Preparatory Study on

Eco-design of CH-Boilers

Task 1 (FINAL)

Definition, Test Standards, Current Legislation & Measures

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Delft, 30 September 2007

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Contents

page

LIST OF TABLES

page

SUMMARY & CONCLUSIONS

This is the draft Task 1 report dealing with legislation, standards and voluntary measures regarding central heating boilers (incl. combi-boilers). Its scope is to identify whether appropriate primary performance and product definitions exist as well as appropriate test standards that could be used for Specific Measures following Annex II of the 2005/32/EC directive as well as Article 14 on Consumer Information. It gives an overview of different product categorisation options as background information and it discusses possible health standards that could be adversely affected by any measures (Art. 15 of 2005/32/EC). The largest part of the report is dedicated to an overview of existing legislation and voluntary measures regarding boilers at the level of the EU, the Member States and Third Countries outside the EU. For a number of countries and measures, where it is believed that they could be exemplary for (parts of) the methodology to be employed in Specific Measures, an in-depth technical overview was given. The analysis of legislation in extra-EU countries also was conducted with a scope of helping to assess how any Specific Measures could affect global competitiveness.

Main findings are that

- Appropriate performance definitions and test standards for evaluating primary energy use and CO_2 emissions of central heating boilers do <u>not</u> exist. The current steady-state efficiencies measured at full-load and 30% part load do not capture highly relevant variations in real-life of boiler (return) temperature, cycling behaviour, room temperatures, control strategies, etc. which are very much dependent on boiler-features. In fact, there are several sources implying that the real-life efficiency of boilers is some 13% lower than the measured steady-state efficiency. This may not seem much, but it means that the current test standard do not capture as much as half of the real-life generator losses of many types. Or, to compare it with policy goals: 13% of the CO_2-emissions of all heating equipment– which in turn is the source of around 40% of all CO_2-emissions in the EU—comes close to the EU Kyoto target.
- This conclusion is also apparent from the current building codes being developed for the *Energy Performance of Buildings* (EPBD), which all employ correction factors and far-reaching boiler models. In fact, the standard that comes closest to describing real-life behaviour is the *Boiler Cycling Method* in prEN 15136-4-1, but this is a building standard and not a product test standard (although it is similar to the ASHRAE 103-1993 approach).
- As a consequence, a direct, technology-independent comparison of products in the same performance category (i.e. load profile) is not possible. Given the history of very long lead times for standard development and given the deadlines set by the Eruropean Institutions for policy goals it is also highly unlikely that a test standard would be available for Specific Measures in time. A complicating factor in this is the fact that there is a huge amount of 30-40 overlapping standards for various types of boilers and/or parts of boilers. In other words, for the design of Specific Measures the same approach has to be followed as with the building standards, i.e. to develop correction factors and models on the basis of technical boiler-features –taking into account the harmonised building standards— and the few measurements that are available from the current EN product test standards.
- In parallel, appropriate test standards could be developed, e.g. 24 hour duty profiles comparable to the EN test standards for water heaters, featuring emulated room and boiler temperature behaviour as well as measurement of fuel use, auxiliary energy use and emissions.
- Regarding the emissions of especially pollutants linked to incomplete combustion (CO, CH_4, C_xH_y), studies show that that during actual operation (including cycling)

the real-life emissions are many times higher than from steady-state testing. Emissions of NO_x seem less susceptible to cycling and therefore the current steady-state testing may be acceptable.

- An exploration of existing health standards showed little grounds to expect any major conflict with Specific Measures. For space heating a possible exception to this rule may be the current requirements for CO-intoxiation, where there may be a methodological problem in view of the new building codes on air-tightness of the building shell. For water heating in combi-boilers the storage water temperatures that are indiscriminately recommended by health authorities as prevention of Legionellosis might be problematic. This report takes stock of current scientific insights and proposes a responsible and proportionate approach for future Tasks of the underlying study.
- There is a EU-wide mandatory measure regarding the energy efficiency of boilers in the form of the Boiler Efficiency Directive (BED, 92/42/EC) from 1992. It is currently not effective in removing the least efficient models from the market and will be superseded by Specific Measures implementing the Ecodesign of EuP Framework Directive 2005/32/EC. The BED also imposes a mandatory energy efficiency labelling scheme, which is no longer in force. NO_x and CO emission limit values for boilers and a NO_x classification are given in harmonised test standards, but they –apart from very lenient restrictions of CO emissions for safety reasons— are mandatory only at the level of some Member States (e.g. Italy). Other Member States are posing more stringent NO_x - and CO limits in their type approval (NL) but most are not setting any limits at all.
- Given the existence of the BED and the GAD (Gas Appliances Directive) mandatory Minimum Energy Efficiency Performance Standards (MEEPS or MEPS) are not allowed in individual EU Member States, following the Articles of the EEC Treaty concerning the free movement of goods in the internal market. Having said that, many Member States that are at an advanced level of implementing energy performance standards for buildings (UK, DK, DE, NL, etc.) are making it difficult not to use the most energy efficient boiler types in new buildings. Other countries, like Italy, fought (and lost) court cases with the European Commission trying to impose more efficient room-sealed boilers in new buildings through national legislation. Official 'voluntary' labelling schemes for boilers exist (e.g. *Blue Ange*l in DE, *HR* in NL, etc.) that are tied into national subsidy schemes, tax credits, guarantee funds for builders, etc..
- Regarding other Member State legislation, i.e. building codes, no fundamental conflict is expected and with appropriately designed Specific Measures there could be a synergy especially with the Building Codes, helping to simplify some of the procedures. Current building codes show considerable similarities regarding the assessment of the heat load of the house, distribution losses and the primary energy requirement of power generation, which are aspects that could wholly or partially be integrated in Specific Measures, supplemented by e.g. ratings from a labelling scheme.
- From a global perspective, the MEPS imposed by the Boiler Efficiency Directive cannot be seen as ambitious. The values are some 5-7% behind other countries like Japan, US, Canada, etc. which are imposing mandatory minimum efficiency values of 80-83% for gas-fired boilers (on Gross Calorific Value) and some 3-4% higher values (also on GCV) for oil-fired boilers. The Japanese Frontrunner Programme is the most stringent. On the other hand, there are also countries like South Korea and Australia that have MEPS of 70-72% (on GCV). The Chinese plans for MEPS on boilers are not known, but –if we take gas-fired instantaneous water heaters as a yardstick—it is not unlikely that China might follow the Japanese example.
- In contrast, emission limit values (ELVs) for NO_x and CO-emissions are still rare. The most stringent can be found in California (15-20 ppm).
- From the methodological perspective the US seem to be leading the way, with efficiency measurements based on the ASHRAE 103-1993 standard, which tries to construct a fairly realistic duty cycle from energy efficiency measurements in

steady-state part-load and full-load as well as losses during heat-up, cool-down and in stand-by. Having said that, the test standard does have some problems e.g. with modulating boilers, where it had to adjust because it was found two-stage modulating boilers in practice were still showing cycling operation most of the time. Also in the ASHRAE standard not all problems addressed for the EN standards are solved. Apart from the ASHRAE standard and a similar standard in Canada, most countries are still using the steady-state efficiency like in the EU. Almost all countries (exception Taiwan) are using the efficiency related to the Gross Calorific Value (or higher heating value) of the fuel and not –as in the EU- the Net Calorific Value. Regarding categorisation the US is using no categories —just 'boilers'— for residential appliances. For commercial appliances the US and most other countries in the world are distinguishing between oil-fired and gas-fired (no subcategories). Low temperature boilers are not nominated in legislation found around the world. A categorisation between condensing and non-condensing –as in the BED—was only found in the voluntary US Energy Star labelling program (minimum efficiency 85% for non-condensing, 95% for condensing types). Energy Star is mandatory for purchases of federal agencies.

- Regarding voluntary measures and building codes the EU seems to be leading the way with a host of tax credits, subsidies and other incentives. The focus seems to be on solar energy (for water heating) and heat pumps, but also for condensing (combi) boilers there are subsidy programmes in countries like Germany and Belgium. As regards the promotion of solar energy the only exception is China, where low-cost solar water heaters make up a substantial part of the market (11%). In the US, where solar water heating was heavily promoted in the 1970s and 1980s, seems much less enthusiastic especially about the economics and gives no incentives for thermal solar water heaters any more. Instead, the US is heavily promoting instantaneous ('tankless') gas-fired water heaters and boilers as the new energy efficient alternative. In Japan, the latest trend in energy efficiency is LHR (Latent Heat Recovery) where utilities (and government) expect a major contribution to 'Kyoto' from the push for condensing instantaneous water heaters and combi-boilers (>95% efficiency on GCV). Utilities have set a sales target of 3,5 million condensing units in Japan 2010.

1 INTRODUCTION

1.1 Scope

This is the draft final report on Task 1 of the preparatory study on the Eco-design of Central Heating Boilers for the European Commission, in the context of the Ecodesign of Energy-using Products directive 2005/32/EC.

Task 1 consists of three subtasks:

1.1 Product category and performance assessment

1.2 Test standards

1.3 Existing legislation,

1.3.1 in the EU

1.3.2 in Member States

1.3.3 outside the EU

These subjects are essential for the design of specific implementing measures following Annex II or —if this is not possible— general measures following Annex I of the 2005/32/EC (hereafter 'the directive').

Product category and performance assessment

As the directive is using CE-marking[1] as a tool it has to be very clear which definitions of products and product categories exist and can be used in legislation. Following Art. 2 of 2005/32/EC, certain categories can be excluded from the scope of measures on the basis of their commercial significance, their environmental impact or their improvement potential. The study of existing categorisation will also show the main functional performance parameter(s) of the product. They are a yardstick for any measure in the field of energy efficiency and emissions. As is mentioned in Art. 15, sub 5 –as well as in Annex II—of the directive the implementing measures shall have *'no significant negative impact on the functionality of the product, from the perspective of the user*'.

Test standards

The existence of harmonised test standards is relevant for a number of reasons. From a formal point of view and following the EU's 'New Approach' any product-oriented legislation should preferably refer to harmonised (EN) test standards. If no test standards exists, they should be developed –at the cost of considerable delay- or the measure should be accompanied by a technical annex in order to meet the requirements of Art.15, sub 7 of the directive (*Conformity assessment by market surveillance authorities*).

If test standards exist they should be appropriate, i.e. they should not only be accurate, reproducible and cost-effective but also be close enough to real-life to bring real savings and/or emission-reductions. Also, in as much as different test standards are used for what are perceived as different types of appliances, they should render it possible —as is indicated in the directive— to make a fair and correct comparison on the basis of the functional performance. This is relevant for correct consumer information (Art. 14 of the directive) and for fair competition in general. Furthermore, Art. 15, sub 4 of the

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[1] Art. 95 of the Treaty establishing the European Community.

directive states that *'health, safety and environment shall not be adversely affected'* by measures. Finally, the information on test and building standards provides input for Task 3 of the underlying study on 'Consumer behaviour and local infrastructure'.

Existing legislation

The study of enforced legislation and existing voluntary measures in the EU, individual Member States and outside the EU should provide insights where Eco-design measures already exist, what methodology is employed for testing and evaluation, what their status and ambition level is and finally –if possible—what the effect has been in transforming the market. From this it is expected that a number of lessons can be learned for the design of any new measures under the 2005/32/EC Directive regarding the issues mentioned. Art. 15, sub 3b explicitly asks the Commission to take into account '*the relevant Community legislation and self-regulation, such as voluntary agreements, which, ..., are expected to achieve the policy objectives more quickly or at a lesser expense than mandatory requirements*.'

In the same article, sub 4, the directive says that *'existing national environmental legislation that Member States consider relevant'* shall be taken into account. Also, an assessment of the impact of certain measures on the '*competitiveness of the industry, including SMEs and including the markets outside the Community*'(also Art. 15, sub 4) may be helped by knowing which legislation is already in place in the world. The impact analysis is the subject of Task 7 of the underlying study.

Task 1 activities and planning

The study started in February 2006 and is conducted by Van Holsteijn en Kemna BV ('VHK') with subcontractor BRG Consult for the market analysis in the Task 2 report. Information on Task 1 was retrieved through literature study and expert interviews. Specifically, drafts were discussed with a group of technical experts, selected by stakeholder associations (CECED, EHI, Orgalime, ANEC) but acting on a personal title. Meetings took place in April, July and September 2006 in Brussels. A project website www.ecoboiler.org is informing the stakeholders on the progress, including preliminary drafts, and provides access to the technical literature (log information on request). Throughout the whole process VHK is keeping close contact with the Commission's technical officer Matthew Kestner (DG TREN, D3). Having said that, the underlying report is strictly the responsibility of VHK and not to be perceived as the opinion of the European Commission nor any of the experts consulted.

The first final draft of the whole study, consisting of 7 tasks, is expected in the summer of 2007. The final report, after corrections and Commission approval, is due in November 2007.

Report structure

The draft Task 1 report contains 30 chapters. After this introductory chapter, Chapter 2 treats subtask 1.1 (product categorisation). Chapters 3 (EN Product Standards), 4 (Health standards) and 5 (Building standards) deal with subtask 1.2, whereas the other 26 chapters deal with existing legislation and voluntary measures first at EU level, then at Member State level and finally it discusses the legislation in countries outside the EU (Subtask 1.3).

Annex A gives the tapping patterns that may be relevant for combi-boiler testing. Annex B gives an overview of the mainly voluntary measures to promote efficient boilers in individual EU Member States. This overview was prepared by BRG Consult as part of their market study. Annex C gives a list of references.

The following paragraphs give a more detailed description of the contract requirements and the activities of the subcontractor per subtask. introduction per subtask, following the format defined in the tender document. Furthermore, they give an overviews of specific considerations from the MEEuP Methodology and discussions with the experts.

1.2 Product category and performance assessment (Subtask 1.1)

The tender document requires VHK to assess relevant product categories and performance parameters on the basis of

- Prodcom category or categories (Eurostat)
- Categories according to EN- or ISO-standard(s)
- Labelling categories (EU Energy Label, Eco-label, Energy Star label)

Categorisation on the basis of functional performance characteristic is the preferred route. The categorisation should ***not*** be based directly on the type of energy source or technology employed. The boundary conditions for implementing measures in the directive aim at maintaining or improving the functional performance, health & safety, economics for the consumer, etc. but are not referring to maintaining the status quo regarding energy sources or technologies employed.

Chapter 2 gives an overview of 18 classification principles currently employed. EN product and building standards give the most detailed classifications regarding fuel types and functional types, also including solar-assisted and electrical heat pump types. The PRODCOM classification was included, but does not add any new aspects. No additional categorisation could be derived from labelling schemes. An EU energy labelling scheme for boilers under directive 92/42/EC exists and was listed as one of the options.

Discussions with the expert group and the Commission are reported separately in the minutes of the expert group meetings (see www.ecoboiler.org).

1.3 Test Standards (Subtask 1.2)

According to the tender requirements the contractor should identify and shortly describe: the harmonised test standards;

- additional sector-specific directions for product-testing, regarding the test procedures for:
- the primary and secondary functional performance parameters mentioned above;
- resources use (e.g. energy, water, paper, toner, detergent, etc.) and emissions (SO_2, NO_x, particulate matter) during product-life;
- safety (gas, oil, electricity, EMC, stability of the product, etc.) ;
- noise and vibrations (if applicable);
- other product specific test procedures.

Apart from mentioning these standards, including a short description, it should also be reported which new standards are being developed, which other international standards could be relevant, which problems (e.g. regarding tolerances, etc.) exist and what alternatives are being developed or should be developed in particular in the context of mandate M341.

The relevant EN harmonised *product test standards* for boilers are addressed Chapter 3.

As requested the content of these standards is described and their current status (revisions) investigated, especially in view of performance and consumption characteristics.

Health standards are the main subject of Chapter 4. There are several health and safety aspects concerning combi-boilers (incl. water heating function) and/or regular boilers:

- Combi-boilers play a role in scalding (burns), for which also requirements are in place or being designed at Member State level.
- Legionellosis-prevention in storage combi-boilers
- Storage combi-boilers are a potential source of thermophylic bacteria[2].
- Gas-fired boilers placed inside the house are a potential source of CO-intoxication and
- there is the quality of the drinking water where e.g. the materials of water heater components in a combi-boiler are relevant.

Data on these subjects has been retrieved, but as yet not reported. Adverse effects of Specific Measures in general terms are not expected. The exception may be the legionellis-prevention, where current recommendations prohibit lower storage temperatures. Also the fact that the safety aspects of CO-intoxication by open heating systems has yet be given attention in the test standards may create some methodological problems. In the final report we will expand on other safety standards and also on the relevant standards for noise.

EN Building Standards for boilers are discussed in Chapter 5.

1.4 Legislation (Subtask 1.3)

The contractor is required to identify the relevant legislation for the product. This task can be subdivided in three parts:

1.3.1 Legislation and Agreements at European Community level

Apart from the obvious environmental directives (RoHS, WEEE, Packaging directive), this includes the GAD (Gas Appliances Directive), EPBD (Energy Performance of Buildings Directive), Energy Labelling Directive and others (Chapter 6). Public description of quality requirements (e.g. “proven design”, maximum failure rate) could not be found.

1.3.2 Legislation at Member State level

This section mainly deals with the implementation of EPBD at Member State level, or rather the national building regulations in which the water heater is evaluated as part of a holistic approach of a building’s energy efficiency. Furthermore, national type approval and voluntary labelling initiatives are discussed Chapters 7 to 23 in as much as they are relevant.

1.3.3 Third Country Legislation

as above, but now for legislation and measures in Third Countries (Chapters 24-31).

VHK has made a comprehensive study of the relevant legal documents and has reported extensively on the methodology and limit values found. During the data retrieval several national experts were consulted, but –as the legislation is covering a wide area where particular issues are easily missed—further input by national experts is very much welcomed.

Other sources of information include the preparatory SAVE study on Heating Appliances 2001. The existing and imminent legislation could provide valuable lessons for a possible methodology of implementing Ecodesign measures and especially the extra-EU legislation is a valuable help in assessing of measures on the impact on global competitiveness.

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[2] Bacteria that thrive at higher temperatures. Especially in Denmark there is a strong awareness on this point.

Chapters 7 to 30 of the report discuss the situation first for the EU and then country by country with each chapter covering one country or region.

2 DEFINITIONS & CATEGORIES

2.1 Performance

This Chapter gives an overview of CH-boiler categories and definitions found in the existing EU product and building standards. Some 18 principles for categorisation were found, which together give the policy makers an understanding of the technical diversity and the various features of boiler equipment in the EU. Combi-boilers are within the scope of the underlying study, although their sanitary water heating function will also at times be addressed in a parallel preparatory study on (dedicated) water heaters.

For the design of Specific Measures under the 2005/32/EC directive the objective is not to distinguish as many catgeories and subcategories as possible, but instead to restrict the number of categories to what is absolutely necessary and preferably only one. The guiding principle should be the product's performance, independent of the technology (incl. energy source).

A boiler is defined as an appliance designed to provide hot water for space heating. It may (but need not) be designed to provide domestic hot water or other functions as well.

The most obvious performance parameter of the boiler is the (nominal) heating capacity in kW, which should be sufficient to cover the space heating need of a dwelling or building on the coldest day of the year or rather the last decade (as defined in relevant test standards). But this is certainly not the only performance parameter and for that reason the boiler test standards also aim to establish what is the performance on the other days. For that reason, the test standards, discussed in the following chapters, distinguish between heating energy efficiency not only at full load, but also at 30% part-load and —on occasion— in stand-by/zero load. As will be argued in the following chapters, this is still a very crude approximation of what happens in real-life. Various studies have shown that the average load over the heating season is more in the range of 10% (e.g. 10 000 kWh / 5 000 h for an average 20 kW boiler). This not only due to the outdoor temperature variations over a heating season, but also due to over-sizing and —for a combi-boiler or boiler heating an indirect cylinder— due to sizing of the boiler primarily for the water heating function. Furthermore, the fixed low return (or average) boiler water temperatures for part-load operation, which are a very important parameter for flue gas energy losses and latent heat recovery, are rarely achieved in real-life.

Also the continuous steady-state operation that most (modulating) boiler types achieve during the tests at 30% load is not an appropriate reflection of real-life behaviour, where boilers have to meet space heating demands that are well below the maximum tundown ratio of the boiler and therefore operate in cycling-mode with extra energy losses and emissions during start and stop. In fact, study of new boilers in Germany show, that especially condensing boilers have a real-life efficiency that is 13% below the nominal part-load efficiency. In terms of generator energy losses, this means that the losses may be more than two times higher than indicated (e.g. 78 instead of 91% efficiency means more than twice the losses). In terms of emissions, especially those emissions related to incomplete combustion (CO, CH_4, C_xH_y) are many times higher during start/stop cycling than during steady-state testing.

What is also not tested is the effect of a thermostat setback during the night and part of the day. To recuperate from such a setback requires the boiler to operate at peak-load for a limited time. From mainly anecdotal evidence it is known that it is not wise from the energy point of view to lower the set-temperature too much and it is known that there are smart and less-smart boiler control strategies to deal with this. But there is no test method to evaluate this. In fact, the boiler's intelligence also in e.g. keeping the boiler water temperature as low as possible and at the same time keeping exactly the desired indoor temperature (avoid room temperature over/undershoot) is not tested at all, although these are (or could be) features incorporated in modern boilers.

Finally, what has only recently been tackled in SAVE studies and first draft test standards is the electricity consumption of fossil-fuel fired boilers (pump, fan, controls). This auxiliary energy (and its emissions for power generation) is still not part of the standard evaluation of a boiler's performance.

Ideally, the test standards would define several 24 hour load profiles, similar to the recently developed tapping patterns of water heaters and evaluate the boiler's performance in coping with these load profiles, monitoring all the relevant resources input (incl. auxiliary energy) and emissions and emulating (not fixing) the relevant outputs such as boiler water temperature and room temperature. Furthermore, for combi-boilers such 24h space heating profiles would allow simultaneous testing with the sanitary hot water tapping pattern.

Unfortunately, our conclusion –as will be elaborated in the underlying study— is that currently no such appropriate test standards exist to quantify the boiler's performance in real-life. This is not only the conclusion from the evaluation of the test standards in the following chapter, but it is also apparent e.g. from the fact that the drafts for harmonised building standards are dealing with all sorts of correction factors and boiler modelling issues that for a large part would not have been necessary if there were appropriate product test standards. Also in the case of the underlying study VHK has no choice but to follow the same approach if Specific Measures are to have effect in real-life and –given the very long time required to make new test standards—elaborate alternative (temporary) proposals that could be implemented within the deadlines posed by the European institutions. The (harmonised) building standards developed under the EU Energy Performance of Buildings Directive (EPBD) will provide some guidance in that respect, whereby the combination of harmonised building standards and current test standards will allow to largely adhere to the 'New Approach'.

2.2 Fuel type

- Gas *('gas-fired')***.** In the EN standard the type of gas is specified by the test gases (e.g. G20, G30), which includes non-methane gases propane/butane ('third family gases') and low-calorific gases. These test gases may vary per country/region and the test gas for which the boiler is tested has to be indicated on the boiler nameplate. A special type of gas-fired boiler is the ***back-boiler*** (UK only), which is placed in the fireplace usually with the appearance of a traditional wood-log fire.
- Oil *('oil-fired')*. The suitability of a boiler for a specific type of heating gas oil is determined by the specific mass —standard or extra light (EL)— and sulphur content (low sulphur is < 50 ppm). The specific mass requires adjustments to the nozzle/combustion control. A low sulphur oil sets some (minor) extra requirements for the lubrification of certain components.
- Coal *('coal-fired')*. Niche market. Coal-fired boilers can be classified by fuel type.
- Biomass**.** Biomass-boilers can be classified by biomass type (wood logs, wood pellets, hey, peat, etc.). For each biomass type the dimensions and water content may be important for the boiler construction.
- Electric boilers (electric resistance boiler, 'Joule effect' boilers). In as much as they can be classified as central heating boilers (not air heating, not local heaters) are a niche market. They can be subdivided into
  - electric storage boilers: boilers with a large storage capacity, usually working on night-tariff current. Can be characterized by voltage (230 or 400 V), capacity of

the heating element (in kW, usually 2-3 kW) and storage capacity (water volume or energy) and

- electric instantaneous boilers: range 2 – 14 kW, 230 or 400V, no or limited storage. Electric boilers of both types can be found in bi-valent systems, e.g. with heat pumps.

▪ Solar-assisted boilers. Solar collectors are mostly used for hot sanitary water heating, but –beyond a certain collector size—can also make a contribution (5-20%) to space heating in a bi-valent system (i.e. system using at least two heat generator types). Solar systems can be subdivided in several ways, e.g. by collector type (Flat Plat or Vacuum Tube), by configuration with a storage tank (separate 'hot top' or conventional tank, integrated collector storage) or the 'auxiliary' heating system, etc..

▪ Heat pump water heaters. Heat pumps can be used for air heating and cooling (usually referred to as 'air-conditioners') but also for water heating in central heating systems. In that latter case, they can be qualified as 'Central Heating Boilers' and are within the scope of the underlying study. Apart from the medium (air/water), heat pumps are characterized by the heat pump principle:

- Carnot cycle, with an electric compressor used as driving force
- Adsorption and
- Absorption (with pump and also without pump as a Diffusion Absorption type)

and the heat source:

- Ground Source Heat Pump GSHP (a.k.a 'vertical ground source heat pump'), where the primary heat exchange takes place 30 to 100 metres in the ground. Beyond 100 m depth these can also be characterized as 'geothermal heat pumps'.
- Groundwater Heat Pumps (GWHP), which use two ground water boreholes – one to mine groundwater and one to drain away the cooled groundwater. GWHPs are considered to achieve higher efficiencies due to the groundwater temperature being more constant.
- Sole Heat Pump (a.k.a. 'horizontal ground source heat pump'), where the heat exchanger coil is placed a few meters below the surface (e.g. in a garden).
- Outside Air Heat Pump, where a fan passes the ambient air over the heat exchanger
- Ventilation Air Heat Pump, where a the heat pump uses the ventilation air from the house. Normally –given the low capacity—used for hot water heating and not space heating (except in low-energy houses).
- Solar Collector Heat Pump. Heat pump using the water from a collector placed on the roof. The appearance is similar to a solar collector, but heat is used (in the heating season) at much lower temperature levels.
- Other heat sources, such as waste water or waste heat.

The efficiency of a heat pump, usually referred to as COP (Coefficient of Performance), highly depends on the temperature level of the heat source and the desired temperature level of the heat output. COP refers to a single steady-state condition (at Tsource and Tsink described in the standards) and is not in itself adequate to describe real efficiency over the heating season. For this the seasonal efficiency is deemed more appropriate (see Task 4 chapter 10.4). Furthermore the primary energy conversion factor of power generation should be taken into account for electric heat pumps [3]. Heat pumps also exist as 'modulating' (with inverter) or 'on/off'. For environmental reasons (Greenhouse Gas Effect), a characterisation of heat pumps by refrigerant may also be useful.

Biomass and coal-fired boilers are out of scope for the Ecodesign study.

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[3] See also the ecologic analysis of heat pump use in Germany by Umweltbundesamt (Federal Environment Agency): „Electric Heat Pumps – a renewable energy source?", Umweltbundesamt 2007 (German) http://www.umweltdaten.de/publikationen/fpdf-l/3192.pdf

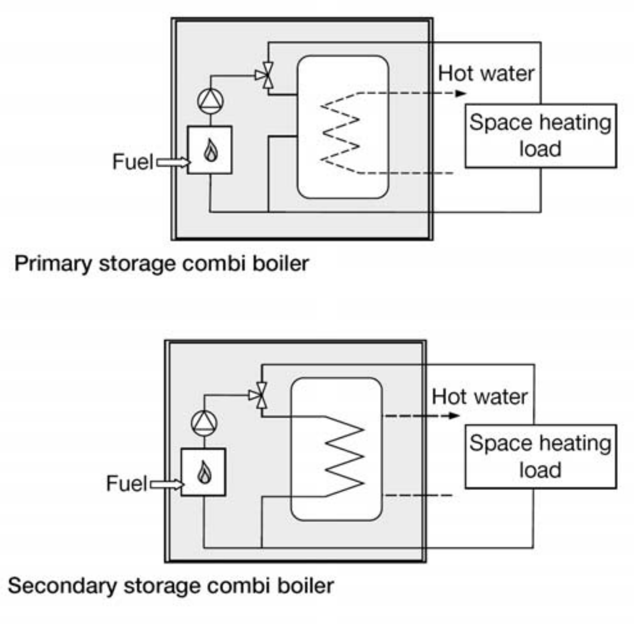
2.3 Functionality (Output)

Refers mainly to the ability of the boiler –as submitted for CE-testing— to provide hot sanitary water. Also in niche markets it can refer to the cooking functions and finally there are boilers that not only produce heat, but also electricity to be fed back into the grid or used in the house.

In that sense the following classification applies:

- Regular boiler: A *boiler* which does not have the capability to provide domestic hot water directly (i.e. not a *combination boiler*). It may nevertheless provide domestic hot water indirectly via a separate hot water storage cylinder.
- Combination boiler ('combi'): A boiler with the capability to provide domestic hot water directly, in some cases containing an internal hot water store. The SAP and EN standards add the following qualifications:
  - Instantaneous combination boiler: A combination boiler without an internal hot water store, or with an internal hot water store of capacity less than 15 litres storage combination boiler
  - Storage combination boiler: A combination boiler with an internal hot water store of capacity at least 15 litres but less than 70 litres, OR a combination boiler with an internal hot water store of capacity at least 70 litres, in which the feed to the space heating circuit is not taken directly from the store. If the store is at least 70 litres and the feed to the space heating circuit is taken directly from the store, treat as a CPSU. Storage combination boilers can be subdivided into
    - Primary, where a primary water store contains mainly water which is common with the space heating circuit and
    - Secondary a secondary water store contains mainly water which is directly usable as domestic hot water. See also classification by storage facilities

Figure 2-1
Primary and secondary store combi-boilers



Please note that in BED-market study by BRG Consult and other sources the above qualifications are not always mutually exclusive: 'Instantaneous' is also applied to 'storage combination boilers', whereby the criterion for instantaneous is that every draw-off provokes a burner action to guarantee the best hot water comfort.

Furthermore, for cooking appliances SEDBUK defines:

- Range cooker with boiler for space heating This type provide an independent water heating function for space heating in addition to the cooking function. There are two design variations:
  - twin burner range cooker/boiler – an appliance with two independently controlled burners, one for the cooking function, one for the water heating function for space heating
  - burner range cooker/boiler – an appliance with a single burner that provides a cooking function and a water heating function.

And finally, for boilers that also deliver electricity there is the

- Combined Heat and Power boiler (CHP). Device that is capable of delivering hot water for space heating (and possibly sanitary water heating) and also electricity to the grid or the building installation. CHP-boilers can be subdivided in size (e.g. mini-CHP for larger buildings, micro CHP for) and type (gas/oil motor, Stirling or fuel cell).

CHP water heaters are out of scope for the Ecodesign study. Range cookers combined with water heating are not in the scope of the market study (niche market), but the combination with the cooking function may be explored in Task 6 (design options).

2.4 By storage configuration and capacity

Boilers can have a storage facility for

- ***Primary store*** of CH-water and
- ***Secondary store*** of sanitary hot water

In general, storage facilities are used to solve a mismatch between heat input and heat output. For primary stores the mismatch may be that the heating system requiring a continuous or semi-continuous heat at a lower power level than the burner can provide. For secondary stores the mismatch is between a user that requires instantaneous hot water and a burner plus heat exchanger that require some time to heat up or that may not be powerful enough to provide the required hot water comfort.

A second function of buffers may be in bi-valent systems, where the output of multiple heat generators (e.g. solar and gas) with different characteristics are brought together to provide one single output performance.

Primary store combi-boilers can roughly be subdivided into:

- No primary store (water content of heat exchanger smaller than ca. 5 l.)
- No primary water storage tank, but merely a boiler with high water content and/or mass.
- Integrated thermal store: An integrated thermal store is designed to store primary hot water, which can be used directly for space heating and indirectly for domestic hot water. The heated primary water is circulated to the space heating (e.g. radiators). The domestic hot water is heated instantaneously by transferring the heat from the stored primary water to the domestic hot water flowing through the heat exchanger. A schematic illustration of an integrated thermal store is shown below. Additionally from SEDBUK: For an appliance to qualify at least 70 litres of the store volume must be available to act as a buffer to the space heating demand. If the volume requirement is not met, then the device may be treated as a 'hot water only thermal store'.
- Hot water only thermal store: A hot water only thermal store is designed to provide domestic hot water only and is heated by a boiler. The domestic hot water is heated by transferring the heat from the primary stored water to the domestic hot water flowing through the heat exchanger, the space heating demand being met directly by the boiler.

- Combined primary storage unit (CPSU): A single appliance designed to provide both space heating and the production of domestic hot water, in which there is a burner that heats a thermal store which contains mainly primary water which is in common with the space heating circuit. The store must have a capacity of at least 70 litres and the feed to the space heating circuit must be taken directly from the store. Note: If the store is a different appliance from the water heater (ie contained within a separate overall casing) the system should be treated as a water heater with a thermal store as described above.

Figure 2-2. Integrated Thermal Store (left) and 'Hot water only' Thermal Store (right)

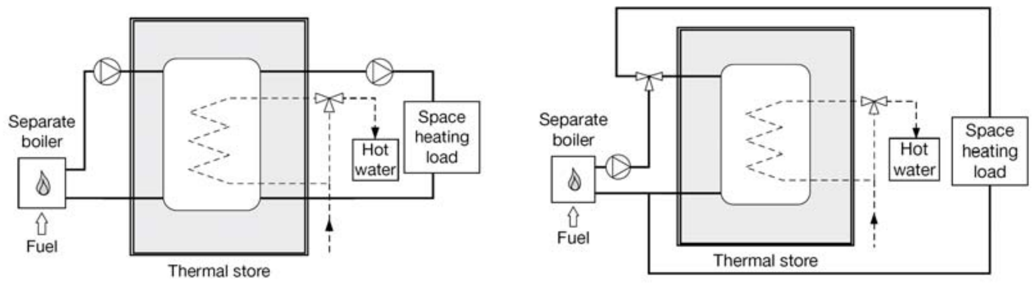
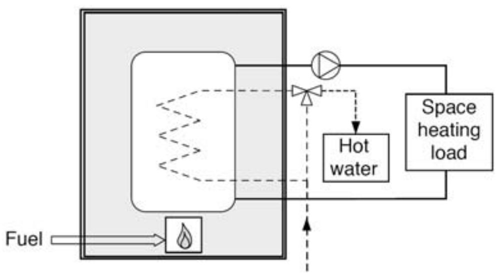


Figure 2-3. CPSU with coil



Secondary store options are:

- No secondary store (a.k.a. 'instantaneous combi'). In the instantaneous boiler the sanitary hot water is led through a coil that is heated directly by the burner. There will be a penalty in terms of waiting time
- Keep hot facility. Facility in an instantaneous boiler (<15 litres) whereby water within the boiler may be kept hot while there is no demand. The water is kept hot either (i) solely by burning fuel, or (ii) by electricity, or (iii) both by burning fuel and by electricity, though not necessarily simultaneously. Its function is to realize short waiting time.
- Instantaneous storage combi. The storage tank of this storage combination boiler may be any size. The sensor is placed near the cold water inlet and with (almost) every draw-off results in burner action to keep up with the hot water demand. Two design variations for heating coils exist: A conventional single-coil version and a double-coil version. The double-coil version can be used e.g. as a 'hot top' solar water tank, whereby the lower coil is used by water from the solar collector to (pre) heat the sanitary water and the top coil is used to lift the output hot water to the required final temperature (if necessary). But the double-coil system can also be used with a mono-valent system (e.g. gas-fired combi), whereby the upper coil is direct-acting in case of hot water demand and the lower coil is used to pre-heat the water to a lower temperature level —e.g. to have a higher boiler efficiency and lower tank standby losses— when there is no hot water demand. In Germany, a dual-coil solution is known as a design variation of the *'Schichtenspeicher'*(layered storage tank) as opposed to the traditional single coil '*Rohrwendelspeiciher*'. In solar systems with auciliary heating the double-coil vessel is usually referred to as

'bivalenten Speicher' as opposed to *'monovalenten Speicher*'. Conventional single coil versions may have a volume as low as 25-35 litres, e.g. to help if there is a large draw-off e.g. for a bath, up to 500 litres or more. Double-coil versions would normally be at least 100-150 litres (typical 200-400). Apart from heating coils, there is another solution called 'tank-in-tank', whereby the corrugated secondary storage tank is placed in a primary tank. Reportedly this leads to a larger heat exchanger surface with added advantages e.g. in heat-up time.

- Non-instantaneous storage combi. The storage tank of this storage combination boiler may be any size but is usually from 45 litres onwards[4]. This storage combi is not triggered immediately by the hot water demand, but relies on the stored volume to provide the hot water, whereby the water is heated when it is most convenient/efficient for the heat source. For an electric boiler this may be at night (low-tariff) and for a gas- or oil-fired burner this may be through a few bursts a day. Furthermore, the average water tank temperature is lower, which gives lower standby losses and gives the possibility of low temperature boiler operation (which also boosts efficiency). It requires that the consumer accepts that there is a limit (albeit high) on the water use and that –mainly towards the last 20% of the storage capacity— there may be a drop in temperature. On the up-side there is the convenience of hardly any waiting time.

The table below gives an overview:

Table 2-1. Boiler definitions relating to sanitary hot water production, by storage & lay out

Function	EN/SAP Definition
REGULAR BOILER with Indirect Cylinder - with external secondary store (sold separately) - with aux.heater for summer mode - without aux. heater for summer mode	Regular boiler with unvented hot water storage tank
COMBINATION BOILER ('combi')	Combi(nation) boiler
- without secondary store (< ca. 5 litres)	Instantaneous combi boiler
- heated by burner (flow-through heat exchanger)	Instantaneous combi boiler
- heated by primary store (secondary coil in primary tank)	
- primary store heated indirectly (through primary coil)	
<70 litres, used for hot water only (CH by burner)	hot water only thermal store
>70 litres, used for CH and hot water	integrated thermal store
- primary store heated directly (by burner)	
>70 litres, used for CH and hot water	Central Primary Storage Unit CPSU
- with secondary store <15 litres	Instantaneous combi boiler with keep-hot ('preheat') facility
- with secondary store >15 litres	Storage combi boiler
- direct-acting ('ínstantaneous')	
- delayed action ('non-instantenuous')	
BI-VALENT SYSTEM (two heat sources, e.g. Solar/gas, heat pump/electric, dual temperature gas or oil)	Bi-valent system
- two secondary store(s) or storage zones (dual coil)	bi-valent storage tank
- one secondary store and instantaneous aux. heater	
- without secondary store, hot water from coil in primary store(s)	

Secondary stores can also be subdivided into ***vented*** and ***unvented,*** depending on whether or not the content of the storage vessel is in contact with the atmosphere. In practice more than 90% of new EU storage tanks for hot sanitary water are unvented, for reasons of health. Vented tanks may still occur in the UK or in single-point applications such as in kitchens, mobile homes, caravans, etc..

[4] Compare prEN 50440

2.5 Water heater flue gas/air intake system

This classification only applies to gas-fired appliances (dedicated water heaters and combi-boilers). The classification is characterised by one letter (B or C) and two digits (B_{xx} or C_{xx}).

Both *Type B* and *Type C* use a chimney for the flue gases[5], but

- Type B takes the combustion air from the indoor water heater room and
- Type C takes the air from the outdoors.

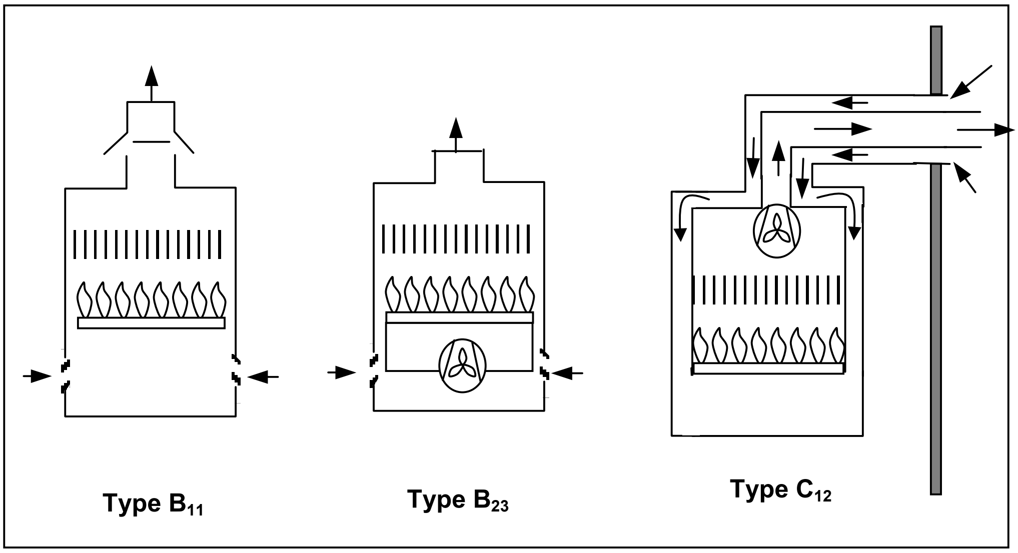
With Type B there is an open connection between the burner and the inside of the house ('open system'), whereas Type C is 'room-sealed'. With Type B, because combustion gases could come inside the house, the EN and local standards specify health and fire requirements for e.g. carbon monoxide and C_xH_y emissions as well as the ventilation of the water heater room ('well-ventilated').

With *Type B* appliances the first digit indicates whether (B_{1x}) or not (B_{2x}) the flue gas duct is preceded by a flue gas damper. With *Type C* appliances the first digit indicates the configuration of the air intake and flue gas ducts: horizontal concentric ducts (C_{1x}), vertical concentric ducts (C_{3x}), side-by-side vertical ducts (C_{4x}), ducts leading to different pressure zones outside the building (C_{5x}), boilers tested without ducts (C_{6x}) and boilers connected to negative pressure chimney for the flue gases and to another pressure zone for the air intake (C_{8x}).

A boiler can be suitable for more than one configuration, e.g. a denomination *'B23, C13, C33, C43, C53'* is quite common for one and the same boiler. Please note that the denomination is a mandatory part of the boiler's nameplate.

The second digit indicates the presence and the position of the combustion air/flue gas fan: '1' is no fan, '2' is with a fan after the burner but before the flue gas damper, '3' is a fan positioned before the burner (a.k.a. 'pre-mix') and '4' is a flue gas fan positioned inside the chimney after the flue gas damper. Basically a fan-less boiler is allowed only for open systems with a flue gas damper, i.e. Type B_{11} (including type B_{11BS}, which is a B_{11} with a thermostatic safety device).

Figure 2-4. Examples flue type/air intake types (see also next chapter)



[5] Systems that do not use chimneys for flue gases are 'Type A' and generally not allowed for CH-boilers.

2.6 Burner flue gas/air intake configuration

For burners, the EN standards distinguish between

- ‘forced draught’, i.e. meaning that there is an air/flue gas fan somewhere before or after the burner that regulates the air intake, or
- ‘atmospheric’, i.e. where the air intake is not fan-assisted. The burner attracts the required quantity of air from its surroundings and only the quantity of gas is regulated. As mentioned, atmospheric burners can only be applied in Type B11 burner/water heater body configurations.

2.7 Condensation

Depending on the total heat exchanger surface, the resistance to corrosion and the resistance to certain temperatures, the heat exchanger of a gas- or oil-fired water heater or combi can technically be seen as standard, low temperature or condensing.

The boiler efficiency directive (BED, 92/42/EC) defines

- ‘standard boiler’: a boiler for which the average water temperature can be restricted by design,[6]
- ‘low-temperature boiler’: a boiler which can work continuously with a water supply temperature of 35 to 400°C, possibly producing condensation in certain circumstances, including condensing boilers using liquid fuel,
- ‘gas condensing boiler’: a boiler designed to condense permanently a large part of the water vapour contained in the combustion gases.

Test standards also indicate a differentiation on the basis of flue gas temperature, but — following discussions in the expert group— this was found not to be in line with current practice. Also the definition of ‘low temperature boiler’ as given above was found confusing. The definition, in conjunction with the relevant current test standards, would lead to the conclusion that a low temperature boiler always requires a provision to collect and conduct the condensate. However, all experts agreed that in practice this is never the case.

In fact, European boiler manufacturers now propose the following description for distinguishing between the different boiler types:[7]

- A condensing boiler always has a nozzle for condensate draining
- A non-condensing boiler never has a nozzle for condensate draining and, for completing this listing,
  - In case of a low temperature boiler the heating system return temperature may be 40°C or lower and
  - In case of a standard boiler the heating system return temperature must be higher than 40°C.

Note: In the Boiler Efficiency Directive 92/42/EC the classification is used to denominate three energy efficiency classes, each with a minimum energy efficiency performance, but also with their specific requirements on boiler temperatures. The Directive relates to the space heating function, but could as well be used for water heaters.

In many countries the category ‘low temperature water heater’ did not exist before the Boiler Efficiency Directive was introduced in 1992 and water heaters were either ‘condensing’ or ‘non-condensing’. For instance, the current UK SAP still defines:

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[6] Also the directive defines ‘back-boiler’: a boiler designed to supply a central-heating system and to be installed in a fireplace recess as part of a back boiler/gas fire combination,

[7] pers. Comm.. Mr. Hormel, Viessmann, July 2006.

- condensing boiler designed to make use of the latent heat released by the condensation of water vapour in the combustion flue products. The water heater must allow the condensate to leave the heat exchanger in liquid form by way of a condensate drain.
- Water heaters not so designed, or without the means to remove the condensate in liquid form, are called 'non-condensing'.

2.8 Burner power control system

On/off boiler: A boiler that only has a single fuel burning rate for space heating. This includes appliances with alternative burning rates set once only at time of installation, referred to as range rating.

Modulating boiler: a boiler with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

2.9 Power class (in kW, residential/commercial)

For gas- or oil-fired boilers (including combis) the classification according to boiler power class may be relevant:

- The EN standards distinguish between <70, 70-300, 300-1000 kW and 1- 10 MW.
- The Boiler Efficiency Directive distinguishes between a class of 4-400 kW and above 400 kW.
- Market statistics distinguish between 'residential' and 'commercial', whereby the exact split varies per country. In Italy it is at 35 kW and in France at 70 kW.

2.10 Burner/water heater configuration

The EN standards make a distinction between

- burner/boiler assembly, where there are different requirements (and CE-marking tests) for the jet burner and the assembly of boiler body plus burner, and
- an integrated boiler, where the burner is not sold/tested separately.

2.11 Boiler water temperature control:

- Fixed (manual setting at installation) within a certain bandwidth, on/off controlled by the room thermostat. For rooms without room thermostat, the temperature control may be supplemented by thermostatic radiator valves or separate electronic systems with or without optimiser.
- Modulating *(a.k.a. systems with 'room compensator')*: PID-type of control on a special modulating room thermostat. The room thermostat is usually typical for a brand. For rooms without room thermostat, the temperature control may be supplemented by thermostatic radiator valves or separate electronic systems with or without optimiser.
- Weather controlled *(a.k.a. systems with 'weather compensator')***:** an outdoor sensor is setting the operating point for the boiler temperature, along a curve (set at installation) that istypical for the lay-out and type of heating system. This system is often combined with thermostatic radiator valves or separate electronic systems with or without optimiser.

2.12 Burner combustion control:

Burner combustion control in principle applies to all fossil fuel fired boilers and combis. The following types can be distinguished:

- Forward control loop: ‘pneumatic control’ whereby the air-fuel ratio is determined with the venturi principle. Air factor is determined by gas flow rate. This is the most common today
- Backward control loop. The air factor is determined on the basis of the combustion (ionisation sensor) and/or the combustion products (e.g. CO sensor).
- Forward & backward control: Based on a combination of the above.

2.13 Mounting position

In market statistics there can be a distinction between:

- Floor-standing and
- Wall-hung water heaters and combis

Wall-hung boilers are typically lighter (30-60 kg), whereas floor-standing boilers typically weigh over 100 kg.

2.14 Efficiency rating

As mentioned, the Boiler Efficiency Directive 92/42/EC distinguishes three classes of boilers (condensing, low temperature, standard) with a minimum efficiency at a specified boiler water temperature and within each class there is a ***star rating*** for every 3% points that the efficiency is above this minimum. The star rating system was repealed by the Ecodesign Directive so it no longer formally exists.

Note that the efficiency values in 92/42/EC –and the EN standards that were changed accordingly—are given on the Net Calorific Value of the fuel and not –as is typically required in building energy performance regulations—on the Gross Calorific Value.

NCV (Net Calorific Value of fuel, *a.k.a. ‘lower heating value’*)

The NCV of a fuel is the energy created by burning one litre of fuel oil or one m³ of gas. Generally speaking, the NCV of one litre of fuel oil or one m³ of gas is about 10 kWh (the amount of energy corresponding to an output of 10 kW during one hour). Because boiler efficiencies based on NCV do not take account of the latent heat (see GCV) the efficiencies of the most-efficient condensing boilers are typically over 100% (theoretically up to 111% for gas-fired boilers and ca. 106% for oil-fired boilers).

GCV (Gross Calorific Value of fuel, *a.k.a. ‘higher heating value’*)

The GCV is equal to the NCV plus the latent heat of the water vapour produced by combustion. The energy contained in this water vapour is equivalent to 10% of the NCV of natural gas (6% for oil): the GCV is thus equal to about 110% of the NCV. By condensing this water vapour (i.e. by cooling it to a temperature of 58°C for natural gas or 46°C for oil), it is possible to recover this heat, thereby increasing the thermal efficiency of the boiler accordingly (see condensing boiler). The maximum theoretical boiler efficiency on GCV is 100% and thereby gives a more familiar picture of the energy saving potential.

2.15 Emission rating (NO_x, CO)

EN standards define a rating for NO_x and CO emissions of combi-boilers at full load. Also at national level there are (much more stringent) ratings in this respect. The EN classification hardly provides a distinguishing feature as most water heaters are in the best emission class. For this reason the rating is used in manufacturer's documentation only very seldom.[8]

2.16 Ignition type

- electronic (through glowing plug or spark plug) or
- pilot flame (almost extinct in new boilers, forbidden to install according to the French RT2005 in new and renovated buildings in France)

2.17 Pump type

Pumps can be

- Autonomous (not integrated in the boiler and no link to the boiler control) or
- Integrated in the boiler and thereby (also) controlled by the boiler-CPU

Furthermore, there is a distinction between pumps with:

- Variable speed
- Discrete speed steps and
- Fixed speed (set at installation)

Variable and discrete speed pumps usually control the flow rate on the basis of the resistance in distribution and emitter system.

There is a voluntary energy efficiency labelling scheme by EuroPump for central heating pumps using the ***'A-G'*** rating and the basic lay-out of the EU Energy Label.

2.18 Materials

A classification used in the BED Market study is:

- Steel/iron (incl. stainless steel)
- Copper
- Aluminium

The EN standards give a more specific range of materials to be used, but this is not normally used for classification.

2.19 Statistics classification

The official Eurostat PRODCOM classification of boilers for trade and production statistics is:

PRODCOM nr.	Description
28.22.12.03	Boilers for central heating using gas
28.22.12.05	Boilers for central heating using fuel (oil)
28.22.12.07	Boilers for central heating, using other types of energy
28.22.12.00	Boilers for central heating, other than those of HS 8402

[8] For oil-fired boilers the emission limit values of NO_x /CO are 185/110 (class1), 120/80 (class 2) and for class 3 120/60 mg/kWh (class 3). For 'forced draught'gas-fired boilers in EN-303-3 the emission limt values for NO_x are 170 mg/kWh (class 1), 120 mg/kWh (class 2) and 80 mg/kWh (class 3). PrEn 13286, for larger gas-boilers gives 5 NO_x classes: 260 mg/kWh (class 1), 200 mg/kWh (class 2), 150 mg/kWh (class 3), 100 mg/kWh (class 4) and 70 mg/kWh (class 5).

3 EN PRODUCT STANDARDS

3.1 Introduction

Given the New Approach of the EC, whereby the legislation has to refer to EN standards, and given the fact that the amendment of these EN standards can take many years, the collection of existing product test standards for central heating boilers is very important.

For oil- and gas-fired heating boilers and burners there are over 30 EN product test standards and amendments (excl. referenced standards) covering roughly 2000 pages. Heat pumps and solar heating add on to that. Standards –e.g. EN 303— can consist of 7 parts and each part can have up to 6 amendments having the size of the original standard.

When comparing the EN test standards it turns out that in fact there is a considerable overlap. Although on one hand this makes the review of the content easier, it also makes it more difficult to follow the various amendments, which are usually different per standard, and to check consistency.

The current EN standards for heating boilers and burners for these heating boilers, are split up

- by flue gas system (type C room-sealed, type B without a fan, type B with forced draught burner),
- by capacity class (up to 70 kW, 70-300 kW, 300-1000 kW) and
- by fuel (oil, gas).
- by configuration (boilers, combi-boilers, boiler-burner assemblies and separate burners)
- by condensing, low temperature and non-condensing boilers

Furthermore, also the different Commission mandates lead to different amendments over periods of more than 10 years. There is the Gas Appliance Directive 90/368/EC (Mandate 105) from 1990 that still today –in 2006— is leading to new test standards and amendments. There is the Boiler Directive 92/42/EC from 1992 that is now incorporated in most relevant standards.

In view of the above it is strongly recommended to the Commission and other relevant bodies to investigate the possibility of making one consolidated test standard that would cover all types of gas- and oil fired boilers. Not only could this cut 80 to 90% of the paperwork, but it would also strengthen the quality of any 'New Approach' legislation in the field of central heating boilers.

The following paragraphs summarize and give details of the most relevant existing standards. Where applicable, it is indicated how particular standards or parts of standards can be relevant for Ecodesign. At the end of this chapter there is a summary and first validation.

The following table gives an overview of the standards discussed.

Table 3-1. Overview Boiler EN Test Standards

GAS-FIRED					
	Type B	**Type B & C**			**Type C**
	incl. not fan-assisted, atmospheric	**fan-assisted ('forced draught burner')**			
burners	**Boilers**		**combi**	**condensing**	**boiler**
EN 676	EN 297	EN 303-1 (general) *NEW*: prEN 15502-1 EN 303-3 (<70 kW) EN 656 (70-300 kW) prEN 13826 (300-1000 kW) prEN 303-7 (< 1000 kW)	EN 625	EN 677	EN 483 (< 70 kW)
OIL-FIRED					
EN 267	(EN 1)	EN 303-1 EN 303-2 EN 303-4 EN 304	EN 303-6	EN 15034 (<1000 kW)	EN 15035

3.2 NPR-CEN/TR 1749:2006 Classification of gas appliances by type

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. Roughly the same type designation applies to oil-fired appliances. 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.

It is not a standard, but the main table of this report is given here for a better understanding of the standards discussed hereafter.

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.

Table 3-2 .Classification of Appliances and flue gas systems

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

* = not admissible in Germany or empty category

3.3 EN 297 Atmospheric gas boilers without fan, <70 kW

Full title: EN 297:1994. Gas-fired central heating boilers - Type B11 and B11BS boilers fitted with atmospheric burners of nominal heat input not exceeding 70 kW.

(most recent amendment EN 297:1994/A6:2003)

Summary:

This standard specifies the requirements and test methods for the construction, safety, fitness for purpose, rational use of energy, classification and marking of gas-fired central heating boilers hereafter referred to as "boilers". This standard applies to type B11 and B11BS boilers

- fitted with atmospheric burners;
- that use gases corresponding to the three gas families and to the pressure stated in 4.1.4;
- that have a nominal heat input not exceeding 70 kW (on net calorific value);
- where the temperature of the heat carrier (water) does not exceed 95°C during normal operation;
- where the minimum water-side operating pressure does not exceed 6 bar.

