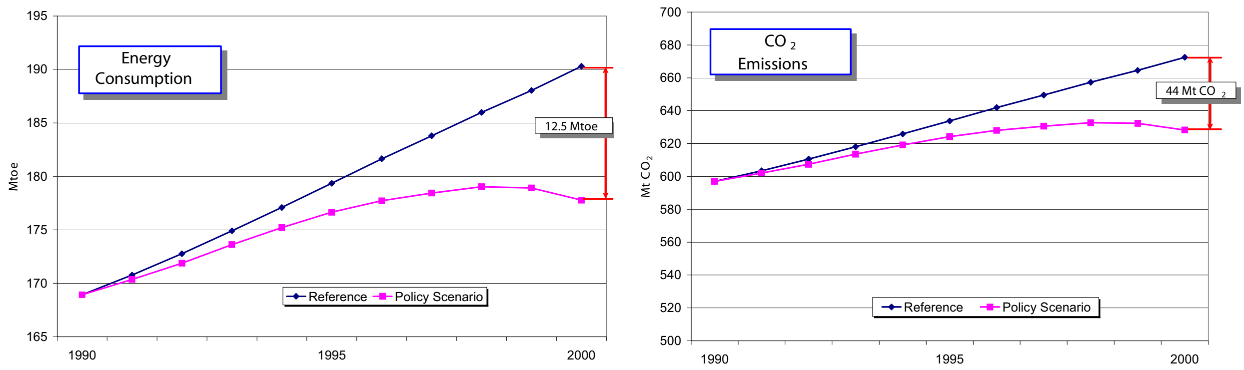

Figure 2a/b. *EU backcasting scenario residential sector (Note: electricity uses + heating, direct + indirect CO_2 emissions, 10 EU countries).*

out measure" scenario. This scenario only takes into consideration the increasing energy demand due to the trends of energy drivers, excluding any measure taken from 1990 onward. In MURE the energy drivers are the number of household and electric appliances. Total achievable savings are 6 Mtoe if referred to a "without measure" scenario, and 3.5 Mtoe if compared with the reference scenario including measures taken in the nineties.

MEASURE IMPACT EVALUATION: BACKCASTING SIMULATION 1990-2000 FOR EU-15

Overall results

The impacts of the policies and measures over the period 1990-2000 are presented in terms of energy saved, CO_2 emission reduction (Figure 2a/b) and specific energy consumption per dwelling (Figure 3). In the backcasting, the reference scenario takes into account only the household and the electricity consumption growth rates of the past decade (corresponding to an annual increment of 1% and 2.3% respectively), as the residual impact of the measures implemented before the year 1990 is small[6]. The policy scenario, in contrast, takes into account all the measures implemented during the decade. It shows an increased impact after the years 1995-1996. Indeed, these years mark a certain revival of energy saving measures in EU countries, e. g. the enforcement of the European directives on energy efficiency labelling of appliances and on boiler efficiencies and the issuing of stricter thermal building regulations at the national level, and more recently, at the EU level.

The total savings presented in Figure 2a (12.5 Mtoe) and the corresponding total CO_2 avoided (44 Mt CO_2)[7] show what could have been achieved if (i) the starting conditions in terms of lifestyle and average size of dwelling had remained unaltered and (ii) the policies had had the effectiveness level equivalent to that simulated in MURE. In reality, the real energy demand trend was quite different from that shown in the Policy Scenario simulation. This is illustrated in Figure 3, in which the dashed line represents the trend of the climate-corrected observed energy consumption data expressed in toe per dwelling. The progress of the observed data follows more or less that of the policy scenario until the years 1994-1996. Starting from 1996, the observed indicator then reverses direction and increases very rapidly to reach the reference level. After this point the curve starts to drop again in line with the development of the policy scenario. The reason for this progression is not clear. This may be due to improved living standards of families (larger dwellings, more appliances, or greater comfort of heating). The sudden increase in the energy demand in the years 1994-1996 may also be linked to the rapid economic growth since 1994[8].

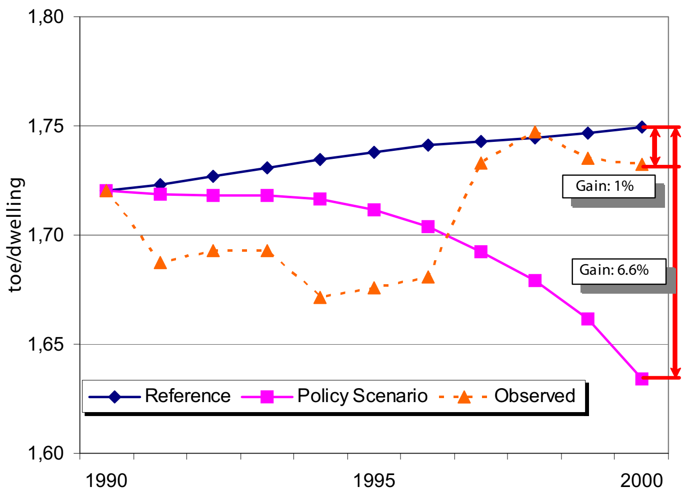

Figure 3. *Backcasting scenario residential sector – unit consumption per household (Note: climate-corrected, electricity uses + heating, 10 EU countries).*

