Fraunhofer Institut Systemtechnik und Innovationsforschung

MURE

MURE Database Case Study

Impact of the Introduction of the EU Boiler Directive 92/42/EEC

Study carried out in the frame of the MURE project
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Cover photo:

High efficiency condensing boiler at the
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1 Introduction

This MURE case study deals with the evaluation of the EU directive 92/42/EEC. The latter comprises efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels. The report presented here reviews the savings of energy and carbon dioxide emissions in the 15 member countries of the European Union which can be imputed to the Directive.

In the first section the methodological approach is presented referring in particular to the application of the MURE database in the context of this case study. The following section briefly summarises the EU directive. In the third section national regulations i.e. the translation of the EU directive into national law, are being outlined and their qualitative differences are being analysed. In the last sections a first approach is made for calculating the amount of energy saving and reduced carbon dioxide emission. The annexes summarise a short description of the MURE tool as well as some out-prints in relation to the case study.

This case study has also benefited from a study for the German Federal Ministry of Economic Affairs comparing regulations for the rational use of energy across Europe (Eichhammer *et al.*, 1999).

2 Methodological approach

The methodological approach used in this case study is based upon the following three steps (for more information concerning the structure of the MURE tool see Annex 1):

- The case study makes use of the measures database within MURE. The information was further complemented through small questionnaire sent to the partners in the MURE Network in the different member states.
- The case study makes further use of the MURE data concerning space heating and warm water preparation in households as well as space heating in the tertiary sector (space heating in industry was neglected given the lower share of space heat compared to households and tertiary and given the much lower share of boilers concerned by the Directive; similarly warm water preparation in industry and tertiary sector was neglected). In some cases the MURE data had to be complemented with other sources.
- Finally, the MURE simulation tool was used to estimate the impact of the measure in the European Union Member States (see Annex 2 for examples of out-prints from the tool).

3 Summary and goals of the EU boiler Directive

There were many good reasons for the Council of the European Communities to adopt the Council Directive 92/42/EEC on May 21, 1992, which deals with efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels.

One driving force was the aimed reduction of greenhouse gas emissions: the Council made 1990 a commitment that the CO_2 emissions in the year 2000 should be stabilised throughout the community at their 1990 level. The domestic and tertiary sectors absorb a major proportion of the final consumption of energy. Because of the trend towards more central heating and a general increase in thermal comfort these sectors will become even more important in the future.

In a second paragraph of the Directive there is mentioned the consumers interest in better boiler efficiencies and also the general economic interest of fewer imports of hydrocarbons, which will have an positive impact on the trade balances.

A third main target coming up with the Directive 92/42/EEC is to reduce the range of technical properties of equipment placed on the market, thus facilitating series production and the realisation of economies of scale. An absence of such a Directive might lead to cheaper but lowly efficient boilers. The efficiency requirements to be met are set out in the Article 5 of the directive, see table 1. The requirements depend on the boiler power and the type of the boiler (standard boiler, low-temperature boiler or condensing boiler). Only boilers fired with gaseous and liquid fuels are concerned. Electrically heated boilers or coal and wood-fired units are not concerned.

Table 1: Efficiency requirements of the Directive 92/42/EEC

Type of boiler	Range of power output	Efficiency of rated output		Efficiency at partload	
	kW	Average boiler-water tempe-rature (in °C)	Efficiency requirement expressed (in %)	Average boiler-water tempe-rature (in °C)	Efficiency requirement expressed (in %)
Standard boilers	4 to 400	70	≥ 84 + 2 logPn	≥ 50	≥ 80 + 3 logPn
Low-tem-perature Boilers(*)	4 to 400	70	≥ 87,5+ 1,5 logPn	40	≥ 87,5+ 1,5 logPn
Gas condensing boilers	4 to 400	70	≥ 91 + 1 logPn	30 (**)	≥ 97 + 1 logPn

(*) Including condensing boilers using liquid fuels.
(**) Temperature of boiler water-supply.
Pn rated power in kW

Each boiler has to be tested and the energy efficiency of the boiler is described by a number of "stars" (*) given by the testing board according to the performance of the boiler. The number of "stars" depends on how close the efficiency of the boiler under test is to the values in the Table 1. If the efficiency of the boiler is equal or greater to the values given in Table 1 one "star" is given, while for every 3 percentage points above the standard values an additional star is given to the boiler. The technical execution is described in the annexes of the Directive. This system has not been working in practice. Actually the EU commission is working on a proposal to include labelling of boilers in another directive concerning labelling of household appliances in order to introduce a better system. The labelling system was also criticised for other reasons: the consumers' associations criticise for example that due to the use of the lower calorific value in the calculation of the boiler efficiency, it can be higher than 100 % (for condensing boilers). That is difficult to point out to consumers.

Until 31 December 1997, Member States shall permit the placing on the market and putting into service of appliances complying with the national rules and schemes in force within their territories before the date of the adoption of the Directive 92/42/EEC.

4 Analysis of national regulations

As Table 2 shows, basically all EU countries have followed the EU boiler regulation which dates from 1992. Most countries signed up the national counterpart to the Directive around 1994 (except for the new EU Member countries Sweden, Austria and Finland). The time when the national legislation entered into force varied from country to country: while the Netherlands had integrated the Directive already by 1993 into their national laws, it took other countries up to four additional years. All countries analysed allowed for transition periods for the introduction of the new efficient boilers up to the end of 1997, which was the maximum allowed by the Directive 92/42/EEC. Exceptions were granted for the new accession countries Austria and Finland (1998 and 2000 respectively) while Sweden was able to cope with the transition time specified by the Directive (see below). In Austria for each province there are separate regulations, but there exists a frame agreement from 1995 between the Federal government and the provincial governments concerning energy consumption.

For this reason, the boiler directive in most countries started to have impact only in 1998. Most EU Member Countries, except Germany have taken up the requirements of the Directive without adding substantially to them, while Germany introduced amongst others the additional requirement that low-temperature boilers (or better) would only be admitted.

Table 2 National adoption of the boiler Directive 92/42/EEC

	Additional requirements at national level compared to Directive	**National counterpart to Directive was signed**	**in force**	**Transition period**
Austria	No	15/6/95	15/6/95	15/6/98
Vorarlberg		15/5/95	15/6/95 24/7/98	
Kärnten		26/6/98	1/10/98	
Oberösterreich		28/8/94	17/5/97	
Belgium				
Denmark	No[1]	6/94	18/6/1994	31/12/97
Finland	No[2]		19/10/97	31/5/98
France		9/5/94	22/6/94	31/12/97
Germany	Yes[3]	22/3/94	22/3/94	31/12/97
Greece	No[2]	16/8/93	1/1/95	31/12/97
Ireland	No[2]	27/7/94	1/8/94	31/12/97
Italy	No[1]	15/11/96	15/11/96	31/12/97
Luxembourg				
The Netherlands	No[1]	5/1/93	14/1/93	31/12/97
Portugal	No[1]	20/5/94	6/8/96	31/12/97
Spain	No[2]	24/2/95	24/8/95	31/12/97
Sweden	No[1]	1/12/97	5/12/97	31/12/97
United Kingdom	No[1]		1/1/94	31/12/97

[1] Original text, but not word by word; [2] Original text;
[3] at minimum low-temperature boiler required

In the following paragraphs some interesting points arising from the questionnaires are described for the different Member States.

Austria

Although energy policy is a task for the provinces in Austria, there exists a frame agreement between the Federal government and the provincial governments concerning energy consumption and minimum demands for energy savings (Vereinbarung zwischen dem Bund und den Ländern gemäß Art. 15a B-VG über die Einsparung von Energie, BGBL. Nr. 388/1995). Within this agreement also the boiler directive was taken up in 1995 and the provinces have had three years to translate the agreement into provincial laws. Some of them are mentioned in Table 2.

The percentage of wood consumption for heating purposes in Austria amounts to 29.9 %, which is unusually high in the European Union (Stanzel *et al.*, 1995). No evaluation and no study about implementation deficits has been carried out in this country.

Denmark

The EU-boiler directive did not mean a rise in efficiency of the installed boilers in 1994, when the European Directive was introduced in Denmark, because the national regulation was already at about the same level. Critics of the Directive have pointed out that if the EU-boiler directive had not been adopted, Denmark would had stricter regulations today. However, it might have been possible for Denmark to opt for stricter requirements (see below for Germany).

Denmark decided to implement the star-rating system, but this system has not been in function because of EU-wide considerations about efficiency labelling for household appliances which might also comprise the labelling of boilers in the future.

Finland

The directive has been quite well accepted by the target groups concerned. No evaluation concerning the Directive exists so far which is not surprising given the fact that Finland had a transition period until the middle of 1998. Deficits in the application of the Directive are not known yet.

Germany

Germany has introduced as the only country additional requirements:

- the boiler capacity must be adapted to the heat consumption of the building;
- there are limits specified for the consumption of auxiliary electricity, in particular for the warm water pumps;
- with validity of 1.1.1998 only low-temperature or condensing boilers are permitted for installation;
- until 31.12.1997 all single houses have to be equipped with thermostatic valves.

Germany has made a first estimate for the evaluation of the impact of the Directive in Germany. According to an estimate of Ziesing *et al.* (1997), the new ordinance will cause a CO_2-reduction of 1.2 Mio. t in the year 2000 compared to mid 1994.

There is a permanent competition between boiler and insulation manufacturers. Both suggest to the owner of a building to buy their product, so the owner might save money as well as heating energy, but as the financial resources of house owners are limited, often only one energetic improvement might be carried out at a time. Regulations are useful for convincing customers. This is one more reason for a frequent sequence of laws which is setting for both heating systems and insulation demanding standards, as for example in Germany, see Figure 1 and the discussion in Eichhammer/Schlomann (1998).

Greece

The boiler directive was adopted by the national rule 335/93 from the 16/08/1993. A second law, the presidential decree 59/95 of 21/02/95 postponed the application date of the national regulation by one year, i. e. the application date was moved to 1/1/1995. No evaluation and no study concerning implementation deficits is available.

Ireland

No evaluation and no study concerning implementation deficits is available.

Italy

There was no time lag between the reception and application of the national regulation. The minimum efficiency levels set by the 92/42/EEC had already been taken up by a national regulation back in 1994 (DPR 08/09/1994 n. 412) which might be the reason why the EU boiler Directive was adopted relatively late in 1996.

The Netherlands

No evaluation and no study concerning implementation deficits is available. The fuel consumption for space heating in the tertiary sector is based to 91 % on natural gas.

Portugal

No evaluation available, but because of expected problems with the application of the Directive a study has been commissioned by the Portuguese Government. The aims of this study are to evaluate the level of application, to estimate the savings and to propose actions which improve the level of application. Natural gas was introduced in Portugal in 1997 only. Therefore, fuel oil and LPG are still dominant for space heating.

Spain

No evaluation is available. The application of the Directive is considered as being satisfactory. Later national regulations include references, in which the importance of the application of the boiler Directive is underlined.

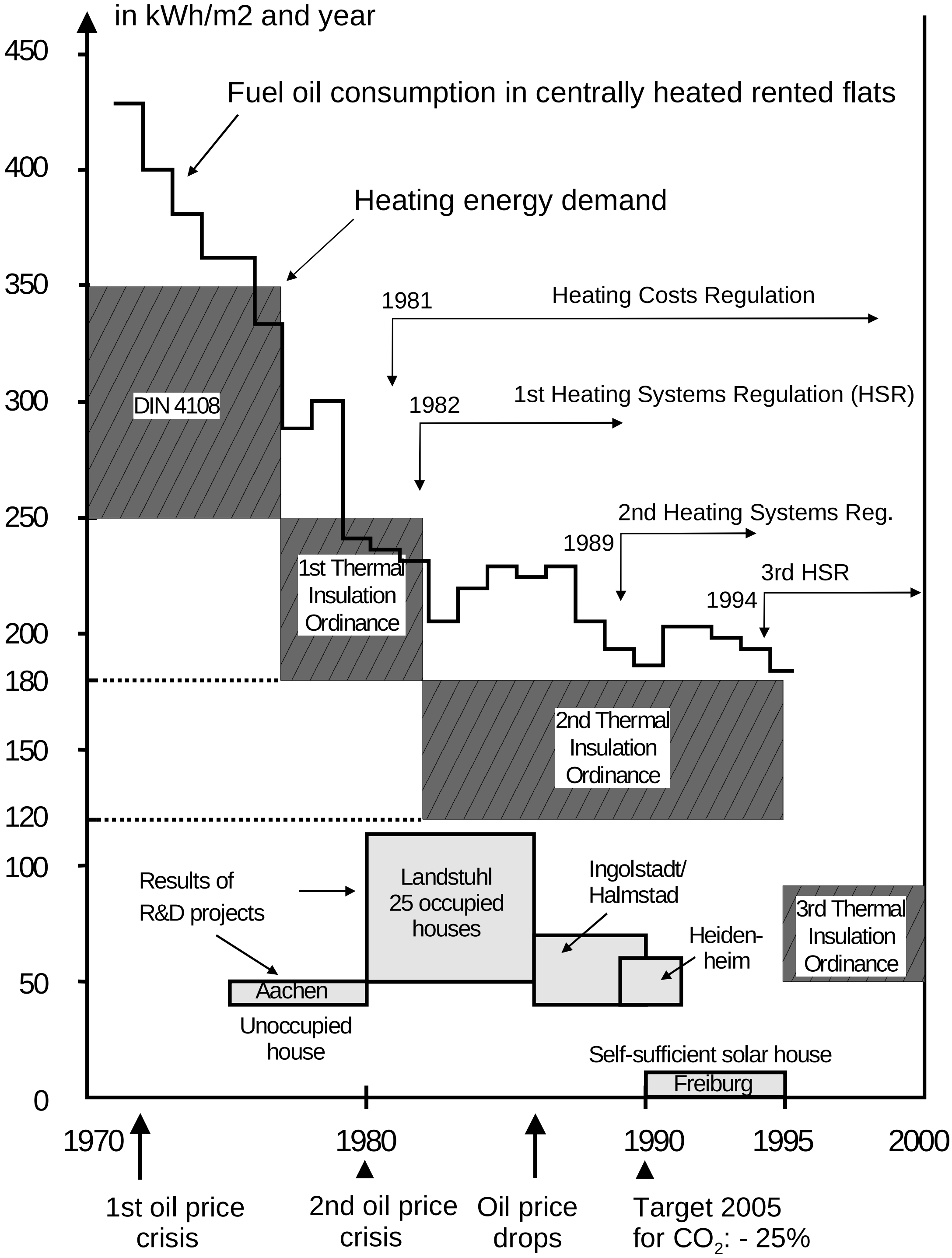

Figure 1 Interrelation between research, proof of technical feasibility and regulation using the example of Thermal Insulation Ordinances and Heating Systems Regulations in Germany (see comments in Echhammer/Schlomann, 1998)

Sweden

The voluntary star-labelling system is not used in Sweden. The efficiency levels which have to be attained, considering the technical demands in the boiler Directive, do not lead to any stricter requirements than the former Swedish regulation; the level of the efficiency demand is almost about the same as before.