Reference to directive: 90/396/EEG PBC 142:2005.

Details:

This standard applies to all boilers of type B and describes basic features and safety measures.

Amendment prA4:2003 adds the type definitions B1 to B5 and sub-indices B11 to B33. It mentions systems with and without draught diverter as well as fan-assisted burners/boilers and describes varies safety devices and controls for atmospheric boilers. Also in EN 297:1994/prA4:2003 we find emission limit values for CO in the flue (<0,1%). The ignition sequence and gas/air mixture conditions plays a major role in testing safety (e.g. incomplete combustion) and CO concentration.

Amendment prA6:2002 applies to type B11 and B11BS boilers (partially) placed outdoors and adds requirements on protection against frost and rain.

Ecodesign relevance: Limited. At best it provides boundary safety provisions to take into account and sets boundaries on possible weight reduction of type B boilers.

3.4 EN 303-1 Boilers with forced draught burners – general requirements

Full title: EN 303-1:1999. Heating boilers - Part 1: Heating boilers with forced draught burners - Terminology, general requirements, testing and marking.

(most recent amendment EN 303-1:1999/A1:2003)

Summary:

Applies to heating boilers with burners using fans up to a nominal heat output of 1000 kW. They are operated, either with negative pressure (natural draught boiler) or with positive pressure (pressurized boiler) in the combustion chamber, in accordance with the boiler manufacturers instructions. This document specifies the necessary terminology, the requirements on the materials and testing of them, and marking requirements for heating boilers. Particular requirements for boilers which can be used with open vented systems are contained in prEN 303-4. The requirements of this standard apply to heating boilers which are tested on a authorized test rig.

Reference to: 89/106/EEG

Prepared by CEN/TC 57

Details:

This standard does not specify minimum efficiency or emission limits. It sets minimum requirements for welded joints, materials, minimum wall thickness. In many respects it is very specific, e.g. mentioning a minimum wall thickness of carbon steel of 4 mm for the walls of a combustion chamber (<100 kW), whereas for copper this is 2 mm and for cast-iron at least 3,5 mm, etc.. It prescribes tests for tensile strength (ISO 185), chemical analysis, Brinell hardness (EN 10003-1) and Izod impact.

Further requirements (par. 4.1.5) regard:

- Venting of the CH circuit
- Cleaning of heating surfaces
- Flame inspection
- Water tightness
- Water connections (G ½ for heat outputs up to 70 kW, G3/4 for >70 kW)
- Connections for control and indicating equipment, and safety thermostat.
- Burner matching dimensions (EN 226 plus prescriptions for holes/threads for burner mounting)
- Thermal insulation (combustable insulation allowed if the materials is temperature resistant up to 120°C an equipped with a non-combustible cover, proper safety devices, etc.)
- Surface temperature, e.g. knobs max. 35 (metals), 48 (porcelain) or 60 K (plastics) above ambient. Also maximum temperatures for sides, top and floor (80 K + ambient)
- Soundness of the combustion system:
    - With a negative pressure in the combustion chamber, air leakage 1% at 0,05 mbar at max. output.
    - With a positive pressure, air leakage 2% at 1,2 times operating pressure
- Safety temperature limiter, control thermostat.
- Electrical safety, etc.

Chapter 5 prescribes test rigs and safety tests, mainly for pressure. Chapter 6 describes boiler data plate requirement. Chapter 7 prescribes the nature of the technical documentation and the operating instructions. Annex A mentions that the EN 303-1 standard is in conflict with the Swedish Ordinance for Pressure Equipments (Ch. 3, section 1, Ordinance AFS 1994:39). The Annex A mentions, as EN 303-1 does not fall under any Directive of the EC, that this A-deviation is valid in Sweden until it is removed.

Annex B (informative) mentions that the Conformity evaluation 'should be carried out if necessary by a third party on the basis of initial type testing, initial inspection of factory and factory production control and continuous surveillance... '.

Ecodesign relevance: Limited. At best it provides boundary conditions on design regarding safety and sets boundaries on possible weight reduction of type B boilers.

Amendment EN 303-1:1999/prA1:2002 is of interest, because it adds definitions related to condensation and low-temperature boilers, e.g. 'low-temperature boilers are considered to be designed to give rise to condensation' (par. 4.1.5.18). Also defines when a condensate discharge is necessary for low-temperature boilers, i.e. if it

- impairs safety or correct operation
- results in spillage from the appliance
- causes deterioration of materials.

not to have one. Minimum inner pipe diameter of discharge shall be at least 13 mm (par. 4.1.6.3). Furthermore, the paragraph 4.1.6.4 requires that for low-temperature boilers, corrosion resistant coatings shall be designed in a way that they show no sign of damage after the pressure tests. Note that compared to the endurance test for low-temperature oil-fired boilers this is very lenient (see EN 303-2).

Ecodesign relevance: Basically it states that all Low Temperatures boilers that are indeed operated at low boiler temperatures should have the same condensate drainage as condensing boilers.

3.5 EN 303-2 Boilers with forced draught burners – atomizing oil burners

Full title: EN 303-2:1998 en. Heating boilers - Part 2: Heating boilers with forced draught burners - Special requirements for boilers with atomizing oil burners.

(most recent amendment EN 303-2:1998/A1:2003)

Summary:

Is applicable to heating boilers in accordance with prEN 303-1 up to a nominal heat output of 1000 kW and prEN 303-4 up to a nominal heat output of 70 kW with atomizing oil burners in accordance with EN 267 which are designed for operating with liquid fuels. The requirements of this standard apply to type testing to heating boilers which are tested on a test rig in accordance with the test code given in EN 304. This standard specifies the necessary heating technical requirements for heating boilers with liquid fuels.

Reference to directive: 89/106/EEG

Prepared by CEN/TC 57

3.5.1 Useful efficiency, excess air, flue gas installation of LT boilers)

Paragraph 3.2 (boiler efficiency) prescribes **minimum efficiency requirements** in full load and part load according to the Boiler Directive 92/42/EC for standard boilers <400 kW[9]. For boilers 400-1000 kW the minimum efficiencies are 89,2% at full load and 87,8% at part load (on net calorific value).

Tolerances on **excess air** (λ, labda) are 10% for boilers up to 300 kW. For boilers 300-1000 kW λ can vary between 1,18 to 1,22.

Paragraph 3.3 and figures 3 and 4 give minimum draught (negative pressure) and flue resistance (positive pressure) requirements. Paragraph 3.4 mentions that if **flue gas temperatures of lower than 160°C may occur**, the manufacturer shall make recommendations regarding the flue installation.

3.5.2 Emission limit values oil burners

Emission limit values are 250 mg/kWh for NO_x, 110 mg/kWh for CO and 10 ppm for C_xH_y (unless at start up). The smoke number (a measure for soot emissions as defined in EN 267) shall not exceed 1. These emission values are determined using gas oil with a viscosity of 4 to 6 mm²/s (cSt) at 20°C.

[9] ≥ 84 + 2.log Pn at full load and ≥ 80 + 3 log Pn at 30% part load.

For boilers >400 kW output, maximum standby loss values are given.

Annex A (informative) gives a boiler classification based on NO_x and CO emission limit values (ELVs). For class 1 the ELVs of NO_x /CO are 185/110. For class 2 120/80 and for class 3 120/60.

Annex B mentions **national deviations**, where efficiency and emission limit values are more stringent. In Switzerland the federal ordinance on Air Pollution Control of 1985-12-16 (as at 1992-01-01) is authorative. In Germany the 1. BimSchV of 1988-07-15 (amended 1994 and 1996), specifying e.g. an ELV for NO_x of 120 mg/kWh with fuel EL is authorative. In Austria Art 15a (Vereinbarung über Schützmassnahmen betreffend Kleinfeuererungsanlagen) specifies ELVs for boilers up to 350 kW of 20mg/MJ for CO, 35 mg/MJ for NO_x and 6 mg/MJ for Organic Combined Carbon (OGC).

Annex C tells manufacturers that when they have tested one combination of a boiler body and a burner they don't have to test the same boiler body with other burners if they comply with certain e.g. minimum dimensions of the combustion chamber.

Ecodesign relevance: Minimum energy efficiency and emission limit values.

The amendment EN 303-2; A1:2003 prescribes minimum efficiencies for **low-temperature boilers**[10] and is also relevant because it prescribes an additional duration test for oil-fired low temperature boilers. The test takes 3 months, during which time the boiler is operated continuously at a cycle of 1 hour off and 5 hour on at a power output that is 18-22% of the maximum an a return temperature of 20-25°C. After the test period there is a visual inspection and no corrosion or other damage should be visible..

Ecodesign relevance: In case a ´low temperature boiler´ should prove to be not only a label for a certain efficiency class but also a technical phenomenon with a useful function of its own, it is imparative that test conditions are well defined and equal for both oil/and gas-fired boilers and not just for oil-fired boilers. In other words, as has been announced in EN303-7, EN 303-1 should be adjusted accordingly for gas appliances.

3.6 EN 303-3 Gas boilers with forced draught burners – assemblies

Full title: EN 303-3:1998**.** Heating boilers - Part 3: Gas-fired central heating boilers - Assembly comprising a boiler body and a forced draught burner.

(most recent amendment EN 303-3:1998/A2:2004. see also EN 303-7: 2004)

Summary:
Specifies the requirements and test methods for the construction, the safety and the rational energy usage of an assembly made up of a boiler body complying with EN 303-1 and a forced draught gas burner complying with EN 676, using combustible gases, hereafter referred to as "boiler".

Reference to directive: 90/396/EEG PBC 142:2005

Prepared by CEN/TC 109

Details:
For **general (safety) principles** a reference is made to EN 303-1 for the boiler body and to EN 676 for the forced draught burner. In par. 4.2 the use of asbestos is explicitly

[10] < 400 kW: LT boiler efficiency higher than or equal to 87,5 + 1,5 log Pn at full load and 30% part load. For 400-1000 kW: LT boiler efficiency higher than or equal to 91,4%.

prohibited. Diameters of flue gas evacuation ducts in various countries are given in table A1 (Annex A).

The limiting temperatures of controls, walls, top, front and floor are repeated from EN 303-1.

3.6.1 CO-concentration

Paragraph 5.3.5 prescribes a **maximum CO-concentration** of 0,10% of dry, air-free combustion products, using a reference gas at nominal output. Several determination methods are given in par. 6.3.5.. The first method uses the actual measurement of CO and CO_2 during combustion tests (in %) at unknown humidity values and then calibrates the measured CO value by using the known CO_2 value of the test gases[11] of dry, air-free combustion (also in %), to arrive at the *'CO-concentration of dry, air-free combustion products'*. The equation[12] follows

$$CO_{dry} = CO_{wet} * (CO_{2\ wet} / CO_{2\ dry})$$

The second method uses the measurement of the concentration of CO and oxygen ("O2 wet") during the combustion test:

$$CO_{dry} = CO_{wet} * (21 / (21 - O2_{wet}))$$

Acceptable tolerances for this assessment are not given, but par. 6.1.2.6 gives as 'maximum uncertainties for the measurement of CO, CO_2 and O2 a value of $\pm$6% full scale.

Ecodesign relevance: The test standard answers to the requirements of repeatability and limited testing costs, but the "dry CO" emissions do not fully reflect the CO-emissions in practice. There may be a deviation in the order of magnitude of max. +10%.
Furthermore, for compliance assessment procedures the tolerance of 6% is relevant.

3.6.2 Useful efficiency full load

Paragraph 5.4 prescribes minimum ***'useful efficiency'*** in full load and part load conditions for standard boilers amongst others according to the Boiler Directive 92/42 (see EN 303-2). The **full load** test conditions prescribe a water temperature of 80°C $\pm$ 2, thermostat or valve settings that produce a temperature difference of 20 K (= '60/80 regime') and maximum nominal heat input. Once thermal equilibrium is reached, the hot CH water from the boiler is collected in a vessel –placed on scales— during 10 minutes. During this time there is a measurement of the water quantity (m1 in kg), the gas rate (Vr(10)), the cold water inlet temperature of the boiler (t1) and the temperature at the boiler outlet (t2). After the 10 minutes test, the vessel is left on the scale for another 10 minutes and then the water quantity is established again (m^2 in kg). The difference (m3=m1-m2) gives a correction for the water evaporation during the 10 minutes test. The corrected mass is set at m=m1+m2.

Another correction concerns the heat loss of the test rig (including a positive contribution from the circulation pump). The calculation of this heat loss ***Dp*** is described in the informative Annex B, where it is suggested to replace the boiler by a small (ca. 250 ml), well insulated electric immersion heater, run the normal test cycle and see how much energy (in W) is needed for the immersion heater to maintain an equilibrium. Running the test at various temperatures, also registering the ambient temperature, will give the test rig heat losses.

Eventually, from the above, the useful efficiency index ηu can be calculated:

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[11] CO2 concentration of the dry test-gases "CO2 dry" is 11,7% (G20), 11,5% (G25), 14% (G30), 13,7% (G31). If actually distributed gases are used, then their 'dry' value shall be determined by analysis.

[12] with a slightly different denomination

$$\eta u = 100 * (4{,}186 * m * (t2 - t1) + Dp) / (10^3 * Vr(10) * Hi)$$

Where ***Hi*** is the **net** calorific value of the gas used, in MJ/m³ at 15°C and 1013,25 mbar dry.

Tolerances on the various relevant temperature and pressure levels during the test are given in paragraph 6.1.2.6. The standard states that the **maximum tolerance** on the result (the efficiency number ***ηu***) should be ± **2%**.

Ecodesign relevance: The details of the test method are relevant in order to establish whether they could be universally applied, i.e. also at other temperature levels and loads.

Another relevant issue is the fact that the efficiency ***ηu*** is determined using the net calorific value, or the 'dry gas' value of the test gas, thus ignoring the latent heat of the water vapour in the combustion gases. If one were to use the gross calorific value, i.e. taking into account the latent heat of the test gas, the efficiency ***ηu*** would be around 10-11% lower for natural gas (8-9% for LPG, 5-6% for oil-fired boilers). Using the gross calorific value would be in line with practice and most building standards (EPBD). Using the net calorific value has the advantage of being in line with the determination of the heat input of the boiler (see below), which is also based on net calorific value of the fuel.
Finally, for the legislator it is also important to know the maximum tolerance level on the outcome: Measurement tolerances should be within 2%, between labs the testing condition tolerances are higher.

3.6.3 Maximum heat input

In the test conditions it is specified that the full load test should be run at the **maximum heat input** of the boiler. Paragraph 6.1.2.7 states that the heat input ***Q*** (in kW) is given by one of the two following expressions:

If the volumetric rate is measured: $Q = 0{,}278 * V_r * H_i$

If the mass rate is measured: $Q = 0{,}278 * M_r * H_i$

Where

Hi is the net calorific value of the gas (see above) in MJ/m³ (volumetric) or MJ/kg (mass)

Mr is the mass rate in kg/h of dry gas

Vr is the volumetric rate in m³/h of dry gas (15°C, 1013,25 mbar), with

$$Vr = V * \{ (pa + pg - ps)/1013{,}25 \} * \{ 288{,}15/(273{,}15 + tg) \},$$

where

V is the measured "wet" gas rate (in m³/h)

pg is the gas pressure at the meter (in mbar)

pa is the atmospheric pressure at the time of the test (in mbar)

ps is the saturated vapour pressure of water at ***tg*** (in mbar)

tg is the gas temperature at the meter (in °C)

Paragraph 6.2 makes the same sort of corrections as par. 6.1.2.7, but it introduces an extra correction factor ***d/dr*** for the density of the actual test gas (incl. humidity) and the (dry) test gas.

General tolerances on the assessment of ***Vr*** at maximum and minimum heat input of ± 5% are mentioned in par. 5.2, but par. 6.4.1 overrules this by demanding only a ± **2% tolerance**.

Ecodesign relevance: The above completes the assessment of ***Vr***, and thereby ***Vr(10)***, as important parameter for the 'useful efficiency' mentioned earlier.

3.6.4 Excess air

The **tolerances on excess air** are practically identical to the ones given in EN 303-2: **10%** up to 300 kW and **5%** between 300 and 1000 kW. The air factor is 1,4 – 0,1 log * ***Pn*** for boilers up to 100 kW and 1,2 for boilers between 100 and 1000 kW nominal heat output[13].

Ecodesign relevance: The (tolerances on) the air factor are very relevant for the efficiency in practice (see Task 6).

3.6.5 Useful efficiency part load

Paragraph 6.4.2 describes the assessment of 'useful efficiency at part load' with a ***Direct Method*** and an ***Indirect Method.*** In the ***Direct Method*** the boiler is operated at 30% of the nominal maximum heat input. For the so-called ***Operating mode No. 1,*** the standard boiler the boiler water return temperature is set at 47 +1°C. For the low temperature and condensing boiler this is 37 + 1°C. The room thermostat is set at a 10 minute cycle, with the shutdown time (t3) and operating times (t1, t2, t21, t22) according to table 6 in par. 6.4.2.3.2. This table 6 indicates these times, based on the possibilities of the boiler tested. If the boiler can modulate to a 30% capacity, then the boiler is operating during the full 10 minutes 'on' at 30% capacity (heat input). The other extreme is, that the boiler cannot modulate at all (only 0 or 100% capacity), in which case the 30% load situation is calculated from a cycle of 3 minutes 'on' and 7 minutes 'off'. If the boiler can modulate its burner not exactly to 30% reduced rate, then the 'on' and 'off' times are chosen proportionally to create the 30% load situation (see table).

Table 3-3. Cycle times at part load EN 303-3 (extract from table 6)

Nr.	Conditions of operation	Heat input (kW)	Cycle time (s)
1	30% reduced rate	Q2 = 0,3 Q1	t2=600
2	Full rate	Q1	t1=180
	Controlled off	—	t3=420
3	Reduced rate	Q2 > 0,3 Q1	t2=(180 * Q1)/Q2
	Controlled off	—	t3= 600 - t2
4	Full rate	Q1	t1= (180 * Q1 - 600 * Q2) / (Q1-Q2)

[13] P_n = nominal heat output in kW

	Reduced rate	Q2 < 0,3 Q1	t2=600-t1
5	Reduced rate 1	Q21 > 0,3 Q1	t1= (180 * Q21 - 600 * Q22) / (Q21-Q22)
	Reduced rate 2	Q22 < 0,3 Q1	t2=600-t21
6	Full rate	Q1	t1= measured Annex D
	Reduced rate	Q2	t2=(190-t1) * Q1
	Controlled off	—	t3= 600 - (t1 + t2)

The last row of the table relates to the case where the ignition cycle of the boiler takes a significant amount of time.

In the so-called ***Operating Mode No. 2*** the boiler flow and return temperatures (on average should be > 50°C for a standard boiler and > 40°C for an LT or condensing boiler) are regulated by the boiler control whilst the heat input should be 30 $\pm$ 2% of the nominal maximum heat input. If the deviation on the heat input is between 2 an 4% than the average efficiency of two cycles (one above and one below 30% capacity) can be taken.

For the ***Indirect Method*** there is no on-off cycle, but the

- Useful efficiency at nominal heat input at 50°C (40°C return, 60°C flow temperature)
- Useful efficiency at minimum controlled rate (η_2 in case there is only one or η_{21} and η_{21} if there are two clear steps in reduced rate)
- Standby losses ***Ps*** at an average boiler water temperature of 50°C and ambient 20°C

are measured at steady-state and the 'useful efficiency at part load' is constructed from these 3 parameters, whereby the standby losses ***Ps*** are used to fill in the energy use during the 'controlled off' periods of the table 3-3 above. These standby losses are determined by circulating water through the boiler loop on a test rig and measuring the electricity consumption of an electric immersion heater in that same loop trying to keep the water temperature at 30 +5 K above ambient (20+5 K in case of an LT boiler). Ultimately, the standby losses are not taken directly from the electricity consumption of the immersion heater ***Pm***, but are corrected with a factor that reflects the actual boiler temperatures ***T*** and the actual ambient temperature ***TA***:

$$Ps = Pm * [\, 30 / (T-TA)\,]^{1,25}$$

(for a standard boiler; for LT boiler change 30 to 20)

The calculation of the overall part load efficiency is as with the Direct Method, using the 10 minute cycle as indicated in the table above and the various time periods t1, t2, etc. as weighting factors for the efficiencies found with the Indirect Method.

Ecodesign relevance: The details of the test method are relevant in order to establish whether they could be universally applied, i.e. also at other temperature levels and loads.

3.6.6 Type B23, forced draught burners, and NO_x emissions (prA1)

The amendment EN 303-3/prA1 deals specifically with the requirements for type B23 boilers, which are boilers without a draught diverter in the chimney (= type B2) but incorporating a fan upstream of the combustion chamber/heat exchanger (see also Task 3 report, section on chimneys). It adds a **classification of NO_x emission limit values**: 170 mg/kWh (class 1), 120 mg/kWh (class 2) and 80 mg/kWh (class 3). The limit values are given for second family gasses. For third family gases the ELVs are multiplied by a factor 1,3. For units intended for propane only, a factor 1,2 applies. For multi-stage or modulating units NO_x content is the arithmetic mean of the NO_x contents measured at the different stages or at the minimum or maximum value. No individual measurement shall exceed the limit value of the class immediately above. No individual measurement shall therefore ever exceed 170 mg/kWh. The adjustment of excess air in par. 6.1.2.8 does not apply. Adjustment of excess air is in accordance with the manufacturer's instruction.

Ecodesign relevance: NO_x limit values and excess air requirements.

3.6.7 Low Temperature (LT) Boilers (prA2)

The amendment EN 303-3/prA2:2003 deals specifically with **low temperature boilers,** i.e. where condensate may occur. It gives the limit values of the Boiler Directive for these boilers and new temperature values for the Direct Method, Operating Mode no. 1 (37°C instead of 47°C) and No. 2 (40°C instead of 50°C), and it prescribes a 30/50°C regime for the Indirect Method. For the Standby-losses Ps it prescribes a temperature level of 20 instead of 30°C above ambient. Unlike EN 303-2 it does not prescribe a real endurance test for LT boilers.

Ecodesign relevance: The details of the test method are relevant in order to establish whether they could be universally applied, i.e. also at other temperature levels and loads.

3.7 EN 303-4 Boilers with forced draught burners – oil burners < 70 kW

Full title: EN 303-4:1999. Heating boilers - Part 4: Heating boilers with forced draught burners - Special requirements for boilers with **forced draught oil burners** with outputs up to 70 kW and a maximum operating pressure of 3 bar - Terminology, special requirements, testing and marking.

Summary:

Is applicable to heating boilers with forced draught oil burners up to a nominal heat output of 70 kW. They are operated, either with negative pressure (natural draught boiler) or with positive pressure (pressurised boiler) in the combustion chamber, in accordance with the boiler manufacturer's instructions. This standard specifies the necessary terminology, the requirements on the materials and testing of them, and marking requirements for heating boilers.

Reference to directive: 89/106/EEG

Prepared by CEN/TC 57

Details:

This Standard is an almost complete duplication of EN 303-1 and EN 303-2 (or vice versa). Also it makes frequent reference to EN 304. For burner dimensions it refers to EN 226. It contains some prescriptions regarding the ageing of insulation materials. It mentions two pressure classes: Class 1 for boilers with an open expansion vessel and a low head (test at 1,5 bar) and Class 2 boilers for closed systems up to 3 bar (test at 4,5 bar).

In burst pressures tests the boilers should resist up to 4 * p_1 + 2 bar (minimum 6 bar, p_1=nominal pressure). Annex A adds some extra tests for chimneys with special wind conditions. Annex B.1 gives some default combustion and composition values for kerosene and fuel oil.[14] Annex B.2 mentions some emission limit values for combustion:

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[14] Kerosene default: Net combustion value Hi= 43,3 MJ/kg. C=85%; H=14,1%, S=0,04% [weight percent]

Fuel- gas oil defaults: Net combustion value Hi= 42,689 MJ/kg. C=86%; H=13,6%, S=0,03% [weight percent] max. 0,2% CO, max. smoke number 2 and max. C_xH_y emissions (unless at start up = first 10 s) 5 ppm.

Ecodesign relevance: Limited. Adds very little to EN 303-2. The emission limits are very lenient.

3.8 Boilers with forced draught burners –combi-boilers <70 kW

3.8.1 EN 303-6: Oil-fired combi-boilers

Full title: EN 303-6:2000 en**.** Heating boilers - Part 6: Heating boilers with forced draught burners - Specific requirements for the domestic hot water operation of **combination** boilers with **atomizing oil burners** of nominal heat input not exceeding 70 kW.

Summary:

Specifies the supplementary requirements and tests for the construction, safety, rational use of energy, fitness for purpose, classification and marking related to the domestic hot water operation of oil-fired combination boilers of nominal heat output not exceeding 70 kW. The domestic hot water is produced on either the instantaneous or storage principle. The domestic hot water production is integrated or coupled, the whole being marketed as a single unit.

No reference to directive.

Prepared by CEN/TC 57

Details:

This standard for oil-fired combi-boilers was conceived before mandate M324 and gives some general and tolerant indications for e.g. 'rational use of energy' when the device is supplying hot water. In that sense e.g. the maximum losses boiler and tank (when applicable) ***qs*** are defined as

$$qs = 0{,}014 * \sqrt[3]{V^2} + 0{,}02 * Qnw,$$

where

qs : losses of boiler and tank in kW

V : water capacity of the tank (incl. water in any integral heat exchanger) and/or the thermal store (in litres)

Qnw : nominal domestic hot water heat input of the boiler, in kW

For combi-boilers where the storage tank can be disconnected, the losses are calculated as the sum of the losses of the boiler (measured according to EN 304/A1, with disconnected or empty tank) and the losses of the tank.

Ecodesign relevance: Limited. Being a pre-M324 standard this standard is not very helpful in a legislative context, given the wide tolerances and crude approximations proposed. Also it contains no 'essential requirements' linked to EU Directives. Reportedly an upcoming EN 13203 bis standard will become the relevant reference (see Lot 2, Ecodesign of Water Heaters)

3.8.2 *EN 625: Gas-fired combi-boilers*

Full title: EN 625:1995. Gas-fired central heating boilers - Specific requirements for the domestic hot water operation of combination boilers of nominal heat input not exceeding 70 kW

Summary:

Specifies the supplementary requirements and tests for the construction, safety, rational use of energy, fitness for purpose, classification and marking of combination boilers. The domestic hot water is produced on either the instantaneous or the storage principle. The domestic hot water production is integrated or coupled, the whole being marketed as a single unit. This standard does not apply to two appliances operating independently of each other - a boiler and a water heater - included in the same case, even if they have a common flue.

Reference to directive: 90/396/EEG PBC 142:2005

This standard is practically identical to EN 303-6, but now relates to gas-fired combi-boilers. As regards the relevance for Ecodesign measures there is the same conclusion. The recent EN 13203 will be the most relevant (see Lot 2, Ecodesign of Water Heaters)

3.9 EN 303-7 Boilers with forced draught burners – gas fired boilers < 1000 kW

Full title: PrEN 303-7 dec. 2003. Heating boilers - Part 7: Gas-fired central heating boilers equipped with a forced draught burner of nominal heat output not exceeding 1000 kW.

Summary:

This European Standard specifies the requirements and test methods for the construction, the safety and the rational energy usage for gas-fired standard and low temperature central heating boilers equipped with a forced draught burner.

These boilers comprise a boiler body and a forced draught gas burner brought together at the producer's assembly facility, the whole being designed and marketed as a complete boiler.

This standard does not apply to the case of the assembly of a boiler body and a forced draught gas burner designed and marketed separately. In this case, EN 303-3 applies.(note, according to NEN this has changed, 303-7 now effectively replaces 303-3 / not clear)

This European Standard applies to type B23 boilers with a nominal heat output not exceeding 1000 kW with a water temperature at normal operation not exceeding 105°C and with a maximum water-side operating pressure not exceeding 8 bar.

Details:

For the most part this standard duplicates EN 303-1 and EN 303-3 (incl. amendments). New is the detailed prescription of the ignition procedure in paragraphs 4.2.5.5 to 4.2.6.8. Also the part on NO_x and CO emissions has been modified and clarified, with an explicit role for the supply voltage. For instance, for boilers > 300 kW, operated at a supply voltage that is 85% of the nominal voltage a higher CO-concentration (0,2%) is allowed compared to operation at nominal voltage (0,1% CO).

For NO_x -measurement reference conditions are now defined with a temperature of 20°C and Relative Humidity of 70% (10 g H_2O/kg air). The classification is as in EN 303-3/prA1, but specifically a limit value of 230 mg/kWh is mentioned for gas G30 for the third family of gases.

3.10 EN 656 Gas boilers, type B, 70-300 kW

Full title: EN 656:1999. Gas-fired central heating boilers - Type B boilers of nominal heat input exceeding 70 kW but not exceeding 300 kW.

Most recent amendment: EN 656:1999/Ontw. A1:2005

Summary:

Specifies the requirements and test methods concerning, in particular the construction, safety, fitness for purpose, and rational use of energy, as well as the classification and marking of gas-fired central heating boilers that are fitted with atmospheric burners, fan assisted atmospheric burners or fully premixed burners, and are hereafter referred to as "boilers".

Reference to directives: 90/396/EEG PBC 142:2005 and 97/23/EG

CEN/TC 109

Details:

To a large extend, except e.g. for the minimum wall thickness of combustion chamber, this standard and its amendments duplicate what is in EN 303-1, EN 303-3 and other standards for gas-fired boilers.

Ecodesign relevance: Limited. But it is reassuring that –apart from some construction details like wall thickness—the demands for these larger type B boilers are not different from the ones for boilers <70 kW.

3.11 PrEN 13836 Gas boilers, type B, 300-1000 kW

Full title: prEN 13836:2006. Gas-fired central heating boilers - Type B boilers of nominal heat input exceeding 300 kW, but not exceeding 1000 kW .

Summary:

Specifies the requirements and test methods concerning, in particular the construction, safety, fitness for purpose, and rational use of energy, as well as the classification and marking of gas-fired central heating boilers that are fitted with atmospheric burners, fan assisted atmospheric burners or fully premixed burners, and are hereafter referred to as "boilers".

Reference to directives 92/42/EC and 90/396/EEC (essential requirements).

Prepared by CEN/TC 109.

Details:

This is a very comprehensive standard, covering most of the subjects addressed in the EN 303 and other standards, occasionaly (e.g. on wall thickness of combustion chamber) adjusted to the higher heat inputs, but a fairly complete compilation of efficiency and emission requirements for type B boilers in general. It covers minimum efficiency requirements in the range of the Boiler Directive (i.e. 4-400 kW) and minimum efficiency for capacities >400 kW.

The CO-emission limit value (ELV) is 0,1%. The standard gives 5 NO_x classes: 260 mg/kWh (class 1), 200 mg/kWh (class 2), 150 mg/kWh (class 3), 100 mg/kWh (class 4) and 70 mg/kWh (class 5).

The minimum energy efficiency up to 400 kW is according to the Boiler Directive. For the 400-100 kW range the efficiencies of standard and low temperature boilers at full load and part load are as described in EN 303-2 (see there).

Paragraph 6.8 describes criteria when condensation occurs: either the flue losses are less than 8% (test as in par. 7.8.1) or the temperature of the flue gases is lower than

80°C (test as in par. 7.8.2). If condensation occurs, the conditions for a low temperature boiler should be met. To determine the flue gas losses the par. 7.8 gives the formula

$$qc = (a + b / CO_2) * \{ (tc - ta) / 100 \}$$

where

qc	: flue gas losses in %
a and ***b***	: coefficients for reference gases in lookup table below
CO_2	: carbon dioxide concentration in the dry product of combustion, in %
tc	: temperature of flue gases in °C
ta	: ambient temperature in °C

Reference gas	G110	G20	G25	G30
a	1,05	0,85	0,85	0,65
b	23,2	36,6	36	42,5

Chapter 7 gives a series of useful tables on test gases and test pressures.

Paragraph 7.6 gives the weighting of NO_x emissions at various loads (partial heat inputs): 0,15 at 70%load; 0,25 at 60% load; 0,30 at 40% load; 0,30 at 20% load.

Ecodesign relevance: As with the type B boilers 70-300 kW it is reassuring that –apart from some construction details like wall thickness—the demands for these larger type B boilers are not very different from the ones for boilers <70 kW or the demands for larger oil boilers. Apart from that, being the most recent and complete standard around, it would probably be an excellent basis – supplemented e.g. with requirements for type C and condensing boilers— for the consolidated standard that would be helpful to implement any legislation in the field of boilers.

3.12 EN 483 Gas boilers, type C <70 kW

Full title: EN 483:1999 en. Gas-fired central heating boilers - Type C boilers of nominal heat input not exceeding 70 kW.

(most recent amendment EN 483:1999/A2:2001 and prA4:2005).

Summary:

This standard specifies the requirements and test methods concerning, in particular, the construction, safety, fitness for purpose, and rational use of energy, as well as the classification and marking of gas-fired central heating boilers that are fitted with atmospheric burners, fan-assisted atmospheric burners or premixed burners, and that are hereafter referred to as "boilers".

Reference to directives: 90/396/EEG PBC 142:2005 and 97/23/EG

Prepared by CEN/TC 109.

Detail:

Other than extensive description of safety precautions and safety tests, EN 483 and its amendments (e.g. prA2:2000) duplicate EN 303 standards but with the addition of e.g. requirements on efficiency for type C boilers.

The recent amendment EN 483:1999;prA4:2005 gives a complete overview of the relevant test procedures for flue ducts and components especially under condensing conditions. Especially for plastic flue ducts and liners this amendment looks very complete, setting robust and stringent requirements.

3.13 EN 677 Gas condensing boilers < 70 kW

Full title: EN 677:1998 en. Gas-fired central heating boilers - Specific requirements for condensing boilers with a nominal heat input not exceeding 70 kW.

Summary:

Applies to gas-fired central heating boilers, which are declared by the manufacturer to be "condensing boilers":

- of types B (excluding appliances without a fan) and C,
- using one or more gases corresponding to the three gas families, and
- for which the nominal heat input is less than or equal to 70 kW. Only covers type testing.

Reference to directives: 90/396/EEG PBC 142:2005 and 92/42/EG (Boiler Directive)

CEN/TC 109

Details:

Requirements are additional to those in EN 297, EN 483 and EN 625. It describes resistance of materials to condensate without specifying tests. It prescribes condensate removal plus –in case the 13 mm condensate sewage pipe is blocked—the boiler should shut or lock out before the CO-concentrations is higher than 0,2%. Control of the combustion products temperature is described. It specifies useful efficiencies according to the Boiler Directive. Efficiency at full load is to be determined at 80/60 boiler temperature regime. Efficiency at part load is to be determined at 30°C boiler return temperature ('condensing').

Annex A specifies the 'correction for the determined efficiency in the low water temperature test of condensing boilers' [15]. If the actual air humidity $X_{air,m}$ (in g/kg dry air) is different from standard air humidity of the combustion products in dry air $X_{air,st}$ (= 10 g/kg), then the correction on the efficiency

$$\Delta \eta_{cond,1} = 0{,}08 * (X_{air,st} - X_{air,m})$$

This is given in %. The provenance of the factor 0,08 is not explained.

Likewise there is a correction if the return water temperature Tret is not according to the standard (=30°C):

$$\Delta \eta_{cond,2} = 0{,}12 * (T_{ret,st} - T_{ret,m})$$

Both these correction factors shall be added to the low water temperature efficiency found. Boundary conditions are that

$$0 < X_{air,m} < 20 \text{ g/kg dry air, and } 25 < T_{ret,m} < 35°C.$$

3.14 EN 267 Forced draught oil burners – definitions etc.

Full title: prEN 267:2005 en. Forced draught oil burners - Definitions, requirements, testing, marking. Will replace EN 267:1999.

Summary:

This European Standard specifies the test requirements for laboratory testing, the terminology, the general requirements for the construction and operation of automatic

[15] Correction is resulting from the study "BCR Contract No. MAT 1-CT92-0009. Final Report. June 1996.

forced draught oil burners supplied with: - a fuel having a viscosity at the burner inlet of 1,6 mm²/s (cSt) up to 6 mm²/s (cSt) at 20°C, and - higher boiling petroleum based first raffinates. To achieve the viscosity required for proper atomisation preheating is necessary. The standard is applicable to: - single burners with a single combustion chamber, although such burners are fitted to a single appliance, in which case the requirements of the relevant appliance standard shall additionally apply; - single-fuel and dual-fuel burners when operating on oil only; - the oil function of dual-fuel burners designed to operate independently on gaseous or liquid fuels. In which case the requirements of EN 676 will also apply in respect of the gaseous fuel function. No reference to directives.

CEN/TC 47

Details:

New in this standard (as compared to previous standards on oil-fired boilers) is the mentioning of 'Fuel preheating' in Par. 4.5.5, which is probably useful outdoors and in colder ambient temperatures. Par. 4.5.6.2 states that an 'Air proving device' that checks whether there is an air flow is necessary in case a pre-mix burner is not used. Par. 4.6 prescribes safe start-up provisions and procedures, including ignition safety times (e.g. max 10 s for a burner < 30 kW).

An emission limit values of 10 ppm C_xH_y (unless at start up = 20 s) is given and a maximum smoke number of 1. Emission classes for NO_x /CO are defined: 250/110 mg/kWh (Class 1), 185/110 mg/kWh (Class 2) and 120/60 mg/kWh (Class 3). If the process is unknown, only the CO limit of 110 mg/kWh applies.

The maximum air factor λmax at maximum and minimum load (Qmax and Qmin) is given in figure 2. At Qmax and in the range 100-1000 kW λmax = 1,2. Between 1 kW and 100 kW the λmax varies from 1,3 to 1,2 (straight line on a logarithmic scale). At Qmin the λmax=1,35 up to 100 kW (range < 3:1) and λmax = 1,55 over 100 kW (range 3:1). The legend of figure 2 is not clear/complete.

The Annex A of EN 267:2005 describe the test to determine the Smoke number (discoloration of a filter paper, measured with a reflectometer). Annex B describes the emission measurements and gives equations and methods how the NO_x emissions should be calibrated to reference conditions for humidity and humidity as well as for nitrogen content of the fuel. For the correction on humidity Annex B prescribes actual measurement of the humidity in the air as a parameter.

In any case the nitrogen content of the fuel should be within the range of 70 to 200 mg/kg to start with and then the result should be calibrated to the reference of 140 mg/kg. This could lead to a correction on the measured value of up to ±14 mg/kWh (0,2 * 70).

Annex C gives conversion factors for NO_x and CO, based on calibration with the measured oxygen concentration (versus reference oxygen concentration).

Annex D describes the measuring method for recording the unburned hydrocarbons (C_xH_y) with a flame ionization detector (FID).

3.15 EN 304 Atomizing oil burners – test code

Full title: EN 304:1993. Heating boilers - Test code for heating boilers for atomizing oil burners.

Most recent amendment: EN 304:1993/A2:2003.

Summary:

The test code applies to the test of the thermal performance of oil-fired heating boilers (hereafter called 'boilers') and combined boilers and water heaters. The requirements are laid down in EN 303 part 1 and EN 303 part. 2. This standard includes the requirements and recommendations for carrying out and evaluating the procedure for testing boilers and also the details of the technical conditions under which the test shall be carried out.

Reference to directive: 89/106/EEG

Details:

This standard does not seem to contain information that hasn't been elaborated in the previous, more recent standards on oil-fired boilers and burners. Amendment A1 (EN 304/A1) from 1998 incorporates the requirements of the Boiler Directive 92/42 as described before (e.g. see EN 303-2 and EN 303-3).

3.16 prEN 15034 Condensing oil boilers <1000 kW

Full title: prEN 15034:2004 en. Heating boilers - Condensing heating boilers for fuel oil.

Summary:

This European Standard applies to oil-fired heating boilers, which are declared by the manufacturer to be condensing boilers up to a nominal heat output of 1 000 kW. This European Standard completes/modifies the European Standards EN 303-1, EN 303-2, EN 304, EN 304/A1 and EN 304/A2 and specifies supplementary requirements for condensing boilers.

No reference to directives.

Prepared by CEN/TC 57

Details:

This is the equivalent of EN 677, but now for oil-fired condensing boilers. What is new, is that the low temperature boilers are now explicitly mentioned and taken into account. Also there is a 4h test to verify that condensate only occurs where it is intended. As opposes to EN 677, this standard explicitly (in par. 5.6 and Annex C) mentions the direct and indirect methods to be applied to part load efficiency (identical to EN 303).

The (informative) Annex B describes a method of transforming results of efficiency tests from net calorific value to gross calorific value of the fuel, due to some member states national legislation demanding results on reference point 'high caloric value' (EN 437: Hs). For oil-fired boilers this implies a ratio of 1,06 (Hi : Hs). For gas-fired boilers a ratio of 1,11 can be applied (reference gas G20).

3.17 prEN 15035 Room-sealed (type C) oil-fired boilers

Full title: prEN 15035:2004**.** Heating boilers - Room sealed operations for boilers for fuel oil.

Summary:

This European Standard applies to type CX3 central heating boilers as specified in 4.1, equipped with atomising oil burners: - type C13, C33, and C53 boilers, including their combustion air supply and combustion products evacuation ducts and their terminals; - type C43 boilers including their connection ducts but without the chimney, which is erected as a shared duct system and which is part of the building; - type C63 boilers, including the connecting piece as specified in 3.7, if not integrated into the boiler; - type C83 boilers, including their connection ducts but without the chimney, which is part of the building; - that have a nominal useful heat output below or equal to 70 kW; - where the temperature of the water does not exceed 100°C during normal operation; - where the maximum water-side operating pressure does not exceed 8 bar. This European Standard is intended to establish specific requirements and test methods for type C atomising oil burner central heating boilers with respect to construction, safety, fitness for purpose, rational use of energy, classification and marking. The European Standard covers only standard tests. For boilers that produce hot water by drum or exchanger, integrated or juxtaposed, (by accumulation of instant production), this standard only applies to hot water re heating system components that are not subject to operating conditions applicable to the boiler heating system. This European Standard covers units consisting of boilers equipped with burners that meet the requirements of EN 267, with the following exceptions: - maximum NO_x and CO emission values, estimated for boilers according to the classes defined in standard EN 303-2; - air factor value, defined by the manufacturer and stated in the boiler's technical specifications; - marking and/or burner data plate, which may provide information for the boiler data plate; - installation recommendations for installing the burner on the boiler, included in the boiler operating instructions. This European Standard gives additional requirements only for room sealed operations and does not contain all requirements applicable to standard, low temperature and condensation boilers.

Reference to BED 92/42/EC.

Prepared by CEN/TC 57

Details:

This is the equivalent of EN 483, but now for room-sealed (type C) oil-fired boilers. It is less extensive than EN 483 and less prescriptive in terms of design solutions, i.e. it uses references instead of copying relevant parts. There is an important focus on the 'soundness of the combustion circuit' (Chapter 5), e.g. specifying maximum leakage rates. A maximum external duct temperature is specified, also taking into account the flue gas temperature classification according to EN 1443 ('T 080' to 'T 600'). Compared to previously discussed standards for oil-fired boilers, this standard contains little new items.

As Annex ZA specifies, prEN 15035 is intended to support requirements of the Boiler Efficiency Directive (BED, 92/42/EC).

3.18 EN 676 Forced draught burners for gas

Full title: EN 676:2003. Automatic forced draught burners for gaseous fuels

Latest amendment: EN 676:2003/pr A2:2005

Reference to directive 90/396/EEG PBC 142:2005.

Prepared by CEN/TC 131.

Summary:

This European Standard specifies the terminology, the general requirements for the construction and operation of automatic forced draught gas burners and also the provision of control and safety devices, and the type test procedure for these burners. This standard is applicable to - automatic gas burners with a combustion air fan (hereinafter called "burners") that are equipped as described in clause 4, intended for use in heat generators of different types, and that are operated with fuel gases; - total pre-mixed burners and nozzle mixed burners. The standard is applicable to - single burners with a single combustion chamber, although such burners are fitted to a single appliance, in which case the requirements of the relevant appliance standard shall additionally apply; - single-fuel and dual-fuel burners when operating only on gas; - the gas function of dual-fuel burners designed to operate simultaneously on gaseous and liquid fuels in which case the requirements of EN 267 will also apply in respect of the liquid fuel function.

Details:

EN 676 is the equivalent of EN 267, but now for gas-fired burners. It contains an extensive collection of safety prescriptions and tests, e.g. regarding the start-up procedures and it is informative regarding the construction practices in different countries. Regarding emissions and energy efficiency requirements the standard contains no new items compared to previously discussed standards.

Annex ZA mentions 'A-deviations' for emissions in Switzerland and the Netherlands, i.e. these countries have more stringent demands on e.g. emissions.

Annex ZB mentions that EN 676 is written to support requirements of the Gas Appliances Directive (GAD, 90/396/EC).

3.19 prEN 15456 Electrical power consumption for heat generators

Full title: prEN 15456:2006 Heating boilers - Electrical power consumption for heat generators - System boundaries – Measurements

Summary:

This document applies to heating boilers (e.g. with forced-draught burners (unit) and burners equipped with a fan including all components specified by the manufacturer to be required for the designed boiler operation. This document applies also to heating boilers sold without burners. This document covers the required definitions, the system boundaries, the measurements for the determination of the electrical power consumption and where applicable the waterside resistance in order to establish the electric auxiliary energy for: ç Oil-fired forced-draught burners in accordance with EN 267, automatic forced-draught burners for gaseous fuels in accordance with EN 676; - Atmospheric oil burners according EN 1. - Heating boilers sold without burners for: - Oil-fired forced-draught burners in accordance with EN 303-1, EN 303-2 and EN 304; - Condensing boilers for liquid fuels in accordance with prEN 15034; - Room sealed boilers for fuel oil in accordance with prEN 15035; - Heating boilers;Heating boilers with forced draught burners; Nominal heat output not exceeding 10 MW and maximum operating temperature of 110°C according to prEN 14394.

Details:

This draft distinguishes between three systems:

- Paragraph 4.1 System with heat generation circulator (pump).
- Paragraph 4.2 System with a single circulator (pump) for heat generation and heat distribution.
- Paragraph 4.3 System without any circulator.

The first system includes the following components:

- Shut-off valves fuel supply
- Integrated fuel supply (pump)
- Supply of combustion air (air fan) resp. flue gas removal (flue exhauster)
- Control and monitoring devices (programming units, monitoring device/detector, etc.)
- Regulating devices with a complete equipment offered sometimes even as an option
- Circulator (pump) for heat generation

The second system uses the latter pump both for heat generation and distribution and the third system has no pump (i.e. the circulation pump is placed somewhere else in the CH system and sold/installed independently of the boiler.

Electricity consumption is measured in full load, 30% part load and stand-by. EN 304 and prEN 15034 are referenced here. Paragraph 6 and Annex B specify some calculations of the pressure drop of pumps, but contain no reference e.g. to the voluntary Energy Label (Europump) for circulation pumps.

3.20 EN 14511 Heat Pump Boilers

Heat pump boilers with air, ground-source or brine to water are a form of electric central heating boilers and thereby within the scope of the assignment. In any case, they can be seen as a design option to improve on electric central heating boilers that rely on the 'Joule effect' (electric resistance heaters). In 2004 the test standards for heat pumps (incl. air conditioners, etc. which are outside our scope) were updated in view of the new mandatory EU Energy Label for Room Air Conditioners. This led to a replacement of the old EN 255 standards by the new EN 14511, in 4 parts. Only the EN 255-3, dealing with heat pumps for sanitary warm water (see report on Lot 2, Ecodesign of Water Heaters) is still valid.

Furthermore, the 14511 series is useful for gas absorption heat pumps as an alternative technology/design option for gas-fired boilers.

3.20.1 Part 1: Terms and definitions

Full title: EN 14511-1:2004 en. Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 1: Terms and definitions.

Replaces: EN 255-1:1997, EN 814-1:1997, EN 12055:1998, prEN 14511-1:2002 .

Summary:

This part of EN 14511 specifies the terms and definitions for the rating and performance of air and water cooled air conditioners, liquid chilling packages, air-to-air, water-to-air, air-to-water and water-to-water heat pumps with electrically driven compressors when used for space heating and/or cooling. This European Standard does not specifically apply to heat pumps for sanitary hot water, although certain definitions can be applied to these. This European Standard applies to factory-made units that can be ducted. This standard applies to factory-made liquid chilling packages with integral condensers or for use with remote condensers. This standard applies to factory-made units of either fixed capacity or variable capacity by any means. Packaged units, single split and multisplit systems are covered by this standard, except water cooled multisplit systems. In the case of units consisting of several parts, this standard applies only to those designed and supplied as a complete package, except for liquid chilling packages with remote condenser. This standard is primarily intended for water and brine chilling packages but can be used for other liquid subject to agreement. This standard applies to air-to-air air conditioners which evaporate the condensate on the condenser side. The units having their condenser cooled by air and by the evaporation of external additional water are not covered by this standard. This standard does not apply to units using transcritical cycles, e.g. with CO_2 as refrigerant. Installations used for heating and/or cooling of industrial processes are not within the scope of this standard.

Reference to directives: **92/75/EEG** (energy label RACs) PBC 115:2004

Prepared by CEN/TC 113

3.20.2 Part 2: Test Conditions

Full Title: EN 14511-2:2004 en. Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 2: Test conditions.

Replaces: EN 255-2:1997, EN 814-2:1997, EN 12055:1998, prEN 14511-2:2002

Summary:

This part of EN 14511 specifies the test conditions for the rating of air and water cooled air conditioners, liquid chilling packages, air-to-air, water-to-air, air-to-water and water-to-water heat pumps with electrically driven compressors when used for space heating and/or cooling. It also specifies test conditions for heat recovery operation of multisplit systems. Otherwise the scope is identical to EN 14511-1 (see par. 1.17.1).

Reference to directives: **92/75/EEG** (energy label RACs) PBC 115:2004

Prepared by CEN/TC 113

3.20.3 Part 3: Test methods

Full title: EN 14511-3:2004 en. Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 3: Test methods

Replaces: EN 255-2:1997, EN 814-2:1997, EN 12055:1998, prEN 14511-3:2002

Summary:

This part of EN 14511 specifies the test methods for the rating and performance of air and water-cooled air conditioners, liquid chilling packages, air-to-air, water-to-air, air-to-water and water-to-water heat pumps with electrically driven compressors when used for space heating and cooling. It also specifies the method of testing and reporting for heat recovery capacities, system reduced capacities and the capacity of individual indoor units of multisplit systems, where applicable. Otherwise the scope is identical to EN 14511-1 (see par. 1.17.1).

Reference to directives: **92/75/EEG** (energy label RACs) PBC 115:2004

Prepared by CEN/TC 113

3.20.4 Part 4: Requirements

Full title: EN 14511-4:2004 en. Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling - Part 4: Requirements. (replaces EN 255-4:1997, EN 814-3:1997, EN 12055:1998, prEN 14511-4:2002).

Summary:

This part of EN 14511 specifies minimum requirements which ensure that air conditioners, heat pumps and liquid chilling packages with electrical driven compressor, are fit for the use designated by the manufacturer when used for space heating and/or cooling. Otherwise the scope is identical to EN 14511-1 (see par. 1.17.1).

3.21 Other product test standards

This chapter discusses the most important test standards for gas- and oil fired boilers, burners and assemblies. If one wants to take into account all restrictions that are relevant for boiler designers and engineers, this collection could be extended to cover also the referenced standards. For the moment, however, this is considered to be outside the scope of our assignment.

The EN standards are applied all over Europe and have replaced most national standards in this respect. Only in Sweden there are special national standards and regulations regarding the pressure resistance of certain parts. Switzerland, Germany, Austria and the Netherlands have more stringent legal requirements on emissions, which will be discussed in later Chapters. There is one German test standard DIN 4702-8 that needs to be mentioned here, because it is used in Germany alongside the EN standard. This DIN-standard calculates the '*Normnutzungsgrad*' (standard utilisation rate) of a heating installation as the average of efficiency measurements at 5 part loads, i.e. at 13/30/39/48/63%, corresponding to 5 outside temperatures, i.e. 11/6/3,3/0,6/–3,9°C. The average load is 39%, which is not very helpful with respect of the real load in a single family home (around 9%). However, if detailed measurement date for the part load of 13% are available this could be interesting.

Finally, it has to be mentioned that we have not discussed here heating installations with active solar thermal installations. Although they exist for space heating, they are more relevant for water heaters and are therefore discussed in the Task 1 report of Lot 2 on Water Heaters.

Also test standards for ***noise*** are not discussed here, but will be incorporated in the Lot 2 report. They are especially relevant to determine whether the appliance can be placed in the living space and thereby gain credits for useful recovery of waste heat.[16]

The product test standards are of course not the only relevant standards for designers of CH boilers. In other parts of the Task 1 report we discuss the EN standards that are currently conceived in the context of the EPBD and the national building codes per country.

3.22 Summary and validation

3.22.1 Safety

Central heating boilers are subject to a host of safety requirements that are specified in the standards. These requirements are (partially) designed to fill in the requirements of the Gas Appliance Directive and in contemplating Ecodesign measures they should be taken into account.

Furthermore, in the context of Ecodesign it might be relevant to what extend the safety and health aspects can also be seen as environmental and whether they are complete. For instance, in the field of avoiding **carbon monoxide poisoning**, the standards address all the 'classical' precautionary measures and tests but there is the question whether the standard takes into account the latest developments in energy efficiency and ventilation of new houses. Specifically, according to the latest regulations have to be fairly airtight, which is tested typically with a blower door tests at 50 mPa negative and positive pressure. Following these requirements, mechanical ventilation is almost a 'must', because the natural ventilation and infiltration alone are not enough. The reason why the legislators in Germany, the UK, etc. make these demands is that ventilation losses of a well-insulated building can determine half of the heat load. And the mechanical ventilation is necessary to still guarantee meeting health requirements.

In that respect the standards still place very little restrictions on e.g. the place where ***type B boilers***, i.e. boilers that take their combustion air from the room, can be installed. According to most standards it is enough that this place is 'well-ventilated'. The fact that an open combustion process sucking up to 10-20 m^3/h out of e.g. a kitchen can make a significant difference for the ventilation balance is not addressed. There may be health effects[17], e.g. a higher risk of CO emissions into the living space because of negative pressure, and there may be energy consumption repercussions. As mentioned, in modern houses the ventilation losses can determine over 50% of the heat load of the house and an extra ventilation requirements of 10-20 m^3/h for a boiler does make a difference that can not be neglected. At this point it we can only assess that the test standards do not deal with this phenomenon, but we will treat this subject later in the study (see system analysis). Some experts point out that limitations on the installation and the requirements for ventilation air and flueing are covered in national legislation. In their opinion the standards are for type testing an appliance and to that end largely cover the safety aspects relevant to ensuring the appliance will operate correctly when installed and operated in accordance with manufacturers instructions and local legislation.

3.22.2 Energy efficiency

Most standards also contain minimum requirements on energy efficiency, e.g. following the Boiler Directive 92/42/EC for boilers 4-400 kW. These requirements and the test

[16] National standards Germany "TA Lärm", "VDI 2715" (April 1999) and others. In France NF D 30 010 (April 1992, for gas-fired boilers) and XP D 35 010 (Dec. 1999, for oil-fired boilers). Note that the EN standards limit 'boilers in the living space' for capacities up to 37 kW.

[17] Some statistical background: Annually 25 000 carbon monoxide exposures in UK homes. 113 000 in the USA (1 in 2400 people) of which 1326 with fatal outcome. 0.002% (1,182) of hospital bed days were for toxic effect of carbon monoxide in England 2002-03. CO poisoning may be acute (inhaling large amount) or chronic (low level inhalation over years). Causes are combustion processes: cars, boat and heating appliances.

methods are identical in all standards discussed above and are summarized in the table below.