6. An example may explain what we understand by "residual impact": if a building regulation is implemented in 1985, there are buildings constructed throughout the nineties, so the reference reflects the introduction of the new buildings according to the 1985 standard. For instance, if the 1985 buildings are 30% more energy-efficient compared to previously existing buildings, and if 1% of the buildings are replaced annually, then the savings are about an additional 0.33% of the energy consumption for heating each year.

7. The CO_2 calculation takes into account both the direct emissions (those originating from the fuel combustion for heating) and the indirect emissions, i. e. the emissions due to the production of the electric energy used in the residential sector.

8. The variations in energy demand are magnified in the figure by the scale chosen in the graph. In reality the energy demand peak of 1998 is only 5% greater than the minimum reached in 1994.

Table 2. Main measures in the MURE backcasting simulation.

Back Casting	Building codes	Boiler substitution	Retrofitting of existing buildings	Appliances Labelling	Renewables	Others
Austria	*Building shell insulation*		*Grants for building erection Reduction of income taxes through energy savings Grants for building erection and renovation*	*Domestic Appliances Labelling*		*District heating coercion in Styria*
Denmark	*1995 Building regulations*	*Heat inspection of small oil heat furnaces*	*Grants for energy saving measures for pensioners' dwellings Grants for connection houses built before 1950 to District CHP systems Grants for product oriented energy savings*	*EU Energy Labelling for Electric Appliances*		
France	*Building Insulation Standard of 1989*	*VAT reduction*	*Reduction of income taxes Financial helps: PAULOS, OPAH and PALULOS*	*Labels on Electric Appliances*		
Germany	*Thermal Insulation Ordinance of 1994*	*Heating Installation Ordinance of 1978/82*	*Economic recovery in the new Federal States Housing modernization programme for new Federal States Financial assistance for low-rent housing Owner-occupier allow-ance CO_2 reduction pro-gramme Ecological tax reform*	*Energy Consumption Labelling Ordinance*	*100-million-DM program-me for renew-ables Market incen-tive program-me for re-newable energies*	*Small Scale Combustion Plant Ordinance*
Greece		*Efficiency standards for new hot water boilers*		*Labelling for energy consumption*	*Tax exception by using RES*	*Allocation of heating costs in collective buildings Inspection standards for central heating systems*
Italy	*Design norms for building and thermal equipment*	*Efficiency standards and labelling for new boilers*	*Financial package for high-efficiency installations Fiscal incentives for energy savings*	*Energy labelling*		*Limit to the internal temperature of buildings*
Nether lands	*The Building Decree*		*The Environmental Action Plan*	*Energy labelling appliances*	*Long term agreement on energy efficiency*	*Energy Performance Standards (EPN) Energy efficient retrofitting programme*
Spain		*Energy Conservation and Efficiency Plan EECP 1991-2000*	*Financial help for energy efficiency*		*Ordinance for Thermal Use of Solar Absorption*	*Norm on Building Thermal Insulation in Catalonia Regulation of thermal installations in buildings*
Sweden	*Building regulations*		*Grants for reduced use of electricity for heating*	*Test, labelling and certification*	*Grants for solar heating systems*	*Technology procurement Contributions to municipal energy advisory services*
UK	*Building regulations 1991*	*Energy Saving Trust*	*Home Energy Efficiency Scheme*	*Minimum energy efficiency*		*Home Energy Conservation Act 1996*

Contribution of energy saving measures in the backcasting simulation

About 70 measures, deployed in different EU-countries, were simulated in the backcasting simulation (Table 2), grouped into the following 5 categories: thermal building codes, boiler substitution and appliance labelling policies (European Directives), retrofitting of existing buildings (generally financial measures), renewables (different instruments) and other measures (fiscal, informative, etc.). Figure 4a/b shows the distribution of the total energy savings among the different types of measures. The large contribution of renewables to the total savings is practically entirely

