Preparatory Study on

Eco-design of Water Heaters

Task 3 Report (FINAL)

Consumer behaviour & local infrastructure

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1 INTRODUCTION

1.1 Scope

Consumer behaviour can –in part- be influenced by product-design but overall it is a very relevant input for the assessment of the environmental impact and the Life Cycle Costs of a product. One aim is to identify barriers and restrictions to possible eco-design measures, due to social, cultural or infra-structural factors. A second aim is to quantify relevant user-parameters that influence the environmental impact during product-life and that are different from the Standard test conditions as described in Subtask 1.2.

1.2 Identification of possible barriers to eco-design innovations

- cultural and social aspects relating to purchase, use and disposal of the product. Including an estimate of the e.g. second-hand market, repairs and product life, etc.
- local infra-structure related to the product. E.g. reliability of the electric grid and how consumers deal with it. Special tariffs and consumer behaviour. For installed appliances: Penetration of gas-grid, logistics of oil/coal/peat/wood storage, chimney renovation costs, etc...

One barrier for Ecodesign is when the buyer of the water heater is not the user and therefore is not confronted with the energy costs. This is certainly true for new buildings, where the purchase of a water heater is simply a part of the building costs. Especially in countries with low energy tariffs and/or a low awareness of the potential house-owners of the energy bill, the energy efficiency of the water heaters will not serious affect the price of the building as a whole, practically allowing builders and specifiers to prescribe the cheapest solution that the legislator will allow. In particular for electric storage water heaters the utilities play an important role. For small electric storage water heaters, usually placed in the kitchen cupboard, the proposals of the kitchen suppliers may play a rol. Compared to the situation with CH Boilers the main difference is that a) for hot water the consumer will be more explicit in his/her wishes regarding hot water comfort, and b) the consumer will more easily decide to purchase and install a small second water heater e.g. for a single outlet in the kitchen. Especially for these appliances the intervention of an installer is not always required.

For water heater-replacements in existing buildings the main influencer of the purchase decision is not the user. Installers –as advisers of the house owner—play an overriding role as the average consumers do not judge themselves expert enough to go against such an advice.

The motives and training level of these specifiers and installers will be a major theme in our study. Also here, there are considerable differences between countries.

The local infra-structure is another major issue. First of all, the penetration rate of e.g. the gas-grid, the availability and infra-structure costs of other fuels (oil, biomass, coal, district heating) is a very important consideration in the legislation and therefore in the study proposed here. Furthermore, the infra-structure would also include the house and certain technical provisions, like chimneys. As an extension on our work in the MEEUP project, we intend to look installation costs for chimneys that are appropriate for condensing water heaters in some other countries besides the Netherlands. Finally, for solar water heaters the climate is of course a major influencing factor.

1.3 User defined parameters

Quantification of user-defined parameters relating to the product, e.g.

- load efficiency (real load vs. nominal capacity);
- temperature- and/or timer settings;
- characteristic of use.

The real-life load of a water heater depends on some consumer-independent factors like the standing losses (storage-type), piping lay-out (waiting time, waste of heat and/or water) and perhaps special control provisions ("comfort" switch, or legionella protection regime if applicable), but most of all it will depend of the tapping behaviour of the consumer: The number of tapping cycles, their flow rate, use (basin or not) timing, desired temperature and duration. In mandate M204 some representative tapping cycles are presented and also in the EN standards for the EPBD tapping behaviour will play a role, but VHK will also investigate if there is any new information from consumer surveys concerning tapping behaviour that could be taken into account, e.g. to improve the dimensioning and lay-out of the system, and that gives some impression on how representative the standard tapping patterns are.

Issues:

- Family size;
- Frequency, duration, timing, etc. of baths vs. showers;
- Typical kitchen use, e.g. hot-fill dishwashers;
- Bathroom use, e.g. sinks and bidet.

1.4 Report structure

This Task report basically consists of two parts: The first part deals with the stakeholders involved in the process of specifying water heaters and in which the installer plays a central role. The second part deals with the local characteristics and technical infrastructure that also define the water heating system.

2 CONSUMERS, INSTALLERS AND OTHER STAKEHOLDERS

This section deals with the process of specifying specifically gas-fired water heaters which appears foremostly a task for the installer. Besides installers also the role of the householder, often the one who initiates the contact (for existing installations) and ultimately pays for the whole thing and other stakeholders such as manufacturers, developers and housing associations is described. The role of utilities and kitchen suppliers will be discussed in later drafts.

2.1 Survey: How households choose their gas appliance

Most of the information in this section is based upon the 1999 study Lower Carbon Futures: Appendix C [1] which presents the findings of a very detailed study of motives and behaviour of actors involved in the process of specifying boilers, but to a large extend is also applicable to gas-fired water heaters. Although it mainly focuses on the residential sector of the UK the findings are so recognisable that they are deemed relevant for the rest of the EU as well, although the percentages presented of course will be different given the spread in legislative environments and market characteristics in other Member States. The study was based upon lengthy interviews with eleven households who recently bought a new boiler/installation or gas water heater, backed up by telephone interviews by GfK with a much larger group of households. Furthermore a group of installers, manufacturers, trade associations, developers, housing associations and local authorities were contacted as well.

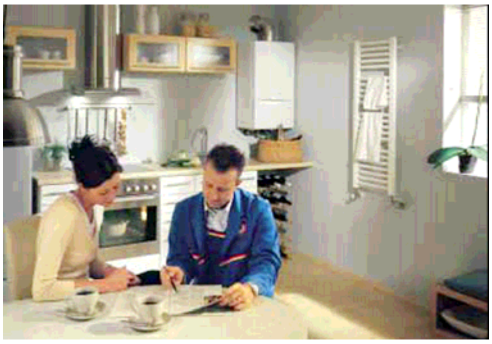

Figure 2-1.
Installer advising a householder (source: www.heizunsgcheck.de)

[1] Banks, N.W., Appendix C: The UK Domestic Heating Industry - Actors, Netwroks and tTheories (Background paper for Lower Carbon Futures study), ECI, Oxford, 1999

2.1.1 Householders

The householders were asked what motivated them to decide for a new installation. The unprompted - no multiple choice but the first answer that sprung into their minds - showed that approximately 2 out of 3 installations are motivated by a breakdown of the old appliance (or concerns related to that).

Reason for new installation	percentage
Fault or breakdown	49
Old installation prone to breakdown (but still working)	14
Reorganisation due to other building project	7
New requirements (e.g. more capacity, combi functions)	7
New kitchen	6
No heating before	6
Efficiency concerns	4
Safety	2
Extension	2
Wasting money concerns	1
Comfort / level of service concerns	1
Other	3
	100

Other important motivators are refurbishments, home improvements or other building reorganisation projects. This includes the listing of "new kitchen" as reason which is typical for the UK, where over 50% of boilers and water heaters are installed between or next to the kitchen cupboards. The report mentions that some 22% of new installations are related to a kitchen refit. Only 5 tot 7 percent mention "changing needs / other requirements" as main reason (e.g. appliance with more output or combi-functionality). Some 4-5 percent mention energy efficiency/running costs.

The respondents were then asked who did the installation. A large majority (over 80%) used an unknown (no friend/relative) professional installer. Some 10% relied on a known installer and 8% had a known, non-professional installer (friend/relative/him-/herself) doing the job.

Who installed the system	percentage
Professional installer	82
Professional installer who is friend or relative	10
Friend or relative	4
Me, spouse or partner	4

The study also makes an important remark about trust in installers. It revealed that some 60% of the respondents would not trust an unknown installer. This is flagged as a potential disincentive in taking inital steps to improve heating systems - especially where one has no pool of objective advice to call on to judge whatever the professional installer may say.

This apparent lack of trust is also recognised by the sector itself, a.o. in publications by the EETB and the European Commission [2].

Householders were also asked how they decided on which installer/installation to use. In case the householder had time to gather information before installation he/she

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[2] Competitiveness of the Construction Industry, DG ENTERPRISE, Education, Training and Image Working Group, Bruxelles, December 2000 (http://www.ceetb.org/docs/Reports/training.pdf)

obtained quotes from a number of installers. Over a half of the householders obtained more than one quote, allowing a comparison.

number of quotes	none	1	2	3	4	5 or more
percentage	12	35	18	25	6	4

This also shows that the other half of respondents apparantly rely on the installer to suggest what he/she thinks fit. This indicates a possibility for installers of introducing more efficient appliances. On the other hand it would also be... if householders asked for certain aspects beforehand, since once the quote is out there it can be regarded as a "fait accompli" and discourages the householder to ask for a more efficient solution.

Some 35% of the respondents described the replacement situation as an emergency, whereas 70% felt they had the time to gather information prior to work being done.

When asked whether the respondent was interested in energy efficiency a large majority indicated they were.

Are you interested in energy efficiency?	agree strongly	agree slightly	neutral	disagree slightly	disagree strongly
percentage	36	42	8	6	8

A similar response was prompted by the question whether one was interested in reducing home energy use.

Are you interested in reducing home energy use?	agree strongly	agree slightly	neutral	disagree slightly	disagree strongly
percentage	45	26	12	12	5

When asked for their interest in heating domestic water in a more environmentally friendly manner, the responses were that some 40% indicated no interest in this.

Are you interested in heating domestic water in a more env...	agree strongly	agree slightly	neutral	disagree slightly	disagree strongly
percentage	31	18	11	8	32

Even more disinterest was noted regarding the application of innovative heating techniques, with only 19% showing a positive attitude and 70% showing a negative attitude.

Are you interested in innovative heating techniques?	agree strongly	agree slightly	neutral	disagree slightly	disagree strongly
percentage	9	10	11	33	37

Whether this expresses a certain conservatism towards actual application of such techniques or just a casual lack of interest in the technicalities involved is not described. Fact is that adoption of an innovation has always been confined to a minority at first, requiring a personal risk and a strong motivation.

The householders where then asked what information they used in the decision process.

Around 71% had used only the information supplied by the installer for choosing their appliance. The remaning 29% actively sought information from other sources; most common were builders / plumbers merchants (20%), local energy centres (17%) and word of mouth (17%). TV and/or general advertising were rarely mentioned.

The actual decision for a new water heater is not always solely in the hands of the installer. In approximately 46-51% of the cases the decision was made by the installer together with a person from the household. The other cases were decided by either the installer alone (27%) or by a member of the household (22 to 27%).

Around one third of the householders responded that the manufacturer or model were considered important. Half of the householders considered it of little to no importance.

This also becomes evident when people are asked why they opted for a certain brand or make. For over half of the households it is that the installer recommended it.

	1994	1995	1996	1997	1998
Recommendation by installer	50	50	54	61	65
Well known make/brand	10	11	9	8	10
Price	9	7	6	7	10
Fuel savings / running costs	7	6	8	5	5
Appearance	5	4	5	6	4
Other	19	22	18	13	6

The influence of installer on householder also stretches out to providing the options from which the householder can choose. In only one/fifth-one/fourth of the cases the householder decided by him-/herself.

	System choice	Make and model choice
I left it up to him	56	50
He gave me a few choices and I chose between them	10	13
I decided and he gave some options	7	7
I decided	20	23
Other	7	7

The statements above indicate a strong influence of installers on the type of boiler fitted. This could be a hindrance in case the installer has a conservative attitude towards new technologies and some interviewees have witnessed such reticence and obstruction from the installers when they were opting e.g. for condensing appliances.

The study suggests that many people put up with appliances that are barely functional, indicating a resilience for poor heating performance and the heating bills that might go with this [3]. Some households remain reluctant to changing their heating system or boiler because of concerns over higher heating bills or that the introduction of new technology requires a change in lifestyle (e.g. no drying of clothes in airing cupboard now that the old boiler has gone) which is not always appreciated.

As mentioned in many other studies, an excellent oppurtunity to inform people regarding improvements in energy performance is when they are planning refurbishments, kitchen refits, extensions, etc. in their existing home or new home.

2.1.2 Installers

Specification of equipment by installers (selecting output, type, brand/model) differs depending on whether the installer is self-employed or working for a larger company. The former situation often has the installer specifying the boiler, often using his/her experience, general guidelines and/or rules-of-thumb. In the latter situation it is often a heating engineer or other desk-bound individual who specifies the boiler and the rest of the heating system.

[3] Poor heating performance or poor heating comfort may also lead to low heating bills (e.g. if only a limited number of rooms is heated adequately due to poor system performance). Heating bills should not be seen seperate from the heating comfort that is achieved.

The specification process also differs depending on whether the installation is new-built or in existing properties.

New-built

Larger housing developers often specify exactly what manufacturer and system types are to be installed. The responsibility of the installers lies in supplying the specified system and installing it.

Smaller builders and housing developers leave more to the installer.

Existing homes

The installer has considerable control over the specification of the gas appliances in the context of existing homes. In doing so many installers make an effort to fit the system that is most appropriate for the preferences and lifestyle of the occupants. The price quote by the installer can be influenced by the amount of work available to him/her - if there's enough work, then the price quote obviously will not be rockbottom.

When specifying appliances the personal experience of the installer with a certain brand or model is very influential. Reliability is paramount, since no installer wants to be called back for repair of a recently installed boiler. Many appliances also require specialised tools, spares and knowledge and there's a limit to the number of appliances an installer has detailed knowledge of.

This loyalty to a certain brand is also fostered by manufacturers, offering incentives such as point schemes for gifts for each appliance sold, comprehensive after sales service and courses at training centres.

The positive side of such loyalty is of course a better familiarity with and support for the product. At the down side one can mention that installers remain rather conservative and wary of new or innovative products, especially if they are made by an unfamiliar manufacturer.

In general the installer has a positive attitude towards energy efficiency. However many misconceptions and myths around condensing appliances remain, e.g. that they only work best during the coldest time of the year, that they are not financially viable, that customers do not want them, etc. [4]

Conclusions

- Installers are broadly responsible for the specification of water heating systems in existing housing;
- Installers are conservative in their approach towards new and innovative techniques. Reasons are:
    - a preference for expanding depth of knowledge, tools and experience for a limited array of appliances;
    - relations that exist between installers and manufacturers (ranging from credit schemes to visits to training centres);
    - installers do not want to be called back for a job on a recently installed product —it costs them money and reputation— and therefore prefer to install trusted, "reliable" technology;
    - that new technologies like the condensing appliances are perceived to give marginal energy savings and are significantly more expensive;
    - that installers do not feel there is a strong demand for new products;
- There is anecdotal evidence that installers have even discouraged interested customers in installing new technologies;
- That this situation of lack of trust by installers and lack of demand from customers is likely to continue until the "chicken-and-egg-situation" is resolved (Authors: and

[4] The survey is from 1999. It would take another 6 years before the condensing boiler would become mandatory for most applications (Part L of Building Regulations).

this has happened in the UK by the introduction of Part L in the Building Regulations prescribing condensing boilers as of 2006).

The average age of installers is also an aspect often overlooked, but closely linked to installer attitude towards newer technologies and the level of experience with these. It is known that the UK suffered from a shortage of plumbing skills early 2000 [5]. The Government and the trade associations tried to overcome this with the introduction of NVQ qualification schemes and many schools started apprentice courses.

2.1.3 Manufacturers

The principle marketing target for manufacturers is the installer, who is essentially the one "pulling the product from the merchants shelf". Brand loyalty of installers is sought, by a.o. providing educational facilities with free products (so that the apprentice-installer gains experience with their products), point-schemes, sophisticated web-sites, promotions in trade press and at builders and plumbers merchants.

The latter is seen as not that effective since most installers already know what they want before they go to the merchant. It is believed only 10% of installers can be influenced on the shop floor. To influence installer preferences merchants do run promotion schemes or offer complete 'heating kits'.

Manufacturers know that it is the installer rather than the householder or merchant who specifies the boiler, but at the same time feel that installers make poor ambassadors for their products. Manufacturers would like to see installers becoming better salesmen and improve the quality of their installations - call backs may affect the reputation of the brand (many faults develop because of the quality of the installation rather than the product itself). That's why training installers to work with their products is an important item, which goes well with efforts in promoting energy efficiency. The the EST (energy Saving Trust, funded by Government) has developed training material for installers as the key to greater efficiency.

2.1.4 Housing developers

In the UK the building sector is a fiercely competitive sector dominated by cost reduction efforts. Developers feel that, location aside, the price is most influential on housing choice. Therefore there is an overriding need to reduce construction costs both to gain a price advantage over competitors and to increase the profit on each house sold. Additional costs which cannot be directly added to the price of a new house are eating directly into the profit margin and are consequently discouraged. It seems to be the industry view that energy efficiency improvements beyond regulated requirements fall into this category.

What developers do to minimise installation costs is to buy in bulk (for larger projects) and settle prices with manufacturers directly. The sub-contractor (installer) is by-passed and the rebate flows directly from manufacturer to developer. Some developers engage in an even tighter relationship with manufacturers by having the manufacturer specify the heating system, based upon drawings and plans supplied by the developer. Such arrangements are called solus-arrangements. When developers are building for housing associations or local authorities the specification might lie in the hands of these parties.

The practice in the UK (and also in Italy and possibly other Member States as well, red.) of producing homes with pre-fitted kitchens —which often includes the water heating appliance— can limit the number of boiler options, sometimes to only those that can be fitted with a fascia. Chances are these are not the most efficient.

Developers are generally not happy with off-standard specification of installations e.g. to improve energy efficiency. It is perceived as something that can create a lot of

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[5] APHCL News Release, "There isn't a shortage of plumbers say APHCL", January 16, 2006 (APHCL = Association of Plumbing & Contractors Ltd.)

problems. Despite this many developers feel that there could be a market or at least an interest in energy efficient housing, especially when compared to existing housing with higher gas bills. The difficulty remains that energy efficiency often is not tangible and therefore hard to sell.

As regards solar panels and other innovative technologies the common feeling is that these technologies are too expensive and that only a small group of people would be interested ("solar is something for technophiles or cranks"). The survey mentions that another reason probably is the lack of familiarity of developers with such technologies that. A solution would be to have more local projects with efficient technology to get more people —including building management— acquainted with it.

Another suppressor of innovation in building practises are lenders (those who issue mortgages or lend money for development). If they feel they would not be able to resell the project —in case a mortgage goes bad— they won't lend the money in the first place. It is thought that lenders are extremely conservative in their tastes, making it difficult to introduce visible energy efficiency options like solar panels. The fact that many other efficient technologies are barely noticable or not visible at all, is often disregarded.

The examples above are classic examples of "split-incentives": the stakeholder responsible for the investment in the boiler is not responsible for paying the heating bills. As long as developers don't see how they can pass on the investment to home-buyers the investment will not be made. The survey suggests introduction of labels, indicating energy efficiency of water heaters (or whole heating systems) as a means for installers and developers to "sell" the higher investment costs.

2.1.5 Local authorities

The survey highlights the difficulties, such as lack of funding and resources, local authorities have in putting to practice energy efficiency initiatives from central government. Local authorities also perceive a lack of co-ordination between government schemes and local actors such as local energy advisory centres, leading to a profusion of schemes and inconsistent messages.

Despite such problems local authorities are recognised as perfect in place for giving advice when planning applications come in and alerting applicants for additional funding for weatherisation or other efficiency improvements.

2.1.6 Conclusions

- The three main reasons for a change of a gas appliance are breakdown, upgrading or changing household needs.
- In almost three quarters of installations for private households the installer has (large) influence on the type of boiler to be installed;
- Some households remain reluctant to change their system because of concerns over higher heating bills or a forced change of habits;
- Installers tend to produce one quote with the least expensive option, even if householders would be prepared to invest in a more efficient system;
- Installers are (seen as) not the best ambassadors for energy efficiency for several reasons:
  - Installers have a strong preference for sturdy, "reliable" and proven technology, to avoid call backs;
  - Installers like to work with a select range of models which they have experience with and tools and spares available;
  - Installers have relations to certain manufacturers (for gifts, promotion, training) making them wary for (new) products of other manufacturers;
  - Installers think energy efficient technologies do not deliver enough benefits for householders and see no demand for these from households;

- Manufacturers do not see a commercial conflict between their commercial business and promotion of energy efficiency;
- Manufacturers do consider installers as conservative and invest in training facilities and programs to improve installer awareness and experience with new technologies;
- Developers who specify (water) heating systems are seriously hampered by 'split incentive' problems e.g. not being able to pass on higher costs Other stakeholders, e.g. lenders, also take a very conservative approach to housing.
- Local authorities can play a major role due to their involvement in both private and commercial projects by sensitising the specifying parties to energy efficiency issues at a natural moment.

The survey concludes that an enthusiastic installer is potentially the key to more efficient heating installations. To improve current installer attitudes training schemes, targeting both actual installation as well as the skills to sell efficient products to the public, have been developed. The development of an A-G label would help to raise awareness of efficiency as an issue with installers. Such a label would also assist other specifiers such as architects, local authority housing officiers and (the small number of) householders who do take a more active role in specification.

2.2 Size and organisation of the sector

2.2.1 Size [6]

Statistical information on the sector of installers is covered by classification NACE 45.3 "Installation work", which in turn is subdivided into four classes: Installation of electrical wiring and fittings (NACE class 45.31); Insulation (NACE class 45.32); plumbing (NACE class 45.33) including all water and gas supply, drainage, heating and ventilation work; and other building activities (NACE class 45.34). Note that the installation of industrial equipment (for example the installation of industrial furnaces and turbines) is excluded. According Eurostat some 2,9 million people where employed in sector 45.3 in the EU25 in 2002 and generated 88,7 billion euro of value added. As such the installation sector as a total made up nearly a quarter of the overall contruction sector (NACE 45) contributing 23,9% of the workforce and 23,1% of the value added.

The largest contributing Member States to the overall performance of the sector 45.3 are the United Kingdom (19,8% of value added in the EU25), Germany (19,2%), France (15,4%) and Italy (12,8%). Other Member states shows shares below 10%. As regards EU25 employment Germany leads (with 17.6% share of EU25 employment), followed by Italy (14,9%) and Spain (14,1%).

A more detailed analysis of the subsector (unfortumately excluding Member States as Spain, Belgium, Czech Republic, Greece and Malta, Netherlands incomplete) shows that plumbing contributes 40,1% tot the total of value added by the sector, second to electrical wiring and fittings (48,2%).

When looking at the size of companies (for the same subset of Member States as above) involved there is no detailed breakdown for the plumbing sector but the installation sector as a whole consists of 35,5% micro-enterprises (1-9 persons employed), 32,9% small enterprises (10-49 persons employed) and 31,6 medium to large enterprises (50-249 and 250+ persons employed).

2.2.2 Organisation

Installers are organised on Europan level through the CEETB, founded in 1976 as the joint European association of electrical, heating, air conditioning, ventilation and

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[6] European business, Facts and figures Data 1995-2004, Eurostat, 2005.

plumbing contractors. CEETB has 25 membership countries and represents about 450.000 specialist building contractors with 2.400.000 employees in the European Union and beyond. According CEETB these companies have a combined overall turnover of about 200 billion Euro.

The CEETB itself is composed of the organisations AIE (International Association of Electrical Contractors), the GCI (International Union of the Associations of Heating Ventilating and Air-Conditioning Contractors) and the UICP (International Union of Roofing and Plumbing Association). Of these the GCI is of course the organisation representing the installers and most relevant here. GCI's 15 member organisations represent 80.000 contracting businesses with a total workforce of more than 500,000. The member organisations of GCI at national level are indicated in figure 2-2 below.

However not all installer companies operating in a country are members of such organisations. As an example the Dutch UNETO-VNI claims there are some 12.300 companies active in the installation sector, employing 120.000 persons and producing an annual turnover of some 12 billion euro. However only 5.000 companies are member of UNETO-VNI (realising a turnover of some 10 billion euro turnover indicating it is mainly the larger companioes that are member). A similar situation can be expected in other member states indicating a significant group of companies that are not represented by national branche associations. Furthermore these organsiations listed below may be representating trades besides that of plumbing /installation work.

Figure 2-2.

MEMBERS GCI at country level		# of members or companies(if indicated on website)	
Austria	B.S.H.L.	Website: http://www.shk.at/	
	VZHL	Website: www.fmmi.at	
Belgium	F.B.I.C. - L.B.I.S.	Website: http://www.lbis-fbic.be	
	UBIC	Website: www.ubic.be	40% of employees
Denmark	DANSK VVS	Website: www.tekniq.dk	
Finland	LVI-Tekniset UrakoitsijatLVI-TU ry	Website: http://www.lvitekniseturakoitsijatlvitu.fi ; http://www.lvi-tu.com	
France	UCF	Website: www.ucf.fr	4600 companies, 55,000 employees, 40 billion francs trunover
Germany	BHKS	Website: http://www.bhks.de	600 companies 45,000 employees
	ZVSHK	Website: http://www.wasserwaermeluft.de	50.000 companies, 300,000 employees
Ireland	M.E. & B.S.C.A.	Website: http://www.cif.ie	3000 members
Italy	ASSISTAL	Website: www.assistal.it	1500 companies
Luxembourg	Fédérations des Installateurs en Equipements Sanitaires et Climatiques	Website: http://www.federation-des-artisans.lu	
Netherlands	UNETO-V.N.I.	Website: www.uneto-vni.nl/ www.vni.org	5000 companies
Norway	N.R.L. - VVS	Website: http://www.nrl.no	
Portugal	AECOPS	Website: http://www.aecops.pt	
Spain	CONAIF	Website: http://www.conaif.com	
Sweden	Platslageriernas Riksförbund	Website: http://www.plr.se	
	VVS - Installatörerna	Website: http://www.vvsi.se	1400 members
Switzerland	Suissetec	Website: http://www.suissetec.ch	3200 members of which
United Kingdom	APHC	Website: http://www.aphc.co.uk	
	HVCA	Website: http://www.hvca.org.uk	
	SNIPEF	Website: http://www.snipef.org	
AFFILIATE MEMBERS			
Australia	AMCA	Website: www.amca.com.au	
Bulgaria	NIS	Website: http://www.nisbg.org	
Canada	Mechanical Contractor Association of Canada	Website: http://www.mcac.ca	
Cyprus	Mechanical Contractor Association of Cyprus	Website:	
Czech Republic	Czech association of mechanical, electrical and plumbing contractors	Website: http://www.amf.cz	
United States	MCAA	Website: http://www.mcaa.org	
	MCA	Website: http://www.ncmca.net	

2.3 Training / certificates / qualifications

Installers carry great responsibility in keeping up to standards the energy efficiency and safety of the heating park and of new installations. For this it is essential that adequate training is followed, often communicated to the public through certification (or qualification) of expertise.

Each Member State has its own set of requirements for installers in order to be allowed to work with gas, electrical and other potentially dangerous goods and equipment. In certain Member States certification or qualification schemes for installers are mandatory. Certification often is only valid for certain specific areas in plumbing. A gas installer is not automatically certified for making oil or electrical installations. In some cases certifications schemes are still in its infancy stage, e.g. for the installation and commissioning of heat pumps and/or solar panels.

Since it is not feasible (not within budget nor timescope of the study) to describe all possible training /certification /qualification schemes existing in all 25 Member States some national schemes are highlighted to serve as an example of approaches found.

2.3.1 Example UK

Education

Becoming a heating system installer in the UK starts with basic skills at two or four GCSEs (A-C)/S grades (1-3) levels (school diploma) or an appropriate Intermediate GNVQ/GSVQ level II or equivalent. After this students (often at age 16-18) can either choose to work as apprentice and attain NVQ levels (NVQ = National Vocational Qualification [7]) through learing at the job combined with part-time training or continue with full-time education. The apprentice route is very popular and leads to relevant NVQ qualification level 1 to 3 in a period of 2 to 4 years [8,9].

Installers who have opted into CORGI's Building Regulations Self-Certification and/or those registered with the OFTEC Competent Person Scheme, are able to certify that their work complies with Building Regulations. The NVQ/SVQ in Gas Service Installation and Maintenance is the only gas qualification that allows for CORGI registration.

Heating installations

In the UK homeowners are required to inform their Local Authority Building Control if they realise new electrical, gas, oil or other installations or make significant changes to existing ones. The Regulation requires such changes to be inspected, possibly by third party involvement. In order to take away some of this burden from homeowners and the local authorities the Regulations also introduced a register of Competent Persons, who can do he necessary installation works themselves and notify this to the authorities directly.

Depending on the type of work different registrations apply:

- Electrical: BRE, BSI, ELECSA, NAPIT and NICEIC
- Gas: CORGI
- Oil: OFTEC
- Solid fuel: HETAS
- CORGI and OFTEC also allow certification including minor electrical works (like realisation of sockets for boilers).

[7] http://www.qca.org.uk/14-19/qualifications/index_nvqs.htm

[8] http://www.wakefield.gov.uk/JobsAndCareers/ApprenticeshipsandAdvanced/GasFitter.htm

[9] http://www.eaifhe.ac.uk/New%20Courses/Jobskills/JS%20Plumbing.htm

Gas equipment

For people working on gas fittings and appliances CORGI registration is a legal requirement.

The Gas Safety (Installation and Use) Regulations 1998 placed specific duties on gas users, installers, suppliers and landlords. Installers of gas equipment are obliged to be CORGI [10] registered. CORGI is charged by the Health and Safety Executive (HSE3) to maintain a register of competent gas installers in Great Britain, Northern Ireland and the Isle of Man. Gas equipment owners are not allowed to have non-CORGI registered installers to work on gas appliances. CORGIS visits each installer before completion of registration.

For new installations (and replacement) this means that all equipment is installed by qualified personel. For existing installations gas equipment owners have to ensure that Gas fittings (appliances, pipework) and flues are maintained in a safe condition. CORGI recommends safety checks on an annual basis: for home owners-occupiers these are not enforced [11], but for landlords these checks are mandatory (the Declaration that goes with it will be legally required from 2007) and tenants have the right to ask for proof of recent checks. CORGI also states that the safety check is not sufficient to provide effective maintenance and vice versa.

The regulations also place a number of restrictions on gas appliances installed in bathrooms, shower rooms and bedrooms which are detailed and prescriptive. For instance it is now illegal to install instantaneous water heaters, which are not room sealed or fitted with a safety device that automatically turns the gas supply off before a dangerous level of poisonous fumes builds up. CORGI installers also have a duty to report any unsafety regarding gas appliances if they encounter these during their work.

LPG

For the installation of LPG equipment the installer has to be CORGI registered, followed by a specialised training which requires a steep entry level and may cost up to 2 years to complete.

The investment costs for CORGI registration are almost 600 euro for registration and 300 euro for annual membership fee. Including the expense of the NVQ and further Accredited Certification schemes for LPG, the total cost of becoming an LPG installer could easily be between three to five thousand pounds.

Oil

OFTEC (Oil Firing Technical Association) is a trade association and maintains the Government register of ‘Competent Persons’ who are qualified to work on oil fired heating and cooking appliances. Although it is not explicityly mentioned that the installer working on the installation should be OFTEC registered, OFTEC mentions evident benefits of hiring OFTEC registered installers since they may notify the works by themseleves, avoiding costly inspection by third parties. The client (homeowner /landlord) receives a certificate confirming that the work done meets the relevant Building Regulations and has to keep the certificate in a safe place since it may be needed when Home Information Packs become mandatory for England and Wales in June 2007. The installation itself must follow strict guidelines from Building Regulations.

OFTEC recommends an annual service and safety check including the flue, but also points to manufacturers service schedules as some boilers may require servicing more often than others. When installing a new/replacement equipment the OFTEC Registered Technician is required to ensure as far as is reasonably practicable that the flue liner should last the life of the appliance and may decide for relining of the chimney with a stainless steel flue liner.

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[10] Confederation for the Registration of Gas Installers

[11] http://www.corgi-gas-safety.com/section_gas_law/house-owner.asp

If a new/replacement is reconnected to existing stainless steel flue liner, the existing stainless steel flue liner may spilt (allowing products of combustion to escape) when it is disturbed without the technician knowing it.