Table 3-4a. Minimum efficiency requirements BED (in NCV)

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

(*) Including condensing boilers using liquid fuels

(**) Temperature of boiler water-supply

(***) Calculation VHK: 91 + log 400 = 91 + 2,6= 93,6% ; 97 + log 400= 97+2,6 = 99,6%

Table 3-4b . BED 92/42/EC Annex II, Energy performance rating ("star-rating" 1992)

Label	Efficiency requirement at nominal output Pn and at an average boiler-water temperature of 70 oC %	Efficiency requirement at part-load of 0,3 Pn and at an average boiler-water temperature of > 50 oC %
*	> 84 + 2 log Pn	> 80 + 3 log Pn
**	> 87 + 2 log Pn	> 83 + 3 log Pn
***	> 90 + 2 log Pn	> 86 + 3 log Pn
****	> 93 + 2 log Pn	> 89 + 3 log Pn

> = greater or equal to

Note: This star-rating has been repealed with the adoption of 2005/32/EC.

The test methods for the calculation of full load and part load efficiency are identical in all standards. Full load efficiency (100% of nominal heat input) is determined with a 60/80°C boiler temperature regime, whereas for part load the 40/60, 30/50 or '30°C return' temperature regime is prescribed. For part load efficiency the manufacturer can choose between a Direct Method and an Indirect Method. These methods are mainly designed for steady state testing, with the exception of the part load measurement of the Direct Method for boilers that cannot modulate back to 30%. In this latter case, cycling is taken into account. The influence of the control method and the influence of standby heat losses (losses in 'burner off' mode, D. 'Stilstandsverluste') as well as the deviations from the ideal boiler return temperature are completely eliminated. Furthermore, in another part of the standards, also the influence of the (control of the) air factor is largely eliminated, because it is fixed. Finally, the ability of the boiler to cope with fluctuations in the fuel quality is also not taken into account: The standard prescribes test gases of an accurately controlled quality, temperature and pressure. Also regarding fluctuations of the supply voltage of the electricity –which might influence e.g. the emissions of CO depending on the design of the boiler—only safety tests are prescribed, but no minimum requirements at 'normal' operation[18]. Finally, the fact that –following the Boiler Directive— all efficiencies are expressed on Net Calorific Value, rather than Gross Calorific Value, makes the outcome of the test result and the saving potential in real-life even less transparent.

Not surprisingly, even for a state-of-the-art, condensing and 30% modulating boiler the actual real-life efficiency is typically 13-15% lower than the part load efficiency indicated by the standard. This will be further elaborated in Task 6.

As a preview, the graph below —based on German research— shows that e.g. a condensing boiler with 103% part load efficiency on *Net* Calorific Value (NCV)

[18] 'normal' being between approx. 190 and 270 V for a grid that is supplying 230 V nominally.

according to EN 303-3 can have a real-life annual efficiency on NCV of 88-90%. In terms of Gross Calorific Value this means that the measured efficiency on GCV of 92-93% in real-life is no more than around 78%. In other words, some 22% of the fuel energy input is lost. An average gas-fired 'low temperature' boiler with a declared efficiency of 87-90% on NCV has an average real-life annual operating efficiency on NCV of around 75%. The latter is the equivalent of around 65% efficiency on GCV for gas-fired appliances [19].

Please note that this still does not include distribution/emitter heat losses and also not the auxiliary electrical energy consumption of the boiler.

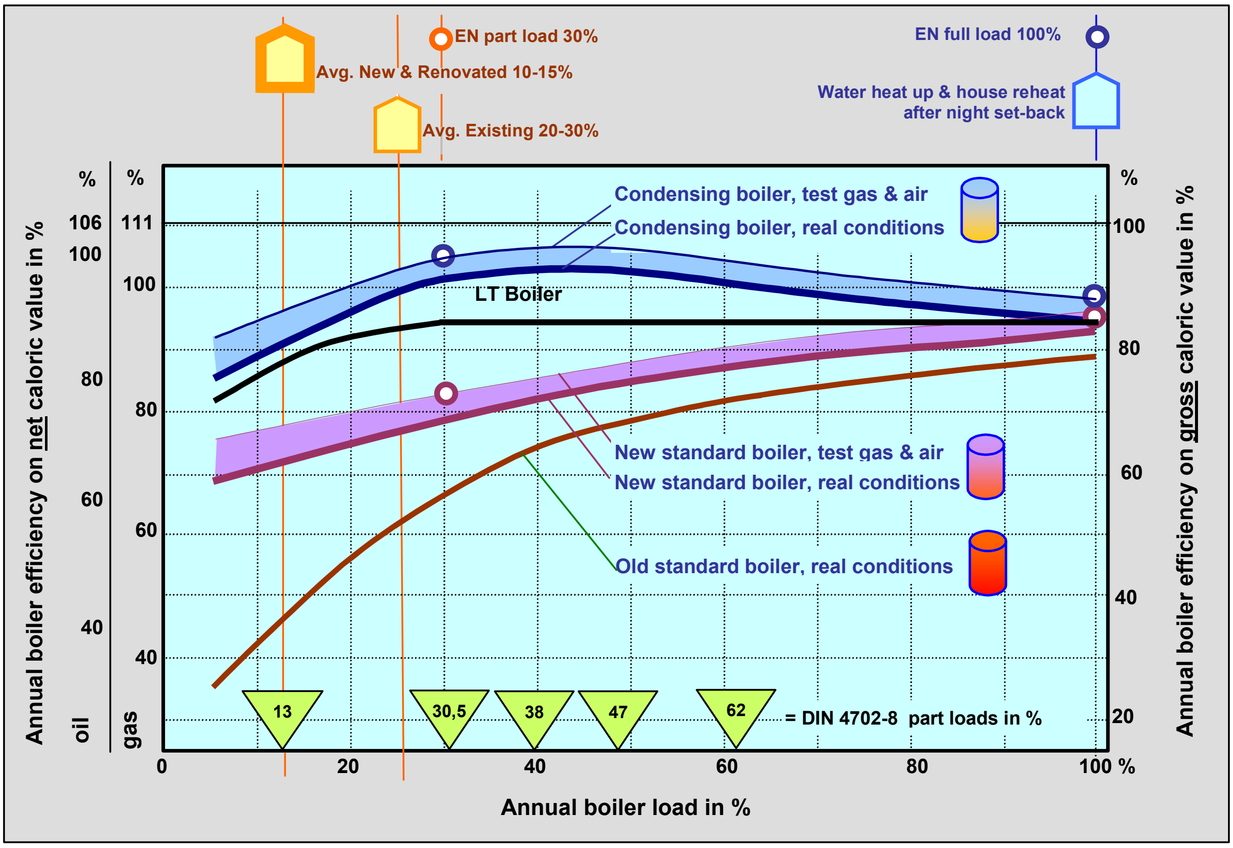


Figure 3.1. Examples of annual boiler efficiency as a function of annual average boiler load and test conditions, for a new condensing boiler, a new standard boiler and an old boiler. [sources: Farago, Deutsche Luft und Raumfahrtzentrum (DLR), Institut für Verbrennungstechnik, Lecture 2005. Wolff, D. et.al. *'Felduntersuchung: Betriebsverhalten von Heizungsanlagen mit Gas-Brennwertkesseln'*, ifHK, Wolfenbüttel, April 2004.] Curve LT Boiler: Hormel, pers. comm.. 2006.

3.22.3 Emissions from combustion

Regarding the emission requirements on combustion products the situation is not clear. Most standards prescribe maximum CO-emissions as a safety feature and those can be regarded as mandatory in the context of the Gas Appliance Directive. However, for NO_x, CO, SO_2, C_xH_y and PM emissions during normal operation it seems that the ELV values are to be regarded more as informative guidelines than requirements. Indication of the CO and NO_x emission class is mandatory. Already in 1998 the Hübner and Boos[20] concluded that the emission limit values (ELVs) and the classification in the standards do not represent the state-of-the-art. And since 1998 these ELVs and classifications have not changed…The table and diagrams below give an overview. For possible

[19] Pers.comm.. DTI/ Marcogaz. regard the values as too low and state that the latest generation of traditional boilers in the market have an annual efficiency of reportedly around 90% upon NGV and more so about 80% GCV.

[20] Hübner, C, Boos R., *Emissions of Oil and Gas Appliances and Requirements in European Standards*, Report for the Austrian Standards Institute, Consumer Council, Vienna, 1998.

Ecodesign measures in the field of emissions from combustion this means that although the measurement methods may be used the ELVs will presumably be updated. Regarding the measurement methods similar corrections as the ones with energy efficiency will be needed to reflect real-life emissions.

Table 3-5. Oil-fired heating systems (Hübner, Boos, 1998)

Heating oil appliances (emission limits in mg/kW h) oil burners		Atomizing oil burner	Heating boilers with atomizing oil burners	Heating boilers with atomizing oil burners - Unit
European Standard	Standard	prEN 267	prEN 303-2	prEN 303-2
	NO_x	250/160/120/70	250	185/120/120
	CO	125/110/60/30	110	110/80/60
	C_xH_y [1)]	-	19	19
	RZ	-	1	1
	remarks		<= 1000 kW	<= 70 kW (?)
1.BImSchV	NO_x	120	120	120
Germany (1.1.1998)	CO	-	-	-
C_xH_y	-	-	-	
RZ	-	-	-	
remarks		<= 120 kW	<= 120 kW	<= 120 kW
KFA-Verordnung (§15a)	NO_x [2)]	126	126	126
Austria (1995, 1998)	CO [2)]	72	72	72
	C_xH_y [2)]	21,6	21,6	21,6
	RZ	1	1	1
	remarks	4-400 kW	4-400 kW	4-400 kW
Luftreinhalteverordnung	NO_x [3)]	124	124	124
Switzerland (1-1-92)	CO [3)]	62	83	62
	C_xH_y [3)]	31	-	-
	RZ	0,5	1	1
	remarks	<= 350 kW	<= 350 kW	<= 350 kW
Blauer Engel	NO_x	120		110
Germany (1998)	CO	60		60
	remarks	<= 120 kW		<= 70 kW

[1)] converted values: ppm (3%O2) into mgC/kWh

[2)] converted values: mg/MJ into mg/kW h

[3)] converted values: mg/m³ (3%O2) into mg/kW h

RZ = Soot number

C_xH_y = volatile organic compounds

Table 3-6. Gas-fired heating systems (Hübner, Boos, 1998)

Gas appliances (emission limits in mg/kWh)		Forced draught burners for gaseous fuels	Gas-fired heating boilers with forced draught burner	Gas-fired central heating boilers fitted with atmospheric burners		Condensing boilers
European Standards		**EN 676**	**prEN 303-3**	**EN 297/prA5**	**prEN 483**	**EN 677**
	NO_x	170	-	260/200/150/100/70		
	CO	100	1070 1)			
	remarks			<= 70 kW	<= 70 kW	<= 70 kW
1.BImSchV	NO_x	80	80	80	80	80
Germany-1998	CO					
	remarks	<= 120 kW	<= 120 kW	<= 120 kW	<= 120 kW	<= 120 kW
KFA-Verordnung (§15a)	NO_x 2)	108	108	108 3)	108 3)	108
Austria (1995, 1998)	CO 2)	72	72	72	72	72
	remarks	<= 350 kW	<= 350 kW	<= 350 kW	<= 350 kW	<= 350 kW
Luftreinhalteverordnung	NO_x 4)	80	80	80 5)	80 5)	80
Switzerland-1992	CO 4)	60	100	100	100	100
	remarks	<= 350 kW	<= 350 kW	<= 350 kW	<= 350 kW	<= 350 kW
Blauer Engel	NO_x	70	70	70	70 (60 6))	60
Germany-1998	CO	60	60	60	60	50
	remarks	<= 120 kW	Units <= 70 kW	<= 70 kW	<= 70 kW	Units <= 70 kW

1) converted values: ppm (0%O2) into mg/kWh
2) converted values: mg/MJ into mg/kWh
3) for gas-fired recirculated water heater, reservoir water heater and single stove: 216 mg/kWh
4) converted values: mg/m³ (3%O2) into mg/kWh
5) for atmospheric burners up to 12 kW nominal heat input: 120 mg/kWh
6) for special kinds of water heaters (Kombiwasserheizer, Umlaufwasserheizer)

In addition, it can be mentioned that in the Netherlands type approval 1996, there are ELVs for NO_x of 70, 105 and 157 ppm (= ca. mg/kWh at 3% O2) for resp. pre-mix, fan-assisted and atmospheric gas-fired boilers up to 35 kW (upper cal. value). The voluntary '*Gaskeur SV*' label specifies NO_x < 40 ppm and CO <160 ppm.[21]

Belgium is also discussing ELVs for NO_x and CO, with current proposals for 2009 close to the emission limit values in Austria and Germany.

Between 1990 and 1995 an extensive field study with emission testings on gas-fired heating systems was carried out in Austria[22]. 500 domestic appliances with a nominal heat input below 350 kW were tested. The selection of the sample was representative for gas heating systems on-site in Austria.

[21] Note that there is a trade-off between NOx and CO emissions. In other words, within one basic burner design the designer can choose to lower NOx with a penalty for CO emissions or lower CO-emissions with a penalty for NOx emissions.

[22] Brötzenberger,H., Kreft,N. (1997): *GF 24 Emissionen von Gasgeräten in Österreich -Emissionsfaktoren und Einsparpotentiale*. ÖVGW Forschung Gas, Österreichische Vereinigung für das Gas- und Wasserfach.

Table 3-7 NO_x and CO emissions of on-site heating systems depending on year of manufacture. Mean values for all types of appliances with an actual heat input of not more than 10% of the nominal heat input. (Source: Brötzenberger & Kreft, 1997)

Year of manufacture	NO_x emissions (mg/kWh)	CO emissions (mg/kWh)
1980 - 84	220	148
1985 - 89	176	61
1990 - 96	115	68

Hübner and Boos 1998 proposed ELVs of 90 mg CO/kWh and 100 mg NO_x /kWh for gas-fired boilers/burners, to be introduced in EN 303-3, EN 676, EN 483 and EN 297. For oil-fired boilers and burners (EN 303-2 and EN 267) they proposed ELVs of 90 mg CO/kWh and 120 mg NO_x /kWh.

3.22.4 Tolerances

The boiler and burner standards state a fairly strict tolerance of ±2% on the declared efficiency value. Through round-robin tests by Labnet[23], this was found to be optimistic. The first round of testing revealed tolerances of up to 4-5% for both full load and part load efficiency assessment. After applying 'Good Laboratory Practice' throughout, the tolerances for full load efficiency testing between laboratories was reduced to close to 2%. For part load efficiencies the tolerance remained over 4%.

For emissions of CO, CO_2 and others, tolerances in the order of magnitude of 6% are mentioned. There have been studies and testing regarding the reproducibility of boilers emissions (CONTRACT NO.: SMT 4 – CT 95 1606 - PROJECT NO.: PL 95-1013 Improvement of inter-laboratory Reproducibility for NOx and CO Measurements.).

Tolerances are a highly relevant subject for conformity testing with any possible measure under the Ecodesign framework directive and should be incorporated in legislation.

[23] Pers. Comm. J. Schweitzer, DGC, 2006.

4 HEALTH STANDARDS

There are several health and safety aspects concerning combi-boilers (incl. water heating function) and/or regular boilers:

- Combi-boilers play a role in scalding (burns), for which also requirements are in place or being designed at Member State level.
- Legionellosis-prevention in storage combi-boilers
- Storage combi-boilers are a potential source of thermophylic bacteria[24].
- Gas-fired boilers placed inside the house are a potential source of CO-intoxication and
- there is the quality of the drinking water where e.g. the materials of water heater components in a combi-boiler are relevant.

Data on these subjects has been retrieved, but as yet not reported. Adverse effects of Specific Measures –in general terms are not expected. The exception may be the legionellis-prevention, where current recommendations prohibit lower storage temperatures. Also the fact that the safety aspects of CO-intoxication by open heating systems has yet be given attention in the test standards may create some methodological problems. In the final report we will expand on other safety standards and also on the relevant standards for noise.

[24] Bacteria that thrive at higher temperatures. Especially in Denmark there is a strong awareness on this point.

5 EN EPBD STANDARDS

5.1 Introduction

Right after the approval of the Energy Performance of Buildings Directive (EPBD) in December 2002 the European Commission has given out a mandate to CEN to elaborate appropriate EN standards that would support the policy and should give guidance to Member States developing national building codes and certification following the requirements of the EPBD. These over 40 new standards[25] would describe the holistic approach to the energy efficiency of buildings and bring together the expertise of all Member States in this field. The idea is, that these standards would eventually lead to a harmonized approach in the EU.

Today (May 2006), this is still an ongoing process. Drafts ('prEN') of the standards are being published for comments and it is hoped that the final drafts will be available for vote in August 2006. The official approval of the standards is expected in April 2007. Whether these standards –as they are today—will lead to a harmonized EU approach remains to be seen. Currently, the published drafts bring together the various approaches in the Member States, either on a normative or an informative basis, and can be seen as a first compromise without too many clear choices on what would be the best approach. Effectively —also following discussions in the EPBD's 'Committee Art. 14'— it is expected that national approaches will prevail and the EN standards will initially have only limited influence. However, a first basis was created, discussions between experts have started and it can be expected that on the long run some convergence will occur.

For the underlying study on the Ecodesign of boilers this means that the current drafts are very useful as a compilation of expertise and standards in all EU countries. Furthermore, following the New Approach, the standards could be eligible as a reference for implementing measures. On the other hand, an interesting question is whether and how implementing measures under the Ecodesign directive could be helpful in simplifying the EN EPBD standards.

The relevant standards to be discussed in this chapter is prEN 15316 on *'Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies'* Specifically, we will discuss *'Part 4-1: Space heating generation systems, combustion systems' (*PrEN 15316-4-1) in detail and give an overview of alternative heating generation systems (heat pump systems in part 4-2, thermal solar systems in part 4-3) and related standards (part 2-3 on space heating distribution systems and part 2-1 on space heating emission systems). All these draft standards have been drawn up by the Technical Committee CEN/TC 228 and we had access only to the published drafts as of October 2005.

[25] Plus the necessary revision of more than 100 underlying standards

5.2 PrEN 15316-4-1 Space heating generation systems, combustion systems

5.2.1 Introduction:

This standard presents methods for calculation of the additional energy requirements of a heat generation system in order to meet the distribution and/or storage sub-system demand. The calculation is based on the performance characteristics of the products given in product standards and on other characteristics required to evaluate the performance of the products as included in the system.

This method can be used for the following applications:

- judging compliance with regulations expressed in terms of energy targets;
- optimisation of the energy performance of a planned heat generation system, by applying the method to several possible options;
- assessing the effect of possible energy conservation measures on an existing heat generation system, by calculating the energy use with and without the energy conservation measure.

The user shall refer to other European Standards or to national documents for input data and detailed calculation procedures not provided by this standard.

Detail:

The standard provides three methods to deal with the applications mentioned in the introduction:

- Typology method (a.k.a. 'seasonal boiler performance method based on system typology')
- Case specific boiler efficiency method
- Boiler cycling method.

For the first method (par. 5.2), the considered calculation period is the heating season. The performance calculation is based on the data related to the boiler directive. The operation conditions taken into account (climate, distribution system connected to the generator, etc.) are approximated by typology of the considered region and are not case specific. If this method is to be applied, an appropriate national annex with the relevant values shall be available.

The second method (par. 5.3) is also based on the data related to the boiler directive, but supplementary data are needed in order to take into account the specific operation conditions of the individual installation. The considered calculation period can be the heating season but may also be a shorter period (month, week, or the operation periods according to EN ISO 13790). The method is not limited and can be used with the default values given in informative annex B.

The third method (par. 5.4) distinguishes in a more explicit way the losses of a generator which occurs during boiler cycling (i.e. combustion losses). Some of the parameters can be measured on site. This method is well adapted for existing buildings.

The calculation method to be applied is chosen as a function of the available data and the objectives of the user.

The first two methods explicitly take the measured efficiency data from the Boiler Efficiency Directive BED at 30% and 100% load measured according to the EN product standards, but also the defaults of the third method are taken from the Boiler Directive. For the second and third method, the declared value for 'losses at 0% load' is assumed available.

5.2.2 Typology method

The typology method largely duplicates the British SAP method for evaluating the boiler performance, using an equation of BED efficiencies at 30 and 100% corrected for certain boiler features. In fact, Annex A gives the SAP methodology as an example of the typology method.

Here we refer to Task 1, Section B report for a full description.

The major benefit of the typology method is its simplicity and ease of use. Drawbacks are, that the correction factors are specific for local circumstances and that it gives a realistic outcome only in some very specific circumstances. For instance, in Britain it would only give a reasonable impression if the boiler is dimensioned for space heating only. For an average new or renovated single family house this means a boiler of around 6-8 kW at full load and therefore a 30% part load at 2 kW. In reality, most new boilers are combi-boilers dimensioned for instantaneous hot water operation (20-28 kW), which means that they are oversized by a factor of 3 or more. For that situation, the typology method does not generate realistic results in absolute terms (in kW) and has only limited use in relative terms (comparison of boiler types, using a reference home) unless it is expanded.

5.2.3 Case specific boiler efficiency method

This method is a duplication of the French Réglémentation Thermique. It uses a simplified boiler boiler, constructed by interpolation of

- Losses at 100% load
- Losses at intermediate (30%) load
- Losses at 0% load

Initially this gives a 'curve'(two consecutive straight lines) of the heat losses versus the power output, but this 'curve' is made more interesting by adding a correction for the difference between the actual boiler temperature **T*actual*** and the boiler temperature at test conditions **T*test***, with roughly the following equation:

$$\textbf{correction}\ \textit{to interpolated efficiency value} = \mathbf{f} * (T_{\text{test}} - T_{\text{actual}})$$

The temperature-corrected efficiency value η corr is now

$$\eta_{corr} = \eta + \textbf{correction} = \eta + f * (T_{test} - T_{actual})$$

The correction factor ***f*** is taken from look-up tables in Annex B.1.3, which says that for most test-boiler efficiencies the correction factor on the temperature difference is 0,1. This means that for every 10°C of boiler water temperature difference 1% is added or subtracted to the interpolated efficiency value found. The exception is the part load efficiency of a condensing boiler, where ***f*** = 0,2 (2% per 10°C of boiler water difference).

The **T*test*** is given in the product test standards: For full load efficiency **T*test*** = 70°C and for the part load it depends on the boiler type (**T*test*** = 50°C for standard boiler, **T*test*** = 40°C for a Low Temperature boiler, **T*test*** = 35°C avg. for a condensing boiler).

But how does this method determine the 'running temperature of the boiler' **T*actual***? The first limitation here is of course the maximum cut-off temperature of the boiler, which is an emergency limit that normally is not reached. The second limitation is set by the type of control, either on the basis of the indoor temperature or on the basis of the outdoor temperature. For the outdoor temperature control the method starts from the average design temperature of the heat emission system (low temperature 35°C, medium temperature 50°C and high temperature 70°C) and then applies a correction factor that is wholly dependent on the national building codes and will therefore not be further discussed. The methodology for the indoor temperature control system is reported below.

Indoor temperature control systems

For the indoor temperature control systems, the method starts by determining the calculated heating power demand of the distribution sub-system per calculation period Φperiod. This calculated heating power demand Φm is calculated in prEN 15316-2-3. This can be set against the nominal (max.) power of the heat emitters (see prEN 15316-2-3) Φnominal. The ratio (Φperiod / Φnominal) is then corrected for the type of heat emitter with the power 1/n that varies between 1 (for floor heating) and 1,3 (for radiators). The result is then applied to the'difference between average heat emitter temperature and air temperature at test conditions' ΔTemitter. For example, in case of a heating radiator the air temperature is 20°C, the nominal power is tested at an average temperature of 70°C (80/60°C) and therefore ΔTemitter = 50°C. To this the internal temperature of the heated space Ti has to be added (e.g. 18-20°C) to find the average temperature of the heat emitters Tem and thereby the average boiler temperature Tactual:

$$T\text{actual} = Tem = Ti + (\Phi period / \Phi nominal)^{1/n} * \Delta Temitter$$

In the best case this temperature correction causes a correction of 3-4 percentage points on the efficiency found from the interpolation.

For instance in the case of a correctly dimensioned Low Temperature boiler (**T*test*** = 40 and 70°C**,** both full and 30% load efficiency are 87%) with radiator heating (**ΔTemitter** = 50°C, n= 1,3**)** working at 31% average load (**Φperiod/ Φnominal** = 0,31) with a room temperature of 18°C, the actual emitter and boiler temperature

T*actual* = $18 + 0{,}31^{1/1{,}3} * 50 = 18 + 0{,}35 * 50$ = ca. 35,7°C, and

η corr = ***87*** + 0,1 * (**70 – 35,**7) = 90,5%

At full load

T*actual* = $18 + 1^{1/1{,}3} * 50 = 18 + 0{,}88 * 50$ = ca. 62°C, and

η corr = ***87*** + 0,1 * (**70 – 62**) = 87,8%

Please note that at 30% there is a new measurement point, not just for the efficiency (which stays the same in this example) but also for **T*test,*** which now becomes 40°C. This causes a jump back of 3%:

T*actual* = $18 + 0{,}3^{1/1{,}3} * 50$ = ca. 35°C, and

η corr = ***87*** + 0,1 * (**40 – 35,**7) = 87,5%

This gives us three points of the 'boiler model', but we still need to calculate the 'losses at 0% load' (stand-by heat loss). Here the method supplies a default equation and default values for the coefficients.

Formula Losses at 0% load =

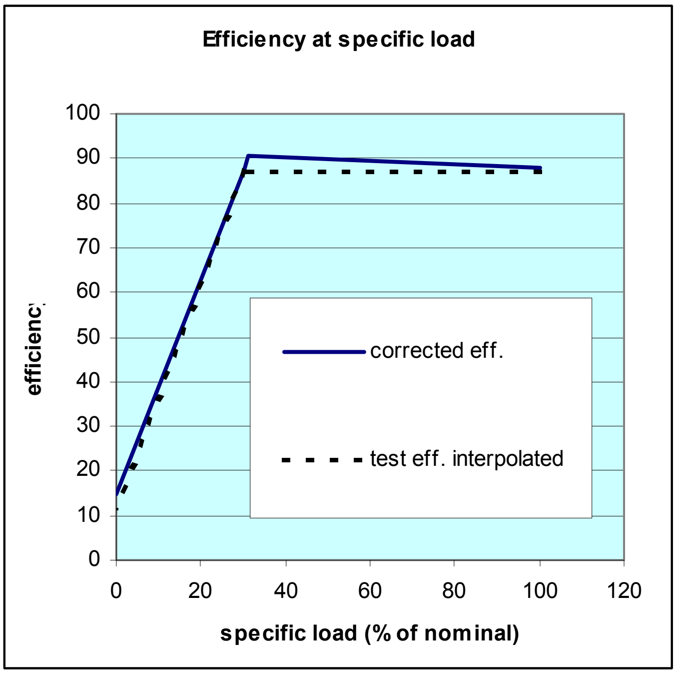
$$\mathbf{Pn} * (E + F * log\ \mathbf{Pn})$$

where ***Pn*** is the nominal boiler power

In case of a standard boiler the values for E and F are 25 resp. –8%. In case of a condensing and Low Temperature boiler the values for E and F are 17,5 and –5,5%. In case of a 15 kW low temperature boiler the default value would be around 11% of nominal power. We add some 2% temperature correction (as above) and would then arrive at a (virtual) 'corrected efficiency' of 13-14% at 0% load.[26]

The 'boiler model' of efficiency[27] versus specific load generated in this example is represented in the diagram below.

Figure 5-1.
Efficiency at specific load



Please note the steep line between 30 and 0% load, resulting e.g. in only a 30% efficiency in case of a 10% specific load. If this boiler model were to be applied to calculate the annual efficiency or the efficiency over a heating system, this would lead to unrealistic low efficiency values (e.g. a value of 60-70% would be more realistic for a 10% annual load, see previous chapter). In the French Réglémentation Thermique it is therefore not used for a whole year or heating season, but for much smaller time periods (a day, a weekend, etc.) where this boiler model is alternated with periods where the boiler is really 'off'. In that sense the prEN 15316-4-1 example in Annex D.2 is somewhat misleading because it does take the whole heating season as a calculation method, but –because it assumes a fairly high specific load of 35%— the outcome still makes sense.

The above represents the most important part of the method. Furthermore, the method gives equations and default values for multiple generator partitioning, auxiliary electrical energy as well as the recoverable part of this electrical energy and the recoverable part of the heat losses through the generator envelope. The latter heat losses are set at 50% for a standard boiler and 75% for a fan-assisted (condensing, low temperature) boiler. These are relatively high values. However, there is probably some error in the coefficient $\mathbf{b_g}$ because the current value implies that the recoverable heat losses are <u>not</u> actually recovered when the boiler is <u>inside</u> the heated space (*sic!*).

[26] Please note that in case of a condensing boiler the temperature correction would be twice as high for the trajectory between 0 and 30% load (because f= 0,2 instead of 0,1)

[27] Please note that the method itself gives a function of the absolute heat loss –not the efficiency—versus the specific load ratio FC. We used 'efficiency' to give a clearer picture of what this method means for an evaluation of the boiler performance.

As it stands today, the Case Specific Boiler Efficiency Method is of limited use for a more general evaluation of the annual boiler efficiency performance. The major drawbacks are similar to the ones with the typology method: It generates acceptable outcomes only in the range between 30 and 100% specific load, i.e. if the boiler is dimensioned correctly and therefore does not have a hot water function. In the range between 0 and 30% specific load, the method has the advantage over the Typology Method that it clearly shows the penalty for over-dimensioning the boiler. But at the moment this penalty is too high if we take the whole heating season –without 'off' mode—as a basis. The heating season should –as is written in the Réglémentation Thermique—be divided into periods of normal heat demand ('day'), low heat demand ('night' or half season) and re-heat after heat demand. But given the fact that these smaller periods are not considered in the standard, we cannot use them as a reference.

5.2.4 Boiler Cycling Method

This calculation method is based on a subdivision of the boiler operating time between burner on-mode and burner off-mode (t_{on} and t_{off}). The time in on-mode is the time the fuel valve is actually open, pre- and post ventilation are not considered. Heating losses (through chimney and through generator envelope) are taken separately for these two time periods ($Q_{ch,on}$ / $Q_{gn,on}$ / $Q_{ch,off}$ / $Q_{gn,off}$).

Auxiliary energy is considered separately for components before (typically burner fan) and after (pump) the burner (W_{br} and W_{af}), each with their own recoverable energy coefficient (k_{br} and k_{af}) and thereby recovered energy ($Q_{br} = k_{br} * W_{br}$ and $Q_{af}=k_{af} * W_{af}$).

The energy balance can be written as

$$Q_{g,out} = Q_{g,in} = Q_{gn} + Q_{br} + Q_{af} - Q_{ch,on} - Q_{ch,off} - Q_{gn,env}$$

The method then continues to detail each of the terms in the equation, basically by measuring several parameters under test conditions. In practice, these values are not provided by manufacturers and in order to apply this method the user would be required to do the measures him/herself (i.e. through a laboratory). Once the measured values are available under test conditions, the method proceeds to calibrate these test values for the actual conditions using a number of equations.

Alternatively, and this provides interesting background information, the method proposes a number of default values in Annex C.

Table C1 .Default flue gas losses of the boiler on-mode as a percentage of nominal power under test conditions (P'ch,on) at typical boiler test temperatures

Description	θgn,test [°C]	P'ch,on [%]
Atmospheric boiler	70	12
Force draught gas boiler	70	10
Oil boiler	70	11
Condensing boiler	50	6

Table C2. Default value of exponent n where Mch,on is heat capacity per kW of the heat exchanger surface between flue gas and water. The exponent n is used with the load factor FC as a multiplier for the chimney losses in on-mode

Description	Mch,on [kg/kWh]	n [%]
Wall mounted boiler	< 1	0,05
Steel boiler	1 – 2	0,1
Cast iron boiler	> 2	0,15

Default losses through the generator envelope Pgn,env = A + B * log Pn, where Pn=nominal combustion power

Table C3. Value of parameters A and B (heat loss through envelope parameters)

Generator insulation type	A [-]	B [-]
Well insulated, high efficiency new generator	1,72	0,44
Well insulated and maintained	3,45	0,88
Old generator with average insulation	6,9	1,76
Old generator, poor insulation	8,36	2,2
No insulation	10,35	2,64

Table C4. Default values of factor kgn,env (reduction factor for recovery of heat losses of envelope)

Generator type and location	kgn,env [-]
Generator installed within the heated space	0,1
Atmospheric generator installed within the heated space	0,2
Generator installed within a boiler room	0,7
Generator installed outdoors	1

Table C6. Default values of P'ch,off (chimney losses in test conditions as % of nominal power)

Description	P'ch,off [%]
Liquid fuel or gas fired boiler with the fan before the combustion chamber and automatic closure of air intake with burner off:	
Premixed burners	0,2
Wall mounted, gas fired boiler with fan and wall flue gas exhaust	0,4
Liquid fuel or gas fired boiler with the fan before the combustion chamber and no closure of air intake with burner off:	
Chimney height < 10 m	1
Chimney height > 10 m	1,2
Atmospheric gas fired boiler:	
Chimney height < 10 m	1,2
Chimney height > 10 m	1,6

Table C5/C7 .Default values of exponents m and p where Mgn,env is the ratio between total boiler weight and nominal combustion power

Description	Mgn,env [kg/kWh]	m [-]
pump always running		0
pump stops a few minutes		
- wall hung boiler	< 1	0,5
- steel boiler	1-3	0,4
- cast iron boiler	>3	0,3

Tables C8 and C12 .Default value of electrical power consumption of auxiliary devices as a multiplier of nominal boiler output Pn (full load) and at part load Pmin (30% for gas, 50% for oil-fired)

Description	at full load	at partload
burner fan and aux. (gas)	0,002 * P	0,002 * Pmin
burner fan & aux. (light oil)	0,003 * P	0,003 * Pmin
burner fan & aux. (heavy oil)	0,004 * P	0,004 * Pmin
primary pump	0,001 * P	

Table C9. Aux. energy recovery factors defaults

kbr and kaf	0,8

Table C13 Additional default data for condensing boilers

Parameter	symbol	value in MJ or
latent condensation heat of water produced per unit mass of fuel (MJ/m³)	CH	3,18
lower combustion heat of fuel (MJ/m³)	LH	34,53
theoretical production of water (kg/m³)	C_{max}	1,6
condensate production at a return temperature of 30°C (nominal power)	C_{30}	0,29
condensate production at a return temperature of 50°C (nominal power)	C_{50}	0
condensate production at a return temperature of 30°C and minimum power output	$C_{30,min}$	0,65
condensate production at a return temperature of 50°C and minimum power output	$C_{50,min}$	0,12

Table C11 Default flue gas losses of the boiler on-mode as a percentage of part load power under test conditions (P'ch,on) at typical boiler test temperatures

Description	$\theta_{gn,test}$ **[°C]**	$P'_{ch,on}$ **[%]**
Atmospheric boiler	70	11
Force draught gas boiler	70	9
Oil boiler	70	10
Condensing boiler	50	5

Actual condensate production c is a function of the actual boiler return temperature T_r:

c= [(c50 - c30).T_r/20] + 2,5.c30 - 1,5.c50

In part load situation cmin, replace c50 an c30 by c30,min and c50,min

The heat recovered from condensation as a percentage of the heat output [in %]:

R= 100 * CH/LH * c/cmax

In part load: **Rmin= 100 * CH/LH * cmin/cmax**

This method/model is undoubtedly closer to the actual operation of the boiler than the previous two methods. It provides insights and default values for a correctly dimensioned boiler operation.

Nevertheless, a drawback of this method is that –if one does not use the default values— it requires the measurement of several parameters that are not provided by the manufacturer under the current CE-marking.
Furthermore, the outcome of this model is not necessarily more accurate than those of the other two methods for the loads below the minimum part load (below 30% for gas and below 50% for oil-fired boilers, typically 10% annual load). The effect of the switching frequency and thereby the losses (and emissions!) of the start-up procedures of up to 20 000 switches per year are not explicitly taken into account. Also the effect of reheats after night set-back of the room-thermostat or full load operation in a hot water mode (for a combi) are not included in the boiler model.

5.3 PrEN 15316-4-2 Heat Pumps

In analogy with the previous standard, this draft standard describes the

- System typology method (tabulated values, par. 5.1)
- The case specific seasonal performance method based on component efficiency data' ('BIN method, par. 5.2)

5.3.1 System Typology Method

For the system typology method, the considered calculation period is the heating season. The performance is chosen from tabulated values for fixed performance classes of the heat pump, based on test results according to the heat pump testing standard EN 14511 (or the former EN 255). The operation conditions (climate, design and operation of the heating system, heat source type) are based on typology of implementation characteristics and are not case specific. This method allows a country/region specific approach and requires a country/region specific national annex.

Therefore, if there is no appropriate national annex available with the adapted values, this method cannot be used. For a more detailed discussion of tabulated values see the '*Boiler legislation per Member State*', section B of the Task 1 report. The Netherlands building code (also given in Annex E) is a typical example of this method.

5.3.2 BIN Method

The principle of the BIN method takes as a basis that heat pump efficiency strongly depends on the operation conditions, i.e. source and sink temperature, the calculation is performed for periods defined by the source and sink temperature. The source and sink temperature level has the most significant impact on heat pump performance.

The calculation method is based on an evaluation of the outside dry bulb air temperature. The annual frequency, which is derived from hourly average values of the outside air temperature, is divided into temperature intervals (bins), which are limited by an upper temperature Θ_{upper} and a lower temperature Θ_{lower}.

Operation conditions of the bins are characterised by operation points in the centre of each bin. With this method it is assumed, that the operation point of a given bin defines the operation conditions of the heat pump within the whole bin.

For each bin, the output capacity and the COP is evaluated from standard test measurements. The difference between the heat requirements and the output energy of the heat pump has to be supplied by the back-up system. Losses associated with the heat pump operation and electricity input to auxiliaries are calculated for each bin, as well.

Weighting of the results for each bin and summing up is performed to determine the total energy input in form of electricity or fuel for the whole period of operation and the seasonal performance factor of the generation subsystem, respectively. Depending on the existence of a back-up system and its operation mode, supplied back-up energy is determined and summed up to determine the overall energy consumption. In other words (calculation example in Annex D) this means that the efficiency (COP) of the heat pump is calculated at 5 operating points with each their own source, sink and outdoor temperatures. The relative weight of each efficiency value in determining the annual average value is determined by the cumulated number of hours of each operating point in the heating season.

The roots of the BIN method are within IEA Annex 28. There the method was developed and tested on its accuracy in predicting the real efficiency. Comparison of test data and calculated data have shown that accuracy in general was very good.

For heat pumps 5 operating points and several additional parameters (e.g. regarding part load operation) are being tested, compared to only be 2 or 3 operating points (30 and 100% load, possibly 0% load) for combustion heating generators. For combustion heating generators average deviations of 13-15% between actual and measured efficiency data are found.

5.4 PrEN 15316-4-2 Thermal solar systems

The method is built on EN 12976-2, which specifies test methods for validating the requirements for Factory Made Solar Systems, as specified in EN 12976-1:2000. The standard also includes two test methods for thermal performance characterization by means of whole system testing.

The EN 12976-2 standard describes, both in the main text and the extensive annexes the test methods for the safety requirements in EN 12976-1. For Ecodesign an interesting issue is the performance testing, where Annex B (normative) describes the reference conditions for performance presentation, like

- collector tilt angle (45 °),
- length of collector circuit (10+10=20 m),
- store ambient temperature (15°C),
- power of indirect (hydraulic) auxiliary heating ((100 ± 30) W per litre of store)
- flowrate of indirect (hydraulic) auxiliary heating (such that temperature drop is (10±2)K)
- power of electrical auxiliary heating ((25 ± 8) W per litre of store)
- temperature of integrated auxiliary heating (52,5°C)
- climate conditions at reference locations (Stockholm, Würzburg, Davos, Athens)
- daily load patterns (one test 100% at 6h after solar noon, second test with pattern of time $t=(t_o + 12)$h draw-off of 40% of daily volume; at $t= (t_o + 17)$h draw-off of 20% ; at $t=(t_o + 22)$h draw-off of 40%)
- daily load volume (closest possible to manufacturer declaration and to choose from 50, 80, 110, 140, 170, 200, 250, 300, 400, 600 l/d)
- draw-off flow rate (10 l/min.)
- cold water temperature at reference locations (from equation and look-up table)
- desired mixing valve temperature (45 °)
- pipe diameter and insulation thickness for pumped and thermosiphon systems (look-up tables)

The test with a duration of one daily load cycle is considered as valid, if during 95% of the draw-off time the hot water temperature does not drop below 45°C.

Furthermore, this test is used to calculated the solar energy fraction. For the total energy overview als the 'parasitic' energy consumption of pump(s), controls, etc. is taken into account.

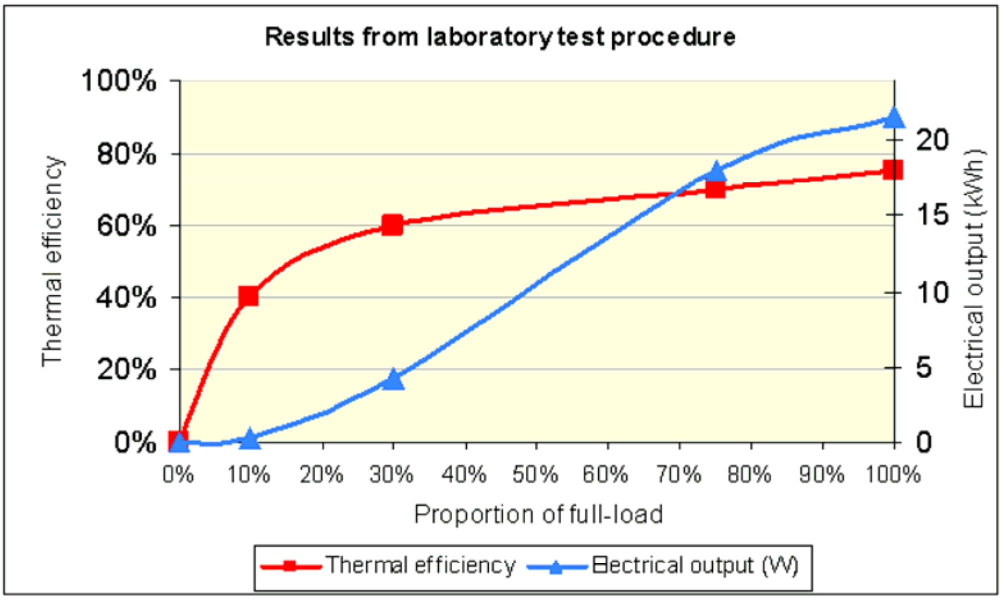
The test method is primarily intended for sanitary hot water production (see Lot 2 report for details), but the principles also to solar assisted space heating. In several national building codes (see Section B, Task 1 report) the maximum contributions of solar thermal installations to space heating (after the hot water demand is fulfilled with solar assistance) is estimated to be modest. For instance for single family houses the maximum contribution is estimated to be in the order of 10% if the collector surface is twice as big as would be necessary for hot water only. For apartment buildings the maximum contribution is around 5%.

However, even with these small contributions, the number of parameters to be tested and test effort is far superior to the one required for combustion appliances.

5.5 PrEN 15316-4-4 Cogeneration (CHP) systems

Cogeneration systems are outside the scope of our assignment, but it is interesting to look at the test requirements for these systems in order to establish whether they are comparable to the ones for combustion appliances. The answer to that is, that they are not. The PrEN 15316-4-4 requires the laboratory assessment of an accurate thermal efficiency vs. load curve such as the one given below. These efficiency values, that could be derived from 4-5 part-load measurement points, should be used in a load profile with 10% bandwidths. Each bandwidth is weighted according to the number of hours per year to arrive at an average annual efficiency.

Figure 5-2. Laboratory assessment of thermal efficiency versus curve



5.6 PrEN 15316-2-1 Space heating emission systems

Full title: Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 2-1: Space heating emission systems

Summary:

The scope of this specific part is to standardise the required inputs, the outputs and the links (structure) of the calculation method in order to achieve a common European calculation method. The energy performance may be assessed either by values of the heat emission system performance factor or by values of the heat emission system losses due to inefficiencies. The method is based on an analysis of the following characteristics of a space heating emission system including control: - non-uniform space temperature distribution; - emitters embedded in the building structure; - control of the indoor temperature. The energy required by the emission system is calculated separately for thermal energy and electrical energy in order to determine the final energy, and subsequently the corresponding primary energy is calculated. The calculation factors for conversion of energy requirements to primary energy shall be decided on a national level.

Prepared by CEN/TC 228.

Detail:

This standard defines the efficiency of the heat emitter in conjunction with the building envelope. Three types of losses are defined:

1. Energy losses due to a non-uniform temperature distribution, caused by
   a. A temperature stratification, resulting in an increased internal temperature under the ceiling and upper parts of the room. ('hot head – cold feet' phenomenon)
   b. An increased internal temperature and heat transfer coefficient near windows (causing extra transmission losses for no reason)
   c. Convection and radiation from the heating system through other outside surfaces (e.g. heating the wall behind the radiator).
2. Energy losses of embedded surface heating devices due to additional transmission losses to the outside (floor/wall/ceiling heating systems only, refers to the level of external insulation of these systems)
3. Control of the indoor temperature: Variations and drifts around the prefixed set point temperature causing extra losses and people setting their thermostat higher to avoid discomfort. Depends on control system, sensor locations and characteristics of the heating system, as well as the ability to use internal gains (solar, people, equipment).

The standard provides several tables with default values, based on the Italian, French and German standards.

Ecodesign relevance:

To better understand this standard and to see why it is a relevant standard for boiler efficiency, one has to realize that it is not rating the energy efficiency of a single radiator, convector or floor heating system —they are always 100% efficient when tested as a single component—but it is rating the efficiency of emitter systems in conjunction with the characteristics of the house and –implicitly—it is thereby also referring to the heating system (including the boiler) as a whole. So, when the standard is talking about *'the efficiency of the emitters'* it just points out where it puts the blame of certain heat losses, based on the technology as we know it today.

For instance, when a radiator is heating the external wall behind it, one can put the blame for the heat loss on the radiator or on the insulation level of the wall. In fact, the Annex A makes the non-uniform temperature distribution losses (point 1 above) dependant on the insulation level of the building. E.g. a radiator in a house with an annual average heat demand of < 20 W/m² has an efficiency of 97%. The same radiator in a house with an annual average heat demand of > 80 W/m² has an efficiency of 90%. The Italian standard (Annex B) makes the heat emission efficiency dependant on the room height and ventilation: At less than 4 metres room height, the radiator has an efficiency of 97% and at 10 metres room height in a non-ventilated space the radiator has an 'efficiency' of 88%. So, the put the blame on the emitter system is a bit arbitrary.

This certainly goes for the second bullet point above: If the builder does not insulate the floor beneath the floor heating system sufficiently, is this a fault of the floor heating system or of the building shell?

Regarding the control losses mentioned at the third point it starts to become interesting for the boiler manufacturer. Certainly, one could blame a typical heating system for its reaction speed (e.g. a floor heating system being slow to pick up on internal gains), but for the most part one could just as well blame the boiler for most of the control losses.

Just because the (thermostatic) radiator valve is a largely autonomous device today, this does not mean that it has to be so in the future.

For instance, if the boiler manufacturer would develop a system with a boiler-CPU, communicating with wireless emitter valves and room sensors that are in the same CE-marked package, there would be no reason to blame the emitter manufacturers for poor control performance. In that way, not only could the boiler optimise the boiler temperature for optimal heating comfort but also find clever methods to optimise the boiler temperature and the flow rate for the most efficient boiler operation (e.g. lowest possible return temperature).

Optimising the boiler temperature for room temperature control may save an extra 3-4% (Annex B2, referring to an outdoor sensor), but optimising the boiler temperature for efficient generator operation might save at least that amount extra. Especially for condensing boilers, every 10°C increase of boiler return temperature may result in 8% less boiler efficiency. [28]

Furthermore, one might realize an electronic PI control locally but it may be more economical to do it centrally and just use a simple sensor and valve-actuator per room. With respect of a cheap TRV[29] such an *'electronic control with optimiser'* could save some 4 (average insulated house at 90 kWh/m².a) to 8% (super-insulated house at 40 kWh/m².a) extra.

All in all, there are some important Eco-design options here, which would not be noticed if we simply blame it on the emitter, as this standard seems to do.

5.7 PrEN 15316-2-3 Space heating distribution systems

Full title: Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 2-3: Space heating distribution systems

Summary:

This standard provides a methodology to calculate/estimate the heat emission of water based distribution systems for heating and the auxiliary energy demand, as well as the recoverable energy. The actual recovered energy depends on the gain to loss ratio. Different levels of accuracy corresponding to the needs of the user and the input data available at each design stage of the project are defined in the standard. The general method of calculation can be applied for any time-step (hour, day, month or year).

Prepared by CEN/TC228.

Detail:

This standard mainly builds on DIN 4701-10. Probably because the German ENEV already prescribes a high insulation level for the piping this subject is not the main subject of this standard. Instead, a large section is dedicated to the electricity consumption and heat recovery from the circulator-pump, including correction factors for

- the temperature control (weather control or other),
- the lay-out (ring circuit, star circuit),
- over-sizing of the radiators to create a low temperature heating (results in 4% more electricity consumption of the pump) and

[28] Reference is the test standard return temperature of 30°C. At 40°C return temperature (+10°C) most of the condensing benefits are lost (losing ca. 4%)+ there are higher flue gas losses (losing another 4%, see e.g. RT 2000)

[29] Thermostatic Radiator Valve, with a bandwidth of 2 Kelvin

- the effect of whether or not hydraulically balancing the system (penalty 25% on electricity consumption of the pump).
- the reduced efficiency of the pump in partial load situations
- the over-dimensioning of the pump at the design point (flow, head. Compared to a reference)
- the pump control: modulating or not (Variable Speed Drive, two or three speed or fixed rpm pumps, effect on electricity between fixed and VSD ca. 50%)
- intermittent (non-stationary, 'on/off') operation, whereby the correction factor is calculated from the pump efficiency at start-up, quasi-stationary operation and stop. (intermittent is saving some 3% versus stationary operation)

Furthermore, the effect of overflow valves and single-pipe systems is discussed. Pump energy is to be established per month. Apart from the detailed method, the standard also gives a simplified calculation method. Regarding recovered heat losses in that method: It is assumed that 25% of the electricity consumption contributes to the pump room heating and another 25% goes into the CH-water.

Annex A provides several tables for electric power consumption of pumps and the heat loss of the distribution system. All heat loss of the distribution system in the heated space is counted as useful (recovered). The heat loss table provides typical values for the heat loss, depending on heated surface (in m²) and the temperature regime. For instance, for a 100 m² heated surface at a temperature regime of 70/90°C the non recoverable heat losses are set at 1133 kWh/year, whereas at 28/35°C regime the non recoverable heat losses are set at 388 kWh/year. The latter example means that for a very efficient house with 40 kWh/m²/a energy consumption, the non recovered heat losses are around 10% of total. If a house would use a 45/55°C regime, the annual net heat loss would be twice as high (though the utilisation factor might decrease, which saves energy; calculation is always needed). In other words, this standard gives an idea how much could be saved (extra) in the distribution system from keeping the boiler temperature low.

6 EU LEGISLATION & RULING

Boilers are regulated through several EU directives. A large part of these are covered within the tests for CE-marking (following Art. 95 of the Treaty). The table below provides an overview of the scope of EU Directives needed for CE marking.

Table 6-1 Scope Directives

	GAD	LVD	EMC-D	PED	MD
Gas safety	3rd party				
Gas efficiency	3rd party				
Electrical safety	3rd party	3rd party			
Electrical immunity & emission		3rd party	3rd party		
Pressure equipment	3rd party			3rd party	
Construction requirements	3rd party				

"3rd party": refers to third party testing required whereas for most other Directives a Technical File suffices.

The following paragraph gives first an overview of the relevant directives, covered or not covered by CE-marking. The list below presents a selection of Directives and harmonised standards relevant for boilers, but should not be perceived as complete. Conformity assessment is the responsibility of specialised Notified Bodies.

6.1 GAD - Gas Appliance Directive (90/396/EEC + 93/68/EC)

- Type of assessment: Third party verification
- Scope: safety, emissions and efficiency of gas appliances
- Example of possibly applicable harmonised standards:
- EN 483:2000 - gas fired central heating boiler (sealed)
- EN 677:1998 - gas fired central heating boiler (condensing)
- EN 625:1996 - gas fired central heating boiler(domestic hot water)
- EN 298:1994 - automatic gas burner control systems
- EN 89: gas fired storage heater for domestic hot water
- EN 437 - describes types of gas, product classification and applicable pressures (between 18-25 mBar)

6.2 Construction Products Directive (89/106/EEC)

- EN 12809:2001 Residential independent boilers fired by solid fuel - Nominal heat output up to 50 kW - Requirements and test methods

6.3 LVD - Low Voltage Directive (73/23/EEC + 93/68/EC)

- Type of assessment: Third party verification
- Scope: safety of electrical appliances
- Example of possibly applicable harmonised standards:

- EN 60335-1: 1995 domestic electric appliances - circulation pumps

6.4 EMC-D - Electromagnetic Compatibility (92/31/EC + 93/68/EC + 2004/108/EC)

- Type of assessment: Third party verification
- Scope: Emissions and immunity of electrical/electronic equipment
- Example of possibly applicable harmonised standards:
  - EN 55014-1:2001 - EMC compatibility - Requirement for household appliances - emissions
  - EN 55014-2:1997 - EMC compatibility - Requirement for household appliances - immunity
  - EN 60730-2-1:1997 - Automatic electrical controls for household and similar use — Part 2: Particular requirements for electrical controls for electrical household appliances
  - EN 60730-2-5:2002 - Automatic electrical controls for household and similar use — Part 2: Particular requirements for automatic electrical burner control systems
  - EN 61000-3-2:2001 (IEC 2000) - limits of harmonic components of input current injected into public supply system
  - EN 61000-3-3:1995 (IEC 1994) - Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current <= 16 A
  - IEC 60255-5:2001 (IEC 2000) - Insulation tests for electrical relays
  - PD IEC TR 60909-1:2002 Factors for the calculation of short-circuit currents according to IEC 60909-0

A new Directive 2004/108/EC on EMC was approved in December 2004[30] repealing directive 89/336/EC.

6.5 PED - Pressure Equipment Directive (97/23/EEC)

- Type of assessment: Third party verification
- Scope: safety of pressurized equipment
- Example of possibly applicable harmonised standards:
  - (various material and joining standards)

6.6 MD - Machinery Directive (98/37/EC + 98/79/EC + (89/392/EEC + 91/368/EEC + 93/44/EEC + 93/68/EEC))

- Type of assessment: Self declaration + Technical File
- Scope: safety of machinery - overlaps with Low Voltage Directive
- "Where, for machinery, the risks are mainly of electrical origin, such machinery shall be covered exclusively by Directive 73/23/EEC (8) – the Low Voltage Directive."

6.7 Packaging Directive (2004/12/EC)

Not included in CE-marking

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[30] DIRECTIVE 2004/108/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC

- Transposed into National Law of Member States, eg.:
- NL - Packaging Convenant
- DE - Grüne Punkt system (Duales System Deutschlands - www.gruenerpunkt.de/index_js.html)
- UK - The Producer Responsibility Obligations (Packaging Waste) Regulations 1997 (as amended), and parallel statutory instruments in the devolved administrations (see note on packaging in UK section)
- Implications: Need to use similar methods/materials as other appliances to facilitate participation in existing compliance schemes. See chapters on national requirements for further details.