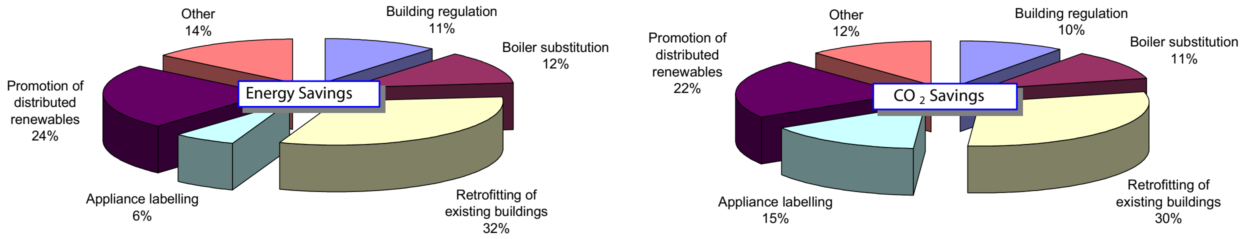

Figure 4a/b. *Backcasting simulation for EU-15: distribution of effects by type of measure.*

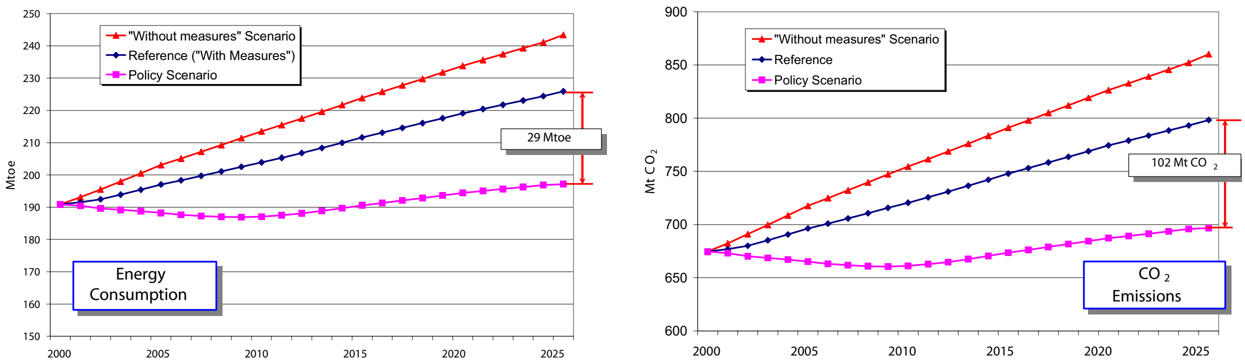

Figure 5a/b. *EU forecasting scenario residential sector (Note: electricity uses + heating, direct + indirect CO_2 emissions, 10 EU countries).*

due to Germany, where 2.3 Mtoe were saved with only two measures[9]. The labelling policies had a small impact, except for the cold appliances, as generally these measures were implemented at the end of the period. In terms of CO_2 emissions, however, their impact is larger due to the fact that the emissions from electricity generation are larger on average in Europe than emissions from heat supply.

MEASURE IMPACT EVALUATION: FORECASTING 2000-2025 FOR EU-15

Overall results

The impacts of the policies and measures over the period 2000-2025 are presented in terms of energy saved, CO_2 emission reduction (Figure 5a/b) and specific energy consumption per dwelling (Figure 6) for the 10 countries investigated. The reference trend includes the growth in the number of households and the electricity consumption growth rates, plus the residual impact of all the energy saving measures implemented before the year 2000. This scenario also takes into account the European trend towards a further increase in heated living space[10].

In the reference, the trend changes significantly over the simulation period. In the Policy Scenario, initially, the energy consumption increases very slowly, but then rises steadily until the end of the forecasting period. This progression can be explained by the fact that the effects of many of the energy saving measures implemented during the 1990-2000 decade (especially thermal building regulation and the labelling policies for electric appliances) petered out at the beginning of the year 2000 so that the increase in energy demand due to the growth in the number of households[11] and electricity consumption[12] prevailed. The predicted savings are 29 Mtoe and 102 Mt of CO_2 respectively, corresponding to an annual saving of about 0.5%[13]. These savings are calculated with respect to the reference, which, as already pointed out, incorporates the residual impacts of previous policy measures. If these residual impacts are eliminated from the reference, i. e. if a "without measure" scenario is plotted, the total savings provided by both the measures implemented before and after 2000 amount to 46 Mtoe (and 163 Mt of $CO_{2)}$ corresponding to an annual saving of 0.8%. It is important to remember here that the objective of the planned EU Directive on Energy Efficiency and Energy Service is 1% savings per year for 2004-2010. This means that the European countries need to double their efforts at least in order to achieve this objective[14] (nevertheless, it is worth noting that if the directive allows counting effect of policy measures from 1995 on, the difference is probably 0.8 against 1%).