For this reason it seems that there will be no energy savings made with the new regulations, the manufacturers will not have to change the technical solutions, the boilers will at the same efficiency levels as before. The only novelty will be the conformity demands and the CE-labelling. The reason why the boilers in Sweden have such a high efficiency can be explained by the climate and the oil crises in the seventies which have led to a large interest in more efficient boilers.

United Kingdom

The value of 76 % for the fuel efficiency of old boilers seemed high for UK (see Table 3).

5 Calculation of energy savings in 2005 in the EU15 (static approach)

In this chapter an approach is made for calculating the amount of energy saving and reduced carbon dioxide emissions for 2005. The approach taken here is a static one, i. e. the estimates are based on the 1995 figures. It is assumed that the energy demand remains unchanged up to 2005 (no change in the numbers of households, in the fuel structure, in comfort levels; no further penetration of well-insulated houses). The so calculated savings are certainly the upper limit, although some compensation for the overestimate occurs through factors that drive heating and hot water demand up as there are population increase and the increase in comfort levels.

The main assumptions for the calculation are shown in the Tables 2 and 3. They have been verified for the different countries through a questionnaire sent to national experts and interviews at the national level. The results of the implementation of the boiler directive on energy savings in households are described in Table 4 for space heating and in Table 5 for sanitary hot water. In the case of sanitary hot water only combined systems for both heating and hot water preparation are taken into account, because separated systems are often characterised by a power lower than 4 kW or are using electricity which is not concerned by the Directive.

In the tertiary sector the impact of the boiler Directive on space heating is much lower. In Table 6 the resulting saving is only 66.8 PJ versus 217.2 PJ in the households. The three countries without specific data are calculated with average values. For the tertiary sector it is assumed, that only 65 % of the boilers are covered by the directive. The other boilers have a rated output of more than 400 kW. **In total 317.2 PJ or 21.3 mill. t CO_2 could be saved in 2005 corresponding to 3.8 % of the fuels concerned by the Directive (gaseous and liquid fuels) or to 2.9 % of the energy used for space heating and warm water in households and for space heating in the tertiary sector (see Figure 2).**

While considering the result, it should be noticed, however that given the boiler lifetime of 15-25 years only a fraction of the total possible boiler stock is penetrated in 2005 as the Directive became mainly effective in 1998 only. After full penetration of the stock (around 2020), the corresponding savings would be *ceteris paribus* up to three times higher. Further, savings in the tertiary sector and industrial sector for warm water preparation as well as savings in the industrial sector for space heating were not taken into account. Given the lower fraction of warm water preparation in those sectors and the small fraction of space heat in industry which is concerned by the Directive, the picture should not be substantially modified.

Table 3: Assumptions for the calculation of energy savings

	Evaluation	Lifetime of boilers (y)	Fuel efficiency for old boilers	Share of total energy consumption of new buildings (in %)[1]
Austria natural gas fuel oil	No	-	 64[2] – 73[3] 60[2] –71[3]	0.5 to 0.7
Belgium				
Denmark	No	20 to 25	85	
Finland	No	20 to 25	76	1 to 2
France				1
Germany	Yes	20 to 25	76	1
Greece	No	20 to 25	76	3
Ireland	No	15 to 20	70	-
Italy	No	-	-	-
Luxembourg				
The Netherlands	No	15	76	10
Portugal	No	20 to 25	76	1
Spain < 60 kW 60-150 kW 150-800 kW	No	20 to 25	 75[4] 75[5] – 80[4] 78[5] – 83[4]	> 1
Sweden	No	20 to 25	85	-
United Kingdom	No	15 to 25[6]	< 76	-

[1] total households = 100 %; [2] Single boiler; [3] Central heating;
[4] since 1980 for new buildings; [5] 1980 for existing buildings;
[6] 15 years for modern boilers, 20 to 25 years for older models (Stanzel *et al.*, 1995)

	Consumption for existing buildings concerning different fuels for space heating 1995, PJ					Energy savings 2005	
	total (incl. other fuels)	gas	oil	electric	coal	PJ	mio. t CO2
A	204	46	62	10	73	7,2	0,5
B	330	142	159	12	16	16,4	1,1
DK	160	27	47	10	14	0,0	0,0
FIN	122	0	35	25	0	1,3	0,1
F	1299	376	327	153	178	38,2	2,6
D	2075	833	866	95	136	64,0	4,4
GR	121	0	58	11	2	2,2	0,2
IRL	66	8	18	2	38	2,1	0,1
I	743	422	187	24	110	22,9	1,5
L	6	2	2	0	1	0,2	0,0
NL	307	302	0	0	0	17,1	1,0
P	64	0	0	1	8	0,0	0,0
E	194	33	27	19	14	1,3	0,1
S	267	1	72	72	40	0,0	0,0
UK	1013	775	38	66	87	44,2	2,7
EU15	**6.970**	**2.967**	**1.899**	**499**	**718**	**217,2**	**14,3**

Table 4: Savings of energy and CO_2-emissions in space heating in the households in 2005 (EU15)

Source: MURE Database (1999)

	Total consumption for combined systems PJ	Distribution per fuel				Energy savings 2005	
		gas	oil	electric	other	PJ	mio. t CO2
A	12	39%	0%	51%	10%	0,3	0,019
B	10	25%	75%	0%	0%	0,5	0,038
DK	23	7%	40%	0%	52%	0,0	0,000
FIN	23	0%	36%	3%	61%	0,3	0,024
F	77	30%	60%	0%	10%	3,8	0,268
D	191	29%	61%	0%	10%	6,5	0,459
GR	0	3%	55%	1%	41%	0,0	0,001
IRL	0	0%	0%	0%	0%	0,0	0,000
I	59	67%	0%	0%	33%	1,5	0,088
L	0	0%	0%	0%	0%	0,0	0,000
NL	22	94%	0%	0%	6%	1,1	0,068
P	0	0%	0%	0%	0%	0,0	0,000
E	24	3%	46%	50%	2%	0,2	0,018
S	54	0%	30%	15%	30%	0,0	0,000
UK	372	86%	10%	0%	4%	19,3	1,188
EU15	**866**	**54%**	**29%**	**3%**	**12%**	**33,6**	**2,2**

Table 5: Savings of energy and CO_2-emissions in sanitary hot water preparation of the households in 2005 (EU15)

Source: MURE Database (1999)

	Total energy consumption PJ	Share of space heating	Consumption for existing buildings concerning different fuels for space heating 1995 PJ				Energy savings 2005	
			gas	oil	electric	coal	PJ	mio. t CO2
A	95	61%	26	27	3	2	1,1	0,1
B	226	72%	79	84	0	0	5,6	0,4
DK	90	70%	28	33	2	0	0,0	0,0
FIN	77	75%	10	47	1	0	0,8	0,1
F	1.311	29%	178	178	26	0	5,6	0,3
D	1.426	63%	440	430	0	25	21,0	1,6
GR	94	40%	0	36	1	0	0,7	0,1
IRL	59	70%	8	33	1	0	2,1	0,2
I	523	55%	130	145	9	4	5,5	0,4
L	10	72%	3	3	0	0	0,2	0,0
NL	305	67%	178	21	5	1	6,5	0,4
P	19	37%	3	3	0	0	0,1	0,0
E	244	38%	14	70	7	1	0,4	0,0
S	186	53%	6	56	36	0	0,0	0,0
UK	972	61%	417	143	15	18	17,2	1,3
EU15	**5.638**	**53%**	**1.520**	**1.309**	**107**	**51**	**66,8**	**4,8**

Table 6: Savings of energy and CO_2-emissions in space heating in the tertiary sector in 2005 (EU15)

Source: MURE Database (1999)

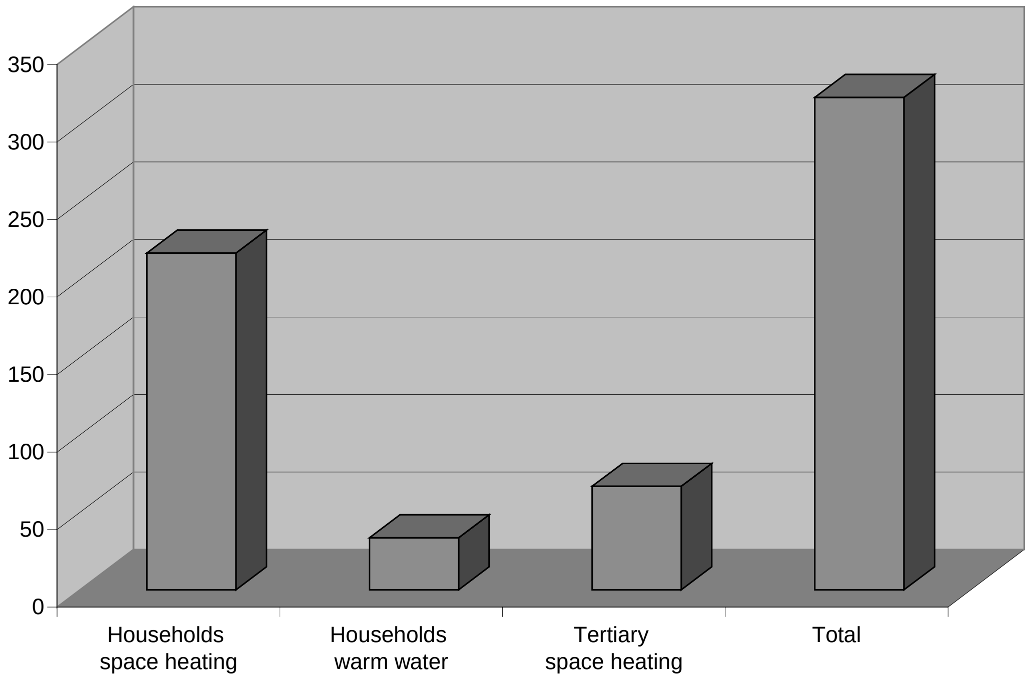

Figure 2 Energy savings in 2005 in the residential and tertiary sector due to the EU boiler Directive 92/42/EEC (static approach)

6 Calculation of energy savings in 2010 in the EU15 (scenario approach)

In difference to the previous chapter, the current chapter describes in a scenario approach the energy savings calculated for space heating in the household sector for 2010. The scenarios are calculated to investigate the interaction with building insulation measures which tend to decrease the savings from the boiler Directive. The three scenarios considered are:

- scenario A: the static approach already described, based on the 1995 demand for heating (no new regulation to improve thermal insulation standards)
- scenario B: new regulation to improve thermal insulation of new buildings (Danish Standard)
- scenario C: new regulation to improve thermal insulation of new buildings (Danish Standard) + intensification of insulation of old buildings

The scenarios so constructed are still not full scenarios in the sense that they assume a constant population (see the Annex 2 where this was introduced for the example of Germany), constant comfort levels and constant fuel split. Therefore they tend to underestimate the savings, as all three factors act to increase the savings (slightly growing population, increase in living standard with increased demand for heating and hot water, fuel shift in favour of new gas-fired systems concerned by the Directive. For the third factor, the main savings are, however related to the fuel substitution itself, which cannot be imputed directly to the boiler Directive (although it is clear that the higher efficiency levels required and additional such as in Germany that only low-temperature boilers are admitted, forces the fuel substitution towards gas. The exact impact of the Directive on the fuel substitution itself is hard to evaluate.

The results are shown in Table 7 and, for the CO_2 –emissions, in Figure 3. In the Scenario A no new national regulations to reduce the space heating are considered. So the data are just extrapolating the results of chapter 5 in the same static approach from 2005 to 2010.