6.8 EPD - Energy Performance of Buildings Directive (2002/91/EC)

Not included in CE-marking

The EU Energy Performance of Buildings Directive (EPD) was published in the European Journal on 4 January 2003. The Directive is a framework Directive, provisions to be implemented through national legislation. The Directive will have far-reaching implications for owners, operators and developers of buildings. Among the key provisions in the Directive are:

- minimum requirements for the energy performance of all new buildings (homes and commercial);
- minimum requirements for the energy performance of existing large buildings subject to major renovation (now commercial only, eventually homes to be included at later stage);
- energy certification of all buildings (with frequently visited public buildings being required to prominently display the energy certificate);
- regular mandatory inspection of boilers (> 10 kW) and air conditioning systems in buildings;

6.9 WEEE Directive (2002/95/EC)

The WEEE Directive on Waste of electrical and electronic equipment applies to electric water heaters (see WEEE Directive, Annex IB: “Other large appliances for heating rooms...”). Appliances not using electricity as primary fuel / energy source for functioning are perceived to be outside the scope of the WEEE Directive or –even in case of doubt—the conformity with this directive is not perceived as critical, given the high metal content of this product.

6.10 RoHS Directive (2002/95/EC)

The RoHS Directive 2002/95/EC on the Restriction of Hazardous Substances may be relevant for the electronics components (Pb) and flame retardants (PBB, PBDE) in plastics components. A point of attention is the maximum allowable concentration of lead (Pb) in copper (brass) and aluminium alloys.

6.11 Boiler Efficiency Directive (92/42/EC)

Regulates minimum efficiency requirements for boilers and a mandatory labelling system, which is now superseded by the Ecodesign directive.

6.12 Drinking Water Directive (98/83/EC)

This is a basic directive addressing mainly bottled water. It does not address any specific subjects that are relevant for combi-boilers like e.g. Legionellosis-prevention, the type of materials that may be in contact with drinking water, etc.. However, it does direct Member States to set values for additional parameters if the protection of the human health within its national territory so requires.

This is the basis for Member State legislation regarding Legionellosis-prevention and the fact that for installations with drinking water only stainless steel, copper-alloys and certain plastics may be used.

6.13 Fluorinated gases (EC 2037/2000 + EC 842/2006)

The use of fluorinated gases can be relevant for boilers when used as foaming agents in insulation foam and when used as a refrigerant in heat pump water heaters.

The most important restrictions on the use of fluorinated gases are regulated by the Regulation EC 2037/2000 following the Montreal protocol [31]. This regulation addresses 'f-gases' on the basis of their Ozone Depletion Potential (ODP).

For stationary applications Regulation EC 842/2006 on certain fluorinated gases was adopted in May 2006 [32]. This regulation addresses 'f-gases' on the basis of their Global Warming Potential (GWP).

It bans some applications of hydrofluorocarbons (HFCs, e.g. R134a), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6), but heat pumps are not one of those applications. It does however place the obligation of periodical leakage inspection of heat pump installations: For installations with more than 3 kg refrigerant of the designated type the frequency is at least [33] once a year. Over 30 kg this is once every six months and with installations containing more than 300 kg the frequency becomes every three months. Furthermore, there are regulations regarding responsible recovery. And there is an obligation for labelling of heat-pumps regarding HFCs used.

As background on the overall ambition level of policy makers, the also recently adopted Directive 2006/40/EC –which prohibits the use of refrigerants with a GWP of over 150 in air conditioners for mobile applications— can be mentioned.

6.14 Ruling Case C-112

Article 95 and others of the EEC Treaty concern the internal market and prohibit Member States to have national legislation that would stand in the way of trade between Member States if the product is already regulated at European level.

More in particular Article 100a concerns the free movement of '*appliances burning gaseous fuels, while ensuring the health and safety of persons and, where appropriate, domestic animals and goods in relation to the hazards resulting from the use of such appliances*.' The Gas Appliances Directive (GAD, 90/396/EEC of 29 June 1990) regulates the health and safety requirements

In that sense, there has been a ruling of The Court of Justice in Case C-112/97[34] of the European Commission against the Italian Republic of 22-26 March 1999 concerning the Italian Decree No. 412 of 26 August 1993, which explicitly required gas-appliances to be

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[31] See also Kemna, R. et al., MEEuP Methodology Report, VHK for the European Commission, Nov. 2005 for an overview

[32] see http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_161/l_16120060614en00010011.pdf

[33] Over 30 kg this is once every six months and with installations containing more than 300 kg the frequency becomes every three months.

[34] See http://curia.europa.eu/en/actu/activites/act99/9909en.htm#To C1 and http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexplus!prod!CELEXnumdoc&numdoc=61997J0112&lg=en

room-sealed ('insulated from the living area') in order to limit energy consumption in new buildings. Implicitly, the Decree No. 412 prohibits 'open' room heating appliances and the Court ruled that the Italian Republic thereby had posed a trade barrier to appliances that were admitted according to the GAD.

This ruling was brought forward by the expert group as a possible barrier to Specific Measures along the same lines, but in our opinion has no bearing on Specific Measures under the Ecodesign of EuP Directive, amongst others because the latter is a European Directive and any measures would be applicable to all Member States if they are deemed appropriate for reasons of environmental impact.

What is more interesting about this case, is the fact that already in 1997 the Italian Republic found the matter of imposing 'room-sealed' (Type C) appliances –for reasons of energy conservation—important enough to go to court.

7 NETHERLANDS

7.1 Introduction

Since 1995, the Netherlands has a legislation in place for new buildings and large renovations specifying mandatory minimum energy performance requirements. The scheme, consisting of Building Regulations (*Bouwbesluit*) and NEN-standards. The standards sets the calculation method for energy performance and the Building Regulations set the minimum Energy Performance Coefficient EPC. Relevant energy performance standards are NEN 5128; 2004 for residential buildings and NEN 2168; 2004 for non-residential buildings. For both standards there is an official software package: EPW 5129 and EPW 2169.

The scheme has been and still is successful in transforming the market towards more energy efficient buildings and as such has been a role model for the energy performance part of the European EPBD (1999-2002).

This cannot be said about the certification part of the EPBD, inspired by Denmark. A voluntary 'energy performance advice' scheme 'EPA' (*Energie Prestatie Advies*) for existing buildings has been introduced in 1999 and was subsidized until 2003. After also the financial incentives for energy saving measures dried up the EPA-scheme came to a screeching halt at around 50 000 audits performed (0,76% of housing stock). This experience and –reportedly—a concern over the cost of mandatory certification for which it would like to find a good solution, has led the Netherlands to apply for the full extension period (til 1.1.2009) to transpose the EPBD into national legislation.

As mentioned, the current scheme –which indirectly promotes the most efficient boilers— is mandatory for <u>new</u> buildings in order to obtain a building permit and a long history (1986-2002) of subsidizing/promoting the most efficient condensing gas-boilers have transformed the Dutch market of <u>existing</u> buildings as well. Although there is no mandatory minimum requirement and the legislation officially allows standard and improved efficiency boilers ('VR' *Verbeterd Rendement*), most Dutch are convinced of the economics of choosing the best condensing gas boiler for new and existing buildings.

Installers are fully trained to install condensing boilers and the adaptation of chimney systems in existing houses poses no particular problems, because

a. most boilers are placed in the attic, requiring only short through-the-roof pre-fab chimney solutions
b. a series of economical inner-liner products has been developed by the Dutch industry to make existing chimneys suitable for condensing boilers (e.g. plastic hoses resistant to the required temperatures)
c. lateral flue exhausts (through the wall of the building) are –under certain circumstances defined in NEN 1087— allowed.

Main niche markets are district heating —from waste incineration, power plant waste heat and large industrial CHP— and local gas heaters. Others, like (local) biomass heaters, oil-fired boilers, etc. are known, but rare.

'Low-temperature boilers' as defined in the European Boiler Directive are hardly known in the Netherlands, mainly because there are no oil boilers (where it could make sense) and because for gas boilers it doesn't make economical sense (expensive chimney, but little benefit in energy saving). The Boiler Directive 92/42 was transposed into Dutch legislation, but had no impact whatsoever.

Open fire places - used a few weeks a year for 'atmosphere' – are quite common, but back boilers do not exist. Electric resistance heating only exists as auxiliary heaters ('electric radiators') and not as a main heating system. The market for heat pumps is just starting up, but –without financial incentives— is seen as expensive for the residential sector. Micro-CHP is still at the experimental stages, mainly because builders and regulators are sceptical regarding the energy saving potential of current products (Stirling, gas motors, etc.).

7.2 Energy & CO_2

7.2.1 Boilers

Starting 1 Jan. 2006, the mandatory minimum EPC value has been lowered to 0,8 (from 1,0 in the 2001-2005 period). Although this value is not an exact representation, it is more or less indicative of the energy use of the building. Therefore, a decrease from 1,0 to 0,8 roughly indicates an energy saving of 20% (compare: at the outset in 1995 the EPC was 1,5). This is a very stringent target, forcing builders into using the very best in insulation measures and installation components. As a consequence, from the table below –taken from NEN 5128 but NEN 2169 has similar values– most builders will choose the *'HR-107'* condensing boiler without a second thought.

Please note that the classes of boiler efficiency are labelled according to the efficiency on net calorific value ('HR-101, HR-104, HR-107), but the efficiency actually used is on gross calorific value. For condensing boilers, the efficiency is measured at 30% of nominal power, whereas for VR and standard boilers the efficiency is measured at nominal power.

Furthermore, for electric heat pumps the efficiency of power generation is immediately taken into account and not –like in some other countries— only implemented as a 'primary energy factor' at the end of the energy performance calculation. This allows a fairly transparent and direct comparison of the primary energy use of the various heat generators. For heat pumps there are default values or values based on minimum quality requirements as mentioned in the table.

Finally, the values in the table above are default values. They are fairly close to normal manufacturer's declarations and are therefore commonly used, but –especially in case of a new and innovative concept— a manufacturer may ask a designated Competent Body (e.g. TNO) to prepare a 'Declaration of Equivalence' (*Gelijkwaardigheidsverklaring*) with new (tested) parameters for his/her product.

Table 7-1. Generation efficiency on gross calorific value of heating installations (extract from NEN 5128:2004 Table 18, Table 19, Table B.2)

Individual CH boilers excl. pilot flame placed within the heated building shell [1]	Low Temperature [2]	High Temperature [3]
Conventional boiler (comply with Boiler Directive = η ≥ ca. 86-87% on net calorific value at 100% power and η >83% at 30% power)	**0,750**	**0,750**
Improved efficiency boiler VR (η ≥ 88,5% net calorific value at 100% power according to EN-297 resp. EN-483)	**0,800**	**0,800**
Condensing boiler HR-100 (η ≥ 100% on net calorific value at 30% power, EN 677 test)	**0,925**	**0,900**
Condensing boiler HR-104 (η ≥ 104% on net calorific value at 30% power, EN 677 test)	**0,950**	**0,925**
Condensing boiler HR-107 (η ≥ 107% on net calorific value) at 30% power, EN 677 test)	**0,975**	**0,950**

Individual or collective electric heat-pump [4]	input temperature ≤ 35	35< input temp ≤45
General heat pump defaults		
- soil/water [5]	3,8 * e * c	3,4 * e * c
- brine/water [6]	4,5 * e * c	4,1 * e * c
- outside air/water [7]	3,7 * e * c	3,3 * e * c
Defaults for heat pumps with minimal COP tested at conditions of Chapter 4 of EN15144-2		
- soil/water (COP 3,4 at B0/W45; COP 4,0 at B0/W35)	4,4 * e * c	4,1 * e * c
- brine/water (COP 4,2 at W10/W45; COP 5,1 at W10/W35)	5,0 * e * c	4,6 * e * c
- outside air/water (COP 2,9 at A7(6)/W45; COP 3,0 at A7(6)/W35; COP 2,0 at A-7(-8)/W45)	3,8 * e * c	3,5 * e * c

[1] = subtract 0,05 from each value when the boiler is in a non-heated space outside the heated building shell or in case of a collective boiler system (e.g. apartment building).

[2] = water input temperature ≤ 55 or water input temperature >55 but with (mixing) devices that guarantee a return temperature ≤ 45.

[3] = water input temperature >55 and return temperature >45 or return temperature ≤ 45 but without a return temperature limitation device.

[4] = parameter e is efficiency of power generation (currently 39%); correction factor c relates to regenerative heat pumps and varies between 1,0 (0 to 50% regeneration), 1,02 (50 to 75%) and 1,04 (> 75%). Resulting efficiencies therefore vary between 1,275 and around 2. These numbers are derived from the measurement of a large number of heat pumps according to EN 255-2 by TNO (see TNO report number 2001-G&I-R079 for methodology). Note that heat pumps that extract heat from ventilation air are not included here, because the capacity is insufficient for space heating purposes. The heat pumps and the boilers are intended for the heating of one residential function with a heated surface smaller than or equal to 500 m².

[5] = A fluid is pumped in a loop between a vertical or horizontal heat exchanger with the soil and a heat exchanger that releases the heat to the heat pump.

[6] = Brine is pumped directly from the soil to the heat exchanger of the heat pump and then returned to the soil without an intermediate fluid.

[7] = With the help of a fan the outside air is passed over the heat exchanger of the heat pump, releasing its heat.

7.2.2 Multiple heat generators

In case of more than one heat generator for the heating of one single space, the share of the preferred ('preferent') heat generator ***f*** in the heat load is first determined and the remainder is partitioned to the other heat generator (s); the overall efficiency is then determined in proportion to the relative share in the heat load and the generation efficiency of each heating appliance.

For the determination of the share ***f***, the NEN 5128:2004 first uses a formula to determine a correlation factor $\boldsymbol{\beta}$ from the ratio of the nominal power ***P*** of the preferred heat generator in kW and the annual gross heating requirement ***Q*** of the building in MJ: $\boldsymbol{\beta} = 1000 * \boldsymbol{P} / 0{,}5 * \boldsymbol{Q}$. And then –using the factor $\boldsymbol{\beta}$ and the type of heat generator (gas-fired boiler, heat pump or district heating)—a look-up table generates the share ***f***. This may seem somewhat complicated for normal gas-boilers, but please note that a heat pump installation with an auxiliary electric heating element also has to be treated as a case of two heat generators.

7.2.3 Solar

Active thermal solar heating installations are incorporated in the legislation, but represent a niche market, mainly for economic reasons in the Dutch climate conditions. For solar-assisted water heating the typical collector surface is around 2,8 m^2. For any meaningful solar-assisted space heating of a home the collector surface is typically 8-12 m^2. NEN 5128 follows a two-step approach in determining the possible contribution of active solar systems. First the captured annual solar energy is determined, not surprisingly as the product of the collector surface (in m^2), the specific solar radiation (in M/m^2) and a shadow-reduction factor (trees, buildings, etc. blocking the sunlight). The 20-page Annex A of NEN 5128 gives the look-up table for solar gain and shadow-reduction factors in dependence of collector angle, orientation, etc. for the Dutch climate. The solar heat captured during the heating season ***Qsolar_winter*** is calculated over the Dutch heating season (Oct.-April). For hot water the solar energy over the whole year ***Qsolar_year*** is assessed

The second step is the partitioning between the captured solar energy to fill in part of the space heating demand ***Qheating*** and the hot water demand ***Qhotwater***. The assumption is, that any thermal solar installation can be used for both space heating and hot water. For the partitioning NEN 5128 uses a look-up table with the ratios ***Qsolar_winter/Qheating*** and ***Qsolar_year/ Qhotwater*** [35] :

Table 7-2. Annual gain of a solar energy system for space heating

	Qsolar_winter / Qheating					
Qsolar_year / Qhotwater	< 0,3	0,5	1	1,5	2	>2,5
≤ 0,25	0	0,10	0,20	0,30	0,35	0,40
0,4	0	0,08	0,18	0,25	0,30	0,35
0,6	0	0,05	0,15	0,20	0,25	0,30
0,8	0	0	0,05	0,10	0,10	0,15
≥ 1	0	0	0	0	0	0

This table reflects

- the fact that the standard efficiency of a standard gas-fired water heater (incl. combi-boiler) is lower than the standard efficiency of a gas-fired CH-boiler and therefore it saves more energy to invest the captured solar energy in hot water generation, and
- an economy of scale, which says that when the captured solar energy can cover only a small part of the hot water demand (e.g. less than 25%), but it could cover more than the heating demand of the space to be heated, then one can partition up to 40% of the captured solar energy to space heating.

Naturally, this latter case occurs only in exceptional circumstances. And, especially given the almost complete lack of financial incentives for renewable energy sources, this

[35] Please note that the NEN standard is using different names and notations, but the principle is what is explained

makes active solar systems for space heating practically non-existent in the Netherlands.

7.2.4 Auxiliary energy

Table 7-3. Defaults for electric auxiliary energy Qaux (NEN 5128;2004, Table 21)

Component	Type	Qaux in kWh
circulation pump individual installation	without pump control	2,2 * Ag;i
	with pump control	1,1 * Ag;i
circulation pump collective installation (excl. DH)	single	1,1 * Ag;i
	combi	2,2 * Ag;i
CH-boiler electronics		0,88 * Ag;i
CH-boiler ventilator		0,61 * Ag;i
Individual heat pump - circulator in case of storage vessel		0,36 * Ag;i

Ag;i =surface of heated zone i in m²

7.2.5 Energy Performance and Costs

To help builders to choose the most economic way to comply with EPC-requirements, the Dutch energy and environmental agency SenterNovem issues software with the costs per EPC-point for various new residential building-types. The table below is an elaboration by VHK of the results of this software for a reference terraced house ('tuinkamerwoning) with certain characteristics shown in the top half of the table. The lower half of the table shows measures to lower the EPC. The table relates to the 2005-situation (with EPC 1,0), but the results are also indicative for 2006.

The table shows that currently in Dutch new homes HR++ glazing and ventilation measures are most economical and solar and heat pump solutions have the worst score. Please note that some measures exclude others, e.g. the builder can choose only one ventilation system.

Table 7-4. Overview EPC-reduction and costs for energy saving Reference house:
SenterNovem "Tuinkamer tussenwoning" (terraced house) with EPC 1,0

Reference Building Shell		**Reference Installation**	
Orientation	*N/Z*	Heating and hotwater	*HR-107 combi (CW=3)*
Rc facade	*3*	Low Temperature heating	*Not installed*
Rc floor of groundfloor	*3*	Ventilation system	*Mechanical extraction*
Rc roof	*3,5*	Ventilators	*DC*
Glazing	*HR++ (U_{glas} < 1,2)*	Heat recovery	*Not installed*
Door	*Insulated (U < 2,0)*	Balanced ventilation	*Cannot be controlled*
Solar shades	*Not installed*	Vent. intake in summer	*Cannot be controlled*
Thermal capacity	*traditional*	Bypass installed	*No*
Lineare heat loss	*Default values*	Cooling	*No cooling*
		Solar water heater	*Not installed*
		PV solar panels	*Not installed*

Energy saving measures, with extra costs and EPC-reductions [1]

Measure	**Extra costs in € incl VAT**	**EPC reduction**	**Cost per %**	**Ranking**
INSULATION				
Roof insulation from Rc 3,5 to Rc 4,5	406	0,02	203	8
Roof insulation from Rc 3,5 to Rc 5,5	773	0,03	258	13
Facade & floor insulation from Rc 3,0 to Rc 4,5	619	0,03	206	9
HR++ glass (Uglas < 1,0 ipv < 1,2)	257	0,02	129	4
VENTILATION				
Mech. extraction + self-regulating window-grids	200	0,03	67	1
Mech. extraction + electr.-regulated grids	2687	0,11	244	11
Mech. room ventilation without heat recovery	2832	0,14	202	7
Central balanced heat recovery, DC fans, η= 75%	2680	0,12	223	10
Central balanced heat recovery, DC fans, η= 95%	2870	0,15	191	5
Room-vent., CO_2 control, heat recov., in 1 room²	1700	0,16	106	2
Room-vent., CO_2 control, heat recov., in 3 rooms[2]	5100	0,26	196	6
HEATING AND HOT WATER				
HR 107 boiler + heat pump water heater (vent. air)	3392	0,04	848	20
Low Temperature system with larger radiators	1029	0,02	515	16
LT system with floor heating	1029	0,03	343	15
LT system el. ground source heat pump+ floor heating	11029	0.11	1002	21
Heat recovery from shower drain[3]	620	0,05	124	3
RENEWABLE ENERGY SOURCES				
Solar water heater combi 2,8 m²	2737	0,11	248	12
Solar combi 5,6 m²	5423	0,20	271	14
PV panels multi-crystallinge 7 m²	7080	0,10	708	18
PV panels multi-crystallinge 7 m²	10115	0,15	674	17
OTHER				
Solar shades 17 m² a € 75/m²	1517	0,02	758	19

Source 1: Based op calculation programma 'EPC en kosten versie 9.0a' SenterNovem 2005
Source 2: Declaration of equivalence (NEN 5128) for the only unit allowed on the NL market, NEN 5128, Cauberg-Huygen 2003 (1 room= living room; 3 rooms= living room + 2 largest bedrooms)
Source 3: Bries waterenenergie wtw

7.3 Other emissions from combustion

Apart from the CE-marking every gas boiler should have a category-indication regarding type and pressure of gas for which it is suited, a country code (NL) and a characterisation of the flue system. In the Netherlands also a NO_x type approval is mandatory for gas-fired boilers, following the *'Typekeuringsbesluit CV-ketels'* (Ministry of VROM, 1995) for domestic boilers and the *'Besluit emission-eisen stookinstallaties B'* (BEES B, Ministry of VROM, 1998) for larger combustion installations[36]. Mandatory NO_x type approval specify a limit of < 70 ppm for atmospheric burners and < 44 ppm for fan-assisted or pre-mix burners.

Table 7-5. Some emission-requirements for smaller installations (source ECN 2005)

Steam or water boilers gas-fired and oil-fired up to 900 kWth	NO_x -requirement [mg/m³ at 3% O2]	NO_x - requirement [g/GJ]	Implemented	Legislation
Atmospheric burners (and air heaters)	157	44	1-1-1996	Type app. CH-Boilers
Fan-assisted burner	105	29	1-1-1996	Type app. CH-Boilers
Pre-mix burner	70	20	1-1-1996	Type app. CH-Boilers

VROM, 1995

There is also a voluntary label *Gaskeur SV* (*Schone Verbranding*) specifying NO_x < 40 ppm and CO < 160 ppm for boilers up to 35 kW b.w.).

The Netherlands has great difficulties in meeting the requirements of the European Air Quality Directive x/x/EC on NO_x, CO and particulate matter. Basically, the population density in the Netherlands (466 inhabitants per sq km) is almost four times as high as the EU average (EU-15 120 inhabitants per sq km), which means that its installations and transport vehicles have to emit only a fraction of the EU average per unit – compared to other countries— to meet these Air Quality requirements with the same efforts. In that context the pressure to tighten the legislative limits for boilers is considerable.

Table 7-6. NO_x -emissions of domestic installations in 2002 (preliminary data, source ECN 2005)

	Number of installations [×1000]	Gas per unit [m³/year]	Gas-use total [PJ]	NO_x per unit [g/GJ1]	NO_x total [kton]
Conventional and VR combi <30 kW	2344	1900	141	56	7,89
HR CV-boilers<30 kW	533	1363	23	30,8	0,71
HR combi boilers <30 kW	1764	1719	96	30,8	2,96
Room heating units (kachels, haarden)	551	1100	19,2	70	1,34
Group heating schemes (groepsverwarming)	451	1100	15,7	56	0,88
District heating	235	pm			
Other (oil, coal, etc.)	114	pm			
Instantaneous gas water heaters kitchen	763	245	5,9	42	0,25
Instantaneous gas water heaters bathroom	511	305	4,9	39,2	0,19
Gasfired water heaters	86	545	1,5	56	0,08
Collective water heating	504	545	8,7	56	0,49
Gas cookers, ovens and hobs	5322	62	10,4	56	0,58
Total households	**-**	**-**	**360**	**-**	**17,27**

Approximately 85% of all new boilers are high efficiency boilers nowadays. Because these boilers are designed around a low NO_x burner (fan-assisted or pre-mix burner), NO_x emissions of the residential sector are slowly declining. VR-boilers (atmospheric,

[36] P. Kroon et al., NOx-UITSTOOT VAN KLEINE BRONNEN, ECN for Ministry of VROM, Feb. 2005.

improved efficiency) usually have a burner with higher NO_x -emission. Assuming that the current share of HR and VR persist in the future –e.g. a stabilizing market share for HR because subsidies are stopped— researchers of ECN assume that the average NO_x -emission will move towards a value of 24 g/GJ (20 * 0,85 + 44 * 0,15), to be achieved in 2012-2014.

In addition, the certification of burners for space heating (<0.9 MWth) causes a decline in the NO_x emissions in public services, the commercial and agricultural sectors. Gas engines are the main small NO_x source in the industry and the agricultural sector.

The second source in industry, space heating, is almost as important as all other small industrial combustion sources. Although NO_x emissions are declining in all these sectors, emissions are not reduced enough to reach the 2010 targets for small sources under all circumstances. The two scenarios result in emissions from 33 to 36 kton (± 15%) with a target of 34 kton. (ECN 2005)

7.4 Labelling

Apart from the SV label mentioned in the previous paragraph, the Netherlands has energy labels and labels for hot water comfort that relate to (combi-) boilers. The boiler classification in NEN 5128 is based on the voluntary 'HR' labelling scheme for condensing boilers by the *Stichting HR*, distinguishing classes *HR-101, HR-104* and *HR-107* also known as 'HR', 'HR+' and 'HR++', representing efficiencies on **net** calorific value of 101, 104 and 107%.

Similarly, there is a *Gaskeur Comfort Warmwater* (CW) labelling scheme for combi-boilers defining comfort-classes (CW 1 to 6), linked to amongst others tapping patterns and waiting time. Also the energy efficiency is defined with 'HRCW' and 'HRww' labels (HR = *Hoog Rendement warm water*; CW= *Comfort Warm water*). This methodology was largely adopted in the NEN5128, but the CW classes 4 to 6 were combined in a 'class 4'. This subject will be discussed more extensively in the preparatory study on hot water appliances.

7.5 Incentives

From 2003 onwards almost all state subsidies on energy saving measures and energy efficient installations and appliances, including boilers, were abolished. In the period 1995-2002 these subsidies were 'fuelled' by a part of the Dutch 'ecotax' on energy (REB, Regulatory Energy Tax) and the administrative part was in the hands of the energy utilities. But since 1.1.2004 this tax has become –for all intentions and purposes— a common state levy. In the 1995-2002 period the subsidy for the (best) condensing boiler was in the order of magnitude of € 150,- per household.

Current Dutch energy efficiency policy for the residential building sector mainly relies on building legislation, the economics of energy saving measures and limited promotion activities. For the non-residential building sector there is only a limited tax deduction facility (*Investeringsaftrek*) for some selected technologies. Also there is an announcement of a temporary programme to subsidize for larger building projects — office buildings and projects of minimum 20 residential dwellings— called *'CO_2-reductie Gebouwde Omgeving 2006'* with a total subsidy ceiling of € 33 million. This would include solar energy, heat pumps, low-e glass ('HR++') and several types of insulation.[37]

Apart from direct state subsidies and tax breaks, a major incentive comes from the guarantee fund GIW of the association of Dutch municipalities (*VNG: Vereniging*

[37] http://www.senternovem.nl/co2-reductie_gebouwde_omgeving/index.asp

Nederlandse Gemeentes) that is looking after the clients of bankrupt builders. To be building under GIW-conditions has become almost a 'must' in the Netherlands, but the VNG puts stricter (quality) conditions on building components than the EPN. For boilers this means that the HR-107 label has become a minimum requirement and for combi-boilers a hot water comfort class of minimum CW 3 is required.

7.6 Outlook

If current Dutch policy persists, the situation for new buildings will roughly stay the same. With 'weather-controlled'[38], modulating HR-107 combi-boiler being the standard practice for new buildings, the only issue being debated for gas-boiler level relates to the size/capacity of the boiler. A 21 kW combi-boiler could still make sense for old houses because cold winters might still require that kind of space heating capacity. But for new or well-insulated houses —that have a maximum space heating requirement of a few kW— the concept of the combi-boiler requiring 21 kW capacity to keep up with the hot water demand seems less appropriate. In fact, the return to a small regular (single) boiler and an indirectly heated well-insulated hot water cylinder might make more sense, e.g. to reduce start/stop losses.

Without financial incentives the future for renewable energy sources (solar, heat pumps) will remain bleak, with the possible exception (?) of solar water heaters and heat pump water heaters that rely on the recovery of heat from ventilation air. For especially the latter, prices may still drop to an acceptable/economical level. On the other hand there is fierce competition from heat recovery ventilation systems, that are more economical already today and of course one can recover the heat from exhaust ventilation air only once. The employment of heat pumps using ventilation air heat recovery for space heating is unlikely, also because the legislator assumes that the capacity will be insufficient and calculates an 'over-ventilation' factor as well as a penalty for auxiliary electric heaters (see paragraph on multiple heat generators).

Air conditioners (reversible heat pumps) have started to become (slightly) more popular in the Netherlands, following a few hot summers. The legislator has recognized this phenomenon and has introduced –amongst others for this reason— the mandatory inclusion of 'summer comfort' in the calculations. Reportedly, this measure, which calculates a cooling load for the building independently of whether it has an air conditioning installation or not, was necessary because under the old standard builders tended to enlarge the glass surface of the house in order to maximize the solar gain and thereby minimize the heat load in winter. One consequence of this behaviour was of course –especially without shades— that the solar gain did not stop after the winter, but led to uncomfortably high room temperatures in summer. And this in turn boosted the need for active air conditioning.

The major change in the Dutch space heating sector may come primarily from technical advancements, e.g. in energy saving micro-CHP (fuel cells) and in reliable, cost-effective gas absorption heat pumps. But this is not expected within the next few years. Fuel cell technology is still perceived to be immature and the power generation efficiency of current micro-CHP products (Stirling, gas motor) is still seen as being too low to comply with the CHP-directive quality standards, i.e. save energy with respect to available single technologies. A gas absorption heat pump may be closer to home for most boiler manufacturers, but plans for the production of the only model introduced as an experiment on the Dutch market 2 years ago —the 'Auris' by Dutch BBT subsidiary Nefit— were recently abandoned because of problems with reliability and –

[38] In the UK called a 'weather compensator', in Germany 'Witterungsbedingte Steuerung', referring to a control device/ function that decreases or increases the boiler temperature depending on the temperature measured by an outdoor sensor.

consequently— price. The declared efficiency of the 'Auris' was in the range of 120-125% (efficiency on gross calorific value at temperatures < 45°C). These values come from the 'Declaration of Equivalence' (compare e.g. UK Building Regulations, Part Q) that Nefit acquired for the Auris.

8 UNITED KINGDOM

8.1 Introduction

Although the UK has still to transpose the EPBD officially, most of the requirements are in place and active. The Building Regulations, Part L, deal with energy efficiency of buildings in a holistic way (both building shell and installations). The part L1 for residential buildings is based on the SAP (Standard Assessment Procedure), which was revised in 2005. For non-residential buildings (Part L2) the methodology is based on the mandatory iSBEM software launched in December 2005. Both of these pieces of legislation will drive the boiler efficiency forward, but the most rigorous measure came from an amendment concerning boiler efficiency. This amendment introduced *'Poorest acceptable boiler SEDBUK to enable adoption of the U-values in Table 1, and reference boiler SEDBUK for use in the Target U-value Method'*. These *'Poorest acceptable boiler SEDBUK to etc…'* indicated the boilers to be condensing and the minimum (SEDBUK) Seasonal Efficiency (in gross calorific value) to be 86% for gas-fired boilers (incl. LPG) and 85% for oil-fired boilers. The amendment was implemented in April 2005 and the market data are showing that the market share of condensing boilers in the UK jumped from 23 to 85% between April and September 2005.[39] There are still some exceptions, also defined in the Building Regulations, where a non-condensing boiler could be applied.

The SAP Appendix D *'Methods of determining seasonal efficiency values for gas and oil boilers'* describes the rules for the SEDBUK (*Seasonal Efficiency of Domestic Boilers in the UK*). After defining various types of boilers, the method starts by mentioning that the 100% and 30% load efficiency test data according to the Boiler Directive 92/42 are the basis of the calculation, but they have to be transformed to a Seasonal Efficiency in the following way:

1. For condensing boilers the maximum full-load efficiency that is accepted is 101%. Likewise the maximum part-load (30%) efficiency cannot be more than 107%. For non-condensing boilers the figures are 92 (full load) and 91% (part-load).
2. The 92/42/EC efficiencies are given on net calorific values of the fuels and have to be transformed to gross calorific values, using as multipliers 0,901 for natural gas, 0,921 for LPG and 0,937 for kerosene or gas oil.
3. Determine whether it has a pilot light (**p**=1, otherwise **p**=0). If it is a storage combination boiler determine from the test report whether the store losses are included (**b**=1, otherwise **b**=0). If it is a storage combination boiler or combined primary storage unit (CPSU), obtain the store volume **V** and calculate the standby loss factor **L** as **L**=0,0945 – 0,0055 * **t** if the insulation thickness **t** is smaller than 10 mm. If the insulation thickness is 10 mm or more, then **L**=0,394 * **t**
4. Then look up the appropriate equation for seasonal efficiency according to the boiler category and calculate the Seasonal Efficiency **E**, using the gross calorific efficiency values on gross calorific value **Efull** and **Epart** as well as all the values found for **p, b, V** and **L**.
5. The generic formula is

[39] Eoin Lees, Presentation at ECCP meeting on energy demand, Feb. 2006.

$$E=0{,}5 * (Efull+Eload) - startstoplosses + (standbyfactor * b * L * V) - 4 * p$$

In other words, the Seasonal Efficiency of a gas-fired boiler is the average of the full-load and part-load efficiencies (on gross calorific value) from which you subtract 'start-stop losses' ranging from 1,7 - 2,0 - 2,1 (regular boiler-instantaneous combi-storage combi) for a modulating boiler and 2,5 – 2,8 – 2,8 (regular boiler-instantaneous combi-storage combi) for an on/off controlled boiler. A gas-fired CPSU and a regular oil boiler don't get minus points for controls, whereas the combi oil boilers always have a subtraction of 2,8 points.

As it appears –but this is a VHK interpretation— the SEDBUK penalties for start-stop losses of gas-fired boilers (not oil and not CPSU) are composed of:

- a base penalty of 2% for start stop losses, taking into account that even with a 30% modulation the boiler will at least half of its time be running in an on/off regime. This base penalty and the other penalties do not apply to CPSUs because it is assumed that all potential start-stop losses are effectively used to heat the store.
- an extra penalty of 0,5% in case of an on/off instead of a modulating burner control
- an extra penalty of 0,1% for any combi, because the mass of the boiler to be heated at each firing period is bigger than with a regular boiler
- an extra penalty of 0,5% for an on-off storage combi, where the extra mass is even higher and the on/off control causes relatively high fluctuations in the boiler temperature. This penalty is partly reduced by the positive effect of effectively using some of the temperature overshoot for the store.
- An extra bonus of 0,4% for a modulating storage combi, taking into account that at the end of each firing period the store can serve to use effectively some of the temperature overshoot in the boiler water. This bonus is partially reduced because of the higher mass of the storage boiler relative to an instantaneous boiler.

The best SEDBUK value one can hope to achieve for a gas-fired regular boiler is 91,7% (gas-fired, modulating, no pilot flame, 101% efficiency in full load and 107% in part load on net calorific value), which is similar to a Dutch 'HR-107' class. The best SEDBUK value for a CSPU could be slightly (1%?) higher depending on the 'standby-losses'of the store.

The '*poorest acceptable value etc.*.' of 86% (gas-fired) or 85% (oil-fired) for condensing boilers –as mentioned in the Building Regulations— is roughly comparable to a Dutch 'HR-101' class or a 4-star classification of condensing boilers according to 92/42/EC.

For oil boilers the 'start-stop losses' are zero for regular boilers and 2,8% for combis. There is no distinction between on-off and modulating. The SAP also contains rules for the calculation and declaration of 'non-condensing twin burner range cooker boilers' where the case emissions play a role. And a method is given for calculating the SEDBUK for boilers fuelled by LPG but tested with natural gas.

The 'standbyfactor' only applies to storage combis (factor 0,209) and CPSUs (factor 0,539). These standby-losses are added to the tested efficiency as a bonus in case the test data take into account the losses of the water tank and not hot water efficiency. And finally, the pilot light gives an extra 4 minus points.

For electric boilers, heat pumps and community heating systems there is no database and the SAP supplies the following efficiency (default) values:

Table 8-1. Seasonal Efficiency of Electric Boilers, Heat Pumps and Community Heating (SAP-2005 Table 4a extract)

Electric boilers	Efficiency %	Heating Type	Responsiveness (R)
Direct acting electric boiler	100	1	1.00
Electric CPSU in heated space a)	100	2	0.75
Dry core storage boiler in heated space a) b)	100	2	0.75
Dry core storage boiler in unheated space a) b)	85	2	0.75
Water storage boiler in heated space a) b)	100	2	0.75
Water storage boiler in unheated space a) b)	85	2	0.75

a) Heated space means within the boundary of the dwelling as defined in

section 1, 'Dwelling dimensions'

b) Store within boiler capable of meeting all space heating needs

Heat Pumps			
Ground-to-water heat pump (electric)	320	1	1.0
Ground-to-water heat pump with auxiliary heater (electric)	300	1	1.0
Water-to-water heat pump (electric)	300	1	1.0
Air-to-water heat pump (electric)	250	1	1.0
Gas-fired, ground or water source	120	1	1.0
Gas-fired, air source	110	1	1.0
Community heating systems	75	1	1.0

Please note that the SAP also gives rules for Micro-CHP, Solid fuel boilers, electric storage systems and electric underfloor heating, but these outside the scope of the underlying study.

In case there is no SEDBUK available –usually the case for older systems— the SAP supplies a set of SEDBUK values that can be used instead:

Table 8-2. Seasonal efficiency for gas and oil boilers if SEDBUK is not available (SAP-2005, Table 4b)

Boiler	Efficiency %	Boiler	Efficiency %
Gas boilers (including LPG) 1998 or later		**Oil boilers**	
Non-condensing (including combis) with automatic ignition	73	Standard oil boiler pre-1985	65
Condensing (including combis) with automatic ignition	83	Standard oil boiler 1985 to 1997	70
Non-condensing (including combis) with permanent pilot light	69	Standard oil boiler, 1998 or later	79
Condensing (including combis) with permanent pilot light	79	Condensing	83
Back boiler	65	Combi, pre-1998	70
Gas boilers (including LPG) pre-1998, with fan-assisted flue		Combi, 1998 or later	76
Low thermal capacity	72	Condensing combi	81
High or unknown thermal capacity	68	Oil room heater + boiler, pre 2000	65
Combi	70	Oil room heater + boiler, 2000 or later	70
Condensing combi	83		
Condensing	83	**Range cooker boilers (mains gas and LPG)**	
Gas boilers (including LPG) pre-1998, with balanced or open flue		Single burner with permanent pilot	46
Wall mounted	65	Single burner with automatic ignition	50
Floor mounted, pre 1979	55	Twin burner with permanent pilot (non-condensing) pre 1998	60
Floor mounted, 1979 to 1997	65	Twin burner with automatic ignition (non-condensing) pre 1998	65
Combi	65	Twin burner with permanent pilot (non-condensing) 1998 or later	65
Back boiler	65	Twin burner with automatic ignition (non-condensing) 1998 or later	70
Combined Primary Storage Units (CPSU) (mains gas and LPG)			
With permanent pilot (non-condensing)	70	**Range cooker boilers (oil)**	
With automatic ignition (non-condensing)	74	Single burner	60
With permanent pilot (condensing)	79	Twin burner (non-condensing) pre 1998	70
With automatic ignition (condensing)	83	Twin burner (non-condensing) 1998 or later	75

After the SEDBUK has been determined, the efficiency values have to be adjusted according to some features that may or may not be part of the boiler. These efficiency adjustments are given below.

Table 8-3. Efficiency adjustments (SAP-2005, Table 4c)

Heating system	Efficiency adjustment, %	
Gas or oil boiler systems with radiators or underfloor heating. The adjustments are to be applied to the space and water heating seasonal efficiency for both the SEDBUK value and for efficiency values from Table 4b.		
1) Efficiency adjustment due to lower temperature of distribution system	Mains gas	Oil/ LPG
Condensing boiler with load compensator a)	+2	+1
Condensing boiler with weather compensator a)	+2	+1
Condensing boiler with under-floor heating a) b)	+3	+2
Condensing boiler with thermal store a)	0	0
2) Efficiency adjustment due to control system		
No thermostatic control of room temperature c)	-5	
No boiler interlock c) -5	-5	
Community heating systems		
3) Efficiency adjustment due to controls		
Flat rate charging d), no thermostatic control of room temperature	-10	
Flat rate charging, programmer and room thermostat	-5	
Flat rate charging, programmer and TRVs (Thermostatic Radiator Valves)	0	
Charging system linked community heating, programmer + TRVs	0	
Heat pumps	Multiply efficiency by:	
4) Efficiency adjustment due to temperature of heat supplied	**Space**	**DHW**
Heat pump with underfloor heating	1,0	
Heat pump with radiators without load or weather compensation e)	0,7	
Heat pump with radiators with load or weather compensation e)	0,75	
Heat pump supplying all Domestic Hot water (DHW)		0,7
Heat pump supplying 50% DHW		1,0

Notes:

. These are mutually exclusive and therefore do not accumulate; if more than one applies, the highest applicable efficiency adjustment is to be used.

. Adjustment is applicable if the boiler supplies only the underfloor heating, and not if it also feeds radiators or supplies hot water.

. These do not accumulate as no thermostatic control or presence of a bypass means that there is no boiler interlock.

. 'Flat rate charging' means that households pay for the heat according to a fixed monthly or annual amount, not depending on the amount of heat actually used. If the charges vary within a scheme for other reasons, for example according to dwelling size, it is still classified as flat rate. The last entry under 'Community heating schemes' refers to a system in which the charges are substantially related to the amount of heat used.

Based on maximum heat distribution temperature of 50°C.

Furthermore, table 4d of the SAP mentions the heating type and responsiveness for wet systems with heat supplied to radiator or under-floor heating. A system with radiators and an underfloor heating system (wet) with pipes in an insulated timber floor are heating type 1 and have Responsiveness R is 1.0. Only where the pipes of the underfloor-heating are in screed or concrete slab the heating type is 4 and R=0.25. The Responsiveness R is a multiplier for the *'useful gains'* fraction from solar and internal gains.

The SAP uses the type of temperature control of the space heating system to adjust the *'Mean internal temperature level of the living area'* (in SAP-2005, table 8) by adding +0.6°C for boiler systems that have no thermostat control and +0.3°C for other systems (heat pumps, community heating systems). This has clear repercussions for the energy use of the building but it is not immediately clear how much (depends also on insulation and other parameters). As a rule of thumb for an average existing building every degree of temperature difference makes a difference of 4% in space heating requirements. So, for instance 0.6°C difference would make a difference in the order of magnitude of 1 to 2% for a modern building.

The type of temperature control also tweaks the difference in temperatures between zones. For this the SAP uses a look-up table for 3 different classes of control:

Table 8-4. Difference in temperatures between zones depending on temperature control types (SAP-2005, extract from tables 4e and 9)

	Control type			
HLP	1	2	3	Type 1
1,0 (or lower)	0,40	1,41	1,75	No time or thermostatic control of room temperature
1,5	0,60	1,49	1,92	Programmer, no thermostat
2,0	0,79	1,57	2,08	Room thermostat only
2,5	0,97	1,65	2,22	Programmer + room thermostat*
3,0	1,15	1,72	2,35	Type 2
3,5	1,32	1,79	2,48	Programmer + at least two room thermostats
4,0	1,48	1,85	2,61	Programmer + room thermostat + TRVs
4,5	1,63	1,90	2,72	Programmer + TRVs + bypass
5,0	1,76	1,94	2,83	Programmer + TRVs + flow switch
5,5	1,89	1,97	2,92	Programmer + TRVs + boiler energy manager
6,0 (or higher)	2,00	2,00	3,00	Type 3
				Time and temperature zone control
				Community Heating only: Charging system linked to the use of community heating, programmer and TRVs

HLP= Heat loss parameter in W/m²K, as part of the transmission losses

For multiple heat generators heating the same zone, the SAP uses a fixed fraction of 10% as the contribution of the secondary heater. This goes for all gas, oil and solid fuel main heating systems, but also for 'other electric systems', not being electric storage heaters, CPSU or electric room heaters.

In case of a group or community heating scheme, the SAP calculates a distribution loss factor of 1.2 for a *'full flow system, not pre-insulated, pre-1991, medium-high temperature (120-140°C)'* and a factor of 1.1 for a *'pre-insulated full-flow system pre-1991 with low temperature (≤ 100°C)'* or a *'pre-insulated variable flow system, post 1990, up to 120°C'*. For a *'modern, post 1990 system operating at 100°C or below with a full control system'* the distribution loss factor is 1.05.

Solar-assisted water heating is a separate Appendix of the SAP (see report Lot 2), but a contribution from active thermal solar panels for space heating is not considered in SAP.

What is considered is the auxiliary electric energy for boiler pump/circulator, boiler fan (in case of a condensing boiler) and a keep-hot facility. This latter feature and others in table 4f of SAP-2005 relate to hot water installations and will be treated in the report on lot 2. For a central heating pump (supplying hot water to radiators or an underfloor system) the SAP calculates 130 $kWh_{electric}$/year (169 kWh if room thermostat is absent). An oil-boiler pump supplying oil to the boiler and –with the same motor— flue fan is rated at 100 kWh/year (130 kWh if room thermostat is absent).

This applies to all oil boilers that provide main heating, but not if the boiler provides hot water only. And a gas boiler flue fan (if fan assisted flue) is rated at 45 kWh/year of electricity consumption.

Note that a part of the circulator and oil-boiler pump energy (i.e. 10 W) is counted as 'useful gains' in calculating the heat demand of the dwelling.

All these data should give enough input to fill in the SAP Worksheet version 9.8, regarding the issue of the heating system. A small and very incomplete part of the SAP Worksheet dealing with heating systems is given below.

Table 8-5. Sample of SAP-2005 Worksheet, version 9.8

9a. Energy requirements – individual heating systems, including micro–CHP			
Note: when space and water heating is provided by community heating use the alternative worksheet 9b			
Space heating			
Fraction of heat from secondary/supplementary system *(use value from Table 11, Appendix F or Appendix N)* (82)			[82]
Efficiency of main heating system, % (83)			[83]
(SEDBUK or from Table 4a or 4b, adjusted by the amount shown in the 'efficiency adjustment' column of Table 4c)			
Efficiency of secondary/supplementary heating system, % *(use value from Table 4a or Appendix E)* (84)			[84]
Space heating fuel (main) requirement, kWh/year	[1 – (82)] × (81) × 100 ÷ (83) =		[85]
Space heating fuel (secondary), kWh/year (85a)	(82) × (81) × 100 ÷ (84) =		[85a]

Once this worksheet has calculated the energy demand, the different items are then multiplied by the fuel rates (in £), a specific emission of CO_2 per kWh and a primary energy factor (2.8 for electricity vs. 1.15 for gas). The complete table –including items that are out of the scope of the underlying study such as solid fuels and CHP— is given in Table 8-6.

For the non-residential buildings there are the Building Regulations Part L2, which are based roughly on the same principles as far as boilers are concerned. But for non-residential buildings in particular there is no SAP with worksheets, but a mandatory iSBEM software package –issued in December 2005— to support implementation. The target values are set by reference to a "notional building" of the same size and geometry, but with standardised insulation levels, system efficiencies etc. The impact of on-site renewables can be included in the carbon calculation.

Recently, the *Non-domestic Heating, Cooling and Ventilation Compliance Guide* has been published.

This draft guide mentions a minimum seasonal efficiency of 84% for single boilers, for gas, LPG and oil. In a multiple boiler system the individual boilers should have at least 80% seasonal efficiency, but the whole installation should have 84% seasonal efficiency or more. This is for boilers in new buildings. In existing buildings the poorest acceptable seasonal efficiency is 80, 81, 82% for gas, LPG and oil respectively.

For heat pumps (all types except absorption heat pumps and gas engine heat pumps) the minimum COP[40] should be 2.0 at worst design conditions. For gas engine heat

[40] Coefficient of performance

pumps a COP of 1.0 is mentioned and for absorption heat pumps even a COP of 0.5 appears to be acceptable. Please note that these numbers may change.

Table 8-6. Fuel prices, additional standing charges, emission factors and primary energy factors (SAP-2005, table 12)

		Additional standing charge (a) GBP	Unit price p/kWh	Emissions kg CO_2 per kWh	Primary energy factor
Gas	mains gas bulk LPG	34	1,63	0,194	1,15
	bottled LPG	62	3,71	0,234	1,10
Oil	heating oil		4,32	0,234	1,10
Solid fuels b)	house coal		2,17	0,265	1,19
	anthracite		1,91	0,291	1,07
	manufactured smokeless fuel		1,99	0,317	1,07
	wood logs		2,67	0,392	1,30
	wood pellets (in bags, for secondary heating)		2,20	0,025	1,10
	wood pellets (bulk supply in bags, for main heating)		5,00	0,025	1,10
	wood chips		3,00	0,025	1,10
	dual fuel appliance (mineral and wood)		1,60	0,025	1,10
Electricity	standard tariff		2,10	0,187	1,10
	7-hour tariff (on-peak)(c)		7,12	0,422	2,8
	7-hour tariff (off-peak) (c)	20	7,65	0,422	2,8
	10-hour tariff (on-peak) (c)		2,94	0,422	2,8
	10-hour tariff (off-peak) (c)	17	7,83	0,422	2,8
	24-hour heating tariff	51	4,29	0,422	2,8
	electricity sold to grid		4,09	0,422	2,8
	electricity displaced from grid		3,00(d)	0,568(d)	2,8(d)
Community Heating Systems		34			
	heat from boilers – gas, oil, solid fuel		1,99	as above(e)	as above(e)
	heat from heat pump		1,99	as above(e)	as above(e)
	heat from boilers – waste combustion		1,99	0,057	1,10
	heat from boilers – biomass or biogas		1,99	0,025	1,10
	waste heat from power stations		1,39	0,018	1,05
	heat from CHP		1,39	as above(e)	as above(e)
	electricity generated by CHP			0,568(d)	2,8(d)

Energy Cost Deflator (f) = 0.91

Note:

a) The standing charge given for electricity is extra amount for the off-peak tariffs, over and above the amount for the standard domestic tariff, as it is assumed that the dwelling has a supply of electricity for reasons other than space and water heating. Standing charges for gas and for off-peak electricity are added to space and water heating costs where those fuels are used for heating or hot water.

b) The specific fuel should be assumed for those appliances that can only burn the particular fuel (including Exempted Appliances within Smoke Control Areas). Where a main heating appliance is classed as dual fuel (i.e. mineral and wood), the data for dual fuel should be used, except where the dwelling is in a Smoke Control Area, when the data for solid mineral fuel should be used. Wood should be specified as fuel for a main heating system only if there is adequate provision (at least 1.5 m^3) for storage of the fuel. Outside Smoke Control Areas an open fire should be considered as dual fuel and a closed room heater without boiler as burning wood logs.

c) With certain appliances using an off-peak tariff, some of the consumption is at the off-peak rate and some at the on-peak rate. The on-peak percentages to be used are given in Table 12a, the remainder being provided at the off-peak rate.

d) Deducted from costs, emissions or primary energy.

e) Take factor from further up the table according to fuel used.

f) An energy cost deflator term is applied before the rating is calculated. It will vary with the weighted average price of heating fuels in future, in such a way as to ensure that the SAP is not affected by the general rate of inflation. However, individual SAP ratings are affected by relative changes in the price of particular heating fuels.

Update (Contribution Dr. Martin Searle, Nov. 2006)

It is important to note that the requirements described in the previous paragraph apply to England and Wales and not Scotland or Northern Ireland.[41] This is thought to explain the fact that condensing boiler sales are not greater than 85% at this time. The regulations in Scotland and Northern Ireland are largely being brought into line with England and Wales although there are some differences.

Since the previous paragraph was written the final requirements have been produced and are now in force. This does slightly change the position from the situation described previously but not to a great extent.

In order to satisfy the Building Regulations the dwelling must meet a carbon emission figure. The dwelling carbon emissions, which are obtained from a SAP (Standard Assessment Procedure) calculation, must be lower than a target carbon emission. The target value is based on the emissions from a dwelling to the same size and shape of the proposed building but using elemental standards for the structure and heating system equivalent to the 2002 standards less 20%.

The calculations can only be made using an approved software package. In addition it is necessary for the person using the software to be trained and registered as competent in the use of the software.

The SEDBUK value is intended to represent a seasonal efficiency. It is recognised that it is difficult to achieve accurate measurements of part load efficiencies and, as an attempt to try and reduce the possible measurement deviations, an efficiency value based on full and part load was chosen. This boiler efficiency value is modified by a constant that is intended to take into account a number of system operating characteristics. Without going into a great deal of detail it was based on the appliance operating at different load conditions throughout the year, providing space heating and hot water during the winter but only hot water during the summer and it assumed basic sizing ratios and a system control philosophy. As mentioned in the previous paragraph, the value is modified by a number of factors, when used in support of building regulations, to take account of differing heating emitters and system controls.

This procedure was developed at a time when standard efficiency boilers were still the norm and only a limited amount of data was available that accurately described the operation of condensing boilers.

Controls

In the current (latest) version Part L of the Building Regulations is now a more strategic document than previously and a lot of the detail has been removed to second tier documents. These are the "Domestic Heating Compliance Guide", which is referenced by Part L1A (new domestic buildings) and L1B (existing domestic buildings) and the "Non domestic Heating, Cooling and Ventilation Compliance Guide". These documents have the same status as the Part L documents. The minimum provisions for the control of gas-fired heating systems are described in par. 2.2 f), Table 2 and are very similar to the ones in Ireland (see next Chapter). The full document is available on the web along with the rest of the UK Building Regulation.

8.2 NO_x, CO, C_xH_y, SO_2, PM10 emissions

The UK follows the EN standards and has no NO_x -limits on domestic gas appliances. Reportedly, there are CO emission limits, but probably mostly relating to safety and not environmental concerns.

[41] This paragraph is largely based on a contribution from Dr. Martin Searle, pers. Comm.., Nov. 2006.

8.3 Labelling

See Annex.

8.4 Incentives

For a full report on the current status of incentives see the Boiler Market Report of BRG Consult for the European Commission to be issued 2006.

8.5 Outlook

Currently, micro-CHP and renewables seem to be the most discussed topics in the British heating industry but they are largely outside the scope of the study. As far as fossil fuel fired boilers are concerned BRE reports that a recently completed DTI sponsored Partners in Innovation Project has developed methods for assessing the seasonal efficiency of boilers and chillers. Currently, plant performance data is limited to the performance of the boilers or chillers under controlled conditions and fixed levels of full load capacity. The aims of the project were to develop a seasonal efficiency rating scheme that would assist building services engineers in their design of efficient plant and also provide a means of stimulating the market towards a life cycle performance approach rather than a pre-occupation solely with first cost. To this end the project partners have developed a rating scheme so that users of boilers and chillers can make a more informed judgement of the likely seasonal performance of their proposed HVAC plant.

The key factors determining the seasonal performance of the boiler or chiller are the efficiency of the plant at part load and the load that the plant experiences in response to the seasonally varying building heating and cooling demand. The project therefore focussed on investigating these two factors.

