SAVE II ACTION
Contract no. XVII/4.1031/ Z/99/283
Labelling and other measures for heating systems in dwellings

Appendix 1

Characterisation of heating systems and their markets

Project Partners:
- BRE Ltd, Watford, UK (Co-ordinator)
- Environmental Change Institute, Oxford, UK
- EnergiE sas, Milan, Italy
- Innovation Energie Developpement, Paris, France
- Irish Energy Centre, Dublin, Ireland
- Omvarden Konsult AB / Four Elements Consulting, Stockholm, Sweden
- Wuppertal Institute, Germany
- Van Holsteijn & Kemna, Delft, Netherlands

Collaborator:
- Danish Gas Technology Centre, Denmark

Task performed by:
EnergiE sas
Via Poerio, 41
20129 Milano
Contact: Andrew Pindar
Tel 02 2040 1812
Fax 02 2941 9029

The contents of this appendix, and revisions resulting from comments
by the eight project partners, are the responsibility of the task authors.

Introduction

The present report characterises heating systems in terms of their material components and use, for example: energy use

- the stock of heating systems, and their age in different member states
- rates at which systems and components are being installed and replaced
- the markets for systems and components
- relationship between age and efficiency

The report uses existing data to provide an overview of heating systems, the present situation and past trends, in the nine partner and to a less extent the 15 EU member countries. In developing the picture preference was given to data provided by national partners, though in most cases this was checked with third partner reports.

The annex to the report provides a detailed quantitative picture of installed heating systems, their age and efficiency according to a developed cross country classification scheme.

Accuracy of Data

All partner supplied data was crossed checked, where possible, with third party sources detailed in the references list, as well as for coherence with other elements of partner supplied data itself. However in spite of the fact that all data sources can be considered as reputable, discrepancies between data sets where often present, and sometimes these were notable.

Though we can be sure that a coherent qualitative picture has been developed, care should be taken regarding the accuracy of any single figure. Generally the numbers presented are quoted to a greater number of significant figures than the accuracy of those numbers warrants. This is simply to ensure the totals are consistent with the sum of constituent parts.

Energy Consumption

Present Situation

Energy consumption for space heating in the nine countries under study (partner countries plus Denmark and Finland) accounts for 87% of total energy consumption for space heating in the 15 EU countries.

Annual energy consumption for space heating in the 15 EU countries amounts to 1.5 - 1.7 PWh, (say in the period 1995 - 2000), that is 68% of total EU household consumption. Space heating in Germany accounts for the largest proportion of total space heating energy use in the nine study countries (above 30%) with the UK and France responsible for the second highest proportion (roughly 20% each).

Table 1. Space heating energy consumption in the 15 EU partner countries. The table provides a coherent cross EU 15 country picture using Eurostat data for 1995, as well listing the latest national partner data (np) for 1995-1998

	1995-1998 (np) (GWh)	1995 (Eurostat, 1999) (GWh)	Proportion of EU total	of nine study countries
Denmark**	34 167	36 128		2%
Finland*	41 366	35 861		2%
France**	282 721	367 280		22%
Germany**	466 000	581 022		35%
Ireland***	21 246	18 800		1%
Italy***	206 400	204 527***		12%
Netherlands**	88 030	83 336		5%
Sweden +	60 760	62 048		4%
UK**	278 338 (lhv)	256 750		16%
Sub Total	1 479 028	1 645 753	87%	100%
Austria		59 391		
Belgium		79 803		
Greece		44 297		
Luxembourg		4 972		
Portugal		8 542		
Spain		51 056		
Sub Total		248 061	13%	
Total		1 893 814	100%	

= 1995, * = 1996, **=1997, ***= 1998
(lhv) =figure explicitly stated as such

Heating system energy consumption as a proportion of total household consumption varies from 59% (the UK) to 77% (Germany).

Table 2. Space heating energy consumption as a proportion of total household energy consumption.

Denmark	66%
Finland	71%
France	62%
Germany	77%
Ireland	73%
Italy	68%
Netherlands	65%
Sweden	62%
UK	59%
Mean	67%

Trends

Though quantitative data to provide definitive trends is not available, indications, though not conclusive, are that overall growth in energy consumption for space heating in the nine partner countries is limited if not contained.

Eurostat data for 1988 and 1995 (Eurostat, 1999), shows that energy use for space heating across five of the nine countries under study, has remained invariant.

This variation does not take account of Sweden, Finland, and Denmark since data for both years is not available - however their impact on total space energy heating consumption is the order of 8%.

And importantly the variation does not take account of Germany. Eurostat data would seem to suggest a 33% increase in space heating energy consumption over the period 1998-1995. A variation in the order of 20% can readily be explained by the increase in household numbers in Germany following reunification in 1990. However whether the remaining 13% indeed represents an increase in space heating energy consumption or is due to other factors, such as possible changes in accounting practices successive to reunification, is not known.

However in all cases Eurostat does not explicitly state whether reported data is climate corrected, (variations in annual weather conditions need to be taken intro consideration before drawing a definitive result).

Table 3. Variation in space heating energy consumption for households between 1988 and 1995. It is not clear whether the data is climate corrected, (Eurostat, 1999 - with correction by BRE for UK).

Denmark	n/a
Finland	n/a
France	6%
Germany	33%
Ireland	-4%
Italy	1%
Netherlands	1%
Sweden	n/a
UK	-4%
Average variation excluding Germany	0
Average variation including Germany	6%

Considering other non climate corrected data for space heating energy consumption, (Table 4), a 1% increase was registered over the roughly 7 year period 1991 to 1997. The data is indicative, in that it is derived from a number of not necessarily coherent sources, for slightly different periods and again as already noted for the most part is not climate corrected

Table 4. Variation in energy consumption for space heating from 1991 to 1998. Shaded cells indicate data obtained directly as a series from national sources/agencies. Figures for other countries were determined from trends of total household energy consumption as reported by Eurostat, and single national partner reported data points. Only data for France was explicitly indicated as climate corrected.

	period	**variation**
Denmark	'91-'97	0%
Finland	'91-'96	-5%
France	'91-'96	1%
Germany	'91-'97	-20%
Ireland	'91-'98	17%
Italy	'91-'98	-5%
Netherlands	'91-'97	5%
Sweden	'91-'97	13%
UK	'91-'97	3%
Average		**1%**

Both

Table 3 and Table 4 show considerable country specific variations in energy consumption, highlighted again in

Table 5 which details the variation in space heating indices over a the twenty year period 1975 to 1995 for a selected number of European countries.

Table 5. Development of final energy consumption of residential space heating, (Voss-Uhlenbrock, 1999).

	1975	1980	1985	1990	1995
Denmark	100	89.08	79.89	73.56	75.86
France	100	95.4	92.9	98.4	101.5
Germany	100	98.83	104.92	101.87	117.1
Netherlands	100	120.9	112.74	105.63	100.46
Sweden	100	93	85	88	89

Table 5 shows, over the 20 year period, 1975 to 1995:

- a 25% reduction in energy consumption in Denmark
- a 11% reduction in Sweden
- invariant consumption in France and the Netherlands
- a 17% increase in Germany

Which is coherent and in part confirmed by national partner data:

- in Denmark total residential space heating consumption (all fuels) has decreased by almost 25% from 60 TWh in 1972 to 44 TWh in 1997.

- in the Netherlands the wide spread introduction of condensing boilers has also helped to contain total energy consumption by heating systems.

Where final energy consumption has been reduced this is due principally to technological improvements, as for example the uptake of condensing boilers in the Netherlands and more generally a European wide improvement of household insulation levels. However there is evidence that notable reductions in energy consumption can still be achieved, for example by continued improvement of insulation levels:

- In Denmark, despite the trend in falling energy consumption (and despite having the lowest unit energy consumption - see below), the DEA estimates that adequate insulation could reduce present heat demand per m^2 by up to 40%.

However another factor also important in curbing energy consumption, is the slow down in heating system installation rates. Following growth in that last thirty years, installation rates of central heating systems in all partner countries (see below) are slowing down considerably (though still proceeding).

Central heating appliances are generally more efficient that individual room appliances, so for any given heat in a dwelling, they would be expected to use less delivered energy. However the installation of central heating is usually associated with considerable increase in the occupants comfort expectation, particularly in respect of the number of rooms heated, and hence in the useful heat requirement.

