Preparatory Study on

Eco-design of Water Heaters

Task 1 Report (FINAL)

Definition, Test Standards, Current Legislation & Measures

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SUMMARY & CONCLUSIONS

This is the draft Task 1 report dealing with legislation, standards and voluntary measures regarding water heaters. 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. Also it could be relevant for labelling under the 92/75/EC directive. 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 water heaters 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 have recently become available for evaluating primary energy use and CO_2 emissions of the main types of water heaters (gas-fired, electric storage),
- They would allow a direct, technology-independent comparison of products in the same performance category (i.e. tapping pattern) and –through recalibration to a uniform basis— between performance categories. In other words, Specific Measures could be designed with in principle a 'level playing field' for all water heating technologies without the need for additional categorisation.
- Having said that, for some smaller market segments the current harmonised test standards are not fully appropriate. They measure energy efficiency and performance in some way but would require tweaking (solar) or a more substantial update (electric instantaneous, heat pump water heater) to be in line with the above. Further study would be required to explore the possibilities of approximating the tapping pattern approach from the energy efficiency and performance parameters that are currently tested as a provisional measure.
- Test standards for NOx and CO-emission measurements of fossil-fuel fired water heaters are not at the same level as the ones for energy, but current practice of testing during steady-state operation might be acceptable at least for Specific Measures concerning at least NOx emissions. In the long run, concurrent monitoring of CO- and NO_x emissions with the tapping patterns is the preferred method.
- An exploration of existing health standards showed little grounds to expect any major conflict with Specific Measures. A possible exception may be the recommended storage water temperatures that are indiscriminately recommended by health authorities as prevention of Legionellosis. This report takes stock of current scientific insights and proposes a responsible and proportionate approach for future Tasks of the underlying study.
- There are no EU-wide mandatory measures regarding the energy efficiency and emissions of water heaters. There has been a voluntary agreement on electric storage water heaters (ending 2001), but reportedly this did not have any noticeable policy impact. Apart from some national type approval requirements on NOx-levels there are also no mandatory measures at product level in Member States. At building level, the mandatory minimum solar contribution to water heating in new buildings in Spain and Portugal should be mentioned.

- Regarding other Member State legislation, 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 hot water demand, 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 other EU framework legislation (e.g. labelling under the 92/75/EC).
- Globally, there may be some urgency for the EU to introduce mandatory Specific Measures in order to avoid dumping of inefficient water heaters and set challenging targets for the EU industry to raise their global competitiveness. The most stringent mandatory minimum efficiency performance standards (MEPS) can be found in the US, at least for storage water heaters, and they set the example for Canada, Australia, New Zealand. For gas-fired instantaneous types MEPS in Asia are the most stringent. The Japanese Frontrunner programme sets efficiency values close to condensing (up to 83% on Gross Calorific Value) and utilities are pushing for sales of 3,5 million condensing water heaters in 2010 . China is reportedly contemplating MEPS for 2008 at levels of 88% (95% in 2015) for gas-fired instantaneous water heaters. MEPS and/or labelling programmes for water heaters are in place in most of Asia, South-America and –reportedly—also in Russia.
- In contrast, emission limit values (ELVs) for NO_x and CO-emissions are still rare. The most stringent can be found in California (20 ppm).
- From the methodological perspective the US seem to be leading the way, with efficiency measurements based on a (crude) 24h tapping pattern and no longer single requirements for storage losses and steady-state combustion efficiency. Canada has followed and future Australian MEPS will probably also go down that route. For now, Asia –where instantaneous gas-fired water heaters are dominant— is staying with the old approach. Secondary ‘comfort’ parameters (waiting time, temperature fluctuations during tapping, minimum flow rate) are not playing any role in MEPS around the world. Efficiency values for fossil-fuel fired water heaters are expressed in Gross Calorific Values. Categorisation is still traditional (electric/non-electric, storage/instantaneous), but behind this categorisation primary energy efficiency seems to be a leading principle with much more stringent limits for electric types. Within the category of electric storage water heaters some countries make a distinction between small and large; in countries where the daily hot water volume is set at 200 litres or more, the class limit is set at 50-78 litres tank capacity.
- In the sphere of voluntary measures and building codes the EU seems to be leading the way as regards the promotion of solar energy and heat pumps for water heaters. 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 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.

As an illustration, the graph on the next page gives a comparison of US and Australian MEPS values with some European voluntary values for electric storage water heaters, against the background of a recently suggested A-G rating in a draft European standard for indirectly heated storage tanks.

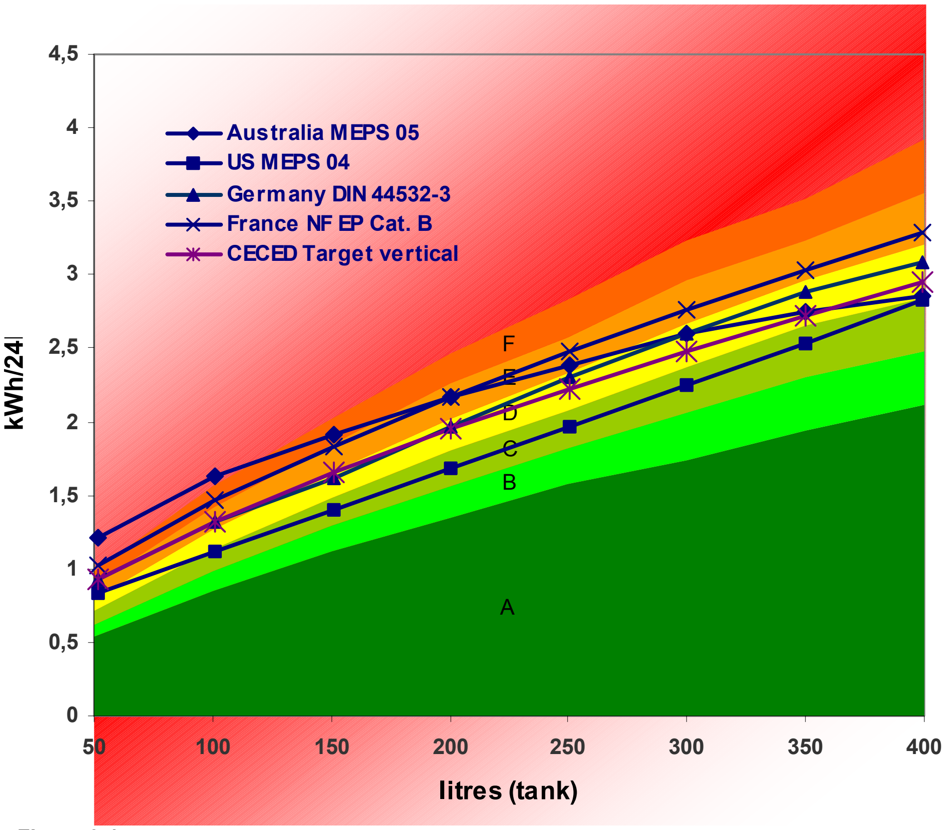

Figure 0-1.
Comparison between require-ments for electric storage water heaters in various countries. Max. storage losses according to Australian MEPS 2005, US MEPS 2004, German DIN 44532-3 (voluntary), the French requirements for the NF Électricité Performance Cat. B certificate and the CECED target for vertical appliances (voluntary) against a background of A-G rating as proposed in prEN 15332; 2006 [VHK 2006]

1 INTRODUCTION

1.1 Scope

This is the draft interim report on Task 1 of the preparatory study on the Eco-design of dedicated gas-, oil- and electric water heaters 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

[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 SME's 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.ecohotwater.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 31 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).

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. In case of water heaters the functional performance is e.g. the ability to deliver the desired quantity of hot water of a desired temperature at a desired flow rate and/or time period[2] every day of the year. Given the EN 13203 and prEN 50440 —developed following mandate M341—this can be expressed as the ability to meet a certain tapping pattern. Secondary 'comfort' product parameters are waiting time, minimum flow rate and temperature fluctuations during tapping, etc..

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 (electric/non-electric, instantaneous/storage) was included, but does not add any new aspects. Labelling schemes for water heaters are rare and from this no additional categorisation could be derived. An EU energy labelling scheme for water heaters under directive 92/75/EC has been discussed for many years, but basically from the minutes of the ELRC-meetings and preparatory SAVE studies it appears that ELRC-proposals for are not finalized.

Some of discussion items of the ELRC were also discussed with the expert group and the Commission. They are reported separately in the minutes of the expert group meetings (see www.ecohotwater.org). One of these topics was the issue whether indirectly fired hot water tanks, (also known as '*indirect cylinders*') can be classified as a water heater. There the general opinion was that these indirect cylinders should not be regarded as a water heater, but as a 'Component'. Like any other 'Component' such as burners, pumps, solar collectors, etc. they can be subject to a specific policy measures (e.g. labelling or CE-marking) and it is clear that these measures should be consistent with an evaluation of the component when it is built into a Product, but it is not in itself a Product that can deliver on its own the primary function.

A similar discussion is still ongoing on the subject of 'Systems' versus 'Products', especially in the context of solar-assisted water heating. Here again, the solar system components would not be able to fulfil the primary function without an auxiliary electric or fossil-fuel fired water heater. Hence, the definition of a solar-assisted water heater, although it is technically a system of several components, should include the auxiliary water heater. The Commission, both from the side of DG ENTR and DG TREN, indicated its flexibility in this respect. The concept of a 'System' is not clearly defined and the trend of the discussion is that the yardstick should not be whether the 'Product' consists of one or more separate physical units, but should depend on the functionality of the configuration—i.e. the ability to meet a tapping pattern—that is offered for CE-marking.

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;

[2] The time period would be limited in case of a storage type water heater

- 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 water heaters addressed in mandate M204[3] are as follows:

- Solar: ISO 9459 /EN 12976, EN 12977 [1997/2001]
- Heat pump: EN 255 [1997]
- Gas instantaneous: EN 26 [1998]
- Gas storage: EN 89 [2000]
- Gas combi: EN 625 [1995]
- Gas WH rating: EN 13203 [2001]
- Oil: EN 303 [2000]
- Solids: EN 12809 [2001]
- Electric instantaneous: EN 50193 [1997]
- Electric storage: HD 500 S1 (IEC 379) [1988]

As requested the content of these standards is described and their current status (revisions) investigated, especially in view of performance and consumption characteristics. Furthermore, new draft standards for electric water heaters (prEN 50440) and indirect cylinders (prEN......) are discussed in Chapter 2. Main issue is the comparison between the traditional steady-state efficiency measurement (incl. storage losses) versus the new methods for testing the efficiency with a 24 hour tapping pattern. For a discussion of older national standards, wholly or partially superseded by harmonised standards, we refer to the SAVE study by Sakulin et al..

In Chapter 5 a discussion of draft *European building standards* prEN 15136-3 is foreseen for the final report, but at the time of this interim report the final form of these standards is not yet known.

Health standards, with the focus on *Legionellosis*, are the main subject of Chapter 4. There are several health and safety aspects concerning water heaters:

- Water heaters play a role in scalding (burns), for which also requirements are in place or being designed at Member State level.
- Water heaters are a potential source of thermophylic bacteria[4].
- Gas-fired water heaters 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 are relevant.

In other words, *Legionellosis* or the kinder variation of *Pontiac fever* are certainly not the only health aspects. But, especially in terms of conserving energy sources and reducing emissions the current measures for fighting *Legionellosis*, i.e. keeping the

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[3] Third draft, mandate to cen and cenelec for the elaboration and adoption of a measurement standards for household appliances: water-heaters, hot water storage appliances and water heating systems. European commission, 4.3.2002

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

water at a constant high temperature, have a high negative impact and that is why they were singled out for this draft interim report. In the final report we will expand on other safety standards and also on the relevant standards for noise.

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. Also the EU Voluntary Agreement on electric storage water heaters was discussed in 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 studies for the 92/75/EC Energy Labelling Directive, where water heaters are one of the products listed. This has resulted in two SAVE studies (EVA 1997 DESWH study, Novem 2001 study) and –as a consequence— a 2002 Commission mandate to CEN/Cenelec to harmonise the energy performance test standards in order to allow for appropriate comparative testing between water heaters employing different energy sources. The first results –i.e. (draft) EN standards for gas-fired and electric water heaters—are now available and are described in subtask 1.2.

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.

Section B of the report discusses 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 water heater categorisation and definition 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 water heating equipment in the EU. To complete this picture, also the combi-boilers were included, although they are not within the scope of the underlying study.

However, 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 water heater is defined as an appliance designed to provide hot sanitary water. It may (but need not) be designed to provide space heating or other functions as well.

Main performance parameters of the water heater –mentioned in the standards— are specific flow rate (in l/min), typically for instantaneous types, and storage volume (in l.) for storage type water heaters. Furthermore, EN 13203-1 defines marks for the tapping capability (1-4 'taps'), which is also known in other standards as hot water capacity, and the quality of the hot water delivery. This quality is defined through a rating system incorporating waiting time, minimum flow rate, temperature fluctuations during tapping, etc.

A tentative definition for the performance parameter –not based on the technology— could be *'the ability to deliver the desired quantity of hot water of a desired temperature at a desired flow rate and/or time period*[5] *every day of the year at a minimum desired quality level'.*

The way to make this operational is given in the very recent EN 13203-2 and prEN 50440 standards —the first standards to follow Commission mandate M324- which define several 24 hour tapping patterns that are specific for a performance level. This will be discussed in detail in Chapter 3, par. 3.3. The tapping patterns are not just a way to measure energy efficiency, but specify the performance in terms of :

- flow rate for each draw-off (challenging the capacity of instantaneous types),
- the minimum and maximum temperature level per draw-off (taking into account that e.g. instantaneous water heater types that have a longer waiting time and challenging storage water heaters reheating only once a day),
- the volume per draw-off (challenging the storage capacity, if any),
- the time period available between draw-offs (to reheat in case of a storage water heater),
- the time of day when hot water is required (challenging solar-assisted and possibly heat pump types),
- the total daily hot water consumption (challenging e.g. storage water heaters reheating only once a day).

[5] The time period would be limited in case of a storage type water heater

Furthermore, because the tapping patterns cover 24 hours, an energy consumption measurement appropriately includes any storage losses. All in all, the tapping patterns give a fairly comprehensive coverage of the performance aspects.

Table 2-1. Overview of tapping patterns in EN 13203-2 and prEN 50440 [VHK 2006]

Size	(Unit)	XXS	XS	S	M	L	XL	XXL
No. pattern EN 13203-2	#			1	2	3	4	5
No. pattern prEN 50440	#	1c	1b	1/1a	2/2a	3/3a		
Application [typical, estimate VHK]		kitchen only (dishwasher-owner)	kitchen + manual dishwashing (very small shower)	single person (incl. small shower)	avg. family (2-4 persons)	large family (4-6 persons,)	very large family (>6 persons) and jacuzzi-owners	multi-family
Draw-off types [typical, estimate VHK]		washing hands, cleaning	kitchen, dishwash (very small shower)	kitchen, dishwash (small shower)	kitchen, showers, occasional bath	kitchen, showers, 2 baths a day	kitchen, showers, very large daily baths	kitchen, shower + bath (simultaneous)
Dwelling area [typical]	m2	n.a.	20-60	n.a.	40-150	100-200	150-300	200-400
Hot water volume/24h	litres/day	36	36	36	100	199	325	400
Max. test flow rate	litres/min.	2*	5-6**	4	5-6**	5-10**	10	16
Largest test draw-off	litres	1,8	5,4	9	24	62	75	107
Min. temperatures	oC	25	25/40	25/40	10/25/40	10/25/40	10/25/40	10/25/40
Max. Temperatures	oC	n.a.	55	55	40/55	40/55	40/55	40/55

* =prEN 50440 mentions 2 litr/min. If storage vessel < 10 litre, otherwise 3-4 litre/min. should apply for dishwashing

**= prEN 50440 mentions 5 litr/min. If storage vessel < 10 litre; EN 13203 mentions 6 litre/min. for shower and 10 litre/min for bath

Note 1: litres mentioned are litres equivalent of 60 oC hot water. For hot water of 40 oC multiply by 1,7 (cold water temperature = 10 oC)

Note 2: 'very small shower' is a 2 minute shower with the most efficient (5 litre/minute of 40 oC water) energy saving showerhead. 'Small shower' is 4 minutes and/or a 2-3 minutes with a less efficient energy saving shower head. A conventional showerhead of 10 litre/minute is assumed for the sizes M, XL and XXL for a shower of 2-3 minutes. The bathtub of tapping pattern 'L' is an older model of 100 litres (40 oC water); modern acrylic bathtubs use 60-80 litres and are often insulated. The 'bath' in sizes XL and XXL are special jacuzzis, hot-tubs, etc. or can be seen as the equivalent of simultaneous showers or small baths.

Having said that, the EN 13203 (dor gas-fired appliances) and prEN 50440 (for electric storage water heaters) are similar but not identical. There are some differences e.g. in flow rate, which perhaps may lead to the necessity of correction factors for Specific Measures. What is also not taken into account –and which was not part of mandate 341— are:

- the distribution energy losses due to longer waiting time (guidance from building standards and/or from recording the total water volume until the minimum temperature is reached, multiplied with an appropriate factor)
- the distribution energy losses because some types have restrictions —i.e. need a chimney— in how close they can be to the tapping points (guidance from building standards) and/or cannot be in the heated area of the house (too big, too noisy),
- the energy losses and emissions of the power generation, fuel preparation and system losses in supplying ambient heat like e.g. over-ventilation of the house in case of heat pump water heaters based on ventilation air (guidance from building standards).
- the environmental impact of production and end-of-life (guidance from the underlying study, e.g. EcoReport)

Finally, EN 13203-2 and prEN 50440 cover the main water heater types, but for smaller market niches such as solar-assisted, heat pump and electric instantaneous water heaters the standards are yet to be adapted. The standard for factory-made solar-assisted water heaters, EN 12976, is already based on a (crude and single) tapping pattern. The standards for heat pump water heaters, EN-255, and electric instantaneous water heaters, EN 50193, both use the steady-state energy efficiency and assess the tapping capability (during a 10 minute operation). thereby might. The adaption of these test standards to mandate M324 may take some time, but in case the delay would exceed the deadline for the introduction of Specific Measures and given that already some form of performance measurement is available the legislator might consider some temporary evaluation based on current standards. The building standards developed under the EU Energy Performance of Buildings Directive (EPBD) could provide some guidance in that respect.