The investment for OFTEC registration by an installer is 60 euros per year for an individual and 670 euro for a company for 5 years. Furthermore the installer must have a Public Liability insurance cover, minimum 1.5 million euro. The necessary courses (there are several modules: for oil storage tank installation, heater installation, pressure jet and/or atomising burner commissioning and servicing, etc.) take half a day to one day to complete. Each installer is visited and accompanied by an OFTEC inspector every 5 years.

Noteworthy is also the campaign "skills for business" which aims to train some 70.000 heating fitters in advicing and installing more efficient appliances and equipment.

Please note that dedicated oil-fired water heaters are rare. Usually oil-fired water heating occurs through a boiler heating an indirect cylinder.

Electrical [12]

Applications for any electrical work must be made before work starts, unless it is to be carried out by a 'Competent Person' who is on an Approved Register, and who is capable of 'self certifying' their own work. In cases where a Competent Person is used, Building Control Section will receive notification after completion of the works.

The scope of the electrical work covered (Part P of Building Regulation) that may affect private homeowners includes:

- New Installations, plus;
- Alterations
- Additions
- All electrical work in Kitchens (except accessory changes)
- All electrical work in bathrooms (except accessory changes)
- Power supplies to Sheds, Greenhouses, other Detached Buildings
- Floor and Heating systems
- Extra Low Voltage systems
- Generators
- Swimming pools
- Saunas
- Photovaltaic systems (Solar Panels)
- Power Supplies in gardens (outside lights, pond pumps etc)

There are certain works that are excluded from the scope of the new regulations, and are considered 'Minor Works'. These include minor repairs to existing fittings, or adding extra sockets or light fittings to an existing circuit.

(Please note: any electrical work in kitchens/bathrooms or other wet areas is not considered minor work, see above)

Any installer on the approved list wishing to self certify their work must use BS 7671:2001 as the standard by which compliance with Part P can be achieved. Any deviation from this standard will require a Building Regulation application to be made.

If a person chooses to use the Councils Building Control Department, the applicant/building owner will be requested on completion to supply an installation and commissioning test certificate completed by a person competent in respect of the inspection and testing of such installations as required by British Standards 7671.

[12] http://www.havant.gov.uk/havant-4145

Any person who undertakes work on domestic electrical installations to which Building Regulations applies and fails to follow one of the above procedures may:

- Potentially put their health and safety and that of others at risk
- Be liable for a fine
- Possibly invalidate the home insurance
- Encounter problems with any future sale of the property.

If people are considering DIY electrical work, they should be aware that this new Regulation is equally applicable to that work.

2.3.2 Example NL

Education

In the Netherlands one becomes a heating system installer by following education or courses relevant for the trade (full-time or part-time). Completion of such courses entitle the person to set up a business (Chamber of Commerce checks credentials) [13].

As regards installer certification /qualification: In addition to what is stated above three voluntary certification schemes exist today: "KOMO-Instal" (which is primarily of interest for installers for large commercial projects and includes heat pump installation), *"erkende installateur"* by Sterkin [14] and *"erkend installatiebedrijf / EVI 2004"* by SEI [15] (the latter two are more oriented towards installers aiming at the residential market).

Sterkin certifies according the REG, REI and RES regulations, that have been drafted by EnergieNed and Gastec and describe the way the installer acquires and maintains his/her certification plus some other pocedural guidelines. REG applies to gas installations, REI to electrical installations and RES to comfort heating (includes fires, stoves, hearth, etc.). The quality of the installer is periodically checked through inspections of work on-site. The installer pays an annual fee for certification of 55 euro per annum plus costs for inspection. Certification through SEI (set up by UNETO-VNI and VEWIN) is very much alike as described above. Cost for SEI certification are minimum 35 euro per year (excluding VAT and extra costs for inspections).

The nature of these schemes is voluntary leaving it up to the consumer to look for and appoint "certified" installers and be certain that the works are performed by a capable company.

Heating installations

Inspection of heating installations in the Netherlands is entirely different from what is now common practice for the UK. The Building Regulations do not specify certification requirements for installers. It does hoewever ask for the whole house including the installation to be conform the requirements of the Building Regulations. For existing installations homewoners are not required to hire a certified professional to do the necessary work on installations.

As regards safety of gas and electrical installations the house-owner bears the responsibility to ensure adequate safety [16]. Communities bear secondary responsibility and are required to make sure the house-owners fullfills his/her task. How this is enforced in practice remains unclear, leading to proposals for a mandatory periodical safety check of installations in dwellings. Although this periodical safety check still is a

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[13] http://www.ez.nl/content.jsp?objectid=17330

[14] http://www.stichtingsterkin.nl/installateurs/index.html

[15] http://www.erkendinstallatiebedrijf.nl/

[16] http://www.vrom.nl/pagina.html?id=11506#5

proposal, a Technical Guideline NTA 8025 [17] has been produced to facilitate those wanting to perform such checks today on voluntary basis.

Heat pumps

For heat pumps there may be a requirement for the installer to be STEK-certified, meaning the installer has the mandatory certificate needed for working with cooling systems with a capcity over 500 W and/or over 3 kg of coolants. The STEK regulation [18] was put into practice following concerns over emissions from ozonde depleting substances from mainly air-conditioning systems. If the installation of heat pump requires a connection to be made in the coolant circuit a STEK certified installer is obliged. However certain heat pumps are hermetically sealed and the only connections to be made are with the heat source side (often a brine solution, water or air) and the central heating or sanitary water side and may be installed without STEK certification. So it kind of depends on the installation at hand whether STEK certification is required.

2.3.3 Example Germany

Education

Like in the Netherlands an installer starts his/her career by following the relevant education or course, who provides the basic knowledge of the trade (Berufsausbuildung Anlagemechaniker etc.). Such courses take in general some 3,5 years to complete. In order to be able to set up a business of his own an installer must become a master in plumbing-, heating- and air-conditiong/ventilation systems (*"Meister für Sanitär-, Heizungs- un Klimatechnike"*). The SHK Master title can be combined with elementary qualifications for electrical installations (e.g. to place a wall outlet for a boiler installation). It takes at least 10 months to become a *Meister*. Another route is through a form of apprenticeship (*Geselle*), which builds upon training in practice (to be completed with courses regarding business and management). This "on the job" route to becoming a *Meister* can take 6 years.

Inspection of heating installations

Periodical safety and efficiency checks are mandatory for heating installations in Germany. The *Erste BundesImmisionsSchutzVerordnung* (1. BImSchV) prescribes maximum emissions of NOx and chimney losses (%) and the periods between checks. This legislation is harmonised at National level.

Next to the BImSchV there is the KüO (*Kehr und Überprüfungsgesetz* = KüO, *Schornsteinfegergesetz*) which prescribes checks of soot formation and other emissions (a.o. carbon monoxide), the siting of the boiler (are ventilation requirements met etc.) and the flue system (check and sweeping if necessary). The implementation of the KüO can be different in the number of checks required in each Bundesland (region).

Together the BImSchV and KUO are the Regulations that underpin the works of the chimney sweepers (*Schornsteinfeger*) who must be allowed to inspect the (water) heating installation, possibly clean the chimney and must be reimbursed fur such inspections/work according a harmonised tarif scheme. The *Schornsteinfeger* also bear a responibility to check the compliance of heating installations with the EnergieEinsparVerordnung which prohibits continuous use of appliances commisioned in 1978 and before.

Depending on the Region the KUO might require two checks per year for oil or solid fuel installations (the regulation does not allow to combine certain checks in one visit), whereas for gas installations the checks may be bi-annual. For bivalent systems (gas or oil in combination with heat pump or solar energy) measurement of chimney losses by the *Schornsteinfeger* is not required. Measurement of soot and/or carbon monoxide

[17] http://www2.nen.nl/nen/servlet/dispatcher.Dispatcher?id=194420

[18] http://www.stek.nl/

however remains responsibility of *Schornsteinfeger*, so these systems will be checked regularly as well.

This structure of mandatory checks by *Schornsteinfeger* are currently subject of much debate among houseowners who prefer alternative (and cheaper) ways of ensuring correct and safe functioning of appliances. The structure is also discussed in the light of the free market of services in the European Union.

Electrical

In Germany inspections of electrical installations in new buildings or after alterations of existing ones are not compulsary [19]. The electrical installer ("*Elektromeister*") is deemed competent enough to realise installations of sufficient quality. Since 1996 there is a voluntary certification scheme for electrical installers, called E-CHECK, for which the *Elektromeister* have to complete an exam to become an member of the association. With E-CHECK the installations should fulfill current standards regarding electrical installations (VDE 0100). Benefits of E-CHECK can be the recognition by certain insurance companies who may offer a discount.

[19] Desmet, G. at al, Overview of Regulations for Electrical Safety in European Residential Buildings, Proceedings 3rd IEEE Benelux Young Researchers Symposium in Electrical Power Engineering, April 2006, Ghent, Belgium

3 HOUSING CHARACTERISTICS

3.1 Introduction

This chapter deals with housing data for system analysis (Task 4), the definition of the basecase (Task 5) and impact analysis (Task 7). It concerns demographics (par 3.2), climate (3.3), physical characteristics (3.4), expenditure (3.5) and financing (3.6). The two final paragraphs deal with the existing studies (3.7) and a VHK update (3.8) on the average EU hot water heat load.

Statistics of housing present a number of problems and it is not uncommon to find several authorative sources using slightly different data. To an extent this is due to the fact that many data are retrieved at local and regional level (cities, villages, provinces, regions) and have to be aggregated a number of times –using slightly different interpretations of definitions- to arrive at a national level. And of course between the Member States the definitoions of buildings and building characteristics are also not harmonised.

Furthermore, there are some very volatile parts of the housing market related to second homes, vacant homes , hotels, trailers/ caravans, etc. where data are scarce and not very reliable. This was true for the EU-15 and for the EU-25 the situation certainly hasn't improved.

Finally, mix-ups occur when researchers and analysts start using official statistics and citing their original source and each other incorrectly. The most frequent mix-ups are between 'dwellings' and 'households' (10-15% difference), lower and upper heating values of fuels (5-10% difference), combustion values of fuels in statistics and in engineering, almost-metric units (1 ton= 907 kg or 1000 kg), etc..

In the following paragraphs we have tried to use a limited number of reliable sources. The most comprehensive of these is the 'Housing Statistics of the European Union 2004', compiled by the National Board of Housing, Building and Planning in Sweden (Boverket) and the Ministry for Regional Development of the Czech Republic. These two have retrieved from Eurostat and national statistics a valuable collection of data that also –for the first time in the series that is prepared for the EU Mininsters of Housing—includes the 10 new Member States. Also the authors have outlined the different definitions of housing and housing characteristics in the Member States in great detail. In this chapter we can not reproduce the complete report, but provide the most important data in a series of summary tables. Only on a very few occasions we have added information from other sources, such as the PRIMES model that is used for long-term projections in the EC DG TREN, data from ESTIF on the thermal solar market and climate data from Eurostat (degree days) and the JRC Ispra database (data on temperatures and solar irradiation for EU capitals).

All in all, we believe that the data in this chapter are not perfect, but they represent the best available at the current time.

3.2 Demographics

Data on EU-25 population, households and household size are shown in Table 3-1.

Main findings are:

- Currently, the EU-25 has 456 million inhabitants and is hardly growing (0,15%/year). In some countries like Italy, Portugal, Hungary, the Czech Republic and the Baltic States the population is expected to decrease. Fastest grower is Ireland, which expects 18% more inhabitants in 15 years from now.
- The number of households, where 'household' may have slightly different definitions per Member State but in general is equal to the number of primary dwellings, is growing faster, i.e. at around 1% per year. Depending on the source, the 2003 number is estimated at 184 (Boverket) or almost 190 mln. (PRIMES).
- The growth of the number of households is mostly due to families becoming smaller in size. Currently 60% of households have 1 or 2 persons. In the Northern Member States and Germany this can increase to over 70% of the households. Also in the South family size is shrinking.
- On average the EU-25 household size in 2003 is 2,5 persons per household. In 1990 this was 2,7 persons per household. The largest average household size is found in Cyprus (3 pp/hh), followed by Spain, Portugal and Poland (all 2,8 pp/hh or above).

The following figures present a graphical overview of the main findings as regards number of buildings (1/2 dwellings / multi-family buildings)

Figure 3-1. Number of ½ dwelling buildings

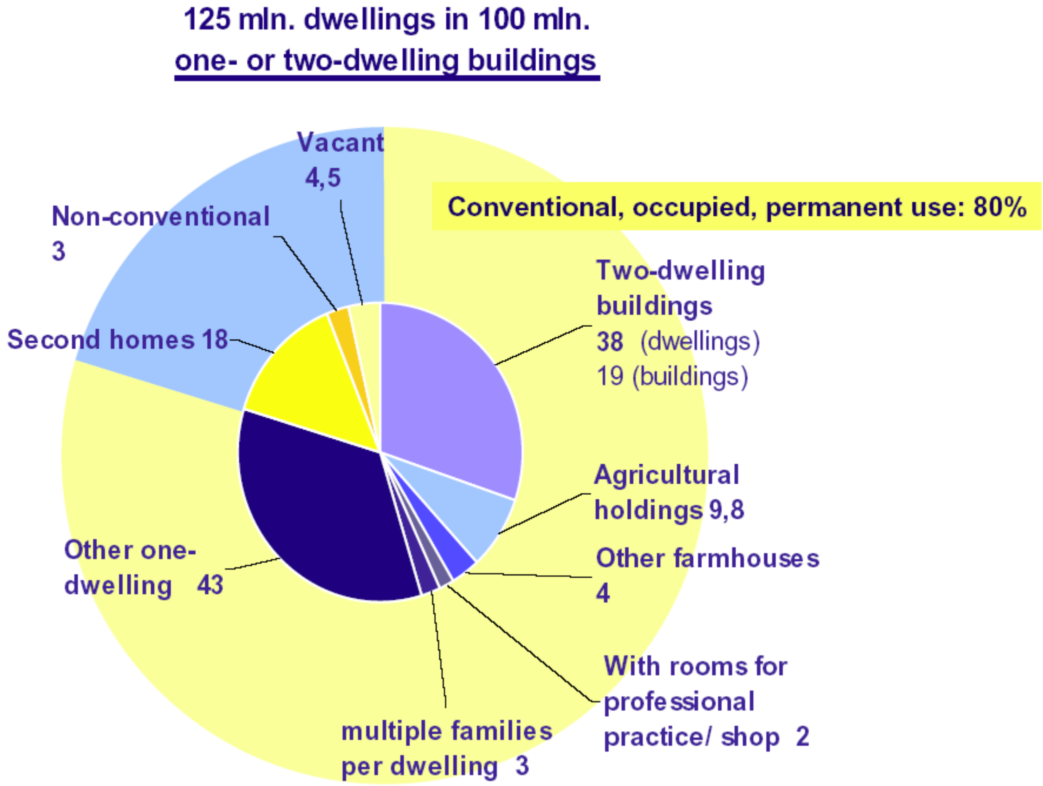


Figure 3-2. Number of multi-family buildings

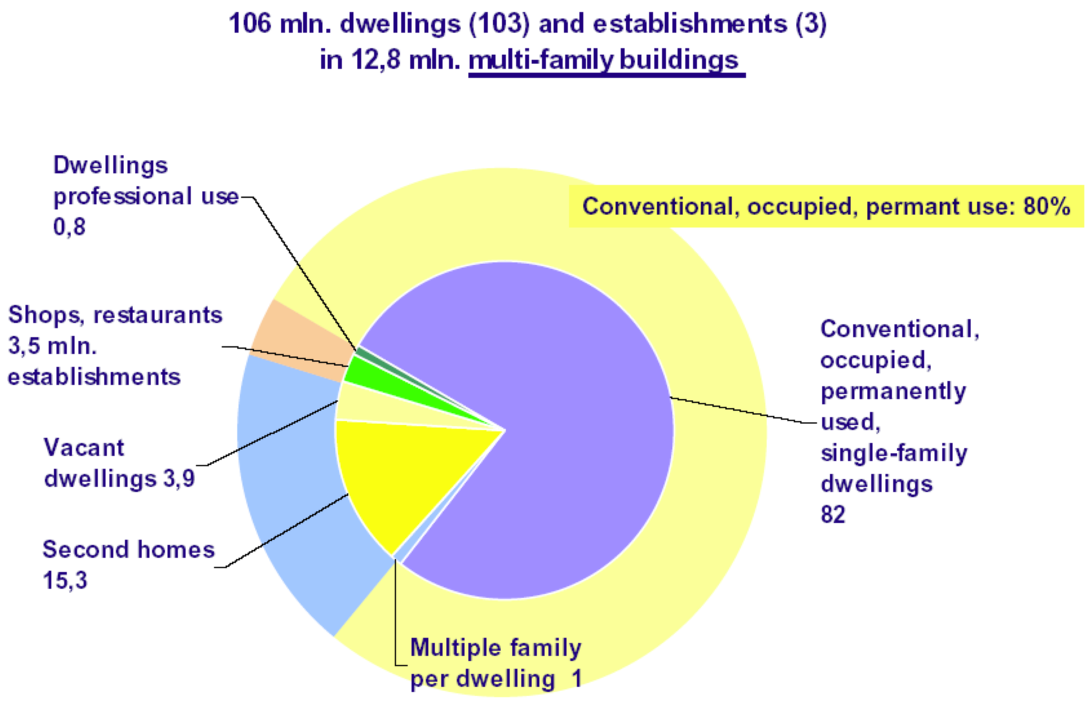
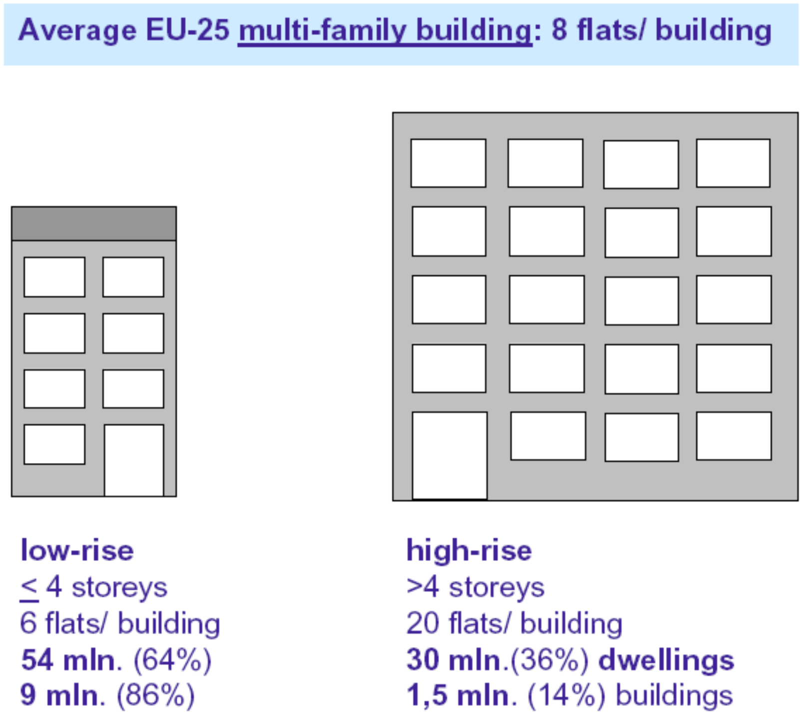


Figure 3-3. Average multi-family building



3.3 Climate

The European climate data are given in Table 3-2. Climatic data is especially relevant for solar water heating systems and heat recovery. With heat recovery is meant that during the heating season the standing losses of e.g. storage cylinders are not really lost but help to decrease the heat load of the house. In the summertime one can argue that the standing losses of cylinders contribute to the heat load of the dwelling and as such might need to be cooled away. For these reasons the climate and heat load of the house is included in the assessment.

The most important indicator for the heat demand of the house for space heating are the degree-days. They indicate the temporal temperature difference between the average daily outdoor temperature and an assumed indoor temperature.

Eurostat's degree days are calculated as:

$$(18°C - Tm) * d$$

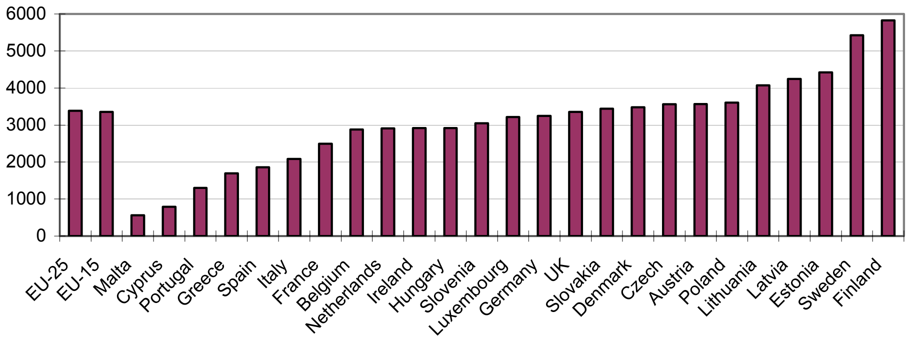
if Tm is lower than or equal to 15°C (heating threshold)

and are nil

if Tm is greater than 15°C, where Tm is the mean ((Tmin + Tmax)/2) outdoor temperature over a day (d=1).

The figure (usually annual degree days) is a graphical display of the data in Table 3-2, relating to the long term average (1980-2004). thus indicates the relative coldness and thus the heat load of dwellings in that particular country.

Figure 3-4.
Heating degree days per country (Eurostat)



Using the degree-days as a parameter, we can also make an estimate of what used to be called the heating season: Heating season in hours = (degree-days + 2000). Heating season in months = rounded (12* heating season in hours/8760).

In the case of combi-boilers it is relevant to note that the concept of 'heating season' is dissappearing since the combi-boiler (including boilers with separate cylinders) is used throughout the year.

Table 3-1 also shows the yearly average of the daily solar irradiation on a horizontal surface and at an optimal collector-angle in Wh/m²/day. These data come from the JRC Ispra database and are relevant for solar-assisted boilers and water heaters.

Also relevant are the average daily temperatures (day and night) per month, not just for the space heating but also for hot water appliances. The yearly average daily temperature is a rough approximation of the soil temperature in a region (heat pump) and the average of this soil temperature and the outside air temperature is an approximation of the cold water temperature.

Main findings are:

- The EU-25 average (weighted by dwelling stock) number of degree days in 2003-'04 is around 3240, which is some 4% lower than the long-term (1980-2004) average of 3386.
- The warmest Member States are Malta (564 degree days long term) and Cyprus (787), with a heating season of 4 months and the coldest are Finland (5823) and Sweden (5423), with a heating season of 10 months. Around 80% of the EU-25 population has a heating season of 6-8 months.
- The yearly average of the daily temperature outside an EU dwelling is 11,7°C, with the coldest month being January (3,5°C) and the warmest August (20,7°C). At the level of country capitals, the coldest month is in Helsinki (FIN) in February (-4,5°C) and the warmest is Lanaca (CY) in August (27,3°C).
- The EU-25 average solar irridiation is 3235 Wh/m²/day on a horizontal surface. With a collector at an optimal angle (typically 35-40°) this increases by 14% to 3700 Wh/m²/day.
- The sunniest countries are Cyprus, Spain, Portugal, Greece and Italy (Rome) with over 4000 Wh/m²/day on a horizontal surface. But the rest, even the colder Scandinavian countries all are in a very narrow bandwidth of between 2554 (Helsinki) and 3357 (Budapest) Wh/m²/day irradiation on a horizontal surface and some 13-14% more at an optimal angle.
- The country with the highest number of solar collector surface –Germany (Berlin)— has a solar irradiation of around 2700-2800 Wh/m²/day on a horizontal surface, which can rise to around 3100-3200 Wh/m²/day at the best collector angle.

3.4 Physical housing characteristics

Table 3-3 gives an overview of the EU-25 dwelling stock, split by primar/secondary, single family/multi-family and year-of-built for the year 2003 (or earlier as indicated in the table). The split-up between primary dwellings (approximately equal to the number of households) and secondary dwellings is accompanied by a line explaining which types of secondary homes are included in the dwelling stock of a Member State. The average age was estimated using the median age per year-of-built class, assuming –from anecdotal data on the Netherlands, that buildings <1919 were built on average in 1880.

Furthermore, the table reports on newly built housing in 2003 and 1990, the number of houses demolished, the floor area of houses in stock and newly built, the number of rooms and the presence of central heating (as opposed to local heaters or no heaters, includes wet/dry/collective central heating), running hot water and the market penetration of solar collectors (% of dwellings). This last figure is a VHK estimate, based on the ESTIF data on stock and sales given in the last lines of the table combined with an estimate of the collector area per Member State.

Main findings are:

- Boverket reports an EU-25 stock of 205 million dwellings in 2003, of which 19% in Germany, 14% in France, 13% in Italy, 12% in the UK and 10% in Spain. If we also include Poland (6%), there are 6 countries that make up three quarters of the EU-25 dwelling stock. The other countries each make up 3,3% (NL) or less of the total.
- Primary dwellings, the principle dwellings where families live, are around 184 million. Around 20,5 secondary dwellings are reported which represent a heterogenous mix of second homes, vacant homes, etc..
- Remarkable in this context is e.g. that
  - Germany does <u>not</u> include vacant homes in its dwelling stock, whereas most countries do.

- France[20] includes hotels in its dwelling stock figure.
- Ireland, France and Poland also include mobile dwellings such as ships and/or permanent caravans (US.: 'trailers').
- Collective homes are reportedly included in the dwelling stock statistics of Belgium, Cyprus, Lithuania, Luxembourg, Poland and Sweden. This could have a negative effect on the primary dwelling stock, because these dwellings house multiple households.
- With the possible exception of Spain, the reported figures on the stock of second homes, winter and summer habitations, etc. after subtraction of the vacant homes are very unlikely. Despite the efforts of Boverket this will probably remain a grey area.

▪ Vacant homes, waiting to be sold, renovated or demolished, are the most substantial part of what is reported as 'secondary homes'. In 2003 some 18 million homes were identified as such. If we exclude the German vacant homes, we find that almost 15 out of the 20 million 'secondary homes' are in fact 'vacant homes'. The remainder are mostly second homes reported by Spain, whereas of course also in many other countries there is a vast –but not reported—stock of weekend/winter/summer cottages.

▪ Single- and two family homes account for 54% of the dwelling stock and multi-family homes for 46%, of which some 16% are high rise buildings with more than 4 storeys. In some countries, notably Germany, a distinction is made in the statistics between single-family and two-family houses, where the latter are slightly less than half of the total. But some countries just count two-family dwellings as (semi-detached) single family homes. Please note that the figures represent the number of dwellings (not the number of buildings).

▪ Every year the EU-25 builds some 2,2 million new dwellings, this is true in 1990 and in 2003. Effectively, given the rise in population and the smaller household size this means that there has been a negative growth rate in many countries, notably in Germany (-16%), Baltics (around -75%), Scandinavia (>-50%), whereas also in Slovakia, Czech Republic and Hungary the new 2003 dwellings are only half of what they were in 1990. The most dramatic increases took place in Ireland (+245%) and in Spain (+63%).

▪ Reporting on demolished dwellings is incomplete, so the figure of 133000 dwellings removed from the 2003 stock is a minimum figure.

▪ The largest fraction of older buildings in the EU-25 can be found in the UK, Denmark, France and Italy, where buildings from before 1919 make up 19-21% of the total stock.

▪ These countries also have the highest average dwelling age of 56-57 years. The youngest building stock can be found in Portugal and Finland (33 years), followed by Ireland, Spain and Greece (35 years). The Netherlands has relatively built the most new dwellings (30% of total) in the period since 1981.

▪ The average EU floor area for existing dwellings is 87 m² or 35 m²/person. For new dwellings this is 103 m² per dwelling. The largest existing houses can be found in Cyprus (145 m²), Luxembourg (125), Denmark (109) and Ireland (106). The smallest existing dwellings (avg. 55-60 m²) can be found in the Baltic States and some countries in Central Europe. However, new dwellings in the Baltics and Central Europe are on or above the EU-average.

▪ Existing dwellings have approx. 4 rooms per dwelling, wheres new dwellings have 4,5. This excludes the hall(s), cellars, etc.. Whether the kitchen is counted as a 'room' depends on the country. Many countries use a definition with a minimum number of square meters. Austria, Denmark, France and Lithuania do not usually count the kitchen as a room. From the number of rooms the number of heat

[20] and in principle also Poland, but the figure presented in the table only includes primary dwellings.

emitters can be estimated to be 6-7 heat emitters per dwelling (including the hall and 2-3 radiators in living room + kitchen).

- Around 78-79% of the dwelling stock –or some 160 million dwellings—are reported to have some form of central heating (wet/dry/district) and running hot water for showers or baths. In friendly climates like Malta (3%), Portugal (4%), Cyprus (27%) the occasional stove is probably enough for space heating. For hot water we find the lowest penetration (60-70%) in the Baltic States and Portugal. In general, the reliability of these figures should not be overrated because it is usually left to the imagination of the people filling in a questionnaire to determine whether they have 'central heating' or not.
- Around 2,5% of the EU-25 dwellings are estimated to have a solar collector mostly for hot water preparation and occasionally space heating. The estimated average collector areas range from 6 m^2 (Austria) to 2,5 m^2 (Cyprus, Greece, Spain, Portugal) per dwelling. The total collector area in the EU in 2005 is 15,5 million m^2 of which over 2 million m^2 was sold in 2005. Around 89% of the collector sales (in m^2) are flat plate glazed types. Unglazed types are 4%, whereas the more expensive vacuum tubes are apparently becoming more popular (6%), especially in Central Europe and Germany. Data are from ESTIF.[21]

3.5 Housing Expenditure

Table 3-4 gives an overview of the expenditure on housing as a percentage of the total household consumption in the EU-25 and per Member State. Furthermore, the housing costs are subdivided in energy costs, building maintenance, water supply and miscellaneous services, as well as the costs of the actual rent and –for owner-occupied dwellings—the imputed rent (interest plus mortgage pay-off). These figures, which are an important check for actual life cycle cost calculation in Task 5, are given per household, for the EU-25 as a total and as percentages.

Main findings:

- The average EU-25 housing costs are € 6.039 per household or 16,4% of total housing expenditure of € 36.872 in 2003. This is an average in straight money terms, however for most households a figure of around 23,4% (weighted by dwelling stock) will sound more familiar. For the whole of the EU-25 the housing costs represent € 1.112 billion (10^9 €).
- The costs for electricity, gas and other fuels in the house amount to € 1006 per household in 2003. For the whole of the EU this is € 185 billion, of which the boiler and water heater energy costs are a substantial part (see also Task 2 report).
- Building maintenance and repairs account for € 316 per household per year, whereas € 413 goes to miscellaneous services. In the whole of the EU this is € 58 and € 78 billion respectively. The statistics are not clear but probably the latter figure includes the repairs and maintenance of the boiler and water heater , whereas the former figure could include replacement of the CH-boiler and larger water heaters.
- The rest of the housing costs – a total of € 792 billion or € 4.303 per household in 2003— goes to actual and imputed rent. As the boiler and the primary water heater are usually part of the house, a small part of this is paying off at least the very first boiler and water heater.

3.6 Housing Ownership and Financing

The investment in a heating installation, whether it is a heat pump, solar system or a boiler/ water heater, involves what most people would call a 'substantial sum' which

[21] www.estif.org

isn't paid in cash but financed through a mortgage or a loan. This is certainly true for new owner-occupied dwellings, where boiler and water heater are usually part of the building costs and included in the mortgage. But also a replacement can be financed through an extension of the mortgage or a loan.