As penetration rates of heating systems increased during the seventies, eighties and early nineties, it was therefore reasonable to see increased total energy use attributable to heating systems. However all things being equal (housing numbers, insulation levels, comfort levels etc.), as penetration levels of heating systems arrive at saturation levels, it is reasonable to expect total energy use to level off.

Comments in relation to specific countries:

Denmark

Total and individual household consumption for space heating have decreased in recent years, mainly due to consumer investments in more efficient home heating and improved insulation levels. Total residential space heating consumption (all fuels) has decreased by almost 25% from 60 TWh in 1972 to 44 TWh in 1997, (DEA, 1998).

Finland

Space heating has become considerably more efficient since the earlier 1970's. The same rate of improvement is expected to hold over the next two decades. The thermal properties of new buildings are continually improving and those buildings which are demolished generally represent the least thermally efficient. The Ministry of Trade and Industry expects total energy use for heating to increase by no more than 15% between 1995 and 2025 (reference case), (MTI, 1997).

Italy

IEA predicts that after a slight increase between 1995 and 2000, space heating consumption should drop back to 1990 levels as a results of technological improvements, (IEA, 1998b).

Despite the increase in the number of households since 1970 and higher standards of living, total energy consumption for space heating has not undergone a significant increase. This is because of the growth of central heating ownership, particularly gas, and the improvement of home insulation measures, (IEA, 1998b).

Netherlands

In the last few years the average temperature corrected household consumption of natural gas has been decreasing, largely as a result of improved home insulation and efficiency improvements, particularly the introduction of condensing boilers. A strong correlation has been established between the age of the dwelling with individual central heating and the annual consumption of gas, (ECI 2000, BEK, 1996; BAK, 1997).

UK

None climate corrected total space heating energy consumption for the UK has risen since the 1970s at an average of about 10% every 10 years, that is about 20% since the 1970's, (BRE, 1998).

Energy Consumption Normalised to Floor Area and Degree Days

Present Situation

Table 6 details total energy consumption for residential space heating normalised to floor space and degree days (i.e. local weather conditions). Figures refer to 1995, with normalised degree days obtained from Eurostat.

A significant variation exists between degree day normalised energy consumption for partner countries, with Germany and Ireland using 84% more energy per m^2/degree day than Sweden. Denmark and Finland have comparable consumption figures (within 20%) of Sweden. Average unit consumption for the nine countries under study is 0.056 kWh/m^2/degree day.

It is also interesting to note that in respect of floor area, Italy has the lowest energy consumption of partner countries. However when normalised to local climatic conditions, unit energy consumption is 10 % above the average value.

Table 6. Energy consumption for space heating as a function of both residential floor area and normalised degree days. All figures for 1995

	Household average floor area (m^2)	(dwellings)	Total floor area (m^2)	degree days	KWh/m^2	KWh/m^2/ degree day
Denmark	107.6	2,437,000	262,221,200	3,310	138	0.042
Finland	78.2	2,224,000	173,916,800	4,336	206	0.048
France	86	27,713,000	2,383,318,000	2,232	154	0.069
Germany	78	36,938,000	2,881,164,000	2,871	202	0.070
Ireland	97	1,123,000	108,931,000	2,454	173	0.070
Italy	96.1	20,360,000	1,956,596,000	1,687	105	0.062
Netherlands	105	6,530,000	685,650,000	2,947	122	0.041
Sweden	90	4,888,000	439,920,000	3,725	141	0.038
UK	85	23,833,000	2,025,805,000	2,517	127	0.050

Sources: Floor area, hosuehold numbers and space heating energy consumption, (Eurostat, 1999). Degree Days, (PRIMES in Energy Outlook, 1999). Figures for Italy, (ENEA, 1999).

Trends

Unit energy consumption (in respect of total floor space) fell in the region of 25 - 35% in the 25 year period of 1975 to 1995, (Voss-Uhlenbrock H, 1999).

Table 7 details the development of unit energy consumption (energy/floor space) from 1975 to 1995. The indexed variation of unit energy consumption follows directly from the indexed variation of total space heating energy consumption (

Table 5) and indexed total dwelling space (shown in

Table 7) considering that indexed unit consumption = index total space heating/indexed total dwelling space.

(We note that indexed development of unit energy consumption here various slightly from the original indexed values reported by Voss-Uhlenbrock H, (1999), since the original text appears to contain a number of errors)

Table 7. Development of unit energy consumption considering (total energy/total swelling area). Based on indexed (w.r.t. 1990) variations in residential floor space and of total residential space heating energy consumption (shown in

Table 5) from Voss-Uhlenbrock H, (1999). (Development of unit energy consumption, kWh/m^2 by author).

Variation	1975	1980	1985	1990	1995
Total Dwelling Space - indexed to 1990					
Denmark		**(227)	(241)	(253)	(262)
France	100	103.5	107.2	110.6	111.1
Germany	100	114.71	126.47	136.59	147.82
Netherlands	100	118.86	133.20	140.89	153.63
Sweden	100	110	122	124	134
Unit Energy Consumption - indexed to 1990					
Denmark		**(190)	(160)	(141)	(139)
France	1.00	0.92	0.87	0.89	0.91
Germany	1.00	0.86	0.83	0.75	0.79
Netherlands	1.00	1.02	0.85	0.75	0.65
Sweden	1.00	0.85	0.70	0.71	0.66
Unit Energy Consumption (kWh/m^2)					
Denmark		190	160	141	139
France	169	155	146	150	154
Germany	255	220	212	190	202
Netherlands	187	190	158	140	122
Sweden	212	179	148	151	141

** Absolute values since data for 1975 not available.

Heating Systems

Present Situation

Of the nine countries under study 85% of households (cross country non weighted average) have central heating systems installed. The lowest proportion of centrally heated homes is in Ireland (73%), the highest in Scandinavia and Finland (>90%).

Definition of central heating can vary, and consequently reported penetration rates, especially in countries with a high presence of electric heating (Finland, France, Sweden and the UK) . Here central includes electrical heating emitters installed in the majority of rooms in the home, which may or may not be centrally controlled. The definition is tenuous and elsewhere such systems maybe identified as room heaters.

Table 8. Penetration of heating systems as a percentage of total households. In Denmark, Finland and Germany block central heating systems are important though precise figures are not available, (np). Figures refer to principal household heating systems, (np).

		Denmark	Finland	France	Germany	Ireland	Italy	Netherlands	Sweden	UK
Central heating systems	Dwelling	36.6	44.8	61.7	74.9	73	48.3	76	52.5	87
	Block	n/a	n/a	15.3	n/a	0	20.3	8	6.5	n/a
	District	54.5	48.1	4.8	12.2	0	1.2	3	41	2
	Total	91.1	92.9	81.8	87.1	73	69.8	87	100	89
	Room	8.9	7.1	18.4	12.9	26	18.9	13	0	10.9
	Total no. Of households heated	100	100	100	100	99	88.7	100	100	100

The breakdown of central heating systems (dwelling, block, district), various somewhat by country; Scandinavia and Finland employing a significant amount of district heating (40-50%).

Block systems are important in France (15% of families) and Italy (20% of families). Though no precise figures are available they are also known to be relevant in Germany.

Room heating still plays an important role across partner countries, providing the only form of space heating in roughly 14% of households (cross country non weighted average). This figure does not consider the use of room heating as a form of secondary (to central) heating.

In Italy 12-13% and in Ireland 1-2% of homes have no means of space heating,

Trends

Household penetration rates of central heating systems have increased by roughly 100% since the earlier 1970's. Penetration rates are still increasing though the actual rate of installation, considered over the last five years is at least half that of the seventies and eighties.

Table 9. Changing household penetration rates of central heating systems, (Based on BRE 1998, ENEA 1999, np).

	Year	% diffusion	year	% diffusion	year	% diffusion	average installation rates (% households/year) 1970/1973-1992	1992-1996/1998
France	1973	49%	1992	82%	1998	87%	1.74%	0.83%
Italy	1970	36%	1992	69%	1998	70%	1.50%	0.17%
UK	1970	31%	1992	83%	1996	87%	2.36%	1.00%

Comments in relation to specific countries:

Italy

Though total penetration rates increased during the 70's, 80' and 90's, there has been a shift from block systems (31% of households in 1970 to 24%, 1998) to dwelling systems (12% to 54% of households over the the same period)

Energy Sources

Present Situation

The preferred choice of fuels for dwelling and block systems, as a proportion of national households, is:

- gas in Netherlands (84%) the UK (71%), Italy (48%), Germany (37%) and France (30%)
- oil in Denmark (23%) and Ireland (28%)
- electricity in Finland (21%) and Sweden (19%)

Together gas, oil and electricity, fuel over well over 90% of dwelling and block systems in most partner countries. The exceptions :

- Ireland where 30% households have solid fuelled dwelling systems.
- Sweden where 20% of households use various combinations of oil, wood, electricity and district heating systems.