2.2 Fuel type

Water heaters can be categorised by fuel type as follows:

- 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 water heater is tested has to be indicated on the water heater nameplate.
- Electric water heaters (electric resistance water heater, 'Joule effect' water heaters). Can be characterized by type (instantaneous or storage), voltage (230 or 400 V), capacity of the heating element (in kW), flow rate (in l/s, for instantaneous types) and/or storage capacity (in litres, for storage types)
- Solar-assisted water heaters. 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 and the heating up of hot sanitary water. In that latter case, they can be qualified as 'Water heaters' 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.

Note that most of the above heat pumps are typically optimal for space heating at a low temperature level. In as much as they are used for hot water heating this is at best a pre-heating of the hot sanitary water and always requires an auxiliary heater to arrive at the necessary temperature level.

The only exception to this rule is the Ventilation Air Heat Pump, which uses relatively high source temperature (18-20°C) that allow the heat pump to reach the required sanitary hot water temperatures.

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 [6]. 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.

- Oil ('oil-fired'). Dedicated oil-fired water heaters are rare, usually it is an oil-fired combi-boiler or a regular oil-fired boiler with an indirect cylinder. The suitability of a water heater or combi 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'). Almost non-existing and –if they exist—combined with other functionality such as a range cooker or space heating. Coal-fired appliances can be classified by fuel type.
- Biomass. Biomass-water heaters can be classified by biomass type (wood logs, wood pellets, hay, peat, etc.). Dedicated biomass-fired water heaters are rare, certainly in the residential sector, usually it is a combination of space- and water heating in a combi-boiler or a regular oil-fired boiler with an indirect cylinder. For each biomass type the dimensions and water content may be important for the appliance construction.

Biomass and coal-fired water heaters or combi-boilers are out of scope for the Ecodesign study.

2.3 Functionality (Output)

Refers mainly to the ability of the water heater –as submitted for CE-testing— to provide also space heating. Also in niche markets it can refer to the cooking functions and finally there are water heaters 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:

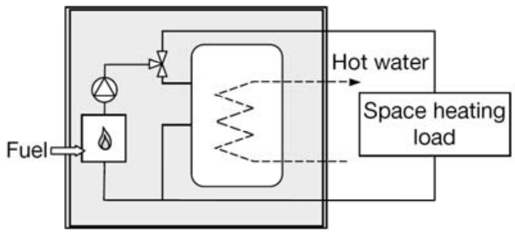
- Indirect cylinder or 'indirectly heated unvented (closed) storage water heater' (prEN 12897: 2004). Vessel complete with heat exchanger (primary heater) for heating and storage of drinking water where the contents are not vented to the atmosphere. Can be defined as a water heater when connected to an external heat source, usually a regular CH-boiler. Having said that, there is a subdivision for indirect cylinders That have an electrical resistance heating element as a secondary heater in summer and those that do not and solely rely on the external heat source also in summer. Note VHK: Following discussions in the expert group it is proposed

[6] 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

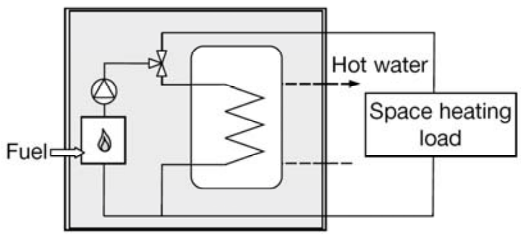
to qualify the storage tank as a 'Component' and not as a water heater 'Product'. It is thereby outside the direct scope of the study, but it will be further taken into account because consistency between product-related measures and components should be strived for.

- Regular (or 'dedicated') water heater: A water heater which only provides domestic hot water directly (i.e. not a combination boiler or similar), subdivided into
  - Instantaneous water heater: A water heater without an internal hot water store, or with an internal hot water store of capacity less than 15 litres (for gas- or oil-fired heaters). Truly instantaneous water heaters are typically used as single-point appliances, dedicated to kitchen or bathroom.
  - Storage water heater: A water heater with an internal hot water store of capacity at least 15 litres. Storage water heaters are typical multi-point appliances – although single-poitn variations do occur—and can be subdivided as indicated in the next paragraph, e.g. by their heating behavior into ' instantaneous storage' and 'non-instantaneous storage' types.
- Combination boiler ('combi'): A space heating boiler with the capability to provide domestic hot water directly, in some cases containing an internal hot water store. The SEDBUK 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 water heater
  - Storage combination boiler: A combination water heater with an internal hot water store of capacity at least 15 litres but less than 70 litres, OR a combination water heater 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 2-2



Primary storage combi boiler



Secondary storage combi boiler

Please note that in the BED-market study by BRG Consult and other sources the above qualifications are not always mutually exclusive: 'Instantaneous' is also applied to 'storage combination water heaters' , 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 there are:

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

And finally, for space/ water heaters that also deliver electricity there is the

- Combined Heat and Power combi (CHP-combi)**.** Device that is capable of delivering hot water for space heating and/or hot sanitary water, as well as electricity to the grid or the building installation. CHP-combi's 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).

By storage configuration and capacity

Water heaters or combi-boilers can have a storage facility for

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

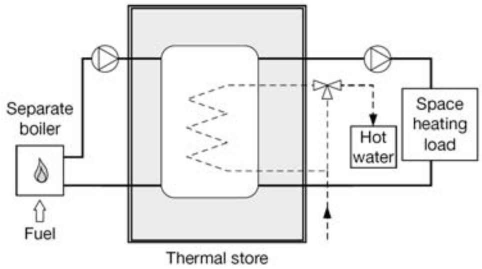
In general, storage facilities are used to solve a mismatch between heat input and heat output. For primary stores the mismatch may be that the heating system requiring a continuous or semi-continuous heat at a lower power level than the burner can provide. For secondary stores the mismatch is between 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.



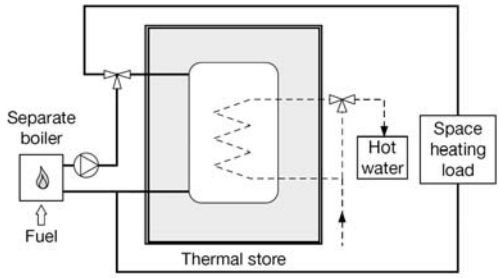
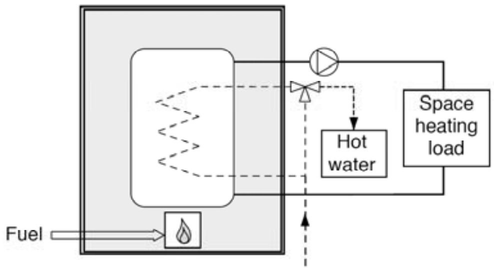


Figure 2-3.
Integrated Thermal Store (left) and 'Hot water only' Thermal Store (right)

Figure 2-4.
CPSU with coil



Secondary store options for combi-boilers and –for the most part—dedicated water heaters are:

- No secondary store ('instantaneous'). In the instantaneous water heater the sanitary hot water is led through a coil that is heated directly by the burner or electrical element. There will be a penalty in terms of waiting time
- Keep hot facility or kitchen water heater. For fossil fuel fired water heaters and combi-boilers this is a facility in an instantaneous water heater (<15 litres) whereby water within the water heater 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, typically at frequent small tappings (kitchen use). For electric water heaters a storage tank with a volume < 15 litres only occurs with small electrical storage heaters for use in the kitchen and with a power of <2 kW.
- Instantaneous storage water heater or combi. The storage tank of this appliance 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 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 water heater efficiency and lower tank standby losses— when there is no hot water demand. 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 secondary storage tank is placed in a primary tank.

- Non-instantaneous storage water heater or combi. The storage tank of this appliance may be any size but is usually from 45 litres onwards[7]. This storage water heater is 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 water heater 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 water heater 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 2-2. Definitions relating to sanitary hot water production, by storage & lay out

Function	EN/ SAP Definition
REGULAR WATER HEATER	
- without secondary store (flow-through heat exchanger)	instantaneous water heater
- with secondary store (hot water tank)	storage water heater
REGULAR BOILER with Indirect Cylinder	
- with external secondary store (sold separately)	Regular boiler with unvented hot water storage tank
- with aux.heater for summer mode	
- without aux. heater for summer mode	
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..

[7] Compare prEN 50440

2.4 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 (Bxx or Cxx).

Both *Type B* and *Type C* use a chimney for the flue gases[8], but

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

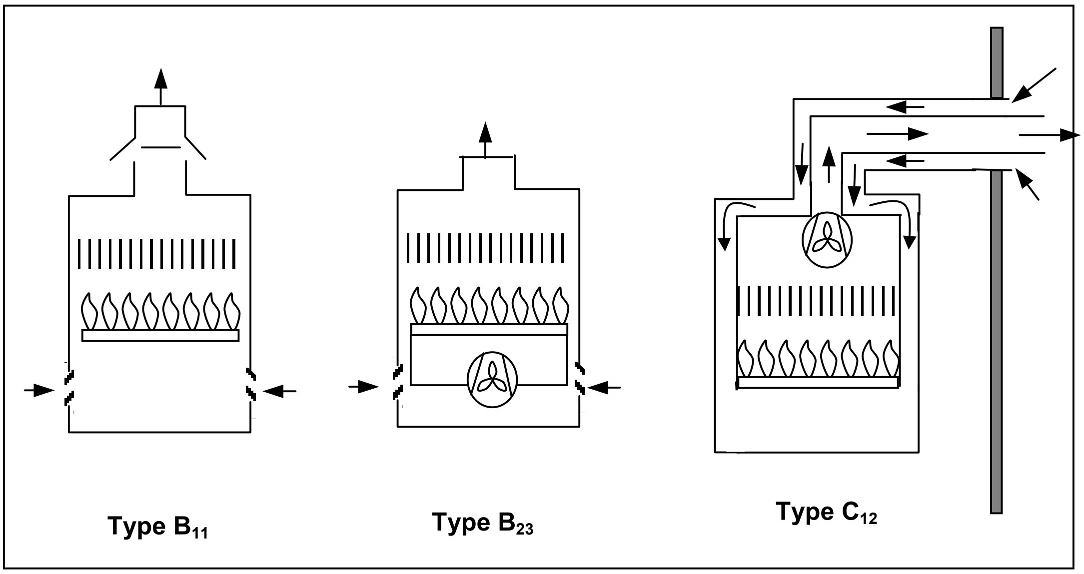
With Type B there is an open connection between the burner and the inside of the house ('open system'), whereas Type C is 'room-sealed'. With Type B, because combustion gases could come inside the house, the EN and local standards specify safety (health and fire) requirements for e.g. carbon monoxide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

With *Type B* water heaters the first digit indicates whether (B1x) or not (B2x) the flue gas duct is preceded by a flue gas damper. With *Type C* water heaters the first digit indicates the configuration of the air intake and flue gas ducts: horizontal concentric ducts (C1x), vertical concentric ducts (C3x), side-by-side vertical ducts (C4x), ducts leading to different pressure zones outside the building (C5x), water heaters tested without ducts (C6x) and water heaters connected to negative pressure chimney for the flue gases and to another pressure zone for the air intake (C8x).

A water heater 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 water heater. Please note that the denomination is a mandatory part of the water heater'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 water heater is allowed only for open systems with a flue gas damper, i.e. Type B11 (including type B11BS, which is a B11 with a thermostatic safety device).

Figure 2-5. Examples flue type/ air intake types (see also next chapter)



2.5 Burner flue gas/ air intake configuration

For burners, the EN standards distinguish between

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

- ‘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.

2.6 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 either be classified 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,[9]

‘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:

- 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 SEDBUK still defines

- condensing water heater or combi as a *water heater* 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.

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[9] 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,

- Water heaters not so designed, or without the means to remove the condensate in liquid form, are called *'non-condensing'*.

2.7 Burner power control system

<u>on/off water heater:</u> A water heater 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.

<u>modulating water heater:</u> a water heater with the capability to vary the fuel burning rate whilst maintaining continuous burner firing.

2.8 Power class (in kW, residential/commercial)

For gas- or oil-fired boiler-based hot water heating systems (combi's) 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.

For central instantaneous water heaters –with or without storage tank— specific power levels are important, e.g. relating to keeping up with a specific flow rate of 10 l./min (600 l./h). Assuming –as in the standard—a cold water temperature of 10°C and a required minimum delivery temperature of 45°C (= 40°C at the tap, after losses in the distribution system) then the power required is 35°C x 600 litres x 1,16 Wh/l.°C = 24 kW. So, in order to guarantee '*unlimited hot water supply*' for shower or bath, this is the power level you need in this specific configuration.

For local instantaneous water heaters –usually flow-through type—there are hardly any distribution losses (gain 10%) and a specific flow rate of 6-9 litres/minute may be acceptable. Hence, a power range of 12 to 20 kW may be acceptable. For electric resistance instantaneous water heaters this will be done with 380 V.

2.9 Burner/water heater configuration

The EN standards make a distinction between

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

2.10 Boiler water temperature control:

This applies only to combi-boilers and regular boilers working with an indirect cylinder and refers to the temperature control of the CH-water running through the heating coil in the storage tank.[10]

- <u>Fixed</u> (manual setting at installation): When in water heating mode the boiler is always set at full-load, e.g. at a CH-water regime of 70/90°C. This *'water heating nominal capacity'* may be a few kW more than the nominal heat input of the *space heating nominal capacity*, which is usually set at a 60/80°C regime.
- <u>Modulating</u> *(a.k.a. systems with 'room compensator')*: Traditionally the combi's and boilers plus indirect cylinders were always working with a fixed, full load. Only in dual coil solar water tanks, where the extra energy required to reach the desired outgoing temperature level of the hot water is not known, boilers have been used in

[10] Or thorugh the external cylinder in a 'tank-in-tank' solution

part load (modulating) to complement the temperature level of the hot sanitary water pre-heated by the sun. More recently, manufacturers are using modulating burners and thereby a modulating CH-water temperature as a standard feature in all storage water heaters in recognition of the fact that a boiler that is working at lower return water temperatures can reduce its flue gas losses and is thereby more efficient. The development of dual coil water tanks (see storage facilities) is an example of where the boiler is working at full load (70/90°C) during draw-offs and is working at lower temperature regimes during pre-heat of the storage tank.

2.11 Burner combustion control

Burner combustion control in principle applies to all fossil fuel fired water heaters and combi's. 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.

2.12 Mounting position

In market statistics there can be a distinction between:

- Floor-standing and
- Wall-hung water heaters and combi's

The storage tank size at which the tank can be wall-hung is reported by CECED to be up to 250 litres.

Specifically for water heaters with storage tanks there is a distinction between

- Vertical cylinders and
- Horizontal cylinders

2.13 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.[11]

2.14 Ignition type

- electronic (through glowing plug or spark plug) or
- pilot flame (almost extinct in new water heaters, except in some dedicated, instantaneous gas-fired water heaters)

[11] 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).

2.15 Pump type

Pumps in boiler-based water-heating systems (combi or regular boiler with indirect cylinder) can be

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

Currently, the pump speed is not a factor in water heater or combi-design. Pumps work at fixed speed when the boiler is operating as a water heater.

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.

2.16 Materials

A classification for water tank material in market studies is

- Stainless steel
- Copper
- Other (enamelled steel, plastics)

The EN standards give a more specific range of materials to be used, but this is not normally used for classification. Note that the water heater material is not only subject to demands on pressure resistance and higher temperatures but also stringent health considerations and therefore certain materials may not be used.

For the heat exchanger material in combi-boilers and regular boilers, some market statistics distinguish between

- Steel/iron
- Copper
- Aluminium

2.17 Statistics classification

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

Regular water heaters:

PRODCOM nr.	Description
29.71.25.30	Electric instantaneous water heaters
29.71.25.50	Electric water heaters (incl. storage water heaters) (excl. instantaneous)
29.71.25.70	Electric immersion heaters (incl. portable immersion heaters for liquids, usually with a handle or a hook)
29.72.12.33	Iron or steel gas domestic appliances with an exhaust outlet (incl. heaters, grates, fires and braziers, for both gas and other fuels; excl. cooking appliances and plate warmers)
29.72.12.35	Iron/steel gas domestic appliances (incl.heaters, grates, fires and braziers, for both gas and other fuels radiators; excl. cooking appliances and plate warmers, those with an exhaust outlet)
29.72.12.53	Iron or steel liquid fuel domestic appliances with an exhaust outlet (incl. heaters, grates, fires and braziers; excl. cooking appliances and plate warmers)
29.72.12.55	Iron or steel liquid fuel domestic appliances (incl. heaters, grates, fires and braziers, radiators; excl. cooking appliances and plate warmers, those with an exhaust outlet)
29.72.11.13	Iron/steel gas domestic cooking appliances and plate warmers, with an oven (incl. those with subsidiary boilers for central heating, separate ovens for both gas and other fuels)
29.72.11.15	Iron or steel gas domestic cooking appliances and plate warmers (incl. those with subsidiary boilers for central heating, for both gas and other fuels; excl. those with ovens)
29.72.11.30	Iron or steel liquid fuel domestic cooking appliances and plate warmers (incl. those with

	subsidiary boilers for central heating)
29.72.11.70	Domestic cooking or heating apparatus... (non-electric) of copper
29.72.14.00	Non-electric instantaneous or storage water heaters

Combi-boilers will be included in the following:

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

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 water heaters is very important.