90% of the savings achievable in 2025 are due to space heating and hot water. As shown in Table 3, the increase in the total energy demand in the Policy Scenario (from 153 to 144 Mtoe) is only due to the increase in final electricity de-

9. The "100-million-DM programme for renewables" and the "Market Incentive Programme for Renewable Energies".
10. The consequence of the assumed increasing living space for new future dwellings (+10% until 2025) is an increase of 3% of the heating demand up to 2025 as new buildings will account for about 30% of the total stock by 2025.
11. According to the forecasts, the population should grow very little during the period (0.1% per year) while the households are supposed to grow much faster due to a decreasing average number of persons per household.
12. This growth is mainly due to the increasing use and ownership of small electric appliances and the diffusion of air conditioning devices in Southern European countries.
13. All figures given in this section are for the 10 countries investigated.
14. This assumes that the five countries not investigated (which represent about 10% of the EU-15 energy consumption) are implementing measures at a similar rate as the ten countries investigated. In general, looking at the measures taken by these countries, this does not seem to be the case; therefore the effort required to reach the level of savings necessary to fulfil the proposed Energy Service Directive is even greater.

mand (the heating reference consumption decreases a little, while the electricity consumption increases steadily[15]).

The contribution of energy saving measures to the forecasting scenarios

84 measures were selected for the forecasting: 54 (80% of the 67 measures considered in the backcasting scenario) were analysed to construct the reference for the forecasting and 30 were included in the policy scenario (Table 4).

The breakdown of these 30 measures is shown in Figure 7a/b, grouped in the same categories as for the backcasting simulation. Once again, the large share of measures concerning renewables here is practically entirely due to Germany, which alone accounted for 5 Mtoe saved ("Renewable Energy Sources Act"). The labelling policies have a small impact as most of the impact of the appliance labelling policy is already included in the reference. Only three countries (Denmark, France and the Netherlands) had actually enforced the new labelling schemes after the year 2000 With regard to boiler replacement, which contributes only 6% to the total savings, the residual potential for boiler efficiency improvements is quite small in the year 2000. However, a comparatively modest penetration of condensing boilers was assumed at European level (even if in some countries, like the NL, this was already the standard by 2000). The 30 measures of the forecast scenario have twice the impact produced by the 70 measures of the backcasting scenario. This is not because the 30 measures analysed here are more efficient, but because the impact in the forecast scenario is spread over 20-25 years. In the backcasting scenario the impact is limited on average to 2-6 years because the majority of the measures issued during the past decade were implemented in the years 1994-1998.

The interaction between the different types of measures simulated has been taken into account as far as possible. Nevertheless, it is difficult to correctly evaluate the mutually reinforcing or hampering influences of measures targeting the same area. This problem is discussed in ADEME 2004. A lot of methodological effort and field studies are still necessary to shed more light on this issue. A general statement which can be made is that the greater the number of measures present, the more carefully the interactions have to be evaluated.

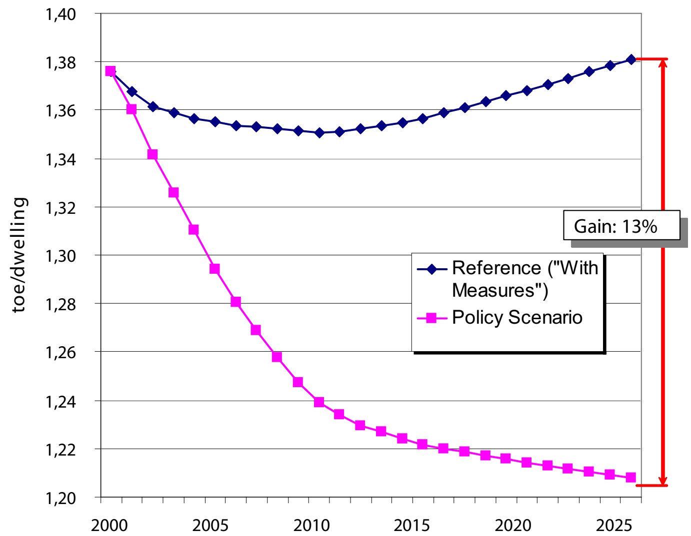

Figure 6. *Forecasting scenario residential sector – unit consumption per household (Note: at normal climate, electricity uses + heating, 10 EU countries).*

Economic Potential Scenario

In the previous section we developed scenarios that described the possible impact on energy consumption of energy efficiency measures as well as of distributed renewables and CHP. In view of the Kyoto target for 2010, which is far from being achieved in the residential sector[16], and in view of further reductions required for the period after Kyoto, it is necessary to investigate how many savings can be achieved when considering all economic savings. This section on an Economic Potential Scenario explores possible energy savings up to a time horizon of 2025. It must be em-

Table 3. Energy consumption and energy savings for the 10 EU countries investigated (Mtoe)

		Electric uses	Heating	Total
Reference	2000	37.7	153.2	190.9
Reference	2025	55.4	170.5	225.9
Policy Scenario	2025	52.8	144.5	197.1
Energy Savings	2025	2.6	26.0	28.8