In the Netherlands all dwelling and block systems are fuelled by gas.

Table 10. Fuel type of dwelling and block systems. Excluding the last row all figures are as a percentage of national households.

	Denmark	Finland	France	Germany	Ireland	Italy	Netherlands	Sweden	UK	Average
gas	11.5	0.4	29.7	36.6	14.6	47.9	84	0.4	71	32.9
electricity	0.7	21.2	22.2	6.2	8.8	0	0	19.4	10	9.2
oil	23.2	18	20.3	30.8	27.7	17.7	0	12.4	3	17
coal	0.7	0	1	0.8	21.9	0	0	0	3	3
wood	0.3	4.7	2.2	0.6	0	0.1	0	2.2	0	1.1
lpg	0	0	1.9	0	0	3	0	0	0	0.5
other	0.2	0.3	0.2	0	0	0	0	24.6	0	2.8
Total	36.6	44.6	77.5	74.9	73	68.7	84	59	87	66.6
oil/electricity/gas as % of dwelling and block heating systems	97	89	93	98	70	96	100	55	97	88

Trends

By far the greatest shift over the last thirty years has been to gas. The increased proportion of homes using gas as been at the expense of fuel oil and solids (mainly coal).

All dwelling and block systems use gas in the Netherlands, 82% of dwelling systems use gas in the UK and 70% of dwelling and block systems use gas in Italy, 53% in Germany and 38% in France.

Finland uses the lowest proportion of gas in dwelling systems; only 0.4% of the roughly 50% of households using dwelling systems employ gas. Here the proportion of homes using electricity is on the increase and reached 24.7% in 1997, (ECI, 2000).

The share of electrical heating also increased substantially in Sweden between 1970 and 1990. In detached houses the growth has been at the expense of oil. Electricity is now the most common form of space heating in detached houses, (ECI, 2000).

However in apartment blocks the growth has been away from oil toward district heating. Around 70% of all apartments are now heated with district heating.

Generally the choice of electricity over other fuel sources is often justified in terms of its relatively low initial investment costs, (ECI 2000, and np).

The gas network

The proportion of heating systems using gas reflects the extent of the gas network in the various partner countries. France, Germany, Italy, the Netherlands and the UK have the most extensive gas networks in Europe, and subsequently gas is used as a fuel for space heating in a considerably high proportion of households, as detailed above.

The following table identifies the extent of the extension of the gas network in partner countries, uptake and projected growth. From which we can note:

- with the exception of the Netherlands and the UK, a significant proportion of households reached by the gas network are still not connected; (Italy 20% , Denmark 76% and Finland 95%).
- in France and Ireland respectively 42% and 26% households homes though actually connected to the gas network still use other fuels for space heating.

Table 11. Extent of gas and expected growth of gas network in partner countries, (ECI , 2000b).

Country	Year of market entry	Ref. Year	% of households reached by network	% of households connected	% of households connected for space heating	Status of network - domestic sector connections
Denmark	1980s	1998	50	12	12	Limited further development
Finland	1970s	1997	32	1.5	0	No further development
France	1960s	1998	72	41	30	Further expansion expected
Germany	1960s	1998	93	42	41	Continuing expansion (high)
Ireland	1970s	1997	40	27	16	Continuing growth
Italy	1960s	1998	87	69.6	55	Continuing growth
Netherlands	1960s	1997	99	97	96	Very limited development if any
Sweden	No data	1998	1.2	1.2	n/a	No further development
UK	1960s	1998	87*	81.9	78	Limited further development

*From BRE

Comments in relation to specific countries:

Denmark

Around 38% of Danish households are heated, directly or indirectly by natural gas. The Danish Natural Gas association as predicted that within the next few years this will increase to 41%, (Dansk Naturagas, 1998).

The direct use of natural gas has seen the most striking growth in market share, from nil at the beginning of the 1980's to 18% by 1997. This has been accompanied by increases in district heating and electricity at the expense of oil, from 70% of domestic space heating in 1972 to less than 30% in 1998, (DEA, 1998).

Finland

Only a tiny proportion households use natural gas for space heating (0.4%). The proportion of electrically heated homes is growing and reached 24.7% in 1997, (Finergy/Sener, 1998).

Germany

Oil and gas cover the largest share of domestic space heating consumption. In the period 1970 to 1995 there was a significant shift from goal and oil to gas. In 1970 solid fuel fed 30% of households, in 1995, less than 5%, (Mure, 2000).

Currently the market for gas systems can be estimated at 550 000 to 600 000 units a year and for oil at roughly 200 000 to 250 000. Virtually all households connected to the natural gas network use natural gas, (np).

Italy

There has also been a similar shift from the use of oil to gas. In 1970 oil accounted for 76% of total household heating energy consumption, and natural gas 10%. In 1998, the share of oil had fallen to 22% and gas increased to 66%, (ENEA, 1999).

Sweden

The share of electrical heating increased substantially between 1970 and 1990. In detached houses the growth has been at the expense of oil. The most common form of space heating in detached houses is now electric due to the low investment costs, (STEM, 1998).

In apartment blocks the growth has been away from oil toward district heating. Around 70% of all apartments now receive heating from district heating systems, (ECI, 2000).

UK

Gas fired central heating increased from 33% of the total of centrally heated houdeholds in 1970 to over 76% in 1996. The use of solid fuel central heating has declined from 29% of the total households to only 4% in 1996, (BRE, 1998).

The predominant source of fuel is gas. The share of oil has in years declined but is showing signs of recover, due its price advantage over gas, (Mure, 2000b).

District Heating

Present Situation

Denmark, Finland, and Sweden have the highest penetration rates of district heating, with respectively 55% , 48% and 40% of households connected (np). Of this, respectively 70%, 80% and 30% of distributed heat is generated within CHP systems, (np and Euroheat, 2000).

The high proportion of homes connected in northern countries might be explained by the fact that central heating is more appropriate for continuous use in colder climates whilst in warmer climates cheaper equipment is used for heating proposes.

Though serving only 3% of households, 90% of the distributed heat in the Netherlands is generated within CHP plants, the highest proportion in Europe.

Italy too has a high proportion of CHP generated district heating (75%), though again only a limited number of households actually served (1%).

The average efficiency of CHP plants in Europe in 1994 was 76% (Euroheat , 1998). It is not clear however if this relates to co-generation plants used within in district heating systems or whether it also includes industrial plant.

Table 12. Percentage of households connected to district heating and relative weight of CHP production, (Euroheat, 2000 and np).

	% of homes served	% distributed heat produced in CHP plants
Denmark	55	72
Finland	48	79
France	5	16
Germany	12	75
Ireland	0	-
Italy	1	75
Netherlands	3	90
Sweden	42	28
UK	2	5

Trends

Denmark hopes to have 60% of households connected by 2005, (DBDH, 1999).

Roughly 12% of households are presently connected in Germany. No expansion is predicted in the near future, though the technical potential remains very high, (np).

Networks in Italy and the UK have mainly developed over the last 5 years with roughly 1% of homes now connected, (np).

Comments in relation to specific countries:

Denmark

Between the earlier 1970's and the late 1990's district heating almost doubled it share from 18% in 1972 to 39% in 1997. More than 50% of households are now connected to district heating systems. The government hopes to connect 60% of households by 2005, (DBDH, 1999).

Germany

- The big district heating systems in Germany are not awaited to expand a lot for the next Years. In opposite most have problems with their economic viability (except this winter with his high oil prices). These systems will mainly just be around in order to stabilise heat selling against the trend of energy saving by better insulation of the houses.
- Additional district heating is coming by very small satellite district heating systems mainly for new built areas where 20 to 100 houses have a common heating system. These systems are economically sound.
- For Germany there exist several potential-analyses for district heating. The potentials are very high, the chances for realising them are not to good.
- For the small district heating systems there are several problems: They are economic if all new houses in one area are connected. The municipalities often try to impose an obligation. But the existing laws hardly help with this. The easiest way is to put it in the contract by selling the land (is it belongs to the municipality). But even these passages have sometimes been denied by courts. Especially the oil industry opposes these regulation because house owners area not free anymore to chose their heating system.