For dedicated water heaters there are several EN product test standards and amendments (excl. referenced standards) covering roughly 200-300 pages. For a discussion of test standards that apply to combi-boilers we refer to the preparatory Ecodesign study on boilers (Lot 1).

Regular ('dedicated') water heaters are subdivided in the standards

- by fuel (gas, electric, solar, heat pump) and
- by storage type (instantaneous and storage)

The current EN standards for combi boilers are subdivided:

- 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 (water heaters, combi-water heaters, water heater-burner assemblies and separate burners)
- by condensing, low temperature and non-condensing water heaters

An extensive discussion of combi-boilers in terms of safety requirements and energy efficiency performance for space heating is given in the Ecodesign of study on boilers (Lot 1). Here we will restrict ourselves to discussing the water heating part.

The following paragraphs summarize and give details of the standards for product testing in terms of performance and energy. Chapter 4 will discuss health standards with a special focus on Legionella. Chapter 5 will discuss the relevant European EN standards in the context of the Energy Performance of Buildings directive.

3.2 Gas-fired water heaters, performance assessment (EN 13203-1: 2006)

Full title: EN 13203-1:2006. Gas-fired domestic appliances producing hot water - Appliances not exceeding 70 kW heat input and 300 litres water storage capacity - Part 1: Assessment of performance of hot water deliveries.

(Replaces 1998 version, **approved April 2006**)

Summary:
This document is applicable to gas-fired appliances producing domestic hot water. It applies to both instantaneous and storage appliances; water-heaters and combination boilers that have: - heat input not exceeding 70 kW; and - hot water storage capacity (if any) not exceeding 300 l. In the case of combination boilers, with or without storage, domestic hot water production is integrated or coupled, the whole being marketed as a single unit. This document is formed in two parts, which cover two aspects of domestic hot water production. EN 13203-1 sets out in qualitative and quantitative terms the performance in delivery of domestic hot water for a selected variety of uses. It also gives

a system for presenting the information to the user. This first part complements EN 26, EN 89 and EN 625. EN 13203-2 sets out a method for assessing the energy performance of the appliances. It defines a number of daily delivery programmes for each domestic hot water use, kitchen, shower, bath and a combination of these, together with corresponding test procedures, enabling the energy performances of different gas-fired appliances to be compared and matched to the needs of the user.

Prepared by CEN/TC 109

Status: Not mandatory under any EU directive

Detail:
The standard characterizes the domestic hot water function of water heaters in two different ways:

- According to specific rate and tapping capability
- According to the quality of the delivery (waiting time, temperature fluctuations, minimum rate)

Specific rate and tapping capability

The specific rate (in litres/minute) is the amount of water of 40°C[12] or higher that the appliance can deliver at test conditions[13]. If the temperature is higher than 40°C ($\Delta T>30K$) this is taken into account in the formula:

$Di = \boldsymbol{m}/10 * \Delta T/30$, where Di is the rate in an interval I and $\boldsymbol{m}$ is the mass of water produced in 10 minutes.

As far as we can see, the tapping capability is almost identical to the specific rate, but in this case only the rate during the first 10 minutes is measured and not –as with the specific rate—during two 10-minute periods with a 20-minute reheating pause in between. This 'tapping capability' is used to propose a label classification: '*1 tap*' is less than 10 l/min., '*2 taps*' is between 10 and 15 l/min., '*3 taps*' is between 15 and 20 litres and finally at '*4 taps*' the water heater can deliver 20 litres of hot water at a temperature of 40°C or higher in 10 minutes.

Quality of delivery

For the quality of delivery the standard proposes a system of particular performance and weighting criteria that will result in a number of points, which are then used to generate 4 performance classes. See the tables below.

Table 3-1. Particular performance and weighting criteria

Particular performance criterion	Symbol	particular performance factor (fi)				Weighting coefficient ai
		0	1	2	3	
Waiting time	tm	>60s	< 60 s	< 35 s	< 5s	4
Temperature variation according to water rate	dT1	> 10 K	< 10 K	< 5K	< 2K	3
Temperature variation at constant water rate	dT2	> 5K	< 5K	< 3K	< 2K	3
Temperature stabilisation time	ts	> 60 s	< 60 s	< 30 s	< 10 s	2
Minimum nominal water rate	Dm	> 6 l/min.	< 6 l/min.	< 4 l/min.	< 2 l/min.	1
Temperature fluctuation between successive deliveries	dT3	>20K	< 20K	< 10 K	< 5K	1

Table 3-2. Classification according to factor F (F= sum of fi ⋆ ai for each factor)

[12] 30 K over the cold water temperature of 10±2 oC

[13] cold water temperature of 10±2 oC; cold water pressure of 2±0,1 bar; ambient temperature of 20±3 oC; electrical supply voltage 230±2 V. The test cycle is 10 minutes tapping, 20 minutes pause, 10 minutes tapping. The specific rate is the average over the two tapping periods: D= (D1+D2)/2

Value of F	Label
<14 points	---
14 to 27 points	*--
28 to 39 points	**-
>40 points + particular factors >2	***

The standard then prescribes test methods. For instance, the water rate is varied between 70 and 95% of the nominal rate.

Finally, par. 6 of the standard proposes that the consumer should be given information about the specific rate, the tapping capability, the quantity of hot water delivered in 10 minutes (number of '*taps*').

Annex A gives varies curves pertaining to preparation and execution of tests.

Annex B is interesting, because –as opposed to the boiler test standards—here it is perfectly acceptable to use flow meters to determine the mass of water tapped and to use (low inertia, 'rapid response') temperature measurements. The boiler test standards (see Lot 1, Task 1 report) still work with a test rig that is measuring the water quantity by filling a container on a scale.

3.3 Gas-fired water heaters, energy use assessment (EN 13203-2: 2006)

Full title: EN 13203-2:2006. Gas-fired domestic appliances producing hot water - Appliances not exceeding 70 kW heat input and 300 litres water storage capacity - Part 2: Assessment of energy consumption.

Summary:
As prEN 13203-1: 2005 above.

Prepared by CEN/TC 109

Status: Prepared under mandate M324, given in the context preparing for 92/75/EC (Energy Labelling)

Details:
The standard defines a method for assessing the energy performance of gas-fired hot water appliances (incl. combi-boilers) with a heat input not exceeding 70 kW and a hot water storage capacity not exceeding 300 litres. The reference conditions and tolerances are as defined in EN 13203-1. The total uncertainty on the outcome should be within ± 2%.

The standard defines the 3 tapping patterns as defined in the mandate M 324 plus two extra large tapping tapping patterns. Within a 24h cycle the patterns specify

- the start time [in 00:00h],
- the total energy content of each draw-off [in kWh equivalent of hot water tapped],
- the minimum temperature at which one should start counting useful energy [in K of ΔT expressed as the difference with the cold water temperature of 10°C],
- for some ('basin' type= bath, dishwashing) draw-offs an average temperature of the tub [in K of ΔT expressed as the difference with the cold water temperature of 10°C] and
- a hot water flow rate corresponding to a temperature rise of 45 K [in l/min.]

Tapping pattern number 1 (11 draw-offs, 36 litres of 60°C) is typical of a one-person household. Tapping pattern number 2 (23 draw-offs, 100 litres of 60°C) is close to the EU single family. Number 3 (24 draw-offs, 199,8 litres) is for families taking two baths daily, whereas number 4 (325 litres) and 5 (400 litres) are probably characteristic of water heaters serving multi-family homes.

A water heater should be tested according to two tapping cycles and the energy use for the other three tapping cycle outcomes can then be found through extrapolation. This has been verified by the industry —testing 36 appliances—and provides a good data base .

To these energy losses during tapping, the standby-losses should be added. These are established in a test of 24 h without tapping. And finally any auxiliary electrical energy is taken into account.

The concept of '*useful energy*' is important, because it means that all water heating up to the desired temperature is considered as waste. This is already a penalty for appliances with long waiting times, i.e. if it takes over 60 seconds before a shower has reached 40°C (ΔT = 30 K) then some 6 litres of on average 25°C (ΔT = 15 K) are thrown away. This is an energy penalty of 0,1 kWh for this draw off. And at 23 draw-offs a day (Tapping pattern no. 2) the volume of water resources wasted can come close to the useful hot water volume.

3.4 Efficiency of electric storage water-heater (prEN 50440)

Full title: PrEN 50440:2005 en. Efficiency of domestic electrical storage water-heaters.

Replaces EN 60379: 2004.

No summary available

Prepared by CLC/TC 59X

Detail:
As EN 12302-2 this draft standard prescribes the three tapping patterns of the mandate M324, but now for electric storage water heaters. It does not incorporate the two tapping patterns for multi-family houses.

However, it does incorporate variations of tapping pattern No. 1 (36 litres) for small (<45 litre) storage water heaters. The first is specifically for kitchen storage water heaters and prescribes 20 draw-offs of 1,05 kWh each [*Note VHK: These small water heaters have a capacity of 10-20 litres (max. 30 litres) and are used as a secondary single-point water heaters under the kitchen sink*]. The second variation is for appliances with a capacity of 30-45 litres that could serve as a multi-point water heater in a one-person household or holiday home. It replaces some smaller draw-offs by 3 larger ones for showers, etc.. The third variation is a simplified tapping pattern with only three draw-offs (0,525 kWh in morning and evening and 1,05 kWh in the evening).

The prescribed flow rates are similar but not identical to those of EN 13203. For water heaters with a rated capacity of less than 10 litres the flow rate is 2 litres/minute; for 10-45 litre capacity the flow rate for all draw-offs is 5 litres/minute; for 45-200 litre capacity the flow rate for all draw-offs is 10 litres/minute; above 200 litre capacity the flow rate corresponds to a maximum of 5% of the rated capacity per minute. Compare: EN 13203 uses flow rates of 3, 4, 6 and 10 litres/minute independently of appliance characteristics.

The standard proposes that only (variations) of tapping pattern no. 1 should be chosen for storage water heaters up to 45 litres and '*the appliance remains energised*', i.e. it reheats immediately.

For storage water heaters above 45 litres rated capacity, the water heater does not reheat immediately, but only after 16 hours. Obviously this simulates a water heater working on night-current, i.e. the water heater capacity should be enough to provide the complete tapping pattern without reheat. Consequently for water heaters 45-100 litre capacity only tapping pattern no. 1 (36 litres applies), for 100-200 litre capacity pattern no. 2 should be used and only if the storage tank volume is bigger than 200 litres pattern no. 3 (or lower) can be used.

At the end of the day, the water temperature in the larger storage tanks may have dropped below 30°C and this may explain why the prEN 50440 at crucial points (in the evening at the tapping cycle no. 3) counts water of 25°C as 'useful' for drawing a bath of 40°C, whereas EN 13203 puts the limit higher.

The method prescribes also the measurement of standby losses (according to EN 60379) for a boiler at a water temperature of 45K above ambient (i.e. at 65°C).

The tolerances on measured values are –as is customary for electrical appliances—wide. The value measured shall not exceed the declared value by more than 15%. If it does, then three other randomly selected water heaters are tested and the average measured value of these three shall not exceed the rated value by 10%.

Due to tweaking for optimal performance from both sides, the EN 13203 and prEN 50440 are not identical. What remains to be seen is, whether the amount of error is acceptable, i.e. if it would influence the ranking on energy efficiency of gas vs. electrical appliances significantly.

3.5 Electric storage water heaters, performance, methods (EN-IEC 60379:2004)

Full title: EN-IEC 60379:2004: Methods for measuring the performance of electric storage water-heaters for household purposes

Summary:
Applies to this equipment, but does not apply to water-heaters using other sources of energy, water-heaters with more than one heated volume and water-heaters without thermal insulation. Lays down and defines the principal performance characteristics of such equipment which are of interest to the user and describes the standard methods for measuring thesecharacteristics. Is concerned neither with safety nor with performance requirements. Consists of four sections concerning with general, definitions, general notes on measurements with a list of and general conditions for the measurements and measuring methods.

CLC/TC 59X

3.6 Indirect cylinders (EN 12897:2006)

Full title: EN 12897: 2006. Water supply — Specification for indirectly heated unvented (closed) storage water heaters

Summary:
This European Standard specifies the performance requirements and methods of test for indirectly heated, unvented (closed) storage water heaters of up to 1000 litres capacity suitable for connection to a water supply at a pressure between 5 Mpa and 100 Mpa (0,5 and 10 bar), and fitted with control and safety devices designed to prevent the operating temperature of the stored drinking water from exceeding 100°C. Whilst storage water heaters intended primarily for direct heating are not covered by this standard, it does allow the provision of electric heating elements for auxiliary use.

Reference to GAD directives

CEN/TC 164

Detail:
Note that this standard treats general aspects of safety and performance. For aspects concerning the rational use of energy the standard provides test methods for standing heat loss, heat exchanger performance and measurement of hot water capacity. For tests following the Commission mandate M326 prEN 15332 hereafter should apply. The procedure for measuring standby loss (Annex A) is similar to prEN 15332, but without the suggestion for a labeling classification. For performance ('hot water capacity') also similar procedures are proposed.

This standard has recently been approved.

3.7 Indirect cylinders – energetic assessment (prEN 15332; 2006)

Full title: prEN 15332:2006. Heating boilers — Energetic assessment of hot water storage tanks

CEN/TC 57

Summary:
This European Standard specifies a method for energetic assessment of unvented (closed) hot water storage tanks with a capacity up to 1500 l, intended to be equipped with an external heat source and used for domestic hot water production. Whilst storage water heaters intended primarily for direct heating are not covered by this standard, it does allow the provision of electric heating elements for auxiliary use.

Note that this standard is only concerned with aspects concerning the rational use of energy following the Commission mandate M326. For other aspects of type approval see EN 12897.

CEN/TC 57

Detail:
This standard measures the heat exchanger capacity as a performance parameter, connecting the storage tank to an external heat source delivering heating water. If the mass flow is not given, the mass flow is determined at around 80°C feed temperature (ΔT with cold water temperature 70°C + cold water temperature normally 10°C), 60°C return temperatur (ΔT with feed temperature 20 K) and and a hot water temperature of 60°C (ΔT with cold water temperature 50°C + cold water temperature 10°C). The performance is derived from the steady-state energy output in terms of hot water (P= 60 * 1,16 * 0,001 * mass of water * temperature difference between sanitary hot water output and cold water input).

This standard also measures the 'hot water capacity'. This is quantity of hot water in litre at usable hot water temperature that could be tapped at one 10 min tapping at a cold water temperature of 10°C and a maximum hot water temperature of 65°C (temperature difference = 55K) with reheating. This parameter can be measured, but also estimated from a known heat exchanger capacity using a formula in the standard.

The standby losses of the storage tank are measured with an additional electric immersion element in the tank and a controller. The energy consumption of the immersion heater to keep the stored temperature at nominal temperature –at least 65°C— is the standby loss (kWh/24h). Ambient temperature is 20 ± 5°C, but may not fluctuate more than 1 K during tests and the temperature difference should be at least 45 K between hot water and ambient.

The standard proposes a labeling classification for storage tanks on the basis of standby losses versus storage capacity. Only a diagram (no formula) is provided. Class boundaries for capacities lower than 50 litres are not indicated.

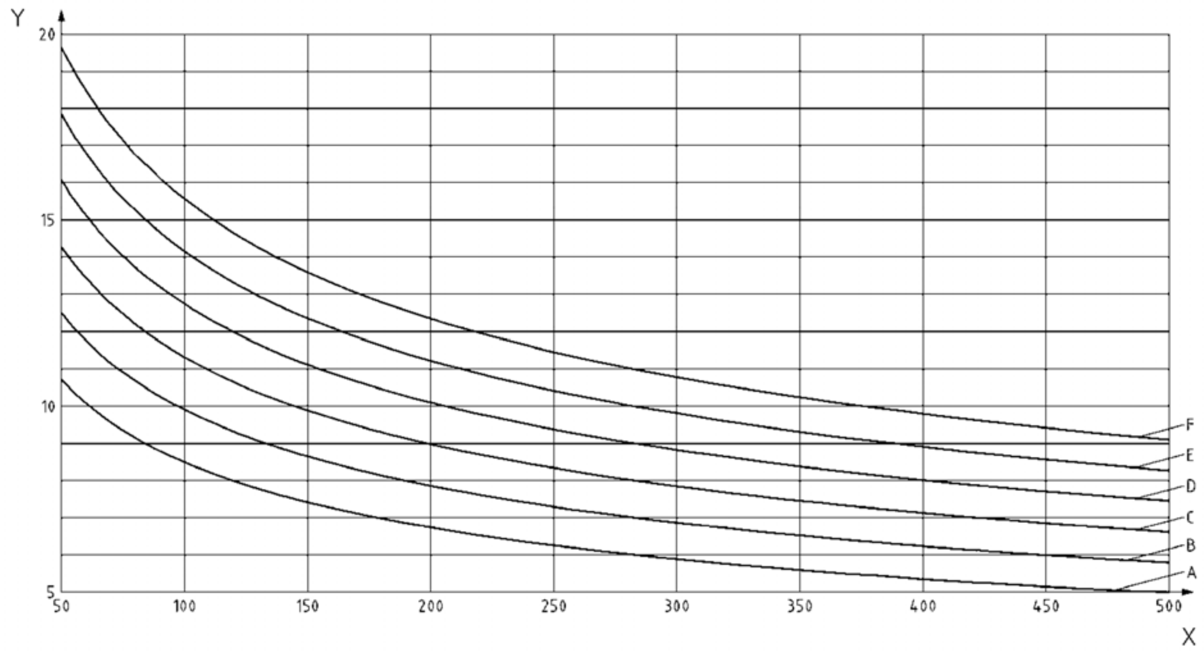

Figure 3-1. PrEN 15332: Suggested A-G labeling classification for hot water storage tanks on the basis of the standby loss related to the hot water capacity in (Wh/l)/d [=Y axis] and the storage capacity in litres [= X axis]. A similar graph exists for capacities 500-2000 litres.