In case of rental apartments and houses, i.e. where the user and the one paying the energy bill is not the same as the owner, an extra difficulty arises to adopt the most efficient technology. A case in point is the situation in Switzerland, where the '*Minergie*' efficiency standard is very popular with owner-occupied dwellings but where the government has a very hard time to convince landlords and owners of apartment buildings to invest in energy saving measures. In other words, this is another aspect to be taken into account, e.g. in the impact analysis.

Finally, there is the issue of 'affordability' for low income groups, where perhaps Ecodesign measures should be accompanied by lateral measures to help these groups. The statistics define 'low-income' if the income is lower than 60% of the median equalized income in a country.

The main findings, which are presented in full in Table 3-5, are:

- Around 61% of the dwelling stock is owner-occupied and 35% is rental. The 4% remainder is owned by a co-operation or there is another ownership situation. The information is not complete, but assuming that these percentages are valid throughout, it means that 124 million dwellings are owner-occupied and 72 million are rental.
- The household size varies with the ownership situation. In public rental dwellings the household size is 2,4 persons per household, in private rental it is only 1,8 persons and in owner-occupied houses it is 2,7 persons per household. The average—as mentioned before—is 2,5 persons per household.
- The rent index (not corrected for inflation) has risen to 122 in 2003 (1996=100). Roughly over the same period the index of the single family house –also not corrected for inflation-- has gone up to around 190 (1995=100). The real price index of the house prices—corrected for inflation (PPS)-- went to 178 over the same period. This is a very rough estimate. The EU-25 data are not complete and that is why no estimate is given in the table.
- From the ratio of the outstanding residential mortgage to GDP (Gross Domestic Product) it is clear that the Dutch are the biggest lenders and that the houses are in fact fully mortgaged and the loan-against-value ratio is on average 112%. The reason is a tax regime which favours maximum mortgaging, as can be see from the line 'Mortgage related interest relief ' and banks that have very few reservations. On the other side of the spectrum we find Italy, Greece and Central European countries where mortgages are (far) lower than 20% of GDP.
- The typical length of the mortgage contract is 20 years with some countries going upo to 30 years. The typical mortgage rate in the EU-25 in 2003 was around 5%.
- Around 15% of the households can be classified as 'low income' according to the definition mentioned earlier. For most EU-15 Member States this means an income of less than 6.000-9.000 PPS per household/year. For some new Member States, especially the Baltic States, this can be as low as around 2.400 PPS per household/year.
- Nonetheless, the ownership situation amongst the low income groups is not very different from the rest: in most countries one third is paying rent and two thirds is owning the house.
- In most countries that are reporting on the issue there is a state subsidy for the low income groups. In Denmark, Finland, France, Sweden, the Netherlands and the UK this subsidy covers more than 14-20% of the total population, i.e. the whole of the low income group. The statistics do not reveal the level of support.

Table 3-1. EU Demographics (source: VHK compilation of 'Housing Statistics of the European Union 2004', Boverket 2005 and PRIOMES 2006)

	Parameter	*unit*	EU-25	A	B	CY	CZ	DK	EST	FIN	F	D	GR	H	IRL	IT	LT	LIT	LUX	MT	NL	PL	P	SK	SLO	E	S	UK
	EU population (Boverket 2005)																											
2	population 2003	k#	**453684**	8067	10356	715	10203	5384	1356	5206	59630	82537	11018	10142	3964	57321	2331	3463	448	397	16193	38219	10407	5379	1995	40683	8941	59329
3	population 2005	k#	**456342**	8128	10370	821	10227	5392	1297	5230	60900	82780	11017	9797	4079	57306	2272	3412	466	399	16343	38562	10094	5418	1981	41348	8917	59786
4	population 2010	k#	**459971**	8125	10478	858	10201	5449	1236	5285	62527	83094	11085	9593	4326	56759	2184	3339	497	406	16733	38553	10129	5457	1965	41774	9014	60904
5	population 2015	k#	**462989**	8123	10578	895	10151	5498	1177	5342	64037	83426	11106	9402	4585	55903	2096	3274	526	417	17071	38538	10125	5487	1945	41992	9115	62180
6	population 2020	k#	**465565**	8132	10681	928	10083	5554	1117	5390	65402	83818	11075	9217	4811	54903	2007	3204	560	424	17400	38425	10089	5510	1918	42012	9237	63668
	No. of households (PRIMES 2006)																											
7	households 1990	mln	**167**	3,0	3,9	0,1	3,6	2,2	0,6	2,0	22,5	33,8	3,3	4,0	1,0	21,5	1,0	1,3	0,1	0,1	6,0	12,3	3,3	2,1	0,6	12,3	3,9	22,5
8	households 1995	mln	**176**	3,1	4,1	0,2	3,8	2,3	0,6	2,2	24,0	35,3	3,5	4,1	1,2	23,0	1,0	1,3	0,2	0,1	6,4	13,1	3,5	2,3	0,6	13,2	4,0	23,9
9	households 2000	mln	**186**	3,2	4,2	0,2	3,9	2,4	0,6	2,3	25,5	36,7	3,7	4,2	1,3	24,4	0,9	1,3	0,2	0,1	6,8	13,8	3,6	2,5	0,6	14,0	4,1	25,3
10	households 2005	mln	**195**	3,4	4,4	0,2	4,1	2,5	0,6	2,4	27,1	38,3	3,9	4,3	1,4	25,6	0,9	1,4	0,2	0,2	7,3	14,4	3,8	2,7	0,7	14,6	4,3	27,0
11	households 2010	mln	**205**	3,5	4,6	0,2	4,2	2,6	0,6	2,5	28,7	39,8	4,1	4,3	1,5	26,8	0,9	1,4	0,2	0,2	7,8	14,9	4,0	2,8	0,7	15,2	4,5	28,6
12	households 2015	mln	**211**	3,6	4,8	0,2	4,2	2,7	0,6	2,6	30,1	40,7	4,2	4,3	1,6	27,8	0,9	1,5	0,2	0,2	8,2	15,0	4,2	2,9	0,7	15,6	4,7	30,1
13	households 2020	mln	**218**	3,6	4,9	0,2	4,2	2,8	0,6	2,7	31,5	41,5	4,3	4,3	1,7	28,7	0,9	1,5	0,2	0,2	8,6	15,1	4,3	2,9	0,7	16,0	4,9	31,6
	Household sizes 2003 (Boverket 2005)																											
14	1 person	%	**30**	31	32	16	30	37	31	39	30	37	20	26	22	25	24	29	29	15	34	25	17	26	22	20	47	31
15	2 persons	%	**30**	29	31	27	28	33	31	32	33	34	28	29	26	27	30	26	29	23	33	23	29	22	23	25	28	34
16	3 persons	%	**17**	17	16	17	19	12	18	13	15	14	21	20	18	21	23	20	17	23	13	20	25	18	21	21	11	16
17	4 persons	%	**15**	15	14	22	17	12	14	10	14	11	20	16	17	19	15	17	16	26	14	18	20	21	23	22	10	13
18	≥5 persons	%	**8**	8	7	18	6	5	6	6	8	4	11	9	18	8	8	8	9	12	6	14	9	14	11	12	4	6
	Persons/ household (Boverket 2005)																											
19	persons/ household 1990	#	**2,7**	2,6	na	**3,2**	2,6	2,3	na	2,4	2,6	2,3	3	2,6	na	2,8	na	na	2,6	na	2,4	3,1	3,1	2,9	3	3,4	2,1	2,5
20	persons/ household 1995	#	**2,6**	2,5	na	**3,2**	na	2,2	2,4	2,3	2,5	2,2	na	na	3,3	2,6	na	2,8	na	3,1	2,4	3,1	na	na	na	3,2	2	2,4
21	persons/ household 2000	#	**2,55**	2,4	2,4	**3,1**	2	2,2	2,4	2,2	2,4	2,2	2,8	2,6	3	2,6	2,5	2,6	2,5	3	2,3	na	2,8	2,6	2,8	3,1	2	2,4
22	persons/ household 2003	#	**2,5**	2,4	2,4	**3**	na	2,2	2,4	2,2	na	2,1	na	na	2,9	2,6	2,5	2,6	na	3	2,3	2,8	na	na	na	2,9	1,9	na

Table 3-2. EU Climate characteristics for buildings 2003 (source: VHK compilation of misc. sources)

Parameter	*unit*	EU-25	A	B	CY	CZ	DK	EST	FIN	F	D	GR	H	IRL	IT	LT	LIT	LUX	MT	NL	PL	P	SK	SLO	E	S	UK
1. Dwelling stock****	k#	**204663**	3280	4820	299	4366	2561	624	2574	29495	38925	5465	4134	1554	26526	967	1292	176	127	6811	11764	5318	1885	785	20947	4351	25617
Degree Days* **																											
2 2003	#	**3247**	3474	2711	728	3455	3287	4421	5658	2361	3135	1732	3078	2665	1971	4245	4076	2953	583	2766	3602	1261	3458	3039	1770	5227	3084
3 2004	#	**3239**	3561	2798	763	3472	3274	4306	5536	2480	3186	1567	2872	2730	2010	4213	4047	3172	500	2774	3518	1368	3387	3049	1915	5268	3075
4 Long term avg. 1980-'04	#	**3386**	3569	2882	787	3559	3479	4420	5823	2494	3244	1698	2917	2916	2085	4243	4071	3216	564	2905	3605	1302	3440	3044	1856	5423	3354
Avg. Solar Irridiation (in country capital)**																											
6 Horizontal, Wh/m²/d	Wh	**3235**	3123	2642	4724	2817	2669	2620	2554	3068	2748	4305	3357	2605	4021	2730	2731	2832	4843	2702	2766	4474	3018	3234	4496	2575	2699
7 Optimal angle, Wh/m²/d	Wh	**3700**	3554	2978	5245	3171	3115	3131	3068	3489	3157	4771	3835	3013	4583	3200	3150	3192	5491	3089	3165	5105	3464	3697	5148	3105	3097
Avg. Daily Temperature (in country capital)**																											
8 Jan	°C	**3,5**	-0,8	3,4	11,8	-1,2	0,7	-3,0	-4,0	4,1	0,4	8,9	-0,8	5,7	8,6	-2,6	-3,8	1,7	na	3,2	-2,1	10,7	-0,7	1,0	6,3	-1,4	5,0
9 Feb	°C	**5,0**	2,4	5,2	12,0	1,5	1,5	-3,4	-4,5	5,8	2,7	9,3	2,0	6,3	8,6	-2,1	-2,2	3,8	na	4,8	0,0	11,9	2,3	3,2	7,9	-1,3	6,1
10 Mar	°C	**7,2**	5,7	7,3	13,7	4,3	2,8	-0,8	-1,6	8,3	4,6	10,5	5,8	7,2	10,9	0,5	0,6	6,4	na	6,6	2,5	14,3	5,7	7,2	11,1	1,0	7,4
11 Apr	°C	**10,3**	10,5	9,7	16,7	8,9	6,6	4,6	3,9	10,1	9,4	13,8	11,4	8,6	13,0	6,7	7,7	9,1	na	9,3	8,5	15,2	10,7	11,0	12,6	4,7	9,3
12 May	°C	**14,8**	16,2	13,8	21,2	14,4	10,9	9,4	9,1	14,3	14,6	19,2	17,1	11,2	17,9	11,7	12,8	13,8	na	13,2	14,1	17,7	16,3	16,5	16,6	9,2	12,5
13 Jun	°C	**18,2**	18,9	16,4	24,8	16,9	14,6	14,9	14,8	17,3	17,1	23,9	20,0	13,4	21,8	16,0	16,4	16,6	na	15,7	16,8	21,0	19,0	20,0	22,0	14,6	15,3
14 Jul	°C	**20,2**	20,4	18,2	27,3	18,5	17,0	17,7	17,6	19,1	19,1	26,2	21,6	15,6	23,8	18,4	18,6	18,2	na	17,7	18,8	22,9	20,5	21,0	24,4	17,5	17,6
15 Aug	°C	**20,7**	20,7	19,0	27,3	19,0	17,9	16,8	16,5	20,1	19,7	25,7	21,6	15,9	24,7	17,5	17,4	19,1	na	18,6	18,4	23,3	20,8	21,6	24,3	17,6	18,4
16 Sep	°C	**16,3**	15,1	15,2	24,8	13,9	13,9	12,0	11,5	15,6	14,7	22,0	15,9	13,8	20,4	12,3	12,0	14,3	na	15,2	13,1	21,1	15,3	15,9	19,7	12,8	15,2
17 Oct	°C	**12,4**	10,7	11,4	21,6	9,6	9,4	6,8	6,2	12,2	10,2	17,8	11,3	11,2	17,2	7,3	7,1	10,5	na	11,3	8,6	18,0	10,8	12,1	15,1	7,6	11,8
18 Nov	°C	**7,4**	4,9	7,0	17,4	3,7	4,7	1,5	0,9	7,2	4,4	13,7	5,4	8,2	13,0	1,8	1,3	5,5	na	7,2	2,8	13,8	5,1	6,5	9,5	3,0	8,1
19 Dec	°C	**3,8**	-0,4	3,8	13,6	-0,7	1,1	-2,7	-3,6	4,7	0,3	9,9	-1,0	5,9	9,5	-3,2	-4,4	2,5	na	3,5	-2,6	11,3	-0,6	1,6	6,5	-0,8	5,3
20 Year*	**°C**	**11,7**	**10,4**	**10,9**	**19,4**	**9,1**	**8,4**	**6,1**	**5,6**	**11,6**	**9,8**	**16,7**	**10,9**	**10,3**	**15,8**	**7,0**	**7,0**	**10,1**	**na**	**10,5**	**8,3**	**16,8**	**10,4**	**11,5**	**14,7**	**7,0**	**11,0**
21 Heating season, months		**7**	**8**	**7**	**4**	**8**	**8**	**9**	**11**	**6**	**7**	**5**	**7**	**7**	**6**	**9**	**8**	**7**	**4**	**7**	**8**	**5**	**7**	**7**	**5**	**10**	**7**

*= A rough approximation of the year-round soil temperature is the average daily temperature over a year in a region. This is relevant for ground source heat pumps. To approximate the real cold water temperature take the average of this soil temperature and the air temperature in a month.

= source JRC Ispra ; http://re.jrc.cec.eu.int/pvgis/solradframe.php?en&europe ; *= Eurostat, *Statistics in Focus, Statistical Aspects of the Energy Economy 2004*, 2005.; ****= source Boverket, used as reference for weighting

Table 3-3. EU Housing Characteristics 2003 (source: VHK compilation of 'Housing Statistics of the European Union 2004', Boverket 2005)

	Parameter	*unit*	**EU-25**	**A**	**B**	**CY**	**CZ**	**DK**	**EST**	**FIN**	**F**	**D**	**GR**	**H**	**IRL**	**IT**	**LT**	**LIT**	**LUX**	**MT**	**NL**	**PL**	**P**	**SK**	**SLO**	**E**	**S**	**UK**
1.	Dwelling stock**	k#	**204663**	3280	4820	299	4366	2561	624	2574	29495	38925	5465	4134	1554	26526	967	1292	176	127	6811	11764	5318	1885	785	20947	4351	25617
2	Primary (= ca. # households)	k#	**184166**	3280	4325	239	4216	2481	566	2378	24525	38944	3674	3863	1382	22004	915	1346	171	129	6996	13337	3651	2072	685	14187	4454	24346
3	Secondary	k#	**20497**	0	495	60	150	80	58	196	4970	-19	1791	271	172	4522	52	-54	5	-2	-185	-1573	1667	-187	100	6760	-103	1271
4	Secondary types, included in dwelling stock*			WSV	WSC VN	WS CV	SVN	V	na	SVN	WSH MV	S	WSV	WSV	WSm VN	WSV	WV	CN	CHM	WSN	V-	SCH MVN	WS VN	V	WSV	WS VN	CV	WSV
5	Vacant dwellings	k#	**18083**		na	72	537	128	68	237	2006	*3192*	514	347	182	5199	58	*48*	*4*	na	150	623	564	219	79	2912	74	871
6	One/two family dwellings	%	**54**	48	75	na	44	61	32	42	57	46	59	66	91	25	29	39	71	na	69	37	77	49	72	53	48	81
7	Multi-family dwellings	%	**46**	52	25	na	57	39	68	58	43	54	41	34	9	75	71	61	29	na	31	63	23	52	28	48	52	19
8	of which high-rise (> 4 storeys),	%	**16**	na	4	na	34	10	na	na	16	6	na	23	na	23	na	na	16	na	7	39	22	38	12	31	na	2
9	New built 2003 (completed)	k#	**2174**	42	41	6	27	24	2	28	334	268	128	*22*	69	*178*	1	5	2	na	60	163	82	14	7	459	24	190
10	New built 1990 (completed)	k#	**2169**	42	43	8	45	27	8	65	336	319	120	44	20	176	13	22	3	na	101	134	66	25	8	281	58	205
11	Demolished/removed	k#	**133**	16	2	0	2	*8*	1	3	21	*22*	na	5	11	na	3	0	na	na	18	5	1	1	0	16	2	15
12	Year of built <1919 *[VHK 1880]*	%	**15**	19	15	na	11	20	9	2	20	15	3	14	10	19	11	6	12	15	7	10	6	3	15	9	12	21
13	Year of built 1919–1945	%	**12**	8	17	7	15	17	14	9	13	13	7	13	8	11	14	23	15	11	13	13	9	7	8	4	20	18
14	Year of built 1946–1970	%	**32**	27	29	17	26	28	30	31	18	47	32	26	16	41	28	33	27	29	31	27	23	35	28	34	33	21
15	Year of built 1971–1980	%	**20**	16	15	21	23	18	22	23	26	11	25	22	18	20	23	18	15	17	19	18	18	26	24	24	17	22
16	Year of built >1980	%	**22**	12	9	27	16	10	20	20	10	15	19	18	16	10	21	14	12	16	30	19	44	21	16	14	10	19
17	of which, year of built >1990	%	**13**	18	15	|	8	7	5	14	12	|	14	7	32	|	4	6	17	12	|	13	|	7	9	16	7	|
18	Avg. age dwellings *[VHK est.]*	yr	**49**	49	50	28	46	57	45	33	52	53	35	48	35	56	46	47	45	48	40	43	33	36	47	39	52	56
19	Floor area/ dwelling (stock)	m²	**87**	94	86	*145*	76	109	60	77	90	90	83	75	104	90	55	61	125	106	98	68	83	56	75	90	92	87
20	Floor area/ dwelling (new 2003)	m²	**103**	101	119	198	105	112	89	90	113	114	125	94	105	82	194	106	120	*106*	116	99	89	118	114	96	128	83
21	Floor area/ person (stock)	m²	**35**	38	36	*48*	29	51	28	36	38	40	*30*	28	35	*35*	24	23	*50*	34	41	22	*30*	26	30	*31*	44	44
22	Number of rooms (stock)	#	**4,0**	4,1	4,3	5,4	2,9	3,8	3,6	3,6	4	4,4	3,8	na	5,6	4,1	2,4	2,5	5,5	na	4,2	3,7	4,3	3,2	2,8	5	4,2	4,7
23	Number of rooms (new built)	#	**4,5**	3,5	5,8	6,1	3,9	3,4	4	3,8	3,9	5,1	3,1	4	5,6	3,8	4,3	3,5	5,2	na	3,9	4,2	4,9	3,1	3,4	5,4	4,2	4,5
24	persons/ household (stock)	#	**2,5**	2,4	2,4	3	2,4	2,2	2,4	2,2	2,4	2,1	2,8	2,6	2,9	2,6	2,5	2,6	2,5	3	2,3	2,8	2,8	2,6	2,8	2,9	1,9	2,4
25	Central heating (wet & dry)	%	**79**	90	73	27	82	92	59	92	91	91	64	53	59	79	65	72	92	3	90	78	4	74	79	42	100	94
26	Bath/shower (hot water)	%	**78**	98	96	99	96	95	67	99	98		98	87	94	99	67	70	94	100	100	87	66	93	92	99	100	99
27	solar sys.penetration, % dwell.***	%	**2,5**	11,8	0,5	66,9	0,3	2,6	0,0	0,1	0,4	3,4	22,3	25,4	0,2	0,6	0,1	0,0	1,5	6,0	1,5	0,2	1,2	0,7	2,6	0,8	1,0	0,3
28	solar collector stock***	000m²	**15573**	2318	68	500	66	337	1	14	396	6554	3047	5250	11	516	3	2	13	19	304	138	161	64	102	527	208	197
29	estimated collect area/ hh	m²	**3**	6	3	2,5	5	5	5	5	3	5	2,5	5	3	3	5	5	5	2,5	3	5	2,5	5	5	3	5	3
30	total solar collector sales 2005	000m²	**2073**	240	28	50	19	21	0	2	164	980	221	1	4	72	1	1	2	4	39	28	16	7	5	107	35	28
31	of which glazed collector sales	%	**89**	97	73	100	70	99	100	100	93	87	100	100	100	96	100	100	100	100	48	85	97	88	94	95	49	64
32	unglazed coll. sales	%	**4**	3	27		17				4	3									52	0						
33	vacuum tube sales	%	**6**	1			13	1			3	10				4						15	3	12	6	5	16	36

* = W=Winter or summer habitation; S=Second homes; C=Collective homes; H=Hotels; M=Trailers & ships; m=Trailers; V=Vacant homes; N=Non-permanent habitation; na= no data available; | = data included in line above; **= dwelling stock data year CY: 2002; FI: 2001; FR: 2002; GR:2001; HU: 2001; LU: 2002; MT: 1983; PL: 2002. PT: 1999 most recent, 2003 is estimate; In other lines, italic font indicate older reference years ***= solar sales and stock data from ESTIF (www.estif.org). Collector area per household estimated by VHK on the basis of general recommendations by authorities for 4-person household.

Table 3-4. EU Housing Expenditure 2003 (source: VHK compilation of 'Housing Statistics of the European Union 2004', Boverket 2005)

	Parameter	*unit*	**EU-25**	**A**	**B**	**CY**	**CZ**	**DK**	**EST**	**FIN**	**F**	**D**	**GR**	**H**	**IRL**	**IT**	**LT**	**LIT**	**LUX**	**MT**	**NL**	**PL**	**P**	**SK**	**SLO**	**E**	**S**	**UK**
1	Primary (= # households)	k#	**184166**	3280	4325	239	4216	2481	566	2378	24525	38944	3674	3863	1382	22004	915	1346	171	129	6996	###	3651	2072	685	14187	4454	24346
Expenditure per household €/yr																												
2	Total, of which	€	**36872**	31690	32542	29285	9498	28031	8384	30256	33759	27082	27893	10055	42211	35350	6512	27317	64815	22340	23699	8806	20987	7849	19259	11286	26856	39877
3	Housing, of which	€	**6039**	6053	7680	6267	2232	8017	1920	7836	8136	6798	4379	1820	9118	7176	1400	4261	14000	2100	5072	2184	2204	2080	3794	3544	7762	7258
4	Electricity, gas & other fuel	€	**1006**	1077	1432	996	798	1682	520	635	1249	1110	614	553	1266	1167	352	1502	1426	na	948	810	546	848	982	339	1746	957
5	Building maintenance & repair	€	**316**	349	163	322	28	364	34	0	439	135	195	60	169	460	189	300	778	na	355	414	42	165	77	260	81	598
6	Water supply, misc. services	€	**413**	792	423	293	161	589	159	91	608	650	112	151	42	495	85	300	648	na	332	167	147	133	327	214	0	319
7	Rent, Imputed rent , of which	€	**4303**	3834	5662	4656	1244	5382	1207	7110	5840	4902	3459	1056	7640	5055	775	2158	11148	na	3436	793	1469	934	2407	2731	5935	5383
8	*Actual rent*	€	***1282***	*887*	*1595*	*674*	*313*	*1906*	*193*	2088	1587	2248	*614*	*70*	*1097*	848	26	109	*1944*	*na*	*1303*	*159*	*231*	*78*	*347*	*181*	*2337*	*1635*
9	*Imputed rent (owner-occupied)*	€	***3020***	*2947*	*4068*	*3983*	*940*	*3476*	*1014*	5023	4220	2654	*2845*	*985*	*###*	*4242*	*749*	*2021*	*9204*	*na*	*2133*	*634*	*1259*	*801*	*2061*	*2528*	*3572*	*3748*
Expenditure EU total (bln. €/yr)																												
10	Total, of which	10^9€	6791	103,9	140,7	7,0	40,0	69,5	4,7	71,9	827,9	1054,7	102,5	38,8	58,3	777,8	6,0	36,8	11,1	2,9	165,8	117,5	76,6	16,3	13,2	160,1	119,6	970,8
11	Housing, of which	10^9€	1112	19,9	33,2	1,5	9,4	19,9	1,1	18,6	199,5	264,7	16,1	7,0	12,6	157,9	1,3	5,7	2,4	0,3	35,5	29,1	8,0	4,3	2,6	50,3	34,6	176,7
12	Electricity, gas & other fuel	10^9€	185	3,5	6,2	0,2	3,4	4,2	0,3	1,5	30,6	43,2	2,3	2,1	1,8	25,7	0,3	2,0	0,2	na	6,6	10,8	2,0	1,8	0,7	4,8	7,8	23,3
13	Building maintenance & repair	10^9€	58	1,1	0,7	0,1	0,1	0,9	0,0	0,0	10,8	5,3	0,7	0,2	0,2	10,1	0,2	0,4	0,1	na	2,5	5,5	0,2	0,3	0,1	3,7	0,4	14,6
14	Water supply, misc. services	10^9€	76	2,6	1,8	0,1	0,7	1,5	0,1	0,2	14,9	25,3	0,4	0,6	0,1	10,9	0,1	0,4	0,1	na	2,3	2,2	0,5	0,3	0,2	3,0	0,0	7,8
15	Rent, Imputed rent , of which	10^9€	792	12,6	24,5	1,1	5,2	13,4	0,7	16,9	143,2	190,9	12,7	4,1	10,6	111,2	0,7	2,9	1,9	na	24,0	10,6	5,4	1,9	1,6	38,7	26,4	131,1
#	*Actual rent*	10^9€	236	2,9	6,9	0,2	1,3	4,7	0,1	5,0	38,9	87,5	2,3	0,3	1,5	18,7	0,0	0,1	0,3	na	9,1	2,1	0,8	0,2	0,2	2,6	10,4	39,8
#	*Imputed rent (owner-occupied)*	10^9€	556	9,7	17,6	1,0	4,0	8,6	0,6	11,9	103,5	103,4	10,5	3,8	9,3	93,3	0,7	2,7	1,6	na	14,9	8,5	4,6	1,7	1,4	35,9	15,9	91,3
Expenditure in % *																												
18	Total, of which	%	**100**	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
19	Housing, of which	%	16,4/ 23,0	19	23,6	21,4	23,5	28,6	22,9	25,9	24,1	25,1	15,7	18,1	21,6	20,3	21,5	15,6	21,6	9,4	21,4	24,8	10,5	26,5	19,7	31,4	28,9	18,2
20	Electricity, gas & other fuel	%	2,7/ 4,2	3	4,4	3,4	8,4	6	6,2	2,1	3,7	4,1	2,2	5,5	3	3,3	5,4	5,5	2,2	na	4	9,2	2,6	10,8	5,1	3	6,5	2,4
21	Building maintenance & repair	%	0,9/ 1,4	1	1	1	0	1	0	0	1	1	1	1	0	1	3	1	1	na	2	5	0	2	0	2	0	2
22	Water supply, misc. services	%	1,1/ 1,6	2,5	1,3	1,0	1,7	2,1	1,9	0,3	1,8	2,4	0,4	1,5	0,1	1,4	1,3	1,1	1,0	na	1,4	1,9	0,7	1,7	1,7	1,9	0,0	0,8
23	Rent, Imputed rent , of which	%	11,7/ 15,8	12,1	17,4	15,9	13,1	19,2	14,4	23,5	17,3	18,1	12,4	10,5	18,1	14,3	11,9	7,9	17,2	na	14,5	9	7	11,9	12,5	24,2	22,1	13,5
#	*Actual rent*	%	*3,5/ 4,4*	*2,8*	*4,9*	*2,3*	*3,3*	*6,8*	*2,3*	*6,9*	*4,7*	*8,3*	*2,2*	*0,7*	*2,6*	*2,4*	*0,4*	*0,4*	*3*	*na*	*5,5*	*1,8*	*1,1*	*1*	*1,8*	*1,6*	*8,7*	*4,1*
#	*Imputed rent (owner-occupied)*	%	*8,2/ 11,4*	*9,3*	*12,5*	*13,6*	*9,9*	*12,4*	*12*	*16,6*	*12,5*	*9,8*	*10,2*	*9,8*	*16*	*12*	*12*	*7,4*	*14,2*	*na*	*9*	*7,2*	*6*	*10*	*10,7*	*22,4*	*13,3*	*9,4*

*= Two EU averages are given: the first is the straight money average, the second is the average percentage weighted by no. of households

Table 3-5. EU Housing Financing 2003 (source: VHK compilation of 'Housing Statistics of the European Union 2004', Boverket 2005)

	Parameter	*unit*	EU-25	A	B	CY	CZ	DK	EST	FIN	F	D	GR	H	IRL	IT	LT	LIT	LUX	MT	NL	PL	P	SK	SLO	E	S	UK
1.	Dwelling stock	k#	**204663**	3280	4820	299	4366	2561	624	2574	29495	38925	5465	4134	1554	26526	967	1292	176	127	6811	11764	5318	1885	785	20947	4351	25617
Ownership																												
2	Rent, % of occupied dwellings	%	**35**	39	31	na	na	40	na	34	38	55	20	7	18	na	21	na	26	26	45	24	na	na	9	11	39	31
3	Owner-occupied, % occ. dwell.	%	**61**	58	68	na	na	53	na	63	56	45	74	92	77	na	79	na	67	70	55	58	na	na	84	82	46	69
4	Co-operative, % occ. dwell.	%	**2**	na	na	na	na	7	na	0	na	na	na	na	na	na	0	na	na	na	na	18	na	na	na	na	15	na
5	Other ownership, % occ. dwell.	%	**2**	3	2	na	na	0	na	3	6	0	6	1	5	na	0	na	7	4	0	0	na	na	7	7	0	0
Persons/hh by ownership																												
6	Public rental , pp/ occ. dwell	#	**2,4**	2,0	2,2	2,5	2,5	1,9	na	1,9	2,6	1,9	na	2,6	3,1	2,7	2,6	na	na	2,8	1,9	na	na	3,0	2,6	3,2	1,7	2,2
7	Private rental , pp/ occ. dwell	#	**1,8**	|	1,9	|	|	1,7	na	1,7	2,1	|	|	0,4	2,4	2,7	2,4	na	1,2	|	1,7	na	na	|	2,6	|	1,6	2,1
8	Owner occupied , pp/occ. dwell	#	**2,7**	2,7	2,6	3,3	2,8	2,5	na	2,4	2,5	2,5	2,9	2,7	3	2,8	2,7	na	2,3	3,2	2,7	na	2,9	3,3	3	3,4	2,7	2,4
9	TOTAL persons/occ. dwelling	#	**2,5**	2,4	2,4	3,1	2,6	2,2	na	2,2	2,4	2,2	2,8	2,7	3	2,8	2,5	2,8	2,5	3,1	2,4	na	2,1	3,2	2,9	2,8	2,1	2,3
Indices Rent/ Houses																												
6	Rent (1996=100)	ndx	**118**	122	113	122	122	120	135	123	112	110	143	134	152	128	201	99	121	110	124	288	120	248	136	136	112	122
7	House, nominal price(1995=100)	ndx	**na**	na	138	na	na	172	na	184	162	na	na	na	268	143	na	na	na	na	205	na	na	na	na	225	175	235
8	House real price (1995=100)	ndx	**na**	na	120	na	na	146	na	159	143	na	na	na	207	117	na	na	na	na	167	na	na	na	na	178	153	210
Mortgage																												
9	Ratio mortgage/ GDP (res.)	%	**na**	na	27	na	3	88	na	36	25	54	17	8	45	13	8	na	33	na	100	5	51	na	na	42	50	70
10	Typical mortgage interest rate	%	**na**	5,3	6,2	na	na	5,0	4,6	3,4	4,6	5,0	5,5	na	3,6	4,6	na	na	na	na	4,5	8,0	4,4	na	na	3,1	4,1	4,7
11	Usual length of contract	yr	**na**	na	20	na	15–20	30	na	15–20	15–20	≤30	15	na	na	10–25	10–20	20–25	20–40	30	≤30	na	25–30	20	na	24	30–50	na
12	Average loan-to-value ratio	%	**na**	60	80–85	na	70	80	na	70–85	66	70	60	na	60–70	na	≤ 85	70–90	≤80	68	112	na	70–80	70	na	83	90–100	70
13	Tax on imputed rent	Y/N	**na**	N	Y	na	N	Y	na	N	N	N	Y	na	N	Y	Y	Y	Y	N	Y	na	N	19	na	N	N	N
14	Mortgage related interest relief	Y/N	**na**	na	Y	na	Y	Y	na	Y	N	N	Y	na	Y	Y	N	Y	Y	Y	Y	na	Y	N	na	N	Y	N
15	Indirect taxes (VAT)	%	**na**	10–20	21	na	5	25	na	22	19.6	16	11–13	na	13.5	4	18	18	3		19	na	0	19	na	7	25	0
Low income groups (<60% median equalized income)																												
16	total	%	**15**	13	na	8	11	18	11	15	11	20	10	21	19	16	17	12	15	11	15	20	5	11	19	10	17	15
17	renting	%	**na**	10	na	7	6	17	8	12	7	21	9	17	17	14	17	8	11	7	15	19	na	11	18	6	12	na
18	owner	%	**na**	28	na	8	24	26	23	25	16	15	16	44	30	24	26	24	na	20	16	25	na	na	23	18	32	na
19	60% median eq. Income in PPS	PPS	**na**	9468	9286	na	4045	10197	2440	7680	8765	9492	5443	3369	7934	7044	2301	2346	14376	5510	8309	2859	4967	3649	6795	6527	7679	8984
20	% all hh receiving allowances	%	**na**	na	na	na	na	21	na	20	20	7	1	na	5	na	6	na	na	na	14	6	na	1	1	12	16	19

3.7 Heat load: Existing studies

3.7.1 Introduction

This section presents the main outcomes of existing studies that will be used to model the heat load for water heating. The first study is the PRIMES Shared Analysis which is a top-down approach for determining residential energy consumption. The second is the ECCP study which combined a top-down appraoch with a bottom-up appraoch, involving many stakeholders.