Italy

About 1% of houdeholds are fed by district heat. The main providers are the municipal utilities in the north (and ACEA in Rome), as well as small systems in the autonomous region of Trento e Bolzano, (np).

UK

Approximately 1% of dwellings are connected to district heat systems, of which 5% are CHP based. The medium term (2010) economic potential for CHP based district heating is estimated as 1 million households, (Mure, 2000b).

Condensing Boilers

Penetration and Sales

The highest penetration is found in the Netherlands; where they account for 36% of all dwelling and block systems, and 30% of households. In the Netherlands condensation boilers currently represent 60% of the boiler market, (ECI, 1999).

Penetration rates in other partner countries are much less, in Denmark 8.7% of gas systems, in France 6.7%, and Germany 5.5%. In Italy and the UK only 1% or less of households are serviced by condensing boilers.

However slowly increasing penetration rates are predicted, with market shares expected to increase to 50% in Germany by 2000, 35% in Denmark by 2005 and 15% in Italy by 2005.

Table 13. Stock penetration and market share of condensing boilers in partner countries

	Current Penetration			condensing boilers as % of total boiler market					Comments	source
	as % of hs'hlds	as % of systems	as % of gas systems	1996	1998	1999	2000	2005		
Denmark	1.0	2.7	8.7		16	23		35		household penetration (Gastec, 1999) sales(DEA, 1999)
Finland		-	-							
France	2.0	2.6	6.7		2	2		2	Condensing boilers have been removed from manufacturers catalogues and production lines stopped. Approximately 500 units a year a sold	household penetration (np) sales (ECI,1999)
Germany	2.0	2.9	5.5	18	27		50		Market expected to be good, limited by legislative barriers for condensate removal	household penetration (german chimney sweepers from np) sales (IER, 1998)
Ireland	-	-	-							
Italy	0.2	0.3	0.4				2	15		household penetration, and sales (PINDAR, 2000)
Netherlands	30	35.7	35.7		60					household penetration, and sales (ECI, 1999)
Sweden										
UK	1.0	1.1	1.4			5				household penetration (Gastec, 1999) sales (Young 200)

Comments in relation to specific countries:

Netherlands

The largest market in the EU for this appliance. Condensing boilers were first introduced in the 1970s. At first they were not popular because they were difficult to control. However subsidy programmes throughout the 80's and 90's and training for installers improved the situation, (ECI, 2000c).

Heat Pumps

Performance coefficients of electric compression heat pumps vary from 2.5 to 5 with respect to delivered energy (efficiencies of 250 to 500%). Heat pumps operate most effectively when the temperature difference between the heat source and heat sink (distribution system) is small.

However though a mature technology, the penetration of heat pumps is still very low. Their diffusion is probably greatest in Germany, which however does not extend beyond 1%, (Mure, 2000).

Hydronic systems are most common in Europe, using with air, ground-water or ground heat source, with ambient air the most common. Ground water and ground pumps though more efficient than air sourced units are more expensive as well as presenting problems of siting and use (e.g. possible freezing of the ground).

Air sourced heat pumps on average achieve 10-30% lower seasonal performance factors than water source systems. This is mainly due to the rapid fall in capacity and performance with decreasing outdoor temperature, the relatively high temperature difference in the evaporator and the energy needed for defrosting the evaporator and to operate the fans.

Air to air pumps do however offer an efficient means of heating in mild climates where winter temperatures are generally above 5°C (COP 2.5 - 3). In humid conditions, below 6°C frost will start to accumulate on the evaporator surface , leading to reduced capacity and performance of the heat pump system. Seasonal efficiency gains in heating (compared to alternative combustion technologies) may readily be lost however if air to air reversible heat pumps units are used to provide space cooling in summer.

New Housing

Fuel uptake follows the general trend in the move to gas. In Denmark gas systems are installed in 99% of new households, in the Netherlands 92%, in Germany in 81%.

However in Finland 70 to 80% of new households are equipped with integrated electrical systems and in France around 50%. In France electrical systems are chosen because of their initial low investment costs, compared to other fuels. However the installation of gas systems is also on the increase, increasing from 26% of new housing in 1995 to 32% in 1998.

Table 14. Fuel type in new housing as percentage of new households.

	gas (%)	electricity (%)	source
Denmark	99		(Dansk Naturgas, 1999)
Finland		70-80	(Finergy/Sener, 1998)
France	32	50	(np)
Germany	71		(IER, 1998)
	75-80		(np)
Netherlands	92		(IER, 1998)

Comments in relation to specific countries:

Denmark

A number of actions have been carried out to prevent an increase in the number of electrically heated dwellings in Denmark (e.g. the 1979 Heating Supply Act and the Electricity Saving Fund), and as a result there has been a considerable fall in the proportion of new building with electric heating

France

Electricity was installed in 48% of new dwellings in 1998 due to low initial investment costs. Between 1995 and 1998 the installation of gas systems in new dwellings increased from 26 to 32%; in part due to the continued extension of the natural gas network, (np).

Germany

Gas boilers are installed in 75 to 80% of new housing. Gas condensing boilers are installed in 40 to 50% of new housing, (np).

Netherlands

The application of e.g. CHP-installations and heat pump-systems is evaluated and in some cases the obligatory installation of condensing boilers is actually replaced by a district-heating system, powered by CHP, heat pump or both.

Heat Generator and System Efficiency

Very little data is available on in-field sampled efficiencies in partner countries, either at nominal power or seasonal.

Table 15 summarises the progressive increase on nominal heat generator efficiency of new generators following technological improvements in Germany over the last thirty years. Oil and gas heat generators have achieved respectively a 25% and 21% efficiency gains.

Table 15. Improvement to generator efficiency in Germany following changes in technology. calculated at nominal generator power, in respect of fuel Lower Heating Value, (Pfitzner and Schäfer 1994, from np).

constructed	oil	gas	comment
Before 1976	79%	81%	Special burner
Before 1982	83%	86%	Low temperature
Before 1990	86%	89%	
Since 1990	91%	92%	Heating
Since 1994/1992	104%	102%	Condensing Boiler

New condensing boilers working with lower return water temperatures (30°C), typical of floor heating and radiant panels, actually achieve efficiencies of 108% (with respect to L.H.V.), with only 3% of the energy content of the fuel lost. This probably represents the theoretical limit for heat generators based on direct recovery of heat from the combustion process.

Table 16 provides, an estimate of the average efficiency of the installed stock of oil and gas heat generators at nominal power (water temperatures 80/60°C) in partner countries based on the age distribution of stock as detailed in Table 21, and the efficiencies of products at the time of installation (much as in Table 15). Stock efficiencies are in the region of 85 to 90% (L.H.V), which lies 10 - 20% lower than presently available best technologies

Table 16. Estimate of average full load efficiency of installed stock of gas and oil generators in partner countries (< 70 kW), authors calculation based on data figures reported in Gastec, 1999, (In respect of fuel L.H.V.).

	Den-mark	France	Germany	Italy	Netherlands	Sweden	UK
Average efficiency	86	86	86	87	91	88	87

Much less information is available regarding seasonal efficiencies of installed stock.

Electronically controlled modulating burners (with or without modulating thermostats), can provide continuos variation of output from 15% to 100% of heat generator nominal power, which follows closely the real building heat demand. Seasonal efficiencies of heat generators employing modulating burners can thus closely match declared heat generator efficiency at nominal power; condensing boilers achieve seasonal efficiencies ion the region 104-107%, (though in traditional radiator configurations seasonal efficiencies of 98% might be more typical).

However the greater part of the stock of installed heat generators will have single or two stage burners which regulate system power output by cyclic on-off switching and which leads to consequently high standby losses. Seasonal efficiencies will vary from heat generator efficiency at nominal power by 10% or more. By way of example Italian legislation, recognises a minimum system seasonal efficiency some 19% lower than heat generator nominal efficiency, (

Table 17).