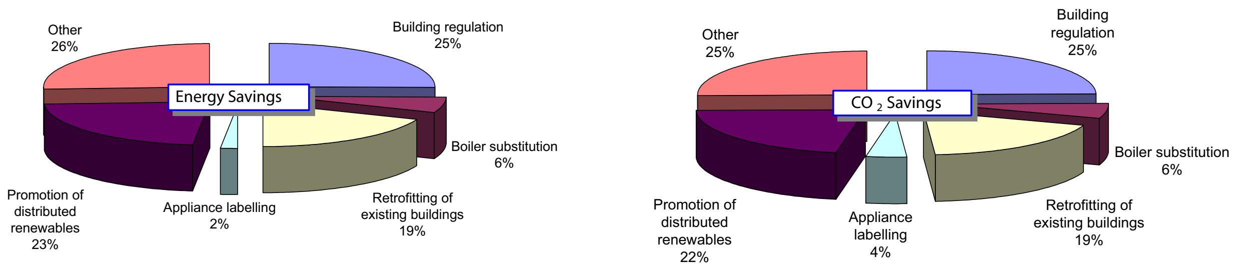

Figure 7a/b. *Forecasting simulation: distribution of effects by type of measure.*

15. It is worth noting here that "electric uses" do not take into account electric heating (included in the heating column) and that the saving mainly refer to the appliances labelling and the improved lighting measures

16. Assuming a flat reduction target of -8% in 2010 for all greenhouse gases and all sectors.

Table 4. Main measures in the forecasting simulation.*

*Note. For the forecasting, the Reference also includes the residual impact of 54 measures from 1990-2000.

Fore casting	*Building codes*	*Boiler substitution*	*Retrofitting*	*Labelling*	*Renewables*	*Others*
Austria					*Grants for renewable energies*	
Denmark	*New building codes*		*Agreement on efficient windows*	*Demand Side Management*		*Heating planning*
France	*Building insulation standards of 2001*			*Minimum efficiency standards*	*Promotion of solar energy*	*Local energy information centres*
Germany			*CO_2 building rehabilitation programme*		*Renewable Energy Sources Act*	*Energy Saving Ordinance*
Greece						*CO_2 emission reduction by en-rgy efficiency improvements in buildings*
Italy		*Explanations for project, installation, working and maintenance of thermal plants*				*Enhancement of efficiency in energy residential uses*
Nether lands	*Building Decree 2002*	*Existing Building Energy Performance (EPA)*		*Energy premiums*		*Regulation energy premiums*
Spain	*Measures in new buildings 2004-2012* *Measures for existing buildings 2004-2012*				*Promotion of renewable energies 2000-2010* *Support of solar thermal energy*	
Sweden		*Swan Labelling for Oil Burners*				*Biofuelled heating systems and energy-efficient windows in houses*
UK	*Revised building regulations 2001*		*Replacement community heating* *New home energy efficiency scheme* *Trasco Affor-dable Warmth Campaign* *Energy Eff. Commitment*			

phasised that the measures included are fully proven and cost-effective today; further technical and economic progress would enlarge the efficiency potential further, hence the potential calculated is conservative.

METHODOLOGY AND MAIN ASSUMPTIONS

Many detailed studies, carried out on energy saving technologies, have shown a variety of options to be economic on a life-cycle basis[17] at energy price levels below the current (2004) price hikes. The developed Economic Potential Scenario tries to integrate the results of these studies by select-

17. For cost-effective measures in buildings see, for example: M. Jakob et al. (2002)

Table 5. Economic potential scenario household sector – settings and assumptions.

	Saving Potential	Stock involved	Main assumptions	Sources
Electric appliances	stock 2000 / new appliances 2025 (kWh/appl./year)			
Refrigerators/freezers	363 / 140	100%	A++ devices in 2025 at level of A devices in 2000	E-GRIDS 2001
Washing machines	223 / 151	100%	Full penetration of A devices by 2025	E-GRIDS 2001
Dishwashers	270 /162	100%	CECED ambitious scenario	CECED 2001
Dryers	251 / 197	100%	CECED ambitious scenario	CECED 2001
Lighting	482 / 390	100%	Comprises rebound effect and increment of lighted space	
Heating				
Reference				
	+10%	30%	10% increase in the area of new houses	Derived from Odyssee database 2004
		9% oil, 2% solids	Autonomous fuel substitution of gas for oil and solids in the reference case	Odyssee database 2004
Economic Potential Scenario				
Boiler replacement	Boiler efficiencies: Gas 80►100% Oil 76►95% Oil 76►90%	 85% 42.5% 42.5%	Strong penetration of condensing boilers	Diffusion indicators Odyssee database 2004 (examples: Nether-lands, Germany, UK)
Building regulation (harmonisation potential)	30%	30% (stock of new buildings up to 2025)	Harmonisation potential derived from benchmarking the 4 best countries, excluding the best one.	Odyssee database 2004
Building regulations (further improvements)	25%	30% (stock of new buildings up to 2025)		
Building refurbishment	30%	29% (equals half of existing stock in 2025)	Insulation of existing buildings in the renovation cycle.	e. g. Jakob 2002
Renewables	Biomass 15%, solar thermal 18% of 2025 heat demand	Biomass: 42% Solar thermal: 42%	Potential from RAGWITZ 2020 study. Solar thermal (mainly for hot water) and biomass (for heat) in addition to classical heating systems and heat pumps.	Ragwitz 2005
Heat pumps	Minimum Coefficient of Performance COP 3.5	Heat pumps: 16%	Heat pumps replace conventional heating systems to a fraction of 16%.	