3.7.2 PRIMES 'Shared Analysis'

The PRIMES model covers the whole EU energy-economy, both the sides of energy supply and energy-demand. It was used for the 'Shared Analysis' in 1999 by the three DGs of the European Commission most involved in energy and climate change (DG TREN, DG ENV, DG ENTR) and later it was used during the ECCP process (see next paragraph). In 2006, the University of Athens (author of the model) has published a long-term forecast on CO2 emissions in the context of the Energy Efficiency improvements planned in the EU.[22]

The historical data in PRIMES are based on official statistics data (e.g. Eurostat) and the researchers use simplified models to produce forecasts. We will not go into detail on the modellingbut the table below shows the main data for the households energy consumption, published in 2006.

It is important to note,

- that these data for the residential sector do not include the power generation losses and the generation and distribution losses of district heating. In PRIMES these losses are partitioned to the energy sector, whereas for the ecological impact assessment these types of losses will eventually have to be partitioned to the final demand sectors (industry, tertiary, residential, transport). This is a disadvantage, but the advantage is that it enables a comparison between the generation losses of fossil fuel fired boilers and the now '100% efficient' district heating and electric heating.
- Furthermore, PRIMES is based, for 1990-2005, on the annual statistics that Eurostat retrieves from the national statistics offices, which in turn are based on the energy deliveries of as reported by energy companies. This means that these data – though not perfect—are probably the most accurate to be found. The disadvantage is of course that they are delivered at a high aggregation level and the PRIMES-authors do not supply an insight in the exact modelling behind these figures.

Data are given for 5-year intervals. For our purpose it was useful to assess an interpolated figure of 17370 kWh per household in 2003, because this is the most recent year for which detailed housing statistics are available for all Member States (see table 3-11). Also the figure of 191,4 mln. households in 2003 is an interpolated figure.

Comparing between Member States, already at this high aggregation level, there are some remarkable figures showing that there is a wide variation of 11300 kWh/household for Spain to 37380 kWh/household for Luxemburg (2005 data).

Climate seems only a part of the explanation of the differences in kWh/household. Compare e.g. Belgium and the Netherlands; compare new Member States (NMS) and the EU-15. This will be explored in par. 3.8. The CO2-emission data per household are –

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[22] Mantzos, L. and Capros, P., European Energy and Transport, Trends to 2030- Update 2005, May 2006 (ref.'PRIMES 2006'). prepared by the Institute of Communication and Computer Systems of National Technical University of Athens (ICCS-NTUA), E3M-Lab, Greece, for the Directorate-General for Energy and Transport and represents that organisation's views on energy facts, figures and projections. These views have not been adopted or in any way approved by the Commission and should not be relied upon as a statement of the Commission's or the Directorate-General's views.

as explained above— as yet not saying too much because they do not include the CO2 emissions in the energy sector that are caused by the energy demand in the residential sector.

The 2006 publication on PRIMES doesn't provide a split-up of the energy consumption per fuel/energy source. For that reason we present data for 2003 compiled in the Ecoheatcool project and then use the percentages to make the split. See table 3-11.

Table 3-10. EU Residential Energy use and CO2-emissions PRIMES (source: PRIMES Baseline Scenario, release 2006)

	Parameter	*unit*	EU-25	AT	BE	CY	CZ	DK	EST	FI	FR	DE	GR	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	SK	SI	ES	SE	UK
	No. of households (PRIMES 2006)																											
1	households 1990	mln	167	3,0	3,9	0,1	3,6	2,2	0,6	2,0	22,5	33,8	3,3	4,0	1,0	21,5	1,0	1,3	0,1	0,1	6,0	12,3	3,3	2,1	0,6	12,3	3,9	22,5
2	households 1995	mln	176	3,1	4,1	0,2	3,8	2,3	0,6	2,2	24,0	35,3	3,5	4,1	1,2	23,0	1,0	1,3	0,2	0,1	6,4	13,1	3,5	2,3	0,6	13,2	4,0	23,9
3	households 2000	mln	186	3,2	4,2	0,2	3,9	2,4	0,6	2,3	25,5	36,7	3,7	4,2	1,3	24,4	0,9	1,3	0,2	0,1	6,8	13,8	3,6	2,5	0,6	14,0	4,1	25,3
4	households 2005	mln	195	3,4	4,4	0,2	4,1	2,5	0,6	2,4	27,1	38,3	3,9	4,3	1,4	25,6	0,9	1,4	0,2	0,2	7,3	14,4	3,8	2,7	0,7	14,6	4,3	27,0
5	households 2010	mln	205	3,5	4,6	0,2	4,2	2,6	0,6	2,5	28,7	39,8	4,1	4,3	1,5	26,8	0,9	1,4	0,2	0,2	7,8	14,9	4,0	2,8	0,7	15,2	4,5	28,6
6	households 2015	mln	211	3,6	4,8	0,2	4,2	2,7	0,6	2,6	30,1	40,7	4,2	4,3	1,6	27,8	0,9	1,5	0,2	0,2	8,2	15,0	4,2	2,9	0,7	15,6	4,7	30,1
7	households 2020	mln	218	3,6	4,9	0,2	4,2	2,8	0,6	2,7	31,5	41,5	4,3	4,3	1,7	28,7	0,9	1,5	0,2	0,2	8,6	15,1	4,3	2,9	0,7	16,0	4,9	31,6
	Residential Energy Consumption in ktoe (1 toe=41,86 GJ=11627 kWh)																											
8	Net energy total 1990	ktoe	261.006	5832	8337	120	8254	4043	1271	5319	35753	58223	3054	5992	2323	30494	2240	1662	519	55	9772	18126	2290	2416	850	9266	6838	37957
9	Net energy total 1995	ktoe	274.621	6256	9295	181	5608	4472	1118	5460	36086	62995	3327	5449	2198	31692	883	1248	559	70	11124	23284	2569	1983	1176	9986	8029	39573
10	Net energy total 2000	ktoe	273.302	6472	9465	219	5260	4141	928	4922	38425	63063	4470	5281	2475	28766	965	1345	596	82	10286	17516	2804	2186	1116	11881	7539	43099
11	Net energy total 2005	ktoe	294.611	7505	9963	254	6022	4293	1001	5260	41352	67715	5647	6563	2821	29410	1368	1425	643	94	10615	17950	3271	2930	1263	14208	7660	45378
12	Net energy total 2010	ktoe	311.966	8156	10314	290	6637	4443	1100	5635	43461	70501	6509	7333	3154	30336	1773	1582	669	109	11115	19188	3942	3440	1393	16075	7821	46990
13	Net energy total 2015	ktoe	327.949	8446	10456	322	7022	4604	1172	5901	44585	72081	7010	8044	3406	32583	2102	1796	679	121	11623	21388	4479	3903	1491	17523	8049	49163
14	Net energy total 2020	ktoe	338.740	8440	10324	340	7271	4700	1240	6009	44927	72615	7281	8463	3609	35141	2341	2026	672	130	12042	24090	4905	4280	1561	17728	8144	50461
	Energy per Household in MWh/hh																											
15	Net energy /househ. 1990	MWh/hh	18,17	22,60	24,85	13,95	26,66	21,37	24,63	30,92	18,48	20,03	10,76	17,42	27,01	16,49	26,04	14,86	60,34	6,39	18,94	17,13	8,07	13,38	16,47	8,76	20,39	19,61
16	Net energy /househ. 1995	MWh/hh	18,10	23,46	26,36	10,52	17,16	22,61	21,66	28,86	17,48	20,75	11,05	15,45	21,30	16,02	10,27	11,16	32,50	8,14	20,21	20,67	8,53	10,02	22,79	8,80	23,34	19,25
17	Net energy /househ. 2000	MWh/hh	17,10	23,52	26,20	12,73	15,68	20,06	17,98	24,88	17,52	19,98	14,05	14,62	22,14	13,71	12,47	12,03	34,65	9,53	17,59	14,76	9,06	10,17	21,63	9,87	21,38	19,81
18	Net energy /househ. 2005	MWh/hh	17,55	25,66	26,33	14,77	17,08	19,97	19,40	25,48	17,74	20,56	16,84	17,75	23,43	13,36	17,67	11,83	37,38	5,46	16,91	14,49	10,01	12,62	20,98	11,31	20,71	19,54
19	Net energy /househ. 2010	MWh/hh	17,73	27,09	26,07	16,86	18,37	19,87	21,32	26,21	17,61	20,60	18,46	19,83	24,45	13,16	22,91	13,14	38,89	6,34	16,57	14,97	11,46	14,28	23,14	12,30	20,21	19,10
20	Net energy /househ. 2015	MWh/hh	18,05	27,28	25,33	18,72	19,44	19,83	22,71	26,39	17,22	20,59	19,41	21,75	24,75	13,63	27,16	13,92	39,47	7,03	16,48	16,58	12,40	15,65	24,77	13,06	19,91	18,99
21	Net energy /househ. 2020	MWh/hh	18,07	27,26	24,50	19,77	20,13	19,52	24,03	25,88	16,58	20,34	19,69	22,88	24,68	14,24	30,24	15,70	39,07	7,56	16,28	18,55	13,26	17,16	25,93	12,88	19,32	18,57
	Residential CO2-emissions (excl. Transport) in Mt CO2																											
22	Mt CO2 total 1990	MtCO2	506	10,1	18,7	0,2	24	4,9	1,2	6,4	55,2	129,8	4,6	13,6	7	65,4	4,4	2,5	1,3	0,1	19,2	33,1	1,6	5,8	1,7	12,9	4,8	77,8
23	Mt CO2 total 1995	MtCO2	486	9,8	20,1	0,2	10,4	4,9	0,5	6,1	52,2	126,4	4,8	9,9	5,7	64,5	0,5	0,8	1,3	0,1	20,6	44,4	1,9	3,3	2,1	13,6	4,5	77,3
24	Mt CO2 total 2000	MtCO2	452	9,6	20	0,2	7,9	3,9	0,3	3,5	54	117,3	7,4	8,8	5,7	55,7	0,3	0,5	1,4	0,1	18,9	27,9	2	3,3	1,3	16,4	3,7	82
25	Mt CO2 total 2005	MtCO2	467	9,9	20,4	0,2	8,7	3,5	0,2	3,1	55	121,6	10,3	10,7	6,1	55,3	0,4	0,5	1,5	0,1	19,1	25,9	2,8	4,7	1,5	19,3	2,6	84
26	Mt CO2 total 2010	MtCO2	483	10,7	20,8	0,2	9,1	3,3	0,3	3,4	57,6	123,7	12,4	11	6,7	55,7	0,5	0,6	1,5	0,1	19,4	26,2	3,9	5,6	1,7	21	2,4	84,7
27	Mt CO2 total 2015	MtCO2	494	10,9	20,7	0,2	9,1	3,3	0,3	3,6	57,5	124,2	13,4	11,3	7	57,9	0,6	0,7	1,5	0,1	19,7	27,4	4,6	6,1	1,9	22,2	2,2	87,3
28	Mt CO2 total 2020	MtCO2	495	10,5	19,8	0,2	9,1	3,3	0,3	3,7	56	123	13,7	11,4	7,3	59,7	0,7	0,9	1,5	0,1	19,8	28,8	5	6,5	2,1	21,8	2	87,7
	CO2-emissions per household																											
29	Mt CO2 /household 1990	tCO2	3,03	3,37	4,79	2,00	6,67	2,23	2,00	3,20	2,45	3,84	1,39	3,40	7,00	3,04	4,40	1,92	13,00	1,00	3,20	2,69	0,48	2,76	2,83	1,05	1,23	3,46
30	Mt CO2 /household 1995	tCO2	2,75	3,16	4,90	1,00	2,74	2,13	0,83	2,77	2,18	3,58	1,37	2,41	4,75	2,80	0,50	0,62	6,50	1,00	3,22	3,39	0,54	1,43	3,50	1,03	1,13	3,23
31	Mt CO2 /household 2000	tCO2	2,43	3,00	4,76	1,00	2,03	1,63	0,50	1,52	2,12	3,20	2,00	2,10	4,38	2,28	0,33	0,38	7,00	1,00	2,78	2,02	0,56	1,32	2,17	1,17	0,90	3,24
32	Mt CO2 /household 2005	tCO2	2,39	2,91	4,64	1,00	2,12	1,40	0,33	1,29	2,03	3,17	2,64	2,49	4,36	2,16	0,44	0,36	7,50	0,50	2,62	1,80	0,74	1,74	2,14	1,32	0,60	3,11
33	Mt CO2 /household 2010	tCO2	2,36	3,06	4,52	1,00	2,17	1,27	0,50	1,36	2,01	3,11	3,02	2,56	4,47	2,08	0,56	0,43	7,50	0,50	2,49	1,76	0,98	2,00	2,43	1,38	0,53	2,96
34	Mt CO2 /household 2015	tCO2	2,34	3,03	4,31	1,00	2,17	1,22	0,50	1,38	1,91	3,05	3,19	2,63	4,38	2,08	0,67	0,47	7,50	0,50	2,40	1,83	1,10	2,10	2,71	1,42	0,47	2,90
35	Mt CO2 /household 2020	tCO2	2,27	2,92	4,04	1,00	2,17	1,18	0,50	1,37	1,78	2,96	3,19	2,65	4,29	2,08	0,78	0,60	7,50	0,50	2,30	1,91	1,16	2,24	3,00	1,36	0,41	2,78

Table 3-11. EU Residential net energy use by energy source 2003 (source: VHK compilation of PRIMES 2006 and Euroheat & Power 'Ecoheatcool' 2006)

	Parameter	*unit*	**EU-25**	**A**	**B**	**CY**	**CZ**	**DK**	**EST**	**FIN**	**F**	**D**	**GR**	**H**	**IRL**	**IT**	**LT**	**LIT**	**LUX**	**MT**	**NL**	**PL**	**P**	**SK**	**SLO**	**E**	**S**	**UK**
	PRIMES Base data (2003= interpolation from PRIMES 2000-2005)																											
1	Energy/hh 2003	kWh/hh	17370	24805	26277	13952	16519	20004	18832	25242	17653	20326	15720	16495	22911	13497	15591	11913	36288	7092	17179	14599	9627	**11637**	**21238**	**10736**	**20979**	**19647**
2	households 2003	mln.	191,4	3,3	4,3	0,2	4,0	2,5	0,6	2,4	26,5	37,7	3,8	4,3	1,4	25,1	0,9	1,4	0,2	0,2	7,1	14,2	3,7	**2,6**	**0,7**	**14,4**	**4,2**	**26,3**
3	Floor area/ dw. 2003	m²	87	94	86	*145*	76	109	60	77	90	90	83	75	104	90	55	61	125	106	98	68	83	56	75	90	92	87
	Residential net energy consumption by fuel in % (Euroheat & Power 2006)																											
4	Coal and Coal Products	%	1,9	1,5	1,1	0,0	6,4	0,0	0,0	0,0	0,6	0,7	0,0	3,0	12,8	0,0	2,0	2,0	0,0	0,0	0,0	18,5	0,0	1,9	0,0	0,4	0,0	1,4
5	Petroleum Products	%	17,8	27,0	34,5	30,0	0,9	14,4	0,0	15,5	19,7	25,0	55,8	3,4	37,2	18,1	4,0	4,1	45,5	33,3	0,5	6,3	24,3	0,0	33,3	28,0	7,7	6,6
6	Natural Gas	%	40,0	21,6	36,2	0,0	39,0	15,6	3,1	0,5	39,6	37,4	0,5	58,3	20,2	57,1	6,0	8,2	36,4	0,0	74,2	18,0	5,6	53,8	7,1	20,4	0,7	65,9
7	Geothermal	%	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
8	Solar/Wind/Other	%	0,2	1,2	0,0	20,0	0,0	0,0	0,0	0,0	0,1	0,3	2,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,9	0,0	0,0	0,2	0,0	0,0
9	Biomass and Waste	%	6,6	17,4	1,4	0,0	5,5	6,9	28,1	13,5	11,4	4,8	10,0	6,8	1,1	2,8	38,0	24,5	0,0	0,0	1,3	10,9	29,0	0,0	21,4	10,9	7,7	0,3
10	Electricity	%	24,8	23,2	26,6	50,0	23,9	23,1	18,8	37,8	28,3	19,6	31,1	17,0	28,7	22,0	10,0	14,3	13,6	66,7	21,9	13,1	40,2	17,0	26,2	40,1	49,8	25,8
11	Heat	%	8,6	8,1	0,3	0,0	24,3	40,0	50,0	32,6	0,0	12,0	0,5	11,5	0,0	0,0	40,0	46,9	4,5	0,0	1,8	33,1	0,0	27,4	11,9	0,0	34,0	0,0
12	TOTAL	%	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
	Residential net energy consumption by fuel in kWh/household (calculated from above)																											
13	Coal and Coal Products	kWh/hh	337	383	297	0	1061	0	0	0	108	151	0	491	2925	0	312	243	0	0	0	2707	0	220	0	44	0	280
14	Petroleum Products	kWh/hh	3092	6704	9056	4186	152	2876	0	3924	3470	5087	8770	562	8531	2444	624	486	16494	2364	89	918	2339	0	7079	3004	1625	1290
15	Natural Gas	kWh/hh	6944	5363	9501	0	6441	3126	588	131	6998	7595	83	9616	4631	7711	935	972	13196	0	12750	2635	540	6258	1517	2187	141	12940
16	Geothermal	kWh/hh	16	0	0	0	0	0	0	0	49	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	Solar/Wind/Other	kWh/hh	33	287	0	2790	0	0	0	0	10	63	331	0	0	0	0	0	0	0	45	0	90	0	0	22	0	0
18	Biomass and Waste	kWh/hh	1151	4310	371	0	909	1375	5296	3401	2021	968	1572	1123	244	380	5924	2917	0	0	224	1595	2789	0	4551	1171	1625	61
19	Electricity	kWh/hh	4305	5746	6978	6976	3940	4626	3531	9548	4997	3984	4881	2808	6581	2963	1559	1702	4948	4728	3758	1909	3869	1976	5562	4308	10454	5076
20	Heat	kWh/hh	1493	2011	74	0	4016	8002	9416	8240	0	2437	83	1895	0	0	6236	5592	1649	0	313	4834	0	3184	2528	0	7134	0
21	TOTAL	kWh/hh	17370	24805	26277	13952	16519	20004	18832	25242	17653	20326	15720	16495	22911	13497	15591	11913	36288	7092	17179	14599	9627	11637	21238	10736	20979	19647
	Residential net energy consumption by fuel in kWh/m² and MJ/m² (calculated from above)																											
22	Avg. kWh/m² (all)	kWh/m²	199	264	304	96	217	183	313	328	197	227	190	220	220	149	281	197	290	67	175	214	116	207	283	119	229	226
23	Avg. MJ/m² (all)	MJ/m²	718	951	1096	347	779	660	1126	1180	709	816	684	792	793	538	1013	708	1045	240	631	771	418	747	1019	429	825	814

3.7.3 *European Climate Change Programme (ECCP)*

The European Climate Change Programme started in 2000 as a collaboration between DG ENV, DG ENTR and DG TREN of the European Commission on one hand and the stakeholders in the relevant sectors on the other hand to identify and evaluate possible EU policy measures. Starting point for the quantitative analyses in this programme – from the side of the Commission— was the so-called Shared Analysis (1999) performed by the University of Athens for the European Commission, using the *PRIMES* model.[23] This analysis was built upon with a higher level of detail by reports of independent consultants and reports by the stakeholders. Especially in the building sector, responsible for 40% of the CO_2-related greenhouse gas emissions, the programme has tried to identify and clarify which products are responsible. EurACE put forward studies by CALEB Consulting and the Commission has tried to harmonise these results with other inputs, e.g. from the then ongoing SAVE studies in the field of space and water heating (BRE 2002, Novem 2001). The outcome of the quantitative analyses were scenarios for the 1990 and 2010 baseline, as well as a scenario for the 2010 'with measures', presented in Annex I of the second ECCP report 2003.

The Annex I of the European Commission's 2nd ECCP Report compiles data on energy demand from the stakeholders and experts in the working groups WG 3 (buildings) and WG 5 (electrical appliances). The Table 3-13 gives a selection of these data, relating to the residential sector. Reference years are 1990 and 2010.

The ECCP project presents the most comprehensive attempt at giving a split-up of EU residential energy use around, but there are some snags:

- The ECCP tables relate to EU-15 and will have to be updated to include the new Member States
- The technical analyses stem from what was available in 2001/2002. This includes the SAVE projects on Heating Systems (BRE, 2002), which was running in parallel. But it excludes the most recent market studies by BRG Consult (see Task 2 report).

Please note that, as opposed to the PRIMES data, the ECCP-tables <u>do</u> include a partitioning of the losses of power generation. For the 1990 data a conversion of 0,5 kg CO2/ $kWh_{electric}$ was used. For 2010 a higher efficiency of 0,45 kg CO2/ $kWh_{electric}$ was used. With these conversion factors the electricity consumption per household that is behind the ECPP-tables can be reconstructed in $kWh_{electric.}$. A summary is shown in Table 3-12 below.

Table 3-12. Electricity consumption per household EU-15 (extract from Table 3-13 next page, converted to kWh electric)

Sector/function group	Reference 1990	Baseline 2010
Electric heating/cooling/ CH pump	1277	1144
Electric water heaters	511	403
Whitegoods & Cooking	1418	975
Lighting	567	650
Electronics	227	832
<u>Misc. Electric</u>	255	234
Total	4255	4237

Please note that the values in this table are fully compatible with the data reported by the JS-WG (Joint Sub Working Group) elsewhere in the 2nd ECCP report.

[23] Please note that the European Commission continues to use the PRIMES model as the basis for its projections and that coherence between these policy documents at a higher aggregation level and the underlying study at product level is important. The latest publication involving PRIMES is 'European energy and transport: Scenarios for energy efficiency and renewables', European Commission, Aug. 2006.

Table 3-13. ECCP Residential sector Baselines 1990-2010 (all values in Mt CO2 eq.)

RESIDENTIAL SECTOR *Sector/function group*	Fuel-Related CO2 emissions (in MtCO2) *Reference 1990*	*Baseline 2010*
Total	762	797
of which		
Spaceheating/cooling, *of which*	481	466
Fossil,*of which*	371	350
Transmission losses	*190*	*186*
-windows	*75*	*70*
-walls	*55*	*55*
-floors	*30*	*30*
-roofs	*30*	*30*
Ventilation losses	*70*	*73*
Heating system losses	*111*	*91*
Electric, *of which*	90	88
Heating (incl. heatpump)	*73*	*68*
Cooling (airconditioners)	*2*	*3*
CH pump	*15*	*17*
District heating	*20*	*28*
Hot water, *of which*	103	115
Fossil	67	84
Electric	36	31
Whitegoods & Cooking, *of which*	109	84
Fossil (mainly hobs)	9	9
Electric, *of which*	100	75
Refrigeration/freezers	*62*	*43*
Washing machines	*20*	*11*
Dishwashers	*7*	*8*
Laundry driers	*4*	*6*
Electric ovens	*7*	*7*
Lighting (electr.)	40	50
Electronics, *of which*	16	64
Consumer el. (TV, audio, IRD,etc.)	15	35
Stand-by	*7*	*12*
On'	*7*	*23*
IT/ office equipment	1	29
Other(electric)	18	18
Autogeneration	0	0
Total (check)	767	797
of which (by energy source)		
Fossil	447	443
Electricity	300	326
Heat	20	28

Source: Composed by VHK 2002 for the European Commission on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.

Note: Conversion Electricity 1990: 1 TWh el. = 0.5 MtCO2; 2010 1 TWh el.= 0.45 MtCO2

3.7.4 Non-heating electricity consumption

The ECCP-tables gave a subdivision of electricity consumption that is not related to space heating/cooling or hot water preparation. On a total of around 4200-4300 kWh per household per annum (kWh/hh.a) the EU-15 used 2400-2500 kWh/hh.a for non-heating purposes in 1990 and with a forecast to rise to 2600-2700 kWh/hh.a in 2010 , mainly due to an increased energy consumption of consumer electronics.

On average, the 2006 PRIMES data for the EU-25 also indicate an average annual electrticity consumption per household in the range of 4200-4300 kWh. Obviously, for the EU-15 the electricity consumption rose more than expected (e.g. due to the not anticipated rise of residential air-conditioners), because the average electricity use of the new Member States is –according to Enerdata—substantially lower varying between 1500 and 2200 kWh/hh.a. The share of electric sanitary water heating is also higher in the new Member States, mainly because they are cheaper than gas-appliances and serve as a back-up for failing district heating. All in all, this leads to an estimate of 2300-2400 kWh/hh.a of non-heating electricity consumption (incl. electric cooking) for the EU-25. For a subdivision per country see the table.

3.8 Heat load: Update VHK 2006

This section continues along the lines of the ECCP approach, i.e. to use PRIMES totals as a basis and try to make an update of the estimate of the hot water demand for the domestic and commercial/industrial sector.

The ECCP/SAVE approach needs to be updated for the EU-25 and we will incorporate the latest findings of the Task 1 (building standards) and Task 2 (BRG Consult data). Also the new Energy Performance of Buildings (EPB) standards provide new inputs on hot water demand and heating.

The Table 3-16 shows the calculations involved for the assessment of water heater energy consumption. The estimate involves an iterative process, whereby all parameters must fit available sources and plausible explanations. In this context the split-up over 25 EU Member States, which is never attempted before, is not an extra burden but provides an extra possibility to test the robustness of the estimates.

3.8.1 Water Heater Energy

Actual measurement of hot water demand in the homes is expensive and therefore rare. If they exist, e.g. in the Netherlands by KIWA, the number of households is small and not deemed representative. Nevertheless, this information was used for tapping patterns that are now incorporated in the building standards. In order to determine the average hot water consumption, these building standards per country will be used in the underlying study. For that reason the standards on hot water demand and distribution losses, which are not strictly part of Task 1 (Task 1 should deal with generator and storage losses of water heaters), were incorporated.

1. Estimating the hot water demand in litres/person.day.

For 5 countries (NL, ES, DE, FR, UK) building standards make estimates in the range of 22-33 litres per person per day.

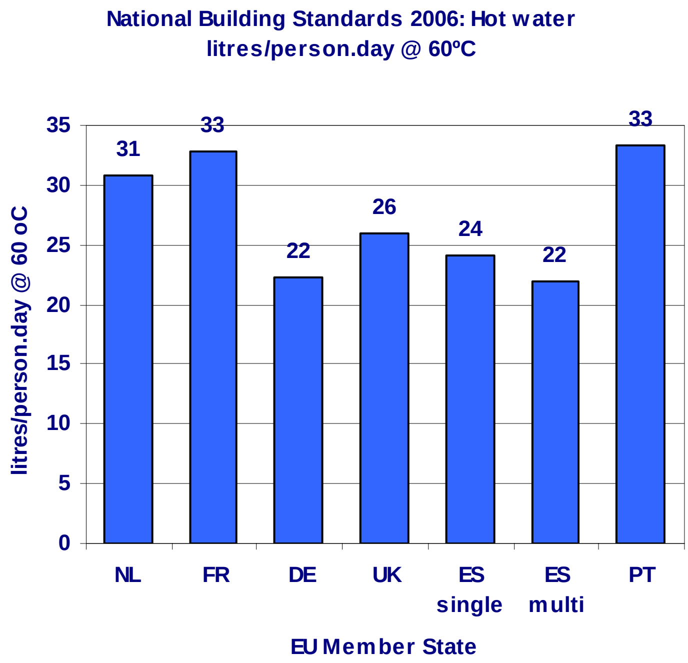
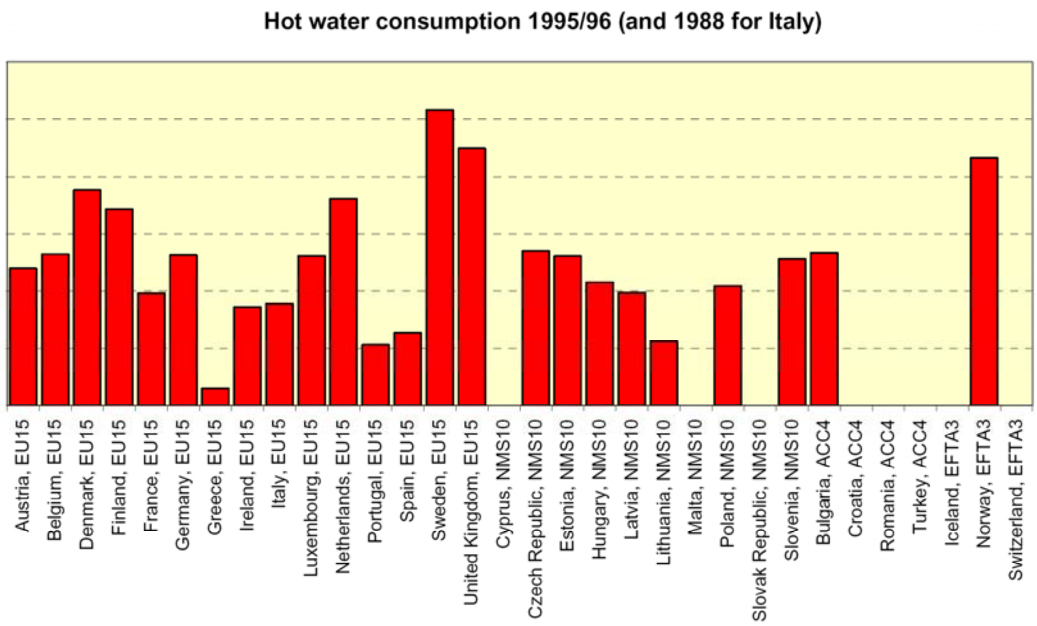


Figure 3-5.