Table 17. Minimum heat generator nominal and system seasonal efficiencies for new and restructured heating plant as defined by Italian legislation (DPR 412/1993) for representative nominal boiler powers (with respect to L.H.V.).

Heat generator nominal power (kW)	heat generator efficiency at nominal power (water temp = 70°C) (%)	heat generator efficiency at 30% of nominal power (water temp = 50°C) (%)	system seasonal efficiency (%)
20	87.9	83.9	68.9
30	88.4	84.4	69.4
40	88.8	84.8	69.8
70	89.5	85.5	70.5
200	90.9	86.9	71.9
300	91.4	87.4	72.4
350	91.6	87.6	72.6

Table 18 provides a first estimate of heat generator seasonal efficiencies of gas and oil heat generators in partner countries by considering that heat generator seasonal efficiencies might lie some roughly 15% below nominal efficiencies, (as in part reported in Table 16).

Table 18. Estimate of seasonal efficiency of installed oil and gas generators in partner countries. Authors calculation based on nominal efficiencies of stock reported in (Gastec, 1999) (with respect to fuel L.H.V.).

	Belgium	Denmark	France	Germany	Italy	Netherlands	Sweden	UK
Gas	72	73	70	72	72	76	79	72
Oil	71	70	72	70	72	-	73	73
Average	71	71	71	71	72	76	73	72

Estimates of seasonal reported in Table 18 compare well with the few data available from other sources detailed in the country specific comments below. However the most recent analysis undertaken specific to this project (Task 2.1), indicates that the figures reported in Table 16 underestimate actual country seasonal efficiencies by some 5 to 10%, (see comment pertinent to the UK below).

A new condensing boiler might thus save up to 30% on heating compared to a gas boiler more than 10 years old, and 15% with respect to a new conventional boiler.

Comments in relation to specific countries:

Italy

Useful efficiency is at 75% for gas systems, 70% for oil, (Mure 200c).

Germany

Annual efficiency of non central heating sources increased by 15% between 1970 and 1995, the efficiency of central heating systems remained constant at about 70%. The average annual efficiency of gas central heating boilers is around 75% and for oil about 70%. Older boilers can have efficiencies of 50%, (Mure, 2000).

(Not defined whether relative to lower or higher heating value of fuel).

UK

A past Save sponsored project identifies the average efficiency of gas central heating boilers as 76% and oil 73%, (Mure, 2000b). Also we have the average efficiency of oil and gas central heating systems as 73%, (BRE, 1998).

However detailed analysis undertaken within the context of the present project (Task 2.1), identifies the seasonal efficiency of gas and oil systems as 77% and 82% respectively (l.h.v.). Giving weight to this analysis would indicate that all the figures reported in Table 18 (not just with respect to the UK) underestimate the actual seasonal efficiencies of systems found in partner countries by some 5 to 10 percentage points.

The average new boiler has a (SEDBUK) seasonal efficiency of 74% and this is expected to increase to 87% by 2020, (ECI, 2000c).

Heat Generator Sales

Considering:

- limited amount of explicit sales data available for partner countries (France, Germany)
- changes in stock levels (Germany, France, UK)
- average age of heating generators (all countries under study except Finland and Ireland)

Total sales appear to be in the region of 3-6% of household numbers. Considering the 120 million households (1996) in the nine countries under study, this equates to sales in the region 3.6 to 7.2 million heat generators per year.

The figure is obviously indicative.

Calculated on the basis of average heat generator age, sales are slightly overestimated in that we assume numbers of installed heat generators equate with number of households serviced by a given fuel. This is obviously not the case in those areas where there block systems are common (for example Germany, Italy, France). Also figures are only available for the average age of gas and oil heat generators.

Similarly where explicit sales data is available this does not necessarily equate with turnover in actual stock levels. There maybe a trend towards or from block systems, with one new system replacing a number of old dwelling systems, or many new dwelling systems replacing one old block system.

Table 19. Estimate of heat generator sales based on average age and penetration of system type (assumed to equate to number of households serviced). Average age based on Gastec (1999)

	number of hs'holds (1996) (1000's)	fuel type	total number of hs'holds serviced (1000's)	average boiler age	units sold
Denmark	2,328	gas	268	14.1	18,987
		oil	540	21.4	25,238
		total		18.5	44,225
		% of hs'holds			1.9%
France	22,889	gas	6,798	14.2	478,735
		oil	4,646	19.4	239,509
		total		15.8	718,243
		% of hs'holds			3.1%
Germany	37,281	gas	13,635	11.53	1,182,557
		oil	11,471	14.6	785,708
		total			1,968,264
		% of hs'holds			5.3%
Italy	20,930	gas	10,031	12	835,926
		oil	3,702	15.5	238,850
		total			1,074,776
		% of hs'holds			5.1%
Netherlands	6,400	gas	5,376	12.5	430,080
		oil			
		total			430,080
		% of hs'holds			6.7%
Sweden	3,889	gas	16	9.4	1,655
		oil	82	23.5	20,521
		overall		22.5	22,176
		% of hs'holds			0.6%
UK	23,482	gas	16,672	12.8	1,302,517
		oil	704	11.8	59,700
		overall		12.7	1,362,217
		% of hs'holds			5.8%
Total	117,199	gas	83,211		4,250,457
9 study countries		oil	3,156		1,369,525
		overall			5,619,982
		% hs'holds			4.8%

Table 20. Heat generator sales, both explicit sales data (in bold) and as based on changes in stock levels.

France (source np) : sales of integrated electric systems are also identified. From their number it would appear that figures refer to the sale of individual heat emitters, not to the number of systems (consisting of number of integrated heaters).
Germany (source German Chimney Sweeps from np) : average figures refer to the period 1988-1998
UK (source BRE, 1999) : Sales based on changes in stock levels. Missing data on replacement sales.

	fuel type	average	1990	1991	1992	1993	1994	1995	1996	1997	1998
France	gas										**206,770**
	of which condensing								**13,180**		
	oil										**491,970**
	total	663,680					**634,400**	**628,000**	**659,000**	**684,000**	**713,000**
	% of households	2.90%									
	electricity						**1,803,800**	**1,706,900**	**1,625,600**	**1,625,200**	**1,678,100**
Germany	gas	**583,944**									**629,800**
	of which condensing	**120,278**									**180,000**
	oil	**243,757**									**189,440**
	total	**947,979**									**819,240**
	% stock	6.2%									
UK	new homes		213,000	250,000	233,000	227,000	224,000	226,000			
	increased penetration		271,000	484,000	211,000	275,000	303,000	255,000			
	replacement		?	?	?	?	?	?			
	overall	528,667	484,000	734,000	444,000	502,000	527,000	481,000			
	% stock	2.03%									

There is some coherence between annual sales based on average generator age and explicit sales figures and changing stock levels:

- France : as determined from average age, sales are 718.000 units/year; explicit sales data show 713.000 units/year (excluding electric)
- Italy : as determined from average age sales are 1.000.000 units/year, available explicit sales data give 1.000.000 units/year

Less so for

- UK : as determined from average age sales are 1.300.000 units/year: determined on the basis of changing stock levels 530.000 units/year. However the stock calculation fails to take account of replacement sales.

- Germany: as determined from average age sales are 1.900.000 units/year: available explicit sales data give 9.000.000 units/year. In Germany block systems are known to be important. As already pointed out sales based on average age will therefore be overestimated.

Heat Generator and Heating System Age

Examining

Table 19 we can note that:

- gas systems are on average 3 to 9 years younger than oil fuelled systems (which is coherent with the general shift from to gas over the last twenty to thirty years noted elsewhere).

- cross country the average age of gas systems varies from of 10 to 14 years, and oil from 13 to 23 years.

- in Denmark the average age of oil systems in 21 years and in Sweden 23 years. In Denmark 60% of oil generators are more than 20 years old and 30% more than 30 years old. In Sweden nearly 50% of oil generators are more than 30 years old.

Little other information is available in respect of the age of other system components; conduits, heat emitters, thermostats, valves etc.

Table 21. Age distribution of installed gas and oil heat generators with nominal power < 70 kW (Gastec, 1999).