ing a variety of technology options for energy savings and renewables based on the findings of these detailed investigations[18]. Another approach for designing such an Economic Potential Scenario is the development of benchmarks from other countries. Such an approach was recently used for Belgium (Eichhammer et al., 2003). This approach derives the economic potential from comparing a given country with other countries that already achieved the savings. This way of constructing a scenario is a very pragmatic view of the actual potential in the real economic world, with real decision makers and actual behaviour and barriers, but with different policies across Europe as regards energy efficiency. This approach gives a realistic economic potential up to 2020. Benchmarking was chosen especially for the saving potential due to enhanced building regulations for new buildings. A "harmonisation potential", i.e. a potential that would be realised if the building regulations were harmonised at the level of the most advanced countries today, was determined.

Table 5 summarises the selection of technology fields for the development of the economic potential scenario:

- Main electric appliances[19].
- Replacement of older conventional boilers by new condensing boilers.

18. There are several options of how to develop such an economic potential scenario. One option would be to use the cost figures for the different measures stored in the MURE model. The main difficulty is to accurately reflect the dynamic cost reduction that is possible in technologies for the rational use of energy if volumes increase (for example the prices of A-class devices have been dropping to levels comparable with B-D class devices due to the large volumes produced).
19. There is also a considerable economic potential for electricity savings in minor electric appliances, especially in stand-by consumption, which was not considered here (see Cremer et al., 2003)

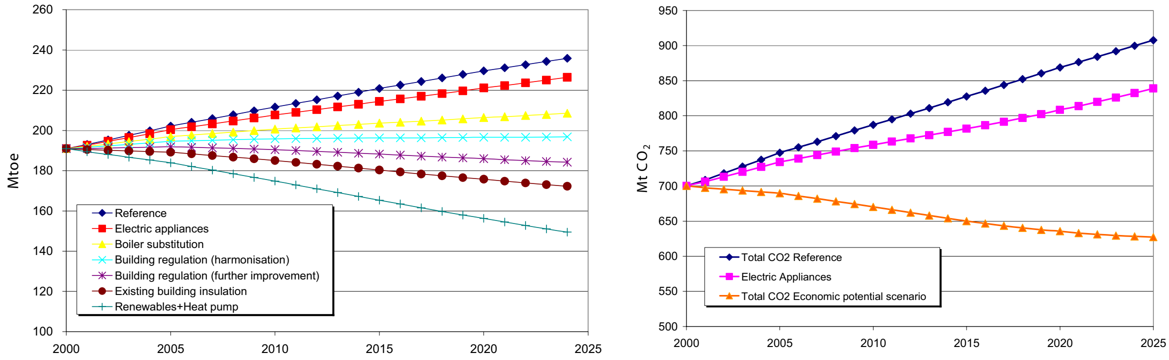

Figure 8a/b. *EU-15 economic potential scenario household sector – energy consumption and CO_2 emissions.*

- Improvement of building regulations, firstly through the harmonisation at the level of the most advanced countries in Europe (to some extent, this is already being initiated through the introduction of the European Energy Performance Directive for Buildings); secondly through more stringent building regulations, which is possible even in the most advanced countries.
- Thermal insulation of existing building stock in the renovation cycle.
- The introduction of renewables, especially biomass for heating purposes, solar thermal mainly for hot water preparation and partially for heating, and PV for solar electricity generation. While biomass use for heating purposes can already be considered economic, even in the case of pellet heating, this is not yet the case for solar thermal and certainly not yet for PV. Therefore these are not really "economic" measures in the strict sense. However, it was assumed that there will be continued support for the solar thermal industry, at least for a number of years, which will help to make part of the potential (established in the FORRES 2020 study; Ragwitz et al., 2005) economic. For PV, it can be assumed that the interest from the public in the development of this technology will be strong enough to insure a certain level of implementation. Both biomass heating and solar thermal systems are considered in combination with classical heating systems or heat pumps.
- Heat pumps replacing classical heating systems with a minimum COP Coefficient of Performance of 3.5.

The reference scenario also integrates the trend towards a further increase in the heated living space, so some saturation effects might show up in the coming two decades. The autonomous shift from solids and oil to gas was integrated in the reference scenario too. This is based on recent projections in the European Union (WETO, 2003 and CEC, 2003).