It was recognised that it would be beyond the scope of this project to develop completely new test procedures and standards.. Therefore, the project partners studied existing efficiency standards and test procedures in the UK, Europe and North America in order to rely, as much as possible, on existing industry standards for boiler and chiller efficiencies.

The EU Boiler Efficiency Directive[42] requires efficiency to be measured at 30% and 100% of output. However, boiler efficiency is comparatively constant over this range of operation and the analysis showed there is little difference between the quoted efficiency at these loads and any seasonally adjusted values. Additionally to this, at the predicted low loads at which the boiler plant may operate for much of the heating season, there is little published information about efficiency but it is clear that it may fall significantly. Consequently the team took a quite pragmatic approach to assessing the efficiency below 30% load and it was decided that an efficiency at 15% load would be more representative of low load operation. As there is no recognised test procedure at this output the efficiency would be either, as determined by the manufacturer, or calculated depending on the burner turndown and control method as follows:

- Fully modulating control to 15%: efficiency at 15% = 30% efficiency x 0,98
- High/low control below 30% load: efficiency at 15% = 30% efficiency x 0,95
- On/off control below 30% load: efficiency at 15% = 30% efficiency x 0,90

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[42] Boiler (Efficiency) Regulations (1993, No 3083), otherwise known as the Boiler Directive UK/EU or Council Directive 92/42/EEC

Note: the efficiencies quoted here do not include electrical loads associated with the burner.

The load profile of buildings is not well known and little detailed monitored data is available. Therefore, this project used computer simulations to determine the hourly heating and cooling load profiles of typical office type buildings over the heating or cooling season. This approach provided greater scope for the project as a wider range of building forms and climates and the simulation of approximately 60 buildings showed a clear and consistent load pattern with most plant operation (both heating and cooling) being below 25-30% of full load. Heating loads were typically below 15% of full load for approximately 50% of the operating period. Full load operation was observed for less than 2% of the time. Using the plant load profiles developed a 'typical' load profile was established that represents office type buildings in the UK. This typical load profile quite accurately reflects the influence of building design, weather, occupancy and location, although naturally the absolute values change significantly.

The load profiles generated by the simulation program show the plant requirement for each hour of the year, and these encompass the whole range of plant output from 1% to 100%. This level of detail is not compatible with the measured efficiency of the plant as described above and therefore the hourly load profiles have been partitioned ('binned') into bands compatible with the efficiency bands for the plant. The binning of the hourly loads provides weighting factors that are the fraction of operating hours at which the plant will operate at that percentage of full load. Hence for chillers the load profile is binned into 25%, 50%, 75%, 100% of full load demand.

For boiler plant there is not an equivalent to the ARI[43] method, but there is little reason not to accept the conceptual approach and use weighting factors for heating plant based on the percentage operation at part loads, therefore the hourly heating loads are binned into 15%, 30% and 100% bands.

The boiler efficiencies derived, as above, for the 15%, 30% and 100% output can now be put together with the weighting factors to provide seasonal efficiencies. From the simulations carried out on the office type buildings a set of banded weighting factors have been derived. These weighting values, for the 15%, 30%, and 100% efficiencies, are 0,50; 0,20; 0,30 respectively. The seasonal efficiency of a boiler is therefore:

Seasonal Boiler Efficiency =

*0,5 * (Eff15%) + 0,20 * (Eff30%) + 0,30 * (Eff100%)*

For example, a condensing boiler with BED efficiencies of 96% full load, 98% at 30% load: with fully modulating controls to 15% full load (therefore at 15% load = 98 * 0.98 = 96%):

Seasonal efficiency of example boiler =

*0,5 * 96 + 0,2 * 98 + 0,3 * 96 = 96,4%*

A rating scheme for boilers on seasonal performance was suggested. This approach is in line with the general approach adopted by the Market Transformation Programme that has been developing similar rating scales for a range of products. The rating scales suggested by this project are shown below. The Boiler Efficiency Directive makes provision for a 'Star Labelling' system and defines bands of stars at 3 percentage points

[43] American Refrigeration Institute Standard 550/590-1998: 'Water chilling packages using the vapor compression cycle This standard describes performance test methods for factory designed and prefabricated water chilling packages including one or more hermetic or open drive compressors and lays down the testing methods and conditions.

increase of efficiency above the base line compliance values. Using this approach, but translating the stars to letter bands, results in the following seasonal efficiency rating system.

Methods of computing the likely seasonal efficiency of boiler have already been included as proposals in the 2005 revision of Part L2 of the Building Regulations.

Table 8-7. Proposed scheme for boiler labelling

Boiler Rating Label	Seasonal Efficiency Range (net efficiency)
A	> 96
B	93 – 96
C	90 – 93
D	87 – 90
E	< 87

Update (contribution Dr. Martin Searle, Nov. 2006)

The above proposals reportedly reflected the position at a relatively early stage in the development and the recommendations changed considerably[44]. In particular the "correction" factors suggested for arriving at a 15% load figure were not progressed. the seasonal performance figure for boilers was being developed for non-domestic buildings. The results of this work have been incorporated into the final version of the *"Non-domestic Heating, Cooling and Ventilation Guide"*. The scheme still uses a "seasonal" efficiency that is based on weighted values of 100%, 30% load factors for a single boiler installation. The situation changes slightly when multiple boiler installations are considered, in this case a 15% load factor is taken into account. The weighting factors are, however, different from those quoted above. The efficiency of a single boiler at 15% load is taken as the same as at 30% load.

Full details of the process for the calculation of seasonal efficiencies can be found in the *"Non-domestic Heating, Cooling and Ventilation Guide"*.

Policy update (Defra, Sept- Oct. 2007)

Currently (Sept. 2007), the UK governement is concerned on the issue of tolerances on efficiency declarations in SEDBUK, a database of boiler seasonal efficiencies that is managed on a day to day basis by Gastec at CRE Ltd.. The UK ministry DEFRA reports [45]that *"it has become apparent that despite requiring independent verification of performance some manufacturer's boiler efficiencies are being overstated. This has become more apparent as manufacturers are competing at the higher end of the efficiency scale and are seeking to show their boiler in the best light; for example, by providing tuned boilers for type testing so they are classified in a higher A to G banding. Indeed, in the last couple of years we have tested nearly 70 production boilers and only one of those performed to the stated claim – the performance ranged from circa half an percent lower to twelve percent lower than claimed value. What appears to be happening is that manufacturers are using the tolerances and uncertainty of measurement permitted in the procedure and standards to the full and it seems, rather disappointingly, that some notified bodies may be turning a blind eye to this in order to retain their contractual relationships. "*

To tackle the problem DEFRA would welcome measures that

- reduce the number of boiler standards;
- tighten the allowable tolerances and uncertainty of measurements;
- demand the use of test equipment that will deliver this level of accuracy;

[44] Contribution by Dr. Martin Searle (Baxi Potterton), pers. comm.., Nov. 2006

[45] Pers. Comm. Sept. 2007. Alan Christie, UK Dept. of Environment, Food and Rural Affairs (DEFRA).

- ensure the effects of pressure, temperature and humidity are taken into account;
- ensure the procedures and standards take account of advances in technology, including that of control systems and software regimes;
- consider the use of more appropriate test schedules, which better reflect actual use; and
- introduce 'out of the box' testing where the tested appliance contains the control software placed on the market.

In terms of measurement uncertainties and tolerances, values of ± 2% (full load efficiency) and ± 4% (part load efficiency) –although not yet officially announced-- are mentioned as limits for SEDBUK declarations. BRE claims that 87% of the test results the receive are already within that bandwidth.

Energy Balance verification

Furthermore, BRE is looking into Energy Balance verification (EBV) as a method to improve data reliability, whereby the manufacturer's declaration is verified using additional (redundant, low-cost) test parameters [46].

The EBV method will require additional data and depending on the part-load method used, may require a further test under continuous firing at full-load or at the minimum firing rate . The first table lists the test conditions and the following table lists the data set required under each test condition.

Table 8-8: Test conditions

Method: (from EN 297, 483, 677 or 304)	Boiler water temperature		
	Gas Condensing	Oil Condensing	Non-condensing
1. Full-load test (compulsory)	flow/return 80/60°C	flow/return 80/60°C	flow/return 80/60°C
2. Part-load test: one of 2a to 2e			
Boiler tested using direct method:			
a) Firing rate of 30%, if possible	return 30°C	Mean 40°C	mean 50°C
b) Minimum firing rate, if >30%	return 30°C	Mean 40°C	mean 50°C 55/45°C
c) 100% firing rate (i.e. on/off)	flow/return 50/30°C	flow/return 50/30°C	flow/return 60/40°C
Boiler tested using indirect method:			
d) Minimum firing rate, if >30%	return 30°C	Mean 40°C	Mean 50°C 55/45°C
e) 100% firing rate (i.e. on/off)	flow/return 50/30°C	flow/return 50/30°C	Flow/return 60/40°C
3. If method 2b or 2c applies an additional continuous firing rate test 3a or 3b is required because method 2b and 2c impose cyclic conditions			
a) Minimum firing rate, if >30%	return 30°C	Mean 40°C	mean 50°C (55/45°C)
b) Full-load	flow/return 50/30°C	flow/return 50/30°C	flow/return 60/40°C

For range-rated boilers the data must be consistent with the heat inputs required to establish conformity to the BED.

For each test condition (in table 1) the information recorded is shown in the table below.

Table 8-9: Information recorded in test

Measurement	Units
Compulsory	

[46] Pers. Comm. Sept. 2007. Bruce Young, Building Research Establishment (BRE), main contractor to DEFRA on SEDBUK.

	Net heat input	kW
	Heat output	kW
	Flow temperature	°C
	Return temperature	°C
	Flue gas temperature†	°C
	Ambient air temperature	°C
	Carbon dioxide concentration in flue gas (dry) †	% v/v
Optional		
	Condensate flow rate	kg/hour
	Ambient air relative humidity	%
	Circulating pump power	Watts
	Fan power (gas boilers)	Watts
	Oil pump power (oil boilers)	Watts

For the part-load efficiency results, flue gas temperature and carbon dioxide concentration is only required under continuous firing conditions and so not required for direct part-load tests where the burner cycles on and off (i.e. method 2b or 2c). Instead data for additional test at the minimum or full firing rate is required.

Where the indirect part-load efficiency method is used, data from the standby heat loss test is required (e.g. as in EN 297, 483).

Where the direct part-load efficiency method is used, standby heat loss or case loss data is not compulsory. However data from a standby heat loss test or case heat loss test (e.g. as in EN304), for a stated mean water rise above the ambient air temperature, may also be provided optionally.

A cautious default is used in the absence of optional data.

PAS 67 (24 h load profile)

As an example of "the use of more appropriate test schedules, which better reflect actual use;" the PAS 67 standard should be mentioned. This test standard, which is nearing completion is designed to test the thermal and electrical performance of micro-cogeneration units or boilers at 100%, 30% and 10% of output plus DHW (Table 2, M324) over a series of 24hour tests, in addition, intermediate load test can also be specified and undertaken. The results are obtained with their intelligent controls enabled, compared with the current very short tests and un-enabled controls for part load tests associated with boiler testing. The contractor for this work, GASTEC UK, claims it could easily be extended to boilers. The robustness of the standard has been tested and is claimed to have real advantages [47].

A second concept proposed by GASTEC at CRE is the use of dynamic test rig wherein the tests are again over a 24hour period but this time the boiler is connected to a rig that permits variation of both the return and flow temperatures. These temperatures will be dependent upon a real heat demand generated by the computer model of a house. GASTEC at CRE is increasingly of the opinion that the real operational efficiency of a condensing boiler is a strong function of its control regime as well as its excess air level and the difference between flue temperature and water return temperature. The boiler and its control circuit are interfaced with a rig which places the control devices (ie including room thermostat and/or external thermostat) within artificial environments whose temperatures are carefully controlled to mimic that of a real house. Heat removal from the rig is by means of a water/water heat exchanger that is programmed to simulate the behaviour of real radiators. GASTEC at CRE believes this compromise of real equipment (ie boiler plus controls) and a simulated environment is the best compromise between the current generation of efficiency rigs (which are inherently very simple) and whole house or matched pair tests which are

[47] Pers. Comm.. Sept. 2007. Mark Crowther, GASTEC at CRE (50% owned by KIWA Group), UK.

inherently very difficult to reproduce and extremely expensive. This work has been sponsored by the UK Carbon Trust.

9 IRELAND

9.1 Introduction

Ireland is still in the process of implementing the EPBD, e.g. through a consultation process. Recently the DEAP, Dwelling Energy Assessment Procedure was published and also the AES Alternative Energy System assessment and the software tool "PASSES" should be ready for implementation by 2007.

The DEAP manual describes the Dwelling Energy Assessment Procedure (DEAP), which is the Irish official procedure for calculating and assessing the energy performance of dwellings. The procedure takes account of the energy required for space heating, ventilation, water heating and lighting, less savings from energy generation technologies. For standardised occupancy, it calculates annual values of delivered energy consumption, primary energy consumption, carbon dioxide emissions and costs, both totals and per square metre of total floor area of the dwelling.

The basic methodology is practically identical to the one for the UK SAP, described earlier and we will not discuss the DEAP in detail but just highlight some new issue, where the DEAP is giving a 5% reduced efficiency in case there is no 'boiler interlock' .

Also new for Ireland is the AES Alternative Energy System assessment, which applies to large buildings > 1000 m², where new opportunities for solar water heating and heat pump water heaters may arise [48].

9.2 DEAP Boiler Interlock

In the DEAP the efficiency for both space and water heating is reduced by 5% if the boiler is not interlocked for both space and water heating. This chapter cites some of the boiler controls in the DEAP.

Heating controls

The influence of the type of controls incorporated into the heating system is represented in a worksheet ('Sh' with reference to Table 4e). The following are descriptions of the types of controls mentioned in Table 4e.

Room thermostat

A sensing device to measure the air temperature within the building and switch on and off the space heating. A single target temperature may be set by the user.

Time switch

A switch operated by a clock to control either space heating or hot water, but not both. The userchooses one or more "on" periods, usually in a daily or weekly cycle.

Programmer

Two switches operated by a clock to control both space heating and hot water. The user chooses one or more "on" periods, usually in a daily or weekly cycle. A mini-programmer allows spaceheating and hot water to be on together, or hot water alone, but not heating alone. A standard programmer uses the same time settings for space heating and hot water. A full programmer allows the time settings for space heating and hot water to be fully independent.

[48] see www.epbd.ie

Programmable room thermostat

A combined time switch and room thermostat which allows the user to set different periods with different target temperatures for space heating, usually in a daily or weekly cycle.

Delayed start thermostat

A device or feature within a device, to delay the chosen starting time for space heating according to the temperature measured inside or outside the building.

Thermostatic radiator valve (TRV)

A radiator valve with an air temperature sensor, used to control the heat output from the radiator by adjusting water flow.

Cylinder thermostat

A sensing device to measure the temperature of the hot water cylinder and switch on and off the water heating. A single target temperature may be set by the user.

Flow switch

A flow switch is a device that detects when there is no water flow through the system because the TRVs on all radiators are closed.

Boiler interlock

This is not a physical device but an arrangement of the system controls so as to ensure that the boiler does not fire when there is no demand for heat. In a system with a combi boiler it can be achieved by fitting a room thermostat. In a system with a regular boiler it can be achieved by correct wiring interconnections between the room thermostat, cylinder thermostat, and motorized valve(s). It may also be achieved by a suitable boiler energy manager.

In systems without an interlock the boiler is kept cycling even though no water is being circulated through the main radiators or to the hot water cylinder. This results in a reduction in operating efficiency and for this reason Table 4e specifies that a seasonal efficiency reduction of 5% should be made for such systems. For the purposes of the DEAP, an interlocked system is one in which both the space and water heating are interlocked. If either is not, the 5% seasonal efficiency reduction is applied to both space and water heating; if both are interlocked no reductions are made.

It is also necessary in the DEAP to specify whether a hot water cylinder has a thermostat or not. A cylinder thermostat normally shuts down the primary circuit pump once the demand temperature in the cylinder is met. The cylinder thermostat itself may not switch off the boiler; this is only done if the pump and boiler are interlocked and so the presence of a cylinder thermostat does not in itself signify the presence of an interlock for water heating. If there is no cylinder thermostat, however, there can be no interlock since the system does not know when the demand temperature is reached. A boiler system with no cylinder thermostat must therefore be considered as having no interlock.

A boiler system with no connected room thermostat - even if there is a cylinder thermostat – must be considered as having no interlock. For solid fuel boilers and dry core electric boilers the boiler interlock question is not relevant and the efficiency values in Table 4a allow for normal operation of these appliances. For such systems there is no efficiency reduction for the absence of interlock, except where the system has "No thermostatic control", for which the efficiency reduction of 5% is made to the space and water heating efficiencies.

Note: TRVs alone do not perform the boiler interlock function and require the addition of a separate room thermostat in one room.

Bypass

A fixed bypass is an arrangement of pipes that ensures a minimum flow rate is maintained through the boiler. This is achieved either by ensuring that one radiator stays open or by adding a short pipe with a valve between the flow and return pipe. A radiator without a TRV or hand valve is a common form of fixed bypass.

The control type 'TRVs + programmer + bypass' is a non-interlocked system in the absence of:

Boiler energy manager

Typically a device intended to improve boiler control using a selection of features such as weather compensation, load compensation, start control, night setback, frost protection, anti-cycling control and hot water over-ride. For the purposes of the DEAP it is an equivalent to a hard-wired interlock and, if present, weather compensation or load compensation.

Time and temperature zone controls

In order for a system to be specified with time and temperature zone control, it must be possible to program the heating times of at least two zones independently, as well as having independent temperature controls. It is not necessary for these zones to correspond exactly with the zone division that defines the living area fraction (section 7.2).

In the case of wet systems this involves separate plumbing circuits, either with its own programmer, or separate channels in the same programmer. (By contrast, TRVs provide only independent temperature control.) Time and temperature zone control can be obtained in the case of electric systems, including underfloor heating, by providing separate temperature and time controls for different rooms.

Weather compensator

A device, or feature within a device, which adjusts the temperature of the water circulating through the heating system according to the temperature measured outside the building.

Load compensator

A device, or feature within a device, which adjusts the temperature of the water circulating through the heating system according to the temperature measured inside the building.

Controls for electric storage heaters

There are three types of control that can be used with electric storage heaters - manual charge control, automatic charge control and CELECT-type control. Automatic charge control can be achieved using internal thermostat(s) or an external temperature sensor to control the extent of charging of the heaters. Availability of electricity to the heaters may be controlled by the electricity supplier on the basis of daily weather predictions (see 24-hour tariff, section 10.3.2).

A CELECT-type controller has electronic sensors throughout the dwelling linked to a central control device. It monitors the individual room sensors and optimises the charging of all the storage heaters individually (and may select direct acting heaters in preference to storage heaters).

10 FINLAND

10.1 Introduction

Due to climatic reasons, Finland already has very demanding thermal requirements on the building shell. In the 2004 version of the Finnish building regulations, thermal requirements were sharpened by 30% and heat recovery from exhaust air became mandatory. If the owner does not want to make use of heat recovery, then the amount of energy that would result from recovered air has to be compensated for by improving the thermal insulation of the building. The compensation principle cannot be used the other way, so that thermal insulation could be compensated with more effective heat recovery, only in very special cases in log constructions where the U-value of walls cannot meet the requirements. Depending on the chosen measures and requirements, adjustments in the Finnish legislation might be necessary while some regulatory and technical objectives can conflict. In order to prevent this from happening, the Finland Ministry of Environment is trying to involve different parties of the construction process in the development of the energy certificate and the new methodology. Compliance with the building regulations is not seen as a problem in Finland.[49]

For obvious reasons there is not much focus on solar systems in the Finnish building regulations. Due to district heating, the share of energy coming from sustainable energy sources (biomass) is already high in Finland.

In Finland, energy certificates are voluntary, based on piloting systems and mainly used by forerunners in the construction sector and the building regulations account for new construction (Sunikka, 2002). Energy labels for one-family housing, or building components like windows, and an Environmental Classification of Buildings exist but they are voluntary and demonstration-like.

10.2 Energy & CO_2

Details of building regulations as far as gas-, oil- or electric CH boilers are concerned are not known. In 1997 the Boiler Directive 92/42/EC was transposed in Finnish legislation through the National Building Code part D7. It is expected that any new legislation will not extend on these minimum requirements, because oil- and gas fired boilers are rare in Finland.

Regarding the implementation of the Buildings Directive, three working groups published their drafts on the new legislation for implementing the EPBD on 14 June 2005. The proposals are open for public consultation until August 22.

The drafts include amendments to the existing Land Use and Building Act. More detailed building regulations for describing the calculation methodology and levels of energy performance requirements will be given in Finland's National Building Code. According to the draft law on energy certification, all building owners, except those of buildings mentioned in Article 4.3 of the EPBD, should have an energy certificate that is no more than 10 years old, at the time of construction, sale or rent of a building.

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[49] Source: **Minna Sunikka,** The Energy Performance of Buildings Directive (EPBD): improving the energy efficiency of the existing housing stock**,** Optimising the impact of Article 7 on the energy certificate, Research task for the '**40%-House',** 17 March 2005

Existing public, office and retail buildings, apartment buildings and single-family houses will have different transition periods. If a building has had an energy audit within the 10 years before the commencement date of the certificate obligation, the audit report will replace the certificate. A voluntary approach is suggested instead of mandatory boiler inspection. Air-conditioning systems must be inspected every 10 years.

10.3 NO_x, CO, C_xH_y, SO_2, PM10 emissions

Apart from energy, also requirements on special minimum emissions of NO_x, CO, etc. of gas- or oilfired boilers are not expected. Most environmental concerns in that context concentrate on the 2.2 million fireplaces plus about 1.5 million wood-fired saunas and boilers in Finland. Most fireplaces are used only occasionally. In 2000, wood-burning fires and stoves are estimated to have caused about 40 per cent of the country's emissions of airborne particles (less than 10 micrometers in size), almost half of its emissions of small particles (less than 2.5 micrometers in size), and almost one fifth of its emissions of volatile organic compounds. Moreover, in the same year, they are estimated to have generated more than 40 per cent of all airborn dioxin emissions of Finland. Most fireplaces are installed in buildings during renovation and it is estimated that their sales will reach nearly 60 000 in 2002. Sales of wood-fired saunas will probably be almost as high.

In equipment used today, combustion conditions are rarely optimal from the point of view of air pollution control. According to the National Climate Strategy, the use of wood as heating fuel should be increased and, thus, it is proposed in the document that boilers using solid fuel should have emission limits so that methane emissions could be reduced. Such limits would also cut the emissions of other hydrocarbons.

Carbon monoxide limits for small boilers (less than 50 kW) would be similar to those of fireplaces. Larger boiler plants would have to improve their efficiency and produce cleaner flue gases. [50]

10.4 Incentives

There are several general subsidies for the renovation of the existing stock.

Annually € 15-17 million are allocated as energy subsidies for apartment blocks. Single-family houses, which account for almost 50% of space heating energy consumption, have been outside the scope of publicly supported energy audit programs. The existing energy subsidies are not likely to increase to motivate improvements suggested in the energy certificate unless single-family housing is included in the program and there is already pressure towards that development.

According to the Ministry, subsidies and the Directive follow different paths at the moment, but in the future it would be good to combine them so that subsidies would be allocated only for the improvements suggested in the energy certificate. Information campaigns that can explain the Directive and make it more approachable for normal citizens need funding first. The National Climate Strategy can give insight to whether subsidies will be expanded to include single-family housing and if so, by when.

[50] Air Pollution Control Programme 2010, The Finnish National Programme for the implementation of Directive 2001/81/EC, approved by the Government on September 26, 2002. See **www.ymparisto.fi**

11 DENMARK

11.1 Introduction

Some 10 years ago Denmark has introduced a system of energy certification or rather 'energy labelling' of new and existing buildings and has been –for the certification part—a role model in the preparatory stages of the EPBD. The certification is mandatory for existing buildings at every sale and renovation of an existing building. For new buildings Denmark is one of the 9 EU Member States that has transposed the EPBD in 2006, meaning that builders have to evaluate the energy performance of the building in a holistic approach as prescribed in the EPBD and comply with minimum requirements on single building components, like boilers, to obtain a building permit. Furthermore, after the building is completed an energy audit has to be performed for the mandatory energy certificate to check whether the house was built according to plan.

The focus of the Danish energy policy has been on developing district heating. Gas- and oil-fired boilers are a relatively small market.

On 16 June 2005, the Danish Parliament unanimously approved a new law on Energy Savings in Buildings (Lov om fremme af energibesparelser i bygninger, Danish Act no. 585 of 24 June 2005). The law implements the requirements in articles 7, 8, 9 and 10 in the EPBD (articles concerning certification, inspection & experts).

On many points, the new law goes further than the minimum requirements in the directive and requires regular energy labelling of all public buildings every 5 years, regular energy labelling of all large buildings (more than 1 000 m² gross area) for trade and services as well as large blocks with flats. For building and apartment for sale or rent the energy labelling will only be valid for 5 years. Energy labelling will include inspection, certification and advising.

For new buildings inspection and certification will be used to ensure fulfilment of building codes. All oil boilers will be regular inspected every one or two year and all heating systems will be included in the 15-year inspection, regardless of the size of the boiler. (webzine 4)

On 17 June 2005, new Energy Requirements were published for both the Buildings Regulations for Small Houses and for the General Building Regulations. The new Requirements will implement articles 3, 4, 5 and 6 in the EPBD (articles concerning methodology, requirements, new buildings & existing buildings). The new requirements came into force by 1 of January 2006 and are based on a new method for calculation of energy performance in buildings. The requirements will reduce energy consumption by 25-30% in new buildings and set requirements for larger renovations and improvements in all buildings, amongst others when replacing boilers. Along with the new requirements Low Energy Classes on 75% and 50% of general energy consumption will also be introduced. These reduced levels are expected to become mandatory in 2010 and 2015 respectively.

The energy regulation and the energy labelling of buildings have been linked together by making the official approval of occupation and use of a new building conditioned by an approved energy audit of the building where the assumptions used in calculating the energy consumptions are controlled. Furthermore, it will be mandatory for the public authorities to implement energy savings measures described in the Energy Certificate having a pay back time less than 5 years. Under the new energy regulations, the energy performance for new buildings will always have to be calculated. The Danish Building Research Institute SBi has developed an electronic tool for calculating the energy performance for a building. There has been great focus on the balance of the degree of details and calculation accuracy, the complexity and applicability and the motivation for energy-efficient solutions and optimisation. As far as possible the calculation method is based on CEN standards and the existing proposals on these. The European standards can easily be incorporated into the software, once they become available.(www.sbi.dk). The case specific boiler model of PrEN 15316-4-1 is used in the Danish EPDB tools for calculating energy performance in new and existing buildings.

11.2 Energy & CO_2

As mentioned, the Buildings Regulations for Small Houses (*Tillæg 9 til Bygningsreglement for småhuse)* and the General Building Regulations *(Tillæg 12 til Bygningsreglement)* prescribe minimum requirements for central heating boilers ('Kedler'):

- Oil-fired boilers should have at least an efficiency [on net calorific value] of **91% in both full load and part-load**. Full load efficiency is to be measured at 70°C boiler temperature, part-load at 40 or –depending on the boiler type- 50°C.[51]
- Gas-fired boilers should have at least an efficiency [on net calorific value] of **96% in full load and 104% in part-load.** Full load efficiency is to be measured at 70°C boiler temperature, part-load at 30°C.[52]

These requirements apply to boilers with a nominal power up to 400 kW. For the replacement of existing boilers with a nominal power of over 100 kW the minimum efficiency shall be 91% [on net calorific value] in part-load and full load.[53] This also applies to boilers with a nominal power of more than 400 kW.

Apart from the requirements on boiler efficiency Denmark is also a frontrunner in the field of minimum efficiency requirements for circulator pumps. Reportedly, variable speed drives (VSDs) are mandatory fopr circulators in Denmark. The preparatory Ecodesign study on motors and pumps should provide more details on this issue.

11.3 NO_x, CO, C_xH_y, SO_2, PM10 emissions

Danish emission inventories are prepared on an annual basis and are reported to the UNECE Framework Convention on Climate Change (UNFCCC or Climate Convention) and to the UNECE Convention on Long-Range Transboundary Air Pollution (LRTAP Convention). Furthermore, a greenhouse gas emission inventory is reported to the EU, due to the EU – as well as the individual member states – being party to the Climate Convention. The annual Danish emission inventories are prepared by the Danish National Environmental Research Institute (NERI). The inventories include the pollutants: CO_2, CH_4, N2O, SO_2, NO_x, NMVOC, CO, particulate matter, heavy metals, dioxins and PAH. In addition to annual total emissions, the report includes sector specific emissions and uncertainty estimates. Every 5 years the reporting includes data

[51] Stk. 3. Kedler til fyring med olie skal have en nyttevirkning på mindst 91 pct. ved CE-mærkning for såvel dellast og fuldlast. (10.3, stk. 3) *Nyttevirkning ved fuldlast og dellast fremgår af kedlens CEmærkning. Nyttevirkningen er målt ved 70°C ved fuldlast og 40°C, henholdsvis 50°C ved dellast afhængig af kedeltype.*

[52] Stk. 4. Kedler til fyring med gas skal have en nyttevirkning ved CE-mærkning på mindst 96 pct. ved fuldlast og 104 pct. ved 30 pct. dellast. *(10.3, stk. 4) Bestemmelsen indebærer anvendelse af kondenserende gaskedler. Nyttevirkningen er målt ved 70°C ved fuldlast og 30°C ved dellast.*

[53] Ved udskiftning af eksisterende kedler med en nominel effekt på over 100 kW skal virkningsgraden ved såvel fuldlast som dellast mindst være 91 pct.

on the geographical distribution of the emissions, a projection of emissions data and details of the activity data –e.g. fuel consumption– on which the inventories are based.

The CH_4 emission from stationary combustion has increased by a factor of 4,3 since 1990. This is a result of the considerable number of lean-burn gas engines installed in CHP plants in Denmark during this period.

SO_2 emission from stationary combustion plants has decreased by 94% from 1980 and 78% from 1995. The large emission decrease is mainly a result of the reduced emission from electricity and district heat production made possible by installation of desulphurisation plants and due to the use of fuels with lower sulphur content. Denmark has a tax on the sulphur content of oil, driving the market towards LowS.

The NO_x emission from stationary combustion plants has decreased by 43% since 1985 and 23% since 1995. The reduced emission is mainly a result of the reduced emission from electricity and district heat production plants in which the use of low NO_x burners has increased. Also, de- NO_x flue gas cleaning units have been put into operation in a greater number of the larger power plants.

The NMVOC emission from stationary combustion plants has increased by 43% from 1985 and 15% from 1995. The increased NMVOC emission results mainly from the increased use of lean-burn gas engines.

Residential plants are the most important stationary combustion source for CO, NMVOC, particulate matter and PAH. Wood combustion in residential plants is the predominant emission source. (source: Danish National Environmental Research Institute, Danish annual emission report and No. 229: Danish emission inventories for stationary combustion plants. Inventories until year 2003, www.dmu.dk). Residential plants account for 7% of the NO_x emission. The fuel origin of this emission is mainly wood, gas oil and natural gas accounting for 36%, 31% and 22% of the residential plant emission, respectively. In other words, 2.1% of total NO_x emissions come from residential oil-fired boilers and 1.5% comes from residential gas-fired boilers.

Stationary combustion accounts for 29% of the total Danish CO emission. Residential plants are the largest emission source, accounting for 88% of the emission. Wood combustion accounts for 90% of the emission from residential plants. This is in spite of the fact that the fuel consumption share is only 19%. Combustion of straw is also a considerable emission sourcewhereas the emission from other fuels used in residential plants is almost negligible.

Denmark has no minimum NO_x requirements for boilers, but only for natural gas engine and turbine > 120 kW input.

All in all, emissions from gas- and oil fired boilers are not a significant contributor to emissions of CH_4, NO_x, SO_2, CO, etc. and it is therefore unlikely that Denmark will go through the trouble of making a special legislation on this topic.

11.4 Labelling

The Danish gas companies and Danish Gas Technology Centre decided to use the well-know EU Energy Label design of whitegoods as the basis for development and implementation of a voluntary labelling scheme for small domestic gas boilers. A similar label was also used for oil boilers.

The aim of this initiative was to give the user an easy-to-use and fair tool for choosing a new domestic gas boiler and thus to promote the use of high-efficient boilers.

The annual efficiency method and the calculation program BOILSIM have formed the measurement and calculation basis for the boiler labelling scheme. To further assist the consumer in achieving a high sanitary hot water comfort and energy optimized operation of the heating system guidelines for choosing the best boiler/hot water tank combination were developed. Storage technology is the main market for sanitary hot water production. A detailed description of the calculation method for the energy label is found in the document “Description of the calculation method for the Danish labelling of gas fired boilers” that can be downloaded from www.dgc.dk.. Basically the boiler is evaluated on the basis of the total energy consumption (gas and electricity) needed to produce 20 000 kWh heat + 2 000 kWh hot water. Electricity consumption is weighted with a factor of 2,75 and the gas consumption with a factor of 1 .

Table 11-1. Danish Criteria for energy labelling of boilers based on total energy consumption

Weighted energy consumption [gas and electricity, kWh]	Energy label
< 23500	A
23500 - 24600	B
24600 - 25800	C
25800 - 27100	D
27100 - 28600	E
28600 - 30200	F
> 30200	G

The annual efficiency of the boiler for heat production is calculated for an annual heat demand of 20000 kWh. The calculation is based on an 8 kW heating installation, dimensioned for an average temperature on the water side of 55°C and ΔT = 15°C at an outdoor temperature of -12°C. It is assumed that the boiler runs at minimum load when the heat demand is smaller than the minimum load of the boiler. The calculation of heat production is made according to the BOILSIM method.

Annual efficiency for production of hot water is calculated for an annual consumption of 2000 kWh, corresponding to the average consumption of Danish single-family homes.

The electricity consumption is calculated for a house with an annual heat demand of 20000 kWh and an annual hot water consumption of 2000 kWh. The pump is assumed to run for the entire heating season = 220 days.

NO_x emission is calculated for an annual consumption of 20000 kWh heat + 2000 kWh hot water, with pure methane (G20) as combustion gas.

The annual environmental load of NO_x emission is graduated on a scale from A to G based on the criteria:

- Annual NO_x emission below 1 kg/year corresponds to A
- Annual NO_x emission between 1 and 2 kg/year corresponds to B
- Annual NO_x emission between 2 and 3 kg/year corresponds to C
- Annual NO_x emission between 3 and 4 kg/year corresponds to D
- Annual NO_x emission between 4 and 5 kg/year corresponds to E
- Annual NO_x emission between 5 and 6 kg/year corresponds to F
- Annual NO_x emission over 6 kg/year corresponds to G.

The hot water demand that can be covered by boiler and hot water tank is determined on the basis of Figure 11.1.

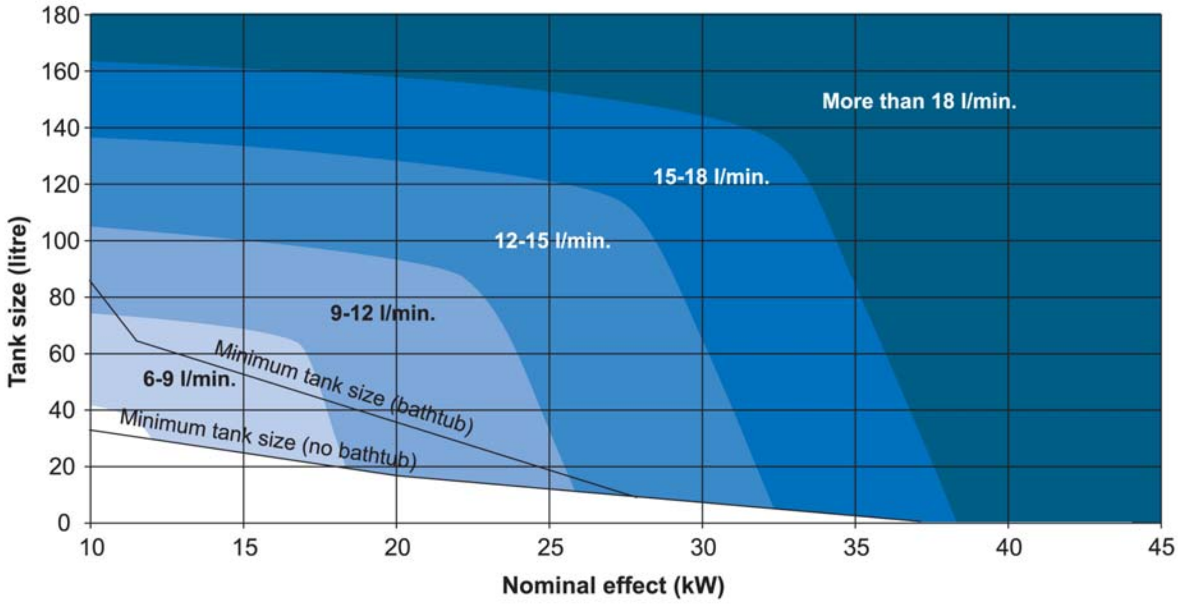

Figure 11-1. Criteria for choice of hot water tank

Table 11-2 shows the definition of the number of taps.

Table 11-2. Definition of the different categories of hot water needs

Hot water need	Litre per minute for 10 minutes	Corresponding to e.g.
Small	6-9	Shower
Normal	9-12	Shower and wash basin at the same time
Large	12-15	Bath tub or two showers at the same time
Very large	15-18	Two showers and wash basin at the same time

Upon adoption of the CEN standard EN 13203, the basis of calculation will be revised with the effect that the CEN standard will then form the basis of choice of hot water tank.

Apart from the label, other tools were developed that explain the contents of the label and facilitate comparison of alternative boilers. Different tools were developed for the consumer and the installer, respectively. Boiler manufacturers are yet another target group. Apart from the advising tools the manufacturers need to know what they are required to do in order to have their new boilers included in the labelling system.

The implementation of the labelling scheme in the market was based on a close cooperation between DGC and the gas companies, boiler industry, Danish Electricity Saving Trust, National Consumer Agency and Danish Energy Authority.

After a one year pilot period it appears that the energy labelling scheme has reportedly indeed influenced the boiler market:

- During this one-year period, the boiler manufacturers have adapted their boilers regarding the electrical components. Boilers that originally were sold with three-stage pumps have been modified to be sold with modulating pumps.

- The supply of the best A labelled boilers is increasing at the expense of B-G labelled boilers.
- The gas company show rooms only show A labelled boilers today.
- As the labelling system is a voluntary system, some boilers are still not labelled.

The Danish gas industry has fully supported the labelling system. Reportedly, the boiler manufacturers' commitment is mainly due to the fact that the labelling system has been prepared for EU standardisation.

11.5 Incentives

As in the Netherlands, large part of the budget for financial incentives has been reduced in recent years. The Danish Energy Authority expects incentives from white certificates, attractive loans for houses with a high energy performance rating, etc., but as far as the plans are known there are no subsidies for efficient gas- or oil-fired boilers.

12 SWEDEN

12.1 Introduction

Gas- and oil-fired central heating boilers are rare in Sweden. Most space heating comes from district heating, heat pumps and CHP. In the country-side, multi-fuel boilers (wood/oil) are quite common. Sweden is a pioneer in electric heat pumps with annual sales up to 40 000 units/year (compare: all EU ca. 70 000 units).

The Government decided on February 9th to refer the proposed law on "energy and indoor environment certification of buildings" to the Council on Legislation (Lagrådet), which will verify that it does not conflict with existing legislation. After approval from the Council, the Government Bill will be presented to the Parliament, and approval to become an Act is expected to be given during the summer. Complementary directions and regulations will define the rules regarding the content of the declaration as well as the requirements for the energy experts. The Act on "energy and indoor environment certification of buildings" is expected to enter into force by 1 October 2006.

In order to cope with the lack of certified independent energy experts, the EPBD will be implemented in the following progressive way:

- All "special buildings", e.g. buildings where public services are provided or that have many visitors, with more than 1000 m^2, and multi-family residential buildings are required to be certified by 31 December 2008;
- Certification of all buildings will be mandatory from 1 January 2009 whenever buildings are constructed, sold or rented out;
- Inspection of air-conditioning systems will start on 1 January 2009.

12.2 Energy & CO_2

There is no knowledge of minimum efficiency requirements for gas- or oil-fired boilers or a holistic approach that would push boiler efficiency upwards, other than the obvious transposition of the EU Boiler Directive. Legislation for heat pumps may be relevant [to do]. Furthermore, the ENPER project reports that electric resistence heaters for space heating are forbidden in Sweden.

12.3 NO_x, CO, C_xH_y, SO_2, PM10 emissions

There are no specific limits for NO_x emissions from boilers. These are set from case to case and common limits for small boilers are 60 ng/J fuel or 100 ng/J for boilers converted to natural gas.

12.4 Labelling

Sweden is part of the group of countries promoting the use of the Nordic Swan eco-label, but this eco-label has so far not singled out gas or oilfired boilers as a subject.

12.5 Incentives

There are incentives (subsidies) to promote the transition from fossil fuel fired boilers and electric resistence heating systems towards heat pumps, district heating (CHP). Heat pumps in themselves (for new buildings) are no longer promoted through subsidies because reportedly consumers are already convinced of the merits.

13 GERMANY

13.1 Introduction

In Germany there is a complex network of laws, standards, labels and incentives that is relevant for the space heating sector. For boilers the most relevant probably are the 'Energie-einsparverordung' ENEV on energy and the 1.BImSchV for other flue gas emissions (NO_X, CO, etc.).

13.2 Energy & CO_2

13.2.1 EnEV

The EnEV was introduced in February 2002 and amended –mainly referencing new DIN standards—two years later. It aims at energy saving in the building sector through the type of holistic approach prescribed in the Buildings Directive. Hereafter we will discuss the issues that are relevant for boilers.

Paragraph 3 of the ENEV 2002 (rev. 2004) specifies limits for primary energy demand and heat transmission losses, according to the table in the annex 1 of the Act.(see below)

Table 13-1. Limits ENEV 2002 (revision 2004) for primary energy demand and heat transmission losses

Ratio A/Ve	Annual primary energy demand Qp´´ in kWh/(m²a) usefull building surface		Qp´ in kWh/(m³a) heated building volume	Specific heat transmission losses of the building shell HT´ in W/(m²K)	
	Residential buildings except those in column 3	Residential buildings with mainly electric hot water devices	Other buildings	Non-residential buildings with ≤30% of building shell is windows + Residential buildings	Non-residential buildings with >30% of building shell is windows +
1	2	3	4	5	6
≤ 0,2	66,00 + 2600/(100+AN)	88	14,72	1,05	1,55
0,3	73,53 + 2600/(100+AN)	95,53	17,13	0,8	1,15
0,4	81,06 + 2600/(100+AN)	103,06	19,54	0,68	0,95
0,5	88,58 + 2600/(100+AN)	110,58	21,95	0,6	0,83
0,6	96,11 + 2600/(100+AN)	118,11	24,36	0,55	0,75
0,7	103,64 + 2600/(100+AN)	125,64	26,77	0,51	0,69
0,8	111,17 + 2600/(100+AN)	133,17	29,18	0,49	0,65
0,9	118,70 + 2600/(100+AN)	140,7	31,59	0,47	0,62
1	126,23 + 2600/(100+AN)	148,23	34	0,45	0,59
≥ 1,05	130,00 + 2600/(100+AN)	152	35,21	0,44	0,58

Intermediate values should be calculated according to the following equations:

Column 2: Qp´´ = 50,94 + 75,29A/Ve+ 2600/(100+ AN) in kWh/(m^2a)

Column 3: Qp´´ = 72,94 + 75,29A/Ve in kWh/(m^2a)

Column 4: Qp´ = 9,9 + 24,1A/Ve in kWh/(m^3a)

Column 5: HT´ = 0,3 + 0,15/(A/Ve) in W/(m^2K)

Column 6: HT´ = 0,35 + 0,24/(A/Ve) in W/(m^2K)

These limits do not apply if 70% of the heat is supplied by cogeneration or renewable energy. Also they do not apply –as far as the limit on annual energy demand is concerned— in case the heat is supplied by local heaters (Einzelfeuerstätten) or devices for which no technical standards (*'Regeln der Technik'*) exist, but in those cases there is a limit on the specific transmission losses. Special requirements regarding summer-comfort exist for building shells with >30% window-surface.

For heating systems it is important to note that if 80% or more of the space heating comes from electric storage heating systems the EnEV exceptionally –until 2010 ('for 8 years from the date of the EnEV')—allows a calculation of the annual primary energy demand with a primary energy factor of 2 [*instead of 3*]. The same applies to local electric water heaters (storage and instantaneous).

EnEV-defines these electric storage heating systems as systems (with a switch) that are linked to ventilation systems with waste heat recovery and that operate (i.e. use a resistance heater to heat up a storage medium) only when the ventilation system is switched off

Another temporary allowance concerns low temperature boilers in one- and two family homes where the system temperature is higher than 55/45°C. In this case —with a 'monolithic' building shell—the limit values for the annual primary energy demand Qp´´ in the table can be increased by 3%. This allowance is valid for 5 years starting from 1 Feb 2002, i.e. until 1 Feb. 2007.

Hot water installations in residential buildings need to be taken into account in the annual primary energy demand. The heat demand[54] Qw is to be set at 12,5 kWh/(m^2a).

In a simplified calculation the annual primary energy demand Qp follows from the sum of this Qw and the annual space heating demand Qh (Jahres-Heizwärmebedarf), multiplied with an installation-factor ep (*Anlagenaufwandszahl*):

$$Qp= (Qh + Qw) * ep$$

The installation-factor ep should be calculated according to DIN 4701 –10, which will be discussed later.

Paragraph 9 of the EnEV specifies the obligation of building owners to stop the operation by 31.12.2006 of CH boilers in the range of 4 to 400 kW that were installed before 1.10.1978. If the burner of the boiler was replaced after 1.11.1996 or if the boiler was otherwise adapted to meet minimum requirements, this can be postponed until 31.12.2008.

Furthermore, paragraph 9 specifies that pipework of the (water) heating installation has to be insulated according to the minimum requirements in table 5 (see below). The

[54] Nutz-Wärmebedarf für die Warmwasserbereitung QW im Sinne von DIN V 4701-10:

table is based on a specific heat conductivity of the insulation material of 0,035 W/(m·K).

Table 13-2. Minimum insulation thickness of CH-pipework (EnEV)

	pipe inner diameter	minimum insulation thickness
1	≤ 22 mm	20 mm
2	> 22 and < 35 mm	30 mm
3	>35 and < 100 mm	as diameter
4	>100 mm	100 mm
5	pipes in walls, at T-joints and other critical places	50% of the above
6	pipes in walls between different users	50% of the above
7	pipes in floors (Fußbodenaufbau) between different users	6 mm

For residential buildings with no more than two dwellings and where the owner occupies (one of the two) dwelling(s), the aforementioned implementation dates do not apply and the implementation of the measures in paragraph 9 can be postponed to two years after the time the house changes owner.

Paragraph 12 of the EnEV lists obligations for those who (re)furbish their house with central heating installations and building owners. Point 1 specifies that there should be an automatic heating control of heating and auxiliary electric devices (e.g. pumps) that operates on the basis of the outdoor temperature (UK: 'weather compensator') or similar and time. For buildings connected to a community or group heating system these requirements are considered fulfilled also without these provisions inside the building, if the supply temperature of the community or group heating system is controlled centrally on the basis of outdoor temperature and time.

Point 2 specifies that there should be room thermostats (e.g. TRVs or central) in every room. This does not apply to oil-fired or solid fuel fired local heaters. For non-residential buildings a group control may be allowed for rooms with similar use.

For new installations or replacements of circulator pumps with a nominal power of more than 25 W, the pump should be fitted with a flow-dependent control that reduces the power automatically in at least three steps, unless this would jeopardize the safety of the boiler.

Hot water circulators (in hot tap water circuits) should have an automatic on-off switch.

Storage cylinders for primary (CH water) or secondary (hot water) storage should have provisions to limit the heat transmission with devices according to current standards (D. *Regeln der Technik*).

The EnEV sets the minimum standards, but the underlying DIN standards determine most of the calculation methods. In the context of the energy performance of buildings the following (pre-) standards are relevant:

- **DIN V 4108-6** (June 2003): Wärmeschutz und Energie-Einsparung in Gebäuden –Teil 6: Berechnung des Jahresheizwärme- und des Jahresheizenergiebedarfs. This standard gives the methodology to calculate the heat balance of residential buildings (heat loss and gains from the building shell) according to EN 832, taking into account the typical German conditions.
- **DIN V 4701-10** (August 2003) Energetische Bewertung heiz- und raumlufttechnischer Anlagen – Teil 10: Heizung, Trinkwassererwärmung, Lüftung.

This standard describes the applicable calculation methodology of the energy performance, to be used in the context of the EnEV. For most of the heat balance of the buildings it refers to DIN V 4108-6 and has a strong focus on the heating, hot water and ventilation appliances.

- **DIN V 4701-10 Bbl 1** (Feb. 2002) Energetische Bewertung heiz- und raumlüfttechnischer Anlagen – Teil 10: Diagramme und Planungshilfen für ausgewählte Anlagensysteme mit Standardkomponenten. This Annex contains diagrams and examples that aim to help builders by providing shortcuts in the energy performance calculations. The outcomes are in line with DIN V 4701-10, but are based on sets of default values and 71 standard configurations of installation components.
- **DIN EN 832** (June 2003) Wärmetechnisches Verhalten von Gebäuden – Berechnung des Heizenergiebedarfs – Wohngebäude (incl. Birichtigung AC:2002).This is the official basis for the heat balance calculations in DIN 4108-6.

Furthermore, for cold bridges the EnEV makes a reference to DIN 4108 Beiblatt 2: 2004-01 and for solar gains to DIN 4108 - 2: 2003-07, Section 8.

Recently EnEV 2007 has been passed and will get into force by the 1.7.2008. General changes relevant to boilers in residential buildings have not been made. EnEV 2007 refers to DIN V 4108-6:2003-06 and DIN V 4710-10:2003-08 as well as EnEV 2002.

The holistic approach was extended and improved for use in non-residential buildings (DIN V 18599): energy use for air conditioning, lighting and auxiliary energy (all HVAC technologies) and interactions between building technologies.

The German electricity primary energy factor has been set to 2,7 (instead of 3) to value only non-renewable energies used for electricity generation. The limits of Table 13-1 have been slightly adopted. (note: primary energy factor of 2 for electric heating systems and electric water heaters is still valid until 2010)

13.2.2 DIN V 4701-10 standard

For boilers the DIN V 4701-10 and its Annex 1 (Beiblatt 1) are the most relevant. Starting point for this standard is, that the heat balance of the building is known and the relevant volumes and surfaces have been determined following the indications of EnEV, EN 832, DIN 4108-6, etc. and that now the influence of the heating, hot water and ventilation components has to be determined (compare installation-factor) to arrive at the annual primary energy demand.

For this there are three methods:

6. The diagram-method, where 71 standard configurations of heating, ventilation and hot water installations are given in *Beiblatt 1* and for each configuration there are diagrams where e.g. the annual primary energy demand Qp can be determined as resulting from the annual heat demand of the building shell Qh and the building surface An.
7. The table method, where for the energy performance of installation-components there are look-up tables e.g. performance as a function of the building surface. The appropriate values have then to be filled in worksheets, similar to e.g. the SAP worksheets in the UK.
8. The detailed method, where the equations are given that describe the physical parameters and their correlation. This is similar as the approach taken in the Dutch EPN method.

The outcome of these methods is the same, only the share of default values varies of course significantly. The methods address the needs in the various planning stages of the construction process (preliminary design, detailed design, technical specifications) and the needs of the different audiences. For a single home built for a private customer the diagram-method may be the beginning and end of meeting the EnEV-requirements.

For larger apartment buildings and non-residential buildings, involving architects and specialized contractors/consultants the challenge will be to tweak all the parameters in the detailed method to find the most cost-effective way to meet quality and energy requirements at the stage of the technical specifications.

In terms of impact on the boiler market and legislation all three methods are relevant, because the default values in the legislation tend to steer market demand. For that purpose VHK has analysed some of the values of the diagram-method and has made some energy performance rankings of the best and worst configurations.

The table below gives all 71 configurations and the look-up values for the annual primary energy demand for a building of 100 m² that is well insulated (40 kWh/(m²a) or less (90 kWh/(m²a)). These values cover the extremes of the diagram-method.

Table 13-3. DIN 4701-10 Bbl 1 Configurations of diagram method with values for building 100 m² (VHK 2006)

Nr. DIN V 4701-10 Bbl.1	**Space heating:** low temp. boiler (NT), condensing (BW), heat pump(WP), electric (EH), community heating (FW)	**Hotwater** central (zen) or local (dez)	**Solar** hot water (TW) or hot water + space heat (TWH)	**Ventilation**, mechanical extract (ABI) or heat recovery (WRG)	**Emitters** radiators (HK) or floor heating (FBH)	**Position** space heater inside (i) or outside (a)	**primary energy demand** kWh/(m²a) for 100 m² building at heat load of shell	
							40,0 kWh/m²a	**90,0 kWh/m²a**
1	NT	zen			HK	i	98,0	157,4
2	NT	zen			HK	i	89,0	148,4
3	NT	zen			HK	i	83,6	143,0
4	NT	zen			HK	a	123,1	186,3
5	NT	zen			HK	a	104,0	167,2
6**	NT	zen		ABI	HK	a	126,4	189,7
7	NT	zen		WRG	HK	i	87,2	146,6
8	NT	zen		WRG	HK	i	78,2	137,6
9	NT	zen		WRG	HK	i	76,4	135,8
10	NT	zen	TW		HK	a	100,2	163,5
11	NT	zen	TW		HK	i	77,4	136,8
12	NT	zen	TW		HK	i	69,7	129,1
13	NT	**dez**			HK	i	105,9	165,3
14	NT	**dez**			HK	a	118,8	182,1
15	NT	**dez**		WRG	HK	i	95,0	154,4
16	BW	zen			HK	a	113,2	171,0
17	BW	zen			HK	a	96,6	154,3
18	BW	zen			HK	i	93,1	148,7
19***	BW	zen			HK	i	89,9	145,4
20	BW	zen			HK	i	84,2	139,7
21	BW	zen			HK	i	81,0	136,5
22	BW	zen			HK	i	84,0	139,6
23	BW	zen			FBH	a	107,3	162,3
24	BW	zen			FBH	i	95,4	149,9
25	BW	zen			FBH	i	86,4	140,9
26	BW	zen		ABI	HK	a	109,9	167,7
27	BW	zen		WRG	HK	i	81,8	137,4
28	BW	zen		WRG	HK	i	72,9	128,5
29	BW	zen		WRG	FBH	i	84,5	139,0
30	BW	zen		WRG	FBH	i	75,5	130,0
31	BW	zen	TW		HK	i	73,2	128,7
32	BW	zen	TW		HK	i	65,5	121,1

33	BW	zen	TW		HK	i	75,5	129,9
34	BW	zen	TW		FBH	i	67,8	122,2
35	BW	zen	TW	WRG	FBH	a	85,7	143,4
36	BW	zen	TW	WRG	HK	i	61,9	117,4
37	BW	zen	TW	WRG	HK	i	54,3	109,8
38	BW	zen	TW	WRG	FBH	a	77,7	132,7
39	BW	zen	TW	WRG	FBH	i	64,6	119,0
40	BW	zen	TW	WRG	FBH	i	56,9	111,3
41	BW	zen	**TWH**		HK	a	85,2	137,2
42	BW	zen	**TWH**		FBH	a	83,5	133,0
43	BW	**dez**			HK	a	110,4	168,1
44	BW	**dez**			HK	i	101,8	157,3
45	BW	**dez**			FBH	a	107,9	162,9
46	BW	**dez**			FBH	i	103,9	158,4
47	BW	**dez**		WRG	HK	i	90,5	146,0
48	BW	**dez**		WRG	FBH	i	93,0	147,5
49	WP	zen			FBH	a	69,0	97,5
50	WP	zen			FBH	a	77,4	105,9
51	WP	zen			FBH	a	74,8	109,3
52	WP	zen			FBH	a	84,0	118,5
53	WP	zen			FBH	a	90,2	140,5
54	WP	zen			FBH	a	100,8	151,0
55	WP	zen		WRG	FBH	i	63,9	114,2
56*	WP	zen		ABI*	FBH	i	80,4	200,4
57*	WP	zen	TW	ABI*	FBH	i	69,4	190,0
58	WP	**dez**			FBH	a	96,9	131,4
59	WP	**dez**			FBH	a	108,2	158,4
60	EH	**dez**		WRG	**EH**	i	139,1	289,1
60a	EH	**dez**		WRG	**EH**	i	92,7	192,7
61	EH	**dez**		WRG	**EH**	i	130,6	280,6
61a	EH	**dez**		WRG	**EH**	i	87,0	187,0
62	EH	**dez**			**LH**	i	99,4	226,7
63	EH	**dez**			**LH**	i	75,9	214,7
64	FW	zen			HK	a	74,1	109,4
65	FW	zen			HK	a	72,6	108,0
66	FW	zen			HK	i	61,5	96,9
67	FW	zen			HK	i	61,3	96,6
68	FW	zen			HK	i	54,7	90,1
69	FW	zen			HK	i	54,5	89,8
70	FW	zen		WRG	HK	a	70,7	106,1
71	FW	zen		WRG	HK	a	89,3	104,6

* ABI is here mechanical extraction ventilation, but with heat pump heat recovery ventilation air for hot water (other ABIs without)
** Nr. 6 as nr. 4, but here with mechanical extraction ventilation (nr. 4 only natural)
*** Nr. 19 as nr. 18 but with optimised electronic control instead of 2K thermostatic radiator valve

In the table below the top 15 and bottom 15 configurations are given for a well insulated building of 100 m² (40 kWh/(m²a).