In the Scenario B it is assumed, that new regulation claims better heat insulation of newly constructed buildings, starting at a certain year. In fact, in some Member countries a revision of the national thermal insulation regulation is planned. The year for which the further tightening of the thermal insulation standard is planned, is taken in the calculations as the year of revisions. For the other countries a revision was suggested in 2005. The type of insulation is chosen corresponding to the Danish insulation regulations (Eichhammer/Schlomann, 1998). This does not mean that the same k-values for insulation as in the Danish standard were chosen but an insulation level which would lead in a warmer climate to the same consumption of space heat in a building with an identical geometry than in Denmark. By using special materials like “Aerogels” it is possible to get an even better insulation (1 to 2 orders of magnitudes down from present level). This materials are used at present for insulating liquid hydrogen (Degen *et al.*, 1992). But from today’s point of view they are much too expensive. The overall effect of the boiler directive is 18 PJ lower than in Scenario A.

Building on the assumptions of Scenario B, in the Scenario C not only new buildings but also a considerable amount of 4 % of old buildings is insulated annually. This is assumed to occur in the renovation cycle which leads to fairly acceptable costs for the measure, as part of the costs occur anyhow while the building is renovated and can therefore not be imputed to energy efficiency. It is further assumed, that the heating demand after the insulating measure is 50 % of the demand before (see for example Bundesministerium für Umwelt, Jugend und Familie, 1998). Scenario C takes into account, that one must insulate the existing buildings to lower the space heating demand in a country in a relatively short time. Every newly constructed building will increase the heat demand , may it as good isolated as possible (Gertis, 1991). The savings in Europe through the boiler directive in Scenario C are 70 PJ lower than in Scenario A., see Table 7.

From this result it clearly appears that insulating existing buildings would, over the next decade, considerably reduce the impact of the boiler Directive (- 20 % compared to - 5 % less energy savings in the case of tighter building regulations for new buildings only).

The scenario approach described here only considered space heating in the household sector. Similar results can be shown for the tertiary sector while the savings in the case of warm water would naturally not be influenced by any change in the building insulation standard (see summary results in Figure 3).

	Revision[1] of national thermal insulation regulation planned for	Energy savings 2010					
		Scenario A (status quo)		Scenario B (better insulation of new buildings)		Scenario C (insulation of new and old buildings)	
		PJ	mio. t CO_2	PJ	mio. t CO_2	PJ	mio. t CO_2
A	*2005*	11,78	0,82	11,37	0,79	10,25	0,71
B	1999	26,68	1,83	24,45	1,68	19,23	1,32
DK	2005	0,00	0,00	0,00	0,00	0,00	0,00
FIN	2003	2,15	0,16	2,04	0,16	1,76	0,13
F	*2005*	62,11	4,19	60,25	4,07	54,35	3,67
D	2000	103,98	7,09	97,22	6,63	78,50	5,36
GR	*2005*	3,56	0,27	3,46	0,26	3,13	0,24
IRL	*2005*	3,43	0,24	3,32	0,24	2,99	0,21
I	*2005*	37,24	2,42	35,90	2,33	32,36	2,10
L	*2005*	0,38	0,03	0,36	0,02	0,33	0,02
NL	2001	27,71	1,65	26,26	1,57	21,72	1,30
P	*2005*	0,01	0,00	0,01	0,00	0,01	0,00
E	*2005*	2,03	0,14	1,97	0,13	1,77	0,12
S	*2005*	0,00	0,00	0,00	0,00	0,00	0,00
UK	2001	71,83	4,34	67,72	4,10	55,95	3,38
EU15		**352,89**	**23,19**	**334,34**	**21,97**	**282,36**	**18,56**

[1] years in italic are set by default

Table 7: Savings of energy and CO_2-emissions in the households in 2010 in the scenarios A,B and C (EU15, space heating only)

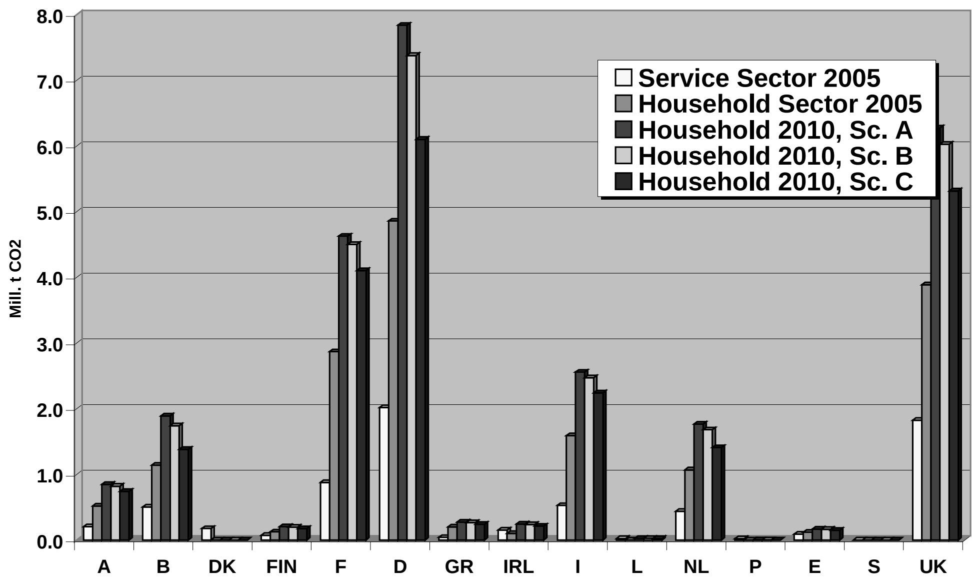

Figure 3: CO_2 savings in 2005 following the EU Directive 92/42/EEC on boiler efficiencies from 1992 (space heating and hot water)

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Annex 1

Information concerning MURE

Designing and evaluating RUE strategies for Europe.

When, in the early 90s, the SAVE programme provided the initial funding for the MURE project, its main objective was to establish a database of Rational Use of Energy (RUE) measures and policies in the EU member states, to serve as permanent, dedicated information basis and monitoring tool. Since then, and thanks to further substantial funding from SAVE, MURE has grown into a full fledged policy support system, allowing to build and run RUE scenarios at the national and European level. It is now recognised as a unique tool providing full coverage of national and European RUE policies and allowing for Europe-wide, across-country comparisons and analyses.

MURE has been adopted by the Directorate General for Energy of the EU for the *ex ante* evaluation of RUE measures and policies. It is extensively used, among other, to calculate the energy savings technical potential of national and European policies based on the promotion of energy efficient technologies in all end-use sectors (household, transport, industry and the services sector), feeding into the debates on energy strategies and the diffusion of Best Available Technologies (BAT) currently carried out at the EU Council and EU Parliament level.

The MURE team.

MURE (***M****esures d'****U****tilisation* ***R****ationnelle de l'****E****nergie*) has been designed and developed by a team of European experts, led and co-ordinated by ISIS (***I****stituto di* ***S****tudi per l'****I****nformatica e i* ***S****istemi - Rome*). The MURE team further includes INESTENE (F), ISI-Fraunhofer (G) and March Consulting Group (UK). A permanent network of correspondents established in all other Member States guarantees the continuous updating of the database.

Main features of MURE.

MURE has three main components:

- a qualitative database of measures undertaken by the 15 Member States of the EU to promote energy conservation in four end-use sectors: Households, Transport, Industry and Tertiary (the services sector). Measures may be legislative, normative, fiscal and financial, but also information campaigns, energy audits, etc.
- a quantitative database of energy related statistics covering the 15 EU Countries and desegregated by end-use sector
- a simulation tool to carry out calculations of energy savings and emissions reduction potentials in each of the four sectors.

The database of measures currently includes some 1000 items, consistently described and classified according to specific keywords, thus allowing to carry out queries based on such descriptors as, e.g. the nature of the measure, the targeted audience, the technologies involved, etc.

Building RUE scenarios with MURE.

The MURE scenarios are built and run on the basis of sets of assumptions concerning mainly two types of variables:

- the energy performance of technologies
- the expected penetration rates of energy efficient technologies (see Figure 1)

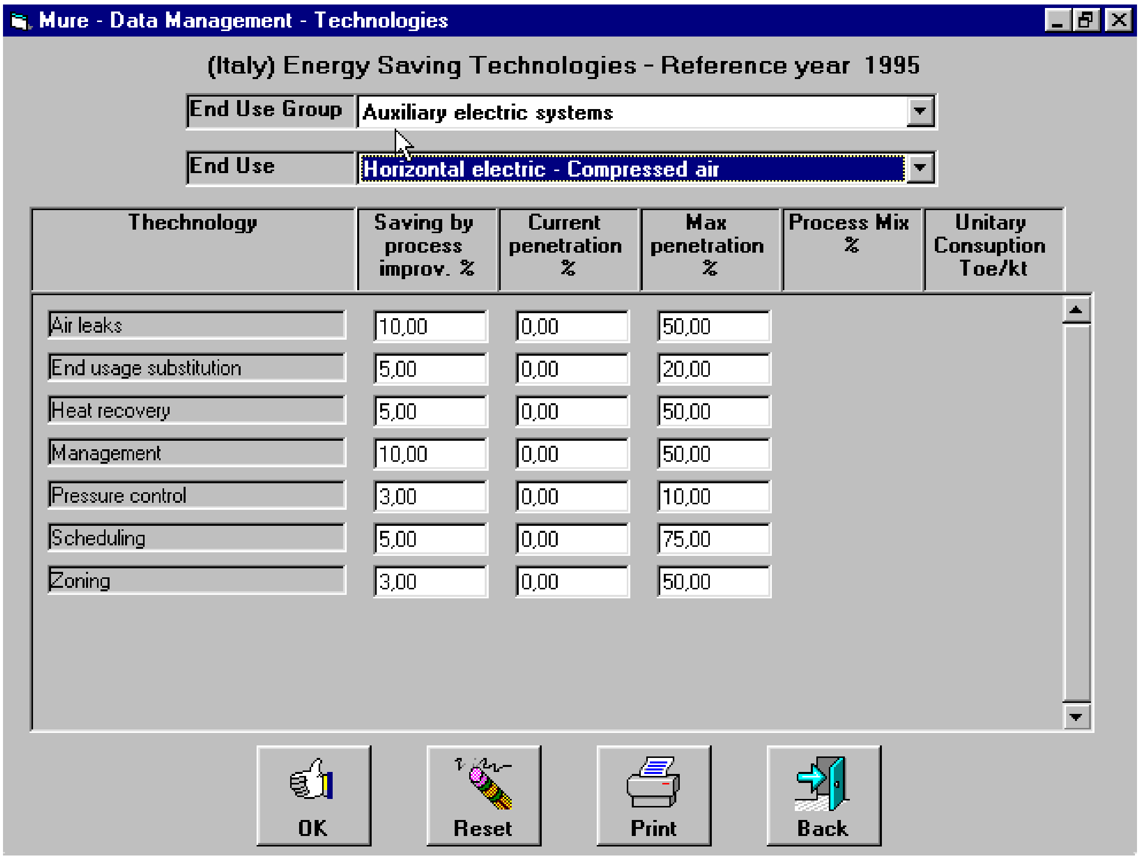


Fig. 1

MURE is therefore a bottom-up, technology-related simulation tool, allowing to:

- choose the end-use sector for the simulation (household or transport or industry or tertiary)
- identify and select the scope of the interventions (or policies) that one wants to simulate, for instance, deciding to look only at building insulation, or at boilers efficiency, etc., or at whatever combination of those

- describe the interventions in detail. This means, for instance, deciding that, within the end of the period analysed in the scenario, the entire stock of newly installed appliances will belong to a given labelling Class, or, for what industrial boilers are concerned, that the EU relevant Directives will be fully enforced, etc. This can be done in a more or less detailed and elaborated way: for instance, for what concerns retrofitting interventions on the insulation of existing buildings (see Figure 2), one may enter into such details as the selection of the insulation material for each building component, the thickness of the layer of insulating material, etc.