	Denmark	France	Germany	Italy	Netherlands	Sweden	UK
Gas							
<1970	0%	0%	0%	0%	1%	0%	1%
1971-1980	19%	22%	19%	11%	14%	0%	16%
1981-1990	54%	48%	28%	48%	44%	45%	45%
>1990	27%	30%	53%	41%	41%	55%	39%
Oil							
<1970	31%	19%	0%	1%	0%	46%	8%
1971-1980	28%	34%	33%	24%	0%	27%	11%

1981-1990	33%	30%	31%	56%	0%	17%	28%
>1990	9%	18%	36%	19%	0%	10%	54%

Heat Generator Technology

There is insufficient data to provide a cross country comparison.

Comments in relation to specific countries:

Germany

Oil

atomising burners are predominant, representing 99% of actual sales and 99% of installed stock of oil systems. The remaining 1% is accountable to vaporising burners, (np).

condensing boilers are on the market but not important

Gas

pressurised boilers have a 56% of market share, and represent 76% of stock
atmospheric boilers have 7% market share, and represent 6% of stock
roomed sealed boilers have a 2% market share and represent 9% of stock

UK

gas single purpose	65%
gas back boiler	14.2%
gas ducted air	3%
Electric floor/ceiling	0.8%

Heat Generator Nominal Power

Nominal power of single dwelling heat generators will generally less than 35 kW, and more likely to be in the range of 20-30 kW.

Available market data show that :

- in France 95% of new systems have nominal power of less than 70 kW, (np).
- in Italy approximately 60% of installed gas heat generators have a nominal power in the range of 12 to 25 kW, (Mure, 2000c).
- in the Netherlands the nominal power of 76% of the heat generator market is 20 to 60 kW, (np).

The correct sizing of heat generators is a complex issue, but two factors of importance are:
- size of homes
- insulation levels

And given relatively similarly sized houses and not too dissimilar insulation levels in partner countries (though homes in Scandanavia and Finland are generally insulated to much higher levels) it is not reasonable to see heat generators of similar size installed across Europe.

Considering the average size of homes in partner countries of 90 m^2, the major part of boilers for dwelling systems might be expected be between 20 and 40 kW.

In the Netherlands the nominal power of heat generators greater than 30 kW has of recent years increased, from 3% of the market in 1990 to 20% in 1990. This might be a sign that the size of homes is increasing, or that there is a shift to block systems; however no data is available in respect of either argument.

Comments in relation to specific countries

Italy

In the north of the country (where winters are relatively severe) for homes of roughly 100 m^2, heat generators for space heating and hot water production usually have a nominal power of 24-28 kW. In the case that the heat generator is only used for space heating this might be in the region of 20 kW.

However the number of homes using block systems as declined from 31% of the total to 24%, with a consequential increase in the use of dwelling systems from 12% to 54% of the total.

Heat Emitters

Little statistical information is available detailing the type of heat emitters used in partner countries.

In hydronic systems anecdotal evidence would suggest that panel or column "radiators" are by far the most common system of ceding heat from the heat transferring fluid to the room space (estimate : more than 90% of systems). Principally made of cast iron, steel and aluminium are also found. The exact form of the radiators varies somewhat, with older tubular designs and newer flat surface emitters which provide greater heat transfer by radiation. Their main advantage is relatively low cost, long life and easy replacement.

Alternatively fan convectors employ an electrical fan to pass air over the fluid carrying conduits to provide greater local control (the speed of the fan can be adjusted) as well as use providing greater flexibility in positioning (they can be installed on the ceiling). They also can be used for cooling. Their use in the domestic sector is limited; they require a drain for condensate removal (when use for cooling) and have a shorter lifetime than traditional radiators, (estimate : less than 2% of systems).

Radiant heating, in the form of extended floor or wall embedded coils or external radiant panels offer a number of advantages over traditional "radiators"; more even temperatures gradients within the heated space providing improved comfort as well as dampening the circulation of household dust (which can cause blackening of walls and act as an irritant). Radiant panels use water distributed at low temperature (30-40°C), which provides significant energy saving potential when used in conjunction with condensing boilers; the low temperature returning fluid allowing the boilers to work at a maximum efficiency. The principal disadvantage are installation costs (in the region of 30%) greater than traditional radiators. Introduced in the the 1950's, radiant heating is becoming increasingly popular, particularly so in Germany, Austria, Switzerland and the Netherlands. However we might estimate a cross country global diffusion of less than 2% of all systems.

By way of example in France steel, aluminium, and cast iron radiators account for 100% of the heat emitters market (steel, 64%, aluminium 14%, tubular cast iron 11.9 %, cast iron 10.1%) (data for 1998). Radiant floor panels were introduced onto the market in 1990, though as yet their impact would seem to be negligible (np).

Table 22. Estimate of penetration of heat emitters for hyrdronic systems in the nine countries under study, (author).

Heat Emitter	Estimate
Panel or column radiators	> 95%
Fan Convectors	< 5%
Radiant heating using floor or wall embedded tuning or radiant panels	<5%

Electrical central heating systems using convective and storage heaters are popular in, France, UK and Germany. As with other fuels, radiant panels are becoming increasingly popular.

In the UK 10% of households have electrical central heating and 4/5 of these use storage heaters, (BRE, 1998).

In France 22% of households have electrical central heating, convective and storage heaters installed throughout the home. Sales of central electric heating for 1998 were: convectors 76%, storage heaters 20%, radiant panels 4% (author based on np data). In many households the individual heaters are centrally controlled ("integrated" systems).

In Germany practically all electrical central heating employs storage heaters (author based on np).

In Sweden, electric central heating is used in 19% of households; 1/3 of systems are hydronic, (np).

Table 23. Estimate of penetration of heat emitter types used in electric central heating, (author). Figures are absolute percentages of households.

	Denmark	Finland	France	Germany	Ireland	Italy	Netherlands	Sweden	UK
storage			4.44	6.1					8
convective			16.9					12.9	
hdyronic								6.5	
other (inc. radiant panels)			0.9	0.1					2
Total	0.7	21.2	22.2	6.5	8.8			19.4	10

Currently about 0.3% of Dutch homes use electrical radiant panels as secondary heating extra comfort reasons (e.g. warm floor in the bathroom and/or in the kitchen). About 150,000 - 200,000 m^2 of electric floor heating systems are being sold annually, more than 90% is installed in existing houses.

Auxiliary Electricity Consumption

The annual electricity consumption of central heating systems varies widely between about 150 and 500 kWh/year. In the Netherlands electricity consumption by auxiliary components of a typical heating system (e.g. circulating pumps) is calculated to be 283 kWh/year (BEK, 97), in Germany 300 kWh/year, (np).

The $C0_2$ emissions from generating 300 kWh/year of electricity equates roughly with the CO_2 emissions of 1000 kWh/year gas generated heat. Considering an average apartment of 100 m^2 and average annual heating loads of from 100 to 200 kWh/y/m^2(

Table 7) , CO_2 emissions generated by auxiliary electrical equipment equate with between 5 to 10% of the emissions generated by fuel combustion to provide space heat.

In Germany it has been estimated that optimising of heating-circulation pumps could save over 2.2 TWh/year, (np).

System Controls

In most partner countries a system with a central heat generator will use a central room thermostat which will generally be situated in the main living area, for example the living room. The central heating boiler is switched on, when the requested temperature (indicated on the thermostat) is higher than the actual space temperature. The central thermostat only controls the temperature of the room in which it is installed. The temperature in all the other rooms of the house are a derivative of the switching behaviour that is caused by this centrally placed thermostat and of the position of the valves on the heat emitters in the rooms.

Thermostats may be integrated with programmable timers, which allow the user to impose a number of temperatures set points during the day, and for the different days of the week, according to occupancy patterns and desired comfort levels (for example lower temperatures at night).

Alternatively the system may simply be controlled by timers which provide temporal intermittence without space temperature feedback.

Block systems usually employ temperature sensors to measure outdoor temperature and outgoing and return water temperatures. The control strategies most often regulate water flow on the basis of calibration curves. To achieve uniform temperatures across all spaces requires a precise calibration and assumes that heat emitters are sized correctly.

The thermal inertia of the building means there can be notable time lag between variation of outdoor temperature and corresponding adjustments in indoor temperatures. The heating plant also has a thermal inertia for which, changes in fluid temperatures are also felt with delay in the living space. The two delays seldom coincide with the result that there can be wide variations in indoor temperature.

Thermostatic radiator valves which allow individual room temperature control are widely installed in the Netherlands, and in Germany, present though less diffuse in Italy and the UK. In Germany Thermostatic valves were made compulsory for new installations since 1978.