These values are the anchor points for an estimate of hot water consumption for other countries. Inputs for this additional assessment are:

- Older data (1995-1998) where Eurostat has tried to assess the hot water demand. Because of lack of definition in the survey the absolute values of this international survey the absolute values cannot be used, but the relative values give an indication. The figure below is an elaboration of these older data by the Ecoheatcool project 2006. It shows e.g. that hot water demand in the North is significantly higher than in the South of Europe, although the Baltic States are the exception.

Figure 3-6.
Hot water consumption.
(source: Ecoheatcool 2006)

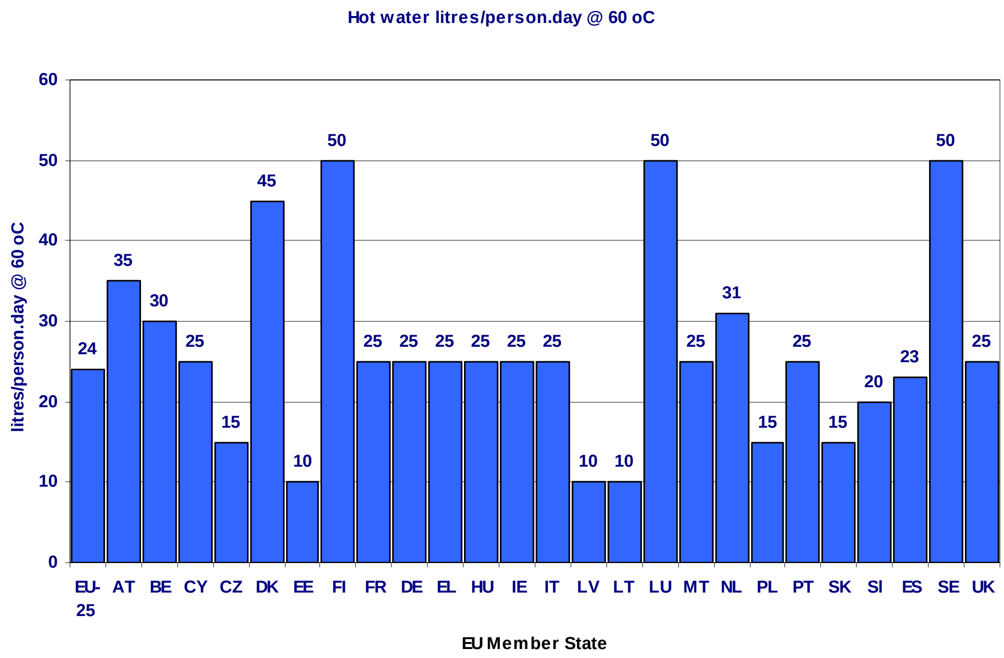


- A second input comes from the absolute limits of the electricity balance. For instance, if there is almost no electric heating in a country and the total electricity consumption is 1500 kWh/household, then –given that on average there is at least a refrigerator, lighting, etc. that will take a minimum of 800-1000 kWh/hh—it is impossible that average electricity consumption for water heating is more than 500-700 kWh. If all this hot water comes from an electric storage water heater at 70% efficiency, then we can calculate that this household can never use more than 17-20 litres of 60°C/hh.day on average. This is a fictituous example, but it comes close to the situation e..g in Baltic States.

- A third input comes from anecdotal data on habits, demographics and the technical limtits of the water heaters.
  - In Scandinavia it is normal for a person to take a daily long hot shower and a few baths (or a sauna) per week. Especially for the large fraction of one- and two person households this doesn't give any problems in terms of time ('bathroom-occupancy') and also the large storage vessels or district heating for water allow this.
  - In Western Europe (NL, UK, IE, North of FR, etc.) it is more common to take a (short) shower every other day and rarely have a bath. For certain countries also the limited capacity of the appliance plays a role, e.g. the limited flow rate of e.g. electric showers in the UK and Ireland or the traditionally smaller storage vessels in the Netherlands.
  - Germany and Belgium/Luxemburg are somewhat in the middle: There is a tradition of huge hot water storage vessels (>200-400 litres) and powerful electric instantaneous water heaters, but at the same time the latest German building standards –presumably reflecting German surveys—anticipate only a very limited hot water demand of 22 litres/person per day.
  - Further down South, the frequency and temperature of showers diminishes, the bidet is used daily, electric storage vessel volumes are much smaller, baths are mainly used for small children or to wash the curtains once a year. The young tend to use more the shower, whereas the older generation is still used to 'wash in parts' ('lavarsi a pezzi'). As the housing statistics in the previous paragraphs show, not all dwellings have showers/bathtubs.
  - In some new Member States, especially in the Baltic States, a significant fraction of dwellings doesn't have its own shower/bathtub/hot water. People use common or public facilities for a full bath/shower, e.g. once a week, and showers at work.
  - Finally, for all countries there is anecdotal evidence that the peak in hot water demand is in the weekends, at which time the technical limitations of the water heaters will play a bigger role than during weekdays.

Interpretation of all of the above lead to a hot water consumption per person per day of minimum 10 ltr. for the Baltic states to 50 ltr. for Nordic countries (and Luxembourg). The EU25 average is 24 l/pppd.

Figure 3-7.



2. Converting hot water demand to net energy demand

Multiplying the estimates of litres/person.day with the average household size (Boverket tables) gives an EU25 average of 59 l/hhd and then with 21,1 kWh/litre (=365 days * 50 degrees * 1,16 Wh/degree) gives the annual net energy demand for hot water.

Figure 3-8.

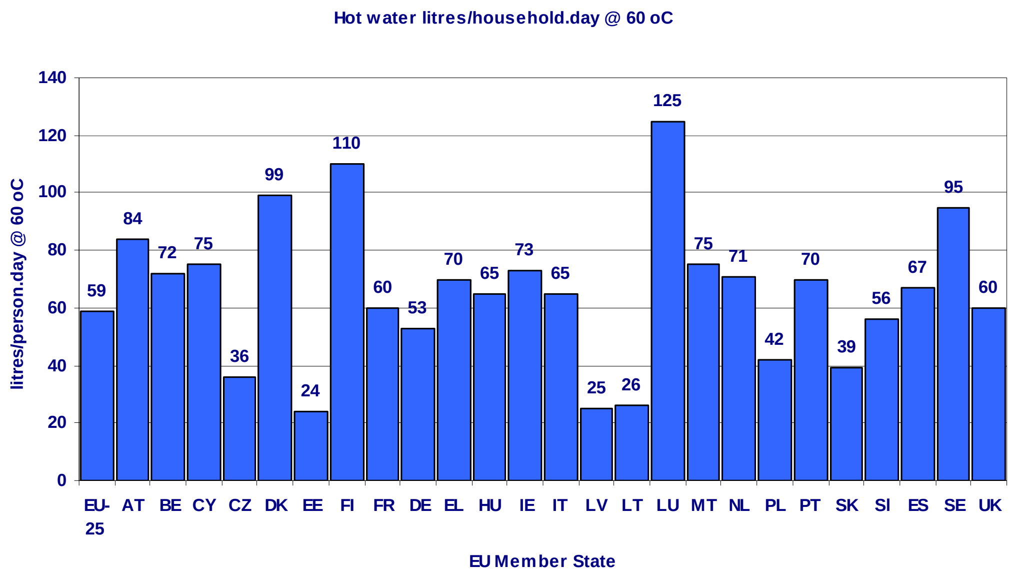


Figure 3-9.

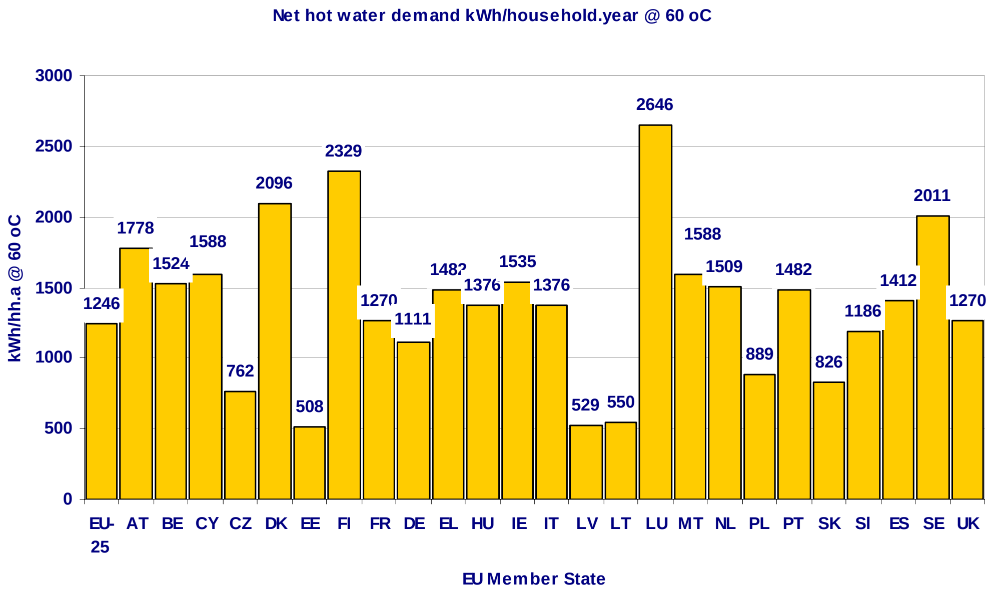
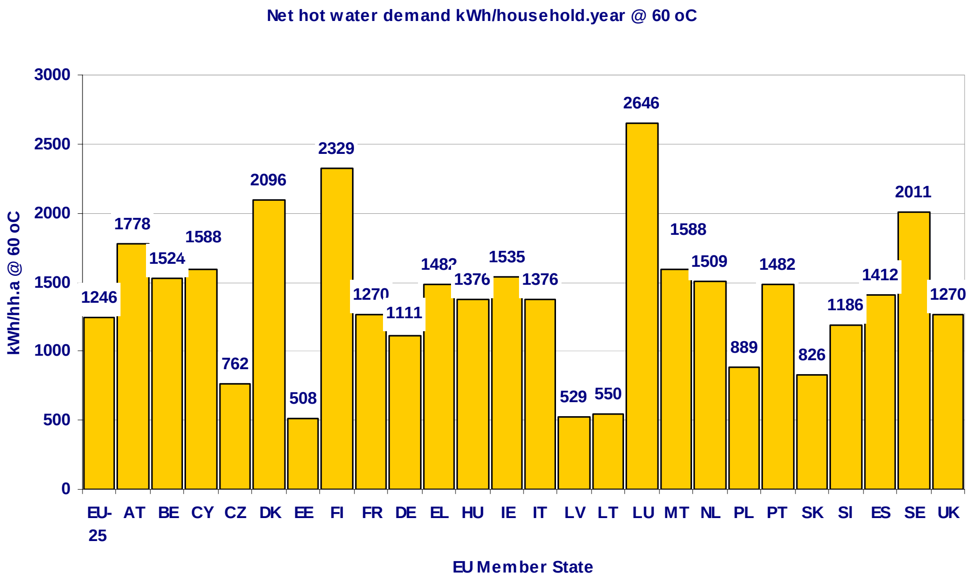


Figure 3-10.



3. Applying an energy efficiency ratio from default building standard data and other sources.

For electric instantaneous heaters 97% was assumed, for storage water heaters 65-70%, for combi-boilers 55%, for indirect cylinders 50%, for dedicated gas water heaters around 45%. These values refer to the installed stock, not the new appliances [24].

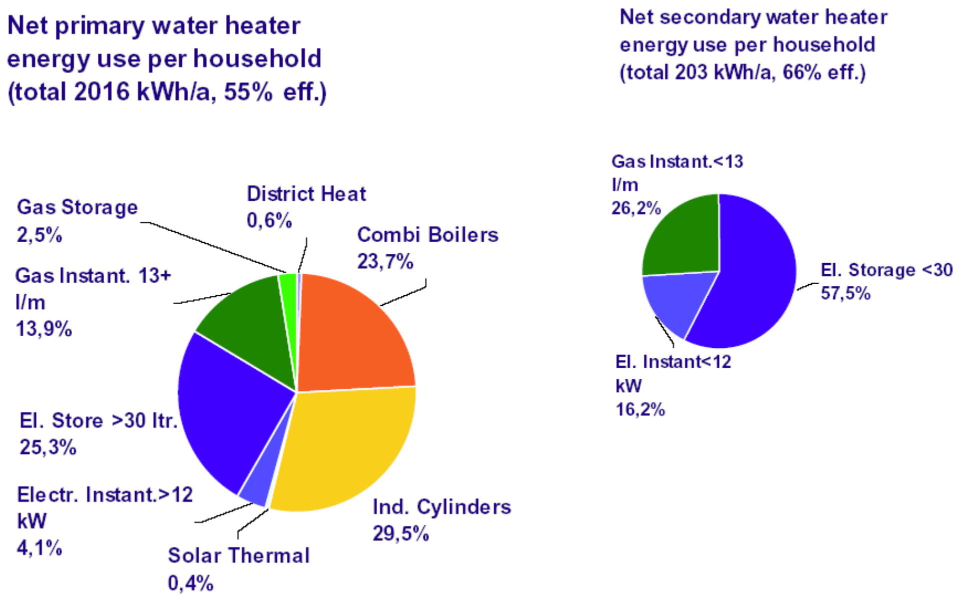
4. Assessing the share of each water heater type in the EU-25 park

For this we used the Task 2 stock data from BRG Consult, distinguishing between primary water heaters and –for 32% of the EU—secondary water heaters. It was

[24] The "Solar Thermal" value (150%) assumes a 90-95% efficient boiler /WH with 50-60% solar contribution. Quantitatively this would appear as a 150% efficiency (1 kWh in à 1,5 kWh output). The value is used as a first rough check on statistics as given."

assumed –roughly as indicated in standards—that the secondary water heater is mainly placed in the kitchen and –if present—takes care of one-third of the hot water drawn off.

Figure 3-11.



The results are also given in Table 3-16.

Table 3-16. EU Hot Water Energy Consumption 2003 (source: VHK 2006 analysis based on Task 2 Report and misc. sources)

	Parameter	*unit*	EU-25	AT	BE	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	SK	SI	ES	SE	UK
	Base data 2003																											
1	Energy/hh 2003, of which	kWh/hha	17370	24805	26277	13952	16519	20004	18832	25242	17653	20326	15720	16495	22911	13497	15591	11913	36288	7092	17179	14599	9627	**11637**	**21238**	**10736**	**20979**	**19647**
3	Households 2003	mln.	191,4	3,3	4,3	0,2	4,0	2,5	0,6	2,4	26,5	37,7	3,8	4,3	1,4	25,1	0,9	1,4	0,2	0,2	7,1	14,2	3,7	**2,6**	**0,7**	**14,4**	**4,2**	**26,3**
4	Persons/ hh 2003	#	**2,5**	2,4	2,4	3	2,4	2,2	2,4	2,2	2,4	2,1	2,8	2,6	2,9	2,6	2,5	2,6	2,5	3	2,3	2,8	2,8	2,6	2,8	2,9	1,9	2,4
5	Floor area/ dw. 2003	m²	87	94	86	*145*	76	109	60	77	90	90	83	75	104	90	55	61	125	106	98	68	83	56	75	90	92	87
6	Secondary WH per hh.	%	32	34	48	8	31	8	11	3	13	45	8	22	81	22	8	12	48	8	28	34	7	19	55	23	1	48
	Sanitary Hot Water (SHW) demand (litres of 60°C per day)																											
7	Litres/person.day	ltr	24	35	30	25	15	45	10	50	25	25	25	25	25	25	10	10	50	25	31	15	25	15	20	23	50	25
8	Litres/hh.day	ltr	59	84	72	75	36	99	24	110	60	53	70	65	73	65	25	26	125	75	71	42	70	39	56	67	95	60
9	Net SHW energy/ hh.yr	kWh/hha	1246	1778	1524	1588	762	2096	508	2329	1270	1111	1482	1376	1535	1376	529	550	2646	1588	1509	889	1482	826	1186	1412	2011	1270
10	of which																											
11	**Primary WH energy**	kWh/hha	**1114**	**1577**	**1281**	**1545**	**683**	**2040**	**489**	**2305**	**1215**	**945**	**1442**	**1275**	**1121**	**1275**	**515**	**528**	**2223**	**1545**	**1369**	**788**	**1447**	**773**	**968**	**1304**	**2004**	**1067**
12	**Second. WH energy**	kWh/hha	**133**	**201**	**244**	**42**	**79**	**56**	**19**	**23**	**55**	**167**	**39**	**101**	**414**	**101**	**14**	**22**	**423**	**42**	**141**	**101**	**35**	**52**	**217**	**108**	**7**	**203**
	Water Heater Park EU-25, market penetration in %																											
	PRIMARY WATER HEATERS (efficiency)																											
13	**District Heat** (100%)		**1%**	**3%**	**0%**	**0%**	**7%**	**15%**	**22%**	**8%**	**0%**	**1%**	**0%**	**2%**	**0%**	**0%**	**12%**	**14%**	**0%**	**0%**	**1%**	**8%**	**0%**	**8%**	**2%**	**0%**	**12%**	**0%**
14	**Linked to Boiler,** of which		**49%**	**47%**	**47%**	**27%**	**51%**	**44%**	**16%**	**31%**	**46%**	**46%**	**27%**	**37%**	**84%**	**55%**	**17%**	**23%**	**47%**	**27%**	**82%**	**31%**	**4%**	**24%**	**44%**	**27%**	**63%**	**83%**
15	Combi Boilers (55%)		23%	6%	21%	1%	24%	1%	4%	0%	28%	6%	1%	15%	2%	49%	5%	7%	21%	1%	71%	7%	3%	15%	5%	20%	0%	31%
16	Ind. Cylinders Int. (50%)		5%	4%	7%	3%	0%	9%	0%	20%	9%	7%	3%	0%	0%	3%	0%	0%	7%	3%	0%	3%	0%	0%	3%	3%	42%	0%
17	Ind. Cylinders Int. (50%)		21%	36%	19%	23%	27%	33%	13%	11%	9%	32%	23%	23%	81%	3%	13%	16%	19%	23%	10%	20%	1%	9%	36%	3%	20%	52%
18	Solar Thermal (150%)		0%	1%	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
19	**Dedicated,** of which		**50%**	**50%**	**53%**	**73%**	**42%**	**41%**	**62%**	**61%**	**53%**	**53%**	**73%**	**60%**	**17%**	**45%**	**71%**	**63%**	**53%**	**73%**	**17%**	**61%**	**96%**	**68%**	**54%**	**73%**	**25%**	**17%**
20	Solar Thermal (150%)		1%	5%	0%	11%	0%	2%	0%	0%	0%	2%	11%	0%	0%	0%	0%	0%	0%	11%	1%	0%	0%	0%	0%	1%	1%	0%
21	Electr. Instant.>12 kW (97%)		7%	2%	0%	1%	2%	0%	2%	1%	0%	29%	1%	0%	4%	0%	2%	4%	0%	1%	0%	7%	0%	5%	0%	0%	0%	8%
22	El. Store >30 ltr. (65%)		29%	42%	33%	61%	36%	38%	59%	61%	46%	13%	61%	43%	9%	35%	69%	59%	33%	61%	11%	50%	14%	53%	53%	29%	24%	8%
23	Gas Instant. 13+ l/m (45%)		11%	0%	17%	0%	0%	0%	0%	0%	6%	5%	0%	6%	0%	7%	0%	0%	17%	0%	3%	0%	81%	1%	0%	42%	0%	0%
24	Gas Storage (45%)		2%	0%	2%	0%	5%	0%	0%	0%	2%	3%	0%	11%	4%	2%	0%	0%	2%	0%	2%	4%	0%	9%	0%	0%	0%	1%
25	*Primary WH avg eff.**		*60%*	*66%*	*56%*	*71%*	*61%*	*67%*	*71%*	*63%*	*58%*	*69%*	*71%*	*58%*	*53%*	*57%*	*67%*	*68%*	*56%*	*71%*	*57%*	*65%*	*48%*	*65%*	*59%*	*54%*	*61%*	*57%*
	SECONDARY WATER HEATERS (efficiency)																											
26	**El. Storage,** of which		**57%**	**85%**	**75%**	**88%**	**55%**	**94%**	**44%**	**70%**	**63%**	**88%**	**88%**	**59%**	**9%**	**99%**	**65%**	**35%**	**75%**	**88%**	**73%**	**19%**	**28%**	**46%**	**98%**	**33%**	**90%**	**8%**
27	<30 Litres Press. (65%),		24%	17%	60%	9%	35%	89%	41%	70%	22%	2%	9%	14%	6%	99%	44%	19%	60%	9%	68%	19%	28%	38%	43%	33%	90%	4%
28	<30 Litres Unpress(65%)		33%	68%	15%	79%	20%	4%	3%	0%	41%	87%	79%	45%	3%	0%	19%	16%	15%	79%	5%	0%	0%	8%	55%	0%	0%	3%
29	**El. Instant<12 kW** (97%)		**24%**	**1%**	**1%**	**7%**	**26%**	**4%**	**22%**	**29%**	**0%**	**5%**	**7%**	**0%**	**90%**	**0%**	**16%**	**36%**	**1%**	**7%**	**1%**	**30%**	**6%**	**36%**	**0%**	**0%**	**10%**	**84%**
30	**Gas Instant.** of which		**18%**	**14%**	**24%**	**5%**	**20%**	**3%**	**35%**	**0%**	**37%**	**6%**	**5%**	**40%**	**1%**	**1%**	**19%**	**28%**	**24%**	**5%**	**26%**	**50%**	**65%**	**18%**	**2%**	**67%**	**0%**	**8%**
31	5 -<10 Litres/min (45%)		9%	0%	9%	1%	0%	0%	19%	0%	37%	0%	1%	20%	0%	1%	0%	0%	9%	1%	13%	0%	65%	14%	1%	67%	0%	0%
32	10 -<13 Litres/min (45%) *		9%	14%	15%	4%	20%	3%	15%	0%	0%	6%	4%	21%	1%	0%	19%	28%	15%	4%	13%	50%	0%	4%	1%	0%	0%	8%
33	*Secondary WH avg eff.**		*69%*	*63%*	*61%*	*66%*	*69%*	*66%*	*65%*	*73%*	*58%*	*65%*	*66%*	*57%*	*94%*	*65%*	*66%*	*70%*	*61%*	*66%*	*60%*	*65%*	*54%*	*73%*	*65%*	*52%*	*68%*	*90%*
	Result: Energy consumption water heaters in kWh/household.year																											
34	**Energy cons. WH**	**kWh/hha**	2048	2719	2706	2240	1240	3115	717	3670	2180	1632	2090	2392	2550	2374	788	808	4698	2240	2641	1365	3067	1266	1971	2624	3281	2112
35	of which electric WH	**kWh/hha**	725	1327	944	1526	474	1278	473	2192	911	717	1424	941	638	847	571	521	1639	1526	398	729	322	724	1125	649	750	420

4 NON-RESIDENTIAL BUILDINGS

4.1 Tertiary sector

The situation for residential buildings is still relatively transparent compared to commercial and institutional buildings and buildings that have a mixed use, e.g. residential buildings with bars, restaurants and shops at the ground floor level or doctors and lawyers with a practice at home. On these items even anecdotal information is scarce.

Another problem is the definition of the sectors. There have been several attempts to capture the floor area in m² of the 'services sector' or 'the other sector' which all have failed for that reason. Examples are the Odyssee indicators[25] project and the Ecoheatcool project[26], which are each comparing 'apples and pears' with errors of up to a factor 2 [27]. But also the PRIMES model, which was following the Eurostat totals for the residential sector, now seems to be using a completely different definition for the tertiary sector [28]. This makes it very difficult to make an assessment, not only of general building characteristics but also of the average (hot water and space) heat load that can be expected. In Table 4-1 a very first attempt by VHK is given to calculate an average heat load from the available EU-wide data. But –although we are fairly confident on the EU average—the accuracy at Member State level is certainly not very good.

To firm up the assessment of the heat load we have consulted several sources at national level.

For an overview of the many inconsistencies between Member States the 2002 European Communities publication of the efforts of some national statistics offices gives a good overview.[29] This is still a relatively good source, which we have summarized in Table 4-2.a and 4.2.b.

Other than that, the best sources are national surveys by energy agencies, utilities, national statistics offices, etc. that at least are defining in detail which sectors are covered. These surveys exist in

- the UK (Dept. of Trade and Energy 2005) , statistics based on BRE input
- Ireland, 2005 survey by the Sustainable Energy Ireland (SEI). [30]
- Norway, 2005 survey of Statistics Norway[31]
- In the Netherlands, 1999 publication by Energie Centrum Nederland (ECN)[32]. Also the efforts of EIM (Economische Instituut voor het Midden- en Kleinbedrijf) need to be mentioned.

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[25] www.odyssee-indicators.org

[26] www.ecohetacool.org (published Oct. 2006)

[27] For instance, the Ecoheatcool project-- of comparing the energy consumption of a German floor area for industrial, agricultural and service sector buildings, including unheated warehouses with Dutch data for the service sectors, without unheated warehouses? Why doesn't a bell start ringing with the Odyssee authors that something might be wrong when the most energy efficient builders in the residential sector (the Netherlands and Sweden) turn out to be greatest energy users per capita and per square meter?

[28] PRIMES 2003: 168 Mtoe; Eurostat 2005 pocketbook energy and transport: 129 Mtoe for the service sector. Perhaps the difference is public lighting?

[29] Energy consumption in the services sector, Surveys of EUMember States Data 1995-1999, European Communities, Luxembourg 2002.

[30] Sustainable Energy Ireland (SEI), Profiling Energy and CO2 Emissions in the Services Sector, April 2005.

[31] Statistics Norway, Dept. of Energy Statistics, *Energy consumption in the services sector 2000,*

- In Sweden and Denmark the national statistics offices are giving already good insights in their regular statistics. [33] The same goes for Germany for the building side[34], but the energy side needs considerable work, especially because statistics are prepared at the level of Länder and not at federal level.
- Also Switzerland has excellent statistics on non-residential buildings, but at the level of Cantons. An example is the Canton of Zürich, which is the only source we found that actually reports on commercial activities in residential buildings (bars, shops, etc. at the bottom of apartment buildings or part of a mainly residential house).
- In the US, the Energy Information administration (EIA) is gathering periodically detailed information on the energy consumption in the commercial building sector [35].
- Natural Resources Canada has published a very recent survey on commercial buildings[36],

It would be certainly outside the scope of our contract to discuss all these individual sources (and more), but it is enough to say that we have studied them extensively to get a better grip on the sector and to confirm at least our heat load estimate.

A final check is of course the ECCP project, where the stakeholders gave their input in estimating the CO2 balance of the tertiary sector. This is given in Table. 4.3.

[32] ECN, Energieverbruik van gebouwgebonden energiefuncties in woningen en utiliteitsgebouwen, Petten, 1999.

[33] Www.sbc.se

[34] Statistisches Budesamt, *Bautätigkeit 2004*, Fachserie 5/ Reihe 1, Sept. 2005

[35] EIA, *1999 Commercial Buildings Energy Consumption Survey.* www.eia.doe.gov

[36] Natural Resources Canada, Commercial and Institutional Consumption of Energy Survey (CICES), December 2005.