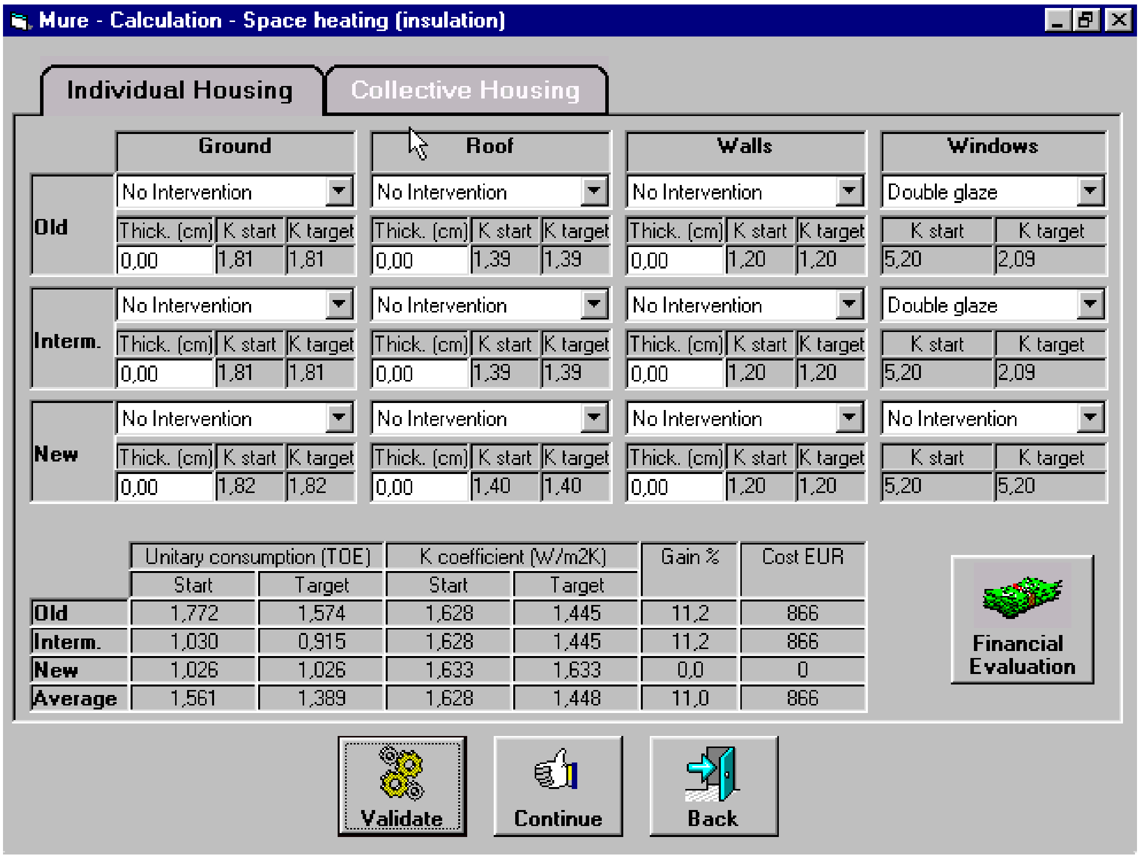


Fig. 2

- make assumptions on the future performance of the technologies (or devices, etc.) involved by the interventions that one has selected. In principle, all such values are already in the MURE database, and, when preparing the scenario, one may simply validate the proposed values, such as, for instance, the reference efficiency of a given class of appliances, or the expected efficiency gains to be expected from the introduction of variable speed motors, etc. However, one may, at this stage, introduce his/her own assumptions concerning this or that technology, if the default values suggested by the database are deemed unrealistic (this could happen, for instance, for the target value proposed by MURE for the average efficiency of future gas boilers, or of solar water heating systems, etc.)
- make assumptions on the future penetration rates that can be expected for each of the envisaged technologies. This means deciding on which share of the total stock (of

appliances, of buildings, of boilers, etc.), the previously described intervention will be actually carried out. This may be quite simple for such interventions as the application of the building codes, for which the most obvious thing to do is use a 100 % share applied to new construction, i.e. all new buildings will conform to the codes. It can be much trickier for other interventions, such as the introduction of advanced industrial production processes, for which the expected rate of penetration clearly depends on the nature of the incentives, if any, and, generally speaking, on a number of behavioural aspects which are not explicitly described in MURE. In such cases, the experience of the analyst defining the scenario is clearly crucial if realistic assumptions must be made

- at this point, MURE runs the calculations, through a sequential process which is thoroughly described both in the manuals and in the actual interactive simulation process, and produces results in terms of technical energy savings potential corresponding to the entire (and cumulated) set of interventions that one has selected. The results are automatically compared to the so-called reference scenario (see Figures 3 and 4). This is meant to be the typical "business as usual" scenario, where reference consumptions, and the evolution of the existing stocks, are roughly extrapolated based on the start-year values as well as on some basic assumptions on variables such as the expected net growth of the number of buildings (there is however some degree of freedom which is left to the user for what concerns the definition of the reference scenario).

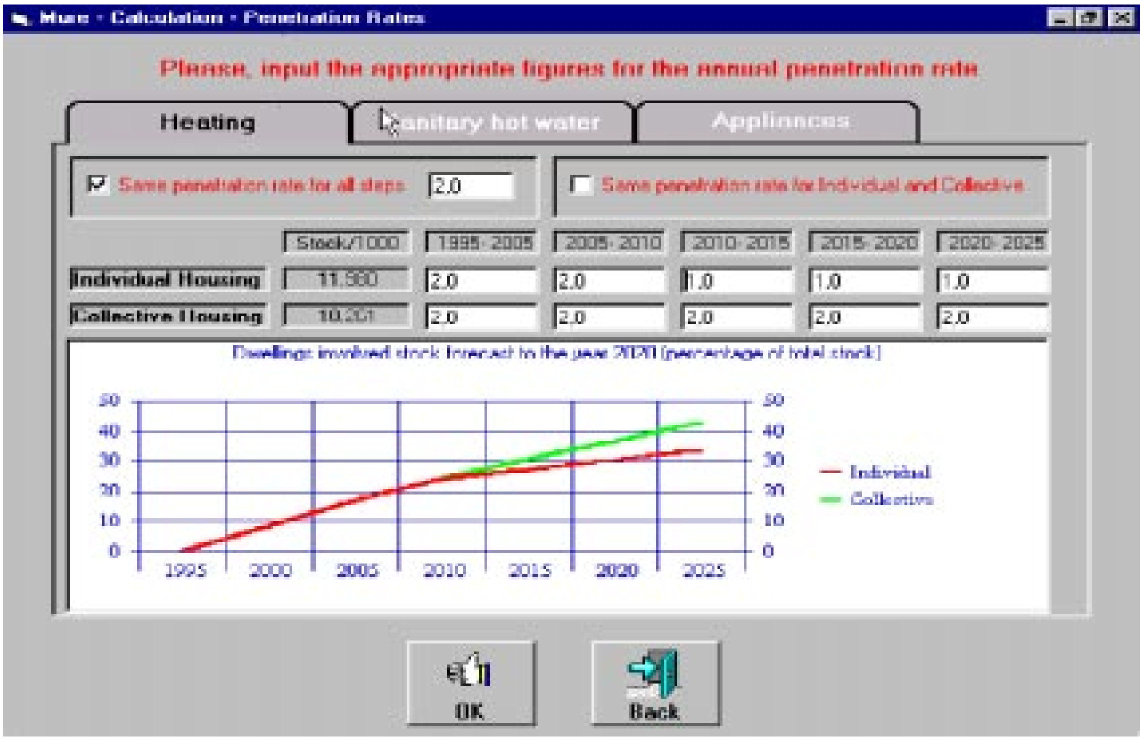


Fig 3

Mure - Calculation - Global Results

View Output Comparison Back

Total Housing	1995	2005	2010	2015	2020	2025
Stock Dwellings/1000	22.241	24.076	24.802	25.423	25.801	25.925
Stock Hot water Systems/1000	20.800	22.334	22.660	22.991	23.042	23.093
Stock Appliances/1000	113.370	130.296	137.494	145.237	151.275	157.670
Involved Stock Dwellings/1000	0	4.069	5.991	7.798	9.491	11.058
Involved Stock Hot water Syster	0	0	0	0	0	0
Involved Stock Appliances/100(	0	0	0	0	0	0
Reference Consumption (kTOE)	37.508,11	39.842,95	40.715,16	41.512,22	41.991,38	42.262,23
Target Consumption (kTOE)	37.508,11	39.485,29	40.192,01	40.834,72	41.170,30	41.308,91
Energy Saved (kTOE)	0,00	357,66	523,16	677,50	821,07	953,32
Energy Saved (gain %)	0,00	0,90	1,28	1,63	1,96	2,26
CO2 reference emission (Ton)	131.816	141.058	144.493	147.771	149.801	151.269
CO2 target emission (Ton)	131.816	140.029	142.988	145.822	147.439	148.527
NOx reference emission (Ton)	97	104	106	109	110	111
NOx target emission (Ton)	97	103	105	107	108	109
SOx reference emission (Ton)	227	241	246	251	254	256
SOx target emission (Ton)	227	239	243	247	249	250
CO reference emission (Ton)	1.358	1.433	1.463	1.488	1.504	1.510
CO target emission (Ton)	1.358	1.417	1.439	1.458	1.467	1.467
VOC reference emission (Ton)	150	159	163	166	168	170
VOC target emission (Ton)	150	158	161	163	165	166
PM reference emission (Ton)	62	65	67	68	69	69
PM target emission (Ton)	62	65	66	67	67	67

Fig 4

In conclusion, as explained above, MURE looks at the impact on energy consumptions of technology related assumptions, mainly dealing with issues such as:

- How efficient future technologies will be?
- How effective energy policies will be in promoting efficient technologies?
- How much energy can be saved, and pollutant emission reduced, if the assumptions made on the two previous issues are realistic?

The basic simulation logic is the same for all end-use sectors; there are however some important differences from one sector to another.

For instance, as far as industry and tertiary are concerned, the assumptions on future penetration rates of energy efficient technologies are facilitated through proposed values, which correspond to the so-called "maximum penetration rates" (i.e.: considering the current structure of industry, and the very nature of the processes, what is the limit beyond which it is deemed unfeasible to introduce new and more efficient technologies?). These values, which are made available by the MURE database and which the analyst can visualise while proceeding with the simulation, are drawn from sectoral studies available at the national and European level.

In the following sections, two examples of RUE scenarios are presented, together with the corresponding results obtained through MURE simulation.

MURE in perspective.

Since its first version was issued, MURE has been widely diffused, and its use is becoming increasingly popular throughout European Energy Agencies and energy planning institutions, at both the national and local level. The inclusion of additional Countries in the database is currently planned, with particular regard to EU neighbours, as a means to ensure consistency and comparability of RUE strategies and studies within wider regions of the world.

To support the dissemination of MURE, the project team has undertaken a variety of initiatives, including:

- the publication of a periodic, dedicated newsletter, MureNews, available at no charge upon subscription request
- a series of presentation seminars and training sessions, organised at national and local level
- the establishment of a MURE website - www.mure2.com – (a download of a free demo-version of the database is envisaged)

Specific agreements can further be made with interested users for the access to the full MURE system (available in CD-ROM) and services, including customisation and the extension to new countries.

The MURE Sectors in deep

HOUSEHOLD

The module covers all relevant household end-uses, i.e. space heating, appliances and hot sanitary water. The quantitative database therefore includes data on stocks and energy consumption of :

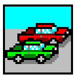
- the individual and collective buildings split by age and type of fuel;
- appliances and lighting systems;
- hot sanitary water systems and devices, split by type of fuel and installation (separated or combined);

as well as complementary technical, economic parameters and forecast data on:

- heating system efficiencies;

- building insulation parameters by building type and components (windows, walls, floor and roof);
- appliances efficiency and energy performances;
- emission factors of the main air pollutants generated by heating systems;
- energy saving technologies installation costs and other financial data;
- stock growth-rates.

The MURE tool allows to simulate the impact of RUE interventions such as:
- building insulation
- boiler substitution and maintenance
- heat pump or solar panels installation
- co-generation district heating connection
- heating control device implementation
- appliances substitution



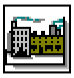
TRANSPORT

The transport module allows to simulate the impact of energy efficient measures on the whole transport system of a given country with particular emphasis on the private (cars) transport mode. Based on the disaggregated data stored in the quantitative database , MURE generates the energy demand by mode and fuel and provides information on energy savings and avoided pollutant emissions for any given RUE scenario. The main quantitative available data concern:
- stocks and registrations of private cars by age, engine size and fuel;
- unit consumptions of new cars by engine size, fuel and travelling area (urban, interurban);
- travelled distance (mileage) by area and fuel;
- traffic and unit consumption data for collective passenger modes;
- traffic and unit consumption for freight modes;
- emission factors.

Moreover MURE transport allows to set up reference transport scenarios, providing forecast values for:
- the car stock growth-rate by fuel;
- specific consumptions and travelled distance trends
- collective passenger mobility trends;
- freight transport traffic trends.

RUE scenarios are built to simulate the impact of technical and non technical energy saving interventions such as:

- car technical improvements (engines, materials, aerodynamic);
- traffic and private mobility regulation;
- passengers and/or goods modal split.



INDUSTRY

The MURE industry sector allows to analyse the energy savings achievable through the application of energy saving technologies to process energy end uses. The underlying databases therefore cover energy consumptions and efficient technologies. Energy consumption data are broken down by energy source and energy end use for the following industry sectors and sub-sectors:

- Chemicals
- Engineering and metal industries (broken down into four sub-sectors: mechanical and electric engineering, transport means, metal articles)
- Food, drink and tobacco (broken down into four sub-sectors: meat, dairy products, breweries, sugar)
- Iron and steel
- Non ferrous metals (broken down into four sub-sectors: aluminium, copper, zinc, lead)
- Non metallic minerals (broken down into four sub-sectors: cement, building materials, glass, ceramics)
- Paper and board
- Textile, leather and clothing
- Timber and wood products.

A wide variety of end uses are considered and ranked by energy source and application, ranging from horizontal electric uses (electric motors, compressed air, lighting, air conditioning and refrigeration), to heating equipment and devices (boilers, dryers and kilns) and to process specific uses (as e.g. glass melting furnaces, brewing process, pulping process, etc.).

The technology database features a comprehensive list of energy saving technologies, together with the corresponding gains (and , when available, maximum penetration rates) for application to the process energy end uses and the subsequent estimation of potential energy savings.

TERTIARY

The MURE tertiary module allows to estimate energy savings achievable through the application of energy efficient technologies to the energy end uses characterising the public and private services sector. As for industry, databases on energy consumptions and on technologies are provided. The former features consumption data broken down by energy source and energy end use, for the following sub-sectors:

- Commercial offices;
- Public buildings
- Hotels and catering
- Retail
- Sports and leisure
- Distribution and warehousing
- Education
- Health

The energy end uses are ranked by energy source (electric and thermal uses) and each end use is linked to one or more energy saving technologies, as described in the technology database.