RESULTS

The results of the projections in the economic potential scenario are shown in Figure 8a/b (energy consumption and CO_2 emissions including indirect emissions from electricity consumption). In the reference scenario, energy consumption would have increased by more than 25% (CO_2 emissions by 35% due to the much stronger growth of electricity consumption, especially for smaller appliances). Electricity alone is responsible for an increase of 20 Mtoe. The different measures that make up the Economic Potential Scenario help to lower energy consumption to a level of around 150 Mtoe (-38% with respect to the reference in 2025 and –19% with respect to the base year 2000).

Improvements in the different fields contribute equally to the reduction in energy consumption. The savings from more efficient appliances appear less important in terms of final energy. However, in primary energy terms or CO_2 terms, they make a large contribution. Boiler substitution, harmonisation of building regulations and the diffusion of renewables represent other important contributions to the reduction.

Comparison of Quantitative Evaluation Results for the Residential Sector

Figures 9a/b and 10a/b summarise the results of the analysis. The figures are provided in terms of energy and CO_2 savings for both the backcasting (impact in the year 2000) and the forecasting exercises (the latter for the time horizons 2010 and 2025). The figures also contain the results from the Economic Potential Scenario as well as the 1% annual savings target of the EU Energy Service Directive (electricity weighted with a factor of 2.5). This was calculated hypothetically for the period 1990-2000, as well as for the period after 2010 because the currently proposed Energy Service Directive is only supposed to cover the period up to 2010.

The following main messages emerge for the backcasting exercise 1990-2000:

- the savings in the year 2000 estimated for the backcasting case (1990-2000)are about 14 Mtoe (nearly 50 Mt CO_2). The savings are in the order of 5-6% of the residential energy consumption in the EU-15.
- If a hypothetical annual 1% savings target is assumed in the period 1990-2000, corresponding to the currently proposed Energy Service Directive, the calculated savings in the nineties in this paper are less than half that expected under this hypothetical target. Hence it would have been necessary to double the efforts made with respect to energy efficiency in order to achieve such a target in the nineties.

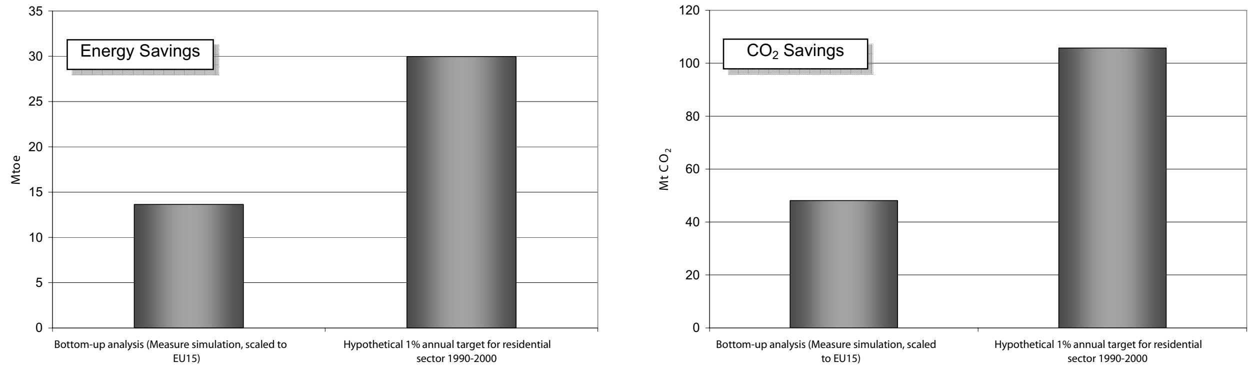

Figure 9a/b. *Energy/CO_2 savings residential sector in the backcasting 1990-2000 (Note: The measure simulation (first column) was carried out for 10 countries representing 90% of the EU-15 energy consumption. Result extrapolated to EU-15 assuming a similar effort for energy saving as in the countries investigated. In reality, the savings are lower because it can be expected that the missing countries have comparatively lower activities in the field of energy savings. Missing data are sometimes also an indicator for missing activities).*