Italian regulation, other than specify minimum control devices (outdoor thermostats, programmable timers), also fixes the maximum allowed indoor temperature as 20°C + 2°C, ad well as the maximum daily and seasonal usage.

A first estimate would be that system controls are replaced together with heat generators. It is likely that failures are not readily recognise, and even then ¼ of households might fail to replace the parts/units.

Table 24. Estimates of the diffusion of control system types and strategies employed in partner countries. Percentage figures refer to total number of households, (np).

	thermostats				programmable thermostats (/simple timers)		thermostatic valves		comments
	legal obligation	indoor	outdoor	indoor-outdoor	legal obligation	Diffusion	Legal obligation	diffusion	
Denmark									
Finland									
France						37% (/15%)		25%	27% of homes have electricity management systems provided by EdF
Germany	use of outdoor or indoor obligatory since 1978. Older systems to be brought in line by 1997	40-50%	30-40%	found in new plant	since 1978	90%	since 1978	90%	
Ireland									
Italy	for large (> 58 kW) systems since 1978 outdoor thermostat obligatory for systems > 35 kW block systems and indoor thermostats for dwelling systems since 1993	40-50%	20-30%	found in new plant	block systems of greater than 35 kW nominal power must use programmable timers which allow the indoor temperature levels to be set to at least two values in the space of 24 hours, as must all dwelling systems.	70%		< 10%	since all 1999 all new block heating systems must provide temperature control and calorific counters for each of individual dwellings serviced. Since 1993 law also has set the maximum indoor temperature allowed as 20+2°C. It also sets, except for extenious conditions, the length of the heating season and the maximum number of hours a day.
Netherlands		90-95%		5%-10%		40-50%	on all new installations in the last 15-20 years		
Sweden									
UK		73%						37%	

References

BAK (1997) *EnergieNed/Basisderzoek Aardgasverbruik Klienverbruikers* 1996. RJ Weegink, April 1998, Arnhem, NL **(taken from ECI, 2000)**
BEK (1996) *EnergieNed/Basisderzoek Elektriciteitsvernruik Klienverbruikers* 1996. RJ Weegink, June 1997, Arnhem, **(taken from ECI, 2000)**
BEK (1997) *EnergieNed/Basisderzoek Elektriciteitsvernruik Klienverbruikers* 1997. Arnhem,
BRE (1998) *Domestic Energy Fact File 1998,* Building Research Establishment Report 354, Building Resarch Establishment, UK
Dansk Naturgas (1998) *Report to the Danish Parliament 1998*, **(taken from ECI, 2000)**
Dansk Naturgas (1999) Dansk Olie Og Naturgas A/S (DONG), January 1999. DONG is the association of Danish natural gas suppliers, **(taken from ECI, 2000)**
DEA (1999) Danish Energy Agency, **(taken from ECI, 2000)**
DEA (1998) *Denmark's Energy Futures*. Published by the Danish Energy Agency and the Ministry of Environment and DBDH (1999) Danish Board of District Heating, **(taken from ECI, 2000)**
Energy, Copenhagen, 1995, **(taken from ECI, 2000)**
ECI (2000) *Country Pictures*, *Supporting Material for Lower Carbon Futures*, Environmental Change Institute, University of Oxford
ECI (2000b) *Appendix R: Development Of The European Gas Network, Supporting document for Lower Carbon Futures,* Environmental Change Institute, University of Oxford
ECI (2000c) *Lower Carbon Futures,* Environmental Change Institute, University of Oxford
ENEA (1999), *Dati ed Analisi Energetica del Settore Residenziale in Italia (1970-1998)*, ENEA, Roma
Energy Outlook (1999), European Union Energy Outlook to 2020
Euroheat (2000), *District heat in Europe, 1999 survey,* Euroheat and Power, Unichal, Brussels, Belgium.
Euroheat (1998), *Euroheat and Power News June 1998*, Euroheat and Power, Unichal, Brussels, Belgium.
Eurostat (1999) *Energy consumption in households*. *European Union and Norway, 1995 survey*. ISBN 92 828 7589X , European Communities
Eurostat *Europe's Environment: Statistical Compendium for the Second Assessment*
Finergy/Sener (1998) Electricity in Finland. Brochure produced by the Finish Energy Industries Federeation (Finergy) and the Finnish Electricity Association (Sener), Finland **(taken from ECI, 2000)**
EU (1992) *Council Directive 92/42/EEC of 21 May 1992 on efficiency requirements for new hot-water boilers fired with liquid or gaseous fuels*
Gastec (1999) *Estimation of energy savings by replacement of fuel oil and gas boilers,* Final Report for SAVE Contract No XVII/4.1031/Z/96-072, Gastec, AC Apeldoorn, The Netherlands
IEA (1998b) *Country Profile - Italy*, in October issue of *Green Times*, Volume 5, Issue 4, **(taken from ECI, 2000)**
IER (1998) *Evaluation and Comparison of Utility's and Governments DSM-Programmes for the Promotion of Condensing Boilers. Final Report, SAVE Contract No. XVII/4.1031/Z/96-136.* Institut für Energiewirtschaft und Rationaelle, Energieanwendung, University of Stuttgart, Germany, August 1998 **(taken from ECI, 2000)**
MTI (1997) *Energy Economy in 2025*: *Review of Various Scenarios.* Ministry of Trade and Industry Publication reference number 7/1997, Finland, **(taken from ECI, 2000)**
MURE (2000) *Best Available Technologies In Housing, German Case Study for MURE II,* Fraunhofer-Institute for Systems and Innovation Research (FhG-ISI)
MURE (2000b) *Best Available Technologies In Housing, UK Case Study for MURE II,* Gillian Fenna, Istituto di Studi per l'Integrazione dei Sistemi , Rome
np - national partner supplied data, without or with only limited original reference information
MURE (2000c) *Best Available Technologies In Housing, Case Study for Italy MURE II,* Stefano Faberi - Riccardo Enei, Istituto di Studi per l'Integrazione dei Sistemi , Rome
Pindar (2000) Personal communication with Ecoflam spa, manufacturer of condensing boilers Italy

STEM (1998) *Energy in Sweden 1998, and Energy in Sweden (Energiläget i siffor) Facts and Figures 1998*. Published by the Swedish National Energy Administration. Energimyndighten, Stockholm, Sweden. **(taken from ECI, 2000)**
Voss-Uhlenbrock H (1999), Schuler A, Weber C, e Fahl U *International Comparison of Instruments: Effective Policy Instruments for Energy Efficiency in Residential Space Heating - an Empirical Analysis*, Universitat Stuggart, Contract N° JOS3-CT97-0014 (DG 12 - WSMN)
Young (2000) Boilers for Domestic Space Heating and Hot Wtaer in the United Kingdom. A Sector Review Paper on Projected Energy Consumption for the Department of the Environment, Transport and the Regions **(taken from ECI, 2000c)**

Annex - heating system stock makeup

Total stock 1995

(Data for Austria, Belgium, Greece, Luxembourg and Spain taken from Eurostat (1999))