Annex 2

Print-outs from the MURE tool

The following example from the MURE database describes a calculation session for Germany

Page 28: **Entrance page**

Entrance page to the MURE Household tool. Allows to prepare the technical parameters for the scenario calculation (technical parameters button), to visualise (and change) the basic data describing the 1995 data (data management button) and to carry out a query or a calculation session (query button)

Page 29-32: **Technical parameters**

Setting of technical parameters such as efficiencies before (page 30) and after intervention (page 31) for oil and gas boilers, stock growth rates for the overall boiler stock which for simplicity reasons was not considered in the case study (page 32). The error, however, is small, given the low growth of population in Europe.

Page 33-39: **Calculation session**

After having chosen the example of Germany one could either first go to a measure (e.g. the German national translation of the EU boiler Directive 42/92/EEC) or directly to the calculation procedure, which is chosen here (page 33).

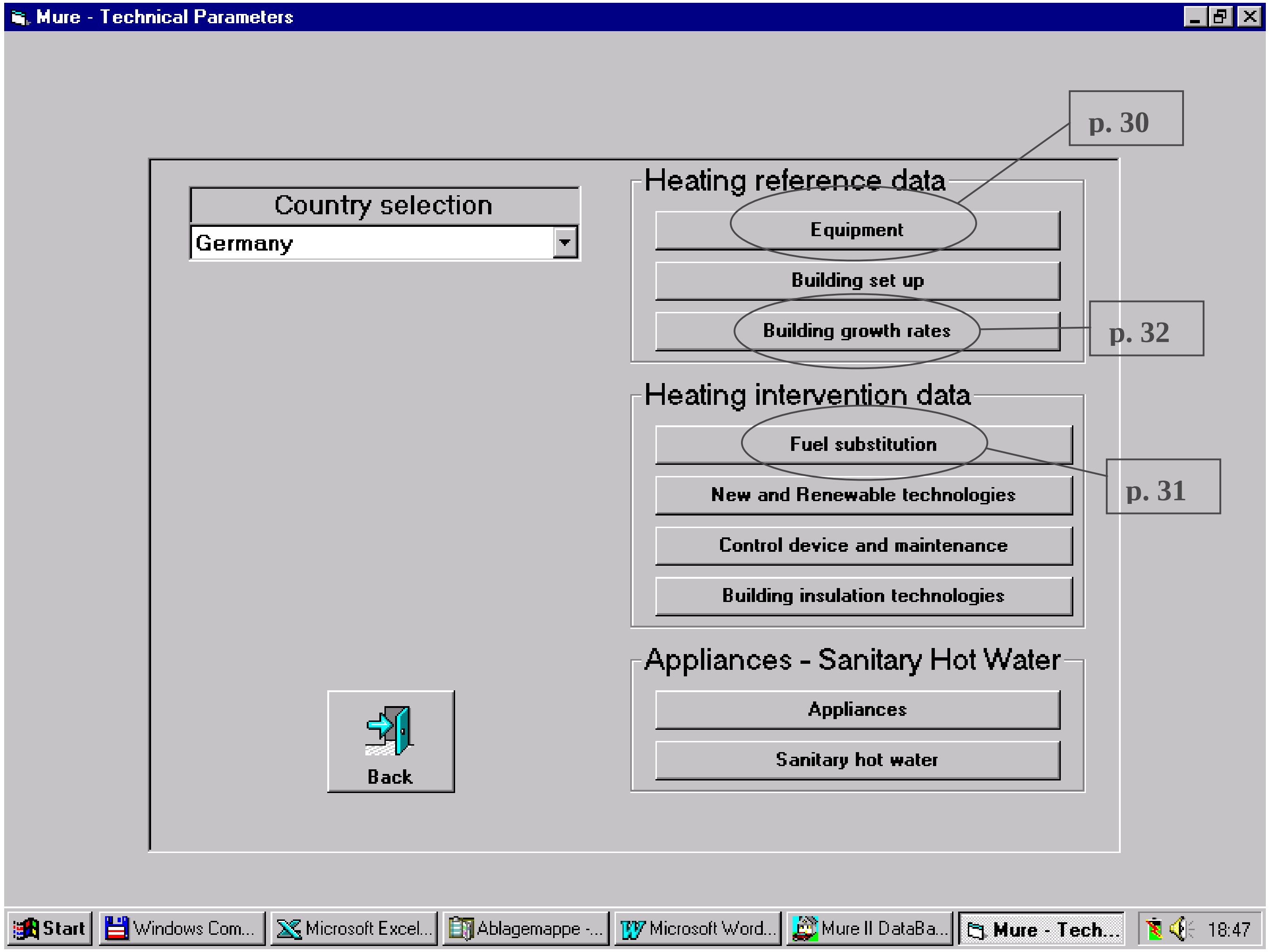
For the simulation of the boiler improvement the button equipment replacement is chosen. One could also chose the buttons heat insulation (which would allow to simulate the interaction with the building codes, as presented in chapter 6) or fuel substitution (which would allow to simulate fuel shift from coal and oil to gas or district heat). For simplicity reasons this was not introduced in the example (page 34).

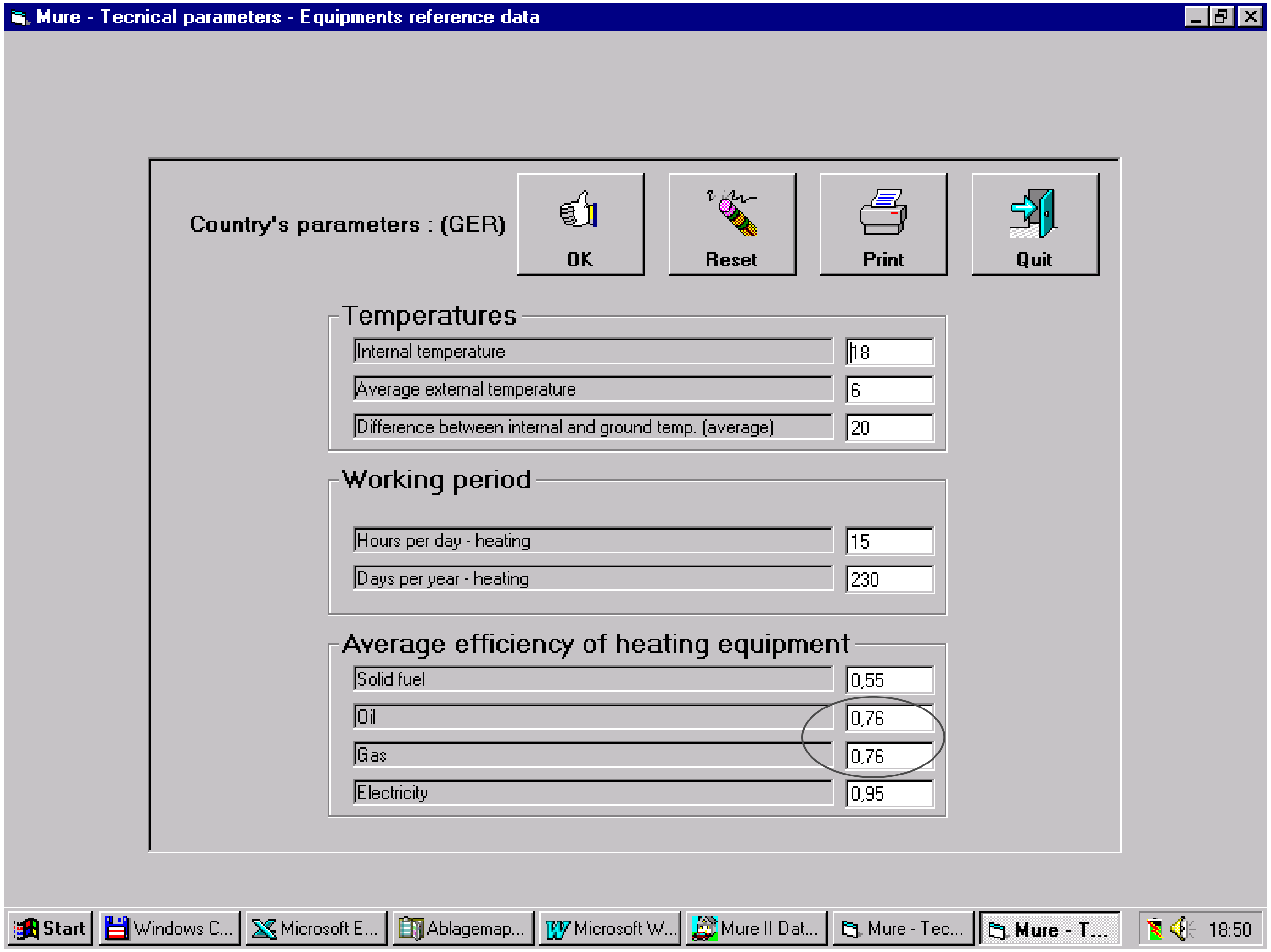
The next screen (page 35) allows to chose the boiler replacement for oil and gas covered by the Directive while coal, electricity etc. remain unchanged. The screen shows the efficiency parameters before and after the intervention, the change in unit consumption etc. The screen would also allow to go for a financial evaluation, which was not specially set up for the example.

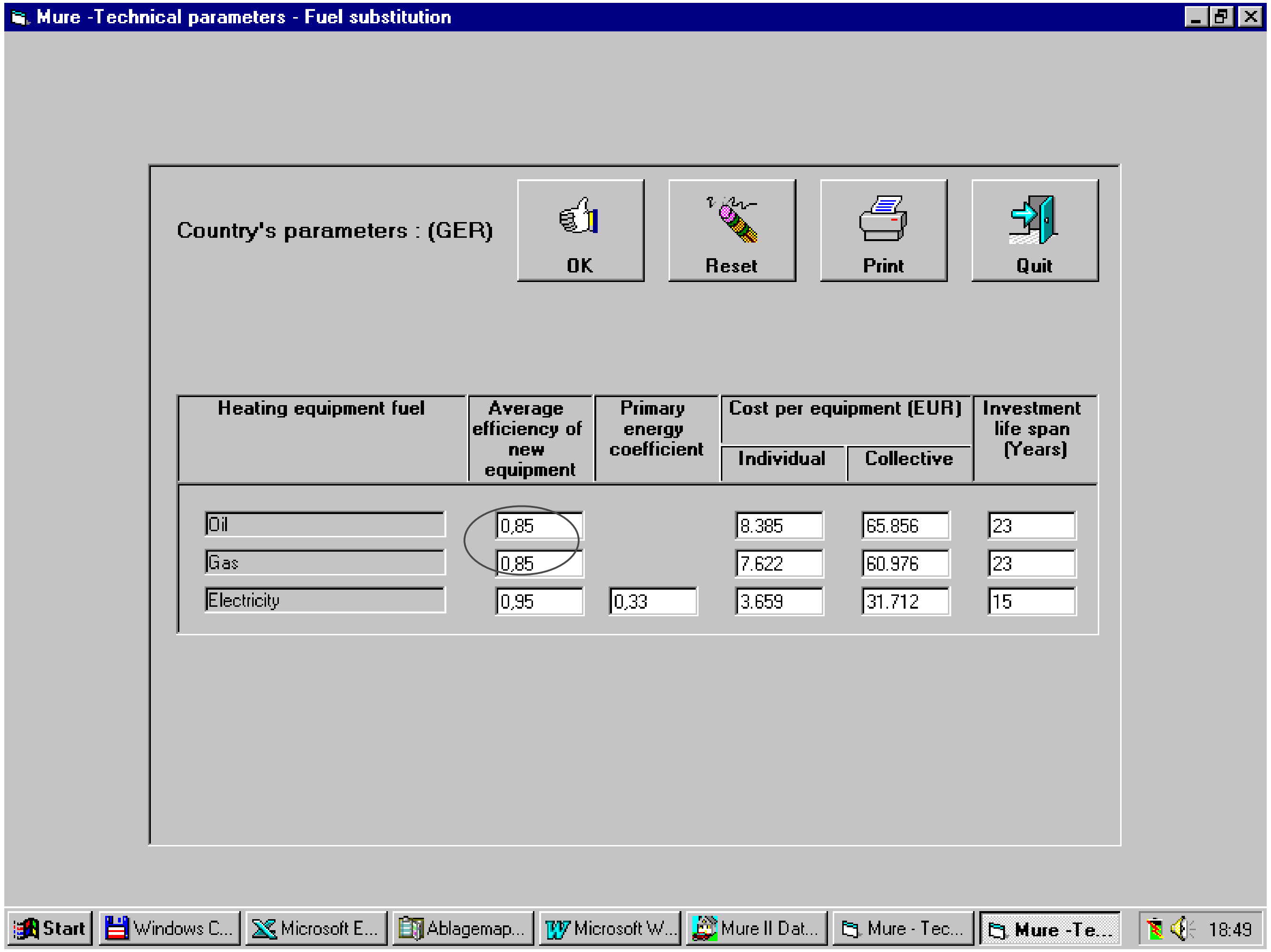
The following pages allow to set bounds in case that not the whole possible stock is concerned (page 36) and show the overall potential and economic calculations over the whole stock considered (page 37). Page 38 allows to chose the parameters for the penetration of the potentially available stock over time. The first growth rate simulates the late start of the boiler Directive in 1998. The approach in MURE is slightly different from the one chosen in the case study. MURE uses a logistics curve which, even after the mean lifetime of the stock has passed, there is still some old stock remaining.