3.8 Sanitary hot water heat pumps (EN 255-3:1997)

Full title: EN 255-3:1997 en. Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors - Heating mode - Part 3: Testing and requirements for marking for sanitary hot water heat pumps.

Most recent amendment: NEN-EN 255-3:1997/C1:1997

Summary:
Specifies methods for testing and reporting of the rating and it specifies requirements for marking of air/water and water/water heat pumps with electrically driven compressors when used for sanitairy hot water. When these units are used for space heating, then EN 255-2 applies. Applies to factory-made units which can be ducted. In the case of units consisting of several parts, the standard applies only to those designed and supplied as a complete package. Does not include any requirement about the quality of water.

CEN/TC 113

Details:
This is the only remaining part of the old EN 255 heat pump standards still in force. All the others –for space heating and cooling—were superseded by EN 14511.

In fact, for test methods and requirements regarding the heat pump part this standard still relies mostly on the now superseded EN 255, parts 1, 2 and 4. See Lot 1 report for more details.

The specific part on sanitary hot water in EN 255-3 is very similar to EN 12302-1. It calculates the specific rate, the tapping capability and the 'maximum quantity of usable hot water in a single tapping' in a similar way. The determination of the energy efficiency is also similar, but not the same: There are two periods with a large draw-off and a reheating period in between. The length of time of the reheating period is undetermined (until thermostat cut-off). And the large draw-offs do not relate to a period of time but to a volume half the size of the storage vessel. The COP (coefficient of performance) is determined on the basis of the useful energy (water warmer than 40°C) from the second draw-off, set against the energy use of the installation. This installation comprises part of fan- or liquid pump input.

Furthermore, the standby effective power input is determined during 24 h of inactivity.

3.9 Gas-fired storage water heaters (EN 89: 1999)

Full title: EN 89:1999 en**.** Gas-fired storage water heaters for the production of domestic hot water

Latest amendment: **pre-amendent. A4:2004 en.**

Summary:
Defines the specifications and test methods for the construction, safety, rational use of energy and fitness for purpose, environment and classification and marking of gas-fired storage water heaters for domestic hot water uses, hereafter called "appliances". Applies to appliances of types B11, B11bis, C11, C12 and C31; - fitted with atmospheric burners; using one or more combustible gases corresponding to the three gas families and the pressures indicated in EN 437; - of nominal heat input not exceeding 150 kW (net calorific value); - using or not the water condensation heat in the combustion products; - appliances whether subject to the water mains pressure or open circuit.

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

CEN/TC 48.

Details:
This standard specifies a minimum efficiency (on net calorific value) of 98% for condensing appliances and 84% for all other types. Measurement is done at a continuous flow rate of 5 litres/minute, during which temperature, mass and gas consumption is measured. The specific rate, as a measure of the performance, is measured identical to EN 12302-1.

Amendment EN 89/A1:1999 deals with Type C appliances with pre-mix burners.

Amendment EN 89/A2:2000 deals with appliances with mechanical flue dampers.

Amendment EN 89/A4:2004 deals with requirements for materials to be used.

3.10 Gas-fired instantaneous water heaters (EN 26:1998)

Full title: EN 26:1998. Gas-fired instantaneous water heaters for sanitary uses production, fitted with atmospheric burners

Latest amendment: **pre-amendent. A3:2004**

Summary:
Defines the specifications and test methods concerning the construction, safety, rational use of energy and fitness for purpose, and also the classification and marking of gas-fired instantaneous water heaters for the production of domestic hot water, hereafter called "water heaters". Applies to water heaters:

- of types A_{AS}, B_{11}, B_{11BS}, C_{11} and C_{21};
- fitted with atmospheric burners;
- using one or more combustible gases corresponding to the three gas families in accordance with table 3 and at the pressure stated in tables 6 and 7 of 7.1.4.;
- of nominal heat input not exceeding 45 kW;
- with an ignition burner or with direct ignition of the main burner.

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

CEN/TC 48.

Details:
For the most part this standard duplicates the test gas, safety and soundness requirements of e.g. EN 303-1 and EN 303-3 on gas-fired boilers. The requirements on rational use of energy are different. The power of the pilot flame should be below 0,17 kW and for appliances with a nominal heat input exceeding 10 kW the minimum

efficiency (on net calorific value) shall not be less than 84%. For appliances smaller than 10 kW, the efficiency shall be more than 82%.

If the efficiency is more than 89%, the appliance runs the risk of condensing and the technical instructions should be given in line with the provisions in force in a country or countries.

Amendment EN 26/A1:2000 concerns the addition of C-type (room-sealed) appliances under this standard. Amendment EN 26/A3:2004 deals with requirements for materials (e.g. also plastics).

3.11 Electrical instantaneous water heaters, performance (EN 50193: 1997)

Full title: EN 50193:1997. Closed electrical instantaneous water heaters - Methods for measuring performance.

Summary:
Applies to hydraulic, closed electrical instantaneous water heaters, for household and similar use. This standard does not apply to storage water heaters (HD 500 S1) and to instantaneous water heaters with electronically controlled power input. This standard specifies definitions, rated power input, dimensions for connection and tests for assessing the performance characteristics. It does not deal with safety requirements which are covered by EN 60335-2-35.

3.12 Thermal solar systems, general requirements (EN 12976-1: 2001)

Full title: EN 12976-1:2001: Thermal solar systems and components – Factory made systems – Part 1: General Requirements.

(imminently to be replaced by prEN 12976-1:2004, which refers to directive 95/204/EG)

Summary:
Specifies requirements on durability, reliability and safety for Factory Made solar heating systems. The standard also includes provisions for evaluation of conformity to these requirements. The requirements apply to Factory Made solar systems as products. The installation of these systems itself is not considered, but requirements are given for the documentation for the installer and the user which is delivered with the system .

Details:
Standard made for factory made, packaged, solar hot water installations, i.e. an integrated system (ICS, Integrated Collector Storage) or a collector/water tank configuration.

Refers to prEN 806-1:1999 regarding suitability for drinking water, prEN 1717:1999 regarding water contamination, test methods in EN 12976-2 for frost protection. Furthermore, the system must resist thermally prolonged high solar radiation without heat consumption. The system will have appropriate reverse flow protection. Storage tank and heat exchangers must withstand tests according to prEN 12897:1997 or at least 1,5 times the nominal maximum working pressure (during 1 hour for non-metallic parts). Electric safety shall conform to EN 60335. Materials used outdoors shall be resistant to UV radiation and other weather conditions.

For tests of collectors, this standard refers to tests according to 12975-1:2000. For the robustness of the support frame against snow and wind ENV 1991-2-3 and ENV 1991-2-4 apply. Piping conforms to ISO/TR 10217, circulation pumps conform to EN 809 and EN 1151. For heat exchangers EN 307 is relevant. Hot water storage vessels comply with prEN 12897. The collector temperature sensor shall withstand 100°C and stagnation conditions as specified in 12975-2:2000. Furthermore, safety valves, safety lines and blow-off valves are prescribed. For lightning protection ENV 61024-1 applies. Finally the standard prescribes the technical documentation with the product. Annex A informs on first party conformity assessment and stipulates that –as per Dec. 2000—the 'Construction Products Directive' (89/106/EEC) does not apply to these products.

Please note, that custom built solar systems, such as described in the NVN-ENV 12977 standards (parts 1 to 3), are outside the scope of the Ecodesign directive. Having said that, most requirements of these systems are similar to the ones for factory built systems.

3.13 Thermal solar systems, test methods (EN 12976-2: 2001)

Full title: EN 12976-2:2001 : Thermal solar systems and components – Factory made systems – Part 2: Test methods.

(imminently to be replaced by prEN 12976-2:2004, which refers to directive 95/204/EG).

Summary:
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.

Details:
The 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 o),
- 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 (Stockhol, 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 o)
- 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 the 'parasitic' energy consumption of pump(s), controls, etc. is taken into account.

Ecodesign relevance: This standard effectively defines an elementary tapping pattern to which solar systems have been tested.

3.14 Solar heating – Domestic water heating systems (ISO 9459-3)

Full title: ISO 9459-3: 1997 Solar heating – Domestic water heating systems- Part 3

Summary:
International Standard ISO 9459-5 was prepared by Technical Committee ISO/TC 180 Solar Energy. ISO 9459 consists of the following parts, under the general title *Solar heating — Domestic water heating systems:*

- Part 1: Performance rating procedure using indoor test methods
- Part 2: Outdoor test methods for system performance characterization and yearly performance prediction of solar-only systems
- Part 3: Performance test for solar plus supplementary systems
- Part 4: System performance characterization by means of component tests and computer simulation
- Part 5: System performance characterization by means of whole system tests and computer simulation

Details:
ISO 9459-3 applies to solar plus supplementary systems and is considered the most relevant for practical use. The performance test is a 'black box' procedure which produces coefficients in a correlation equation that can be used with daily mean values of local solar irradiation, ambient air temperature and cold water temperature data to predict annual system performance. The test is limited to predicting annual performance for one load pattern.

The load pattern for water heating is given in the table below:

Time of day (h)	Percentage of daily total load drawn of
07:00	15
08:00	15
11:00	10
13:00	10
15:00	12,5
16:00	12,5
17:00	12,5
18:00	12,5

The standard prescribes measurements at a minimum of 5 data points in order to calculate the partitioning of the solar contribution and the contribution of the auxiliary system.

4 HEALTH STANDARDS

4.1 Introduction

Large part of the EU water heaters are storage water heaters, i.e. appliances with a storage vessel where the sanitary hot water is stored at a continuous temperature of 60°C. Large part of the heat loss of these water heaters is caused by the high water temperature, which –for health reasons— is substantially higher than what would be functionally required for a water heater (e.g. 45°C). The reason is the fear of the so-called '*Legionellaire's disease*' caused by the *Legionella* bacteria[14] , which is thereby causing considerable energy consumption and CO_2 emissions[15].

In the context of Eco-design it is therefore a relevant question whether the action of setting the 60°C water storage temperature for all domestic hot water heaters is correct, proportionate and in line with the scientific insights and the existing legislation.

4.2 Scientific insights

Legionella bacteria are always present in water systems, but in large quantities they can cause a severe pneumonia. This type of pneumonia can be treated with special antibiotics. The infection takes place through aerosols, i.e. very small water drops containing the bacteria and inhaled during showers, in whirlpools, from humidifiers and air-conditioning installations (cooling towers), etc.. It is not infectious amongst humans. Though estimates by the World Health Organisation are much higher, registered cases in EU Member States are never above 250 annual casualties per country. Groups that are more susceptible are the sick and the elderly, whereas children are generally unaffected. The mortality rate is slightly higher than with most types of pneumonia, i.e. around 15% whereas 5-10% is 'normal'.[16] As it is relatively rare, there is a risk of a (too) late diagnosis.[17]

Statistics on the exact causes of these casualties are lacking or imprecise. Research in France 1999 by the *Institut de Veille Sanitaire* showed that of the 440 declared cases (including 59 deaths) some 19% occurred in hospitals, 11% in retirement homes, 10% in hotels, campings, sports facilities and other sites with intermittent use. Also spas and aquatic centres showed a relatively high risk. For over half of the cases the place of contamination could not be assessed. In France (5% of total), but also in the UK, where '*vented*' water tanks were the standard practice until recently, it is believed that a significant number of *Legionella* cases are 'imported' by travellers abroad. The European Working Group on *Legionella* Infections EWGLI (www.ewgli.org) has published *European Guidelines for Control and Prevention of Travel Associated Legionnaires' Disease* approved and endorsed as an official document by the EU Committee for the Epidemiological Surveillance and Control of Communicable Diseases in the Community, instituted by Decision No 2119/98/EC of the European Parliament and the Council.

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[14] Note that *Legionella* can also cause Pontiac fever, which is an illness similar to influenza and lasts for a couple of days.

[15] Quantification to follow in upcoming tasks.

[16] However, the most common bacterial cause of community-acquired pneumonia - the streptococcus pneumonia—has a mortality rate of 25%. (source: Pneumonia – a patient's guide, in www.medic8.com/healthguide/articles/pneumonia.html)

[17] Diagnostics is often slow. In the Netherlands the only accepted method for living *Legionella* is a culture as described in NEN 6265. This takes one or two weeks. Another method is the DNA method, by which the DNA profile of *Legionella* can be determined within one day, measuring both dead and living *Legionella*. In medecine it is used e.g. to determine the serogroup and the origine of the *Legionella*.

From measurements of '*Legionella*' in hot water systems it was shown that mostly collective installations show high concentrations, especially in 'dead ends' of the piping[18] and where large hot water storage vessels are not used for a long time. In residential installations for one or two family homes with limited hot water storage (e.g. below 400 litres) concentrations are below any risk threshold. This goes certainly for vessels that are always kept at 60ºC, but also no casualties were ever reported for electric night-tariff storage water heaters where also the water may be stored for large parts of the day at temperatures that are favourable for *Legionella* growth (between 20 and 45ºC).

Water heaters most at risk would be solar thermal installations, where especially in winter or half-season relatively large storage vessels contain sanitary hot water that may sit up to days in low (lukewarm) temperatures. Yet, despite millions of installed solar thermal systems in use worldwide, no cases of *Legionella* have been reported that could be traced back to the solar water heater.

The important question here is whether a continuous storage temperature of 60ºC is not 'overkill' as a measure. Bacterial research has shown that at 70ºC *Legionella* is killed in a matter of seconds and at 60ºC a residence time of 2 minutes is enough to kill >90% of *Legionella*. At a typical flow rate for showers of 10 litres/min, this would mean that it is enough for water in a solar boiler to pass through a 20 litre 60ºC zone in a 'hot top' tank created by an auxiliary heater to eliminate >90% of *Legionella*. If the auxiliary heater is of the instantaneous ('flow-through') type, then it is sufficient to heat up to 70ºC (followed by a mixing valve to avoid burns) to kill any *Legionella* that might have built up in the storage tank. This means that not only the temperature but also the residence time is an important factor. In fact, at a residence time of 2 hours even a temperature level of 50ºC will kill more than 90% of *Legionella*.

At the temperature level that is favourable for *Legionella* growth, i.e. between 20 and 45ºC, the residence time also plays a major role, but now in a reverse sense. Most cases of excessive *Legionella* growthºCcur with large water tanks (>400 litres), extensive piping (>3 litres water content) and intermittent use. Although there is only anecdotal research and surveys with small sample size it appears that if the storage vessel is dimensioned for complete use of the volume within 1 or 2 days (e.g. 100-200 litres for a single family) the risk of *Legionella* growth is much less.

Apart from the residence time and the temperature there are other factors that play a role. Van Wolferen[19] lists the following factors promoting the growth of *Legionella*:

- Water. *Legionella*e live in water; without water they will die very quickly.
- Oxygen. *Legionella*e are aerobic bacteria that will die very quickly in anoxic water
- Water temperature. As discussed.
- Residence time. As discussed
- Standstill and stagnation. *Legionella*e thrive in stagnant water. Pipes or parts of an installation that have not been flushed are breeding grounds for *Legionella*.
- Acidity. *Legionella* can grow at pH of 5,5 to 9,2 and will survive a pH of 2,2 for 5 minutes
- Sediment and biofilm. *Legionella* requires different nutrients than other bacteria and finds them specifically in sediment and/or biofilm. Biofilm is a slimy, algaeous deposition on parts of the installation; this deposition is composed of a random collection of bacteria, protozoa and amoeba. The nutrients are procured from both the water and the inside surface of the pipe. In this biofilm, *Legionella* is more resistant to unfavourable conditions than when living free in water. Research has shown that does not easily attach itself to stainless steel and also copper tends to resist it. Plastics behave in various different ways. Rubber and comparable

[18] Parts of hot water distribution systems where there is no/little circulation, usually from renovations of the hot water piping in a building.

[19] **Van Wolferen, Hans**, *'Legionella in Hot Tap Production'*, in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

materials offer a favourable basis for biofilm and *Legionella*. Scale ('calcium') and sediment can overlie and thus efface the original biofilm-resistant properties of the material.

Control measures and disinfection methods, listed by van Wolferen are

- Thermal prevention**.** As discussed (above 50ºC or below 20ºC)
- Thermal disinfection, by weekly pipe flushing (20 minutes at 60ºC, 10 min. at 65ºC, 5 min. at 70ºC) or water reheating (10 min. at 60ºC, 1 min. at 65ºC and 10 s. at 70ºC) . Also steam cleaning of spas and aqua centres is used (60-70ºC but at longer times).
- Chemical disinfection in higher doses during short time (hours) or low concentrations continuously: NaOCl (can cause corrosion on copper piping), ClO_2 (less corrosive), $ClNH_2$ (up to 2 mg/l, only to be used continuously, may release ammonia), H_2O_2 (hydrogen peroxide, only used for short periodic treatment, max. 24 h.)
- Physical or chemical-physical disinfection.
  - *Anodic oxidation*: By way of electrolysis, substances in the water are converted into oxygen radicals, atomic oxygen, hydroxyl radicals, elementary chlorine an HOCl. Kills all bacteria in the system.
  - *Copper/silver ionisation*: Formation of copper ions (100-400 mg/l and silver ions (10-40 mg/l) by way of ionisation.
  - *Membrane filtration*: Microfiltration and ultrafiltration to keep out passing bacteria.
  - *UV disinfection*: Local UV radiation kills passing bacteria.
  - *Electrical pulses*: This affect the cell wall of the bacteria.