As % of total households

Type of heating system	Fuel	Technology	Denmark	Finland	France	Germany	Ireland	Italy	Netherlands	Sweden	UK	Austria	Belgium	Greece	Luxembourg	Spain
home/dwelling	Total		36,6	44,6	62,0	74,9	73,0	48,3	76,0	59,0	87,0	56,9	63,3	56,7	86,3	39,9
	Gas		11,5	0,4	20,0	36,6	14,6	37,3	76,0	0,4	71,0	18,2	24,1	0,1	28,1	12,1
	of which	conventional	10,5		18,0	34,6	14,6	37,1	46,0		70,0					
		condensing	1,0		2,0	2,0	0,0	0,2	30,0		1,0					
	Electr		0,7	21,2	22,2	6,2	8,8			19,4	10,0	1,1	2,7	0,6	4,8	6,0
	of which	storage			4,44	6,1					8,0					
		convective			16,9					12,9						
		hdyronic								6,5						
		other			0,9	0,1					2,0					
	Oil		23,2	18,0	15,0	30,8	27,7	8,2		12,4	3,0	21,4	35,7	54,9	51,2	14,3
	Coal		0,7		0,6	0,8	21,9	0,0			3,0	3,8	0,4	0,5	0,2	2,4
	Wood		0,3	4,7	2,2	0,6				2,2		10,1	0,0	0,5	0,0	1,8
	Lpg				1,9			2,8				0,8	0,4	0,1	1,2	3,3
	Other		0,2	0,3	0,1			0,0		24,6		1,5			0,8	0,0
block	Total		0,0	0,0	15,5	0,0	0,0	20,4	8,0	0,0	0,0					
	Gas				9,7			10,6	8,0							
	Electr															
	Oil				5,3			9,5								
	Coal				0,4											
	Wood							0,1								
	Lpg							0,2								
	Other				0,1											
district	Total		54,5	48,1	4,8	12,2	0,0	1,2	3,0	41,0	2,0	11,1	0,1			
	Gas															
	Electr															
	Oil															
	Coal															
	Wood															
	Lpg															
	CHP					4,2		1,1	3,0		2,0					
	Other					8,0		0,2								
room	Total		8,9	7,1	18,4	12,9	26,0	18,9	13,0	0,0	10,6	32,0	36,6	46,4	13,7	49,7
	Gas		0,2		0,6	4,6	1,0	7,8	12,4		7,0	6,7	14,1		3,1	0,1
	Electr		6,2		6,5	–	1,6	1,1	0,1		1,8	9,0	6,2	10,1	2,2	29,4
	Oil		0,7		1,8	3,4	3,4	0,3	0,2		0,0	4,5	6,8	15,1	3,3	0,3
	Coal		0,6		2,2	4,0		0,2	0,1		1,8	3,1	6,9	0,6	2,2	1,9
	Wood			7,0	6,8	0,8	8,0	8,1	0,2			8,2	1,2	16,6	2,2	6,2
	Lpg						1,2	1,4	0,1			0,2	1,1	4,0	0,6	11,2
	Other		1,2	0,1	0,4		10,8					0,3	0,3		0,1	0,6
Non							1,8	11,2								

Total stock 1995 - summary

(Data for Austria, Belgium, Greece, Luxembourg and Spain taken from Eurostat (1999)
In Greece some households use more than one type of fuel at the same time))

		Denmark	Finland	France	Germany	Ireland	Italy	Netherlands	Sweden	UK	Austria	Belgium	Greece	Luxembourg	Spain
Central Heating Only (dwelling, block, district)															
	Total	91,1	92,7	82,3	87,1	73,0	69,9	87,0	100,0	89,0	68,0	63,4	56,7	86,3	39,9
	Gas	11,5	0,4	29,7	36,6	14,6	47,9	84,0	0,4	71,0	18,2	24,1	0,1	28,1	12,1
	Electr	0,7	21,2	22,2	6,2	8,8	0,0	0,0	19,4	10,0	1,1	2,7	0,6	4,8	6,0
	Oil	23,2	18,0	20,3	30,8	27,7	17,7	0,0	12,4	3,0	21,4	35,7	54,9	51,2	14,3
	Coal	0,7	0,0	1,0	0,8	21,9	0,0	0,0	0,0	3,0	3,8	0,4	0,5	0,2	2,4
	Wood	0,3	4,7	2,2	0,6	0,0	0,1	0,0	2,2	0,0	10,1	0,0	0,5	0,0	1,8
	Lpg	0,0	0,0	1,9	0,0	0,0	3,0	0,0	0,0	0,0	0,8	0,4	0,1	1,2	3,3
	Other	0,2	0,3	0,2	0,0	0,0	0,0	0,0	24,6	0,0	1,5	0,0	0,0	0,8	0,0
		36,6	44,6	77,5	74,9	73,0	68,7	84,0	59,0	87,0	56,9	63,3	56,7	86,3	39,9
	District	54,5	48,1	4,8	12,2	0,0	1,2	3,0	41,0	2,0	11,1	0,1	0,0	0,0	0,0
All Heating															
	Total	100,0	99,8	100,7	100,0	99,0	88,8	100,0	100,0	99,6	100,0	100,0	103,1	100,0	89,6
	Gas	11,7	0,4	30,3	41,2	15,6	55,7	96,4	0,4	78,0	24,9	38,2	0,1	31,2	12,2
	Electr	6,9	21,2	28,7	6,2	10,3	1,1	0,1	19,4	11,8	10,1	8,9	10,7	7,0	35,4
	Oil	23,9	18,0	22,1	34,2	31,1	18,0	0,2	12,4	3,0	25,9	42,5	70,0	54,5	14,6
	Coal	1,3	0,0	3,2	4,8	21,9	0,2	0,1	0,0	4,8	6,9	7,3	1,1	2,4	4,3
	Wood	0,3	11,7	9,0	1,4	8,0	8,2	0,2	2,2	0,0	18,3	1,2	17,1	2,2	8,0
	Lpg	0,0	0,0	1,9	0,0	1,2	4,4	0,1	0,0	0,0	1,0	1,5	4,1	1,8	14,5
	District	54,5	48,1	4,8	12,2	0,0	1,2	3,0	41,0	2,0	11,1	0,1	0,0	0,0	0,0
	Other	1,4	0,4	0,6	0,0	10,8	0,0	0,0	24,6	0,0	1,8	0,3	0,0	0,9	0,6
Total (Heating + No heating)		100,0	99,8	100,7	100,0	100,8	100,0	100,0	100,0	99,6	100,0	100,0	103,9	100,0	100,4

Age distribution and nominal efficiency of installed gas and oil heat generators - 1995

Type of heating system	Fuel	Tecnology		Average efficiency related to age of appl. [full load **boiler** eff. on LHV]																				
				Average					Denmark				Finland				France				Germany			
				All years	<1970	1971–1980	1981–1990	>1990	<1970	1971–1980	1981–1990	>1990	<1970	1971–1980	1981–1990	>1990	<1970	1971–1980	1981–1990	>1990	<1970	1971–1980	1981–1990	>1990
home/dwelling	Total																							
	Gas																							
	of which	conventional	*distribution by age*		*1%*	*15%*	*41%*	*41%*	*0%*	*19%*	*49%*	*26%*					*0%*	*23%*	*34%*	*42%*	*0*	*19%*	*22%*	*59%*
			efficiency		82	84	87	91		84	87.13	91.8						85	83.28	87.92	79	83	88	92
		condensing	*distribution by age*						*0%*	*0%*	*71%*	*29%*							*44%*	*66%*				*100%*
			efficiency	98							93	98							95	95				102
	Oil		*distribution by age*		*14%*	*24%*	*32%*	*30%*	*31%*	*26%*	*33%*	*9%*					*0%*	*23%*	*34%*	*42%*	*0%*	*32%*	*23%*	*45%*
			efficiency		80	84	88	91	82	85	87	88					80	85	90.5	90.5		81	85	91

Denmark, Finland, France, Germany. Average = nine country average. Grey empty cells indicate value not applicable. Empty cells indicates no data available

Age distribution and nominal efficiency of installed gas and oil heat generators - 1995

Ireland., Italy, The Netherlands, Sweden and UK. Average = nine country average. Grey empty cells indicate not applicable. Empty cells indicates no data available

Type of heating system	Fuel	Tecnology		Ireland <1970	Ireland 1971–1980	Ireland 1981–1990	Ireland All years	Italy <1970	Italy 1971–1980	Italy 1981–1990	Italy >1990	Netherlands <1970	Netherlands 1971–1980	Netherlands 1981–1990	Netherlands >1990	Sweden <1970	Sweden 1971–1980	Sweden 1981–1990	Sweden >1990	UK <1970	UK 1971–1980	UK 1981–1990	UK >1990
				Average efficiency related to age of appl. [full load **boiler** eff. on LHV]																			
home/dwelling	Total																						
	Gas																						
	of which	conventional	*distribution by age*	0%	0%	15%	85%	0%	11%	48%	41%	6%	17%	49%	29%	0%	0%	48%	52%	1%	16%	45%	38%
			efficiency			86	89	80	82	86	88	86	87	89	91			92	94	81	84	86	89
		condensing	*distribution by age*					0%	0%	0%	100%	0%	0%	17%	83%	0%	0%	33%	67%	0%	0%	17%	83%
			efficiency								95			104	104			95	97			96	97
	Oil		*distribution by age*	30%	20%	25%	25%	1%	24%	56%	19%					46%	27%	17%	10%	6%	11%	26%	54%
			efficiency	72	83	86	92	80	84	88	90					86	88	90	93	72	83	86	92