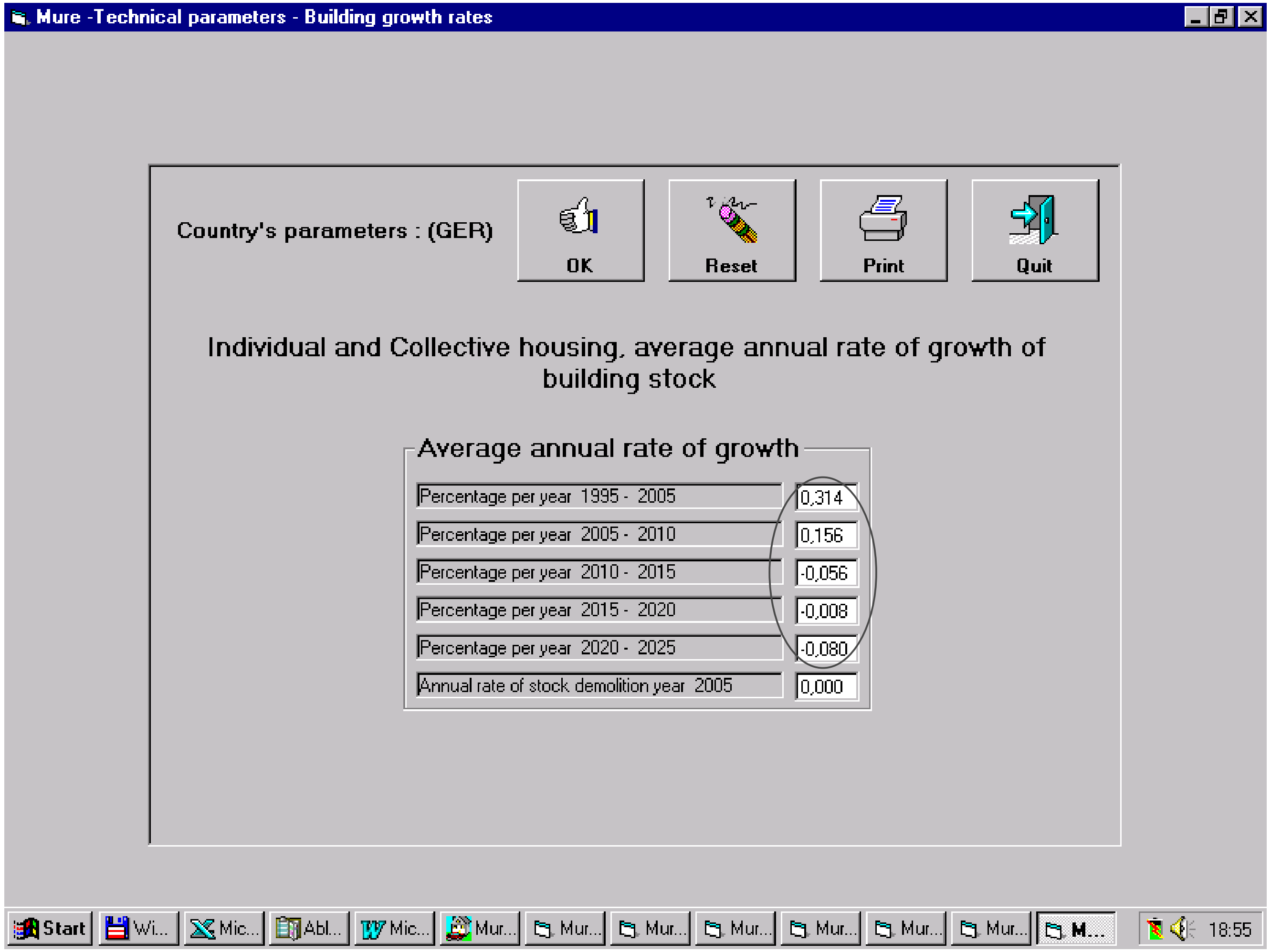
The last page (page 39) resumes the results in form of a scenario (stock involved, energy savings in given years, CO_2-emissions saved and other emissions saved etc. The latter are not visible on the out-print). The results can also be transferred to Excel spreadsheets, printed or presented in graphical form. They can also be saved for further sessions and comparison purposes.

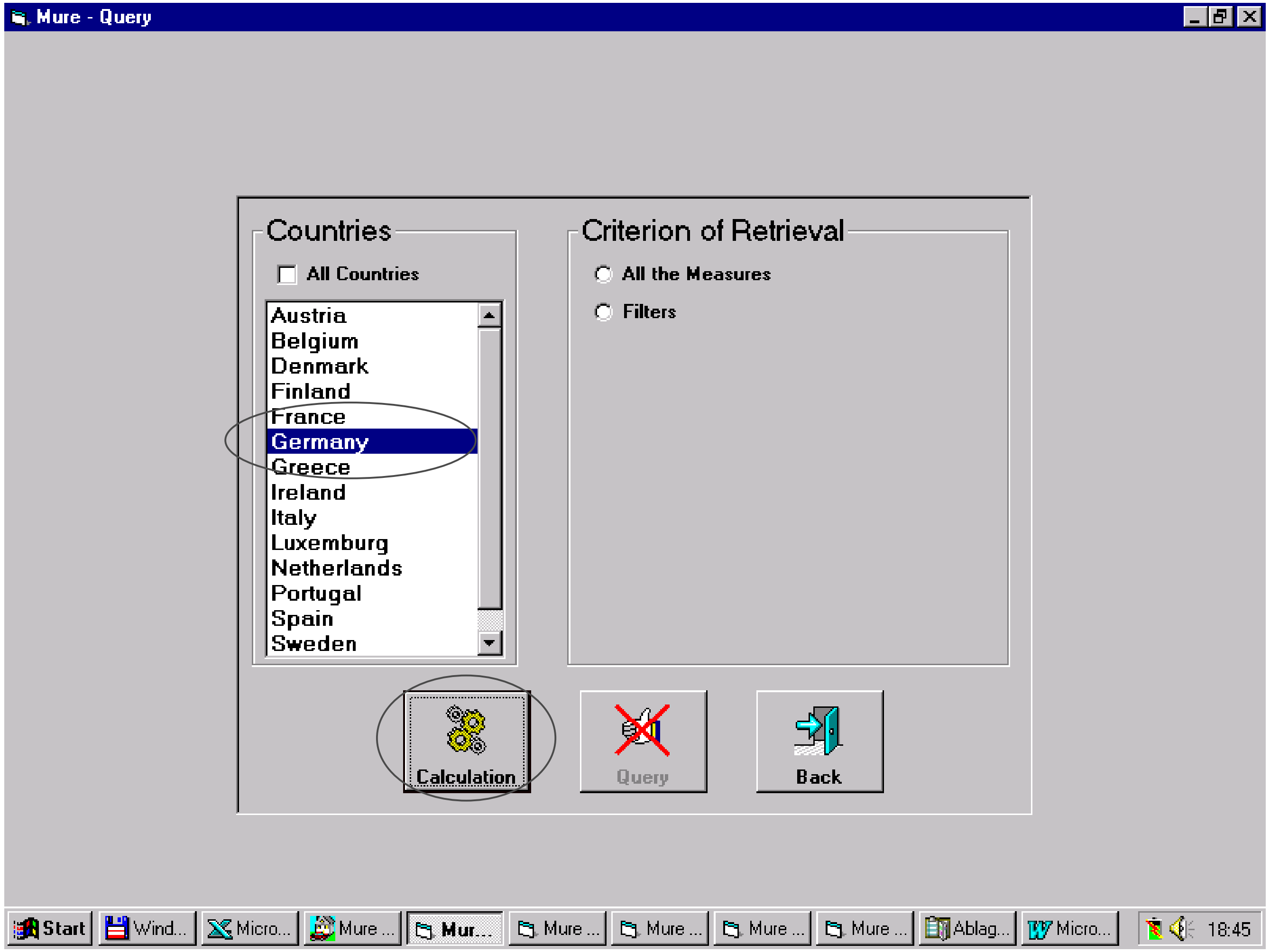

Mure II DataBase - Main
Welcome to the Mure II DataBase
Household
Click on your choice :
Query
Technical parameters
Data Management
Graphs
End of Job
I.S.I.S. Via Flaminia 21 Rome (I) Tel.06/3612920 - email isis@mclink.it
Start
Windows Com...
Microsoft Excel...
Ablagemappe -...
Microsoft Word...
Mure II Dat...
Mure - Technic...
18:48

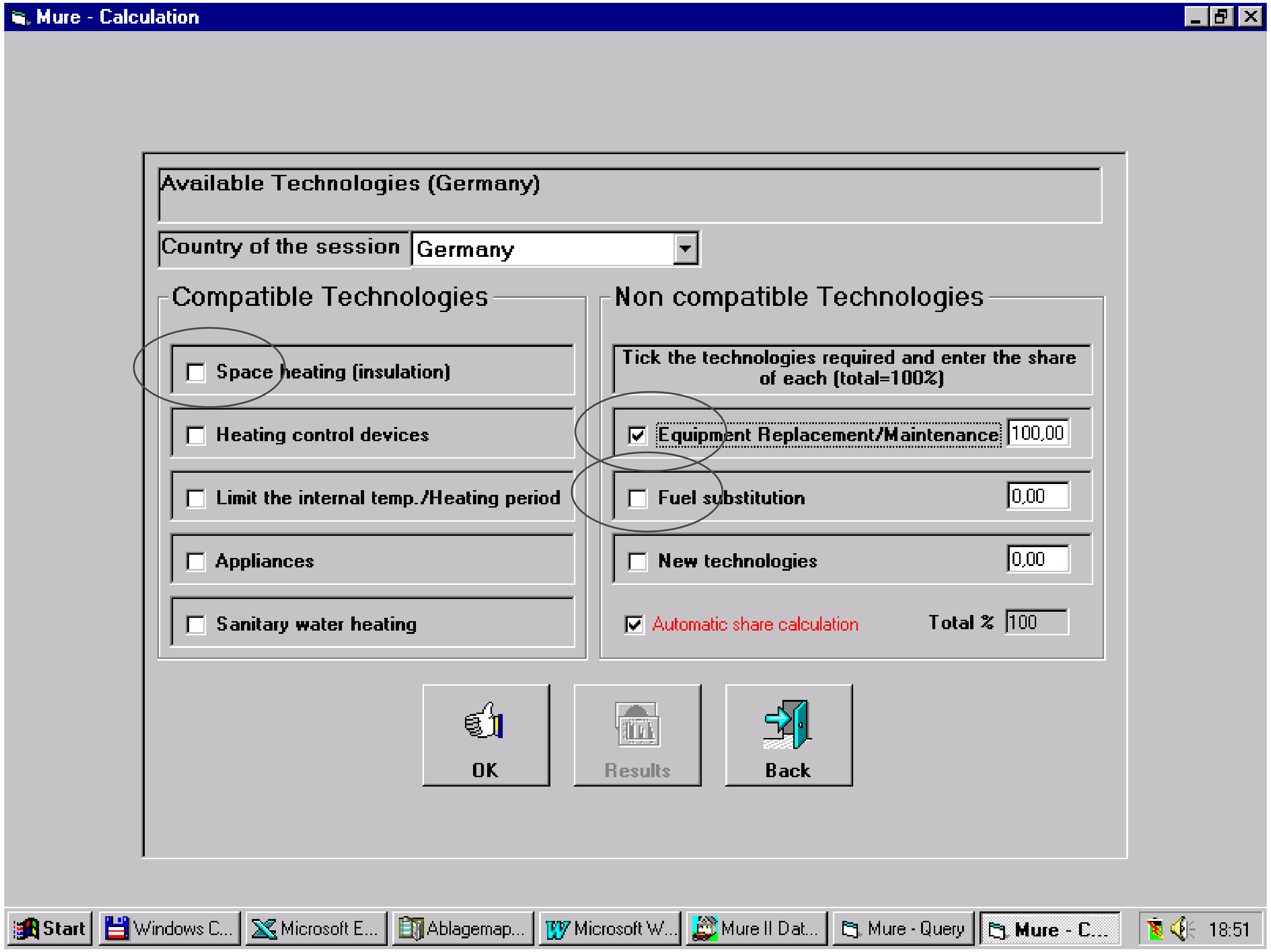

Mure - Technical Parameters
p. 30
Country selection
Germany
Heating reference data
Equipment
Building set up
Building growth rates
p. 32
Heating intervention data
Fuel substitution
p. 31
New and Renewable technologies
Control device and maintenance
Building insulation technologies
Appliances - Sanitary Hot Water
Appliances
Sanitary hot water
Back
Start
Windows Com...
Microsoft Excel...
Ablagemappe -...
Microsoft Word...
Mure II DataBa...
Mure - Tech...
18:47