Table 13-4. DIN 4701-10 Bbl 1 Ranking of configurations for well insulated building 40 kWh/(m²a) (VHK 2006)

Nr. DIN V 4701-10 Bbl.1	**Space heating:** low temp. boiler (NT), condensing(BW), heat pump(WP), electric (EH), community heating (FW)	**Hotwater** central (zen) or local (dez)	**Solar** hot water (TW) or hot water + space heat (TWH)	**Ventilation**, mechanical extract (ABI) or heat recovery (WRG)	**Emitters** radiators (HK) or floor heating (FBH)	**Position** space heater inside (i) or outside (a)	**primary energy demand** kWh/(m²a) for 100 m² building at heat load of shell	
							40,0 kWh/m²a	**90,0 kWh/m²a**
Top 15								
37	BW	zen	TW	WRG	HK	i	54,3	109,8
69	FW	zen			HK	i	54,5	89,8
68	FW	zen			HK	i	54,7	90,1
40	BW	zen	TW	WRG	FBH	i	56,9	111,3
67	FW	zen			HK	i	61,3	96,6
66	FW	zen			HK	i	61,5	96,9
36	BW	zen	TW	WRG	HK	i	61,9	117,4
55	WP	zen		WRG	FBH	i	63,9	114,2
39	BW	zen	TW	WRG	FBH	i	64,6	119,0
32	BW	zen	TW		HK	i	65,5	121,1
34	BW	zen	TW		FBH	i	67,8	122,2
49	WP	zen			FBH	a	69,0	97,5
57*	WP	zen	TW	ABI*	FBH	i	69,4	190,0
12	NT	zen	TW		HK	i	69,7	129,1
70	FW	zen		WRG	HK	a	70,7	106,1
Bottom 15								
10	NT	zen	TW		HK	a	100,2	163,5
54	WP	zen			FBH	a	100,8	151,0
44	BW	**dez**			HK	i	101,8	157,3
46	BW	**dez**			FBH	i	103,9	158,4
5	NT	zen			HK	a	104,0	167,2
13	NT	**dez**			HK	i	105,9	165,3
23	BW	zen			FBH	a	107,3	162,3
45	BW	**dez**			FBH	a	107,9	162,9
59	WP	**dez**			FBH	a	108,2	158,4
26	BW	zen		ABI	HK	a	109,9	167,7
43	BW	**dez**			HK	a	110,4	168,1
16	BW	zen			HK	a	113,2	171,0
14	NT	**dez**			HK	a	118,8	182,1
4	NT	zen			HK	a	123,1	186,3
6**	NT	zen		ABI	HK	a	126,4	189,7
61	EH	**dez**		WRG	**EH**	i	130,6	280,6
60	EH	**dez**		WRG	**EH**	i	139,1	289,1

* ABI is here mechanical extraction ventilation, but with heat pump heat recovery ventilation air for hot water (other ABIs without)
** Nr. 6 as nr. 4, but here with mechanical extraction ventilation (nr. 4 only natural)
*** Nr. 19 as nr. 18 but with optimised electronic control instead of 2K thermostatic radiator valve

The ranking shows the highest score for a condensing gas- or oil fired boiler with a secondary store (hot water tank with two coils) placed inside the heated zone, solar collector and a heat recovery ventilation unit. In the top 15 there are several configurations with a community heating system coming from a CHP-plant. The differences between these installations are small, e.g. nr. 68 has a different the temperature regime with respect of nr. 69.

The condensing boilers are well represented, but always with solar heating and heat recovery ventilation systems. The first heat pump configuration lands at position nr. 8. Both for heat pumps and floor heating systems it seems that the heat demand of a 100 m² house is simply too small. At higher heat demands (worse insulation and/or bigger buildings) their score is much better (see also table following page).

At the bottom end of the ranking we see the electric (water) heating configurations (valid from 2010), which –even with the EnEV allowance— do not come close to meeting the EnEV limit for the annual primary energy demand, which will be around 92-94 kWh/(m²a) for this building.

The two mechanical ventilation extraction systems (ABI) can be found in the bottom 15. The same goes for condensing gas- or oil boilers with electric local water heaters. All in all, without the solar water heating and the ventilation heat recovery, the condensing boilers are also well represented at the bottom of the ranking.

The table below shows the top 15 configurations for 100 m² buildings with a heat load of 90 kWh/(m²a). For these higher heat loads —probably also representative for slightly bigger houses— we see a clear supremacy of community heating (from CHP) and low temperature heat pump systems.

Table 13-5. DIN 4701-10 Bbl 1 Ranking of configurations for poorly insulated building 90 kWh/(m²a) (VHK 2006)

Nr. DIN V 4701-10 Bbl.1	Space heating: low temp. boiler (NT), condensing(BW), heat pump(WP), electric (EH), community heating (FW)	Hotwater central (zen) or local (dez)	Solar hot water (TW) or hot water + space heat (TWH)	Ventilation, mechanical extract (ABI) or heat recovery (WRG)	Emitters radiators (HK) or floor heating (FBH)	Position space heater inside (i) or outside (a)	primary energy demand kWh/(m²a) for 100 m² building at heat load of shell 40,0 kWh/m²a	90,0 kWh/m²a
69	FW	zen			HK	i	54,5	89,8
68	FW	zen			HK	i	54,7	90,1
67	FW	zen			HK	i	61,3	96,6
66	FW	zen			HK	i	61,5	96,9
49	WP	zen			FBH	a	69,0	97,5
71	FW	zen		WRG	HK	a	89,3	104,6
50	WP	zen			FBH	a	77,4	105,9
70	FW	zen		WRG	HK	a	70,7	106,1
65	FW	zen			HK	a	72,6	108,0
51	WP	zen			FBH	a	74,8	109,3
64	FW	zen			HK	a	74,1	109,4
37	BW	zen	TW	WRG	HK	i	54,3	109,8
40	BW	zen	TW	WRG	FBH	i	56,9	111,3
55	WP	zen		WRG	FBH	i	63,9	114,2
36	BW	zen	TW	WRG	HK	i	61,9	117,4

The efficiency data for this Annex (Beiblatt) come from section C of the main DIN V 4701-10 where the installation-factors for installations are calculated from tables (Table method). These tables are composed using certain default values/equations in the Detailed Method. The table on the next page summarizes the default values and equations relating to boilers that are used in the Detailed Method to create the tables for the Table Method. Note that we did not use the notation of the DIN V 4701-10, but our own notation without subscripts and Greek letters because it fits better analytical tools that were used to study the consequences.

Table 13-6. Summary default values and equations for boiler efficiency, DIN V 4701-10 for Anhang C (VHK 2006)

	space heating operation	hot water operation
Boiler efficiency (net calorific value)	eta30	eta100
standard boiler	(81,5 + 2,0 log (Qn)) / 100	(85,0 + 2,0 log (Qn)) / 100
low-temperature boiler**	(89 + 1,5 log (Qn)) / 100	(88,5 + 1,5 log (Qn)) / 100
gas condensing	(98,0 + 1,0 log (Qn)) / 100	(92,0 + 1,0 log (Qn)) / 100
gas improved condensing*	(103,0 + 1,0 log (Qn)) / 100	(94,0 + 1,0 log (Qn)) / 100
oil condensing	(98,0 + 1,0 log (Qn)) / 105	(92,0 + 1,0 log (Qn)) / 105
oil improved condensing*	(103,0 + 1,0 log (Qn)) / 105	(94,0 + 1,0 log (Qn)) / 105
*= if the default values of improved condensing are used, the actual boilers have to be shown to respond to these values		
**= instantaneous combis are calculated as low temperature boilers		
The above temperature-dependent efficiency values are used to calculate the seasonal efficiencies etaX		
etaX oil	1,05 * eta30 + qsb * (1 - fc) / phiH	
etaX gas	1,00 * eta30 + qsb * (1 - fc) / phiH	
where the heat loss factor of the boiler fc		
if boiler outside heated shell fc =1, else fc=	25 * qsb	
Standby losses qsb are		
standard boiler	$0,12 (Qn/ 0,42)^{-0,4}$	$0,12 (Qn/ 0,42)^{-0,4}$
low-temperature & condensing	$0,06 (Qn/ 0,42)^{-0,4}$	$0,06 (Qn/ 0,42)^{-0,4}$
instantaneous combi with store V<2 ltr**		0,012
instantaneous combi with store 2<V<10 ltr**		0,022
where nominal power of boiler Qn in kW	$0,42 * AN^{0,7}$	24
(AN=Nützfläche= 0,32 * volume heated building shell)		
Load-value phi (alpha= share of boiler in total of heat or hot water generators used, usually alpha=1)	$phiH = 0,046 * (Qn / 0,42)^{0,286}$	phiTW = QTW * alpha / (Qn * 350 * 24)
Heat demand for hot water QTW		$70,56 * AN^{0,7} + 2,12 * AN^{1,2}$
Load-factor of the boiler fphi	(1 + (1 / 0,3 - 1) * qsb) / (1 + (1 / phiH - 1) * qsb)	
Result: Installation-factors (Aufwandzahl)		
standard and low temperature boiler	eH= 1 / (fphi * etaX)	
condensing all types	eH = 1 / (fphi * (etaX + 0,003 * (teta30 - tetaX))	
all combi-boilers (tH=185, tTW=350)	eTW = (1 + (1 / PhiTW - 1) * (1 – tH / tTW) * qsb) / eta100	
teta30 is test return temperature at 30% load (30°C default for condensing); tetaX is the average boiler temperature from a look-up table. For condensing boilers tetaX=26°C for floorheating (35/28 regime) and tetaX=35°C for radiator heating at 55/45 regime and 38°C at 70/55 regime		
Add:		
Auxiliary energy electric Paux in kWel	$0,015 Qn^{0,48}$	$0,045 Qn^{0,48}$

In case of combi-boilers and indirectly heated cylinders: storage (and part of distribution) losses	
Standby losses storage combi qsbC in kWh/d	$qsbC = 0{,}4 + 0{,}2 * V^{0,4}$
	where volume tank $V = 6 * AN^{0,7}$
Standby solar combi qsbCS in kWh/d	$(0{,}4 + 0{,}2 * (Vaux + Vsol)^{0,4}) * (Vaux / (Vaux + Vsol))$
Vaux=volume for auxiliary heating coil; Vsol=solar part of tank	
Heat loss store solar/electric combi qTWse in kWh/m²a	(1,0 * ((50 - tetaAmb) / 45) * tW * qsbC) / AN
Heat loss other tap water store qTWs in kWh/m²a	(1,2 * ((50 - tetaAmb) / 45) * tW * qsbC) / AN
tetaAmb=20, tW=350	
bonus for useful storage loss qTWh in kWh/m²a	tH / tTW * (1 - fa) * qTWs
heat loss factor fa=0,15 if boiler inside and fa=1 if boiler outside heated area, tH=185 days, tTW=350 days	

The above equations describe not the complete picture, e.g. heat pumps, storage, distribution and heat emitter losses are not shown. But it is a sufficient for a first analysis.

13.2.3 Boiler efficiency eta30

At (98+logQn) % the default efficiency values for condensing boilers at 30% load (eta30) are slightly (1 point) above the minimum values mentioned in the boiler directive 92/42/EC, which means that they are 3 points below what is the minimum efficiency of condensing boilers in practice (i.e. 101%, used in UK) and 9 points below the best class of condensing boilers (107%, used in NL practice). There is an 'improved condensing boiler' at 103+logQn % (compare to 104% in DK), but it is not used in the Diagram Method or the Table Method.

13.2.4 Relationship between eH and boiler efficiency eta30

The installation factor for heating eH depends linearly of the boiler efficiency eta30, if the boiler is placed <u>outside the heated</u> part of the building shell. So, if the DIN-standard had used in the Diagram Method an efficiency eta30 of 103% instead of 98% this leads to an eH that is ca. 5% better and consequently an annual primary energy factor that is 5% lower than the ones shown previously.

In case the boiler is positioned inside the heated part of the building shell –this is only possible with closed systems[55] — a part of the heat losses are added to the useful heating of the building. In case of a small building of e.g. 100 m² the fact whether a boiler is <u>inside or outside</u> the building shell may make a <u>difference of 8%</u> on the eH (for combi-boilers) Therefore, in case the boiler is placed inside also the efficiency improvement of the boiler from 98 to 103% only brings an improvement of only 3-4%.

Similarly, for a storage combi or a regular combi heating an indirect cylinder, around 85% of the heat loss of the storage tank is counted as useful heat during the heating season if the appliance is placed inside the heated building shell. Over a whole year this means that ca. 45% (=185/350 * 85%) of this heat loss is counted as useful.

13.2.5 Instantaneous combi

For an instantaneous combi boiler, there is only a minor penalty –if any— for small storage tanks that improve the hot water comfort. In case the storage volume is smaller

[55] In a closed system the air needed for the combustion is taken from outdoors. In an open system it is taken from the room where the boiler is installed. In both systems the flue gases of course go outdoors (chimney).

than 2 litres there is practically no penalty and if the storage volume is 2-10 litres the default heat loss (qsb) is 2,2% instead of 1,2% (compare to UK penalty for a 'keep-hot facility').

13.2.6 (Combi)boiler size

For the nominal power of any combi the default value in the Table Method and Diagram Method is 24 kW during hot water operation. This is the current practice whereby a boiler can keep up with the hot water demand, but it does not allow for situations with a large water tank indirectly heated by a smaller boiler of e.g. 10 kW that could be better sized for the space heating demand (compare NL discussion in paragraph on 'Outlook'). Overall, the interaction between boiler size & burner modulation versus start-stop losses is not taken into account. Also, if the boiler operation does not have to keep up with the tap water demand, there may be possibilities –also depending on e.g. the hot water storage temperature— to operate at a lower boiler temperature, which would move the efficiency more towards eta30 instead of eta100.

13.2.7 Solar combi

It seems remarkable that the heat losses of the solar (part of the) storage tank are not taken into account, but they are taken into account elsewhere, i.e. at the calculation of the hot water contribution (see report on lot 2). Also the factor 1,0 for an electrical immersion heater instead of 1,2 for a fossil fuel auxiliary heating is not a promotion of electric heaters, but can be explained technically from the heat loss of the pipework in the case of a gas- or oil-fired auxiliary heater instead of a situation with an electric immersion heater, where such losses do not occurr.

13.2.8 Heat pumps and solar-assisted space heating

As mentioned, the table does not include heat pumps. Heat pumps for hot water installations will be discussed in the Report on Lot2; here we will limit ourselves to heat pumps linked to hydronic systems. The Diagram Method and the Table Method both use floor heating at a temperature regime of 35/28°C. The table below gives the default values for the efficiency or COP (coefficient of performance) eps, the source temperature tetaS (in °C) resulting in a correction factor and the auxiliary electric energy PauxHP.

The German efficiency values for heat pumps are comparable to the ones in the Netherlands and much higher than the values in the UK. The latter are set at 300% or less.

For community/district heating systems based on cogeneration the default installation-factor eH=1,01 and electricity use is neglected. For local cogeneration (mini- and micro-CHP) the default is eH=1 and also electricity consumption is neglected.

For solar-assisted space heating the maximum coverage for single family homes is set at 10% and for multi-family homes at 5%. The condition is that the total collector surface should be at least 1,8 times the calculated collector surface for hot tap water. The Diagram Method assumes 10% coverage.

Table 13-7. Default values Heat Pumps for Diagram and Table Method DIN V 4701-10

Type of HP	Parameter	Unit	Value	
Soil-water	eps		4	
	tetaS	°C	0	
	correction factor from tetaS		1,08	
	eH	1 / (eps * correction)	0,23	(1/ 432%)
	PauxHP	W	1,2 * AN0,9	
Water-water	eps		4,9	
	tetaS	°C	10	
	correction factor from tetaS		1,068	
	eH	1/(eps*cf)	0,19	(1/ 524%)
	PauxHP	W	2 * AN0,9	
Air-water	eps1		2,6	
	eps2		3,1	
	eps3		4	
	eH	1 / (0,103 * eps1 + 0,903 * eps2 + 0,061 * eps3)	0,30	(1/331%)
Ventilation air —water	eps		3,80	
	eH	1/(1,068 * eps)	0,25	(1/406%)

13.2.9 Other energy loss

Apart from generator efficiency the DIN V 4701-10 also treats distribution, storage and emitter losses. These are conventional and will be discussed only briefly.

For the distribution losses it is relevant that in Germany often the circulator pump is not part of the boiler (as in NL and UK), but a separate appliance installed in the heating circuit. For this reason there is a separate section dealing with pump energy, which also includes a correction factor for pump control. Also the pump energy for floor heating circulators is taken into account.

For emitters there is an installation-factor (Aufwandzahl), depending on the type of control used and the annual heat demand in kWh/(m²a). The table on the next page gives an overview.

For primary storage vessels (i.e. of heating water) that may be used to minimize the number of boiler-switches or to store solar energy there is a section dealing with storage losses.

Other than that the heat loss of the pipework, for which the EnEV already specifies minimum insulation, is calculated in a conventional way, taking into account that some parts may be in unheated parts of the building

13.2.10 Primary energy factors

At the very end of the procedure the annual primary energy demand is calculated. The DIN V 4701-10 gives the values in the table below

Table 13-8. Pimary energy factors DIN V 4701-10

heating oil, natural gas, LPG	1,1
electircity	3
community heating from CHP fossil	0,7
community heating from CHP renewable	0
community heating from power plant fossil	1,3
community heating from power plant renewable	0,1

Until 2010, as mentioned earlier, the EnEV allows a factor 2 instead of 3 for electric (water) heating under certain conditions.

Table 13-9. Installation factor e at various annual heat demand + annual heat loss q in DIN V 4701-10 (source VHK)

		heating energy demand q in kWh/(m²a)						heat loss
	type of control	40	50	60	70	80	90	q in kWh/m²a
Radiators etc. (Freie Heizflächen)								
a) mainly against outer walls	Thermostatic Radiator Valves and other P-controllers with nominal P-range of							
	2 Kelvin	1,08	1,07	1,06	1,05	1,04	1,04	3,3
	1 Kelvin	1,03	1,02	1,02	1,02	1,01	1,01	1,1
	Electronic controls	1,02	1,01	1,01	1,01	1,01	1,01	0,7
	Electronic control with optimisation	1,01	1,01	1,01	1,01	1	1	0,4
b) mainly against inner walls		add 0,03	add 0,02	add 0,02	add 0,02	add 0,01	add 0,01	q+1,1
Floorheating etc. (Integrierte Heizflächen)								
	TRV per room with 2-point control in range							
	2 Kelvin	1,08	1,07	1,06	1,05	1,04	1,04	3,3
	1 Kelvin	1,03	1,02	1,02	1,02	1,01	1,01	1,1
	Electronic controls	1,02	1,01	1,01	1,01	1,01	1,01	0,7
	Electronic control with optimisation	1,01	1,01	1,01	1,01	1	1	0,4
Electric room heating	Outer wall (direct)	1,02	1,01	1,01	1,01	1,01	1,01	0,7
	Outer wall (storage)	1,11	1,09	1,07	1,06	1,06	1,05	4,4
	Inner wall	add 0,03	add 0,02	add 0,02	add 0,02	add 0,01	add 0,01	q+1,1

13.3 NO_x, CO, C_xH_y, SO_2, PM10 emissions

Legal requirements exist in Germany to control waste gas emissions from boilers, generally known as 1.BImSchV (Bundes Imissionsschutzverordnung). This is a law first passed in 1987, updated in 1988 and 1997. The 1988 update, following a transition period, came into force on the 30th September 1993. A new BImSchV was passed in March 1997 which came into force on 1st January 1998 for new boilers, and sets out a transition period for older oil and gas boilers running until 2004. The law covers both boilers in use and new boilers, laying down limits on NO_x emissions.

The responsibility for checking that boilers comply with the BImSchV falls to the chimney sweeps. The user has 6 weeks following a notice by the chimney sweep that the boiler does not conform to make the necessary changes. In many cases under the previous BImSchV, this was just a case of regulating soot emissions or changing the burner. If after a second visit by the chimney sweep the boiler still does not conform, a warning is issued and eventually fines may be imposed. The new BImSchV is much more specific in its requirements, but it remains to be seen how great an impact this will have on forcing replacement. Related to this is the replacement of boilers on the basis of their age under the EnEV, aiming at a population of 4,3 million boilers that are over 15 years old. At the current rate of replacement sales, only about 10% of this older park is being replaced each year.

As far as oil and gas boilers are concerned, the 1988 law (§7) simply stated that boilers should meet modern technological standards in order to minimise NO_x emissions, but the 1997 amendment sets an upper limit for NO_x emissions of:

- 120 mg/kW for oil
- 80 mg/kW for gas.

The limit values for NOx have to be complied with only at type tests, not at regular monitoring by chimney sweeps.

Furthermore, there are limits for 'flue gas losses', which are a part of the energy losses from a boiler contained in the flue gasses.[56]: Max. 11% for boilers 4-25 kW, 10% for 25-50 kW and 9% for boilers over 50 kW.

All boilers installed in Germany from the 1st January 1998 must meet the new standards for waste gas emissions. All boilers in Germany must have met the same standards as those laid down for new boilers by 1 Nov. 2004.

For industrial installations the 'Technische Anleitung zur Reinhaltung der Luft' (*TA Luft*) is the most important piece of legislation regarding emissions. The latest 2002 version contains limits for fine dust and emissions of NO_x, SO_2, etc..

For larger boilers (Grossfeuerungsanlagen) there is the 13.BimSchV. This act, together with the 1. BimSchV (Kleinfeuerungsanlagen), has been updated in 2005 to contain also limit values for PM10, SO_2, etc.[57]

Apart from the 1.BimSchV there is also the 22.BimSchV, which is the transposition of the EU Air Quality directive on SO_2, NO2 and PM10, limiting the concentration of these emissions in the German area. These limits are not directly linked to boilers, but of course the boilers can make an important contribution.

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[56] Other losses are e.g. radiation and convection losses of the boiler itself, which occur during stationary operation and during standby. The flue gas losses can be measured by multiplying the m³ flue gas with specific heat and the temperature difference with ambient.

[57] UmweltBundesAmt, *Hintergrundpapier zum Thema Staub/Feinstaub (PM)*, March 2005, Berlin

Please note that 1. BimSchV applies to installations with a rated thermal input below 20MW, TA Luft for 20 MW - < 50 MW and 13. BImSchV: ≥ 50 MW.

The Umweltbundesamt informs us that the ordinance on small and medium size combustion plants (1.BImSchV) is currently being amended, the new ordinance shall come into force in 2008. The amendment will focus on installations with solid fuels, but some changes to the provisions for gas- and oil fired installations are planned, too. The draft is still under discussion, so changes may take place before the new ordinance comes into force.

Amendment of the ordinance on small and medium size combustion plants:

Planned changes for gas- and oil fired installations, Limit values to be complied with in type tests

If light fuel oil according to DIN 51603–1, September 2003 is used

Rated thermal input [kW]	NO_x-Emissions [mg/kWh]
< 120	110
>120 – 400	120
> 400	185

If gas from the public gas network is used

Rated thermal input [kW]	NO_x-Emissions [mg/kWh]
< 120	60
>120 – 400	80
> 400	120

Possibilities to reduce the emission of nitrogen oxide by primary measures according to the state of the art have to be exploited. The minimum efficiency for larger boilers (according to DIN 4702-8) laid down in §7 (3) shall also be adapted to the state of the art and raised to 94 %. The provisions for NOx and efficiency have to be complied with at type tests.

Other changes

The regular inspection of gas- and oil-fired installations according to the 1.BImSchV (measurement of exhaust gas loss and smoke number) shall be reduced; it is planned to perform it every three years after the amendment has come into force. At the same time it shall be extended to smaller installations with a rated thermal input from 4 kW on.

The exception from compulsory measurements for bivalent installations (gas or oil fired in combination with a solar system or a heat pump) shall be cancelled.

13.4 Labelling

Apart from the legislation, the Blue Angel ecolabel and recommendations of the DVGW are influential in the market.

For boilers RAL-UZ 41 (atmospheric gas boiler), 46 (oil boiler) and 61 (gas condensing boiler) of the Blue Angel are relevant. The table below gives a summary of the requirements for all heating systems.

Table 13-10. Summary Blue Angel Heating System limit values

Product group	Sphere of validity	NO_x	CO	C_xH_y continu-ous	C_xH_y at start-up	Soot (PM)	Efficiency) depending on the power	Electric power Sleep mode***	Electric power operation ***	Electric energy Cold start ***	Heating-Water-Side Resist.*
unit	kW	mg/kWh	mg/kWh	mg/kWh	ppm	smoke spot nr.	%	W	W	Wh	mbar
RAL-UZ 9 Oil burners	≤120	≤120	≤ 60	≤ 15	≤ 30	≤ 0,5	-	-	250	25	-
RAL-UZ 39 Special gas boilers	≤ 70	≤ 70	≤ 60	-	-	-	10 kW: ≥90; 70 kW: ≥91	8	15	-	800
RAL-UZ 40 Combined water heaters and ciruclation water heaters for use of gas	≤ 30	≤ 60	≤ 60	-	-	-	10 kW: ≥89,5 30 kW:≥90	8	80	-	800
RAL-UZ 41 Combined gas-burner and boiler units	≤ 70	≤ 70	≤ 60	-	-	-	10 kW: ≥90 70 kW: ≥91	8	200	-	800
RAL-UZ 46 Combined oil-burner and boiler units	≤ 70	≤ 110	≤ 60	≤ 15	≤ 30	≤ 0,5	10 kW: ≥90 70 kW: ≥91	8	220	25	800
RAL-UZ 61 Gas condensing heating devices	≤ 70	≤ 60	≤ 50	-	-	-	with 75/60**: 10 kW: ≥100 70 kW: ≥101 with 40/30**: 10 kW: ≥103 70 kW: ≥104	15	With pre-mix burner: 80; With flue gas fan: 200	-	800
RAL-UZ 71 Gas heaters and gas heating elements	≤ 11 ≤ 22	≤ 100 ≤ 130	≤ 80 ≤ 60	-	-	-	Gas heaters ≤4 kW: ≥82,5 >4 kW: ≥84,5 Gas heating elements:≥89	-	-	-	-
RAL-UZ 80 Gas burner, fan-assisted	≤ 120	≤ 70	≤ 60	-	-	-	-	-	200	-	-

* = resistence at temperature difference of 10 K

** = at temperatures of 75/60 or 40/30°C

*** = sleep and on-mode measured during 10 minutes, cold start during 5 minutes

For heat pumps and circulators the following Blue Angel labels are relevant:

- RAL-UZ 121 “energy saving heat pumps with electricity-driven compressors”
- RAL-UZ 118 gas-fired heat pumps (Absorption, Adsorption, gas-motor driven heat pumps)
- RAL-UZ 105 “Circulation pumps for heating systems”

Apart from the Blue Angel there is also the quality mark by the German Society of Gas and Water Technologists (DVGW) worth mentioning. The DVGW limits for NO_x emissions are given below (status 2000).

Table 13-11. DVGW NO_x limits for natural gas appliances (2000)

Flued Appliances	mg(NO_x)/kWh (ppm @0% O2)
Boiler ≥ 120 kW input	80 (45)
Boiler < 120 kW input	120 (68)
Wall mounted boiler with warm water production	60 (34)
Fan assisted burner	100 (57)
Condensing appliance	60 (34)
Room heater (flued)	150 (85)

Quality mark of the DVGW (German Society of Gas and Water Technologists)

14 ITALY

14.1 Introduction

In 1993 Italy was one of the first countries to implement minimum building installation standards with the Decreto di Legge (DLg) 412 [58]. The Decreto N. 412 is in fact an elaboration of article 4 of the wider building regulations in DLg 10 of Januari 1991.

The basis of DLg 412 is a minimum requirement for the average overall seasonal efficiency ("rendimento globale medio stagionale") of 65 + 3 log P(n)%, where P is the rated power of the heat generator. It is defined as the ratio between the useful heat demand in the heating season and the primary energy, including the electrical energy (calculated as 10 MJ = 1 kWh). It takes into account the efficiency of heat production, distribution, emission and control.

The dimensioning of the boiler is also prescribed through DLg 412 (Art. 1), in the sense that the calculation has to take into account –using the appropriate UNI standard—the internal temperature, the climate (5 zones for Italy), the insulation of the building shell and the boiler (control) regime.

The N. 412 (in art. 3) also contains a minimum efficiency standard that relates strictly to the heat generator, but this article is superseded by the Italian transposition of the EU Boiler Directive in 1996.

In October 2005 the Italian implementation of the EPBD 2002/91/EC, the DLg N. 192 was published. This builds on and amends DLg 412. This publication should have been followed in 120 days by a series of other decrees, but this is delayed. As a consequence the implications of DLg 192 are not very clear. The following section is from a personal communication of the Italian Association of Boiler Manufacturers *Assothermica*[59], trying to explain the implications –as far as they are known— of DLg 192 for the Italian boiler market.

14.2 Energy & CO_2

The DLg 192, the Italian implementation of the 2002/91 directive, needs of a series of decrees that still have to be issued *(*see *art.4-General Criteria, calculation methodology, requirements of the energetic performance).*

These decrees had to be issued within 120 days from the date of implementation of the DL 192: the 120 days are already passed, but the decrees have not been published yet, (are foreseen long times).

Scope of the DL 192 (art.1) - principal points

- Calculation methodology of the integrated energetic performances of the buildings.
- Minimum requirements for energetic performances of buildings; winter and summer climatization, hot sanitary water, ventilation and illumination.
- Energetic certification of buildings: mandatory for the new buildings and voluntary for those existing.

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[58] D.P.R. 26 agosto 1993, n. 412 (1) (G. U. n.96 del 14 ottobre 1993). Regolamento recante norme per la progettazione, l'installazione, l'esercizio e la manutenzione degli impianti termici degli edifici ai fini del contenimento dei consumi di energia, in attuazione dell'arta' 4, comma 4, della legge 9 gennaio 1991, n. 10.

[59] Pers. Comm.. Giampiero Colli, secretary of Assothermica

Field of application (art. 3)

The DL 192 will apply to the new buildings, to the renovations and also to the substitution of the heat generators in the existing installations.

Calculation methodology and requisite of energetic performance (art. 4)

As mentioned, a series of decrees should be iussed (not yet done).

Energetic certification of the buildings (art. 6)

It will be mandatory for all new buildings within one year from the date of gone into effect of the DL 192; for the existing buildings it will be voluntary.

Also for the energetic certification and kept into account of the anticipated decrees to the art. 4, that have to be iussed, the publication of national guide lines is foreseen.

Energetic performance requirements of the buildings (art. 11 and 12) – transitorial period.

The DL192 cancel and replaces part of the legislation in force (law 10 and DPR 412).

Without the decrees of which to the art. 4, there would be a legislative void, since they would missed all the dispositions for the calculation of the buildings and the heatng installations.

(the previous Italian legislation considered only the energetic performances of the winter climatization).

For this reason, **the annexes** propose and modify/cancel some parts of the legislation in force. that has been cancelled. Of particular interest for boilers are annexes **C, I** and **L**

Annex C - of the energetic performance of the buildings:

it concerns the calculation of the insulation of the building (requirement of primary energy and *"trasmittanze"*)

point 5 defines ηg "*minimum requirements of middle seasonal efficiency of the heating installation",* which is is raised by 10 points in comparison to what foreseen by the DPR 412/93, the legislation in force before the DL 192.

Annex I: Transitorial regime for the energetic performance of the heating installation.

Of particular interest is point 4, indicating conditions to respect in the replacement of the heat generators.

There are two suitable methods. The first is a simplified method, with the suggestion of a type configuration. The second method is much more complicated, requiring the verification of the annual requirement of primary energy.

Requirements to allow the simplified method:

- 3 or 4 stars boiler (according to 92/42 directive)
- average water temperature of the installation not more than 60°C
- presence of devices for climate control

Annex L: Transitorial regime for the exercise and maintenance of the heating installation.

Mainly deals with the periodical inspection of gas heating installations less than 35 kW. Before this was to occur every year and now it is every 2 years for boilers type B, every 4 years for boilers type C and for all the instalations older than 8 years.

The Dls 192 does not introduce any obligation for types of boilers (es. condensing boilers); this obligation would result in fact an obstacle to the free circulation of type boilers (es.standard) admitted by the 92/42 directive. Nevertheless the new prescriptions for the new installations and for the replacements should move the Italian market toward the classified boilers 3 and 4 stars (see table 14-4).

New installations and restructurings (annex C point 5)

This decree, as also in the preceding legislation, it defines only minimum requirements fo seasonal average global efficiency ηg, for the heating installations ; in the new istallations this mimum requirements has been improved of 10 points in comparison to the preceding legislation.

DPR 412 /1993 (old legislation)	DL 192 /2005
ηg = 65+3log Pn	ηg = 75+3log Pn

Table 14-1. Approach to the Italian market - some notes (personal comment G. Colli, Assothermica, 2006)

stars	100%Pn	30%Pn	Notes	Type	Chimney
*	≥ 84+2log PN	≥ 80+3log PN	Standard boilers; in Italy they represent 90% of the replacement market (in practice close to 100% of the total market)	Atmospheric boilers, type B	No problems; used in old installations with collective chimney
**	≥ 87+2log PN	≥ 83+3log PN			
***	≥ 90+2log PN	≥ 86+3log PN	Hight efficiency boilers; before DL 192 they were 4% of the market, now should replace the *;**.	Generally type C;better if pre-mix burner tecnology; for open chamber it is very difficult to reach the 3 stars	Problems in replacement with collective chimney.
****	≥ 93+2log PN	≥ 89+3log PN	In practice these are all condensing boilers because it is not possible to reach these levels of efficiency without condensing;before DL192 they were only 6%of the market	Pre-mix boilers generally type C	These type of boilers need special chimney.

The ηg seasonal average global efficiency of the heating installation, is calculated with the following formula (the product of 4 outputs):

$$\eta g = \eta mp * \eta d * \eta r * \eta d$$

where:

ηmp is the seasonal average efficiency of production, whose calculation is complex: for simplicity it is estimated to be equivalent to the part load efficiency (30%) of the generator, tested according to 92/42 directive.

ηd is the seasonal average efficiency of distribution and it depends on the insulation of the pipes (tabular values according to the middle water temperature of nstallation)

ηr is the seasonal average efficiency of regulation and it depends on the type of regulation (tabular values from 0,95 to 0,99) **ηe** is the seasonal average efficiency of emittion and it depends on the type of radiator (tabular values from 0,95 to 0,98).

The Table 14-2 simulates a simplified calculation of **ηg**, the seasonal average global efficiency of the heating installation, that varies changin the generator and modifying the distribution, the regulation, the emittion, and the average boiler water temperature.

Table 14-2. Example heating installation 27 kW (personal comment G. Colli, Assothermica, 2006)

Efficiencies		Type of Boiler					
symbol	name	Existing	*	**		***	****
			Standard			High efficiency	Condensing
ηmp	(part load of boiler)	0,82	0,843	0,873	Minimum Requirement of DL 192 = 75 +3 log Pn	0,903	1,04
ηr	(regulation)	0,88	0,93	0,93		0,95	0,95
ηe	(emission)	0,93	0,93	0,94		0,96	0,96
ηd	(distribution)	0,95	0,95	0,95		0,96	0,96
ηg	installation total	0,638	0,693	0,725	0,791	0,791	0,911
	average water temperature in °C	70	70	70		60	47,5

From the Table 14-2 it is clear that an installation of 27 kW has to reach (applying the DL 192) the seasonal middle global efficiency ηg = 0,791; this result is obtainable only starting at least from a 3 stars heat generator (better if it were 4 stars).

The DL 192 gives a clear indication in favour, also in the replacements, of the installation of a 3 stars boilers. If the market follows this indication, it will be possible to obtain a significant improvement of the seasonal average global efficiency of the existing installations, with positive results for the consumption and air pollution. The Italian association of boiler manufacturers Assothermica expects from this legislation that for existing buildings the market will move towards 3 star boilers and for new buildings towards condensing boilers.

15 FRANCE

15.1 Introduction

In 2000, the new *Réglementation Thermique (RT2000)* was adopted, which marks the transition from single component regulations to a holistic approach for the whole building based on heat loss calculations and credits for installation components. Also in another way the *RT2000* is a breakthrough, because it does not implicitly promote nuclear power but instead calculates in primary energy from thermal power.

The recent *'Arrêts'* from 2003/2004 take into account CHP, heat recovery from ventilation, etc. For individual builders/owners the RT2000 is translated into a simple points-scheme, whereby the builder has to score a minimum of 18 points. Compare: The best building shell insulation (walls and glazing) give the builder a maximum of 5 points, a condensing boiler gives 6 credit points but a low temperature boiler only 3 points. Class C *'ventilation hydroreglable'* scores 4 credit points. As in most countries, the French legislation is not completely in line with the latest prEN-insights but –also because *CSTB* delivers the most convenors for the relevant Working Groups—is expected to catch up fast.

The new RT2005 has recently been adopted. Although it contains several new items e.g. regarding solar water heating and ventilation it is similar to the RT 2000 as regards the space heating methodology. Therefore, at this time the paragraph below just gives a short summary of the requirements.

15.2 Energy & CO_2

15.2.1 Default values

The current RT2005 requires the builder to state the efficiency (on net calorific value) of the heat generator at loads of 30% and 100%. For oil- and gas fired boilers this efficiency figure can be taken from CE-marking tests, which are accepted as a certification.[60] If no value is known, the RT2005 accepts the minimum values of the EU Boiler Directive as defaults[61]. The default minimum return boiler temperatures (θ min) per boiler type are 45, 35 and 20°C for regular, low-temperature and condensing boilers respectively.

The zero load losses Q_{po} ('*Pertes a charge nulle*' in kW) are defined as $Q_{po} = P_n * (E + F * \text{Log } P_n) / 100$, where the default E=2,5 for atmospheric boilers and E=1,75 for fan-assisted/pre-mix boilers. The capacity-dependent factor F is –0,8 for atmospheric and –0,55 for fan-assisted/pre-mix boilers. For instance, for a 21 kW pre-mix boiler the zero

[60] In general, the RT2000 subtracts 15% on the performance values of uncertified (not 3rd party tested) installations.

[61] For 100% load the boiler efficiencies are: 84+2.Log Pn, 87,5 + 1,5.Log Pn and 91+ Log Pn for standard, LT and condensing boiler respectively.

For 30% load the boiler efficiencies are: 80+ 3.Log Pn, 87,5 + 1,5.Log Pn and 97+ Log Pn for regular, LT and condensing boiler respectively.

load losses Q_{po} are around 1% of the nominal power.[62] For an atmospheric boiler of the same size they are around 1,5%.[63]

The default auxiliary electric power of a gas- or oilfired boiler (in kW) is given by $P_{cir.g}$ = 20 + H*P_n, where H=1,6 (boilers with pilot flames are no longer allowed in the RT 2005).

15.2.2 General calculation method

The performance of the heat generator is calculated as energy losses at a certain boiler load and not as an efficiency value. A regular boiler is calculated through a general method (*méthode general).* For this *méthode général* three levels of load are distinguished: losses at full load (Q_{P100}), intermediate load (Q_{Pint}) and zero load (Q_{Po}). The 100 and 30% load losses are determined by the 100% and 30% load efficiency measured during the CE-tests, but there is a correction factor 'a' that takes into account that the CE-tests for the 30% load take place at higher boiler temperatures than the ones in practice. This correction can add up to 3% to the measured efficiency of the condensing boiler and 0,5% to the measured efficiency of the other types of boilers at 30% load. [64]

The zero load losses Q_{po} ('*Pertes a charge nulle*' in kW) —when they are not default values— should be calculated from the zero load losses as declared by the manufacturer. There is an equation in case the losses of the pilot flame are not declared.[65] For oil- and gas-fired boilers the Q_{po} is then corrected for the temperature difference between the minimum boiler temperature θ_{whg} and the ambient temperature θ_{amb} in the 'boiler room', according to the equation.

$$Q_{Po} = Q_{Po} * ((\theta_{whg} - \theta_{amb}) /30)^{1,25}$$

with $\theta_{amb} = \theta i - b * (\theta i - \theta e)$, where θi is the internal temperature (usually 20°C) and θe the external temperature defined per month. The placement factor 'b' is defined elsewhere in the RT2000.

The above results in 3 points of a load-loss function (P-Q). Through interpolation this function is completed and allows the RT2000 to calculate the losses as a function of the load, per month and per temperature zone in the building. In this calculation 4 power states are distinguished:

- Normal
- Off
- Reduced
- Start-up ('rélance')

[62] Pre-mix or fan-assisted 21 kW boiler Qp0= 21 * (1,75 + 1,32 * - 0,55) = 0,214 kW

[63] Atmospheric Qp0= 21 * (2,5 + 1,32 * - 0,88) = 0,302 kW

[64] For condensing boilers the RT2000 indicates that lowering the boiler temperature by 5°C results in a 1% efficiency increase, whereas with other boiler types lowering the boiler temperature by 10°C results in 1% efficiency increase. So effectively the efficiency at intermediate load is

Rtest30% + a* (θ measured - θ actual), where θ is the boiler return temperature. The factor 'a' is either 0,2 for a condensing boiler or 0,1 for other types. If one considers the default minimum boiler temperatures mentioned (45, 35, 20°C) versus the test-temperatures —50, 40, 35°C for standard, low-temperature and condensing boiler— this correction adds up to 3% to the measured efficiency of the condensing boiler and 0,5% to the measured efficiency of the other types of boilers at 30% load.

[65] QP0 = QP0withoutpilot + (1 – Rv/100)*Pv, where Rv is the pilot flame efficiency and Pv is the pilot flame power

And the month is divided up into 'sub-periods', which could be

- Normal
- Nights
- Weekends
- Holidays

Apart from the heat losses, also the annual consumption of the auxiliary electric energy $Q_{cir.g}$ is taken into account as a function of the electric power of the components $P_{cir.g}$ and the number of operating hours of the boiler t_{f_g}. [66]

The number of operating hours are calculated as a fraction of the heating system (t_c in h) from the ratio between the nominal power Pn and the actual power Px, both including generator losses Q_{Px}.

$$t_{f\_g} = ((Q_{Px} + P_x)/ (Q_{Px} + P_n)) * t_c$$

Depending on where the boiler is placed, a part of the auxiliary electric energy can be considered as recoverable (*récupérable*). If the boiler is in the heated volume of the building this fraction is set at 90%. If the boiler is outside the heated volume of the building, the recoverable fraction $Q_{cir.g\_rec}$ is 90% * (1-b). The placement factor 'b' is defined elsewhere in the Th-Bat.. Finally this multiplier has to be applied to the heat emitted by the electrical components; generally it is assumed that the electrical components have an efficiency of 40%, so 60% of their consumed power is considered as heat (multiplier $\mathbf{p}_{\_Qcir.g}$ = 60%).

$$Q_{cir.g\_rec} = Q_{cir.g} * 0{,}9 * (1-b) * \mathbf{p}_{\_Qcir.g}$$

In an analogue fashion also a part of heat losses of the boiler can be considered as recoverable, depending on the position of the boiler inside or outside the heated volume. Only the radiation and convection losses through the boiler housing are considered, of course not the flue gas losses. The RT2000 gives those losses as 50% in case of an atmospheric boiler and 75% in case of a fan-assisted boiler (usually LT or condensing).

The total recoverable losses Q_{g_rec} are the sum of the above:

$$Q_{g\_rec} = Q_{cir.g\_rec} + Q_{par\_rec}$$

For a regular boiler, the heat losses of the boiler are now defined and can be used in the calculation of the total energy demand calculation of the building.

15.2.3 Special calculation method for combi-boilers

For combi-boilers the above losses from the *méthode general* have to be supplemented by other losses[67]. The RT2005 defines the situation where

- the space heating stops if there is hot water demand and where
- the heat generator works at full load in case of hot water demand.

as the situation where storage and start-stop losses have to be added from another method -*méthode pour la production intermittente d'eau chaude*. These losses $Q_{g,w}$ are a function of the hot water demand (Q_w in kWh), the distribution losses of hot water ($Q_{d,w}$), the generator efficiency R_{Pn} at nominal (100%):

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[66] $Q_{cir.g} = P_{cir.g} / 1000 * t_{f\_g}$

[67] It is the question whether storage combi-boilers also fall under this definition.

$$Q_{g,w} = Q_w * ((1- R_{Pn} + A)/R_{Pn}) + Q_{d,w} * (1/R_{Pint}) + P_v * t_c$$

The value of 'A' is 0,28 (28%) for a boiler without pilot flame. The first term of the equation above is the largest. For instance, for a boiler with default condensing efficiency R_{Pn} = 91% as much as 40% of Q_W is counted as loss.[68] Previously, in case there was a pilot flame only 25% of Q_w is counted as loss. Obviously, the RT2000 saw the pilot flame as making a useful contribution in reducing the start-stop and standing losses on one hand (first term), whereas in the last term of the equation —$P_v * t_c$ — it was counted as loss during operation.

A second remark, as least as important, is that this considerable energy loss is fixed – independent of the actual combi-boiler design. When the distribution losses are added, this means that standard any gas- or oil-fired combi-boiler is given at least some 50% losses in hot water mode.

For gas- or oil fired (combi-) boilers –during the heating season—the minimum values of the Boiler Efficiency Directive 92/42/EC apply. The standby losses (in %) for gas- or oil fired boilers are 1,75 - 0,55 * log Pn for boilers with fan-assisted burners and 2,5 – 0,8 * log Pn for boilers with burners that are not fan-assisted. If the boiler is placed inside the heated surface, the part of these losses that goes through the boiler envelope (75% for fan-assisted, 50% for not fan-assisted boilers) is recoverable. The auxiliary electric energy (in W) is given by the formula 20 + 1,6 * Pn, where Pn is given in kW (!!), which is fully recoverable. How much of the total "recoverable' standing losses and electrical energy is actually "recovered" depends on the heating season, but the RT 2005 gives here a default value of 60%.

The partitioning of energy losses between the hot water function and the space heating function of a combi-boiler or a boiler with an external cylinder is as follows:

- If there is a simultaneous hot water and space heating the generator losses –during this period are partitioned according to the respective heat demands.
- If there is no heat demand, then the generator losses are attributed to the space heating function[69].
- If there is only space heating demand or only hot water demand, all energy is partitioned to the respective function responsible for the demand.
- In case of collective space heating and hot water supply, the energy is partitioned according to the floor area of the individual dwellings.

15.2.4 Heat pumps and solar

The original RT2000 contained a provisional section on heat pumps and no section on solar-assisted space heating. These items will be discussed when more information on the RT2005 is available.

15.3 NO_x, CO, C_xH_y, SO_2, PM10 emissions

No data found

15.4 Labelling

Seen Annex

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[68] $((1- R_{Pn} + A)/R_{Pn}) = ((1- 0,91 + 0,28)/0,91) = 0,4$ (40%)

[69] In other words the RT 2005 does not distinguish between summer and winter efficiency like in some other countries

15.5 Incentives

Tax reduction on the income tax (*Credit d'impot*) of 25% of the materials costs of a condensing boileron. For a low temperature boiler 15%. E.g. at a 50% income tax scale this means an effective contribution of the state of 12,5 and 7,5% on material costs. For heat pumps and renewables (solar) systems tax reductions of 40-50% exist.

16 AUSTRIA

Austria has delegated the energy performance of buildings legislation to the regional level. This means that some 6 or 7 pieces of legislation have been investigated for specific boiler requirements, directly or indirectly. Luckily, although the incentives differ from region to region the minimum energy efficiency standards and minimum emission standards in all *'Länder'* are the same.

For the minimum efficiency the Austrian Länder all have adopted the 92/42 Boiler Directive limts. For the emissions of NO_x, dust, etc. the limit values given in the table below apply. OGC is the emission of hydrocarbons C_xH_y measured as carbon.

Table 16-1. Emission limits Austria

Burner	CO	NO_x	OGC	Dust
	mg/MJ	mg/MJ	mg/MJ	mg/MJ
Oil-fired burners (all types)	20	35	6	1
Gas-fired, atmospheric, natural gas	20	30 ***)		
Gas-fired, atmospheric, LPG	35	40 ***)		
Gas-fired, fan-assisted, natural gas	20	30		
Gas-fired, fan-assisted, LPG	20	40		

***) For instantaneous heaters, storage heaters and local heaters this NO_x -limit can be surpassed by a maximum of 100%.

17 BELGIUM & LUXEMBURG

In Belgium the implementation of the Energy Performance of Buildings Directive (EPBD) is the responsibility of the Regions.[70] In the Flemish Region, the Flemish Energy Agency is responsible for Articles 3, 4, 5, 6 and 7. The Department of Environment, Nature and Energy is responsible for Articles 8 and 9.

The energy performance decree was approved on 7 May 2004 by the Flemish parliament. This decree transposes Articles 3, 4, 5, 6 and 7 into regional law and sets up the monitoring methodology. An execution order of the Flemish government of 11 March 2005 lays down the actual energy performance requirements and the calculation procedure. An execution order of 2 December 2005 introduces an energy certificate obligation for new buildings. Other execution orders will follow. All legal documents can be found on

www.energiesparen.be/energieprestatie (in Dutch).

The calculation procedure of the energy performance of new residential buildings, offices and schools is part of the execution order of 11 March 2005. Software has been developed to calculate and check the compliance with the energy efficiency and indoor climate requirements. Use of this software, which needs further completion, will be mandatory.

New requirements are in force with respect to every building for which a building permit is requested after January 2006. There are requirements with respect to thermal insulation, the overall energy performance level and the indoor climate (ventilation, overheating) for those buildings that use energy to create specific indoor climate conditions for human beings.[71]

There are specific sets of requirements:

- for each construction activity type: new building, refurbishment of a small building, extension of an existing building, major renovation of large building;
- depending on the use of the building: residential, offices or schools, industry, other non-residential.

New residential buildings, offices and schools have the most stringent requirements. Energy performance requirements will be set in the future for other types of non-residential buildings. But already requirements have to be complied with for all construction activities and building types requiring a building permit for indoor climate and thermal insulation.

The new energy performance regulation entails important new procedures and monitoring rules to ensure compliance with the energy performance requirements. A *'reporter'*, which can be an architect or engineer, must calculate (as-built) and report (after the end of the work) in the *'EPB declaration'* the executed works to the authorities. The reporter must be appointed before the start of the construction work, the start date of which has to be reported to the Flemish Energy Agency (VEA) to allow time for site checks. Both the announcement of the start of the construction and the *'EPB declaration'* must be sent electronically (web application) to the VEA energy performance database (under development). This database and its application are the core of the control system. In case of non-compliance administrative fines will be

[70] Source: Wina Roelens (Flemish Energy Agency), Status of EPBD implementation in Belgium (Flanders), www.buildingsplatform.eu

[71] www.energiesparen.be/energieprestatie/professioneel/eisen/ tabel.php

imposed on the owner of the building, on the building constructor (when he is a promoter), or on the reporter (when it appears that the *'EPB declaration'* contains errors). The execution order for the feasibility study of alternative (EPBD-art. 5) systems for new buildings with a total useful floor area over 1 000 m^2 is under development and will be adopted by the end of 2006.

An energy performance certificate is required for all new buildings for which the Energy performance has to be calculated, and for which a building permit has been requested, since the first of January 2006. The drafting and delivery of this energy performance certificate is part of the procedure related to the *'EPB declaration'* after construction.

The executive order with respect to the energy performance certificate of public buildings is in the process of approval. Public buildings are government-owned buildings, school buildings and health and welfare services. An operational rating system will be used for the certification of public buildings which should all have a certificate in 2008.

Energy performance certificates for buildings that are being sold or rented will be introduced in 2008 (residential buildings) and 2009 (non-residential buildings). The legislative instruments and supporting software tools are being developed.

The regulation related to the inspection of boilers is being drafted, the adoption of which is expected by the end of 2006. The mandatory inspections and advisory support will start in 2009. According to the draft regulation boilers using liquids or solid fuel should be inspected annually whereas natural gas boilers will require inspection every 2 years. The inspections will be performed by a qualified boiler technician.

One of the most remarkable items in the Flamish EPB method is the fact that there is only <u>one fixed efficiency for all fossil-fuel fired water heaters and the hot water function of combi-boilers, i.e. 50%</u>**.** More or less as an explanation, the Belgian legislator adds that "*if in some years time the manufacturers have worked out appropriate standards to deal with the measurement of energy performance of water heaters this could be adapted in the legislation"*. A primary energy factor will be applied afterwards. The efficiencies values relate to the lower heating values (net calorific value), but internally the software programme recalculates those values to gross calorific values.

Regarding NO_x and CO emissions of gas-fired boilers, Belgium is reported ly preparing new limit values. Currently only NO_x emission limit values of 100 mg/m^3 (49 ppm) apply to larger gas-fired boilers (> 100 kW).[72]

[72] Yamada and Desprets, 1997

18 SPAIN

18.1 Introduction

From a situation in 1990 with 27% penetration of CH systems, Spain evolved to a 40% penetration rate 1998 and currently more than half of the households have a central heating system[73]. The energy consumption of households in Spain is growing at a rate of 1,3% per year, despite the fact that vthe population growth is low. One reason is a decrease in average household size. Another reason is that –despite the installation of new heating systems with higher efficiency—the comfort level of heating has increased and the penetration of (new) household appliances and consumer electronics is growing. In 1998 space heating accounted for 45% and water heating for 21% of the energy consumption of the average Spanish household. The share of the domestic sector is relatively low (16%) in the Spanish total energy consumption, which is made up for 42% by the transportation sector. The tertiary sector accounts for 8%, industry 31% and agriculture 3%.[74]

Spain is an interesting country from the policy point of view, because it has adopted extensive new building code called CTE very recently (March 2006)[75]. The most spectacular provision in the CTE is that it makes solar assisted water heating compulsory for new buildings (relevant for combi-boilers), but also for space heating the code contains some interesting provisions .