Table 4-1. EU Tertiairy Sector Heat Load Assessment (VHK 2006)

Parameter	*unit*	EU-25	AT	BE	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	SK	SI	ES	SE	UK
Base data 2003 (Ecoheatcool vs. VHK)																											
Ecoheatcool est. floor area	*mln m²*	*6310*	*119*	*151*	*7*	*100*	*114*	*14*	*101*	*861*	*1852*	*149*	*101*	*58*	*453*	*23*	*14*	*7*	*4*	*183*	*382*	*126*	*81*	*16*	*341*	*161*	*892*
VHK est.heat. floor area	***mln m²***	**4655**	**80**	**114**	**7**	**100**	**70**	**7**	**70**	**800**	**1000**	**121**	**80**	**44**	**450**	**12**	**10**	**5**	**4**	**270**	**200**	**80**	**35**	**16**	**340**	**90**	**650**
Tertiary Energy Consumption in ktoe (1 toe=41,86 GJ= 11627 kWh) PRIMES																											
PRIMES 2003 (calc.)	ktoe	167810	3228	4344	156	4179	2900	419	3542	26883	33506	2835	3847	2000	15493	674	623	140	55	12078	10553	2475	1371	681	10030	5570	20228
Eurostat 2003	**ktoe**	**129156**	**2802**	**3837**	**140**	**3483**	**1959**	**344**	**1717**	**24923**	**23994**	**1663**	**3055**	**1708**	**13483**	**569**	**527**	**95**	**55**	**7587**	**6237**	**1979**	**1146**	**236**	**6962**	**4713**	**15942**
Tertiary sector kWh/floor area (VHK/Eurostat)																											
kWh per m² tertiary	kWh/m²	323	407	392	233	405	325	571	285	362	279	160	444	455	348	551	613	224	146	327	363	288	381	171	238	609	285
compare:																											
kWh per m² residential '03	kWh/m²	*180*	*259*	*264*	*82*	*193*	*171*	*288*	*292*	*171*	*212*	*129*	*220*	*187*	*137*	*252*	*201*	*320*	*72*	*177*	*250*	*79*	*171*	*230*	*79*	*215*	*225*
Tertairy heating share of total kWh/floor area (excl. cooling)																											
kWh per m² tertiary	kWh/m²	197	248	239	70	247	198	349	350	221	170	97	271	278	213	336	374	137	60	186	221	175	232	105	145	371	174
compare:																											
kWh per m² residential	kWh/m²	*145*	*195*	*237*	*44*	*166*	*124*	*276*	*231*	*139*	*174*	*123*	*159*	*167*	*99*	*242*	*160*	*225*	*22*	*112*	*171*	*41*	*155*	*208*	*60*	*152*	*164*
Tertairy heating load kWh/floor area (excl. Cooling)																											
kWh per m² tertiary	kWh/m²	117	144	142	51	155	127	235	240	128	98	55	154	168	117	207	239	75	42	102	134	109	139	62	91	289	100
compare:																											
kWh per m² residential	kWh/m²	*86*	*113*	*141*	*32*	*104*	*79*	*186*	*158*	*80*	*100*	*69*	*90*	*101*	*54*	*149*	*102*	*123*	*16*	*61*	*104*	*25*	*93*	*124*	*37*	*118*	*94*

Table 4-2a. EU Services sector: Energy consumption for space heating and hot water 1995-1999 (source: VHK compilation of Eurostat 2002) in TJ (Terajoules)

Parameter	*unit*	EU-25	AT	BE	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	SK	SI	ES	SE	UK*
1. Hotels and Restaurants (NACE 55)																											
Consumption per m² (MJ/m²)			-	-	-	-	320	-	791	785	821	na	-	-	-	-	-	-	-		-	-	-	-	624	518	
Heating Oil	TJ		3557	2213	-	-	319	-	973	15324	28002	2512	-	-	16440	-	-	-	-		-	1239	-	-	1356	12	32200
Natural gas	TJ		885	6708	-	-	452	-	66	19620	24679	0	-	-	60041	-	-	-	-		-	-	-	-	639	63	79300
LPG and Manuf. gas	TJ		337	113	-	-	109	-	na	na	1965	494	-	-	16014	-	-	-	-		-	4007	-	-	168	na	-
Solid fuels	TJ		na	-	-	-	-	-	na	na	2200	6099	-	-	na	-	-	-	-		-	-	-	-	2	na	600
Electricity	TJ		2072	144	-	-	233	-	486	8114	8319	0	-	-	2758	-	-	-	-		-	442	-	-	468	540	3200
District heating	TJ		476	-	-	-	1054	-	1896	-	-	-	-	-	14524	-	-	-	-		-	-	-	-	-	1508	-
Other	TJ		1179	-	-	-	-	-	87	5101	9652	109	-	-	463	-	-	-	-		-	-	-	-	0	197	-
TOTAL	TJ		8506	9178	-	-	2167	-	3508	48159	74817	9214	-	-	110240	-	-	-	-		-	5688	-	-	2633	3508	-
2. Health & social work (NACE 85)																											
Consumption per m² (MJ/m²)			-	na	-	-	648	-	980	691	731	na	-	-		-	-	-	-		-		-	-	343	579	-
Heating Oil	TJ		958	4591	-	-	254	-	2326	31277	48772	3804	-	-	8514	-	-	-	-		-	1009	-	-	680	1963	2500
Natural gas	TJ		2064	6092	-	-	1539	-	0	33005	46418	-	-	-	32346	-	-	-	-		-		-	-	549	502	73900
LPG and Manuf. gas	TJ		4		-	-	11	-	na	na	-	100	-	-	212	-	-	-	-		-	121	-	-	60	na	-
Solid fuels	TJ		na	38	-	-	-	-	-	-	3840	1382	-	-	na	-	-	-	-		-		-	-	5	na	100
Electricity	TJ		1219	160	-	-	92	-	317	8132	4809	0	-	-	1138	-	-	-	-		-	295	-	-	127	306	2600
District heating	TJ		6072		-	-	4308	-	5465		-	-	-	-	23068	-	-	-	-		-		-	-	-	1137	-
Other	TJ		255	116	-	-	-	-	143	8927	16819	-	-	-	72	-	-	-	-		-		-	-	9	665	-
TOTAL	TJ		10572	10997	-	-	6204	-	8251	81341	120658	5286	-	-	65350	-	-	-	-		-	1425	-	-	1430	14806	-
3. Education (NACE 80)																											
Consumption per m² (MJ/m²)			-	-	-	-	410	-	678	490	655	na	-	-		-	-	-	-		-		-	-	251	523	-
Heating Oil	TJ		3919	7855	-	-	348	-	3045	27090	36716	na	-	-	3462	-	-	-	-		-	96	-	-	616	3785	40900
Natural gas	TJ		5560	7611	-	-	1606	-	56	33299	34956	na	-	-	10861	-	-	-	-		-		-	-	409	264	44000
LPG and Manuf. gas	TJ		43	33	-	-	25	-	na	na	-	na	-	-	5	-	-	-	-		-	293	-	-	22	na	-
Solid fuels	TJ		na	36	-	-	-	-	na	na	2897	na	-	-	na	-	-	-	-		-		-	-	1	na	13900
Electricity	TJ		575	93	-	-	131	-	198	5216	821	na	-	-	155	-	-	-	-		-	229	-	-	38	814	5900
District heating	TJ		3984	-	-	-	5647	-	5116	-	-	-	-	-	10	-	-	-	-		-		-	-		8362	-
Other	TJ		288	94	-	-	-	-	407	10466	12665	na	-	-	0	-	-	-	-		-		-	-	1	565	-
TOTAL	TJ		14369	15722	-	-	7757	-	8822	76071	88055	na	-	-	14493	-	-	-	-		-	618	-	-	1087	1379	-
4. Other community, social and personal service activities (NACE 90-93)																											
Consumption per m² (MJ/m²)					-	-	395	-	851	979	842	na	-	-		-	-	-	-		-		-	-	264	502	-
Heating Oil	TJ		3604	7451	-	-	269	-	719	10174	17512	376	-	-	3906	-	-	-	-		-	281	-	-	137	1615	31800
Natural gas	TJ		4163	14048	-	-	1097	-	3	19840	16654	66	-	-	29214	-	-	-	-		-		-	-	323	112	57600
LPG and Manuf. gas	TJ		133	53	-	-	15	-	na	na	-	-	-	-	219	-	-	-	-		-	1415	-	-	18	na	-
Solid fuels	TJ		na	6	-	-	-	-	na	na	1392	800	-	-	na	-	-	-	-		-		-	-	0	na	20500
Electricity	TJ		1156	158	-	-	148	-	281	8042	6059	0	-	-	1732	-	-	-	-		-	716	-	-	140	749	-
District heating	TJ		4326	-	-	-	3456	-	2093	-	-	-	-	-	7537	-	-	-	-		-		-	-		2451	-
Other	TJ		2998	112	-	-	-	-	489	2222	6034	4	-	-	8096	-	-	-	-		-		-	-	0	142	-
TOTAL	TJ		16380	21828	-	-	4985	-	3585	40278	47651	1246	-	-	50704	-	-	-	-		-	2412	-	-	618	5069	-

Table 4-2b. c'td EU Services sector: Energy consumption for space heating and hot water 1995-1999 (source: VHK compilation of Eurostat 2002)

Parameter	*unit*	EU-25	AT	BE	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IE	IT	LV	LT	LU	MT	NL	PL	PT	SK	SI	ES	SE	UK*
5.- Offices and Administration (NACE 60-67, 70-75, 99)																											
Consumption per m² (MJ/m²)					-	-	na	-	613	698	911	na	-	-		-	-	-	-	370	-		-	-	193	486	
Heating Oil			2953	16047	-	-	1099	-	4102	35799	83289	1598	-	-	11561	-	-	-	-	296	-	1227	-	-	1373	4555	9500
Natural gas			3268	16105	-	-	1741	-	20	48664	76700	0	-	-	71509	-	-	-	-	12375	-		-	-	1092	1439	91800
LPG and Manuf. gas			771	8	-	-	38	-	na	na	2568	46	-	-	123	-	-	-	-		-	1386	-	-	143	na	-
Solid fuels			na	24	-	-	-	-	na	na	6567	3673	-	-	na	-	-	-	-		-		-	-	27	na	3900
Electricity			2861	643	-	-	304	-	1742	23594	12042	0	-	-	2088	-	-	-	-	10409	-	1234	-	-	2391	1735	15400
District heating			5062	-	-	-	6798	-	11305	-	-	-	-	-	14041	-	-	-	-	990	-		-	-		14765	-
Other			379	60	-	-	-	-	208	15475	28721	6	-	-	376	-	-	-	-	80	-		-	-	5	312	-
TOTAL			15294	32887	-	-	9980	-	17377	123532	209887	5323	-	-	99698	-	-	-	-	24150	-	3847	-	-	5031	22806	-
6. Commerce (NACE 50-52).																											
Consumption per m² (MJ/m²)					-	-	306	-	657	446	666	na	-	-		-	-	-	-		-		-	-	226	494	-
Heating Oil			2541	6123	-	-	3140	-	4229	26127	72079	3097	-	-	1586	-	-	-	-		-	0	-	-	148	1139	10500
Natural gas			1415	6511	-	-	1137	-	499	28935	68004	0	-	-	31308	-	-	-	-		-	-	-	-	249	156	47000
LPG and Manuf. gas			212	101	-	-	95	-	na	na	605	421	-	-	51	-	-	-	-		-	163	-	-	4	na	
Solid fuels			na	-	-	-	-	-	na	na	5692	10010	-	-	na	-	-	-	-		-		-	-	0	na	17200
Electricity			732	802	-	-	499	-	774	18464	14522	1	-	-	2653	-	-	-	-		-	1214	-	-	1419	1105	-
District heating			625	-	-	-	7018	-	783	-	-	-	-	-	242	-	-	-	-		-		-	-		3724	-
Other			869	51	-	-	-	-	27	4760	24858	50	-	-	0	-	-	-	-		-		-	-	0	132	-
TOTAL			6394	13588	-	-	11889	-	13359	78286	185760	13579	-	-	35840	-	-	-	-		-	1377	-	-	1820	6256	-
Space heating & SHW TOTALS BY FUEL																											
Consumption per m² (MJ/m²)			80		-	-		-	697	616	839	na	-	-		-	-	-	-		-		-	-	255	516	-
Heating Oil			17531	4428	-	-	5429	-	15394	145791	286370	11388	-	-	45469	-	-	-	-		-	3852	-	-	4310	14258	118400
Natural gas			17356	57075	-	-	7572	-	644	183363	267411	0	-	-	235278	-	-	-	-		-		-	-	3261	2536	359500
LPG and Manuf. gas			1500	308	-	-	293	-	na	na	5138	1127	-	-	16624	-	-	-	-		-	7386	-	-	415	na	-
Solid fuels			na	104	-	-	-	-	na	na	22588	21964	-	-	na	-	-	-	-		-		-	-	35	na	18500
Electricity			8614	2	-	-	1407	-	3798	71562	46572	1	-	-	10524	-	-	-	-		-	4130	-	-	4583	5249	64800
District heating			20545		-	-	28281	-	33706	-	-	-	-	-	59423	-	-	-	-		-		-	-		4218	-
Other			5968	433	-	-	-	-	1361	46951	98749	170	-	-	9007	-	-	-	-		-		-	-	15	2013	-
TOTAL			71515	1042	-	-	42982	-	54902	447667	726828	34648	-	-	376325	-	-	-	-		-	15367	-	-	12619	66235	561200
Service Sector TOTALS BY FUEL																											
Heating Oil				44280	-	-	19288	-	15394	158656	536000	na	-	-	45469	-	-	-	-		-		-	-	5352	-	-
Natural gas				57075	-	-	9888	-	644	211457	420000	na	-	-	235278	-	-	-	-		-		-	-	5515	-	-
LPG and Manuf. gas				308	-	-	293	-	na	na	26000	na	-	-	16624	-	-	-	-		-		-	-	1424	-	-
Solid fuels				104	-	-	-	-	na	na	436000	na	-	-	0	-	-	-	-		-		-	-	135	-	-
Electricity				47844	-	-	34934	-	44176	262562	115	na	-	-	204576	-	-	-	-		-		-	-	44060	-	-
District heating					-	-	28380	-	33706	-	-	-	-	-	59423	-	-	-	-		-		-	-		-	-
Other /DH				433	-	-	-	-	1361	54587	3000	na	-	-	14680	-	-	-	-		-		-	-	25	-	-
TOTAL			144278	150044	-	-	92783	-	95281	687262	1536000	na	-	-	576050	-	-	-	-		-		-	-	56511	-	-
YEAR			1998	1996	-	-	1997	-	1998	1996	1997	1998	-	-	1999	-	-	-	-		-		-	-	1998	1997	1995
floor area referred to	mln. M²						116			726	866	24-29								65		81			49		

*= UK No breakdown by branch is available for space heating and hot water but for all uses. The figures shown by branch correspond to all uses and their addition is not equal to the figures shown under TOTAL

source: *Energy consumption in the services sector, Survey of EU Member States*, European Communities 2002.

Table 4-3. ECCP Tertiary Sector Baselines 1990-2010

TERTIARY SECTOR	Fuel-Related CO2 emissions (in MtCO2)	
Sector/function group	*Reference 1990*	*Baseline 2010*
Total	457	523
of which		
Spaceheating/cooling, *of which*	305	308
Fossil,*of which*	227	214
Transmission losses	*116*	*113*
-windows	*46*	*43*
-walls	*34*	*34*
-floors	*18*	*18*
-roofs	*18*	*18*
Ventilation losses	*43*	*45*
Heating system losses	*68*	*56*
Electric, *of which*	78	94
Heating (incl. heatpump)	*33*	*31*
Cooling (airconditioners)	*32*	*48*
CH pump	*13*	*15*
District heating	*?*	*?*
Hot water, *of which*	35	39
Fossil	24	30
Electric	11	9
Whitegoods & Cooking, *of which*	26	37
Fossil (mainly hobs)		
Electric, *of which*	26	37
Refrigeration/freezers	*14*	*20*
Washing machines		
Dishwashers		
Laundry driers		
Electric ovens	*12*	*17*
Lighting (incl. Street lighting)	*65*	*89*
Electronics, *of which*	14	34
Consumer el. (TV, audio, IRD,etc.)		
Stand-by		
On'		
IT/ office equipment	14	34
Industrial Motors, *of which*		
Variable speed drives (VSDs)		
Pumps		
Compressors		
Fans		
System opt.		
Other(conveyors & misc.)	12	16
Ind. process heat		
Autogeneration	neg	neg
Total (check)	457	523
of which (by energy source)		
Fossil	251	244
Electricity	206	279
Heat	?	?

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.

Note: Conversion Electricity 1990: 1 TWh el. = 0.5 MtCO2; 2010 1 TWh el.= 0.45 MtCO2

4.2 Industrial Buildings

No attempts to make an EU-wide analysis of the heating requirements (space heating and hot water) were found. Also PRIMES and Eurostat figures on the industry are at such an aggregated level that it is impossible to make a split-up that would lead to the identification of heating requirements. This means that we have to rely on the stakeholder approach in the ECCP and national statistics and surveys.

The relevant extract of the ECCP is given in Table 4-4. It identifies 76 Mt CO2 for space heating and cooling in 1990 and projects 72 Mt CO2 in 2010, but the share of district heating is not known. Without the cooling and the CH pump these figures are 65 Mt CO2 (1990) and 57 Mt CO2 (2010). Compared to the teriary sector in Table 4-3 this means that the industrial space heating requirement in the industrial sector is around 23% of that in the tertiary sector. The water heating requirement is not indicated since in this sector it is extremely difficult to distinguish hot water production for industrial processes (clearly outside the scope of the study) form other hot water uses.

Table 4-4. Industrial Sector Baselines 1990- 2010 (ECCP 2003)

INDUSTRIAL SECTOR	Fuel-Related CO2 emissions (in MtCO2)	
Sector/function group	*Reference 1990*	*Baseline 2010*
Total	1031	959
of which		
Spaceheating/cooling, *of which*	76	72
Fossil, *of which*	57	53
Transmission losses	*29*	*28*
-windows	*11*	*10*
-walls	*8*	*8*
-floors	*5*	*5*
-roofs	*5*	*5*
Ventilation losses	*11*	*11*
Heating system losses	*17*	*14*
Electric, *of which*	19	19
Heating (incl. heatpump)	*8*	*7*
Cooling (airconditioners)	*8*	*12*
CH pump	*3*	*3*
District heating	*na*	*na*

Source: Composed by VHK 2002 on basis of European Climate Change Programme(ECCP) working group reports & docs JSWG and WG3 ('provisional analysis'), European Commission, 2001.

** = rough estimates based on PRIMES figures for 2010 following The Shared Analysis project "Economic Foundations for Energy Policy", European Commission, Dec. 1999. PRIMES "full flexibility scenario incl. ACEA agreement" with a price of 20 EUR/t CO2 abated. Accuracy plus or minus 10-15%*

Note: Conversion Electricity 1990: 1 TWh el. = 0.5 MtCO2; 2010 1 TWh el.= 0.45 MtCO2

4.3 Main findings on non-residential heat load

The previous paragraphs shed some light on the very difficult subject of non-residential energy consumption for hot water.

From the tables presented in these paragraphs a *sector total* of number of buildings could be constructed. For industrial buildings the totals were constructed from the few countries that provided enough insight in the national buildings make-up and then extrapolated over the EU25.

These totals were subsequently combined with data from BRGC on the average number of tapping points in the buildings per sector, giving a estimated total of 70 million (33% of residential tapping points).

Figure 4-1. Number of buildings in tertiary sector

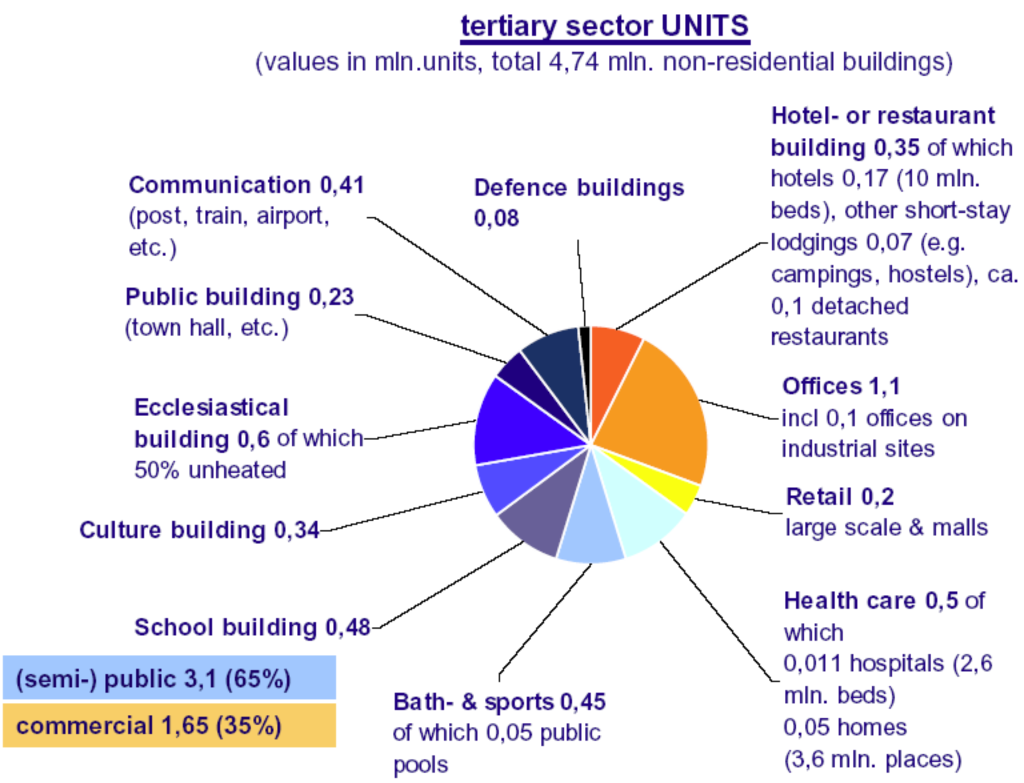


Figure 4-2. Number of buildings in Industrial sector

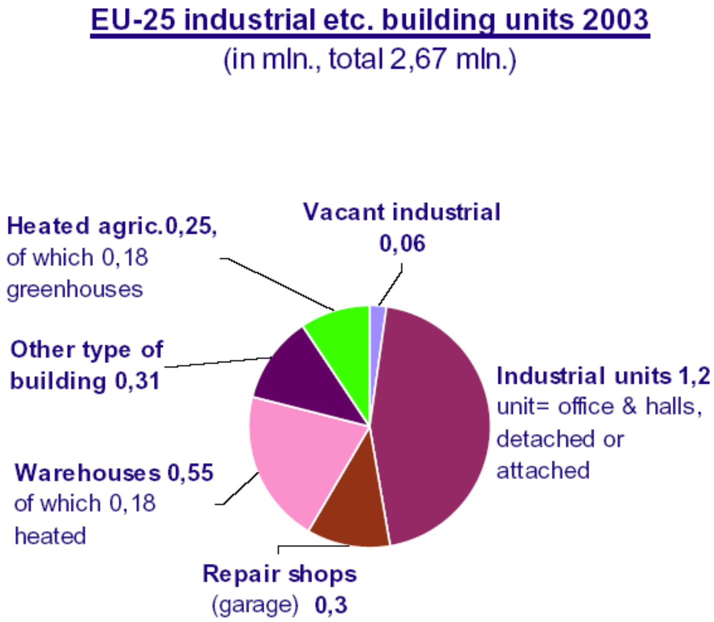
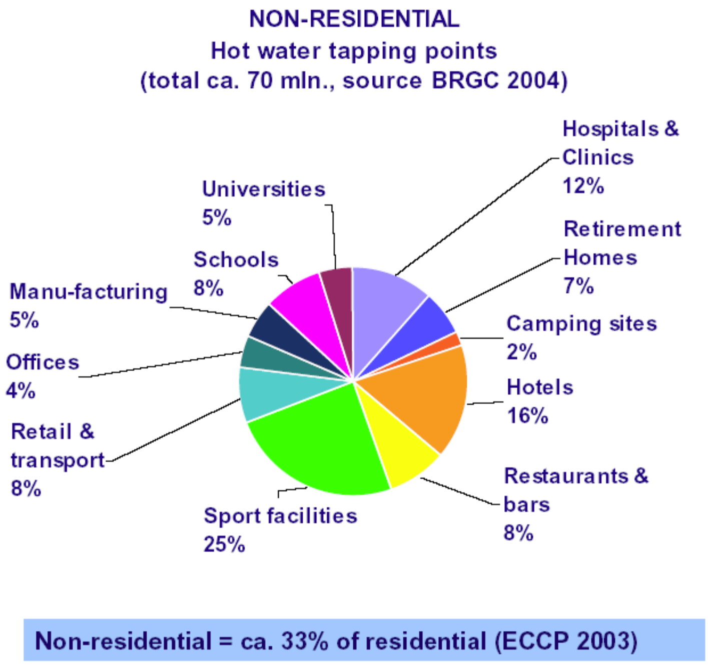


Figure 4-3. Number of non-residential tapping points



5 ENERGY SUPPLY INFRASTRUCTURE

This Chapter describes the fuel infrastructure (including electricity) for fossil fuel fired water heaters in Europe. It describes what fuels are used by water heaters today, what the costs are and the potential for fuel switching.

The share of fuels used by households is based on the share of space heating boilers since space heating (still) is the single largest energy consumer in dwellings. Furthermore, over 80% of boilers are also used for water heating (see Task 2).

5.1 Fuel use by boiler stock

Based upon data by BRG Consult the breakdown of the individual boiler stock by fuel type (including electric boilers) looks like this: Some 72% of individual boiler stock is fuelled by gas, some 20% by oil, some 2% by electricity and 6% by solid fuels. These figures relate to individual central heating systems only.

Table 5-1. individual and collective boiler stock by fuel type (in '000 units)

	GAS	OIL	ELECTRIC	SOLID
	gas (ind + coll)	oil (jet, ind+coll.)	electric (wet boiler + hp)	solid
Austria	733	347	58	420
Belgium	1326	939	0	59
Cyprus	0	0	0	0
CzechRep.	1149	3	11	511
Denmark	308	370	13	51
Estonia	16	21	3	14
Finland	0	455	46	322
France	8923	4396	86	492
Germany	11045	6552	66	128
Greece	78	1670	0	100
Hungary	1273	4	0	173
Ireland	470	472	37	197
Italy	14200	910	89	79
Latvia	37	1	0	74
Lithuania	82	8	0	145
LUX	0	0	0	0
Malta	0	0	0	0
Netherlands	5044	1	9	50
Poland	1208	155	0	1761
Portugal	190	46	0	22
Slovakia	406	0	0	241
Slovenia	62	221	0	166
Spain	4179	1624	0	345
Sweden	17	393	1 038	467
UK	19714	1114	587	385
TOTAL EU22	70461	19 699	2 043	6202
	72%	20%	2%	6%

When assessed on the basis of number of dwellings the collective boilers have to be included in the assessment. This is done by taking the total number of collective dwellings (based upon BRG Consult data) and making a split up between gas and oil boilers according the sales figures of collective gas and oil boilers (based upon calculation in paragraph 3.3.2 of Task 2, Table 3-9).

The result is that the importance of oil heating increases (oil boilers are more often used on collective basis): Some 62% of dwellings with central heating are heated by gas, some 32% by oil, 2% by electricity and 5% by solid fuels.

Table 5-2. Dwellings in EU-25 by type of fuel.

	'000 dwellings heated by: (individual wet systems and collective systems only)					% of total dwelling heated by: (individual wet systems and collective systems only)			
	gas	oil	electric	solid	total dwellings	gas	oil	electric	solid
Austria	958	1022	58	420	4020	24%	25%	1,4%	10%
Belgium	1400	1090		59	3724	38%	29%		2%
Cyprus									
CzechRep.	1364	63	11	511	3994	34%	2%	0,3%	13%
Denmark	342	445	13	51	2800	12%	16%	0,5%	2%
Estonia	33	70	3	14	622	5%	11%	0,5%	2%
Finland	20	512	46	322	2871	1%	18%	1,6%	11%
France	10418	7739	86	492	30218	34%	26%	0,3%	2%
Germany	14500*	15024*	66	128	38398	38%	39%	0,2%	0%
Greece	78	2630		100	5650	1%	47%		2%
Hungary	1421	4		173	4173	34%	0%		4%
Ireland	470	520	37	197	1370	34%	38%	2,7%	14%
Italy	15238	5340	89	79	27941	55%	19%	0,3%	0%
Latvia	80	125		74	965	8%	13%		8%
Lithuania	108	82		145	1304	8%	6%		11%
Luxembourg									
Malta									
Netherlands	5909	129	9	50	6810	87%	2%	0,1%	1%
Poland	1841	822		1761	12683	15%	6%		14%
Portugal	191	64		22	5271	4%	1%		0%
Slovakia	551	0		241	1899	29%	0%		13%
Slovenia	78	265		166	796	10%	33%		21%
Spain	4312	3108		345	22098	20%	14%		2%
Sweden	89	717	1038	467	5060	2%	14%	20,5%	9%
UK	19763	1189	587	385	25055	79%	5%	2,3%	2%
TOTAL EU22	79168	40956	2043	6202	207728	38%	20%	1,0%	3%
	62%	32%	2%	5%					

* note that boiler stock data are slightly different from data Statistisches Bundesamt: There 11,2 mln. oil, 16,75 mln. gas on a total of 35,1 mln. conventional occupied dwellings (excl. coll. Homes) for Germany 2002.

These figures do not take into account dwellings with local heating, nor dwellings with a gas connection for cooking or sanitary water only (oil for cooking is rare).

Since ecodesign options for central heating boilers are partly governed by the access to fuels, it is important to complete the assessment of the fuel infrastructure for EU households and expand beyond the figures quoted above. For this an assessment of the development of the natural gas grid, LPG supply and heating oil supply is added.

5.2 Natural gas grid

Current connections

The total number of gas boilers in individual and collective systems in stock is some 72 mln. units (70,3 individual wet system gas boilers plus some 1.7 mln. collective gas boilers) which translates to a same volume of individual gas customers. The total reported number of domestic gas grid customers (by Eurogas) is 97 mln. which in many countries is higher than the number of gas boilers serviced in that country.

Table 5-3. Stock of residential boilers in '000 units (BRGC) and '000 domestic gas customers (Eurogas)

	BRGConsult gas ind. wet 2004	BRGConsult coll.boiler gas 2004	BRGConsult total gas (ind + coll)	Eurogas domestic customers 2004	Difference(can be local gas heater and/or cooking appliance)
Austria	732	45	777	1273	496
Belgium	1316	17	1333	2565	1232
CzechRep.	1145	44	1189	2592,4	1404
Denmark	308	7	315	340	25
Estonia	16	3	19	63	44
Finland	0	4	4	34	30
France	8907	302	9209	10731	1522
Germany	11010	698	11708	17730	6022
Greece	78	0	78	30,8	-47
Hungary	1261	32	1293	3106	1813
Ireland	470	0	470	471,7	2
Italy	14194	209	14403	15050	647
Latvia	37	9	46	425	379
Lithuania	82	5	87	518	431
Netherlands	5038	174	5212	6351	1138
Poland	1198	129	1327	6963	5636
Portugal	189	0	189	744	555
Slovakia	401	30	431	1440	1009
Slovenia	62	3	65	105	40
Spain	4172	28	4200	5378	1178
Sweden	16	15	31	52	21
UK	19705	12	19717	21378	1661
TOTAL EU22	70339	1766	72105	97411	25306

The difference most likely concerns gas customers that use gas just for local heating and/or cooking. The BRGC figures do not provide details for the fuel of this park of "non central heating" costumers (e.g. "dry gas/electric" and "no central heating" = local, room-based heating or no heating at all).

The 2001 SAVE Heating Systems study does provide insight in the fuel source used for local heaters. It identified some 7.65 mln. households with local gas heaters in 1995, reduced to 3.2 mln. households in 2005 for the EU15. For the EU25 the number of local heaters is presumably higher than for the EU15. If a total of 3 to 7 million local gas heaters number is subtracted from the total remainder of gas customers this leaves some 17 to 22 mln. customers using gas for cooking, but heating their premises with a different fuel.

When assessed on basis of the total number of dwellings [37] in the EU22 some 38% of dwellings are using gas for their central heating. To this has to be added an unknown percentage of dwellings that are heated by local gas heaters and dwellings that use gas for cooking (see remark in previous paragraph).

[37] "All" meaning the total of dwellings as presented by BRGC, which includes second homes etc.

Figure 5-1.
European Natural gas Transmission systems in 2002[38]

Gas grid growth

According Eurogas the European natural gas network grows at a rate of some 2% per year (expressed as domestic costumers).

Table 5-4. Growth in number of customers connected to natural gas grid x 1000 and in %

	Gas boilers table above	Domestic customers ('000) at 1 Jan 2005	Growth 2003-2004	2002-2003	2001-2002	2000-2001
Austria	733	1273	2,3%	-2,8%	1,5%	0,0%
Belgium	1326	2565	2,5%	0,0%	1,7%	1,7%
Cyprus	0	n.a.				
Czech Rep.	1149	2592	1,1%	1,3%	1,7%	1,3%
Denmark	308	340	2,7%	1,1%	0,2%	3,6%
Estonia	16	63	-1,6%			
Finland	0	34	-0,9%	0,3%	2,4%	1,5%
France	8923	10731	0,5%	1,3%	1,6%	2,1%
Germany	11045	17730	0,8%	0,5%	2,0%	2,9%
Greece	78	31	94,9%	68,1%	46,9%	0,0%
Hungary	1273	3106	2,2%	2,3%	3,0%	2,2%
Ireland	470	472	5,1%	9,1%	8,2%	7,9%
Italy	14200	15050	0,0%	0,3%	1,4%	0,7%
Latvia	37	425	0,6%			
Lithuania	82	518	0,0%			
Luxembourg	0	70	0,0%	-3,7%	0,0%	0,0%
Malta	0	n.a.				
Netherlands	5044	6351	-2,4%	-4,3%	1,5%	0,9%
Poland	1208	6963	15,0%			
Portugal	190	744	8,9%	4,5%	26,0%	
Slovakia	406	1440	1,1%	1,5%	2,2%	
Slovenia	62	105	5,0%			
Spain	4179	5378	6,7%	4,1%	7,2%	9,6%
Sweden	17	52	0,0%	0,0%	0,0%	0,0%
UK	19714	21378	1,1%	0,9%	0,9%	0,5%
EU15		82199	1,1%	1,4%	2,0%	2,5%
EU25 (excl. Malta, Cyprus)	70461	97846	2,0%			

values in italic are based upon totals of domestic and non-domestic customers which have been split up using a share of 0.95 for domestic and 0.05 for non-domestic costumers.

On average the number of domestic gas costumers in the EU25 in 2004 has risen with 2% from 2003 [39]. Most countries experience a steady growth of number of domestic customers between 0 - 3% annually.

[38] http://www.gascentre.unece.org/minisitepub/rsng/index.htm

Countries experiencing relatively large growth figures in 2003-2004 are Greece (94.9%, coming from a very low absolute figure to start with), Poland (15%), Spain (6.7%) and Portugal (8.9%), Ireland (5.1%) and Slovenia (5%).