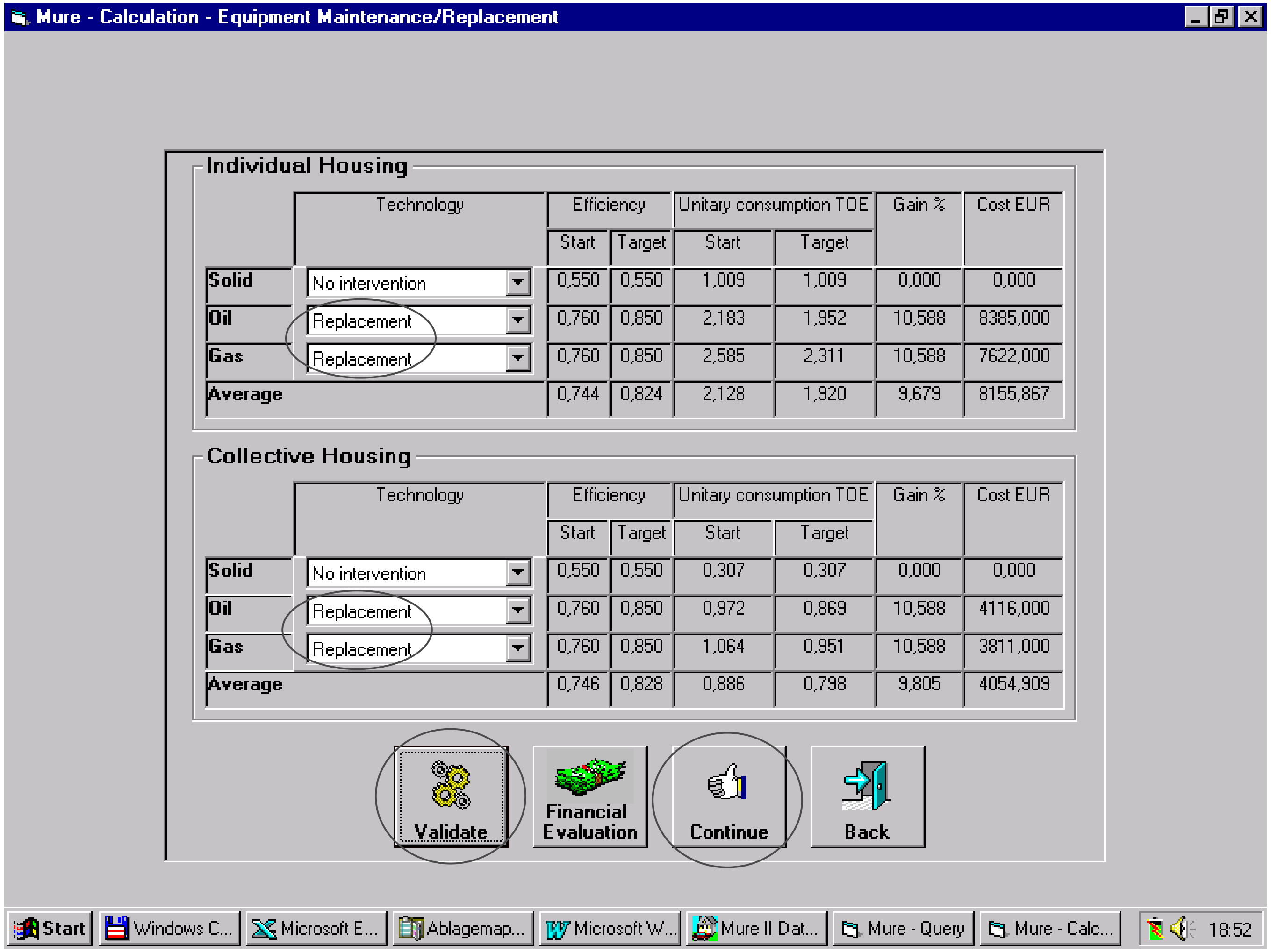

Mure - Tecnical parameters - Equipments reference data
Country's parameters : (GER)
OK
Reset
Print
Quit
Temperatures
Internal temperature
18
Average external temperature
6
Difference between internal and ground temp. (average)
20
Working period
Hours per day - heating
15
Days per year - heating
230
Average efficiency of heating equipment
Solid fuel
0,55
Oil
0,76
Gas
0,76
Electricity
0,95
Start
Windows C...
Microsoft E...
Ablagemap...
Microsoft W...
Mure II Dat...
Mure - Tec...
Mure - T...
18:50


Mure -Technical parameters - Fuel substitution
Country's parameters : (GER)
OK
Reset
Print
Quit
Heating equipment fuel
Average efficiency of new equipment
Primary energy coefficient
Cost per equipment (EUR)
Individual
Collective
Investment life span (Years)
Oil 0,85 8.385 65.856 23
Gas 0,85 7.622 60.976 23
Electricity 0,95 0,33 3.659 31.712 15
Start
Windows C...
Microsoft E...
Ablagemap...
Microsoft W...
Mure II Dat...
Mure - Tec...
Mure -Te...
18:49


Mure -Technical parameters - Building growth rates
Country's parameters : (GER)
OK
Reset
Print
Quit
Individual and Collective housing, average annual rate of growth of building stock
Average annual rate of growth
Percentage per year 1995 - 2005
0,314
Percentage per year 2005 - 2010
0,156
Percentage per year 2010 - 2015
-0,056
Percentage per year 2015 - 2020
-0,008
Percentage per year 2020 - 2025
-0,080
Annual rate of stock demolition year 2005
0,000
Start
18:55


Mure - Query
Countries
All Countries
Austria
Belgium
Denmark
Finland
France
Germany
Greece
Ireland
Italy
Luxemburg
Netherlands
Portugal
Spain
Sweden
Criterion of Retrieval
All the Measures
Filters
Calculation
Query
Back
Start
Wind...
Micro...
Mure ...
Mur...
Mure ...
Mure ...
Mure ...
Mure ...
Ablag...
Micro...
18:45


Mure - Calculation
Available Technologies (Germany)
Country of the session
Germany
Compatible Technologies
Space heating (insulation)
Heating control devices
Limit the internal temp./Heating period
Appliances
Sanitary water heating
Non compatible Technologies
Tick the technologies required and enter the share of each (total=100%)
Equipment Replacement/Maintenance
100,00
Fuel substitution
0,00
New technologies
0,00
Automatic share calculation
Total %
100
OK
Results
Back
Start
Windows C...
Microsoft E...
Ablagemap...
Microsoft W...
Mure II Dat...
Mure - Query
Mure - C...
18:51