18.2 General requirements

For heating equipment, including water heaters, the new Spanish Building Code CTE of March 2006 refers to the RITE[76]. The Royal Decree 1751/1998 approves the Regulations of Thermal Installations in Buildings (RITE) and its Complementary Technical Instructions (ITE) and creates the Advisory Committee for Thermal Installations in Buildings. In 2002 the RITE has been amended. RITE is formed by 18 articles and six chapters:

Chapter I : Aim and Field of Application

Chapter II : Aims of the Installations and its Components

Chapter III : Installation Projects

Chapter IV : Systems Starting Conditions and Maintenance

Chapter V : Manufacturers, Installers, Technical Services, Owners and Users

Chapter VI : Punishments

Regarding the field of application of RITE, article 1 states it as heating, climate77 and hot water producer systems in non-industrial buildings. Article 1 also states that the presentation of an thermal installation project is not mandatory as long as its power is in the range of 5-70 kW. If it is in the range 5-70 kW, a document should be submitted by the installer, which will play the same role as the more powerful installations projects.

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[73] Source: INE (Instituto Nacional de Estadistica)

[74] Boletin IDEA, number 1 – Oct. 2000

[75] download http://www.boe.es/boe/dias/2006/03/28/pdfs/SUP06_074C.pdf. For English text of the solar energy paragraphs www.estif.org.

[76] for instance see http://www.mtas.es/Insht/legislation/RD/rite_ite_09.htm#ite09_05

[77] Reversable Air-Conditioners

Chapter II defines the aims of the installations as thermal comfort and hygiene, security, energy efficiency, equipment durability and environmental protection. Moreover, it establishes as compulsory all the ITE regulations.

All the thermal installations of which power exceeds 70 kW must be included and described in the construction project of the building, as it is stated in chapter III. Concerning the bureaucratic procedure, which is defined in chapter IV, the are several steps to be followed:

- first step is the presentation of the installation project to the competent authority.
- the installer will submit a report which ensures that the installation process followed the project already submitted to the competent authority.
- finally, if the documents are accepted, the user is provided with an installation certificate which will be asked for by the energy companies.

Chapter V sets up a new professional card for installers and maintenance services, as well as several other administrative procedures for manufacturers and owners.

The ITE 02, concerning design regulations, is the most extensive part of the ITE document. It is divided into 16 chapters dealing with most of the features of the thermal installations parts and features.

Concerning hot water systems, ITE 02.5 points out that:

- Water temperature will be the minimum value which is appropriate for the uses of the water. Regarding the temperature in the hot water storage tanks, it must follow the guidelines given by the UNE 100030 Standard about water and legionnaire's disease, which states a minimum temperature of 55°C and advises to take it now and then to 70°C. The distribution temperature must be over 50°C in the return pipe to the entrance of the stock deposit. The cold water must not exceed 20°C. (ITE 02.5.1)
- Generators. The choice of the generator equipment has to be based on the load, the use of the water and the sensible use of the energy. (It is not allowed because of health reasons to produce hot water mixing cool water with steam.) (ITE 02.5.2)
- The distribution system will be designed so that the time passed from the opening of the tap and the water arrival is minimum. The distribution pipes have to be insulated. (ITE 02.5.3)
- the use of electric energy for the water heating by "Joule effect" in centralized equipment is only allowed, as an auxiliary source, when:
  - free or latent energy is used, accounting for at least 66% of the global energy consumption
  - dealing with a hot water generator system based on a heat pump (it establishes the features of the heat pump).
  - hot water storage tanks are used, if the storage tanks capacity is enough to generate during the low electricity demand period (low-tariff period) of the day enough hot water for the whole day. In the equipment project should be pointed out the amount of hours per day in which the electricity is not needed to generate hot water, which is taken from the storage tanks.

The paragraph related to thermal insulation, ITE 02.10, points out the necessity of the insulation of all the heating systems components. The insulating materials thickness is defined by an annex of the document, annex 03.1 and their features are defined by two Spanish standards: UNE 100171 and UNE 100172. The most important points of the aforementioned annex are:

- insulation is mandatory for all the items when dealing with fluids which temperature is:
  - lower than the environment temperature.

- higher than 40°C and are placed in non-heated areas.
- Minimum thickness of the insulating material for hot fluids is 20 mm; 30 mm for cold fluids (when placed outside the thickness must be increased by 10 mm for hot fluids and 20 for cold fluids).

▪ For underground pipes other measures may be justified.

ITE 02.6 deals with the power/dimensioning of the heating equipment. Firstly, the sum of the powers of the heat or cold generators should be equal to the sum of the maximum simultaneous loads of the emitters. It is also stated that generators must be connected in parallel and must be independent. Secondly, regarding the heat generator, if its power exceeds 400 kW, then the system must have at least two heat generators (new feature of the code). Moreover, it will be necessary two boilers when the heat generator also generates heat for the hot water system, and, as well as when the power exceeds 400 kW, should be operated independently depending on the demand.

Concerning heat distribution and pipes, ITE 02.8 states that all the distribution circuits must be divided taking into consideration the use timing, the type of emitters and the service to be given in each part of the buildings. The supply pipes must have a safety valve and a meter and their diameter depends on the power of the equipment installed.

The paragraph related to thermal insulation, ITE 02.10, points out the necessity of the insulation of all the heating systems components. The insulating materials thickness is defined by an annex of the document, annex 03.1 and their features are defined by two Spanish standards: UNE 100171 and UNE 100172. The most important points of the aforementioned annex are:

▪ insulation is mandatory for all the items when dealing with fluids which temperature is:
  - lower than the environment temperature.
  - higher than 40° C and are placed in non-heated areas.
  - Minimum thickness of the insulating material for hot fluids is 20 mm; 30 mm for cold fluids (when placed outside the thickness must be increased by 10 mm for hot fluids and 20 for cold fluids).

▪ For underground pipes other measures may be justified.

In order to ensure appropriate efficiency and minimal energy consumption, ITE 02.11, related to systems control, states that it is mandatory for all the installations to have an automatic control system. Again, the necessity of independently controlled subsystems is stressed, as well as the fact that the emitters must have a manual control system. For heating and climate systems means of control are:

▪ for individual installations: thermostat or similar.
▪ for collective installations (flats): temperature control system depending on the outside temperature as well as thermostatic valves (excepting toilets, kitchens and corridors).

Regarding hot water generators, it is pointed out that those devices must have a temperature control system.

In ITE 02, related to design of systems and, as it has already been said, one of the most important chapters of the document, ITE 02.12 and ITE 02.13 deal with measurements. About consumption, ITE 02.13 states that in buildings with several users, it has to be possible to distribute individually the energy demand due to the heating, air-conditioning

systems or hot water systems. Furthermore, the installation must allow the users to regulate the consumption as well as to interrupt the supply outside the room.

For the first time a Spanish technical code deals with individual installations, which was identified as a necessity by the specialists. ITE 09 states the features of the individual installations with a power value lower than 70 kW (otherwise ITE 02 is the reference). Regarding heat generators, ITE 09.2 states that systems which combine heating and hot water must have two different power levels, one for each mode.

Finally ITE 10 deals with specific installations and approaches the solar hot water producers and the climate systems for swimming-pools.

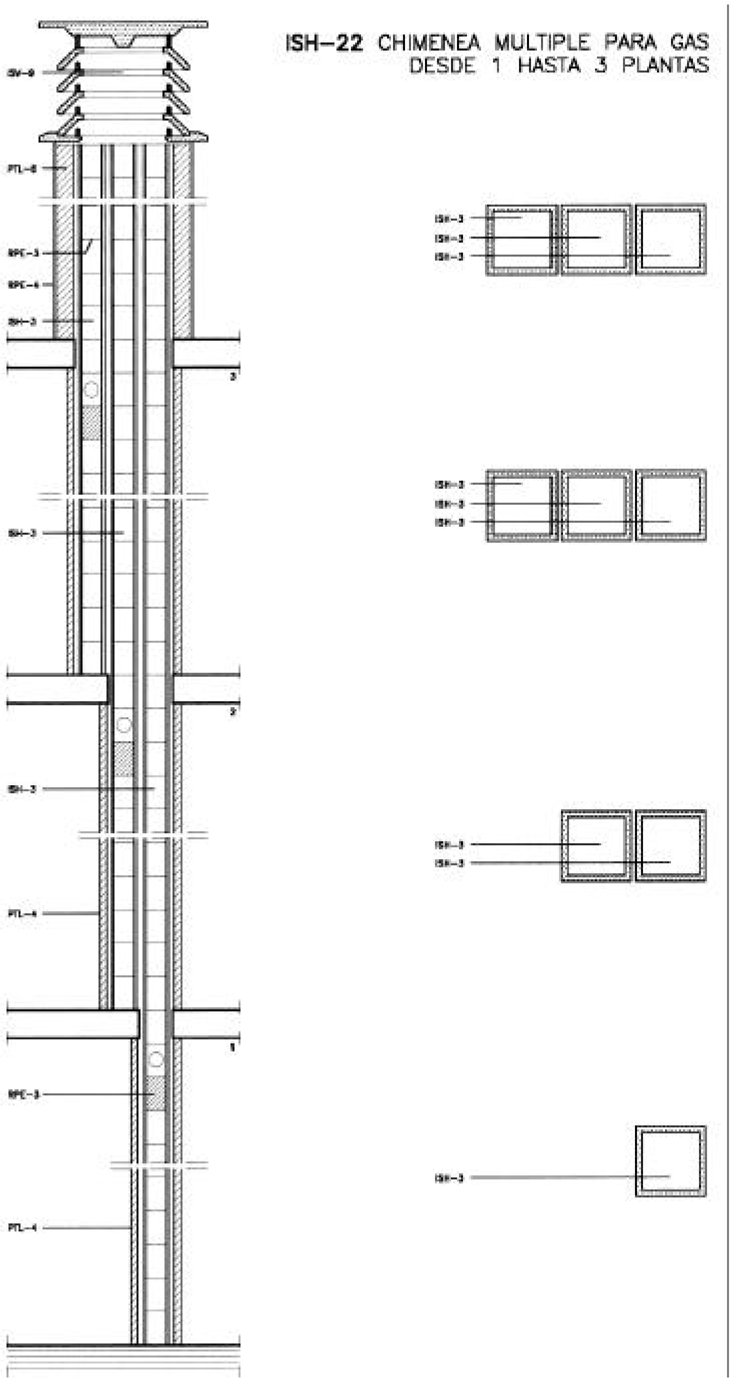
Regarding consumption levels, ITE 02.13 states that in buildings with several users, it has to be possible to individually distribute the energy demand for heating, air-conditioning systems or hot water systems. Furthermore, the installation must allow the users to control the consumption as well as to interrupt the supply outside the room.

ITE 09 relates to individual installations with a power value lower than 70 kW (otherwise ITE 02 is the reference). ITE 09.2 states that heat generators which combine heating and hot water (e.g. combi-boilers) must have two different power levels, one for each mode. For the minimum efficiency of boilers the ITE refers to the Spanish transposition of the European Boiler Efficiency Directive 92/42/EC.

ITE 09.05 contains new provisions (compared to the 1998 version) concerning the mandatory installation of room thermostats with temperature sensor in a reference room. In the other rooms of the house (with some exception for cellar, utility room, etc.) radiators have to be euipped with a thermostatic valve (TRV).

ITE 09.03 regulates chimneys and ducts for flue gases. It refers to the Norma Tecnológica de la Edificación NTE-ISH. Furthermore, a number of local laws apply. In short they say that façade-outlets are acceptable if the boiler is gas-fired, room-sealed and/or fan-assisted. For other fuels and atmospheric boilers usually only vertical outlets are allowed. The NTE-ISH has very specific requirements for collective chimneys, whereby the chimneys for medium-height apartment buildings (4 to 8 floors, the most common type in Spain) are partially (or wholly for the top floor) segmented per apartment. Pictures on the next page show the cross-section of an approved chimney for a 3-floor apartment building, a top view of a chimney exit (photo left) and a roof with typical chimney outlet also showing the separate outlets of the kitchen hoods.

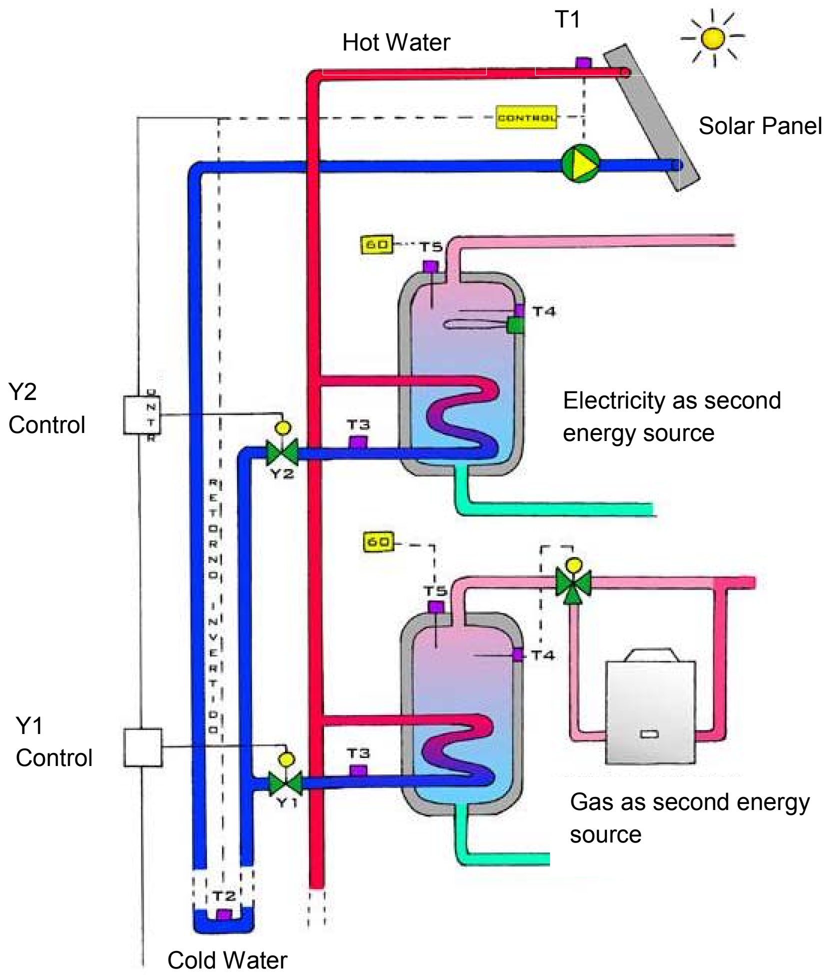
As a conclusion, three main characteristics of the 1998 ITE can be pointed out (Arizmendi, 1998). Firstly that the code is mostly related to central heating, climate and hot water systems, since only one of the eleven chapters deals with individual installations. Secondly that there are frequent references to the Spanish National Technical Standards, the so called UNE Standards. And finally that the European legislation is for the first time a clear and important reference in the codes concerning these kind of systems.


ISH-22 CHIMENEA MULTIPLE PARA GAS
DESDE 1 HASTA 3 PLANTAS

EXAMPLE

An example of a hot water generator system based on solar panels for a dwelling building is the system is given by Ribot, J. His proposal is a system with a storage tank in every dwelling, instead of a single main tank, where the flow of the heating fluid is regulated by a valve depending on the heat necessity. A sketch of the system can be seen in the next diagram.

Figure 18-1.
Hot water system based on solar energy
Source: www.arrakis.es/~jji/Acudis.htm



18.3 Solar water heating

18.3.1 Introduction

Because of the appropriate climate and the energy and money saving, hot water generator systems based on solar energy are becoming an important issue in Spain. Actually, chapter number 10 of the ITE regulation deals with it. Besides of the subsidies given by IDAE and several other energy agencies to promote the use of the solar energy, several local governments have invested in solar panels for the hot water generation in local facilities, such as schools or swimming-pools in recent years. A further step has been taken by the Barcelona Local Government, and a mandatory regulation about solar panels for hot water has been established in 1999. In February 2006, the whole region of Catalonia adopted mandatory solar water heating for sustainable buildings through the Decree 21/2006. And finally, in March 2006, the Spanish Technical Building Code (CTE) by Royal Decree 314/2006 of 17 March 2006 prescribed a minimum solar contribution.

18.4 CTE March 2006

The Spanish Technical Building Code (CTE) by Royal Decree 314/2006 of 17 March 2006 prescribes a minimum solar contribution for the whole of Spain, which depends on:

- The total domestic hot water demand per building in litres per day (l/d)
- The climatic zone (I to V) and
- The auxiliary heating energy source: Fossil or Electric.

For residential dwellings, with a water consumption up to 5000 l/d and fossil fuel fired auxiliary water heating or a water consumption up to 1000 l/d and electric resistance auxiliary heating ('Joule effect') the minimum solar contribution is given below:

Table 18-1. Minimum solar contribution in % (CTE 2006)

climate zone—>	I	II	III	IV	V
with auxiliary heating					
Fossil-fuel fired (50-5000 l/d)	30%	30%	50%	60%	70%
Electric resistance (50-1000 l/d)	50%	60%	70%	70%	70%

The climate zones in Spain are given in figure 18.2.

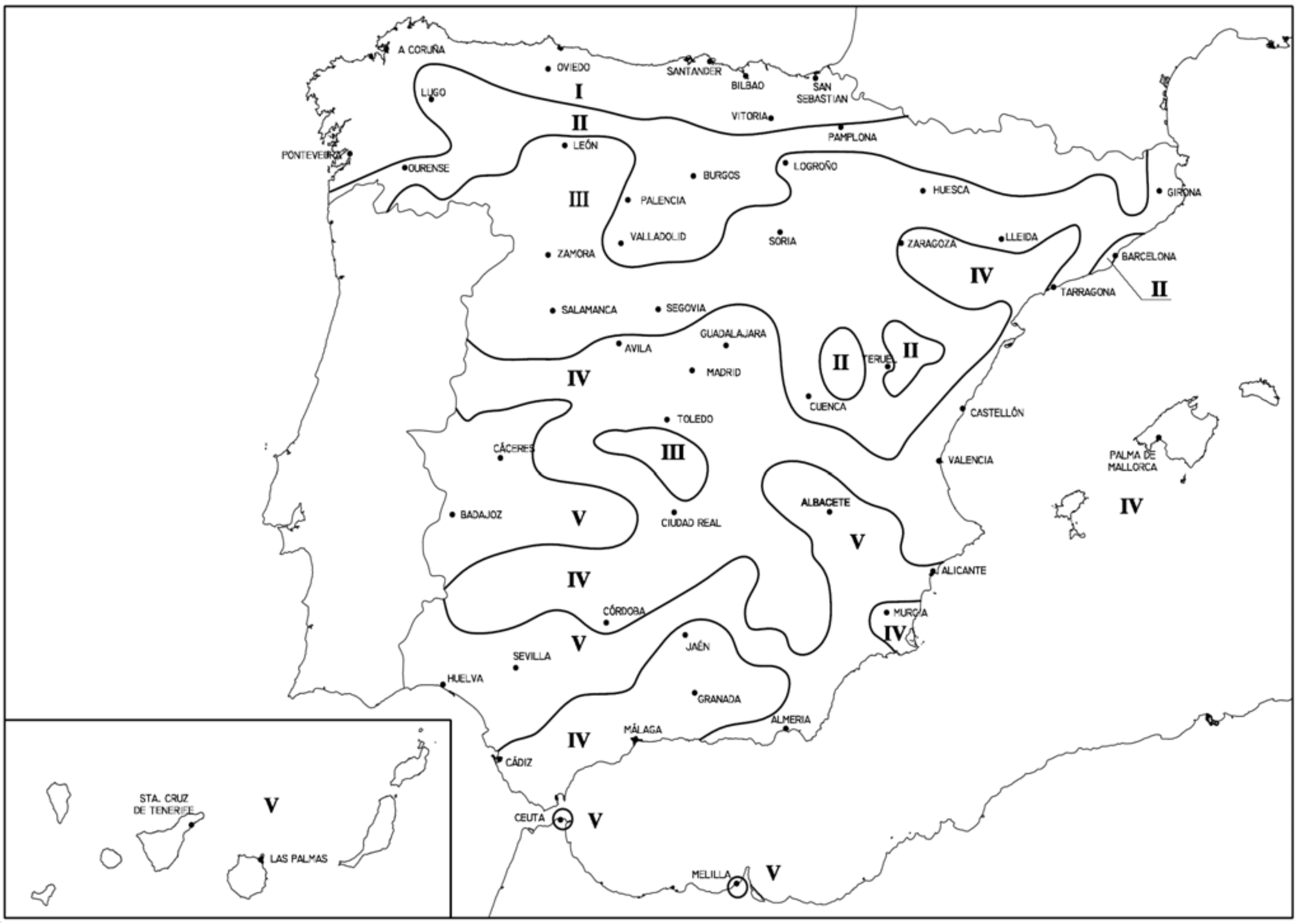


Figure 18-2.
Climate zones in Spain

For larger buildings, i.e. with a hot water demand above the values mentioned, the minimum solar contribution has to be higher. For swimming pools there is a separate set of minimum values.

The builder has to submit a plan, incorporating the expected hot water demand and the installation characteristics, to show that the minimum solar contribution requirements are met.

The hot water demand is determined through the following look-up table, which is similar but not identical to the one used in Barcelona.

The values in table 18-2 were calculated with a cold water temperature of 12°C, which means there is a temperature difference of 48°C (60-12) with the reference [78]. Multiplied with the specific heat of 1,66 Wh/l * K this results in ca. 80 Wh/litre.

The number of persons per bedroom can be calculated from the number of bedrooms (see table 18-3).

[78] Please note that the calculation was done in UNE 94002;2005 with a temperature of the solar storage tank of 45°C, but this value was recalculated to 60°C.

Table 18-2. Reference hot water demand in litres per day at 60°C (CTE, 2006)

	litres	
single-family dwelling	30	per person
multi-family dwelling	22	per person
Hospitals and clínics	55	per bed
Hotel ****	70	per bed
Hotel ***	55	per bed
Hotel/Hostel **	40	per bed
Camping	40	per site
Hostel/Boarding house*	35	per bed
Homes for the elderly, student dormitories, etc.	55	per bed
Dressing rooms/collective showers	15	per service
Schools	3	per pupil
Barracks	20	per person
Factories and shops	15	per person
Offices	3	per person
Gyms	20 to 25	per user
Laundromats	3 to 5	per kg laundry
Restaurants	5 to 10	per meal
Cafeterías	1	per meal

Note: The demand was calculated from UNE 94002:2005, using Ti=12°C (constant) and T=45°C.

Table 18-3. Number of bedrooms versus number of persons per dwelling CTE, 2006)

no. of bedrooms	1	2	3	4	5	6	7	more than 7
no. of persons	1,5	3	4	6	7	8	9	no. of bedrooms

VHK example

With 2,5 persons per dwelling, 30 litres/person/day, the total consumption per dwelling during a year of 350 days is 26250 litres. In terms of energy at 80 Wh/litre this amounts to 2100 kWh.
This is a relatively high value compared to other EU Member States, so it is assumed that this includes the hot water distribution losses and the storage losses.

The global solar radiation in Spain is given:

Table 18-4. Global solar radiation (CTE, 2006)

Climate zone	MJ/m².day	kWh/m².day
I	$H < 13,7$	$H < 3,8$
II	$13,7 \leq H < 15,1$	$3,8 \leq H < 4,2$
III	$15,1 \leq H < 16,6$	$4,2 \leq H < 4,6$
IV	$16,6 \leq H < 18,0$	$4,6 \leq H < 5,0$
V	$H \geq 18,0$	$H \geq 5,0$

Furthermore, the CTE contains a comprehensive list of requirements for the individual installation components and their maintenance. The full translation in English –as well as a link to the orginal— can be found at the ESTIF website [79]. Here we will just present some highlights:

- Irrespective of the application and the technology used, the minimum nominal efficiency of the collector must be 40%. Furthermore, the average actual efficiency over the period of use, must be at least 20%.
- Per month of the year, the period of overheating, i.e. when the theoretically solar gain from the installation exceeds the demand, must be established and appropriate measures must be taken to protect the installation.
- In installations intended exclusively for the production of DHW it is recommended that the collectors have a global loss coefficient below 10 Wm^2/K.
- The solar system, and more in particular the solar storage tank, must be designed in accordance with (hot water energy) demand and not with supply (the solar collector)
- The ratio between collector area A (in m^2) and the storage volume V (in litres) is given by $50 < V/A < 180$
- The minimum capacity P of the heat exchanger inside the solar storage tank: $P \geq 500 * A$
- For a small system the electric power of the circulator shall be less than 50W or 2% of the calorific value that the collectors can deliver. For larger system this is 1% of the calorific value[80]
- For calculation of the effect of tilt angle and orientation of the collector, CTE provides a look-up diagram and table, where first the orientation (azimuth angle) is assessed and then a tilt angle must be chosen in such a way that the maximum loss is 10%. In case of superimposed collectors the maximum loss may be 20%. In case the collector is integrated in the building shell ('architectural integration') the maximum loss from the tilt angle may be 40%. (see fig. 18.3)
- For the shading factor, another diagram is given but the same look-up table applies (Annex B).

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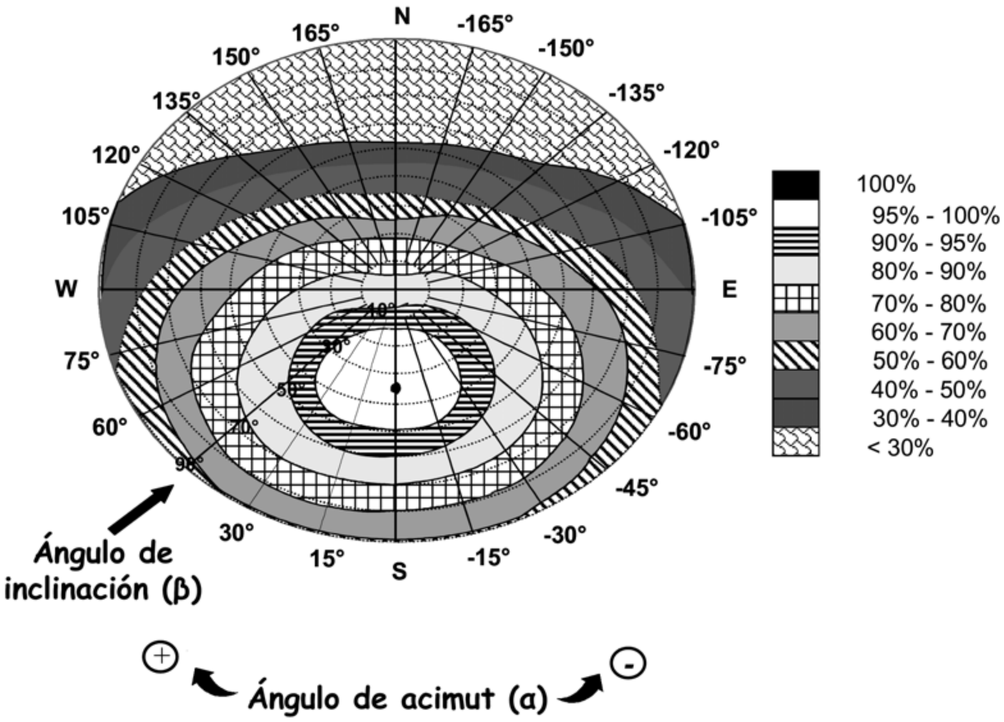
[79] English: www.estif.org/fileadmin/downloads/CTE_solar_thermal_sections_ENGLISH.pdf

Spanish original: www.boe.es/boe/dias/2006/03/28/pdfs/SUP06_074C.pdf

[80] Note that ESTIF calculates with 0,7 kWth/m² of collector area for statistical purposes.

Figure 18-3.
Look-up diagram for orientation (azimuth) and inclination of collector Spain (CTE, 2006)



19 PORTUGAL

19.1 Introduction

On 4 April 2006, the Official Journal published three Decrees regarding the transposition of the EPBD in national law [81]:

- Decree 78/2006 – It creates and defines the operational rules for the System for Energy and Indoor Air Quality Certification of Buildings (SCE) – articles 7 & 10;
- Decree 79/2006 – It establishes the new revision of the Regulations for HVAC systems, including requirements for regular inspection of boilers and air-conditioners (RSECE) – articles 8 & 9;
- Decree 80/2006 - It establishes the new revision of the Thermal Regulations for Buildings (RCCTE) – articles 3 to 6.

In Portugal, the implementation of the EPBD is the overall responsibility of the Ministry of the Economy, Directorate General for Geology and Energy, who coordinated the legal procedures and is responsible for the Certification system. The direct responsibility for the two regulations lies with the Ministry of Public Works, who updated them at the request of the Ministry of the Economy. More information is available on www.dgge.pt and www.adene.pt .

Status of the implementation: Calculation procedures

The calculation procedures (art. 3) are included in the Building regulations for residential buildings and in the HVAC regulations for non-residential buildings. A general description of the calculation method is given in www.p3e-portugal.com.

A software tool shall be available from INETI (at a nominal cost) in September 2006.

Requirements for new buildings and major renovations

The new requirements are mandatory for building permits requested after 3 July 2006. The type and level of requirements are function of the type of building (dwellings, office buildings, schools, etc.) and cover:

- Maximum Heating and Cooling needs per m² of floor area (residential only);
- Maximum U-value;
- Minimum shading requirements for all windows;
- Minimum requirements for thermal bridges;
- **Maximum consumption for production of hot water, including mandatory installation of solar water heaters (all buildings);**
- Maximum primary energy consumption per m² of floor area (all buildings);
- Minimum efficiency and quality requirements for heating and cooling components (non-residential buildings).

The proof of compliance must be made when requesting the building permit and after completion of the building. Control of the regulation is the responsibility of the City where the building is located, based on a Declaration of Compliance with the building regulations issued by an accredited expert registered in the SCE (Building Certification System).

[81] Source: Maldonado, E (University of Porto), Nascimento, C. (ADENE), Implementation of the EPBD in Portugal: Status and Planning, paper P08 for www.buildingsplatform.eu.

Requirements for existing non-residential buildings larger than 1000 m²

If the primary energy consumption of a building exceeds a certain level, fixed by type by the HVAC regulations RSECE, an energy plan must be prepared and all measures with payback shorter than 8 years must be implemented over three years. These requirements shall start in 2008 or 2009, depending on the size of the building.

Certification of buildings

Certification is mandatory for all new buildings requesting a use permit after mid 2007. The exact date shall be decided by the Government by 4 December 2006. For public buildings, a certification is needed from 1 January 2008 or 2009, depending on size. Other buildings when rent or sold must have an energy performance certificate from 1 January 2009.

Inspection of boilers and air conditioning

Inspections of boilers and air-conditioners are covered by the HVAC regulations adopted by the Government on 4 April 2006 and it shall become mandatory from 1 January 2009. The procedures for inspection of boilers and air conditioning systems are still under discussion.

19.2 Consumption of hot water

Decree 80/2006 – the new revision of the Thermal Regulations for Buildings (RCCTE) – establishes a maximum consumption level for sanitary hot water N_a in kWh/m²a .

$$N_a = 0{,}081 * M_{AQS} * n_d / A_p$$

Where M_{AQS} is the average daily hot water consumption given by the expression

M_{AQS} = 40 litres * number of occupants

The number of occupants of a dwelling is given by the number of bedrooms + 1 (n+1). Only a studio counts as 2 occupants. In general, for apartment buildings a default value of MAQS = 100 litres/dwelling*day applies.

The number of days the hot water is consumed n_d depends on the use. If it is a permanent residence n_d = 365. If the house is empty one day a week n_d = 313, one-and-a-half day n_d =287 and if the occupants go away 2 days a week n_d=261.

If the floor area of the dwelling Ap (in m²) is 80 m², then for a permanent residence the value of N_a = 0,081 * 100 * 365 / 80 = 36,95 kWh/m²a.

The energy consumption for water heating N_{ac} is given by the expression

$$N_{ac} = (Q_d / \eta_a - E_{solar} - E_{ren}) / A_p$$

Where Q_d is energy use of conventional water heating systems in kWh/a, given by

$Q_d = (M_{AQS} * 4187 * \Delta T * n_d) / 3\ 600\ 000$

The temperature difference between the incoming cold water (15°C) and the supplied hot water (60°C) is set at 45°C. For M_{AQS} =100 litres the Q_a of a 2,5 person permanent residence is therefore Q_a = (100 * 4187 * 45 * 365) / 3 600 000 = 1910 kWh/a .

The efficiency of the water heating system ηa should be provided by the manufacturer on the basis of standard tests. Alternatively, the following values may be used.

Table 19-1. Efficiency of water heaters, default values (RTCCE, 2006)

	< 50 mm	50-100 mm	> 100 mm
Electric storage water heaters	80%	90%	95%
Gas-fired storage water heaters	70%	75%	80%
Storage wall-hung combi boiler	65%	82%	87%
Instantaneous gas-fired water heater	50%		

The values mentioned above must be reduced by 10 percentage points if the insulation of the distribution pipes for hot water is less than 10 mm thick. So, if we produce the 1910 kWh/a mentioned above with a well insulated gas-fired storage water heater and piping featuring an efficiency of 80%, the ratio Q_a / ηa becomes 1910/0,8 = 2387 kWh/year. At A_p=80 m², this means that N_{ac} = 2387/80 = 29,83 kWh/m²a, which is well below the limit value [82].

The contribution of the solar energy Esolar should be calculated using the SOLTHERM software programme from INETI. The solar system should be certified according to the rules of law and installed by an accredited installer (approved by the Ministry DGGE). There should be a maintenance contract guaranteeing efficient operation for at least a period until 6 years after installation.

The contribution of other forms of renewable energy Eren, as well as the contribution from (ventilation) heat recovery, should be calculated according to well-established methods by licensed entities.

19.3 Minimum solar energy system

Please note that Article 7, sub 2, of the RTCCE makes it mandatory to have at least 1 m² of solar collector area per occupant (ca. 2,5 m² per dwelling), provided that the collector area can have an orientation between SouthEast and SouthWest. Furthermore, the minimum collector area can be reduced proportionally if this area would occupy more than 50% of the available area of a terrace or veranda.

[82] It is not clear how the primary energy factor (which is more than 3,3 in Portugal) fits into this minimum requirement in the case of electric water heaters. Fpu for electricity = 0,290, whereas fossil fuels = 0,086 units of primary energy

20 CYPRUS

Cyprus is completely dependent on imported fossil fuels, which is strenuous on both the economy and the environment. In 1997, energy imports corresponded to 61 percent of the country's total domestic exports and 9,1 percent of the total imports for home consumption. The boiler market is very small with hot water being the main interest and some additional heating in the winter,

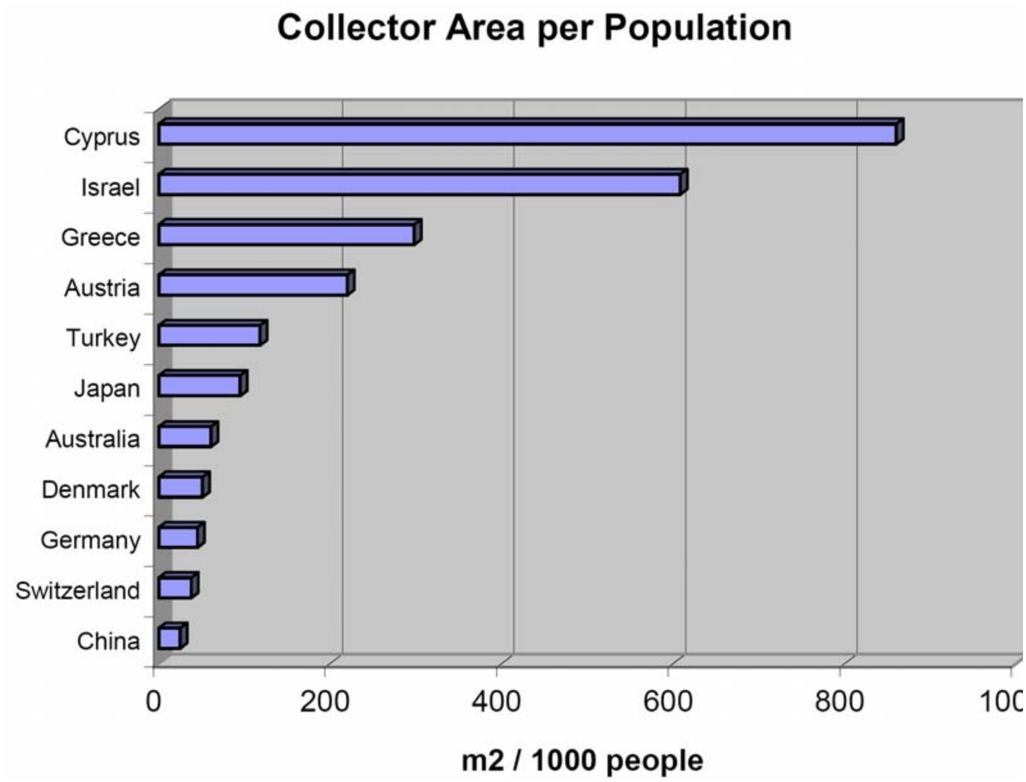
The use of solar power as an alternative energy source is extremely beneficial if not necessary. Solar water heaters were first produced and installed in 1960. Since then, a remarkable expansion in the use of solar water heaters has taken place, ranking the country among the leaders in terms of total number of solar water heaters in use per person[83]. The Government of Cyprus in partnership with the Applied Energy Center of the Ministry of Commerce, Industry and Tourism helped expand the promotion of solar energy. It made the production materials duty-free, provided technical support for the preparation of relevant standards and made the installation of solar water heaters compulsory on state-built housing. However, the most important factor contributing to this project was the enterprising industry, which correctly identified the prime application of solar water heaters and boosted the improvement of technology and promotion of the systems. It also provided technical support that consisted of testing collectors and advising the industry and consumers about the improvement of products and their efficient utilization. In the domestic sector, the payback period of a typical solar system is estimated to be around four years.

At the beginning of 1999, approximately 92 per cent of the households and 50 per cent of the hotels in Cyprus had solar water heating systems. Cyprus is one of the leading countries in terms of installed solar collectors per capita, 0,86 m² of solar collector per capita.

- There are currently a number of small and large solar water heater manufacturers in Cyprus, employing about 300 people and producing about 35 m² of solar collectors annually.
- The estimated current area of installed solar collectors in Cyprus is 600 m², and the solar thermal-energy production is 336 000 MW/year.
- Annual savings per square meter of installed collector area in Cyprus are 550 kwh.
- Consequential to the extensive use of solar heaters, 4% of total CO_2 emissions are avoided, which is approximately 286 tons of CO_2/year.

[83] source: UN DESA SIDS Network: Cyprus, Success Stories. (www.sidsnet.org)

Figure 20-1.
2002 Penetration Rate of Solar Water Heating in Selected Countries (Sources: Cyprus, UN DESA SIDS Network, Success Stories; Others: IEA Solar Heating Worldwide, Markets and Contribution to the Energy Supply 2001)



21 GREECE

As a result of the government programmes started in the early 1980s, 25% of all households now have simple technology, (99% of residential systems are closed loop, batch thermosiphonic designs) and low cost (costing on average € 700) solar water heating systems, backed-up by gas or electricity[84]. Twenty years of experience has revealed few maintenance and operational problems and a consumer base that will continue to replace their old systems with solar thermal systems, even though subsidies have now been removed.

Solar water heating systems for the service and industrial sector have been less successful, partly because they have been less cost effective, but also because the promotion has been made on the basis of Government grants, which has been less consistently applied and therefore has been more unpredictable than the tax deductions and soft loans for the residential sector. Analysis suggest that the reasons for success in Greece are:

- Domestic hot water was largely heated by electricity, against which solar thermal technology can be competitive;
- Houses commonly have flat roofs, which is easy and cheap to install solar thermal technology;
- Greece has favourable solar conditions;
- State support and committed champions were important in supporting the initial introduction of thermal solar technologies to the Greek domestic hot water sector; and
- Finally, quality control has helped to minimize operational problems, reduced maintenance costs and built the consumer confidence. This is expected to help to sustain the sector also in the future.

Greece has so far not been a significant market for gas boilers, but the extension of the gas grid in Greece is now underway and this may stimulate the growth for gas boilers.

[84] Greek Experience – Solar Thermal Programme Results and lesson s (source: -Sun in Action II - a Solar Thermal Strategy for Europe)

22 BALTIC STATES

22.1 Introduction

This section summarizes the situation in Latvia, Lithania, Estonia. All Baltic States have reported the transposition of –at least part of— the EPBD (91/2002/EC) per 1 Jan. 2006. However, although most of the countries have a building code with minimum insulation standards at component level and some even at building level (relating to the surface of the building), no information was found on a holistic approach including installation components such as boilers or water heaters. It is estimated that the Boiler Directive 92/42/EC has been transposed into national legislation in most countries, but again there is no evidence that any country has expanded on this e.g. with emission standards. One reason can be that the countries depend on district heating and biomass for their space heating. Regulation of the energy efficiency and emissions of gas-fired boilers, although a growing market, probably has no high priority.

The following paragraphs represent some fragmented information on the building regulations and incentives in the Baltic States that could be retrieved so far.

22.2 Lithuania

The Apartment Houses Modernisation Programme is the basis for the energy performance of buildings strategy of Lithuania. This Programme is described in Art. 25 to 30 of the RESOLUTION No 1323 of 12 December 2005 on THE CONVERGENCE PROGRAMME OF LITHUANIA OF 2005. The relevant articles –cited below— are self-explanatory:

Apartment Houses Modernisation Programme

Article 25. The Apartment Houses Modernisation Programme has been approved by Resolution No 1213 of 23 September 2004 of the Government of the Republic of Lithuania (*Valstybės žinios* (Official Gazette) No 143-5232, 2004, No 78-2839, 2005). The Programme is in line with the European Union directives directly dealing with improvement of energy efficiency in buildings, such as Council Directive 93/76/EEC of 13 September 1993 to limit carbon dioxide emissions in improving energy efficiency (SAVE) and Directive 2002/91/EC of the European Parliament and the Council of 16 December 2002 on the energy performance of buildings.

The Apartment Houses Modernisation Programme implements the goal of Lithuania's Housing Strategy approved by Resolution No 60 of 21 January 2004 of the Government of the Republic of Lithuania (*Valstybės žinios* (Official Gazette) No 13-387, 2004), i.e. to ensure efficient use, maintenance, renewal and modernisation of the existing housing stock and a rational use of energy resources. The Programme is scheduled for the period of 2005 to 2020.

Article 26. **Overview**. The issue of a rational use of energy in residential buildings becomes increasingly painful and cannot be solved by homeowners alone. In Lithuania, more than 60% of apartment houses were built during the last four decades of the last century. The use of energy is not efficient in these buildings (20% to 30% of heating is lost). Their maintenance costs are very high in winter, and their owners, who are often low-income people, cannot pay heating bills. For low-income families, a part of expenses on heating and hot water is covered by the state. By the data of the Ministry of Social Security and Labour, about 7% of Lithuania's population are entitled to the reimbursement of expenses on heating. With the rise of energy prices, more budgetary funds would be needed for compensations. A large part of energy resources is imported, which has a negative effect on the balance of payments.

Article 27. Goals. Lithuania's Housing Strategy provides that the existing apartment houses and, where possible and economically efficient, the engineering and technical installations thereof will be renovated and modernised by 2020. For about 70% of apartment houses, relative consumption of thermal energy will be down by 10% to 30%.

The key goal of the Programme is to help owners of apartment houses and low-income families to modernise their homes, by improving energy efficiency and reducing expenses on heating.

Article 28. Measures. State-supported measures aimed at modernising apartment houses include: major repair or reconstruction of heating and hot and cold water supply installations; hermetisation or replacement of windows and outer doors; major repair or reconstruction of roofs through additional thermal insulation, including the construction of new sloping roofs (excluding construction of attic premises); glazing of balconies (loggia); thermal insulation of exterior walls and reinforcement of wall structures; hermetisation of walls and junctures of block houses; thermal insulation of cellar ceilings; major repair or replacement of lifts; replacement or reconstruction of common use electric installations. The Programme provides for the allocation of state support to owners of apartment houses by reimbursing up to 30% of their investment in the modernisation of such houses, depending on the energy-efficiency of individual modernisation projects. Low-income families (one-person households) will be supported additionally, by reimbursing a larger part of the related costs.

Article 29. Financing. Modernisation of apartment houses will be financed by the homeowners' private funds, long-term loans from commercial banks, municipal funds, targeted support by the State, and from other sources.

Only houses built before 1993 are eligible to the state support.

To take up an investment project under the Apartment Houses Modernisation Programme, homeowners have to pool a down payment of at least 10% of the total estimated value of the investment to be made. Banks, too, contribute to investment projects by granting loans. Such loans are granted for up to 90% of the value of the investment.

State support is given in the following manner: by reimbursing a portion of the investment in the modernisation of an apartment house depending on the energy-efficiency of the project or by reimbursing the costs for low-income families.

It has been estimated that the implementation of the Programme will require at least 7 billion litas in the period until 2020 or, for comparison, 7,9% of the GDP of 2008. 30% of this expenditure would be financed from the state budget, through statutory state support. A certain amount of the expenditure would be borne by general government. The state budget of 2006 allocates 6 million litas for this Programme or 0,01% of the GDP of 2006. For 2007 and 2008, budget allocations are expected to amount to 15 million and 25 million litas, respectively. In the future, state budget appropriations for the Programme will be planned by taking into consideration the financial capacity of the state to implement the provisions of the Stability and Growth Pact.

Article 30. Economic Impact. The Apartment Houses Modernisation Programme will improve sustainability of general government finances in the long run and will be beneficial for the following reasons:

30.1. the future requirement for general government funds for heating compensations to socially disadvantaged groups of population will be lower, meaning better utilisation of general government finances;

30.2. small and medium construction business will be promoted;

30.3. expenditure on fuel (purchased during the heating season) will be lower, meaning a lower current account deficit;

30.4. positive social (promotion of reduction of unemployment) and environmental (lower levels of CO_2 emissions) aspects.

A research into how much GDP productivity will grow as a result of housing renovation projects that will lower the consumption of fuel for heating is planned.

In 2002 Lithuania has implemented the Boiler Directive 92/42/EC through Order no. 45[85]. The 1978 EU Boiler Inspection directive 78/130, currently incorporated in the Buildings directive 91/2002/EC, has been transposed through order no. 474 also in 2002 [86].

22.3 Latvia

The Latvian Convergence Programme 2004-2007 [87] does not contain a separate section on housing or energy performance of buildings, but in the section on Energy Supply mentions that for modernisation of heating systems in line with environmental requirements and raising energy efficiency of heat production, distribution and end-use, notably by reducing the sulphur content of fuels, the Latvian central government funds and EU Structural Funds will be attracted amounting to 13 million lats from 2004 to 2007.

22.4 Estonia

Estonia has postponed the introduction of taxes on energy products, previously foreseen for 2006, because of the sharp rise in fuel prices.

Housing is a small part of state expenditure (1,2%), but rising at 14% over the last year. Although the high oil prices have their effect on the Estonian economy and the Convergence Programme 2005-2008 mentions that the energy consumption of buildings is high not only because of the colder climate but also because of the low building standards, no specific measures were mentioned.

[85] ORDER OF THE MINISTER OF ECONOMY OF THE REPUBLIC OF LITHUANIA ON THE APPROVAL OF THE TECHNICAL REGULATION FOR NEW HOT-WATER BOILERS FIRED WITH LIQUID OR GASEOUS FUELS, 11 February 2002 No. 45, Vilnius, Latvia.

[86] Minister of Economy of the Republic of Lithuania, ORDER NO. 474 ON THE APPROVAL OF THE TECHNICAL REGULATION OF inspection OF EFFiciency OF HEAT GENERATORS AND INSULATION OF heat AND HOT-WATER DISTRIBUTION IN NON-INDUSTRIAL BUILDINGS, 31 December 2002, Vilnius.

[87] Latvian Ministry of Finance, Convergence Programme 2004-2007, Riga, Dec. 2004.

23 CENTRAL EUROPE

23.1 Introduction

This section summarizes the situation in Poland, Hungary, Czech Republic, Slovakia and Slovenia. Detailled information on energy performance of buildings regulations transposing the EPBD (91/2002/EC) could not be found, although most of the countries have a building code with minimum insulation standards at component level and some even at building level (relating to the surface of the building), no information was found on a holistic approach including installation components such as boilers. It is estimated that the Boiler Directive 92/42/EC has been transposed into national legislation in most countries, but again there is no evidence that any country has expanded on this. One reason can be that the countries depend on district heating and biomass for their space heating. Regulation of the energy efficiency and emissions of gas-fired water heaters, although a rising market, therefore probably has no high priority.

The following paragraphs represent some fragmented information on the building regulations and incentives in Central Europe that could be retrieved so far.

23.2 Poland

Transposition of the Boiler Directive takes place in Energy Efficiency Law for new water gas and oil boilers Dz.U.n/r97 poz 880 and 881 of 2003.

Energy performance in the National Building Code was mainly focused on transmission losses of single components and for industrial buildings and single family buildings it still is. For instance, for insulated outside walls and roofs in single family houses the U-value should be lower than 0,3 W/(m²K) at indoor temperature of 16°C. For windows the U value limit is 2 W/(m²K).

For multifamily buildings the code specifies a surface-related energy demand indicator E, dependent on the A/V ratio (surface/volume ratio. For instance E=29 kWh/m² if A/V < 0,20; E=37,4 kWh/m² if A/V > 0,9. For A/V values in between 0,2 and 0,9 the equation is E = 26,6 + 12 * A/V kWh/m² ([88]) More information at the Polish Build Research Institute ITB (www.itb.pl).

Limit values for water heaters were not found.

The following was found on NO_x limits in Poland from an Australian worldwide study in 2000. Yamada and Desprets (1997) quote the standards and unit conversions as given in Table 23-1. The standard for boilers is not mandatory.

Table 23-1. NO_x emission standards in Poland (Yamada and Desprets, 1997).

Natural gas and LPG Appliances	$g(NO_x)$ / GJ (ppm @ 0% O2)
Burners, heat input between 10 kW and 10 MW	60 (122)
Boilers <1 MW input	35 (71)

[88] www.worldenergy.org/wec-geis/edc/countries/Poland.asp

23.3 Czech Republic

In the Czech Convergence Programme (Nov. 2005) no reference to state expenditure regarding housing or energy efficiency was found. Also eco tax as an instrument wasn't mentioned.

The following was found on NO_x limits in Czechoslovakia from an Australian worldwide study.

Table 23-2. NO_x emission standards in Czechoslovakia (Yamada and Desprets, 1997)

Flued Appliances	mg(NO_x) / m³ (3% O_2) (ppm @ 0% O_2)
Very small LPG furnace	200 (114)
Central heating natural gas boiler (fan assisted) < 0,2 MW output	260 (148)
Natural gas boiler (atmospheric) < 0,2 MW output	200 (114)
Natural gas boiler (fan assisted) < 0,2 MW output	150 (85)
All natural gas boilers > 0,2 MW output	200 (114)
LPG boiler (atmospheric) < 0,2 MW output	315 (179)
LPG boiler (fan assisted) < 0,2 MW output	262 (149)
All LPG boilers > 0,2 MW output	200 (114)

Euroheat & Power[89] reports the following Regulations on Buildings:

- Decree No. 137/1998 Coll. (resulting from the Contstruction Law) establishes thermal and energy properties of the buildings that must be met by both new construction and refurbished buildings. The decree sets the formula for calculating the heating consumption including ventilation, the energy saving and the appropriate capacity. The decree also gives the option of calculating according to the Czech State Norm Nr. 730450, 060210 and EN 832 starting from Jan. 2002. The specific energy consumption in the decree is binding for all constructions an refurbished buildings financed through public budgets. For privately financed buildings a threshold for the overall consumption of 700 GJ/year is foreseen.
- Decree No. 152/2001 Coll. Established rules for the heating and distribution of Domestic Hot Water (DHW). Specific consumption indicators are applied to new and refurbished buildings, both for heating (0,55 GJ/m²/heating season, unless solid fuels are used[90]) and hot water (0,2 GJ/m²a or 0,3 GJ/m³ for a district heating system; 0,25 GJ/m² or 0,35 GJ/m³ in an installation for hot water preparation). Note that the average surface for a flat is 45m² and for a house 96,9 m².
- Decree No. 215/2001 Coll. is the transposition of the labelling directive 92/75/EC and the various European minimum efficiency standards.

23.4 Hungary

From a personal communication of Dr. Magyar Zoltan, member of the EPBD-CA (Concerted Action), it was understood that Hungary is currently working on the EPBD but that the inclusion of boilers and water heaters in a holistic approach to the energy performance of buildings is at its very early stages.

[89] Euroheat & Power, District Heating and Cooling, Country by Country / 2005 Survey, Brussels, May 2005.

[90] In the case of solid fuels the requirement is 0,7 GJ/m²/heating season

23.5 Slovakia

The Slovakian Convergence Programme (Ministry of Finance, Nov. 2005) mentions that almost 50% public expenditure savings in the area of the housing support in 2002-2008 was achieved through a revision of the method of granting, and amounts of, subsidies. The main source of consolidation in this area may be deemed to be the reduction of the state premium in building saving schemes, and a decrease in expenditure related to subsidisation of interest rates on granted mortgage loans. Savings were achieved mainly thanks to the general drop in interest rates in the market, enabling a significant reduction in the extent of provided aid.

Under the *National Programme of Environmental Assessment and Ecolabelling in the Slovak Republic (NPEHOV) - Heating Boilers for Gaseous Fuels with Atmospheric Burner* there is a Slovakian eco-label that was introduced in 1997. Reportedly this started as a cooperative programme of the Czech Ecolabelling Programme, German Ecolabelling Programme and Nordic Ecolabelling Programme with reference to Council Regulation 880/92 EEC. Competent body is Ministry of the Environment of the Slovak Republic and technical support is Slovak Environmental Agency [91].

23.6 Slovenia

State aid in the field of energy saving increased from 119 million SIT (€ 0,8 million) in 2002 to 583 million SIT (€ 2,4 million) in 2004, amounting to 0,6% of State Aid. State Aid for environmental protection in general amounted to 5679 million SIT (€ 23 million) in 2004[92]. In 2004, aid for environmental protection and energy saving was granted on the basis of the following schemes: Promotion of the Recovery of Renewable Energy, Efficient Use of Energy and of Cogeneration Plants, Programme of the Ecological Rehabilitation of Mining Buildings, Structures and Plants for the Extraction of Hydrocarbons in the Republic of Slovenia (Nafta Lendava), The Reduction of Burdening the Environment with CO_2 Emission and Co-financing Environmental Investments.

[91] Source: www.clasponline.org

[92] Ministry of Finance, Seventht Survey on State Aid in Slovenia (2002-2004), Republic of Slovenia, June 2005

24 SWITZERLAND

24.1 Energy

For many years energy efficiency has been a high priority in Swiss policy, where the Swiss have often preceded EU Member States in the field of legislation. Efficiency of water heaters can be promoted either through the energy performance of buildings or through measures directly affecting products.

Regarding the energy performance of buildings the mandatory standard is SIA 380/1 (1998; revised 2001), which follows the traditional approach of minimum standards per item. Since 1998, roughly 10% of new buildings were built following the voluntary quality label '*Minergie*' (38-42 kWh/m²a), which uses half of the energy and requires controlled mechanical ventilation systems with waste heat recovery. A recent even more ambitious standard is '*Minergie-P*' (30 kWh/m²a). Despite higher building costs (+6%), *Minergie* has become the norm for all new public buildings and renovations, as well as for federally subsidised construction. It is promoted by special mortgage rates, etc.. For water heating solar energy (with auxiliary source), block or district heating, heat pumps, etc. are the preferred solutions. The most efficient heat pump water heaters and solar collectors are listed on the www.topten.ch webiste. In a conventional Minergie house (42-45 kWh/m²a) the energy consumption can be partitioned between space heating and conventional hot water preparation in a ratio 2 to 1 [93], which means that around 4 kWh/day is 'available' for water heating. This already pushes house owners to chose the most efficient appliance, but it cannot be termed a true minimum standard.