The assessment of what is an acceptable concentration level of *Legionella* is difficult because the disease is rare and levels are often set as a result of outbreaks affecting larger groups, e.g. at exhibitions or in hotels. For instance, following an outbreak at a public exhibition, the Temporary Decree in the Netherlands found any detectable level of *Legionella* (50 cfu/l.) unacceptable for any tapping point producing aerosols (showers). In the ***UK***, where even vented water tanks are allowed, for places accessible to the public (not private homes) the health inspection defines a level below 100 cfu/l. as acceptable and 1000 cfu/l. as a cause for immediate action. In Denmark, levels below 1000 cfu/l. are no cause for action and immediate action must be undertaken at levels above 100 000 cfu/l..

In the ***Netherlands*** –as in other countries— a methodology for Risk Analysis of hot water installation has been developed, that can also be applied to residential hot water systems. The Risk Analysis evaluates the risk of each component in a water heating system, based e.g. on residence time, periodical desinfection and temperature. Risks are negative (**-**, **--**, **---** rating indicating levels of *Legionella* growth), neutral (0, no or very low growth) or positive (+, ++, +++ indicating levels of *Legionella* destruction). As a principle, every component should have at least a neutral (0) or positive rating (+) when the components are used in parallel. When the components are used in series, than a positive-risk component can compensate a preceding equivalent negative-risk component. In other words, a '+' after heater system compensates for a '**-**' storage vessel, a '+++' after heater compensates for a '**---**' pre-heater. The table below gives risk factors for hot water storage tanks:

Table 4-1. Risk factors depending on temperature, periodical thermal disinfection and residence time in hot water storage vessels (source: ISSO 55.1, 2001)

risk —>	- - -	- -	-	0	+	++	+++
25-45ºC daily thermal disinfection				unlimited			
25-45ºC weekly thermal disinfection**			unlimited				
25-45ºC no thermal disinfection	unlimited						
45-50ºC		unlimited					
>50ºC				unlimited			
55-60ºC					>1 hour	>2 hours	>3 hours
60-65ºC					> 3 min.	> 5 min.	> 10 min.
65-70ºC					>20 s.	>40 s.	>60 s.

ISSO 55.1 guidelines for weekly thermal disinfection of storage vessels are slightly higher than those mentioned above, i.e. 20 minutes at 60ºC, 10 min. at 65ºC and 5 minutes at 70ºC. The guidelines add that

- If the purpose of a storage vessel is also to neutralise any *Legionella* growth in preceding vessels, it should be guaranteed that the water remains in the vessel for minimally the required time at the given temperature. Under no condition may a shorter residence time and/or a lower temperature occur.
- In all storage vessels, thermal stratification may occur whereby there is a water in the vessel that has a lower temperature than the temperature indicated by the thermostat. This may happen if the heating element/coil is not positioned straight at the bottom of the vessel or (e.g. in the case of a vented storage tank) the vessel is not sufficiently charged.
- During peak hours, a temporary drop in temperature may occur. In most cases, this is permissible as long as the water reaches the set temperature for one or more hours daily. However, it is not permitted if a vessel is used as a 'after heater' for thermal disinfection of water coming from preceding vessels.

An IEA Legionella Workshop in Delft, 2001, where an international group of experts has discussed the problem (e.g. TNO, BBRI, EdF, DVGW, DTI, Boverket, BSRIA), gives an overview of the most recent research in the field:

In ***Denmark*** [20] two studies on domestic water heaters were done. The first study was on the growth of bacteria in 12 'solar prepared' tanks and 12 traditional tanks, in the context of preparing for new Danish Building regulations that might want to make 'solar prepared' tanks mandatory. There were hardly any differences in bacterial counts. The bacterial counts were low compared to other investigations on larger systems in flats. In a second following study hot water samples were taken from actual domestic hot water systems and checked for *Legionella*. Five out of 24 boilers contained *Legionella*: none in the solar prepared tanks, one in traditional tanks and 4 out of 8 in the solar tanks. The level was considered low, despite the fact that the temperature level found in the systems was at a fairly favourable temperature (40-50ºC) for bacterial growth.

In ***France*** [21] research was done with *Legionella* injected in a large hot water system (3 vessels of 1500 litres each). The *Legionella* was attacked with different control strategies. Main conclusions are that *Legionella* reduces 2 log for a heating period of 8 hours at 65ºC. After 2 days there was no *Legionella* detected at the output of systems (in any scenario). A temperature of 70ºC eliminated *Legionella* in the tank, but it was still present in piping without circulation.

[20] **Bagh, L.K. (Rovesta) and Ellehauge (DTI)**, '*Bacterial Growth in Solar Heating Prepared and Traditional Tanks*', in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

[21] **Ziegler, B. (EdF)**, *'Concentration of Legionella in hot water electrical storage systems'*, in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

A ***Belgian*** [22] research project was performed in 2000-2002 aiming at in-situ evaluation of anti *Legionella* treatments for sanitary hot water (physical and chemical).

4.3 Legislation

EU-directives on the subject are very general. The Drinking Water Directive 98/83/EC states that 'water should be safe'. The European standard 806-2 is stating 'The hot water temperature in the pipe work shall not drop below 50ºC.' Some (older) national standards on water heaters, may mention a minimum storage temperature of 60ºC, but in this context the legal status of standards has to be well understood. When standards are not backed up by legislation ('New Approach') they are not mandatory. Furthermore, the fact that an appliance conforms to an industry standard –confirmed by third party testing and/or CE-marking— does not relief in any way the responsibility and liability of the manufacturer for his products.

In the ***Netherlands***, following the outbreak of *Legionella* at a public manifestation with a whirlpool/ fountain in Bovenkarspel (32 casualties), *Legionella* became a political priority. This resulted in the *Temporary Decree for Legionella Prevention in Tap Water*, in which is stated that by 15 Oct. 2001 all public or collective drinking water systems should have a risk analysis. If there is a risk, a control plan should be implemented. Temperature at the tap should be at least 60ºC in those larger installations.

Denmark [23] has no specific legislation. Normal regulations for hot water production apply. All measures are recommendations. A minimum temperature of 50ºC at the tapping point is sufficient. Proposed reaction limits: < 1000 cfu/l no action, > 100000 corrective measures should be taken (cfu= colony forming unit).

France [24] has new regulations with three main requirements: 1. Temperature of domestic should never exceed 50ºC at draw-off point (mixing valve is necessary); 2. The temperature of collective distribution networks should be higher than 50ºC; 3. If there is a storage vessel with volume >400 litres or the volume of the pipe leading to the most distant draw-off point is more than 3 litres, then water that is stored for more than 24 hours should be heated up to a temperature of more than 60ºC.

CECED reports that starting 15 December 2006 a minimum storage temperature of 55 °C will come into force for storage water heaters. Details, e.g. how this will inflict solar water heaters are not reported.[25]

In ***Germany*** [26] the codes of practice W551 (new buildings) and W552 (existing buildings) have been in use for several years. These codes aim to reduce *Legionella* in drinking water systems and conduits. A distinction is made between small and large systems. Small systems (storage vessel <400 litres, pipework volume < 3 litres) are considered to have very low risk and receive no special attention. These are typical installations in one or two family houses. Large systems should be designed so that they are heated up to 60ºC once a day. In Germany, the maximum water temperature at the draw-off point should be 45ºC to avoid burns (in most countries this is 50ºC or even there is no limit). In 2003 Germany has introduced a mandatory inspection scheme for *Legionella* (Trinkwasserverordnung).

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[22] **De Cuyper, K. (BBRI)**, *'In situ survey of Legionella in Belgium'*, in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

[23] **Bagh, L.K. and Ellehauge, K.**, *'Legionella and Hot Water Systems in Denmark'*, in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

[24] **Bonnefoi, F.**, *'Present regulation and new regulation project on Legionella prevention in France'*, in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

[25] Pers. Comm.. M. Rambaldi, CECED, 3.12.2006

[26] **Waider, D.**, *'DVGW Code of Practice W 551'*, in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

Sweden[27] has no specific legionella legislation. Normal regulations for hot water production apply. A minimum temperature of 50°C at the tapping point and in circulation systems is deemed sufficient. There is a recommendation that the temperature and calorifiers or storage tanks should not be less than 60°C. Some 95% of solar thermal systems are used both for hot water and for space heating (central heating water). There is a low risk of *Legionella* growth, because it is the primary water (CH water) that is normally stored. There are no known cases of Legionellosis in Thermal Solar systems in Sweden.

In ***Belgium*** [28], as in the Netherlands, an outbreak of Legionellosis at a public exhibition in November 1999 prompted new initiatives for regulations. In the region of Flanders these concern water systems in buildings open to the public. Requirements are cold water < 20°C and hot water >60°C. All systems must have a risk analysis performed, a *Legionella* managing plan and a logbook.

The ***United Kingdom*** has an approved code of practice and guidelines in place since 1991, revisied in 2001. The Health and Safety at Work etc. Act of 1974 gives health & safety inspectors the possibility to inspect and enter all site, to issue enforcement notices an eventually prosecute. Temperature in storage >60°C, cold water <20°C. Action levels at inspections: <100 cfu/litre means 'under control', >1000 cfu/litre means immediate action. There are thousands of companies that do inspections. For individual houses there are nearly no restrictions.

Outside the EU, there seems to be less concern over Legionellosis. For instance in the ***US***, where the disease was first discovered in 1978 and where estimates of casualties are certainly not lower than in Europe, no federal or state regulations were found on the issue of hot water storage temperature. The US government (DoE site www.eere.gov) is recommending in its Energy Guidelines residential customers to lower their hot water storage temperature to 120°F (48°C), which is –in a liability conscious country— at least remarkable.

The table on the following page gives an overview of the guidelines in the various EU Countries.

[27] **Jönsson, B. (Boverket)**, *'Regulatory Aspects: Sweden'*, in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

[28] **De Cuyper, K. (BBRI)**, *'Legionella in Belgium'*, in Proceeding IEA Workshop Legionella, Delft, The Netherlands, 4/5 Oct. 2001.

Table 4-2. References for National Guidelines for Control and Prevention of Legionnaires' Disease (EWGLI 2005)

Country	Name of document	Year	Publication
Belgium	Relatif aux dangers de et aux mesures préventives contre une contamination par Legionella en Belgique (C.S.H.: 4870)	Sept. 2000	Conseil Supérieur d'Hygiène Brussels
	Recommendations Pour La Prevention Des Infections A Legionella Dans Les Etablissements De Soins No CSH: 7509	January 2002	As above
Czech Republic	Metodicky navod k zajisteni programu surveillance legioneloz	2000	Ministerstvo Zdravoknictvi Praha
Denmark	Guidelines: Legionella En Vejledning: Legionella i varmt brugsvand. Overvågning, udbredelse og forebyggelse af legionærsygdom. ISBN 87-89148-25-8	1998 2000	Statens Serum Institut, Copenhagen As above
France	Guide des bonnes pratiques: Legionella et tours aéroréfrigeérantes	June 2001	Directorate-General of Health, Paris
	Gestion du risque lié aux legionelles: Rapport du Conseil Supérieur d'Hygiène Publique de France	July 2001	As above
Germany	Drinking water heating systems and conduits; Technical measures to decrease legionella growth	1993	W 551 DVGW, Bonn
	Drinking water heating systems and conduits; Technical measures to decrease Legionella growth; rehabilitation and operation	1996	W 552 DVGW Bonn
	Protection of Infection Act (IfSG) Act on Prevention and Control of Infectious Diseases in Man	July 2000	Federal Ministry of Health
Ireland	The Management of Legionnaires' Disease in Ireland	2002	National Disease Surveillance Centre, Dublin
Italy	Linee -guida per la prevenzione ed il controllo della legionellosi	May 2000	Gazzetta Ufficiale, serie generale, n.103
Latvia	Epidemiological surveillance of legionellosis	Oct 1998	Ministry of Welfare
Malta	Code of Practice for the Prevention of Legionnaires' Disease in Hotels and Other Establishments	March 1999	Health Division, Malta
Netherlands	Modelbeheersplan Legionellapreventie in Leidingwater Distribution No 16827	feb-02	VROM (The Netherlands Ministry of Housing)
	Risico analyse, ISSO 55.1		ISSO
Norway	Tiltak mot Legionella-bakterier i VVS-installasjoner ("Actions against Legionella-bacteria in water systems") (1993) ISBN 82-7364-069-8.	1993	Statens institutt for folkehelse
	Smittevern 5. Smittevernhåndbok for kommune-helsetjenesten 2002-2003 ("Communicable Disease Control Handbook") (2001) ISBN 82-7364-177-5.	2001	As above
Portugal	Doença dos Legionários. Procedimentos de controlo nos empreendimentos turísticos	July 2001	Direcção Geral de Saúde e Direcção Geral de Turismo
Spain	Recomendaçiones para la prevención y control de la legionelosis	1999	Dirección General de Salud Pública. Ministerio de Sanidad y Consumo. ISBN 84-7670-507-7.
	Guía para la prevención y control de la proliferación y diseminación de legionella en instalaciones	2001	AENOR
	Real Decreto 909/2001 Criterios higiénico-sanitarios para la prevención y control de la legionelosis. Boletín Oficial del Estado no. 180	2001	Ministero de Sanidad y Consumo.
Switzerland	Légionelles et légionellose. Particularités bioloqiques, épidémiologie, aspects cliniques, enquêtes environnementales, prévention et mesures de lutte.	1999	Office Fédéral de la Santé Publique, Berne
United Kingdom	Legionnaires' disease The control of Legionella bacteria in water systems (L8)	2000	Health and Safety Commission
WHO	Guidelines For Safe Recreational-Water Environments. Vol. 2: Swimming pools, spas and similar recreational-water environments	August 2000	WHO Headquarters Geneva

Apart from Legionella it must be mentioned that this isn't the only health concern related to hot water systems and temperature. As mentioned, the German legislator concerned about the risk scalding (burns) with higher temperatures (>45°C). Anti-scalding legislation is contemplated in the UK. In Canada anti-scalding (<49°C) was in troduced in 2004[29], making an anti-scalding mixing valve a necessity.

In Denmark there is a concern over bacterial growth in general, causing skin allergies and bad odor. From studies it was found that –through thermophiles (bacteria that thrive at high temperatures)—the Heterotrophic plate counts (HPC) were higher at higher temperatures. Furthermore, higher temperatures cause concern on the product-life (corrosion) and the effect of scaling (calcium deposits). The latter influences energy efficiency, but also interacts with biofilms.

There is the risk of CO-intoxication with open combustion appliances, which in the UK alone is leading to around 30 deaths annually. And finally, much further down the risk scale, there is always the possibility of gas-, LPG- and oil-leaks, which may lead to explosions, fire, etc..

4.4 Conclusions

In general, one can conclude that the recommendation by some public health authorities –to store sanitary hot water continuously at a temperature of at least 60ºC in all types of water heating installations may be –in view of the scientific insights— too blunt.

It is incoherent with other parts of guidelines where the recommended water temperature at the tapping point is 50ºC. Of course there is a compromise here with the other risk of burns from hot water, but from the point of view of *Legionella* prevention it may address the wrong issue: known cases of *Legionellaire's disease* from hot water systems involved the piping and not the storage vessel.

Given the penalty in terms of energy consumption as manufacturers of conventional (non-solar) water heaters followed the recommendation to the letter— the recommendation appears disproportionate, especially for domestic hot water systems in one or two family households.

Mandatory provisions in legislation relate to hot water systems in buildings open to the public (hotels, swimming pools, hospitals, etc.) and –as far as hot water installations in single/double family homes are concerned— to the minimum water temperature at the tapping point (Sweden, minimum 50ºC) and to the minimum water temperature in re-circulation hot water systems (also Sweden, minimum 50ºC) in individual homes.

In other words, there are no mandatory legal provisions that prescribe a minimum continuous storage temperature of hot waters in vessels and that would keep us from proposing Eco-design measures that are based on the scientific insights.

- For hot water storage vessels this means to follow the principles of the Risk Analysis explained earlier.
- For hot water piping networks it seems most appropriate to adhere to the legislation in some Member States (i.e. Sweden) and assume a minimum water temperature of 50ºC at the tapping points (with a mandatory mixing valve in Germany where the maximum tapping temperature should not exceed 45ºC)

[29] Building Code, O.Reg.23/04

5 EU BUILDING STANDARDS

As mentioned by the convenor of the TC during the last stakeholder expert meeting the building standards regarding the energy efficiency of hot water systems are currently being revised. Consequently, we will wait with a detailed discussion of prEN 15316-3, parts 1 to 3 until such time that the standards are in the form of a final draft.

6 EU LEGISLATION & VOLUNTARY AGREEMENT

Water heating appliances 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 CE 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 water heaters, 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 water heater (sealed)
- EN 677:1998 - gas fired central heating water heater (condensing)
- EN 625:1996 - gas fired central heating water heater (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 water heaters 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

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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

- "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

- 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 Energy Labelling Directive (92/75/EC)

Water heaters are on the list of appliances to be labelled with a mandatory EU Energy Label according to the 92/75/EC Framework Directive. However, pending appropriate test standards, this has not been implemented so far.

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 hot water appliances 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, not specified in Annex I, 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 water heaters 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 CECED Voluntary Commitment

In November 1999 the European Committee of Domestic Equipment Manufacturers (CECED) presented a commitment about reducing standing losses of domestic electric storage water heaters (DESWH) to the European Commission. By signing the voluntary commitment participants commit themselves to reduce the total energy consumption of storage water heaters and thereby CO_2 emissions caused by power generation.

The originally 10 participants in this Commitment represent more than 70% of the European market in the product group domestic electric storage water heaters.

[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.

Participants are Atlantic (FR), BAXI (IT), Bosch-Siemens (DE, excl. Siemens Heiztechnik which is no longer producing water heaters), Electrolux (S), Fagor (ES), Heatrae Sadia (UK), Lorenzi Vasco (ceased 2006), Merloni Termosanitari (IT), State France (FR), Stiebel Eltron (DE) and Vaillant (DE). The number of brands affected by the Commitment is close to 120.