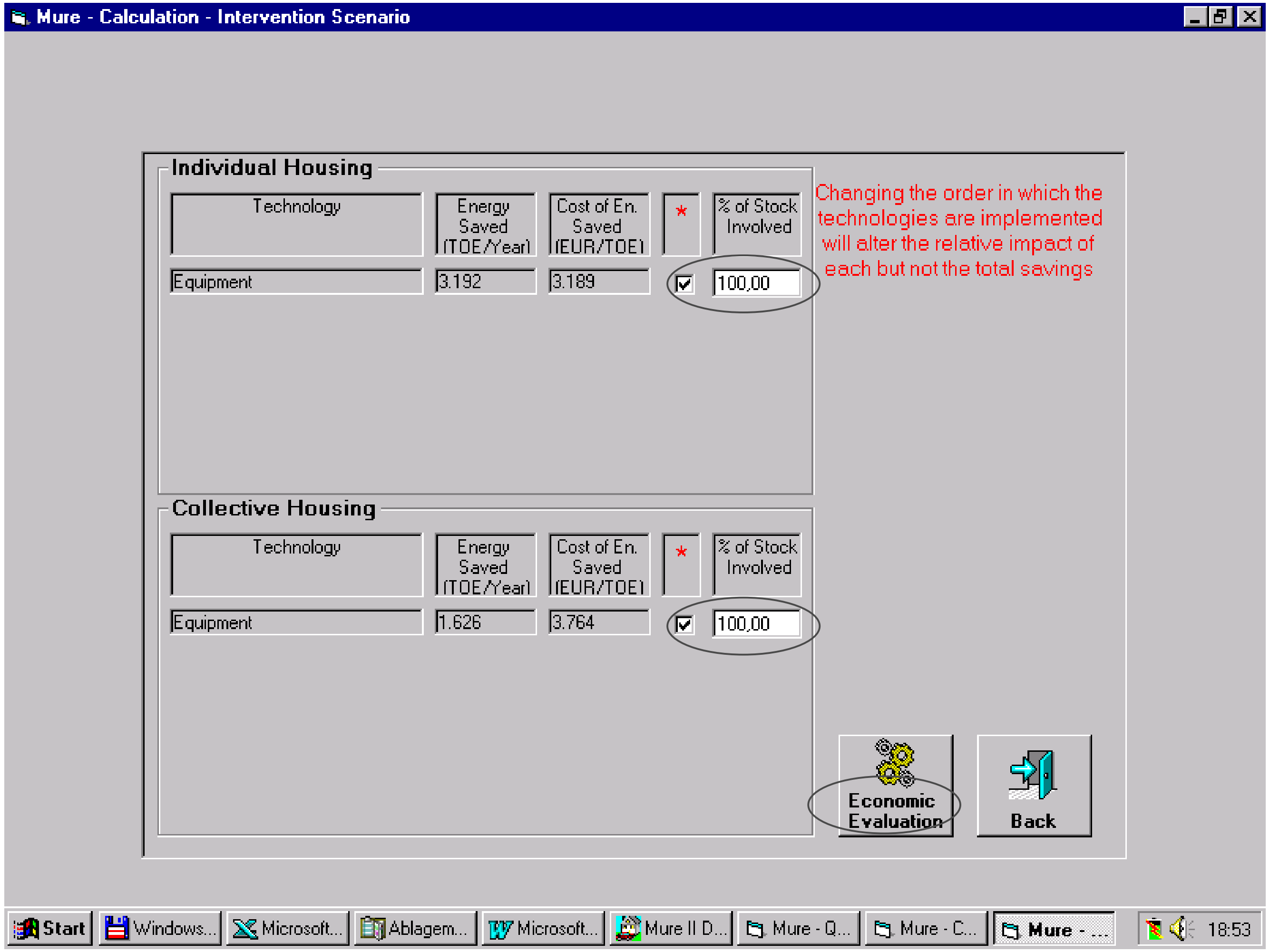


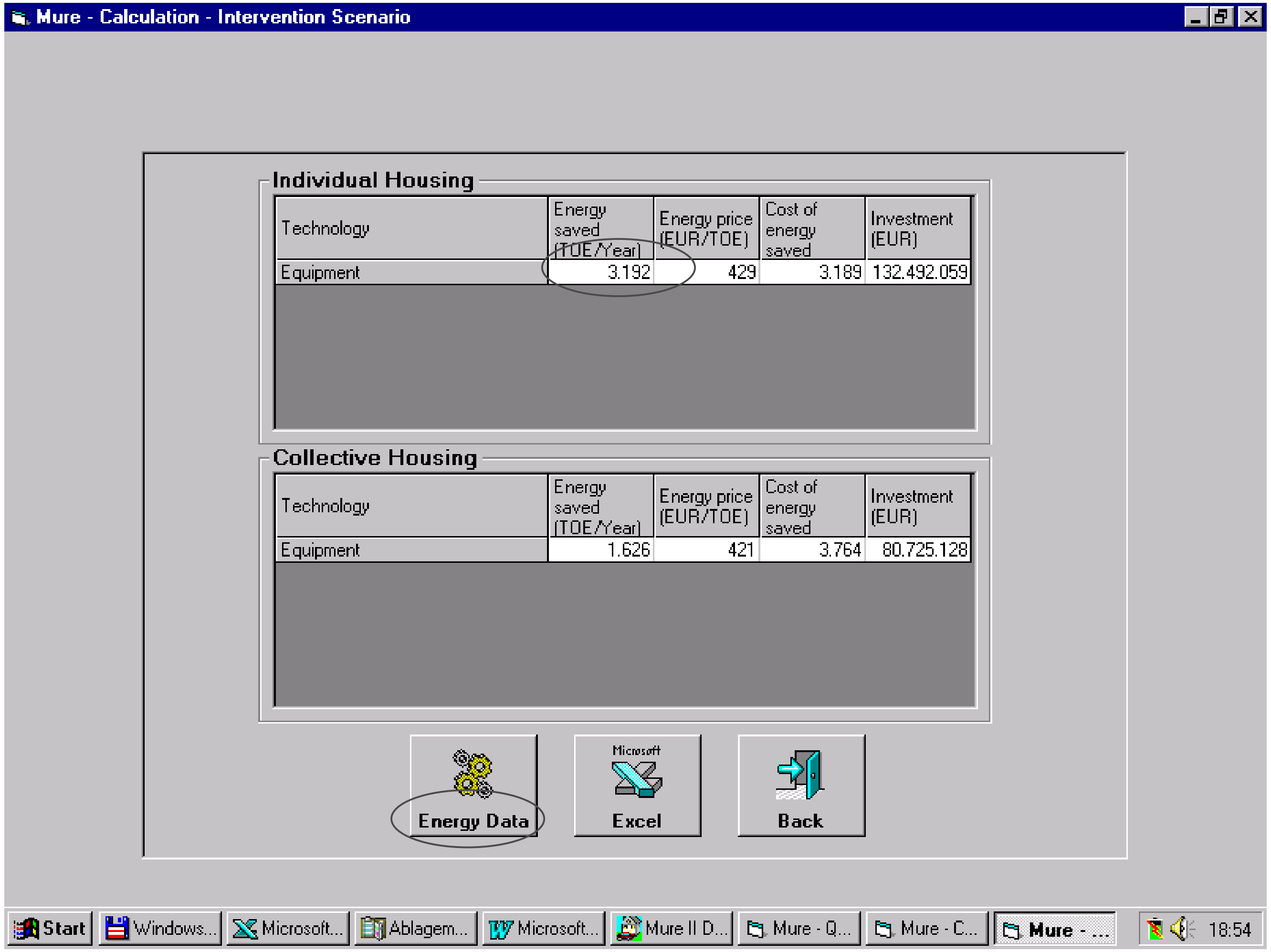
Individual Housing

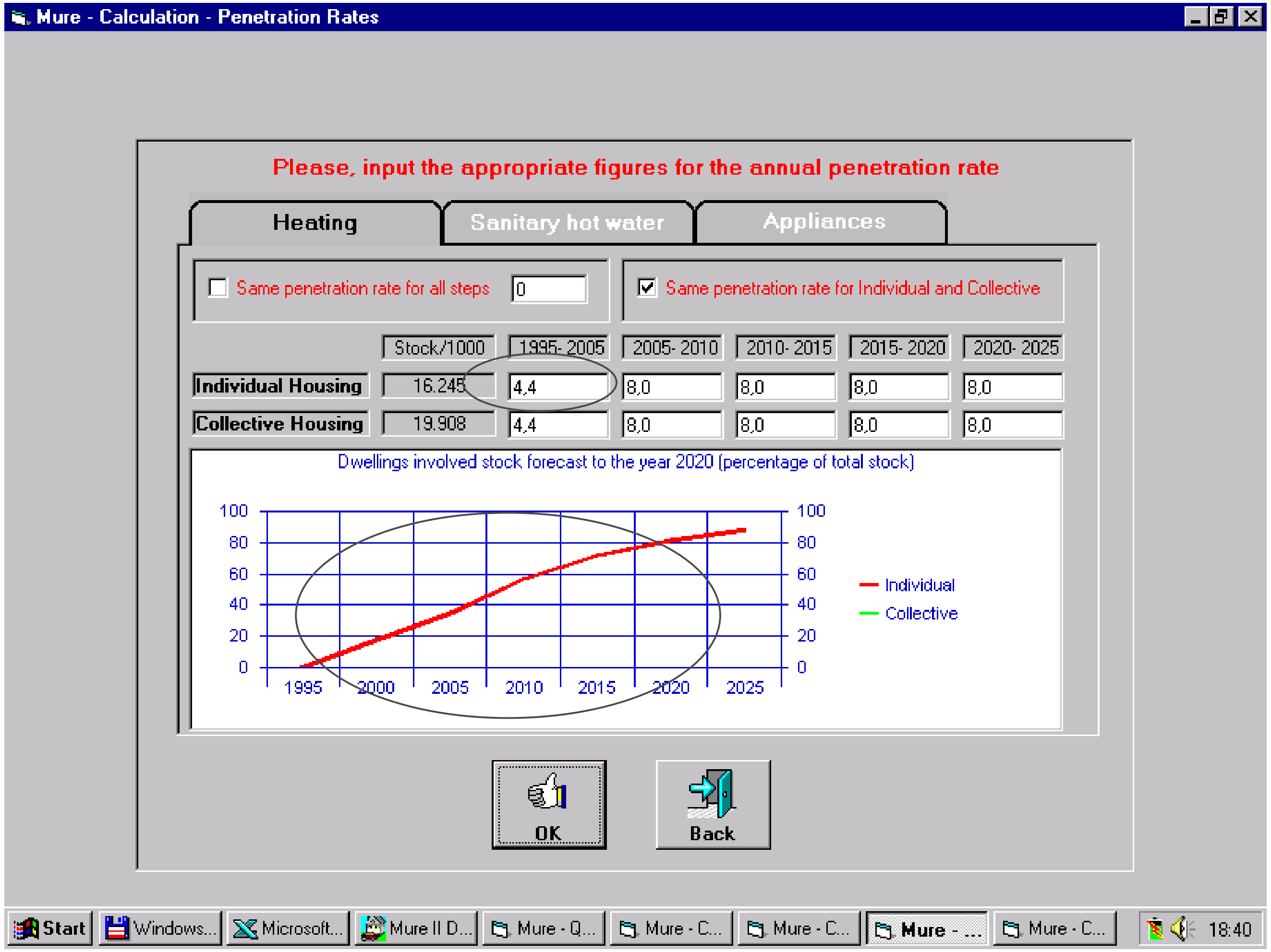
	Technology	Efficiency Start	Efficiency Target	Unitary consumption TOE Start	Unitary consumption TOE Target	Gain %	Cost EUR
Solid	No intervention	0,550	0,550	1,009	1,009	0,000	0,000
Oil	Replacement	0,760	0,850	2,183	1,952	10,588	8385,000
Gas	Replacement	0,760	0,850	2,585	2,311	10,588	7622,000
Average		0,744	0,824	2,128	1,920	9,679	8155,867

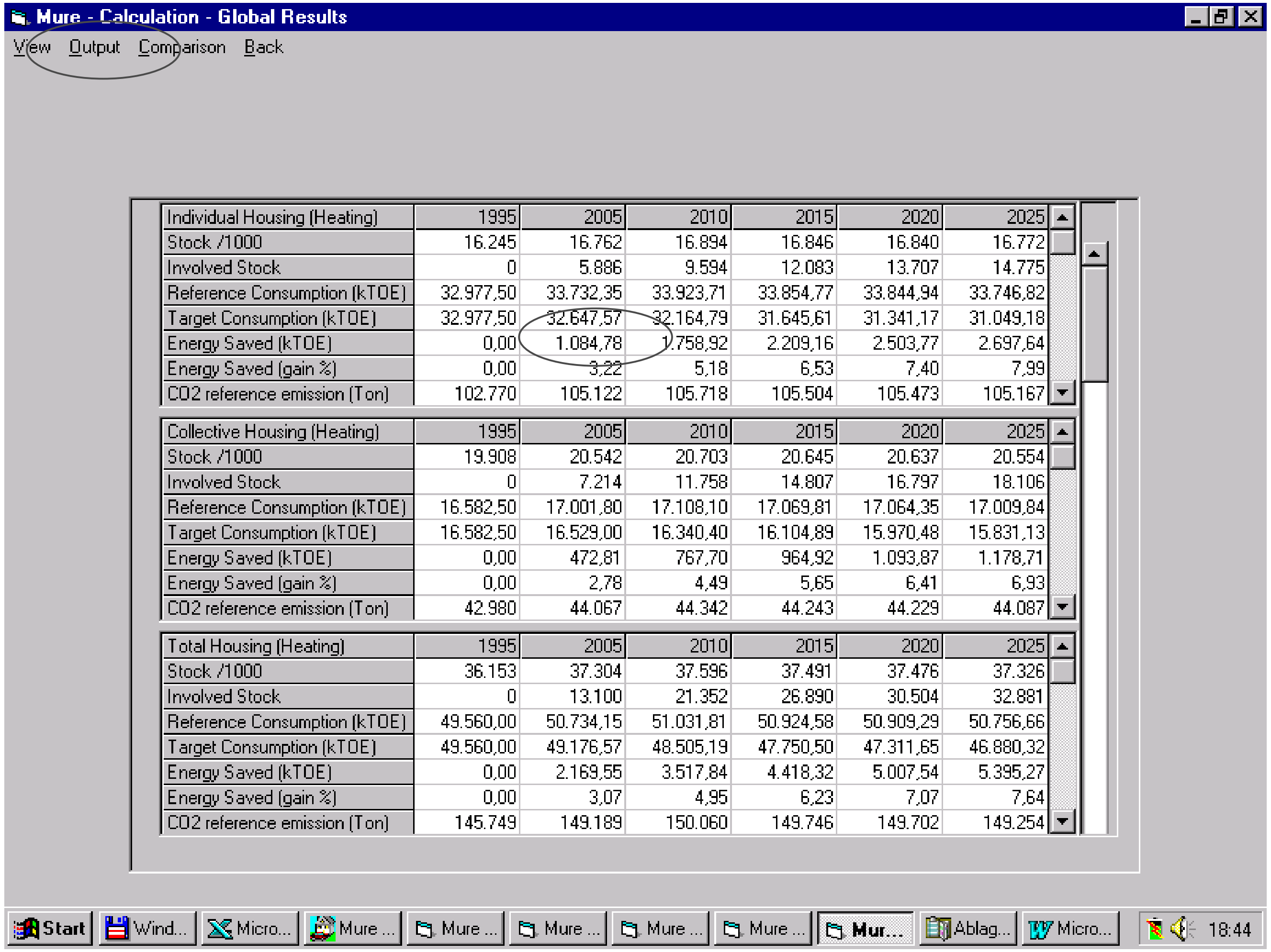
Collective Housing

	Technology	Efficiency Start	Efficiency Target	Unitary consumption TOE Start	Unitary consumption TOE Target	Gain %	Cost EUR
Solid	No intervention	0,550	0,550	0,307	0,307	0,000	0,000
Oil	Replacement	0,760	0,850	0,972	0,869	10,588	4116,000
Gas	Replacement	0,760	0,850	1,064	0,951	10,588	3811,000
Average		0,746	0,828	0,886	0,798	9,805	4054,909


Mure - Calculation - Intervention Scenario
Individual Housing
Technology
Energy Saved (TOE/Year)
Cost of En. Saved (EUR/TOE)
*
% of Stock Involved
Equipment
3.192
3.189
100,00
Changing the order in which the technologies are implemented will alter the relative impact of each but not the total savings
Collective Housing
Technology
Energy Saved (TOE/Year)
Cost of En. Saved (EUR/TOE)
*
% of Stock Involved
Equipment
1.626
3.764
100,00
Economic Evaluation
Back
Start
Windows...
Microsoft...
Ablagem...
Microsoft...
Mure II D...
Mure - Q...
Mure - C...
Mure - ...
18:53


Mure - Calculation - Intervention Scenario
Individual Housing
Technology
Energy saved (TOE/Year)
Energy price (EUR/TOE)
Cost of energy saved
Investment (EUR)
Equipment
3.192
429
3.189
132.492.059
Collective Housing
Technology
Energy saved (TOE/Year)
Energy price (EUR/TOE)
Cost of energy saved
Investment (EUR)
Equipment
1.626
421
3.764
80.725.128
Energy Data
Microsoft
Excel
Back
Start
Windows...
Microsoft...
Ablagem...
Microsoft...
Mure II D...
Mure - Q...
Mure - C...
Mure - ...
18:54


Mure - Calculation - Penetration Rates
Please, input the appropriate figures for the annual penetration rate
Heating
Sanitary hot water
Appliances
Same penetration rate for all steps
0
Same penetration rate for Individual and Collective
Stock/1000
1995- 2005
2005- 2010
2010- 2015
2015- 2020
2020- 2025
Individual Housing
16.245
4,4
8,0
8,0
8,0
8,0
Collective Housing
19.908
4,4
8,0
8,0
8,0
8,0
Dwellings involved stock forecast to the year 2020 (percentage of total stock)
100
80
60
40
20
0
1995
2000
2005
2010
2015
2020
2025
Individual
Collective
OK
Back
Start
Windows...
Microsoft...
Mure II D...
Mure - Q...
Mure - C...
Mure - C...
Mure - ...
Mure - C...
18:40



Individual Housing (Heating)	1995	2005	2010	2015	2020	2025
Stock /1000	16.245	16.762	16.894	16.846	16.840	16.772
Involved Stock	0	5.886	9.594	12.083	13.707	14.775
Reference Consumption (kTOE)	32.977,50	33.732,35	33.923,71	33.854,77	33.844,94	33.746,82
Target Consumption (kTOE)	32.977,50	32.647,57	32.164,79	31.645,61	31.341,17	31.049,18
Energy Saved (kTOE)	0,00	1.084,78	1.758,92	2.209,16	2.503,77	2.697,64
Energy Saved (gain %)	0,00	3,22	5,18	6,53	7,40	7,99
CO2 reference emission (Ton)	102.770	105.122	105.718	105.504	105.473	105.167

Collective Housing (Heating)	1995	2005	2010	2015	2020	2025
Stock /1000	19.908	20.542	20.703	20.645	20.637	20.554
Involved Stock	0	7.214	11.758	14.807	16.797	18.106
Reference Consumption (kTOE)	16.582,50	17.001,80	17.108,10	17.069,81	17.064,35	17.009,84
Target Consumption (kTOE)	16.582,50	16.529,00	16.340,40	16.104,89	15.970,48	15.831,13
Energy Saved (kTOE)	0,00	472,81	767,70	964,92	1.093,87	1.178,71
Energy Saved (gain %)	0,00	2,78	4,49	5,65	6,41	6,93
CO2 reference emission (Ton)	42.980	44.067	44.342	44.243	44.229	44.087

Total Housing (Heating)	1995	2005	2010	2015	2020	2025
Stock /1000	36.153	37.304	37.596	37.491	37.476	37.326
Involved Stock	0	13.100	21.352	26.890	30.504	32.881
Reference Consumption (kTOE)	49.560,00	50.734,15	51.031,81	50.924,58	50.909,29	50.756,66
Target Consumption (kTOE)	49.560,00	49.176,57	48.505,19	47.750,50	47.311,65	46.880,32
Energy Saved (kTOE)	0,00	2.169,55	3.517,84	4.418,32	5.007,54	5.395,27
Energy Saved (gain %)	0,00	3,07	4,95	6,23	7,07	7,64
CO2 reference emission (Ton)	145.749	149.189	150.060	149.746	149.702	149.254