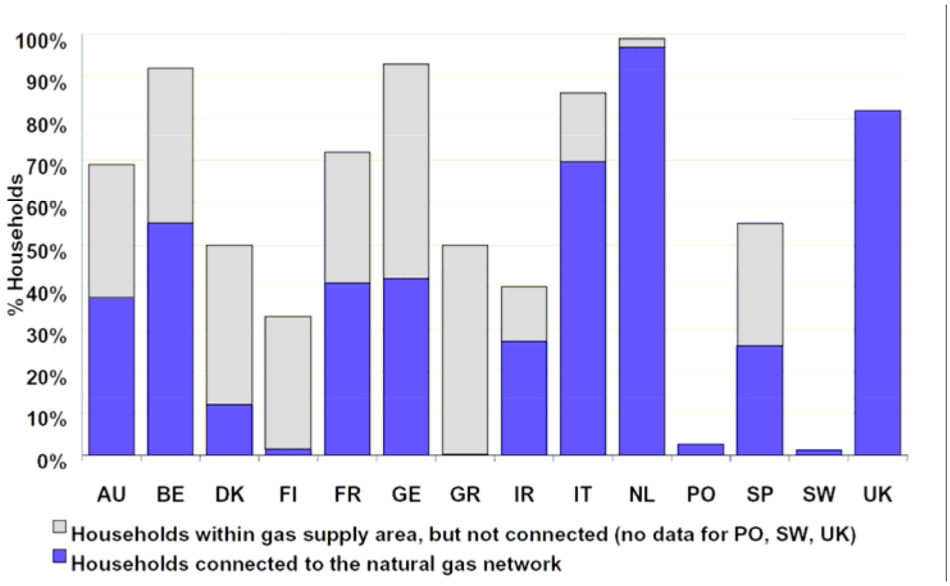
Negative growth figures for the Netherlands (-2.4%) are likely to be caused by either a decline in the non-domestic sector or through statistical errors (rounding of figures etc.). The negative growth figures for Estonia (-1.6%) and Finland (-0.9%) are probably caused by the very small absolute base, so that even tiny abbreviations occur as relatively large disruptions.

Fuel switching

Griffin (2000) [40] reports that attempts to project fuel-switching to natural gas will have to take into account infrastructural limitations and the economic feasibility of fuel switching for the individual consumer. This will depend directly on such factors as the cost of connection to the network (and the existence of schemes to deal with this), the cost of structural changes within the household, the cost of new appliances and the effects on running costs (dependent on climate as well), also in relation to the costs of other fuels.

Some data was found on the total number of households living in gas supply areas. Figure 5.2 below presents the picture based upon numbers dating from the years 1997-2000.

Figure 5-2.
Households within gas supply area and connected to gas supply [41]



The figure does not take into account the obstacles for households to get connected, for instance Denmark shows a high percentage of households living within the gas supply network but (as other data shows) most of these households are connected to District Heating networks. Nor does the figure take into account the development of gas grids, as is happening in Portugal and Greece. The figure thus only presents a theoretical potential for fuel switch towards gas.

Anecdotal evidence suggests that in the new accession countries: In Slovakia the share of households connected is 85%, but only 25% use gas for heating.

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[39] Figures are taken from the 2000 to 2005 Annual Reports by Eurogas (www.eurogas.org).

[40] Griffin, Harriet, Appendix R: Development of the European Gas Network, supporting document for Lower Carbon Futures, Environmental Change Institute, University of Oxford, UK, 2000.

[41] Griffin, Harriet, Appendix R: Development of the European Gas Network, supporting document for Lower Carbon Futures, Environmental Change Institute, University of Oxford, UK, 2000.

Costs of realisation of a gas network connection

The costs for connecting a household to a gas network depend on several factors, the most important of course the distance from dwelling to mains gas supply. Other factors may concern the number of connections to be made (one-off or 'x'% of multiple dwellings), the capacity of the connection, local circumstances (like does the connection needs to cross a road or not) and the tariffs used.

Anecdotal evidence from the UK [42] suggest connection costs to be in the area of 700 GBP (1050 euro) to maximum 1400 GBP (2000 euro) per household (penetration 40% or less). A case study shows that the costs can however be reduced by intensive cooperation of parties involved to 85 GBP (125 euro) per household (depending on circumstances of course). In Belgium urban areas a tariff of € 200,- is fairly standard (www.iveg.be), but the actual costs area close to € 700,-. In the Netherlands a new connection is not subsidized by the utility and the tariff reflects the costs: ca. € 700,-/dwelling (www.essent.nl) . In Germany, tariffs between € 1000,- and € 3000 are reported (www.energieverbraucher.de), whereby the lower tariff is applicable to urban areas. On top of that various German gas utilities give subsidies of on average € 500,- for those switching towards gas. In Italy a gas grid connection tariffs are found of € 100,- (Italimpianti) to € 300,- (Energas). The Danish DTI reports a cost of around € 1000,- per connection. Finally, it can be mentioned that several gas utilities in several countries offer the possibility to discount the connection costs in the energy rate.Prices are perceived to be end-consumer prices (not confirmed).

5.2.1 LPG as heating fuel

Besides using natural gas from the gas network liquefied petroleum gas (LPG) can also be used as (cooking and) heating fuel. In fact in Portugal LPG is the most used form of gas (mainly for water heating: 64% of households, data relate to 1998-1999) [43].

This section discusses trends in application of bulk LPG (in stationary containers) and does not concern the use of LPG through (portable) cylinders or cartridges.

In essence the use of LPG is quite similar to that of fuel oil: One needs a storage tank which is periodically filled. A large difference is that LPG tanks are usually sited outside the dwelling , above ground (although underground is also possible) whereas storage for oil is usually inside the dwelling.

The number of LPG consumers in Europe is difficult to assess, data is scattered and fuel end-use (cooking, space-heating and or water-heating) tends to get mixed.

All in all BRGC estimates the number of central heating boilers using LPG as fuel is around 4% of sales, with main areas of demand (90%) found in non-basified areas in Italy, Spain, France, UK and Portugal (p. 63 of BRGC Draft Final report).

Costs of realisation of a LPG storage tank

The installation itself normally costs between EUR 200 - 450 (GBP 150-300), after which an annual rental fee of between EUR 90-150 (GBP 60-100) [44] is paid. This fee covers for the installation, 24/7 emergency cover, testing and maintenance (including parts). Running costs vary depending on usage and appliances.

Using the example of a three bedroom property, the following costs are based on an 'A' rated boiler at retail price with flue arrangements (LPG conversion kit & Worcester Greenstar II 28 HE system boiler, Oil Grant Vortex 26kw Kitchen system oil boiler & balanced flue kit) and bunded tank.

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[42] Leap-frogging the status quo, First Annual Report, Design & Demonstration Unit, Oct 2003 - Mar 2005 (accessed at http://www.dti.gov.uk/files/file16629.pdf)

[43] Lower carbon Futures, Country profile Portugal, by Environmental Change Institute, Oxford, http://www.eci.ox.ac.uk/lowercf/countrypictures/CP_portugal.pdf#search=%22portugal%20lpg%20heating%20cooking%22

[44] Quote from http://www.shellgas.co.uk/index.html?page=64

Table 5-5. Tank costs for heating oil and LPG in the UK

Source: www.RuralFuel.co.uk	Heating Oil	LPG
Tank	1300	225
Tank installation	600	260
Boiler	3500	1780
Annual service	110 (includes parts which need regular changing due to heating oil viscosity)	80
Tank maintenance	Householders' responsibility	90
Total cost	5560	2435

Numbers have been converted from GBP to EUR with 1 GBP = 1.49 EUR and rounded.

In this example the LPG installation is around 3000 cheaper than the equivalent oil installation.

Besides the purchase price of the boiler (part of Task 2, Market Analysis) the price of the storage tank is an important element of the total price. When looking more closely at prices of oil storage tanks the price of 1300 euro may be considered relatively high, considering offers for plastic 'tank-in-tank' (no bund required) systems of 500 to 600 euro [45] (for 1500 litre).

Figure 5-3.
plastic oil storage tanks[46]

LPG storage tanks are usually not owned by the customer but by the supplier who also takes care of maintenance.

Siting of LPG bulk storage tanks

Siting of LPG storage is subject to Codes and Practices, in many cases a permit from local authority is needed. Requirements relating to siting concern fire safety measures, ability to perform inspections, access and ability to fill up the tank, etc. The proximity of the tank to nearest buildings ranges from 0.3 - 7.5 m, depending on capacity of tank and existence of fire wall.

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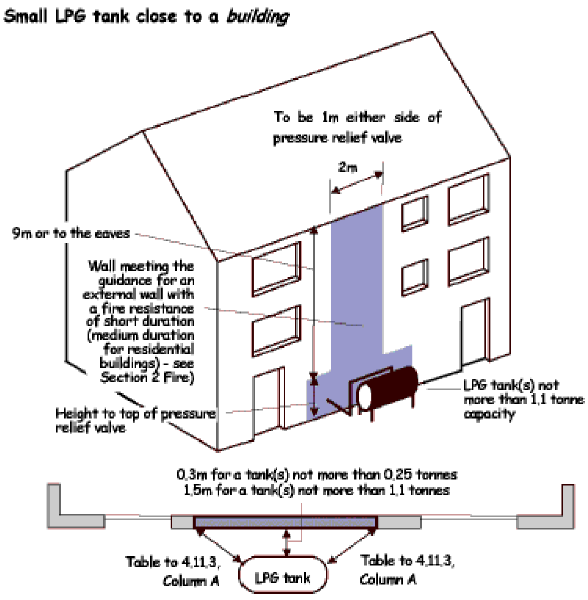
[45] http://www.heizungs-discount.de/Online-Katalog/Oltanks/oltanks.html

[46] Source: www.heizungsdiscount.de

Figure 5-4.
Siting of LPG tanks according UK Code of Practice (< 4 tonne) [47]



Other requirements to siting of tank are [48]:

- good natural ventilation on site;
- adequate surface quality (hard, flat, incombustible, even with surrounding terrain);
- access for supply, inspection/maintenance or emergencies (no shrubberies);
- no danger of collision with vehicles etc. (protection may be needed);
- supply truck should be able to reach and leave the site. Gas supply hose may not be led through enclosed spaces (buildings). Supplier must be able to visually check storage tank as well as supply truck;
- no electrical installations within 5 metres of tank;
- no smoking or objects with surface temperature over 300°C in 5 metres range;
- in case storage tank is in terrain open for public access it should be protected with a fence in a range of 1.5 metres.

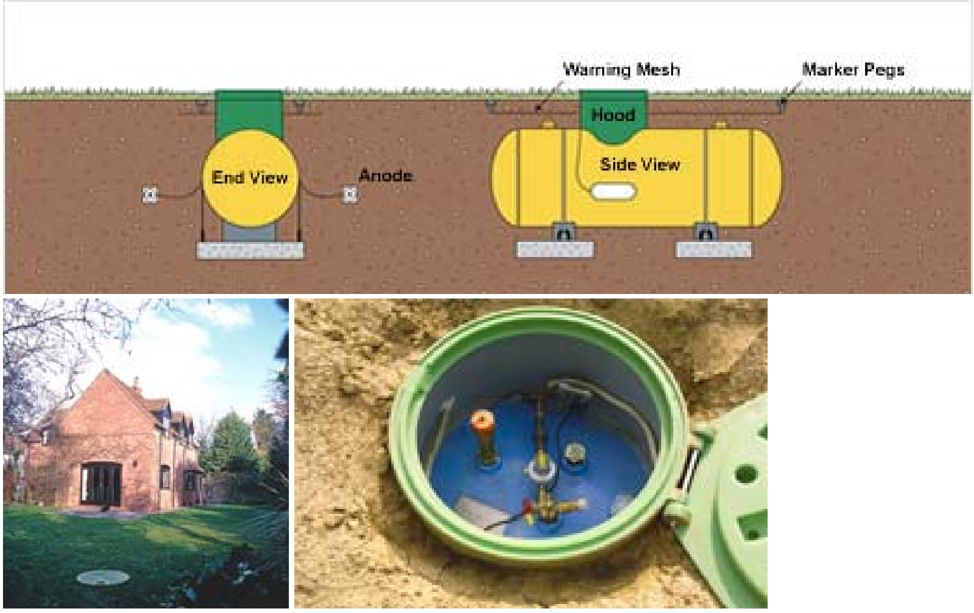
Figure 5-5.
Above ground LPG storage tank [49]

[47] http://www.sbsa.gov.uk/current_standards/th_html_2006/bsthd-81.htm#4111

[48] Source: www.shellgas.nl

[49] www.calorgas.co.uk

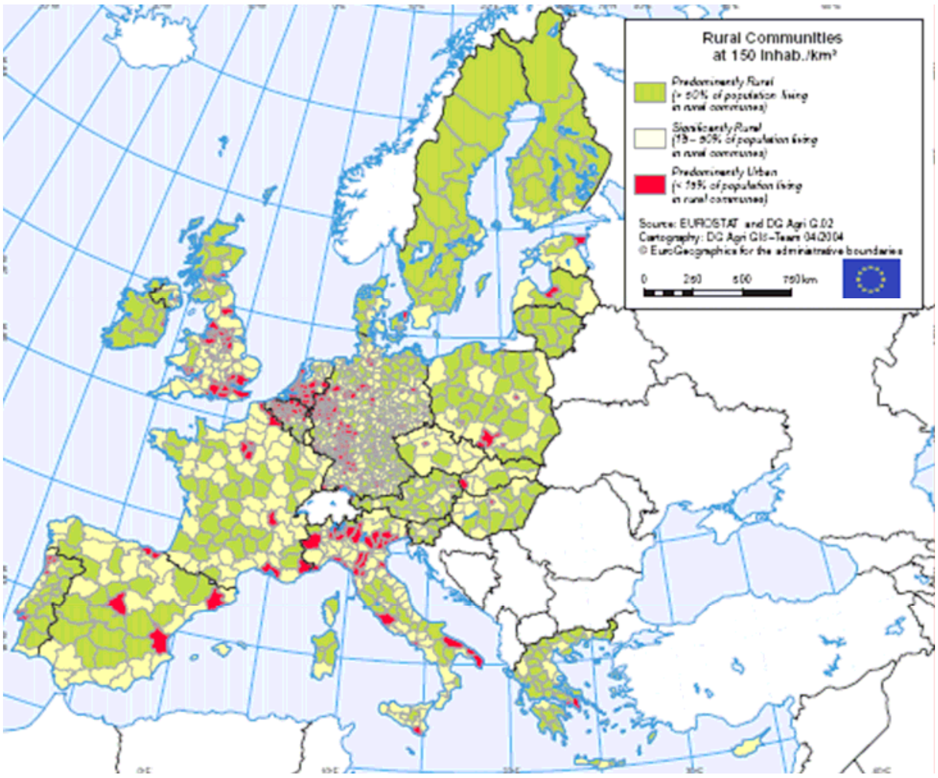
Figure 5-6.
Underground LPG storage tank [50]



Potential of LPG fuelled households

Guidelines like mentioned above limit siting of LPG bulk storage to (predominantly) rural areas. According to the OECD definition, which is based on population density, rural regions [51] represent in the EU25 92% of the territory. Furthermore, 19% of the population live in predominantly rural regions and 37% live in significantly rural regions [52].

Figure 5-7.
Fact sheet - New perspectives for EU rural development, European Commission 2004. Predominantly rural = green, significantly rural = light yellow, significantly urban = red.



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[50] www.calorgas.co.uk

[51] The OECD definition is based on the share of population living in rural communes (i.e. with less than 150 inhabitants per km²) in a given NUTS III region. See Extended Impact Assessment - SEC(2004)931. This is the only definition of rural areas internationally recognised. However, in some cases, it doesn't fully take into account the population living in more densely populated rural areas, particularly in peri-urban zones.

[52] European Commission, Proposal for a COUNCIL DECISION on Community strategic guidelines for Rural Development , SEC (2005) 914, Brussels, July 2005.

Figure 5-8.
A possible classification of communes[53]

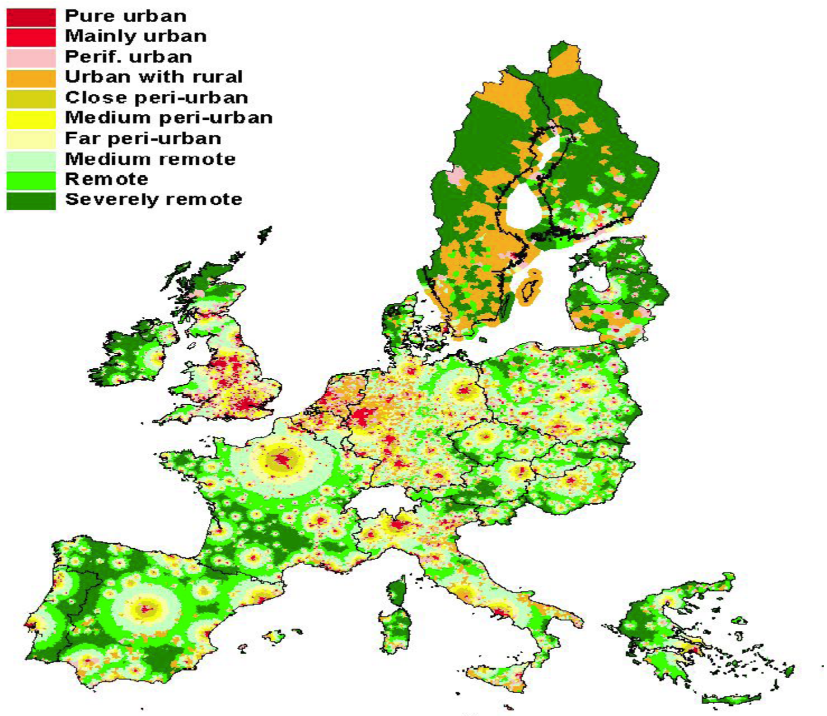

Table 5-6. EU-25 split of urban and rural population

	population ('000)	Urban	Rural	source	year
Austria	8032	67%	33%	1)	2001
Belgium	10287	100%	0%	1)	2001
Cyprus	789	61%	28%	1)	2001
Czech Rep.	10224	74%	26%	1)	2001
Denmark	5349	85%	15%	1)	2001
Estonia	1364	69%	31%	1)	2001
Finland	5176	61%	39%	1)	2001
France	58620	76%	24%	1)	1999
Germany	82335	88%	12%	2)	no data
Greece	10950	69%	31%	2)	no data
Hungary	10188	64%	36%	1)	2001
Ireland	3917	60%	40%	1)	2002
Italy	57157	14%	86%	1)	2001
Latvia	2355	68%	32%	1)	2001
Lithuania	3481	67%	33%	1)	2001
Luxembourg	442	81%	19%	1)	no data
Malta	383	-	-		no data
Netherlands	15864	64%	36%	1)	2000
Poland	38251	62%	38%	1)	2001
Portugal	10356	55%	45%	1)	2001
Slovakia	5380	56%	44%	1)	2001
Slovenia	1996	49%	49%	1)	2002
Spain	40721	76%	24%	2)	no data
Sweden	8896	33%	67%	2)	no data
UK	59114	91%	9%	2)	no data
EU15		85%	15%	2)	no data
EU25		19% predominantly rural 37% significantly rural 44% significantly urban			

Source:
1) UN Human Settlements (http://w3.unece.org/stat/HumanSettlements.asp)
2) Eurostat

[53] Gallego, F.J. Mapping rural/urban areas from population density grids, Institute for Environment and Sustainability, JRC, Ispra (Italy), 2004.

5.3 Heating oil

In 2004 some 41 million dwellings are heated by oil boilers (almost 20% of all dwellings [54]). The total number of oil boilers in stock is probably around 24 million of which 19.4 million are found in individual systems and some 4.3 million serve in collective housing (using an average of 5 dwellings per collectively used oil boiler). In the UK most oil boilers use Kerosene which has a slightly lower heat output per litre than light fuel oil or Gas oil). Kerosene also has poorer lubrication characteristics and is rarely used as heating fuel on the Main Land..

Siting of an oil storage tank is, similar to LPG tanks, bounded by Codes of Practice and local requirements. Unlike LPG however the vapour from oil storage tanks does not usually lead to explosive environments, making the requirements for siting somewhat more relaxed.

However, in case of leaks (spills in case of oil storage) the danger for pollution of the environment is more eminent and that's why legislation and codes of practice focus on that issue.

Options for siting an oil storage tank depend on requirements regarding secondary containment and/or fire protection [55]. The requirements described below are from an English document, but similar provisions apply in most other Member States as well.

Secondary containment, eg. a bund capable of retaining 110% of the tank capacity, is required to reduce the risk of oil spills to the environment. A bund is required in case of a tank capacity over 2500 litres, when the tank is sited close to open water, an open drain, borehole or spring, and/or on hardened surfaces allowing oil to spill into the above. A bund is also required for situations where the overflow vent is not visible by the person responsible for tank filling and if the tanks supplies a building other than a single family dwelling.

The fire protection requirements specify minimum distances from walls, boundaries and eaves with a certain fire-resistance and openings and/or flue terminations. Placement in a fire resistant chamber might be required. Furthermore the tank has to be placed on a non-combustible surface which extends 300 mm outside the tank.

Figure 5-9. Bunded tank [56]

Costs of realisation of an Heating Oil storage tank

See: Costs of realisation of a LPG storage tank, section 4.2.1.

Oil spills

Oil spills can be an extra cost for oil storage tanks owners and fines can be substantial: For UK commercial storage (capacity from 200 litres and upwards) the fine is 5000 GBP (EUR 7450) for non-compliance and 20.000 GBP (30.000 EUR) if spill occurs (www.ruralfuel.co.uk)

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[54] Dwellings following the definition by BRGC which includes second homes etc.

[55] The requirements stem from www.oftec.co.uk http://www.oftec.co.uk/publications/T14_Iss2_sept_05.pdf

[56] www.oftec.co.uk/ consumers/regulations_ storage_tanks.htm

5.4 Electricity

This study assumes that all households (and non-residential users) are connected to the mains electric network (230V, 50Hz).

If we look at space heating boilers only (just to complete the overview) there are some 2 million individual central heating systems that are fuelled by electric central heating boilers of which some 1.1 are of the electric immersion (resistance heating) type and some 0.9 million are electric heat pumps. This represents approximately 1% of the total dwelling stock.

Relevant for electric hot water and space heating is the maximum power to be drawn from the general fuse-box. In most countries this is limited to approximately 6kW, although in for instance the UK larger power can be supplied provided the wiring is suited for the current (larger diameter wires). Generally speaking all connectiosn of higher power than 12kW are powered by three-phase electricity for which a dedicated circuit needs to be established in the metering cupboard.

These high power fuse boxes with larger capacity need to be installed by a competent installer for electric installations. The costs for such installations are approximately a few hundred euro (depending on location, age of existing installation, etc.).

6 CHIMNEYS, FLUES AND PLUMES

6.1 Introduction

This section describes solutions to realise facade- and rooftop flue gas outlets for condensing oil- and gas-fired heaters (boilers and water heaters). it is believed that in many countries these solutions are not applied through lack of knowledge/ training of the installers, and is typical of the first few years in which a country is confronted with the condensing heat generator technology without proper training of the installers.

It is clear that where the following text states 'boilers' this also includes oil- and gas-fired water heaters (like combi-boilers, but also -condensing- gas storage water heaters and instantaneous water heaters). For readability these terms are assumed to be covered in the general term 'boiler'.

6.2 Classification of gas appliances according to the method of evacuation of the products of combustion

In 1999 TC 109 produced the CEN Report CR 1749: European scheme for the classification of gas appliances according to the method of evacuation of the products of combustion (types)appliance categories, which identifies the various ways (or types) of evacuation of combustion products, often combined with ways to supply air for combustion.

The table on the following page gives an overview of the categories of flue gas systems. Basically, there are three main categories: A (no flue gas exhaust), B (open systems with a flue gas exhaust) and C (room-sealed or ‘closed’ systems, i.e. that take the combustion air from outside). For central heating boilers only type B and C are relevant.

After this letter there are two digits. In the B-type this relates to the presence of a flue damper (no=1, yes=2) or whether the flue gas is collective (=3). With the C-type this relates to several (1 to 8) configurations, e.g. vertical or horizontal pipe, air intake from the same pressure zone as the flue gas exhaust or not, chimney and boiler certified separately, etc..

The second digit relates to whether the combustion takes place without a fan (=1), after the heat exchangers (=2) or before the burner (=3). For flue gas systems of type B11 (open system with flue damper and no fan), which is normally only allowed in a well-ventilated boiler room or similar— there is an extra denomination ‘B11BS’ if the type B11 is equipped with a thermal security provision and could thereby sometimes be used in a living space. It shuts off the gas supply if it detects flue gases in the room; after a while it automatically checks if the situation has improved.

For Germany and Austria an extra indent "x" in the column "Airtight enclosure" stands for appliances that fulfil higher standards on airtightness of the enclosure: all parts (of the cabinet /flue gas system) under positive pressure are leakproof so no critical quantities of flue gases can escape.

Most boiler manufacturers test and certify their models with several types of flue systems and present these options in the brochures and installation manuals that go with the product. But the installer must always respect the national regulation specifying requirements for chimneys.

Table 6-1: Classification of Appliances and flue gas systems according CR1749

		Flue gas system	Supply air	type of flue gas system	Position of fan	Airtight enclosure	Remarks
A	A1	no	from room (open system)	open exhaust (flue gas emitted in surroundings)	1 no fan		
	A2				2 after heat exchanger		
	A3				3 before burner		
B	B11	yes		1 with flue damper	1 no fan		(B12/14 not admissible in DE)
	B12				2 after heat exchanger		
	B13				3 before burner		
	B14				4 behind flow direction		
	B21			2 without flue damper	1 no fan		(B21 not admissable in DE)
	B22				2 after heat exchanger		
	B23				3 before burner		
	B31			3 without flue damper, collective chimney	1 no fan		(B31 empty category)
	B32				2 after heat exchanger		
	B33				3 before burner		
C	C11		from outside (room sealed)	1 Lateral (horizontal, through wall/roof) flue exhaust and air intake - in same pressure zone	1 no fan		
	C12				2 after heat exchanger	x	
	C13				3 before burner	x	
	C21			2 Combined single shaft air intake / flue exhaust	1 no fan		(typical for UK)
	C22				2 after heat exchanger		
	C23				3 before burner		
	C31			3 Vertical (through roof) flue exhaust and air intake - in same pressure zone	1 no fan		(C31 not admissible in DE)
	C32				2 after heat exchanger	x	
	C33				3 before burner	x	
	C41			4 Dedicated separate shafts for flue exhaust and air intake (possibly collectively used)	1 no fan		(C41 not admissible in DE)
	C42				2 after heat exchanger	x	
	C43				3 before burner	x	
	C51			5 Flue exhaust and air intake in different pressure zones	1 no fan		(C51 not admissible in DE)
	C52				2 after heat exchanger	x	
	C53				3 before burner	x	
	C61			6 Gas-fired appliance to be connected with flue gas / air intake system tested and certified separately	1 no fan		(C61 not admissible in DE and C6x Belgium)
	C62				2 after heat exchanger	x	
	C63				3 before burner	x	
	C71			7 vertical flue exhaust and air-intake - air intake from loft space	1 no fan		(C7x not admissable in DE, typical for UK)
	C72				2 after heat exchanger	x	
	C73				3 before burner	x	
	C81			8 Flue exhaust connected to negative pressure chimney shaft, air intake from different pressure zone	1 no fan		
	C82				2 after heat exchanger	x	
	C83				3 before burner	x	

Although in CR 1749 a wide range of methods of evacuation of combustion products are mentioned some evacuation methods are typical for certain EU countries. The national regulations per country stipulate the possible methods.

In Sector Group Forum Gas TC 109 – TC 166 changes of CR 1749 can be discussed. The classification is introduced in the Harmonised Standards (e.g. EN 483) developed in the light of the Gas Appliances Directive 90/396/EEC.

6.3 Classification and designation of Chimneys

The type of chimney that can be applied to a certain boiler and site depends on the chimney performance. EN 1443:2003 designates chimneys in terms of a coded string for the following performance aspects: temperature class, pressure class, condensate resistance class, corrision resistance class and soot fire resistance class.

The above general designation string is further complicated depending upon the product standard in question. This means that the designation string can be different for chimneys made of metal, plastic, clay/ceramic or concrete. The examples below already show the differences between metal and plastic designations.

Table 6-2: Designation of chimneys accoridng EN1443, two examples

Example plastic	System chimney	EN14471	T120	P1	W	1/2	O (30)	I C/E L
Example metal	System chimney	EN1856-1	T250	N1	D	Vm - L11045/063	O (40)	
relates to:								
Product description	...							
European standard		ENxxx						
Temperature class			Txxx					
Pressure class				P/N/H,1/2/3				
Resistance to Condensate class					W/D			
Corrosion resistance class						(V),1/2/3		
for metals: Liner specifications						*Lxxxxx*		
Soot fire resistance class							O/G	
Distance to combustible material							(xx)	
for plastics: Location Fire behaviour Enclosure								... ...

The sections below describe the common chimney performance characteristics that are covered by most chimney designation requirements. Note that these are not exhaustive and the designation may differ from type and material of chimney.

6.3.1 Product description

Describes the product in general terms, e.g. system chimney, non-bonded flue block, single wall chimney, liner, etc.

6.3.2 European standard

Gives European standard for which the product has been tested, e.g.:

Table 6-3: Some European standards for chimneys, structured by material

EN 1856-1	for metal chimneys, e.g. stainless steel, aluminium
EN 14471	for plastic chimneys, e.g. polypropylene

EN 13063-1 -2	for clay/ceramic products
EN 1858	for concrete products

6.3.4 Temperature class

Temperature class is expressed as "T" followed by a number which is less than or equal to the nominal working temperature i.e. the average flue gas temperature in °C obtained during the nominal/rated output (usually the maximum operating level, DE: Nenndauerbelastung), eg. T120 is max 120°C and T450 is max. 450°C.

Table 6-4: Temperature classes

Temperature class	design operating temperature ºC
T080	>80
T100	>100
T120	>120
T140	>140
T160	>160
T200	>200
T250	>250
T300	>300
T400	>400
T450	>450
T600	>600

The flue gas temperature is mainly determined by the type of boiler. Most conventional, atmospheric gas and oil-fired boilers operate with average flue gas temperatures of 200-250°C. The maximum temperatures may be higher (up to 300°C). Plastic flue liners (PP - polypropylene) can widthstand operating temperatures up to 120°C and are therefore not suited for conventional and low temperature boilers. Modern condensing boilers produce flue gases at an average temperature of 60°C with a maximum of 120°C. In that case plastic flues and chimneys can be used and in fact are –for cost and technical reasons—very common.

6.3.5 Pressure class

Pressure class is expressed as either "N", "P" or "H" followed by either "1" or "2". N relates in general to natural draught chimneys i.e. operating under negative pressure where the value 1 or 2 allows for a different class of leakage rate for the product. In the UK for instance the value N2 will be assigned as a minimum for masonry chimneys. Simple slide-in aluminium tubes (no seals) are often tested as N1 and not suited for fanned boilers. P and H relate to chimneys which operate under 'normal' and 'high' positive pressure e.g. for fan assisted applications and diesel generators respectively.

Table 6-5: Pressure classes

Pressure class	Leakage rate	Test Pressure (Pa)
N1	2.0	40 for negative pressure chimneys
N2	3.0	20 for negative pressure chimneys
P1	0.006	200 for positive pressure chimneys
P2	0.120	200 for positive pressure chimneys
H1	0.006	5000 for high positive pressure chimneys
H2	0.120	5000 for high positive pressure chimneys

6.3.6 Corrosion class

This designation refers to operating conditions (wet or dry), corrosion characteristics of the fuel used and (if applicable) the properties of the liner.

Operating conditions

The indent W or D in the chimney designation indicates whether the chimney is suited for wet or dry operating conditions.