The Commitment was notified in 2000. The European Commission consolidated the endorsement process by the official recognition from DG Competition in November 2001 that energy savings outweigh the restrictions on competition.

Manufacturers have been acting in the spirit of the commitment since the first targets were shaped in 1998.

The Commitment combines three elements:

- a standing losses declaration in the form of additional and clearly visible data,
- a stepwise phase-out of less efficient appliances ranking in certain draft energy label classes according discussion with the Commission in 1998, 1999,
- a reduction of the European fleet consumption of appliances - as calculated by a notary

The phase out after December 31, 2000 of less efficient water heaters produced for and import in the Union is based on the following formula which define for the different types of products the maximum allowable standing losses values (Emax expressed in kWh per 24 hours):

Small appliances

- Unvented products: Emax = 0,1474 + 0,0719 $* V^{2/3}$
- Vented products: Emax = 0,1561 + 0,0802 $* V^{2/3}$

Vertical appliances

- Vented products: Emax = 0,236 + 0,074 $* V^{2/3}$
- Unvented products: Emax = 0,224 + 0,0663 $* V^{2/3}$

Horizontal appliances

- Unvented products: Emax = 0,939 + 0,0104 $* V$
- Vented products: Emax = 1,034 + 0,0116 $* V$

Furthermore, each participant is committed to contributing to the overall objective for the European Production ("fleet target") to achieve a reduction in the weighted average standing losses by the beginning of 2002. By this engagement each manufacturer undertakes to reduce the weighted average standing losses for each rated capacity of his production to the following thresholds (Emax expressed in kWh per 24 hours):

- Horizontal appliances (45-220 litres): Emax = 0,75 + 0,008 $* V$
- Vertical appliances (45-220 litres): Emax = 0,2 + 0,051 $* V^{2/3}$
- Small appliances (25-45 litres): Emax = 0,13 + 0,0553 $* V^{2/3}$

Note: For a comparison of the fleet-target values for vertical appliances e.g. with MEPS outside the EU see the Chapter on Australia in this report.

The table below gives the outcome of the notary report for the full year 2001. Histograms in the report that for vertical and horizontal appliances the participants performed more or less on target for capacities up to 100-120 litres. For small appliances (30 litre) they performed 5% better than target.

Table 6-2. CECED Voluntary Commitment Notary Report on 2001 (CECED 2003)

DESWH Type/Category	Number of pieces Produced/Imported (n)	Weighted standing losses per category/capacity class (kWh per 24 hours) (a)	n x a	Overall savings
Vertical unvented 50 lt	413 858	0,91	376 723	
Vertical unvented 65 lt	4 935	0,65	3 208	
Vertical unvented 70 lt	1 134	1,82	2 064	
Vertical unvented 75 lt	255 426	1,16	296 877	
Vertical unvented 80 lt	202 476	1,07	215 971	
Vertical unvented 95 lt	81 166	1,25	101 285	
Vertical unvented 100 lt	187 118	1,1	205 912	
Vertical unvented 120 lt	130 974	1,29	169 607	
Vertical unvented 125 lt	1 430	2,04	2 917	
Vertical unvented 145 lt	3 110	2,16	6 718	
Vertical unvented 150 lt	304 580	1,33	406 185	
Vertical unvented 170 lt	2 142	2,27	4 853	
Vertical unvented 180 lt	699	4,06	2 838	
Vertical unvented 200 lt	355 813	1,59	566 803	
Vertical unvented 210 lt	4 311	3	12 941	
Vertical unvented 300 lt	3 865	2,2	8 503	
Vertical unvented 400 lt	1 032	2,67	2 760	
Vertical unvented 600 lt	265	4,6	1 219	
Vertical unvented 1000 lt	85	5,7	485	
Horizontal unvented 50 lt	2 951	1,01	2 981	
Horizontal unvented 75 lt	33 194	1,44	47 639	
Horizontal unvented 80 lt	3 368	1,6	5 381	
Horizontal unvented 95 lt	9 826	1,43	14 034	
Horizontal unvented 100 lt	16 668	1,24	20 712	
Horizontal unvented 150 lt	21 757	1,61	35 085	
Horizontal unvented 200 lt	13 045	1,88	24 469	
Small unvented 30 lt	297 623	0,64	190 104	
Total of the year 2001	2 352 851		2 728 271	1,16
compare:				
Total of the year 2000	2 345 372		2 812 246	1,2

7 NETHERLANDS

7.1 Introduction

In the Netherlands energy efficiency and emission reduction of water heaters is promoted through several Gaskeur labels and the Netherlands Building Regulations and energy performance for buildings rules ('EPC'). This chapter gives an overview of the EPC rules for water heaters as they are defined in the NEN 5128:2004, which are very much linked to the Gaskeur labels. The final paragraphs deal with labelling systems and type approval.

7.2 NEN 5128:2004

The annual net heat requirement $Q_{tap\text{-}net}$ for hot water (in MJ) is calculated from the total heated surface of the building A (in m²) with $Q_{tap\text{-}net} = 68 * A$. For instance, for a dwelling with 90 m² surface this amounts to 6120 MJ.

It is assumed that 80% of this requirement results from the bathroom taps and 20% from kitchen draw-offs. This is especially relevant for the system efficiency in case of multiple hot water installations. If a dwelling has two hot water installations, one for the kitchen and one for the bathroom, the individual efficiencies of these installations are weighted with a ratio 20:80. In case of multiple bathrooms and kitchens in one dwelling the system efficiency can either be partitioned on the basis of straight numbers (e.g. 2 bathrooms → each counts for 50%) or the surface area of the dwelling that depends on the bathroom or kitchen.

For each hot water installation the ***system efficiency*** has to be assessed. For hot water to the bathroom the default ***internal distribution ('piping') efficiency*** is 86%. For hot water going to the kitchen tap, the default efficiency is 48% if the internal diameter of the hot water tube is less than 10 mm over 2/3 of its length or 36% if the diameter is larger than 10 mm. Instead of the default values one can use the following look-up table:

For a single installation —using the default values— without circulation-loop, without solar assistance, the primary gross energy requirement Qtap-gross can be calculated from the heated surface of the house A as follows

$$Q_{tap\text{-}gross} = (0{,}8/0{,}86 + 0{,}2/0{,}48) * Q_{tap\text{-}net} * A = 1{,}346 * 68 * A = 91{,}6 * A$$

Or, in other words, the overall distribution efficiency of this installation is 1/1,346 = 74%.

In case of a circulation-loop supplying the hot water, a ***circulation efficiency*** multiplier has to be taken into account. Basically, this calculation is based on a heat loss of 10 W per meter of piping that is outside the heated area of the house, which comes down to 300 MJ/m/year.

In case of collective heating/district heating where a heat exchanger (NL. *'afleverset'*) is used to convert the district heat to sanitary hot water, an extra ***conversion efficiency*** multiplier applies. Depending on the design temperature this conversion efficiency multiplier is 0,75 (high = HT) or 0,85 (low=LT).

Table 7-1. Sanitary hot water distribution efficiency (NEN 5128:2004)

length of pipe (in m) —>	**0-2**	**2-4**	**4-6**	**6-8**	**8-10**	**10-12**	**12-14**	**>14**
kitchen								
piping ≤ 8 mm internal diameter over 2/3 of its length	1,00	0,86	0,75	0,67	0,60	0,55	0,50	0,46
piping ≤ 10 mm internal diameter over 2/3 of its length	1,00	0,79	0,65	0,55	**0,48**	0,43	0,38	0,35
piping >10 mm internal diameter over 2/3 of its length	1,00	0,69	0,53	0,43	**0,36**	0,31	0,27	0,24
bathroom								
all	1,00	0,95	0,90	**0,86**	0,82	0,78	0,75	0,72

Another multiplier, in case of district heating or block heating is the ***external distribution efficiency***, which cover the losses in piping outside the building. If the sanitary hot water is heated outside the building and distributed to the individual user, then this multiplier is default 0,75. If a heat exchanger is used at dwelling/building level, the default multiplier is 0,90 for LT systems and 0,80 for HT systems. Instead of default values, NEN 5128:2004 also gives a more comprehensive method to exactly calculate the values for a specific situation.

The system efficiency η_{sys} is thus:

$$\eta_{sys} = \eta_{int.distribution} * \eta_{circulation} * \eta_{conversion} * \eta_{ext.distribution}$$

Please note that in the NEN 5128:2004 the penalty for internal distribution losses is very significant and –apart from the comfort factor—explains why even in new single family homes (> 80% of NL dwellings) small electric storage boilers are popular. In the Dutch situation the combi-boiler is usually placed in the attic, whereas the kitchen is far away on the ground floor of a single family house.

The gross sanitary hot water heat requirement is

$$Q_{tap\text{-}gross} = Q_{tap\text{-}net} / \eta_{sys}$$

The value of $Q_{tap\text{-}gross}$ determines the so-called application class, at which the generator efficiency should be determined. Characteristic values are 6500 MJ (Class 1), 9000 MJ (Class 2), 11500 MJ (Class 3) and 14000 MJ (Class 4). For hot water installations that are only used in the kitchen there is a 'kitchen' class. Intermediate values should be found through interpolation between these characteristic values, which most often means that the efficiency of a generator has to be determined for two classes.

The classes in NEN 5128:2004 correspond to the *Gaskeur CW* ("Comfort Warmwater") *classification*, where water heaters are tested with a tapping pattern very similar to the EN 13203-2 tapping patterns. *CW1* corresponds with the NEN5128 'kitchen' class, *CW1 plus an extra evening shower* (as in CW2) corresponds to NEN 5128 Class 1. NEN 5128 Classes 2 and 3 correspond to *CW2* and *CW3* respectively, whereas NEN 5128 Class 4 corresponds to *CW-4, 5 and 6*.

The *Gaskeur* labeling scheme, which also —apart from energy efficiency— relates to certain comfort aspects, basically provides the input for the generator efficiency of gas-fired appliances in NEN 5128:2004.

In this table the correction factor ctap is relevant for individual installations (>90% of NL dwellings). This correction factor assesses the generator efficiency for an application class that is different from the application class for which this generator was originally tested by Gaskeur. This is necessary for an exact assessment of intermediate values, as mentioned above. But, when looking at the content of this table, one can also say that it takes into account the ***over-sizing*** of the installation. For instance, if the installation is tested for CW3 (11500 MJ/year) and used in a house with a calculated calculated requirement $Q_{tap\text{-}gross}$ of 11500 MJ or more than the correction factor is c_{tap} =1, but if the same installation is used in a house that has a calculated requirement $Q_{tap-gross}$ of only 6500 MJ, then the correction factor c_{tap} =0,85.

Please note that typically the maximum electric power in a Dutch single family home is limited to 3,6 kW (fuse of 16A). For that reason, electric flow-through water heaters, which usually require a higher power level, are rare in the Netherlands and therefore not incorporated in the table.

Table 7-2. Correction factor c_{tap} for individual gas-fired, electrical and CHP appliances (NEN 5128:2004, table 30)

	$c_{tap-gross}$ in MJ				
efficiency according to class	**≤ 2000**	**6500**	**9000**	**11500**	**≥ 14000**
Class 1 (CW-1*)	1	1	1	1	1
Class 2 (CW-2)	0,72	0,9	1	1	1
Class 3 (CW-3)	0,72	0,85	0,925	1	1
Class 4 (CW-4/5/6)	0,68	0,8	0,867	0,933	1

Table . Correction factor c_{tap} for individual heat pumps (NEN 5128:2004, table 31)

	$Q_{tap-gross}$ in MJ			
efficiency according to class	**≤ 6500**	**9000**	**11500**	**≥ 14000**
Class 1 (CW-1*)	1	n.a.	n.a.	n.a.
Class 2 (CW-2)	0,6	1	n.a.	n.a.
Class 3 (CW-3)	0,49	0,81	1	n.a.
Class 4 (CW-4/5/6)	0,45	0,75	0,92	1

Table 7-3. Generator efficiency for sanitary hot water heaters (NEN 5128: 2004)

Individual installations	η_{gen}
gas-fired combi or dedicated water heater	0,3
gas-fired dedicated water heater with CW-label	$c_{tap} \cdot 0{,}4$
gas-fired dedicated water heater with HRww-label	$c_{tap} \cdot 0{,}625$
gas-fired combi with CW-label	$c_{tap} \cdot 0{,}5$
gas-fired combi with HR/ CW-label	$c_{tap} \cdot 0{,}6$
gas-fired combi with HRww-label	$c_{tap} \cdot 0{,}675$
electric heat pump using return ventilation air, not specified	$1{,}4 \cdot \eta_{el}$
el. heat pump using return ventilation air, meeting min. specs. in Annex C*	$c_{tap} \cdot (2{,}2 \cdot \eta_{el})$
combi-heat pump using other heat source (not ventilation air)	$1{,}4 \cdot \eta_{el} \cdot c_{bron}$
electric storage water heater (bathroom and/or kitchen)	$c_{tap} \cdot (0{,}75 \cdot \eta_{el})$
CHP (Combined Heat and Power) installation	$c_{tap} \cdot \eta_{gentapchp} \cdot 0{,}8$
Collective appliances heating a circulation-loop with hot water	
Directly gas-fired appliance (>70 kW)	0,5
Indirectly (through heat exchanger) gas-fired storage appliance	$0{,}9 \cdot \eta_{genheat}$
el. combi-heat pump using other heat source than ventilation air	$1{,}4 \cdot \eta_{el}$
el. combi-heat pump using brine as a heat source*	$(2{,}2 \cdot \eta_{el}) \cdot c_{bron}$
el. combi-heat pump using soil as a heat source*	$(2{,}0 \cdot \eta_{el}) \cdot c_{bron}$
el. storage water heater	$0{,}75 \cdot \eta_{el}$
CHP at building level, method with equivalent power generation efficiency	$0{,}9 \cdot \eta_{genheatchp}$
CHP at building level, extended method with explicit compensation of power generation	$0{,}9 \cdot \eta_{genheatchp}$
Collective appliances heating a CH-loop, connected to 'converter' that supplies hot water	
CHP at building level, method with equivalent power generation efficiency	$\eta_{genheatchp}$

CHP at building level, extended method with explicit compensation of power generation	$\eta_{genheatchp}$
Block/district heating, method with equivalent generation efficiency	$\eta_{equivtap}$

Legend:

c_{tap} = correction factor for the application class (see table below)

c_{bron} = correction factor for the heat source in case of collective or regenerating HP (annex B.4 → correction

factor c_{bron} varies between 1,0 (<50% regeneration), 1,02 (50-75% regeneration) and 1,04 (>75% regeneration)

η_{el} = power generation efficiency (paragraph 15.2 —> η_{el} = 0,39)

$\eta_{genheat}$ = generation efficiency for heating (as in paragraph 8.4)

$\eta_{genheatchp}$ = generation efficiency for heating in a CHP installation at building level (Annex B.5.1)

$\eta_{gentapchp}$ = generation efficiency for water heating in a CHP installation

$\eta_{equivtap}$ = equivalent generation efficiency for external SHW supply (according to 15,3—> 1,0)

* = el. HP with an efficiency on upper value of at least 85,8% for ventilation air or brine as heat sources. In case of soil as a heat source the efficiency should be at least 78% (2 · η_{el})

7.3 Solar energy

In the case of solar-assisted water heating, the captured annual solar energy is determined as the product of the collector surface (in m²), the specific solar radiation (in MJ/ m²) and a shadow-reduction factor (trees, buildings, etc. blocking the sunlight). The 20-page Annex A of NEN 5128 gives the look-up tables for solar gain and shadow-reduction factors in dependence of collector angle, orientation, etc. for the Dutch climate. For hot water the solar energy over the whole year Q_{solar_year} is assessed.

The annual efficiency of the solar system for SHW is determined from the ratio between the gross hot water requirement $Q_{tap\text{-}gross}$ and the captured Q_{solar_year} (see table, intermediate values to be assessed through linear interpolation).

Table 7-4. Annual efficiency of solar energy system for sanitary hot water (NEN 5128:2004)

ratio Qtap-gross/ Qsolar_year	Annual efficiency solar η_{solar}
<0,38	0,63 · (Qtap-gross/ Qsolar_year)
0,38	0,24
0,80	0,30
1,20	0,36
>=1,60	0,40

The annual solar contribution to the hot water generation Q_{solar_tap} is

$$Q_{solar\_tap} = \eta_{solar} * Q_{solar\_year}$$

The primary energy requirement for hot water Q_{prim} is

$$Q_{prim} = (Q_{tap\text{-}gross} - Q_{solar\_tap}) / \eta_{gen}$$

7.4 Labels

The Gaskeur label is a voluntary labelling scheme for gas appliances (bothe boilers and water heaters) managed by an independent foundation Stichting Energie Prestatie Keur (EPK, site www.gaskeur.nl). The foundation was founded by the heating industry and certification institute Gastec, which is now part of KIWA (www.kiwa.nl). For water heaters several types of labels exist:

Gaskeur CW (‘Comfort Hot Water’) is a performance label, where the comfort level depends on the tapping pattern and some additional secondary parameters. For instance, ‘CW-3’ corresponds with the EN 13203 tapping pattern no. 2, as is explained in the previous paragraphs. The label is voluntary, but there is a full collaboration from industry, because important parties in the building process (e.g. Guarantee Fund) use it for the purpose of specification of the minimum performance desired.

Gaskeur HRww ('High Efficiency Hot Water) is a volunatary energy mark for gas appliances meeting certain minimum efficiency requirements. The NEN 5128 refers to the minimum levels in 2004 of 62,5% for dedicated water heaters and 67,5% for combi-boilers. But these levels –measured during the designated tapping pattern (usually CW3) may change independently of the NEN 5128. For instance, current proposals are going in the direction of a 75% efficiency for water heaters and combi's with a storage function and 80% for those without storage function.