Regarding the products: In the 1990s, Switzerland used a system of target values with supporting endorsement labels to improve the energy efficiency of household appliances and the standby power use of home and office electronics equipment. The program is currently being revised. The Decree on the Use of Energy (DEU) by the Swiss Federal Parliament, which became effective in March 1992, gave the Swiss Federal Office of Energy the power to issue requirements concerning the energy consumption of electrical appliances. Parliamentarians stated that mandatory energy efficiency standards should not be introduced unless the energy consumption appliances on the market failed to attain certain goals (target values) issued by the government for set dates in the future. However, should the target value approach fail, mandatory standards could be imposed without seeking further political approval [94].

NO_X

In 1985 Switzerland adopted the Ordinance on Air Pollution Control (OAPC) was introduced for –amongst others— 'directly fired storage water heaters' and 'continuous flow water heaters. This Ordinance –which is periodically updated (last version as at 28 March 2000)[95] prescribes for both types a maximum CO-emission of 100 ppm. For storage water heaters capacity from 30 to 400 litres the maximum flue gas losses are 12%, for larger installations 6%. The maximum standby losses per 24 h of storage water heaters depend on the volume of the tank.

NO_x emission limits for gas-fired equipment are shown in Table 24-1. If requirements are not met, renovation of the system will be forced. However, for smaller systems rated

[93] www.energie.ch/themen/bautechnik/minergie/index.htm

[94] www.clasponline.org

[95] Pers. Comm.. DiPrenda, 2006.

less than 70 kW, if NO_x emissions are not within limits, retrofit of the equipment is not required (Benedek and Goodman, 1994; Yamada and Desprets, 1997).

Table 24-1. NO_x emission standards in Switzerland.

Appliance	mg(NO_x)/m³(3% O_2) (ppm @ 0% O_2)
Atmospheric (natural draft) natural gas burner < 12kW output	120 (68)
Atmospheric (natural draft) natural gas burner 12 kW < heat output < 350 kW	80 (45)
Fan assisted natural gas burner £ 350 kW output	80 (45)
Atmospheric (natural draft) LPG burner < 12kW output	120 (68)
Atmospheric (natural draft) LPG burner 12 kW < heat output < 350 kW	90 (51)

Table 24-2. Max. Standby losses of storage water heaters, Switzerland (OAPC, 2000)

water storage capacity of the installation in litres	30	80	130	190	280	340	400	500	600	over 700
limit values standby losses in kWh/24h	1,9	3,04	4,04	5,12	6,46	7,19	7,9	8,75	9,36	9,81

In the case of continuous flow water heaters for drinking water (35-350 kW), flue gas losses and standby losses shall not exceed the following limit values:

$$qA = 12{,}5 - 2 \log QF$$

Where:

qA = flue gas losses in percentage of maximum heat input

log QF = logarithmic value of heat input in kW

Such installations must be equipped with an automatic ignition system.

The ordinance contains some general NO_x limit values, but these typically apply to larger installations than most water heaters.

25 UNITED STATES

25.1 Introduction

Though it is true that the dominant US heating systems are 'dry systems' (air heating) and not the EU 'wet systems', the general perception that the US heating experience is therefore not relevant for Europe is not true.

- First of all, 'wet systems' are applied in certain parts of the US and –in as much as the legislator takes this into account—this experience is directly relevant.
- Second, fossil-fuel fired boilers for 'dry systems' are not dissimilar to boilers for 'wet systems'. They both have a combustion process that can be single-stage/two-stage/step-modulating, a heat exchanger system that can be condensing or non-condensing, an air/flue system that can be fan-assisted and/or room-sealed, etc.. This means that, although the values may be different, the same or very similar principles apply.
- Thirdly, the United States is a large country stretching from Alaska to Florida, i.e. with many very different climate zones. Yet, the US have introduced federal Minimum Energy Efficiency Performance Standards (MEEPS) based on a single set of minimum efficiency (AFUE) values for the whole country, using a single test standard (ANSI/ASHRAE 103-1993) for all types of gas- and oil-fired furnaces and boilers.
- Fourthly, the US have been the first country to introduce these MEEPS, already in the 1980s. This means that it has already gone through a well-documented process of several studies, procedures, updates of standards that has led to the current state. It also means that many generations of furnaces and boilers have been tested according to this standard and a broad experience was gathered on test procedures, leading to several improvements.

25.2 Federal: Energy & CO_2 of space heating equipment

The US has had federal minimum energy efficiency standards for boilers and furnaces since the 1980s. The latest update of the Code of Federal Regulations (10 CFR Part 430) minimum standard stems from 1997. Studies are currently underway for new regulations, but the process is expected to take some time (2008?).

The minimum efficiency standards relate to the Annual Fuel Utilization Efficiency (AFUE). The U.S. Department of Energy (DOE) test procedure for determining the Annual Fuel Utilization Efficiency (AFUE) of residential central furnaces and boilers[96] references the industry test standard ANSI/ASHRAE 103-1993 (ASHRAE 103-1993) of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). The standard was initially developed in 1982 based on the DOE test procedures for single stage furnaces and boilers recommended by Kelly et al [97]. It was subsequently revised in 1988 and again in 1993 to include test procedures for condensing units, modulating (or multi-fire) units, and for units employing a short post-purge period after the burner is shut off. In 1998 ASHRAE organized the Standard Project Committee (SPC) 103R to begin the revision process to ASHRAE 103-1993 following comments from the industry on the need to address some possible

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[96] Code of Federal Regulations, 10 CFR Part 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces (May 1997)", January 1,2002.

[97] Kelly, G.E., Chi, J., Kuklewicz, M.E., "Recommended Testing and Calculation Procedures for Determining the Seasonal Performance of Residential Central Furnaces and Boilers", NBSIR 78-1543, March 1978.

shortcomings of the standard based on user experiences. The issues concerned anomalies in the outcomes of the calculating methode of the Annual Fuel Utilization Efficiency (AFUE) for single-stage vs. multi-stage burners, the calculation for the number of annual Burner Operating Hours (BOH) for a modulating furnace (or boiler) and some other minor issues (e.g for units with long post-purge times)[98]. Since 2004 the US government is involved in a public consultation process called ANOPR (Advance Notice of Proposed Rulemaking) for an update of the MEEPS, although it is questionable whether this will lead to new legislation under the current administration.[99] In any case the ANOPR has led to public reports and proposals that might relevant for any EU rule-making.

The current test procedure in ASHRAE 103-1993 is a comprehensive standard, which is very similar to the 'Boiler Cycling Method' in the new prEN 15316. One major difference is of course that the prEN 15136 —although it provides a vast range of default values— is a building code that can leave open the exact values of the variables, whereas ASHRAE 103-1993 is a product testing standard, which means that it provides fixed values for heating systems and burner loads.

For instance, it prescribes the calculation of the AFUE (on Gross Calorific Value) of a single stage furnace by using test data from the steady state, cool down and heat up tests at the rated input. In the calculation procedure, the average furnace cycling times are assumed to be 3,87 minutes on and 13,3 minutes off based on the characteristic responses of the room thermostat and a furnace oversize factor of 0,7 with respect to the building heating load. This results in the furnace operating at an average of 22,5% of the rated capacity during the heating season. The average US heating season is given as 4160 h/yr (non-heating season 4600 h/yr). For modulating boilers ASHRAE 103-1993 measures at reduced and modulating stages. With condensing boilers, the quantity of condensate is assessed.

The AFUE is widely accepted by US stakeholders as being much more realistic than the steady-state efficiency, which is the one currently used in the EU. Because the ASHRAE 103-1993 also –as one of the elements of the procedure— determines the steady-state efficiency –which is the one currently used in the EU— the difference with the AFUE is known. Anecdotal evidence suggests that the difference between AFUE and steady-state efficiency can be up to 10-12 percentage points.

As regards levels, the current US MEEPS for gas-fired residential boilers set a minimum **AFUE of 80%**.[100] For commercial models the minimum AFUE is 80% for gas-fired models and 83% for oil-fired boilers. Furthermore, the **US Energy Star levels are 85%** for non-condensing and **95% for condensing boilers**. Please note that these are values on Gross Calorific Value; translated into Net Calorific Value (NCV) as in Europe the efficiency values are 10% higher for gas-fired appliances (90 and 100% as minimum, 95 and 105% as Energy Star values). As mentioned these absolute values should be interpreted with caution because –e.g. regarding the generator envelope losses— an air heating system has some important differences with a 'wet' CH boiler. Furthermore, it might be of interest that the new proposals on lawmaking for boilers include the electricity consumption of fans, etc..

The relevant US federal legislation for heating boilers [101] is contained in:

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[98] Stanley T. Liu, Proposed Revisions of Part of the Test Procedures for Furnaces and Boilers in ASHRAE Standard 103-1993, U.S DEPARTMENT OF COMMERCE, National Institute of Standard and Technology (NIST), NISTIR 6913, Sept. 2002.

[99] I.e. not before 2008-2009 (estimate VHK on the basis of US contacts)

[100] CAafue: The Combined Appliance Annual Fuel Utilization Efficiency ("CAafue") is the effective efficiency of the combined appliance in performing the function of space heating. When the primary heating source of the combined appliance is a residential boiler, the CAafue is the same as the AFUE of the boiler as determined by DOE test procedures specified in 10 CFR 430.

[101] http://www.eia.doe.gov/oiaf/aeo/assumption/residential.html

- Energy Policy Act of 2005 (EPACT05). Providing 10% tax credits in 2006 and 2007 for Energy efficient gas, propane, or oil furnaces or boilers, energy efficient central air conditioners, air and ground source heat pumps, hot water heaters, and windows. Consumers can claim a 30 percent tax credit in 2006 and 2007 for purchases of solar PV, solar water heaters, and fuel cells, subject to a cap. Not for heaters, but for several pieces of whitegoods the EPACT05 includes production tax credits for energy efficient refrigerators, dishwashers, and clothes washers in 2006 and 2007, with dollar amounts varying by type of appliance and level of efficiency met, subject to annual caps.
- Energy Policy Act of 1992 (EPACT92). Providing a comprehensive home labeling system (incl. Boilers). Water saving showerheads were an issue, where 33% saving on shower water (10% on total) was projected.
- National Appliance Energy Conservation Act of 1987 (NAECA), which is the one responsible for the MEEPS. NAECA standards implemented in the module include: a Seasonal Energy Efficiency Rating (SEER) of 10.0 for heat pumps increasing to 13.0 in 2006; an Annual Fuel Utilization Efficiency (energy output over energy input) of 0.78 for oil and gas furnaces; an Efficiency Factor of 0.86 for electric water heaters; increasing to .90 in 2004; etc.

The Federal Energy Management Programme (FEMP), which addresses purchases by federal gencies, recommends a minimum AFUE of 90% (AFUE 97%= best available) for residential gas-furnaces, which is in all cases a condensing furnace.

25.3 Federal: Energy & CO_2 for water heaters

Since the 1980s the US has had federal minimum energy efficiency standards for water heaters, with possible relevance for combi-boilers. The latest change of the Code of Federal Regulations (10 CFR Part 430) minimum standard stems from 2001 and prescribes minimum energy factor (EF), effective as of 2004.

Studies are currently underway for new regulations, but the process is expected to take some time (2008?).

The 2004 minimum efficiency values for fossil-fuel-fired water heaters are shown in the table below:

Table 25-1. US Minimum energy efficiency standards Water Heaters effective 2004 (US DoE, 2001)

Water Heater	Minim Energy Factor, April 2004
gas-fired storage water heaters	0,67 – 0,0019 * rated volume in gallons
oil-fired storage water heaters	0,59 – 0,0019 * rated volume in gallons
tabletop storage water heater*	0,93 – 0,00132 * rated volume in gallons
gas-fired instantaneous water heaters	0,62– 0,0019 * rated volume in gallons

Note: 1 US gallon = 3,8 litres.

* = *Tabletop water heater* means a water heater in a rectangular box enclosure designed to slide into a kitchen countertop space with typical dimensions of 36 inches high, 25 inches deep and 24 inches wide.

The energy factor and test method are defined in 10 CFR Part 430, Subpart B, Appendix E of the 1998 Ruling.

Generally, the energy factor is defined as the ratio between the hot water energy output and the energy input, during a 24h test. The hot water output is the temperature difference between the cold water (14,4°C) and hot water (57,2°C) multiplied with the total 24h tapping volume of 243 litres and the specific heat of the water (1,16 Wh/K.l, resulting in 14 kWh/day). The energy input is measured during a 24-hour tapping cycle, where each hour for the first 6 hours a volume of 40,5 litres is drawn off at a flow rate of 11,4 litres/minute. After the last tapping the rest of the approx. 17-18 hours the water heater remains connected and –in case of a storage heater— the water in the tank will be kept at the prescribed temperature. Of course, there is a host of test method prescriptions and there are a number of corrections to be applied (see document [102] for details). The test sequence is similar for instantaneous and storage water heaters, but for gas-fired instantaneous water heaters the test method distinguishes between non-modulating and modulating burners. In case of the latter, the first three draw-offs are at maximum flow rate and the last three draw-offs are at minimum flow rate.

Furthermore, in case of a heat pump water heater where the storage tank is not included in the package delivered by the manufacturer, the test method prescribes –in order to be able to do the tests— a substitute tank with certain dimensions (178 litres), energy efficiency (just above the minimum standard) and heating elements (two 4,5 kW elements that cannot work simultaneously).

VHK Note

Although undoubtedly helped by the water volume of 243 litres/day and a slightly lower storage volume, the US ***minimum*** energy efficiency levels for storage water heaters come close to the ***best*** EU labelling values. For instance, a US gas-fired 30 gallon (114 litres) water heater has to meet a minimum energy efficiency level of 61,3%, whereas in the Netherlands the minimum is 62,5% to obtain the 'HRww' ('High efficiency hot water') label.

For 30 gallon (114 litres) electric storage water heater the US minimum level is 93%, which means that –even assuming 100% generation efficiency— the standby (storage) losses can be no higher than 7% of 14 kWh, which is 0,98 kWh/24h or 40 W (50 W when corrected to 65°C). Comparing this with the classification in the European prEN 15332:2006 a cylinder with such standby losses would be C-rated (on a scale A=best, G=worst). Comparing this with the minimum requirement for standing losses according to EN 89;1997 for a 10 kW gas-fired storage heater, the European minimum ($q = 11V^{2/3} + 0{,}015 * Qn = 11 * 114^{2/3} + 0{,}015 * 10000 = 407$ W) is much higher [see also Chapter on Australia].

The US legislation is oriented towards design options like near-condensing gas-fired technology (83% efficiency on GCV), heat traps, flue baffles, 3 inch insulation, etc.. Furthermore, the official government's consumer guides are promoting to step up further towards room-sealed, fan-assisted combustion technology, instantaneous ('tankless') gas-fired heaters, etc. apart from the obvious solar and heat pump water heaters.

Regarding the storage temperature the governments EERE website recommends a setting of 120°F (48°C) or lower, giving as a rule-of-thumb that each 10°F reduction in water temperature will generally save 3–5% on the total water heating costs. Other recommendations for existing storage water heaters include the installation of timers, insulation of the hot water pipes, fixing leaks, installing water-saving showerheads and aerating faucets, extra insulation jackets for the tank, drain-water heat recovery, etc. (EERE Consumer Guide 2006).

Federal agencies are required by the Energy Policy Act of 2005 (P.L. 109-58) and Federal Acquisition Regulations (FAR) Subpart 23.2 to specify and buy ENERGY STAR®-qualified products or, in categories with no ENERGY STAR label, FEMP-designated products which are among the highest 25 percent of equivalent products for energy efficiency. For gas storage water heaters smaller than 50 gallons the energy factor should be higher than 0,62.

25.4 NO_x emissions

Domestic NO_x restrictions in the USA are driven by compliance with National Ambient Air Quality Standards, which are implemented by states. Each state is divided into regions that are designated "attainment" or "non-attainment" areas. Non-attainment areas for ozone in California, the Northeast, Texas and the Midwest states have considered introducing stricter NO_x emission controls, including for domestic

[102] www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

appliances. California leads the way in appliance regulations, under requirements from the US EPA, to review the standards regularly and update them as necessary.

NO_x emissions standards are in force for central heating systems and water heaters in the South Coast Air Quality Management District (AQMD), which covers the Los Angeles area of California. The statutory rules can be downloaded from the website www.aqmd.gov. Rule 1146.2 relates to boilers and water heaters of Type 1 (< 400 000 Btu/h $\leq$ ca. 120 kW) and Type 2 (400 000 to 2 million Btu/h = ca. 120 – 600 kW). For Type 1 the NO_x limit value is 40 ng/J or 55 ppm (@ 3% O_2). For Type 2 the NO_x limit is 30 ppm (@ 3% O_2). For Type 1 the CO limit is 400 ppm. By 1 Jan. 2006 all Type 2 units older than 15 years can no longer be in use, i.e. they have to be replaced by boilers, water heaters or process heaters that comply with the limit values.

By 2010 the NO_x limit will be reduced to 20 ppm for type 2 units. By 2012 the NO_x limit will be reduced to **20 ppm** (14 ng/J) also for type 1 units.

For the largest heating boilers several California districts have legislation in place that will prescribe emission limit values of **9 ppm** NO_x.

Another rule, Rule 1121, "Control of Nitrogen Oxides from Residential Type, Natural Gas-Fired Water Heaters", was adopted on December 1, 1978, and subsequently amended on March 10, 1995, December 10, 1999, and September 3, 2004. This rule is relevant for combi-boilers. The current version prescribes a staged reduction of NO_x emissions for the water heaters: Until 2002 the limit was 55 ppm**,** between 2002 and 2005 the limit value was 30 ppm and

> *On or after January 1, 2006, for water heaters less than or equal to 50 gallon capacity, excluding direct-vent, power-vent and power direct-vent water heaters; on or after January 1, 2007 for water heaters greater than 50 gallon capacity, excluding direct-vent, power-vent and power direct-vent water heaters* [103]*; and on and after January 1, 2008 for all direct-vent, powervent, and power direct-vent water heaters; no person shall manufacture for sale, distribute, sell, offer for sale, or install within the South Coast Air Quality Management District any gas-fired water heaters unless the water heater is certified pursuant to subdivision (d) to a* NO_x *emission level of less than or equal to:*
>
> *(A) 10 nanograms of* NO_x *(calculated as* NO_2*) per joule of heat output (23 lb per billion Btu of heat output); or*
>
> *(B)* ***15 ppm****v at 3%* O_2*, dry (17,5 lb per billion Btu of heat input).*

Furthermore, under the provisions of this rule, emission mitigation fees are collected from water heater manufacturers to fund stationary and mobile source emission reduction projects targeted at offsetting NO_x emissions from water heaters that do not currently meet Rule 1121 emission standards. Mitigation fees are being collected until January 1, 2008, after which, the water heater manufacturers are required to meet more stringent NO_x emission standards per Rule 1121.[104] In the San Francisco area (Bay Area Air Quality Management District) the same standards for furnaces (Regulation 9 Rule 4) and water heaters (Regulation 9, Rule 6) apply and can be downloaded from the website www.baaqmd.gov. 40 ng (NO_x)/J (output) limits for water heaters also apply in the California districts of Sacramento, Ventura, San Joaquin Valley, San Diego, etc..

[103] 'Power-vent' in Europe is referred to as fan-assisted. 'Direct-vent' in Europe is referred to as 'room-sealed', i.e. that the appliance takes the combustion air from outside the building and —of course— exhausts outside the building.

[104] As of April 30, 2005, the AQMD has available $ 1 227 743 from emission mitigation fees collected under Rule 1121.

26 CANADA

Canada has a mandatory MEPS for self-contained gas-fired boilers that use propane or natural gas and are intended for use in low-pressure steam or hot water central heating system, and have an input rate of less than 88 kilowatts (300 000 Btu/h). This MEP is effective of 31 December 1998 and for hot water systems (boilers) the allowable minimum Annual Fuel Utilization Efficiency (AFUE) is **80% on Gross Calorific Value**. The AFUE is based on the test standard CAN/CGA P.2-1991 *Testing Method for Measuring Annual Fuel Utilization Efficiencies of Residential Furnaces and Boilers*, which is similar to the ASHRAE 103-1993. The purpose of this document is to provide a method of measuring annual fuel utilization efficiencies of central furnaces and boilers with natural gas, propane, fuel oil or electric input intended for use in residential applications. It includes:

- A test method for cyclic and part load performance,
- methods for interpolating and extrapolating test data,
- calculation procedures for establishing seasonal performance.

Regarding MEPS for water heaters, an amendment to the Energy Efficiency Regulations was approved in late August and registered on September 1, 2004.[105] This amendment entails a change in the test procedure, whereby Canada now also –as in the US—tests on the basis of a tapping pattern for fossil-fuel fired water heaters, with relevance for combi-boilers. This regulation applies to natural gas and propane gas storage-type water heaters having an input of 75 000 Btu/h (21,98 kW) or less and a storage capacity of 20 to 100 US gal. (76 to 380 litres) and to oil-fired storage tank water heaters with an input rating of 107 000 kJ/h or 30,5 kW or less and manufacturer's specified storage capacity of 190 litres (50 U.S. gal.) or less.

Table 26-1. Canada MEPS 2004: Maximum Standby Loss or Minimum Energy Factor (EF)

Oil-fired storage water heaters	EF greater than or equal to: 0,59 - 0,0005 V
Gas-fired storage water heaters	EF greater than or equal to: 0,67 - 0,0005 V

V = rated storage capacity in litres.
* supply pipe external to tank and connection near the bottom.
Energy Factor (EF) and standby loss are defined in the CSA test procedures.

The test standard for gas equipment is CAN/CSA-P.3-04, “Testing Method for Measuring Energy Consumption and Determining Efficiencies of Gas-Fired Storage Water Heaters”.

For oil-fired water heaters, the test standard is CAN/CSA-B211-00, “Energy Efficiency of Oil-Fired Storage Tank Water Heaters”.

As in the US, Canada uses the Energy Star and the EnerGuide label. Instead of the US Green Seal label there is the EcoLogo (Environmental Choice Program, EPC) endorsement label. For details see www.clasponline.org or www.apec-esis.org.

[105] The amendment has been published in the Canada Gazette Part II: http://canadagazette.gc.ca/partII/2004/20040922/html/sor191-e.html

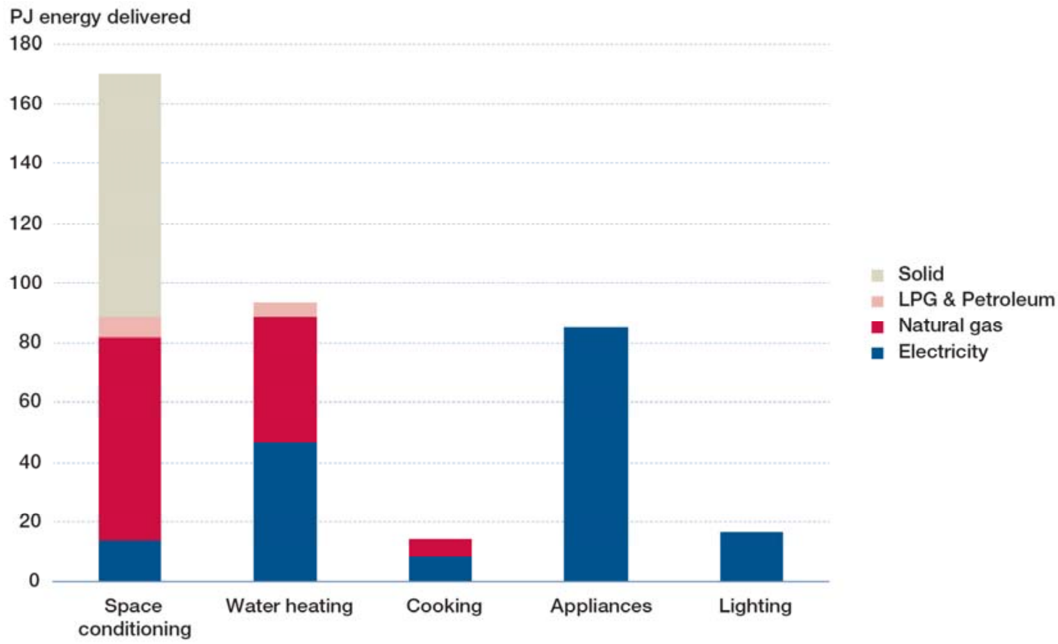
27 AUSTRALIA

27.1 Introduction

The aim of the Australian energy policy in the field of appliance energy efficiency is to adopt the world's best practice. As a consequence the Australian government, as well as certain districts (Victoria), regularly perform technical studies of the global state of the art in minimum standards and labeling that are a valuable information resource.

Similar to the US Australia uses pre-dominantly dedicated gas-fired and electric water heaters. Combi-boilers are rare. Space heating equipment uses >50% solid fuels (biomass) and 35-40% gas. Most water heating is electric; gas water heaters are 47% of the stock (28% storage, 19% instantaneous). The graph below shows the fuel use in PJ for space heaters, water heaters and other appliances. In terms of energy use (in PJ) space heating ranks first (see graph below). But –because the biomass usage is counted as CO_2-neutral— water heaters rank first in terms of CO_2-emissions.

Figure 27-1
Australia, residential sector 1999 — energy use by end-use and energy type [GWA et al, 2002]



For gas appliances the management of minimum energy efficiency standards and labels is in the hands of AGA (Audtralian Gas Association). Minimum NO_x emission limits were found only for unflued domestic gas appliances (largely forbidden in the EU) and will therefore not be further discussed.[106]

27.2 Preparatory study MEPS for packaged boilers

Domestic boilers in Australia are generally the low temperature hot water type, being almost exclusively used in central space heating applications. There is an annual market

[106] *Bob Joynt and Stephen Wu,Nitrogen oxides emissions standards for domestic gas appliances - background study, for Australia Dept. of Env. And Heritage (DEH), February 2000, www.deh.gov.au/atmosphere/airquality/publications/residential/index.html*

of about 6 000 units and the total stock is estimated at 90 000 units (market penetration 1,2%).

Nevertheless, in 2001 the National Appliance and Equipment Energy Efficiency Program prepared an analysis of the potential for Minimum Energy Performance Standards (MEPS) for Packaged Boilers. [107]

Emissions have been estimated using the following assumptions:

- that most domestic boilers are used in the cooler climate areas to provide hydronic heating;
- they operate for 8 hours per day for 3 months of the year.
- average boiler capacity in the domestic sector is 18kW, average boiler efficiency is 80%.

Total gas consumption is estimated at 5,3 PJ (1500 GWh/a). Estimated annual emissions are 270 kt CO_2-e, or 1.8% of emissions from all water heating tasks in the domestic sector.

Recommendations were that ultimately, applying a MEPS to boilers to increase the boiler's efficiency to this maximum practical level would mean enforcing condensing flue boilers. Furthermore, the low level of potential greenhouse saving, together with the economic impact derived from the relatively low heating requirements in Australia, does not justify initiating a specific MEPS for boilers.

In the rest of this Chapter we will describe measures for water heaters, which may be relevant from the methodology point of view for combi-boilers.

27.3 MEPS for gas-fired water heaters

The current MEPS level and test method for gas water heaters are contained in AS4552-2000 (AG102-2000). This standard requires a **minimum thermal efficiency of 70%** for both storage and instantaneous water heaters, and a volumedependent maximum **maintenance rate** defined by the following formula:

$$M = 0{,}42 + 0{,}2V^{2/3} + 0{,}006R$$

where:

M = Maintenance rate in MJ/h

V = Nominal capacity in litres

R = Nominal gas consumption in MJ/h

The standard (and the labeling) are currently under review[108]. A 2003 discussion paper by the Sustainable Energy Authority Victoria [109]proposes a MEPS level that –as the US MEPS—no longer lists combustion efficiency and standing energy as separate items, but uses an integrated Annual Energy Consumption (AEC in MJ/year) MEPS for gas water heaters would be specified in terms of the minimum overall efficiency to deliver a specified task (e.g. 37,7 MJ/day of hot water) as a function of tank size.

For gas storage water heaters of 50 litres or more a proposal is mentioned of

AEC ≤ 21 100 + 20,7 * volume (litres).

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[107] Prepared for the Australian Greenhouse Office by Mark Ellis & Associates, Final Report March 1st, 2001.

[108] See e.g. ENERGY LABELLING & MINIMUM ENERGY PERFORMANCE STANDARDS FOR DOMESTIC GAS APPLIANCES

Produced for the SUSTAINABLE ENERGY AUTHORITY VICTORIA, by Mark Ellis & Associates, Energy Efficient Strategies, George Wilkenfeld & Associates, November 2002

[109] Sustainable Energy Authority Victoria, Driving Energy Efficiency Improvements to Domestic Gas Appliances, Discussion Paper July 2003

For instantaneous gas water heaters the electricity consumption needs to be taken into account and the proposal is AEC ≤ 22 135 MJ/year.

In order to enable in-use energy consumption to be estimated for a range of hot water delivery tasks and climates, it is also recommended that the key performance parameters—thermal efficiency, maintenance rate, pilot rate, electrical energy consumption, etc.— of registered models should be generally available, for example on a related web site. Note that the individual parameters might not be publicly accessible, but might be used to allow estimation of annual energy consumption and running costs for a range of different hot water requirements. This would reportedly be a significant benefit to consumers when evaluating water heater models.

Details on the status of these proposals, which reportedly were planned to take effect in 2007, were not found.

27.4 Labelling

AS4552/AG102 also provides the methodology for the mandatory labelling of gas water heaters[110]. The star rating is based on comparison with the annual gas consumption of a reference water heater with a storage volume of 140 litres and a burner rating of 30MJ/h. The star rating scale is based on 7% intervals, such that units consuming between 100% and 93% of the energy of the reference get one star, those consuming between 86% and 93% get two stars and so on. The energy rating label for gas water heaters includes both a star rating to allow comparisons of energy efficiency and an Annual Energy Consumption (in MJ/year) which gives an estimate of the annual gas consumption based on a hot water usage of 200 Litres/day (raised by 45°C above cold water temperature). In 2003 there were very few one star water heater models, and over 60% of the certified water heater models are rated four stars or more.

Figure 27-2. Australia mandatory star rating label (left) and TESAW label for electric (mid) and gas appliances (right) [www.energyrating.gov.au]

The Top Energy Saver Award Winner (TESAW) program is new for 2004 and has replaced the Galaxy Energy Awards. Appliances are granted the award if they achieve the efficiency benchmark set by the government (usually the top 5-10% of models on the market). The TESAW label is an endorsement label - it is complementary to the normal Australian star rating label. This enables consumers to instantly recognize the most efficient models on the market. All appliances that carry a comparative energy rating label (gas and electric) are eligible.

[110] A similar scheme exists also for electric water heaters

Each year, government officials review the energy efficiency of all products on the market. In consultation with industry, they set minimum energy efficiency criteria (usually a minimum star rating) for TESAW awards for the coming year. From the start of the award period (November), manufacturers of existing products or new products that meet the minimum energy efficiency criteria are eligible to apply. Once an award is granted, the manufacturer is eligible to display the TESAW label on the award winning product in retail stores and on promotional material pertaining to the product.

The 2006 levels for standby losses of electric storage water heaters are e.g. around 1 kWh/day for 50 litre tanks and 1,3 kWh/day for 80 litre tanks[111]. All gas water heaters with 5 or 6 stars receive the TESAW label in 2006.

[111] see for more details www.energyrating.gov.au/tesaw-criteria.html

28 JAPAN

28.1 Introduction

In Japan, the most of the large-size water heaters are installed outside of houses. Outside installation requires the noise from water heaters to be reduced, especially in residential neighborhoods. In addition, NO_x emission from the water heaters must be reduced to prevent air pollution[112]. Although no statistics were found, anecdotal evidence suggests that gas-fired instantaneous water heaters of considerable capacity (34-52 kW) are the dominant type[113]. The market share of fan-assisted burners (with burners modulating back to 20% of capacity) is significant. The gas may be City gas or LPG. Unlike in most other countries, in Japan there also seems to exist a significant market for dedicated oil-fired water heaters.

28.2 Energy

The following evaluation criteria for manufacturers regarding improvement of the performance of "Designated Machineries" pursuant to the provision in Paragraph 1 of Article 18 of the Law Concerning the Rational Use of Energy (Law No.49 of 1979) are defined for water heaters:

- Gas Water Heaters (Notification No.434 of METI, December 27, 2002)
- Oil Water Heaters (Notification No.435 of METI, December 27, 2002)
- The requirements are also used in the TopRunner program.

28.2.1 Residential Gas Water Heaters

The energy performance criteria apply to water heaters and water heaters combined with special bath tub gas water heaters and space heaters. For hot water supply sections and bath tub gas water heaters, the energy efficiency is the heat efficiency (%) measured as specified by JIS S2109.

For heating sections, energy consumption efficiency is heat efficiency (%) value obtained when the value of the temperature difference of circulating warm water becomes the specified level.

For bath tub gas water heaters (with hot water supply functions), the energy efficiency is the weighted average value obtained by a 1:3,3 ratio (1 for bath section heat efficiency, 3,3 for hot water supply section heat efficiency). For gas heaters (with hot water supply functions), energy consumption efficiency is the weighted average value obtained by a 1:3 ratio (1 for heating section heat efficiency, 3 for hot water supply section heat efficiency).

[112] Tokyo Gas and Gastar Co., Ltd. have jointly developed a low noise (<45 dBA) and low NO_x (<50 ppm) burner with a maximum input of 52 kW that reportedly meets these requirements. (www.tokyo-gas.co.jp/techno/stp/e_txt/14e.htm)

[113] E.g. see product range of Japanes manufacturers, e.g. Chofu (www.chofu.co.jp/english/gas.htm)

Table 28-1. Japan minimum energy efficiency targets for Gas-fired Water Heaters (ECCJ, 2006)

Gas water heater type	ventilation / circulation	exhaust	Category	Target (%)
Gas instant water heaters	natural vent.	Unvented type	A	83,5
		Vented type	B	78,0
	forced vent.	Indoor type	C	80,0
		Outdoor type	D	82,0
Bath tub gas water heaters (without hot water supply functions)	natural vent./ natural circulation	Vented type or direct vent type (the height where the air supply and exhaust part penetrates external wall is as high as vented types)	E	75,5
		Direct vent type (other than types of the height where the air supply and exhaust part penetrates external wall is as high as vented types)	F	71,0
		Outdoor type	G	76,4
	forced vent./ natural circulation		H	70,8
	forced vent./ forced circulation		I	77,0
Bath tub gas water heaters (with hot water supply functions)	natural vent./ natural circulation	Vented type or direct vent type (the height where the air supply and exhaust part penetrates external wall is as high as vented types)	J	78,0
		Direct vent type (other than types of the height where the air supply and exhaust part penetrates external wall is as high as vented types)	K	77,0
		Outdoor type	L	78,9
	forced vent./ natural circulation		M	76,1
	forced vent./ forced circulation	Indoor type	N	78,8
		Outdoor type	O	80,4
Gas heaters (without hot water supply functions)			P	83,4
Gas heaters (with hot water supply functions)			Q	83,0

For gas instant water heaters and bath tub gas water heaters these target levels reportedly are approx. a 4,1% improvement in efficiency compared to 2000 levels by 2006. For gas heaters the improvement is 3,3% (without hot water supply) and 1,1% (with hot water supply) compared to 2002 levels by 2008.

No translation of JIS S2109 was found, but the method was cited on a scientific publication[114] showing that the efficiency is on the Gross Calorific Value (Higher Heating Value) of the fuel.

Many of the appliances in the table are combi-appliances, used for space heating, hot water and the Japanese concept of bath tub heating. As a reference value for space heating only, the 'gas heaters without hot water supply function' with a limit of 83,4% on Gross Calorific Value can be taken (93% on Net Calorific Value). These are near-condensing types.

28.2.2 Residential oil-fired water heaters

The energy efficiency of residential oil-fired water heaters is the heat efficiency (%) measured as specified by JIS S3031 (no translation available). The table below gives the target values for 2006.

Table 28-2. Japan minimum energy efficiency targets for Oil-fired Water Heaters (ECCJ, 2006)

[114] Kyudae HWANG et al., THERMAL EFFICIENCY ENHANCEMENT ON GAS-FIRED WATER HEATER USING TITANIUM HEAT EXCHANGER FOR LATENT HEAT RECOVERY, Waseda University, Tokyo, Japan.

Purpose	Heating type	Air supply and exhaust type or control method	Category	Target (%)
For hot water supply	Instantaneous		A	86,0
	Storage type with rapid heating system		B	87,0
	Storage type other than rapid heating		C	85,0
For space heating	Instantaneous	Unvented type	D	85,3
		Vented type	E	79,4
		Direct vent type	F	82,1
	Storage type with rapid heating	On/off control type	G	87,0
		Other control type	H	82,0
	Storage type other than rapid heating		I	84,0
For bath water heating	Water heaters with center flue heat exchanger		J	75,0
	Water heaters without center flue heat exchanger		K	61,0

Rapid heating system refers to equipment of which heating time (as measured by the heating speed measurement method described in JIS S3031) is within 200 seconds.

The targets reportedly constitute approximately a 3,5% improvement in efficiency compared to 2000 levels by 2006.

Many of the appliances in the table can be combi-appliances, also used for space heating, hot water and the Japanese concept of bath tub heating. The reference values for space heating seem to be used not so much to promote the best practice in each type, but rather to discourage certain types, e.g. such as oil-fired on/off controlled heaters with 'rapid heating' and 'unvented instantaneous' types where limits of 85-87% on Gross Calorific Value (91-93% on Net calorific value) are found. For oil-fired heating appliances these are challenging values and as far as MEPS are concerned, currently the highest in the world.

In Japan, the latest trend in energy efficiency is LHR (Latent Heat Recovery) where utilities (and government) expect a major contribution to 'Kyoto' from the push for condensing instantaneous water heaters and combi-boilers (>95% efficiency on GCV). Utilities have set a sales target of 3,5 million condensing units in Japan 2010.

28.3 NO_x

Current Japanese minimum NO_x emission levels for flued larger residential water heaters and boilers are reported to be 60 ppm @ 0% O_2 (Report of the Commission on Countermeasures for Small Sources of NO_x Emissions, Environment Agency [115]). The water heater target does not apply to LPG appliances.

Unflued appliances still seem to exist in Japan; for those a limit of 10 ppm NO_2 @ 0% O_2 applies. Emission limit values for other pollutants were not found.

[115] www.gas.or.jp/e_kankyo/3_1.html

29 CHINA

Indications of the development of Chinese mandatory policy measures for space heating appliances were not found. However, and this is relevant for combi-boilers and indicative for the ambtion level of the Chines government, currently policy measures (MEPS) are under development for gas water heaters in China.[116]

There are three types of domestic water heaters in China: gas water heaters, electric water heaters, and solar water heaters. The most popular type is the gas water heater (57,4%), followed by electric water heater (31,3%), and solar water heaters (11,3%).[117] Among gas water heaters, the instantaneous type is the dominant type with 94% market share. According to a recent CNIS report, the current stock of gas water heaters is estimated to be around 62 million units. Future sales are estimated to be 10 million units in 2006, and would rise by 2 million unit every five years until 2020 (Fu, 2005). Using the same increment, total sales of gas water heaters is projected to reach 20 million by 2030. Testing at the National Test Laboratory for Gas Appliances in Tianjin indicates that the average efficiency of gas water heaters is about 86,9%[118]. To assess the impact of raising energy efficiency of water heaters through standards, it is assumed that the minimum standards for gas water heaters will be raised to 88% by 2008 and 96% by 2015.[119]

Current baseline usage is estimated to be 182 m³ of natural gas per unit in north China and 146 m³ natural gas per unit in south China, with an average usage of 161 m³ per water heater per year.[120] Chinese households use hot water heaters mostly for taking showers, which might partially explain the relatively low energy costs compared to e.g. EU and US.

Table 29-1. Annual energy use of water heaters in China (Jiang Lin, 2006)

	Average Efficiency	UEC (m³/year)
Baseline	86,4%	161
MEPS at 88%	88,7%	157
MEPS at 96%	96,0%	145

For electric storage water heaters there is a voluntary label issued by the China Certification Centre for Energy Conservation Product (CECP)[121] based on the IEC 60379 test standard. A certification programme for solar water heaters is under consideration, based on the standard GB/T 12915-1991 Test methods to determine the thermal performance of domestic solar water heaters. The typical solar water heater is of the ICS-type (Integrated Collector Storage) with vacuum tubes collector. Consumer prices for all types of water heaters (incl. solar) are around $ 100,-/unit.[122]

[116] Source: Jiang Lin, *Mitigating Carbon Emissions: the Potential of Improving Efficiency of Household Appliances in China*, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratories, July 2006

[117] CNIS (China National Institute of Standardization), unplublished report, cited by Jiang Lin.

[118] Testing report on the energy efficiency of instantaneous gas water heaters, National Quality Supervision and Testing Center for Gas Appliances, 2005

[119] Jiang Lin, ibid

[120] Fu Z., 2005, research note on gas water heaters. In Jiang Lin, ibid

[121] The CECP was established by the State Economic and Trade Comission (SETC) and the China State Bureau of Quality and Techical Supervision (CSBTS) in 1998. (www.clasponline.org)

[122] Jiang Lin, ibid.

30 OTHER COUNTRIES

This chapter lists the minimum standards and labeling activities in the field of water heaters in other countries without going into detail. More information at www.clasponline.org, www.apec-esis.org and others.

30.1 South-Korea

South-Korea has MEPS for gas boilers up to 69,5 kW in place since 2001. The minimum energy efficiency level effective as of 1 Jan. 2003 is set at **72%**. A voluntary target exists of 80,6%. The applicable test standards are KS B 8101, KS B 8127 and KS B 8109. The implementing agency is the Korea Institute of Energy Research. Furthermore, Korea has a mandatory labelling programme with 5 grades of energy efficiency with 72% being the lowest and 80,6% being the highest class.

More information also at Korea Energy Management Corporation

http://www.kemco.or.kr/english/index.html or

http://www.kier.re.kr/indexe.htm

30.2 Taiwan

Chinese Taipei (Taiwan) has Efficiency Standard is applicable to steam boilers with oil or gas firing, but **not** for flow-through boilers. Energy Efficiencies are calculated with Heat Loss Method by low heating value (NGV), which are regulated by CNS 2141. Values vary between 89 and 93,5%. The boiler is under full load and waste heat recovery systems should be included if present. More information: www.moeaec.gov.tw or www.clasponline.org.

30.3 Mexico

Reportedly, Mexico has minimum energy efficiency standards for packaged boilers introduced in 1996. The relevant test standard is NOM-002-ENER-1995. Mexico is working with Canada and the US on a program to harmonise energy labels and standards More information at www.conae.gob.mx - Comision Nacional de Ahorro de Energía (CONAE - National Energy Savings Commission) (Spanish).

ANNEX A

Tapping Patterns (relevant for Combi-boilers)

PrEN 50440

EN 13203-2

Table A1. Flow rates prEN 50440 and EN 13203-3

prEN 50440 flow rates	
Flow rate for rated storage capacity less than 10 litres	2 l./min
Flow rate for rated storage capacity less than 10 litres	5 l./min

EN 13203-2 flow rates corresponding to a temperature rise of 45K

Type of tapping	l/min
Household cleaning [4, 6]	3
Small [4, 5]	3
Floor cleaning [1, 2]	3
Dish washing [1, 3]	4
Large (cycle no. 1) [4, 6]	4
Shower [7]	6
Bath [1, 2]	10
Shower + bath	16

1 = "basin" type of tapping. With the aim to arrive at an average temperature of the tub, so all supplied energy can be considered useful (from dT=0K)

2 = desired basin temperature at dT= 30 K (T= 40°C)

3 = desired basin temperature at dT= 45 K (T= 55°C) and dT=50 K (T=60°C) in cycle no. 1 of prEN 50440

4 = "continuous flow" type of tapping, not a shower. Start counting useful energy above a level of (desired temperature minus 15 K)

5 = desired flow temperature at dT= 30 K —> start counting at dT=15 K (T=25°C)

6 = desired flow temperature at dT = 45 K —> start counting at dT= 30 K (T=40°C)

7 = "continuous flow" shower, desired flow temperature at dT= 30K, start counting useful energy at dT=30 (T=40°C)

Table A2. prEN 50440 Daily tapping patterns I – 36 litres at 60°C								
Tapping pattern No. —>		1	1a	1b	1c			
Nr.	Time of the day [hh:mm]	Energy [kWh] initial pattern	Energy [kWh] simplified pattern (storage WH only)	Energy [kWh] Initial pattern with showers and dishwashing	Energy [kWh] Initial pattern without showers and dishwashing	Type of tapping	dT desired [K] to be achieved during tapping	Minimal T [°C] for start of counting useful energy
1 - To	07:00	0,105		0,105	0,105	small		25
2	07:30	0,105	0,525	0,105	0,105	small		25
3	08:30	0,105		0,105	0,105	small		25
4	09:30	0,105		0,105	0,105	small		25
5	11:30	0,105		0,105	0,105	small		25
6	11:45	0,105		0,105	0,105	small		25
	12:00			0,105	0,105	small		25
	12:30			0,105	0,105	small		25
	12:45			0,105	0,105	small		25
7	12:45	0,315	0,525	0,21		dishwashing	50	0
8	18:00	0,105		0,105	0,105	small		25
9	18:15	0,105		0,105	0,105	clean		45
	18:30				0,105	clean		25
	19:00				0,105	clean		25
	19:30			0,105	0,105	clean		25
	20:00			0,105	0,105	clean		25
10	20:30	0,42	1,05	0,21		dishwashing	50	0
	20:45				0,105	clean		25
	21:00				0,105	clean		25
	21:15				0,105	clean		25
				0,315		small shower		40
11	21:30	0,525				large		45
	21:30				0,105	small		25
	21:45				0,105	small		25
Total [kWh]		2,1		2,1	2,1			
				equivalent hot water		36 litres at 60°C		

Table A3. prEN 50440 Daily tapping pattern II - 100,2 litres at 60°C

Tapping pattern No. —>		**2**	**2a**			
Nr.	**Time of the day [hh:mm]**	**Energy [kWh] initial pattern**	**Energy [kWh] simplified pattern (storage WH only)**	**Type of tapping**	**dT desired [K] to be achieved during tapping**	**Minimal T [°C] for start of counting useful energy**
1- To	07:00	0,105		small		25
2	07:15	1,400		shower		40
	07:15		2,240	morning demand		25
3	07:30	0,105		Small		25
4	08:01	0,105		Small		25
5	08:15	0,105		Small		25
6	08:30	0,105		Small		25
7	08:45	0,105		Small		25
8	09:00	0,105		Small		25
9	09:30	0,105		Small		25
10	10:30	0,105		Floor	30	10
11	11:30	0,105		Small		25
12	11:45	0,105		Small		25
	12:00		0,945	noon demand		25
13	12:45	0,315		dishwashing	45	10
14	14:30	0,105		Small		25
15	15:30	0,105		Small		25
16	16:30	0,105		Small		25
17	18:00	0,105		Small		25
18	18:15	0,105		Clean		40
19	18:30	0,105		Clean		40
20	19:00	0,105		Small		25
	20:15		2,660	evening demand		25
21	20:30	0,735		dishwashing	45	10
22	21:15	0,105		Small		25
23	21:30	1,400		shower		40
Total [kWh]		5,845	5,845			
		equivalent hot water		100,2 litres at 60ºC		

Table A4. prEN 50440 Daily tapping pattern III - 200 litres at 60°C

Tapping pattern No. —>		3	3a			
Nr.	**Time of the day [hh:mm]**	**Energy [kWh] initial pattern**	**Energy [kWh] simplified pattern (storage WH only)**	**Type of tapping**	**dT desired [K] to be achieved during tapping**	**Minimal T [°C] for start of counting useful energy**
1 – To	07:00	0,105		small		25
2	07:05	1,400		shower		40
	07:30		5,845	morning demand		25
3	07:30	0,105		small		25
4	07:45	0,105		small		25
5	08:05	3,605		bath	30	10
6	08:25	0,105		small		25
7	08:30	0,105		small		25
8	08:45	0,105		small		25
9	09:00	0,105		small		25
10	09:30	0,105		small		25
11	10:30	0,105		floor	30	10
12	11:30	0,105		small		25
13	11:45	0,105		small		25
	12:30		0,840	noon demand		25
14	12:45	0,315		dishwashing	45	10
15	14:30	0,105		small		25
16	15:30	0,105		small		25
17	16:30	0,105		small		25
18	18:00	0,105		small		25
19	18:15	0,105		clean		40
20	18:30	0,105		clean		40
21	19:00	0,105		small		25
	20:00		4,970	evening demand		25
22	20:30	0,735		dishwashing	45	10
23	21:00	3,605		bath	30	10
24	21:30	0,105		small		25
Total [kWh]		11,655	11,655			
			equivalent hot water	199,8 litres at 60ºC		

Table A5. EN 13203 Daily tapping pattern No. 1

Tapping pattern No. —>		**1**			
Nr.	**Time of the day [hh:mm]**	**Energy [kWh] initial pattern**	**Type of tapping**	**dT desired [K] to be achieved during tapping**	**Minimal dT [K] =start of counting useful energy**
1 - To	07:00	0,105	small		15
2	07:30	0,105	small		15
3	08:30	0,105	small		15
4	09:30	0,105	small		15
5	11:30	0,105	small		15
6	11:45	0,105	small		15
7	12:45	0,315	dishwashing	45	0
8	18:00	0,105	small		15
9	18:15	0,105	clean		30
10	20:30	0,42	dishwashing	45	0
11	21:30	0,525	large		30
Total [kWh]		2,1			
	equivalent hot water		36 litres at 60°C		

Table A6. EN 13203-2 Daily tapping pattern No. 2

Tapping pattern No. —>		2			
Nr.	**Time of the day [hh:mm]**	**Energy [kWh] initial pattern**	**Type of tapping**	**dT desired [K] to be achieved during tapping**	**Min. dT [°C] = start of counting useful energy**
1- To	07:00	0,105	small		15
2	07:15	1,400	shower		30
3	07:30	0,105	Small		15
4	08:01	0,105	Small		15
5	08:15	0,105	Small		15
6	08:30	0,105	Small		15
7	08:45	0,105	Small		15
8	09:00	0,105	Small		15
9	09:30	0,105	Small		15
10	10:30	0,105	Floor	30	0
11	11:30	0,105	Small		15
12	11:45	0,105	Small		15
13	12:45	0,315	dishwashing	45	0
14	14:30	0,105	Small		15
15	15:30	0,105	Small		15
16	16:30	0,105	Small		15
17	18:00	0,105	Small		15
18	18:15	0,105	Clean		30
19	18:30	0,105	Clean		30
20	19:00	0,105	Small		15
21	20:30	0,735	dishwashing	45	0
22	21:15	0,105	Small		15
23	21:30	1,400	shower		30
Total [kWh]		5,845			
		equivalent hot water	100,2 litres at 60ºC		

Table A7. EN 13203-2 Daily tapping pattern No. 3

Tapping pattern No. —>		3			
Nr.	**Time of the day [hh:mm]**	**Energy [kWh] initial pattern**	**Type of tapping**	**dT desired [K] to be achieved during tapping**	**Min. dT [°C] = start of counting useful energy**
1 – To	07:00	0,105	small		15
2	07:05	1,400	shower		30
3	07:30	0,105	small		15
4	07:45	0,105	small		15
5	08:05	3,605	bath	30	0
6	08:25	0,105	small		15
7	08:30	0,105	small		15
8	08:45	0,105	small		15
9	09:00	0,105	small		15
10	09:30	0,105	small		15
11	10:30	0,105	floor	30	0
12	11:30	0,105	small		15
13	11:45	0,105	small		15
14	12:45	0,315	dishwashing	45	0
15	14:30	0,105	small		15
16	15:30	0,105	small		15
17	16:30	0,105	small		15
18	18:00	0,105	small		15
19	18:15	0,105	clean		30
20	18:30	0,105	clean		30
21	19:00	0,105	small		15
22	20:30	0,735	dishwashing	45	0
23	21:00	3,605	bath	30	0
24	21:30	0,105	small		15
Total [kWh]		11,655			
		equivalent hot water	199,8 litres at 60ºC		

Table A8. EN 13203-2 Daily tapping pattern no. 4

Tapping pattern No. —>		**4**			
Nr.	**Time of the day [hh:mm]**	**Energy [kWh] initial pattern**	**Type of tapping**	**dT desired [K] to be achieved during tapping**	**Min. dT [°C] = start of counting useful energy**
1 – To	07:00	0,105	small		15
2	07:15	1,820	shower		30
3	07:26	0,105	small		15
4	07:45	4,420	bath	30	0
5	08:01	0,105	small		15
6	08:15	0,105	small		15
7	08:30	0,105	small		15
8	08:45	0,105	small		15
9	09:00	0,105	small		15
10	09:30	0,105	small		15
11	10:00	0,105	small		15
12	10:30	0,105	floor	30	0
13	11:00	0,105	small		15
14	11:30	0,105	small		15
15	11:45	0,105	small		15
16	12:45	0,735	dishwashing	45	0
17	14:30	0,105	small		15
18	15:00	0,105	small		15
19	15:30	0,105	small		15
20	16:00	0,105	small		15
21	16:30	0,105	small		15
22	17:00	0,105	small		15
23	18:00	0,105	small		15
24	18:15	0,105	clean		30
25	18:30	0,105	clean		30
26	19:00	0,105	small		15
27	20:30	0,735	dishwashing	45	0
28	20:46	4,420	bath	30	0
29	21:15	0,105	small		15
30	21:30	4,420	bath	30	0
Total [kWh]		19,070			
		equivalent hot water	325 litres at 60ºC		

Table A9. EN 13203-2 Daily tapping pattern no. 5

Tapping pattern No. —>		**5**			
Nr.	**Time of the day [hh:mm]**	**Energy [kWh] initial pattern**	**Type of tapping**	**dT desired [K] to be achieved during tapping**	**Min. dT [°C] = start of counting useful energy**
1 – To	07:00	0,105	small		15
2	07:15	1,820	shower		30
3	07:26	0,105	small		15
4	07:45	6,240	shower+bath	30	0
5	08:01	0,105	small		15
6	08:15	0,105	small		15
7	08:30	0,105	small		15
8	08:45	0,105	small		15
9	09:00	0,105	small		15
10	09:30	0,105	small		15
11	10:00	0,105	small		15
12	10:30	0,105	floor	30	0
13	11:00	0,105	small		15
14	11:30	0,105	small		15
15	11:45	0,105	small		15
16	12:45	0,735	dishwashing	45	0
17	14:30	0,105	small		15
18	15:00	0,105	small		15
19	15:30	0,105	small		15
20	16:00	0,105	small		15
21	16:30	0,105	small		15
22	17:00	0,105	small		15
23	18:00	0,105	small		15
24	18:15	0,105	clean		30
25	18:30	0,105	clean		30
26	19:00	0,105	small		15
27	20:30	0,735	dishwashing	45	0
28	20:46	6,240	shower+bath	30	0
29	21:15	0,105	small		15
30	21:30	6,240	shower+bath	30	0
Total [kWh]		24,530			
		equivalent hot water	420 litres at 60ºC		

ANNEX B

Legislation and Incentives

In Member States:

Overview and Links

by

BRG Consult

June 2006

ANNEX C

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