Table 6-6: Condensate resistance

W	wet operating conditions
D	dry operating conditions

Condensation in the chimney occurs if the wall temperature of the flue is below the dew point of the flue gases. LT boilers produce fluegases with low temperatures, with the result that the gases can condensate on the inner wall of the chimney.

When installing condesing boilers as retrofit, the flue gas system must be suitable for condensing application and the consistence of the old system must be checked. Normally changing a boiler means at the same time changing the flue.

Fuel types

The corrosion resistance class of the chimney is indicated by a number that relates to the type of fuel:

Table 6-7: Corrosion resistance class

V1	is for gas and light fuel oil (kerosene) with a sulphur content below 50mg/m^3.
V2	is for light oil / wood in open fires (DE: Naturbelassenes Holz)
V3	for heavy oil / wood in closed stoves / coal and peat
Vm	not tested and approved but rating declared by the manufacturer

The corrosion class for gas (natural or LPG) is "1": condensate that is produced when gas flue gases cool down is slightly acidic, much like normal rain water. Ceramic (for wet conditions), corrosion-resistant metals and plastics can be used (provided flue gases are not too hot).

Normally oil-fired boilers require chimney materials in corrosion class "2", but "low-sulphur content fuel oil" does not produce condensate with sulphuric substances and such condensate can be disposed off like normal gas fired boiler condensate. Suitable materials for low or no sulphuric substances in flue gases are: Polypropylene, PVDF, Stainless steel or Aluminium (thick wall).

Liner specifications

Important parameters for corrosion resistance of metal flues are flue material and wall thickness. At the moment there is no European standard specifying wall thickness of all possible flue pipes and many member states still have a minimum flue wall thickness specified in their national legislation. The standard EN 1856-1 (metal chimneys) therefore asks for flue liner specifications to be indicated in the product designation, enabling checks for compliance with national regulations by (local) authorities.

Two features are specified, firstly a code for the minimum material grade and secondly material thickness (used for metal liners).

Table 6-8 : Liner specifications

Material grade		Wall thickness (example)	
L11	for Aluminium 99% pure	040	means 0.4 mm thickness
L20	for stainless steel 304		etc.
L30	for stainless steel 304L		
L40	for stainless steel 316		
L50	for stainless steel 316L		

For system chimneys (sold together with gas boilers) the current EN483/A4 contains criteria for the flue section of gas appliances so that these system chimneys are in line with the requirements of the CPD. Note that these criteria have not been officially agreed by TC 166 (relevant for chimney components).

Table 6-9: Extract from EN483/A4 regarding wall thickness of metal chimneys

Material	Symbol	Minimum nominal thickness (mm) [b)	
		non-condensing	condensing
EN AW-4047A	EN AW AlSi12(A), and Cu<0,1%, Zn<0,15% (cast aluminium)	0.5	1.5
EN AW-1200A	EN AW-Al99,0	0.5	1.5
EN AW-6060	EN AW-AlMgSi	0.5	1.5
1.4401	X5CrNiMo 17-12-2	0.4	0.4
1.4404 [a)]	X2CrNiMo 17-12-2	0.4	0.4
1.4432	X2CrNiMo 17-12-3	0.4	0.4
1.4539	X1NiCrMoCu 25-20-5	0.4	0.4
1.4401	X5CrNiMo 17-12-2	0.11 [c)]	0.11 [c)]
1.4404 [a)]	X2CrNiMo 17-12-2	0.11 [c)]	0.11 [c)]
1.4432	X2CrNiMo 17-12-3	0.11 [c)]	0.11 [c)]
1.4539	X1NiCrMoCu 25-20-5	0.11 [c)]	0.11 [c)]

[a)] Equivalent for material N° 1.4404 = 1.4571 (symbol X6CrNiMoTi 17-12-2).

[b)] According to declaration of manufacturer, see defnition 3.4.19 (of EN483:1999/prA4:2006)

[c)] Flexible liners only allowed when installed in an existing chimney

6.3.7 Soot fire resistance

Expressed as either G (with soot fire resistance) or O (without soot fire resistance), followed by the declared minimum distance to combustibles expressed in mm.

Table 6-10: Soot fire resistance

O	not soot fire resistant
G	soot fire resistant

To obtain the G classification means that the product has been tested at 1000°C for 30 minutes and remains intact and the temperature of combustible material at the designated distance does not exceed 100°C at T.amb. 20°C.

Minimum distance to combustible materials

The "O/Gxx" value indicates the minimum distance to combustible materials. The two digits describe the minimum distance to the chimney wall in mm. O50 indicates a minimum distance of 50 mm or 5 cm.

The distance to combustibles has to be read in conjunction with the soot fire resistance classification and is not a stand alone classification.

6.3.8 Additional designation

As said before different chimney materials may require different designations. For certain chimney products dimensions, thermal resistance, wall temperatures, flow resistance for the flue gas or freeze-thaw resistance etc. shall be included in the designation. These aspects are all described in the relevant European Standards.

Table 6-11: Example of additional designation for plastic and metal liners

Plastic liners		
Location	I/E/B	internal / external / both
Reaction to fire	F0/F1	classes F0 or F1

Enclosure class	L0/L/L1	classes L0/L/L1
Metal liners		
Heat resistance	Gxx,	where 'xx' indicates the heat resistance of the chimney wall material in m^2K/W multiplied by a factor 100. Therefore R40 indicates a heat resistance of 0.40 m^2K/W

For CE marking purposes the manufacturer must mark the product with all the information prescribed in the Annex ZA of the relevant harmonised product standard.

Sometimes this includes the product designation, sometimes it doesn't (depends on relevant standard and Annex ZA). It is also possible that other information, not included in the designation string, is part of the required marking.

Note that the CE marking does not always need to be on the product itself, in certain cases the marking can be put on a label, the packaging or the accompanying commercial documents.

6.4 Retrofitting of flue systems

The chimney material and performance is not the only relevant factor to consider when replacing boiler type and/or renovation of the flue gas system. The dimensions of the new chimney is at least as important for proper functioning, as well as the proper configuration of air inlets and exhausts.

For both single- or multi-family houses, single or collective shafts, flue-only or combined with air supply, etc. the chimney industry has come up with clever solutions to tackle many retrofit issues, such as illustrated below.

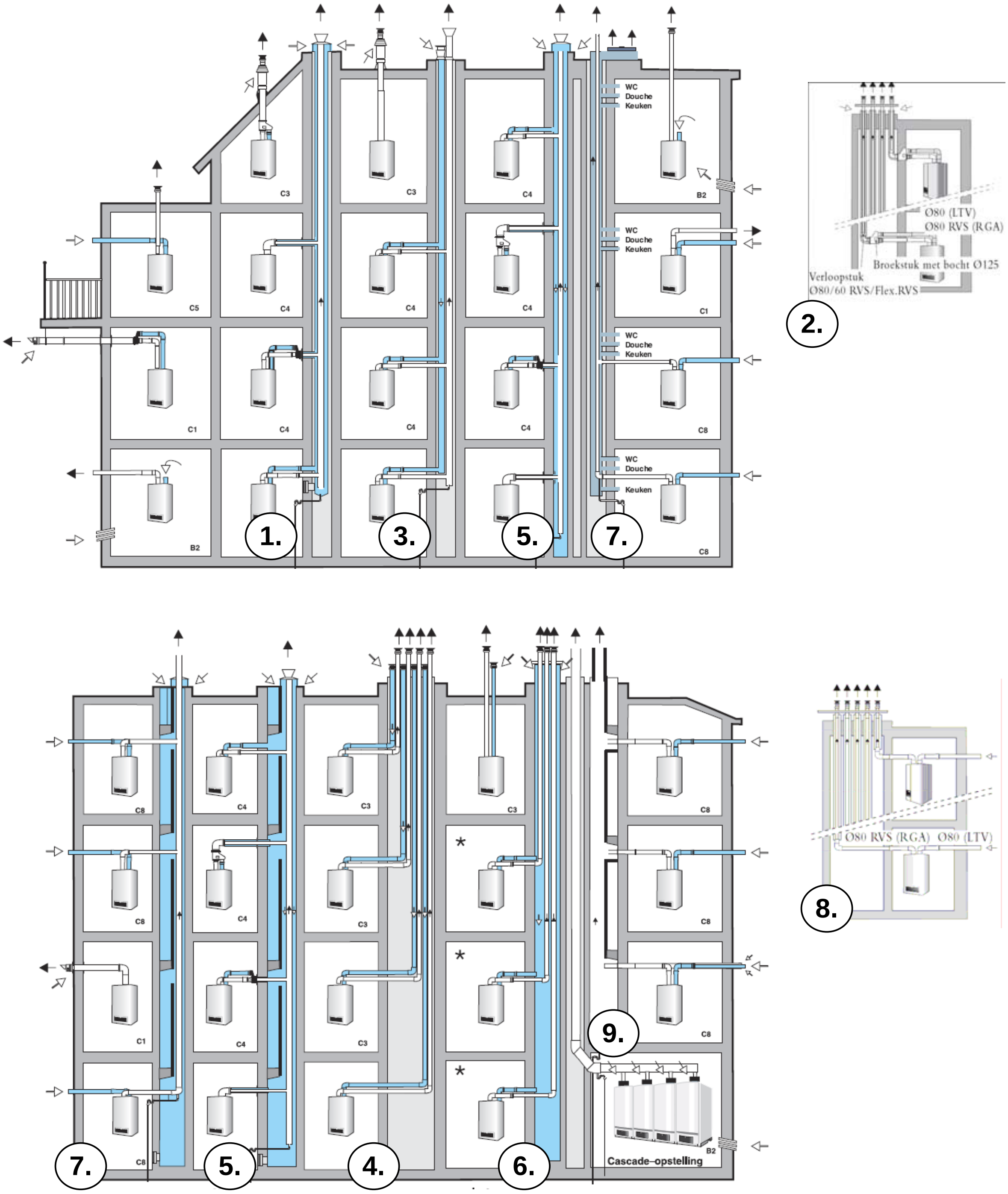


Figure 6-1. Chimney solutions (picture courtesy of Nefit-Buderus)

6.4.1 Mutli-family retrofits

A well-known retrofit problem occurs in multi-family buildings with individual appartment-owners on each floor. In such cases it can be difficult to introduce a condensing boiler on one floor whereas the other floors are still using old, atmospheric boilers, especially if all are connected to a collective flue/air shaft.

To raise the flue outlet of this individual boiler to the roof level is often not a desirable option.

To guide the flue outlet to the facade (lateral outlet) is often not an option in such buildings, either from technical point of view (too close to facade openings, in danger of not catching enough wind, too far from roof, etc.) or from easthetic/practical point of view (the lateral outlet is a nuisance for neighbours and/or easthetically undesirable because of the plumes).

A lot thus depends on how the collective chimney shaft is used and how much surplus space it provides. The table below indicates several options open to builders/house owners to connect boilers to a flue/air system in a multi-family house (the numbers refer to the numbers in figure 10-2).

Table 6-12. Flue gas exhaust options for multi-floor housing

Options		Class
1.	boilers are connected to a collective concentric flue/air system	C4
2.	boilers are connected to individual concentric flue/air pipes, the pipes are combined i a single shaft (also as flexible liner in existing individual flue pipe and remaining cavity functions as air supply)	C3
	flue gas exhaust and air intake through a parallel liner in existing shafts (flexible liners possible)	
3.	boilers are connected to a collectively used parallel air duct and flue exhaust	C4
4.	boiler are connected to individual parallel air/flue pipes (nees enough space in shaft to accomodate this)	C3
5.	flue gas exhaust through collective liner, air intake collective through shaft cavity	C4
6.	flue gas exhaust through individual liners, air intake collective through shaft cavity	C4
7.	flue gas exhaust through collective liner, air intake individual from facade	C5
8.	flue gas exhaust through individual liners, air intake individual from facade	C5
9.	flue gas through existing chimney (no liner > condensate proof surface treatment), air intake through facade	C5

Not included in this overview is the possibility for insertion of flue liners in dedicated ventilation ducts/shafts (and retrieve ventilation air from elsewhere). The extremely small diameters that stainless steel and plastic flexible liners offer (80, 60, 50 and even 45 mm - in combination with suitable boilers) are versatile enough to enable this.

Another option for combining old and new boilers in a house with a collective parallel flue/air shafts is the insertion of flue liners in the air shaft. The fan-assisted boilers can cope with the reduced air and flue pipe cross sections. The flue gas shaft remains operational for the old boilers not replaced yet (figure below). The reduced cross section of the air shaft should of course not hinder the functioning of the atmospheric boilers.

Figure 6-2. Buderus solution for combining old boilers and new condensing ones in a single chimney (with separate flue gas and air shaft).

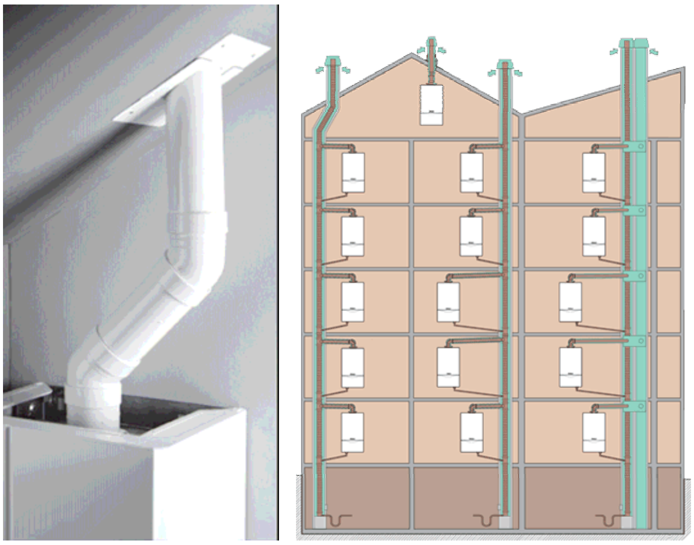
A final option, not investigated thoroughly and as such presented as merely an idea, is to insert a metal (e.g. stainless steel) flexible flue liner of small diameter in the existing collective chimney/ flue shaft, provided the shaft is large enough. The metal liner should be able to widthstand the operating temperatures of the conventional boilers that still use the same shaft. Since the cross section of the new flue pipe is smaller than what was needed before (replaces atmospheric boiler), there should be no negative effect on the functioning of the other boilers. The supply air can be drawn from the facade.

One note regarding collective flues as described in options 1, 3, 5, 7 and 9: Virtually all modern boilers are fan-assisted and thus the flue pipe is under positive pressure. In order to avoid leakage of flue gases through boilers that are not operated, a boiler with flue gas return valve can be selected, thereby preventing such reverse flue gas flow.

German manufacturer Vaillant added another function to the flue liner by proposing condensate drainage through the flue liner in case there is no possibility to connect the condensing boilers to the household wastewater system on each floor. Provided that the flue system protrudes through each floor the bottom-side of this liner collects all condensate that may occur in the flue pipe and boiler and is connected to a drain. Needless to say that this improves renovation economics by combining two functions in a single product.

Figure 6-3 (left): Example of a concentric system including concentric bends (figure: Muelink&grol)

Figure 6-3(right)
Vaillant collective condensate drainage solution (with condensate drain at bottom of each chimney) [57]



Liner propertiesand pressure loss

An important factor to consider when applying flue liners in multi-floor buildings is the maximum allowable pressure drop. Most fan-assisted room-sealed boilers allow a pressure drop of 75 to 125 Pa from air inlet to flue gas outlet without performance being affected[58]. The table below gives average pipe diameters for positive and negative pressure chimneys[59].

Table 6-13. Recommended diameters (mm) collective air intake / flue exhaust systems

	Positive pressure					Negative pressure				
Floors	conc.		par		C5	conc.		par		C5
	flue	air	flue	air	flue	flue	air	flue	air	flue
2	90	125	80	80	75	135	260	135	220	135
3	100	150	100	100	90	160	300	160	260	160
4	110	165	110	110	105	170	315	170	270	170

57 source: www.bauzentrale.de

58 The capacity for hot water supply may be affected (up to 6% less capacity)

59 Nefit-Buderus, Technisch Bulletin 19, September 2005, Deventer, The Netherlands

6	130	200	135	135	125	185	350	185	300	185
8	150	230	150	150	140	205	385	205	330	205
10	165	260	170	170	160	220	420	220	360	220
12	180	275	185	185	170	240	450	240	385	240
16	200	330	210	210	195	275	520	275	445	275
20	220	360	235	235	220	310	585	310	505	310

As can be seen from the table there often is more than enough space for insertion of positive pressure liners in negative pressure flues, even creating concentric systems. Calculations by Nefit-Buderus show that 50 to 60 mm diameter flues can be applied up to respectively five (5) and seven (7) floors up in combination with certain boiler models (boilers can be boosted to increase maximum allowable pressure drop). The tables below give some examples of pressure drop calculations for two 600 mm applications and a 50 mm application [60].

Table 6-14 .Example 1: 60 mm over 5 floors, type C5

Application 7. Air from facade, flue liner in existing individual flue pipe (C5) 5 floors (12.2 m vertical: 4*2.8m +1*1m) Flue exhaust	Pressure drop
12.2 m flexible liner stainless steel 60mm	42.7 Pa
Flue cap	1.3 Pa
1 adapter ø80/60	5.0 Pa
2 bends 90º ø80mm	10.4 Pa
1 m stainless ø80mm	1.0 Pa
Air intake	
1 m plastic ø80mm	0.7 Pa
1 bend 90º ø80mm	2.9 Pa
Total	64 Pa

Table 6-15 .Example 2: 60 mm over 4 floors, type C3

Application 2. Individual air and flue liner concentric in existing 100 mm pipe (C3) 4 floors (9.4 m vertical: 3*2.8m +1*1m) Flue exhaust	Pressure drop
9.4 m flexible liner stainless steel ø60mm	32.9 Pa
Flue cap	1.3 Pa
1 adapter ø80/60	5.0 Pa
2 bends 90º ø80mm	10.4 Pa
1 m stainless ø80mm	1.0 Pa
Air intake	
9.4 m concentric (existing pipe)	10.0 Pa
1 m plastic ø80mm	0.7 Pa
1 bend 90º ø80mm	2.9 Pa
Total	64.2 Pa

Table 6-16. Example 3: 50 mm over 3 floors, type C5

Application 7. Air from facade, flue liner in existing individual flue pipe 100 mm (C5)

[60] Nefit-Buderus, Technisch Bulletin 17, March 2005, Deventer, The Netherlands

3 floors (6.0 m vertical: 2*2.8m +1*0.4m)	
Flue exhaust	Pressure drop
6 m flexible liner stainless steel ø50mm	60.0 Pa
Flue cap	1.3 Pa
1 adapter ø80/60	5.0 Pa
2 bends 45º ø80mm	3.2 Pa
1 m stainless ø80mm	1.0 Pa
Air intake	
1 m plastic ø80mm	0.7 Pa
1 bend 90º ø80mm	2.9 Pa
Total	74.0 Pa

Figure 6-4.
Inserting the flexible liner
figure: Muelink&Grol)

The effect of reduced performance (capacity) is probably only noticeable in instantaneous combi-boiler configurations on the lowest floor where hot water performance is reduced by maximum 6% [61]. The efficiency of the boiler is not affected.

Note that with at a pressure reduction of 1 Pa per m pipe (ø80mm) and a maximum pressure by the boiler of 125 Pa a straight flue pipe of 125 m can theoretically be installed (neglecting air intake pressure loss). With a small 50 mm diameter liner the pressure drop is much larger (10 Pa/m) but the maximum allowable length is still 12.5 m. Flexible liners (plastic and/or stainless steel) should not be applied horizontally or at modest slopes: Check the installation instructions for the minimum slope.

6.4.2 Free-standing / terraced house retrofit

With boilers that are placed directly under the roof of the main house —e.g. an accessible attic— or the roof of an extension of the main house —e.g. utility room— chimney renewal is relatively easy and cheap. There are several boiler manufacturers and specialists that can supply a flue/air system chimney for a few hundred euros that can be mounted in a couple of hours. For truly condensing boilers (max. temperature 120°C) these sets can be completely made of plastic; for LT boilers at least a part of this chimney set has to be made of stainless steel or thick-wall aluminium (follow national building codes for miminum wall thickness).

The renovation of lateral (through-the-wall) flue gas outlets is not always self-evident and depends on local building regulations and the possibility of nuisance from plumes. In the case of terraced housing it is often not so difficult to extend the flue to roof level and "plume management-kits" (extended chimneys) are easily available. For free-standing or semi-terraced housing plumes from lateral outlets are considered less of a problem in general.

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[61] Nefit-Buderus, Technical Bulletin 20, December 2005, Deventer, The Netherlands

For larger dwellings where the flue spans one or more floors similar solutions as for multi-family dwellings apply, e.g. the insertion of (flexible) liners in existing flue or air shafts.

Many of these solutions have become possible because of the material properties of plastics and metals that allow the design of very compact flue/(air) solutions, like ready-made concentric pipes and bends and flexible liners (plus accompanying products like roof terminals, studs, etc.).

Glazed ceramic pipes by example are also perfectly suited for corrosive, hot and condensing flue gases, but flexible and/or and concentric solutions are either not possible or much more diffcult to apply in most retrofit applications where a standard boiler is replaced by a condensing boiler.

6.5 Legislation

6.5.1 Harmonised Standards

Chimney products need to have CE markings, just as any other construction product covered by the "Construction Products Directive" 89/106/EEC. Below are listed the standards relevant for chimneys (and to a lesser degree combustion air pipes), sorted by material and based on the essential requirements as mentioned in the CPD. The harmonisation of standards for chimneys and flues is the responsibility of CEN Technical Body CEN/TC 166 (Chimneys) [62]. For extra clarification some standards are accompanied by explanatory text [63].

Most of the standards are relevant for type B/C boilers, whereas for type C6 boilers + air/flue systems the boiler test standards apply (see EN483/A1).

Table 6-17. EN standards related to various flue gas systems and components

General	
CEN/TR 1749:2006	European classification of gas appliances according flue systems
	This technical report has been prepared under the aegis of the Sector Forum Gas Utilisation committee to provide guidance to CEN Technical Committees who are preparing European Standards for appliances burning combustible gases. It gives details of a general scheme for the classification of such appliances according to the method of evacuating the products of combustion. It must be stressed that this scheme only concerns appliances that are intended to be installed within buildings. It does not apply to outdoor appliances. This form of appliance classification is widely used in the preparation of European Standards for gas appliances to identify the requirements and methods of test that are applicable to the various methods of evacuating the products of combustion. Appliances classified in this way are generally described as "types" and this description has been retained for the purposes of this general scheme. The main purpose of the scheme is to promote harmonization in the classification of appliance types. This should ensure that there is a clear understanding of the various appliance types and will avoid confusion arising from Technical Committees describing them in different ways. CEN Technical committees are therefore requested to use this scheme in all circumstances in which it is appropriate. They should not deviate from it unless there are sound technical reasons for so doing.
EN 1443:2003	Chimneys - General requirements
	This European Standard specifies general requirements and the basic performance criteria and specifies limit values where appropriate for chimneys (including connecting flue pipes and their fittings) used to convey the products of combustion from heating appliances to the outside atmosphere. It is intended to be used as a reference for product standards for chimneys, flues and specific products (elements, kits and terminals) used in the construction of chimneys. It also identifies minimum requirements for marking and evaluation of conformity.
EN 13216-1:2004	Chimneys - Test methods for system chimneys - Part 1: General test methods
EN 13384-1:2003 /A1:2005/C1:2007	Chimneys - Thermal and fluid dynamic calculation methods - Part 1: Chimneys serving single appliances
EN 13384-2:2003	Chimneys - Thermal and fluid dynamic calculation methods - Part 2: Chimneys for heating appliances
EN 13384-3:2005	Chimneys - Thermal and fluid dynamic calculation methods - Part 3: Methods for development of diagrams and tables for chimneys serving single appliances

[62] The list of standards under the responsibility of TC166 can be found at http://www.cenorm.be/newapproach/dirlist.asp (search Construction Products > Chimneys)

[63] Please note that many titles of standards were translated from Dutch and therefore may not correspond with official English titles.

EN 14297:2004	Chimneys - test methods for the icing and thaw resistance of chimney products
EN 12101-7:2004	Installations for control of smoke and heat - Part 7: Flues
EN 1998-6:2005	Eurocode 8: Design and calculation of earthquake resistant constructions - Part 6: Towers, masts and chimneys
Plastics	
EN 14471:2005	Chimneys - System chimneys with plastic flue liners - Requirements and test methods
	This European standard specifies the performance requirements and test methods for system chimneys with plastic flue liners used to convey the products of combustion from appliances to the outside atmosphere. It also specifies the requirements for marking, manufacturer's instructions and evaluation of conformity. This European standard describes chimneys components from which system chimneys can be assembled.
EN 14241-1:2005	Chimneys - Elastomeric seals and sealing products - Material requirements and test methods - Part 1: Seals in exhaust systems
Metals	
EN 1856-1:2003 /A1:2006	Chimneys - Requirements for metal chimneys - Part 1: System chimney products
	This standard specifies the performance requirements for single- and multi-wall system chimney products of combustion liners (chimney sections, chimney fittings and terminals, including supports) used to convey the products of combustion from appliances to the outside atmosphere. It also specifies the requirements for marking, manufacturer's instructions, product information and evaluation of conformity. Metal liners and metal connecting flue pipes not covered here, are included in prEN 1856-2:1996.
EN 1856-2:2004	Chimneys - Requirements for metal chimneys - Part 2: Metal liners and connecting flue pipes
	This document specifies the performance requirements for rigid or flexible metal liners, rigid connecting flue pipes and rigid fittings used to convey the products of combustion from appliances to the outside atmosphere (including their supports). Vitreous enamelled connecting flue pipes are also covered by this document. Rigid liners can be used as flue liners for renovation or adaptation of existing chimneys and as flue liners of custom built chimneys. Flexible metal liners described in this document are exclusively for renovation or adaptation of existing chimneys. This document also specifies the requirements for marking, manufacturer's instructions, product information and evaluation of conformity. Flexible connecting flue pipes and extensible flexible products designed to be compressed or extended along their length are excluded from the scope of this document. Single wall and multi-wall system chimney products are covered by EN 1856-1.
EN 1859:2000 /A1:2006	Chimneys - Metal chimneys and flue liners - Test methods
EN 12391-1:2004	Execution standard - Code of practice for Chimneys - Requirements for metal chimneys - Part 1: Chimneys for non-room sealed heating appliances
EN 15287-1:2005	Chimneys - Design, realisation and practice of chimneys - Part 1: Chimneys for room sealed heating appliances
EN 14989-1:2007	Chimneys - Requirements and test methods for metal chimneys and material independent air supply ducts for room sealed heating applications - Part 1: Vertical air/flue terminals for C6-type appliances
EN 14989-2:2004	Chimneys and air supply duct systems for room sealed appliances - Requirements and test methods - Part 2: Flue and air supply ducts for individual room sealed appliances
EN 13084-6:2004	Free standing chimneys - Part 6: Steel liners - Design and realisation
EN 13084-7:2005	Free standing chimneys - Part 7: Requirements for cylindrical steel components to be used in single-sided steel chimneys and chimney lining
Ceramic	
EN 1457:1999 /A1:2004/C1:2007	Chimneys - Clay/Ceramic Flue Liners - Requirements and test methods
EN 13069:2005	Chimneys - Clay/ceramic outer walls for system chimneys - Requirements and test methods
EN 1806:2006	Chimneys - Clay/ceramic flue blocks for single wall chimneys - Requirements and test methods
EN 13502:2002	Chimneys - Requirements and test methods for clay/ceramic flue terminals
EN 13063-1:2005/A1:2007	Chimneys - System chimneys with clay/ceramic flue liners - Part 1: Requirements and test methods for soot fire resistance
EN 13063-2:2005/A1:2007	Chimneys - System chimneys with clay/ceramic flue liners - Part 2: Requirements and test methods under wet conditions
EN 13063-3:2007	Chimneys - System chimneys with clay/ceramic flue liners - Part 3: Requirements and test methods for air flue system chimneys
Concrete	
EN 1857:2003 /C1:2006/prA1:2007	Chimneys - Components - Concrete flue liners
EN 1858:2003	Chimneys - Components - Concrete flue blocks
EN 12446:2003	Chimneys - Components - Concrete outer wall elements
prEN 13084-2:2005	Free standing chimneys - Part 2: Concrete chimneys
prEN 13359:1998	Chimneys - Components - Concrete in-situ insert parts

Stone	
EN 13084-4:2005	Free standing chimneys - Part 4: Stone inner cladding - Design and realisation
EN 13084-5:2005	Free standing chimneys - Part 5: Materials for stone inner cladding - Product specifications

Product-related health and safety risks should be no longer an issue. For more information on the legal background see van Rienen and Wasser [64], that give an extensive presentation of the implications of the Gas Appliances Directive and the EU product-related legislation in general.

6.5.2 Design, installation and commisioning

Besides fulfilling the product standards the design, installation and commissioning of chimneys must be in accordance with the national building regulations -if they exist. These building regulations a.o. describe where flue outlets may be positioned (distance to openings, distance from roof, etc.) and despite efforts to harmonise design,installation and commissioning guidelines (e.g. EN 12391-1) there are still many differences in national legislation. Some examples:

In some countries concentric flue systems are compulsary because of safety reasons (the constructions prevents leakage of flue gases), other countries prefer parallel pipes.

Some countries (e.g. Belgium) do not allow certain solutions (C6 system chimneys) leaving it up to the person responsible for installing the chimney to use a different route to show compliance with building regulations.

Regarding lateral outlets the Feueranlagenverordnung (FeuVO) of Bayern and Baden-Wurttemberg [65] by example states that lateral chimneys are allowed, if:

- A flue exhaust over the roof is not possible;
- the appliance is of the 'closed' type;
- the appliance is max. 11 kW (for space heating) or max. 28 kW (for water heating);
- and no nuisance or other hindrance/danger is caused.

Pluming, or the formation of visible white clouds of moist air, also occurs with atmospheric boilers at cold outside temperatures and has been the inspiration for many Christmas cards, but with condensing boilers emitting flue gases with close to 100% relative humidity (due to low temperatures) the visibility near the outlet is higher and can be considered a nuisance at ground level or easthetically undesirable (in case of historic city views). In many member states [66] this has led to the situation that in practice lateral outlets at ground level for terraced houses and lateral outlets for flats are not acceptable. For semi-terraced houses and freestanding houses, lateral flue gas outlets are still an accepted solution.

TC 166 is in the process of preparing general commissioning standards of metal chimneys for normal and room sealed boilers (EN 12391-1 and 15287-1 and 2). Countries who do not have legislation can adopt these standards as a technical report.

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[64] **Van Rienen, W., Wasser, U**., *EG-Recht der Gas- und Wasserversorgungstechnik*, Wirtschafts- und Verlagsgesellschaft Gas und Wasser mbH, Bonn, 1999.

[65] FeuVO's of other regions do not mention this explicitly and only require the flue exhaust to be positioned far enough from the roof or other building parts.

[66] For instance in Italy the cause of hindrance by flue gas outlets is regulated in the Codice Civile art. 844 - Immissioni: *"Il proprietario di un fondo non può impedire le immissioni di fumo o di calore, le esalazioni, i rumori, gli scuotimenti e simili propagazioni derivanti dal fondo del vicino, se non superano la normale tollerabilità, avuto anche riguardo alla condizione dei luoghi. Nell'applicare questa norma l'autorità giudiziaria deve contemperare le esigenze della produzione con le ragioni della proprietà. Può tener conto della priorità di un determinato uso."*

6.5.3 *Private labels*

Test institutes may also carry private labels, indicating that certain product or production standards have been met or that the product complies with certain national regulations. Some examples are shown below.

Figure 6-5
Examples of labels for flue systems