Gaskeur SV ('Clean Combustion') is replacing a previous 'low-NO_x' label. Appliances qualifying for the Gaskeur SV label have to meet emission limit values for NO_x of <40 ppm and CO < 160 ppm.

Gaskeur NZ ('Auxiliary Heating Solar Systems') applies to gas appliances that are (especially suited) to function as an auxiliary heating for solar systems.

For the performance of solar thermal systems the EPK manages the ***Zonnekeur*** label, which is also the basis for government subsidy programmes (if and when they exist).

Type approval

According to a study by ECN [34] gas-fired storage water heaters (and of course combi-boilers) are subject to type approval 'Typekeuringsbesluit' (BEES A), which sets a basic NO_x level of 157 ppm (157 mg/m³ at 3% O2) for atmospheric burners, 105 ppm for fan-assisted burners and 70 ppm for pre-mix burners.

[34] P. Kroon et al., Nox-uitstoot van kleine bronnen, ECN for Ministry of VROM, Feb. 2005.

8 BELGIUM & LUXEMBURG

In Belgium the implementation of the Energy Performance of Buildings Directive (EPBD) is the responsibility of the Regions.[35] 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.[36]

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

[35] Source: Wina Roelens (Flemish Energy Agency), Status of EPBD implementation in Belgium (Flanders), www.buildingsplatform.eu

[36] 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 m² 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, 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"*. Likewise, for all <u>electric water heaters the energy efficiency is set at 75%</u>. For this latter value 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.

9 FRANCE

9.1 Introduction

France is promoting the energy efficiency of water heaters mainly through building regulations (RT 2005) and voluntary NF quality labels issued by AFNOR (www.afnor.fr.). This chapter has a focus on the RT2005 methodology, whereby NF-mark limit values are discussed 'on the side'.

9.2 Réglémentation Thermique 2005

The RT 2005 calculates the energy requirement for hot water from

- The net hot water demand Q_w in kWh,
- The hot water distribution losses $Q_{d,w}$ in kWh,
- The hot water storage losses $Q_{s,w}$ in kWh and
- The hot water generation losses $Q_{g,w}$ in kWh.

9.2.1 Hot water energy demand

The net annual hot water energy demand Q_w is a product of the temperature difference between the cold water input (Θ_{cw} , to be determined per month but the annual average is 10,9°C) and the hot water output at the draw-off point (Θ_{uw}, given as 40°C for dwellings), the specific heat of the water (c_w = 1,163 Wh/kg.K), the number of litres of hot water per week V_{uw} (from a look-up table, e.g. for dwellings 12,2 litres/m² surface of the dwelling) and finally the number of weeks per year excluding holidays (n_{sem} = 50).

$$Q_w = c_w * V_{uw} * (\Theta_{uw} - \Theta_{cw}) * n_{sem}$$

Consider a residential dwelling of 80 m² . The average cold water temperature is 10,9°C. The occupants use 12,2 litres of 40°C per m² per week, which adds up to 976 litres per week or 48800 litres per year. The net annual hot water energy demand in Wh is calculated using the specific heat of water (1,163 Wh per K per litre) as follows [37]

$$Q_w = 1{,}163 * (40-10{,}9) * 48800 = 1651553 \text{ Wh} = 1652 \text{ kWh}$$

[37] Compare France 1652 kWh = 5947 MJ. In the Netherlands the 80 m² dwelling would use 80 x 68 = 5440 MJ, which is fairly similar (10% lower)

Table 9-1. Look-up table for Vuw = a · Nu in litres per week (RT 2000/ RT 2005)

Type d'activités	a	Nu
Dwelling	12,2	Floor area (m²)
Accommodation	330	Number of beds
Health establishment without accommodation	120	Number of beds
Health establishment with accommodation − with laundry	1050	Number of beds
Health establishment with accommodation − without laundry	665	Number of beds
Education	Hot water requirements not taken into account	
Offices		
Theatres and lecture theatres		
Shops		
Catering, 2 meals per day. Traditional cuisine	255	Number of guests per meal
Catering, 2 meals per day. Self service	95	Number of guests per meal
Catering, 1 meal per day. Traditional cuisine	125	Number of guests per meal
Catering, 1 meal per day. Self service	45	Number of guests per meal
Hotel, 1-star, without laundry	665	Number of rooms
Hotel, 1-star, with laundry	830	Number of rooms
Hotel, 2-star, without laundry	910	Number of rooms
Hotel, 2-star, with laundry	1075	Number of rooms
Hotel, 3-star, without laundry	1160	Number of rooms
Hotel, 3-star, with laundry	1325	Number of rooms
Hotel, 4-star and GC, without laundry	1405	Number of rooms
Hotel, 4-star and GC, with	1570	Number of rooms
Sports establishment	1200	Number of installed showers
Storage	Hot water requirements not taken into account	
Industry		
Transport		
Other		

9.2.2 Distribution losses

For the hot water distribution losses $\mathbf{Q_{dw}}$ the Réglémentation Thermique assumes that in residential dwellings 4 tappings per sub-period take place for each tapping point and that at every tapping 1,2 litres of water in the pipes[38] cools down from 55°C to ambient temperature (say 20°C in the heated volume). Every week has 14 sub-periods (day/night/etc.), which adds up to 728 sub-periods per year. So, for instance in the case of 3 tapping points (1 kitchen, 2 bathroom)

$$Q_{dw} = 1{,}163 * (55\text{-}20) * 1{,}2 * 728 * 4 * 3 = 426718 \text{ Wh} = 427 \text{ kWh}$$

In as much as the hot water tubes are placed within the heated volume, Q_{dw} is counted as 'recoverable energy' in the months of the heating season. This calculation has to be done per month and depends on the climate zone (The RT distinguishes 3 climate zones for France). For instance the maximum recoverable losses in a heating season of 5000 h/yr are 57% of the total Just as a rough estimate, one can assume that around half of the heat losses can be counted as recoverable.[39] In the above example this amounts to around 215 kWh. It is remarkable that in France, unlike in other countries, the distance between the heat generator and the tapping points is not a parameter here.

[38] 1,2 litres corresponds to 5 meters of pipe with inner/outer diameter of 16/18 mm

[39] The RT assumes that 60% of annual distribution losses are recoverable if the piping is in a heated surface. Given that not all piping will be inside the heated surface 50% is the estimate here. Please note that heat is not equivalent to the primary energy requirement. Generation losses and losses in the power generation (in case of electric water heaters) should be calculated over the full amount of the distribution losses Qdw.

The above applies for direct distribution of hot water from individual installations inside dwellings. For hot water distributed through a circulation circuit, the RT 2005 uses an elaborate method that does consider the length and diameter of the piping, emission coefficients, insulation, electricity use of the circulator, etc.. For piping of a hot water installation that are constantly kept warm, the RT 2005 prescribes a maximum loss coefficient (in W/m * K) of 3,3 d + 0,22, where d is the external diameter of the pipe without insulation, expressed in metres.

9.2.3 Storage losses

The monthly hot water storage losses $\mathbf{Q_{sw}}$ can be calculated from the cooling constant C_r (in Wh per K per litre per day), the volume of the tank, the temperature difference between the storage temperature (default 65°C) and the ambient (say 20°C) multiplied by the number of 'occupied days' per month (nj,occ=30).

$Q_{sw\_month} = C_r * V_s * (65-20) * 30$ (in Wh/month)

For our convenience (the RT 2005 prescribes a monthly calculation) the annual storage losses $\mathbf{Q_{sw}}$ can be estimated from multiplying the above by 12.

For indirect cylinders the RT 2005 has defined the following minimum requirements. For electrically heated cylinders the minimum value for $C_r = 1{,}25 * V_s^{-0{,}33}$ for $V_s \leq 500$ litres, or $C_r = 2 * V_s^{-0{,}4}$ for $V_s > 500$ litres. For not electrically heated cylinders $C_r = 3{,}3 * V_s^{-0{,}45}$ (used to be $4{,}2 * V_s^{-0{,}45}$ in RT 2000).

For electric storage water heaters the minimum values for C_r (in Wh/l d) are:

- With volume < 75 litres: $0{,}1474 + 0{,}0719\ V^{2/3}$
- Horizontal tank > 75 litres: $0{,}939 + 0{,}0104\ V$
- Vertical tank > 75 litres: $0{,}224 + 0{,}0663\ V^{2/3}$

For gas-fired storage water heaters the RT 2005 refers to the requirements of EN 89. The maximum allowed standing losses (in W) at a nominal heat input power P_n (in W) and storage tank volume V_s (in litres) are

- $9 * V_s^{2/3} + 0{,}017 * P_n$ if $V_s > 200$ litres and the heat-up time is less than 45 minutes and
- $11 * V_s^{2/3} + 0{,}015 * P_n$ for all other gas-fired storage water heaters.

For gas-fired storage water heaters the standard limit values for standing losses (P_{o_norm}), expressed as a percentage of P_n, are 1,7% and 1,5% respectively for the two cases.

For pre-fabricated solar hot water tanks the RT 2005 prescribes that the loss coefficient UA (in W/K) should be less than $0{,}16\ V^{1/2}$, where V is the volume of the storage tank.

For individual installations, with the exception of solar installations, the RT 2005 assumes that the storage tanks are inside the heated surface, i.e. that a part of the losses (during the heating season) is recoverable. For all other water heater installations (collective, solar) the storage tank is assumed to be outside the heated surface of the house.

9.2.4 Generation losses

For the hot water generation losses the *méthode pour la production intermittente d'eau chaude* applies. These hot water generator 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%) load, the number of hours per year the generator works in hot water mode t_c and the pilot flame power consumption P_v which is partitioned to the hot water generation:

$$Q_{g,w} = Q_w * ((1 - R_{Pn} + A)/R_{Pn}) + Q_{d,w} * (1/R_{Pint}) + P_v$$

The value of 'A' is 0,28 (28%) for a boiler/water heater without pilot flame and 0,14 for a water heater with pilot flame (since the RT 2005 a pilot flame for boilers is no longer allowed). The first term of the equation above is the largest. For instance, for a boiler with default condensing efficiency R_{Pn} = 91% and the boiler has no pilot flame, as much as 40% of Q_w is counted as loss [40]. In case there is a pilot flame only 25% of Q_w is counted as loss, but of course the term $P_v * t_c$ is not zero. Obviously, the RT 2000 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 is counted as loss during operation.

Note that for combi-boilers the value of 'A' is 0,28 by default, because in Art. 51 the RT 2005 has prescribed that ('permanent') pilot flames are no longer allowed for heating appliances. Also for combi-appliances the RT 2005 assumes that the space heating stops if there is hot water demand and that the hot water generator losses come on top of (have to be added to) the space heating losses in the *méthode general*.

A second remark, as least as important, is that this considerable energy loss of 28% is fixed –independent of the actual combi-boiler or water heater design. When the distribution losses are added, this means that by default any gas- or oil-fired combi-boiler is given at least some 50% losses in hot water mode.

The generator efficiency at nominal load (NCV) R_{Pn} is 100% for electric water heaters, but of course here the power generation losses (factor 2,58 = 39% efficiency) have to be taken into account afterwards to arrive at primary energy.

For gas-fired storage water heaters EN 89 applies, which prescribes a minimum efficiency (on net calorific value) of 98% for condensing appliances and 84% for all other types. Measurement is done at a continuous flow rate of 5 litres/minute, during which temperature, mass and gas consumption is measured.

For gas-fired instantaneous water heaters the RT 2005 refers to the minimum requirements of EN 26:

- The power of the pilot flame should be below 0,17 kW.
- For appliances with a nominal heat input exceeding 10 kW the minimum efficiency (on net calorific value) shall not be less than 84%.
- For appliances smaller than 10 kW, the efficiency shall be more than 82%.

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[41].
- 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.

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[40] $((1- R_{Pn} + A)/R_{Pn}) = ((1- 0,91 + 0,28)/0,91) = 0,4$ (40%)

[41] In other words the RT 2005 does not distinguish between summer and winter efficiency like in some other countries

9.2.5 Solar contribution

A calculation method for solar installations providing hot water (pre)heating is new in RT 2005. The method relates to a solar collector plus tank system. It is not applicable to Integrated Collector Storage, solar air heaters, heat pumps with atmospheric collectors, etc., but it does however include the special case of a "*Plancher Solaire*". This is a French invention from the 1970's, that does not use water storage but whereby the solar heat is captured in a piece of concrete on the roof through which hot water pipes are running. Through its thermal inertia and mass the concrete can store the heat and give it off to the fluid running through the pipes.

The RT 2005 method involves the following calculation steps:

- Solar energy contribution to space and hot water heating
- Transmission losses (storage tank, auxiliary heater)
- Storage losses of the auxiliary heater
- Potentially recoverable losses
- Auxiliary electric energy (mainly pump)

The calculation method refers to EN 12975-2, 12976-1 and 12976-2, i.e. with a focus on complete factory-produced products. Hereafter we will illustrate the method for the case of a conventional solar installation only used for water heating and using the default values as much as possible.

The share F (in %) of the solar energy contribution to hot water (and space heating) is determined with a formula derived from the so-called f-chart method, whereby

$$F = c_w * (aY + bX + cY^2 + dX^2 + eY^3 + fX^3)$$

With c_w being a correction factor that only has an effect in case of a "*plancher solaire*" (default c_w=0,94); otherwise c_w=1.

The values for the coefficients a to f are given in a look-up table. They are different for conventional installations and the "*plancher solaire*". For the conventional installation, ignoring cw (=1) and the coefficient f (=0), the above formula can be rewritten as

$$F=1{,}029\ Y - 0{,}065\ X - 0{,}245\ Y^2 + 0{,}0018\ X^2 + 0{,}0215\ Y^3$$

X is the ratio between the capturing losses and the hot water demand Q. Y is the ratio between the absorbed solar energy and the hot water demand Q. The relevant equations are

$$X = A_c * U_c * \Delta T * t_{mois} * c_{os} / Q$$

$$= 1{,}2 * 19{,}66 * 62 * 8760 * 1 / 2079000 = 6{,}163$$

$$Y = A_c * I_{sc} * t_{mois} / Q$$

$$= 1{,}2 * 126 * 8760 / 2079000 = 0{,}637$$

Where

A_c = Equivalent collector area in m².

Example:
Assume A=5 m² and a storage vessel of 300 litres in zone H1a in April (153 W/m²). The default Ac=0,4 * A= 2 m². The default Uc=17 +8/A= 18,6. The hot water demand including distribution losses is 2079 kWh per year → 173 kWh/month.
If we assume e.g. a cold water temperature of 12°C and an outdoor temperature of 13°C, then Θ_{ref} = 11,6 + 1,18*40 + 3,86*12 - 2,32*13= 75 and $\Delta T = \Theta_{ref} - \Theta_{ext}$ = 75-13 = 62 K. The correction factor $C_{os} = (V_{conv}/ V_s)^{0,25} = (5*75/ 300)^{0,25} = 1{,}057$.
$X = A_c * U_c * \Delta T * t_{mois} * c_{os} / Q$ = 2 * 18,6 * 62 * 750 * 1,057 /173000 = 10,568
$Y = A_c * I_{sc} * t_{mois} / Q$ = 2 * 153 * 750 / 173000 = 1,326
Substituting X and Y in the formula for F we find F=50 % for the month of April in zone H1A. This 50% of 173 kWh corresponds to 86,5 kWh.

This takes into account the optical efficiency ($\eta 0$ = 60% default) and the efficiency of the collector piping (F. boucle de captage, $\eta\rho$ = 80% by default for collectors with glass) and multiplies both with the gross collector area A. If no specific information on the collector is known, one can use the default of Ac = 0,4 * A.

U_c = Capturing loss coefficient in W/(m².K). Basically this is the collector specific loss coefficient a_1 in W/(m².K) –measured according to EN 12975-2 – taking into account the optical efficiency. So in fact Uc= a_1 / η_0 . If no specific information on the collector is known, one can use the default of Uc = 17 + 8/A, where A is the gross collector area.

ΔT = temperature difference over the collector in K. For solar assistance with hot water the equation is

$$\Delta T = \Theta_{ref} - \Theta_{ext}$$

with

$$\Theta_{ref} = 11{,}6 + 1{,}18 * \Theta_{uw} + 3{,}86 * \Theta_{cw} - 2{,}32 * \Theta_{ext}$$

Where

Θ_{ref} = reference temperature

Θ_{ext} = outdoor temperature

Θ_{uw} = water temperature at tapping point = 40°C

Θ_{cw} = cold water temperature in that month (average over a year in France is 10,9°C, but given that solar installations work mainly in summer when also the cold water temperature is higher, 12°C is probably closer to the average)

t_{mois} = number of hours per month (e.g. 750)

c_{os} = correction factor that takes into account the over- or under sizing of the storage tank. The reference is a hot water storage volume V_{conv} of 75 litres per m² of collector surface A, whereas Vs is the actual storage volume used. The correction factor is defined as

$$C_{os} = (V_{conv}/ V_s)^{0,25}$$

In case $V_{conv} = V_s$ the correction factor C_{os} = 1 .

I_{sc} = monthly average of solar irradiation on the plane of the collector. RT2005 gives a look-up table for the case where the collector has an angle of 40-50°C with respect of the horizontal plane and is oriented somewhere between South-East and South-West. The table relates to the 8 French climate zones, where e.g. H1a is the area around and North of Paris and H3 is the French Riviera (Nice etc.).

In case the orientation is not between SE and SW, but at least between East and West (with S in the middle) and height of the surrounding obstacles is limited, the values in the table have to be multiplied with factor 0,8. In all other cases, solar energy should not be taken into consideration.