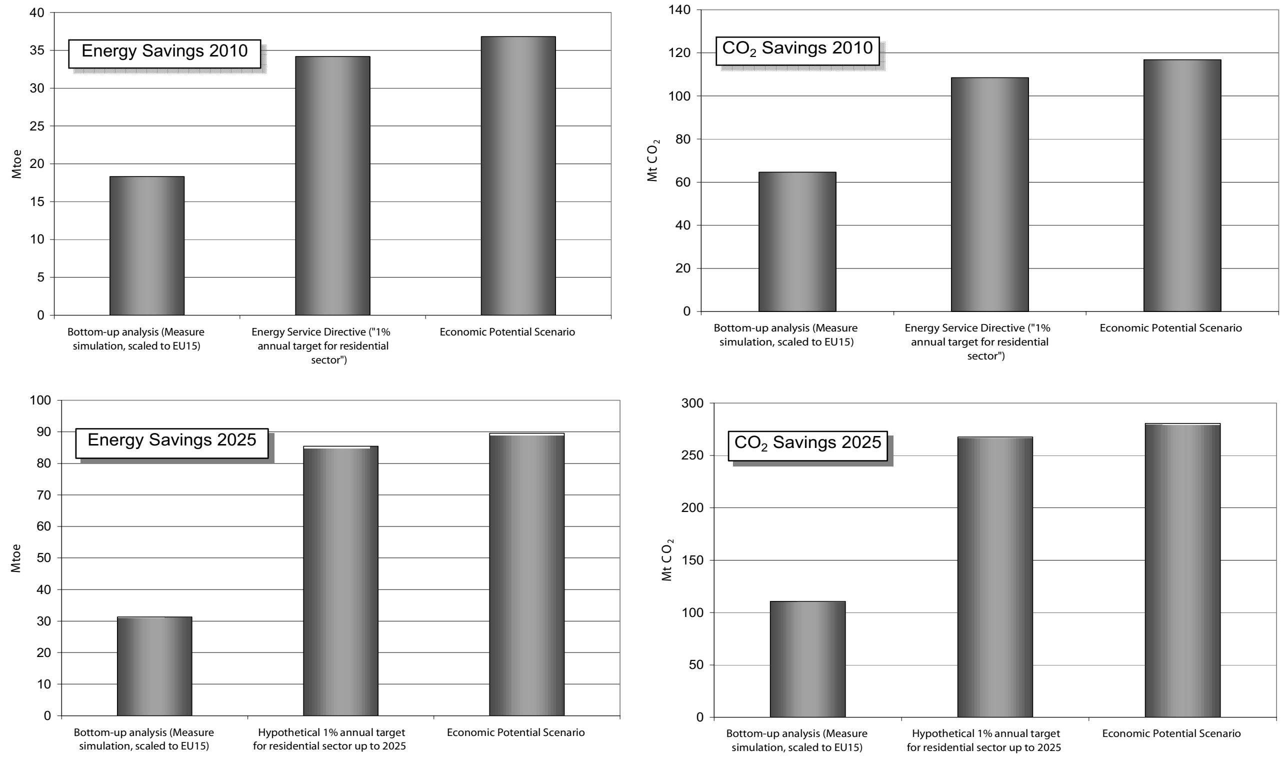

Figure 10a-d. *Energy / CO_2 savings residential sector in the forecasting 2010 and 2025 (See note Figure 9a/b).*

The following main messages emerge for the forecasting exercise for 2000-2025:

- For 2010, the savings calculated are around 18 Mtoe for the EU-15 (64 Mt CO_2). The projected savings are somewhat above the savings for the nineties, indicating increased efforts compared with the previous decade, but still within the same range.
- The Energy Service Directive, which aims at the year 2010, would require an effort which is twice as large as that forecasted. This is in agreement with the ratio observed for the backcasting and indicates that the efforts are not yet sufficient. However it must be considered that the nineties were characterised by "easier" savings, e. g. in the refurbishment of buildings in Eastern Germany, which cannot be repeated. Hence efforts have already increased simply to sustain the previous level of achievement.
- The calculations for the Economic Potential Scenario show that the figures from the Energy Service Directive (applied in a flat rate to the residential sector) are ambitious at the EU level but still within economic reach. At the time horizon of 2010, savings of around 37 Mtoe (117 Mt CO_2) seem possible, representing 17% of the reference energy consumption in the residential sector. For the year 2025, economic savings could more than double to 90 Mtoe (280 Mt CO_2), representing 38% of the reference energy consumption in the residential sector at that time.

- Crucial measures to close the gap between the measures currently initiated in the residential sector and the Economic Potential Scenario include the Energy Performance Directive for Buildings EPBD (which is already decided but where much depends on the actual implementation of the Directive and its provisions in the EU Member States), the proposed Energy Service Directive as well as the possible RES-H Directive for thermal uses of renewables, both of which are still uncertain. All three measures combined would double the savings calculated, showing the huge impact and the strategic importance of the Energy Service Directive, in particular, and the RES-H Directive for distributed renewables in the heat market.

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Acknowledgements

Thanks to all national teams from the Odyssee-MURE project (ADENE Portugal; CRES Greece; DEA, Denmark; ECN, The Netherlands; Econotec, Belgium; ENEA, Italy; EVA, Austria; Fraunhofer ISI, Germany; IDAE, Spain; IFE, Norway; AEA Technology, United Kingdom; Motiva, Finland; SEI, Ireland; STEM Sweden) as well as to ENERDATA France for their contributions to the gathering of energy efficiency measures and inputs to the analysis. Further thanks to the EU SAVE programme for support of the project and to ADEME for the project lead.