Table 9-2. Monthly average solar irradiation at 45 ° oriented versus South, in W/m² (RT 2005)

Zone	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
H1a	52	84	119	153	183	187	184	187	157	104	61	41
H1b	46	80	117	156	183	193	199	189	148	98	58	40
H1c	65	98	146	174	190	207	221	212	178	117	74	59
H2a	59	85	119	153	184	193	190	185	159	110	75	52
H2b	70	105	154	187	210	214	203	207	208	124	77	64
H2c	84	121	159	183	198	206	218	210	183	123	85	69
H2d	110	149	181	207	227	246	259	256	219	156	115	99
H3	124	136	180	199	215	233	244	245	216	161	122	116

Q = hot water demand in Wh (in this case). The hot water energy demand Q is the sum of the hot water need Q_w and the distribution losses Q_{dw} :

$$Q = Q_w + Q_{dw}$$

For instance fom the examples above Qw = 1652 kWh and Qdw = 427 kWh, resulting in Q= 2079 kWh/year.

Please note that the above example calculates the solar contribution F to the hot water demand and NOT the energy saving. In order to assess the net energy saving of a solar assisted water heater with respect of a conventional water heater we have to take into account that we need a bigger or separate storage vessel (with more standing losses), that there is an electric circulation pump and electric controls and that we have some extra distribution heat losses in the piping.

For instance, for pre-fabricated solar hot water tanks the RT 2005 prescribes that the loss coefficient UA (in W/K) should be less than 0,16 $V^{1/2}$, where V is the volume of the storage tank. For a 300 litre tank UA = 2,77 W/K (determined according to EN 12977-3). At a temperature of the stored water of 40°C and an ambient temperature of 20°C this results in a loss of 20 * 2,77= 55,4 W. Over 750 hours this results in energy losses of 41,5 kWh. To this we add the primary energy use of the pump, e.g. 10W during 400 h results in 4 $kWh_{electric}$, which comes down to ca. 10 $kWh_{primary}$. So, if we neglect the extra distribution losses, the actual net saving in the month of April is 86,5 – 51,5 = 35 kWh. This equals some 20% of the hot water energy demand, but the actual saving is higher because you are also avoiding the generation losses for 50% of the conventional water heater. In case of a gas-fired heater with 84% generation efficiency the generation losses are 16%, so you are saving an extra 8% on top of this 20% (total 28% net saving). In case of an electric heater the (power) generation efficiency is only 39% and the extra saving would be 30% (total 50% net primary energy saving).

Of course the above is in some respects a simplification and a worst case, e.g. using default (minimum) values for the components, a storage vessel that could probably be smaller, a climate zone H1a instead of H3, etc.. But it only goes to show that the RT2005 calculation method allows a realistic evaluation of the solar contribution on one hand and the net saving on the other.

10 GERMANY

10.1 Introduction

In Germany the efficiency of water heaters is mainly part of the Energie-einsparverordnung (ENEV), which uses the DIN 4701-10;2003. Dedicated water heaters are not subject to BIMSchV (Bundes IMmissions SchutzVerordnung), nor are they treated as a category in the voluntary Blue Angel labeling scheme. This chapter will focus on the methodology related to the treatment of water heaters in the ENEV.

10.2 Hot water energy demand q_{TW}

The hot water energy demand in Germany according to DIN 4701-10 is q_{TW} =12,5 kWh/(m²a). E.g. for an 80 m² dwelling this is 1000 kWh/a (3600 MJ/a). This is more than 30% lower than the comparable values in France and the Netherlands.[42] At least partially this can be explained by a smaller average household size (or more m² per person).

10.3 Hot water distribution losses

For hot water distribution losses the DIN 4701-10 distinguishes between centralized (collective) distribution with circulation-circuits and individual installations. The general formula for both is

$$Q_{TW,d,i} = 0{,}001 * U_i * L_i * (\Theta_{TW,m} - \Theta_{u,m}) * t_{TW} * z$$

Where

$Q_{TW,d,i}$ = heat loss of pipe-section i [kWh/a]

U_i = specific heat transmission coefficient per length of pipe [W/mK], default U =0,2 W/mK

L_i = length of pipe-section i [W/mK]

$\Theta_{TW,m}$ = average temperature of pipe [°C], default 50°C with circulation loop, 32°C without circulation

$\Theta_{u,m}$ = average temperature indoors [°C], default 20°C

t_{TW} = standby period for hot water [h/d], default 350

z = for circulation systems z= operating time of circulation pump [h/d] = 10+ 1/(0,07 + (50/AN)); for non circulation systems z=24 h/d.

In case of circulation systems where the circulation pump is not running continuously, the heat losses have to be calculated during the time z that the pump is running with $\Theta_{TW,m}$ = 50°C. To this, the heat loss during the time (z-24) with $\Theta_{TW,m}$ = 32°C has to be added.

If the piping is inside the house 45% of the distribution losses can be recovered.

In circulation systems there is a double pipe from heat generator to the ring-net (length LV, default LV= 26 + 0,02 AN), there is the ring-net with double piping (length LS, default Ls = 0,075 AN) and there are single pipes to the tapping point (length LSL,

[42] France 1652 kWh = 5947 MJ. In the Netherlands the 80 m² dwelling would use 80 x 68 = 5440 MJ.

default LSL = 6 * (AN/80)). A special case is where all tapping points share the common wall of two adjacent rooms (default LSL = 4 * (AN/80).

In case of a direct feed of the hot water from the heat generator all double piping becomes single piping (half the lengths LV and LS), whereas the length of the single pipes stays the same.

In case of single-point water heater situated near the tapping point (instantaneous or small storage) the length of piping per tapping point is only 1 * (AN/80). In case of a multi-point, single (bath)room water heater the piping length is 3 * (AN/80).

For circulation systems the auxiliary pump power Ppump [W] has to be taken into account. The simplified assumption for the Table Method is $P_{pump} = 27 + 0{,}008\ A_N$.

Example
For instance, in a dwelling of 80 m² without circulation-circuit and a central water heating device serving both kitchen and bathroom the distribution losses are 120 kWh/year using the default values. If the same water heater is in the bathroom and the kitchen is either adjacent or served by a single-point water heater, the distribution losses are only 80 kWh/year.

10.4 Hot water storage losses $q_{TW,,s}$

For an indirectly heated cylinder the annual heat loss per unit of floor area of the dwelling is calculated with

$$q_{TW,,s} = 1{,}2 * \{ (50 - \Theta_{u,m})/45 \} * t_{TW} * q_{B,S} / A_N$$

where

$q_{TW,,s}$ = the annual standing losses in kwh per m² of floor area of the dwelling [kWh/(m²a)]

$\Theta_{u,m}$ = average ambient temperature [°C], default 20°C

t_{TW} = period of standing losses in days/year [d/a], default 350

$q_{B,S}$ = standing losses in kWh/day (test according to DIN 4753-8;1996 or with combi-boilers EN 625)

A_N = surface area of the dwelling [m²]

If the storage tank is inside the heated building shell then 45% of the heat can be recovered[43].

If $q_{B,S}$ is unknown (Table method) then the formula $q_{B,S} = 0{,}4 + 0{,}2\ V^{0,4}$ can be used to make an estimate, where V is the volume of the storage tank.

Also for the Table Method, the volume V of the storage tank can be estimated with V= 6 $A_N^{0,7}$. This is valid for storage tanks up to 1000 litres.

For bi-valent storage tanks, where the lower part is used as a solar storage tank, the heat losses of this lower part are not taken into account (!). The standby-losses of the storage tank are determined through

$$q_{B,S} = (0{,}4 + 0{,}2\ (V_{S,aux} + V_{S,sol})^{0,4} * \{ V_{S,aux} / (V_{S,aux} + V_{S,sol}) \}$$

[43] $Q_{h,TW,s} = (t_{HP} / t_{TW}) * (1 - f_a) * q_{TW,s}$ where

$Q_{h,TW,s}$ = the annual recovered heat loss of the storage tank in kwh per m² of floor area of the dwelling [kWh/(m²a)]

t_{HP} = heating season [d/a], default 185

t_{TW} = period of standing losses in days/year [d/a], default 350

f_a = heat loss factor, if the tank is inside f_a=0,15 and if it is outside f_a=1.

$q_{TW,,s}$ = the annual standing losses in kwh per m² of floor area of the dwelling [kWh/(m² a)]

For a bi-valent storage tank (up to 1000 l.) that is heated exclusively through electricity, the factor 1 instead of 1,2 in the calculation of the heat losses should be used.

The auxiliary energy needed for the circulation pump in case of an indirect cylinder should be added. In DIN 4701-10 it is calculated on the basis of the nominal power of the pump (in W) multiplied by the operating time. The operating time is determined as the ratio between the total hot water energy demand (incl. Losses) and the nominal heat capacity of the heat generator (in kW). In case the pump power P_{pump} is unknown (Tabel Method), it can be estimated with $P_{pump} = 44 + 0{,}059\ A_N$ and the operating time t_p is estimated with the formula $t_p = 170 * 5\ A_N^{0,5}$.

For electric storage water heaters the annual heat loss can be calculated similarly as above with

$$q_{TW,,s} = \{ (55 - \Theta_{u,m})/45 \} * t_{TW} * q_{B,S} / A_N$$

If the storage tank is inside the heated building shell then 45% of the heat can be recovered. [44]

The standing losses $q_{B,S}$ shall be determined according to DIN 44532-2.

If $q_{B,S}$ is unknown (Table method) then the formula $q_{B,S} = 0{,}29 + 0{,}019\ V^{0,8}$ can be used to make an estimate, where V is the volume of the storage tank.

Also for the Table Method, the volume V of the storage tank can be estimated as follows:

Nighttime electric storage heater (heated mainly during the night): $V = 8{,}5 * A_N^{0,7}$

Daytime electric storage heater (instantaneous reheat): $V = 4 * A_N^{0,7}$

In case of one or more electric instantaneous water heaters in the dwelling, the standing heat losses are

$$q_{B,S} = 0{,}0045\ A_N$$

Gasfired storage water heaters follow the same equation

$$q_{TW,,s} = \{ (55 - \Theta_{u,m})/45 \} * t_{TW} * q_{B,S} / A_N$$

Here the standing losses $q_{B,S}$ in kWh/day should be tested according to DIN 3377:1980 with an assumed average temperature difference between ambient and storage water of 50°C.

Only for room-sealed appliances 45% of the heat can be recovered (as above).

If $q_{B,S}$ is unknown (Table method) then the formula $q_{B,S} = 2 + 0{,}033\ V^{1,1}$ can be used to make an estimate, where V is the volume of the storage tank. Also for the Table Method, the volume V of the storage tank can be estimated with $V = 4 * A_N^{0,7}$.

10.5 Coverage of hot water energy demand

In case of bi-valent systems, such as solar systems or heat pumps that require an auxiliary (electric or fossil-fule fired) heating, the share of each heat generator has to be established.

For heat pump systems without auxiliary heater DIN 4701-10 assumes a 100% coverage. For other heat pumps it assumes 95% or that the coverage is integrated in the generation losses.

[44] $Q_{h,TW,s} = (t_{HP} / t_{TW}) * (1 - f_a) * q_{TW,s}$ where

$Q_{h,TW,s}$ = the annual recovered heat loss of the storage tank in kwh per m² of floor area of the dwelling [kWh/(m² a)]

t_{HP} = heating season [d/a], default 185

t_{TW} = period of standing losses in days/year [d/a], default 350

f_a = heat loss factor, if the tank is inside f_a=0,15 and if it is outside f_a=1.

$q_{TW,,s}$ = the annual standing losses in kwh per m² of floor area of the dwelling [kWh/(m² a)]

The calculation of the contribution of solar water heaters is slightly more complicated and will be covered more in detail hereafter.

The share of the sanitary hot water heater demand $\alpha_{TW,sol}$ (in %) that can be covered by the contribution of a solar energy system is

$$\alpha_{TW,sol} = Q_{TW,sol} / Q_{TW} = Q_{TW,sol} / \{ (q_{TW} + q_{TW,ce} + q_{TW,d} + q_{TW,s}) * A_N \}$$

where

Q_{TW} = Annual heat demand for sanitary hot water in kWh/a, which is the sum of the net hot water demand (q_{TW}), the conversion losses ($q_{TW,ce}$), the distribution losses ($q_{TW,d}$) and the storage losses ($q_{TW,s}$) in kWh/m²a, multiplied with the floor area of the dwelling A_N in m².

$Q_{TW,sol}$ = Annual energy gain from thermal solar installation in kWh/a, defined as

$$Q_{TW,sol} = Q_{sys} * f_{NA} * f_{slr} * f_{d,sol} * f_{S,Vsol} * f_{S,Vaux} * f_{S,loss} + Q_{TW,s} * f_{S,\Theta} * f_{S,t} * f_{S,an}$$

where

Q_{sys} = annual reference energy gain of solar collectors [kWh/a]

f_{NA} = correction for inclination and orientation of the collector [-]

f_{slr} = correction for load factor of the solar installation [-]

$f_{d,sol}$ = correction for heat losses of the solar circuit [-]

$f_{S,Vsol}$ = correction for the volume of the solar part of the storage tank [-]

$f_{S,Vaux}$ = correction for the standby ('hot top') part of the storage tank [-]

$f_{S,loss}$ = correction for the heat loss rate of the storage tank [-]

$Q_{TW,s}$ = standing losses of the storage tank [kWh/a], as $Q_{TW,,s} = 1{,}2 * \{ (50 - \Theta_{u,m})/45 \} * t_{TW} * q_{B,S}$

$f_{S,\Theta}$ = correction for storage temperature [-]

$f_{S,t}$ = correction for operating time [-]

$f_{S,an}$ = correction for connections to storage tank [-]

The standard distinguishes between "small" solar systems, i.e. for dwelling area $A_N <$ 500 m² and using a bi-valent storage tank ('hot-top'), and "large"solar systems, i.e. for 500< A_N<3000 m² and using a separate solar storage tank that feeds into a regular hot water storage tank.

Annual solar gain Q_{sys} "small" systems:

$Q_{sys} = (271 * \eta_o - 18{,}8\ k_1 - 653\ k_2 + 172\ IAM\ (50°) - 0{,}792\ C - 20{,}7) * A_c$

"large" systems:

$Q_{sys} = (355 * \eta_o - 26{,}8\ k_1 - 992\ k_2 + 221\ IAM\ (50°) - 0{,}655\ C) * A_c$

where

η_o = conversion factor [-] according to manufacturer or look-up table 5.1-10

k_1 , k_2 = heat transmission coefficients in W/(m²K) according to manufacturer or look-up table 5.1-10

IAM (50°) = inclination correction at 50° according to manufacturer or look-up table 5.1-10 (for tube collectors $IAM(50°) = IAM_L\ (40°) * IAM_T\ (40°)$)

C = effective heat capacity in kJ/(kgK) according to manufacturer or look-up table 5.1-10

A_c = collector surface in m²

Alternatively, the value of Q_{sys} can also be calculated according to EN 12976-2 and EN 12977-2 for the reference location of Würzburg.

Correction for inclination and orientation f_{NA}

The standard prescribes the following look-up table, with f_{NA} =1 for the inclination of 45°C and a South (γ = 0) orientation.

Table 10-1. Correction for inclination and orientation (DIN 4701-10; 2003 . Table 5.1-4)

orientation—>	East γ = -90				South γ =0				West γ =90
	-90	**-60**	**-40**	**-20**	**0**	**20**	**40**	**60**	**90**
inclination (deg)									
0	0,810	0,810	0,810	0,810	0,810	0,810	0,810	0,810	0,810
15	0,799	0,855	0,883	0,902	0,911	0,909	0,895	0,872	0,813
30	0,787	0,881	0,927	0,962	0,976	0,972	0,952	0,913	0,830
45	0,763	0,881	0,940	0,981	1,000	0,997	0,971	0,926	0,820
60	0,718	0,848	0,909	0,953	0,978	0,977	0,952	0,905	0,786
75	0,646	0,777	0,805	0,865	0,887	0,890	0,883	0,846	0,724
90	0,542	0,655	0,682	0,692	0,706	0,725	0,749	0,736	0,631

Correction for solar load ratio f_{slr}

If the load factor of the installation is different from the reference installation than the following correction applies:

"small" installation: $f_{slr} = -2{,}73 - 0{,}6 * \ln (A_c/Q_{TW})$

"large" installation: $f_{slr} = -2{,}9 - 0{,}6 * \ln (A_c/Q_{TW})$

Correction for heat losses of solar circuit f_{slr}

If the length of the piping between collector and storage tank is different from the reference installation than the following correction applies:

"small" installation: $f_{d,sol} = 1{,}037 - 0{,}00185 * L_{sol}$, with L_{sol} is the total length of the piping

"large" installation: $f_{d,sol} = 1$.

Correction for solar storage volume $f_{S,Vsol}$

If the solar volume of the storage tank is different from the reference installation than the following correction applies:

"small" installation: $f_{S,Vsol} = 0{,}8 + 5{,}305 * (V_{S,sol} / Q_{TW}) – 27{,}02 * (V_{S,sol} / Q_{TW})^2$

"large" installation: $f_{S,Vsol} = 1{,}207 * (V_{S,sol} / Q_{TW})$

Correction for standby storage volume $f_{S,Vaux}$

If the standby volume of the storage tank is different from the reference installation than the following correction applies:

"small" installation: $f_{S,Vaux} = 1{,}12 - 2{,}36 * (V_{S,aux} / Q_{TW})$

"large" installation: $f_{S,Vaux} = 1$

Correction for standing losses of storage tank $f_{S,loss}$

If a bivalent storage tank has standing heat losses different from the reference installation than the following correction applies:

"small" installation: $f_{S,loss} = 1{,}22 - 0{,}464 * v\ Q_{TW} * (q_{B,s} / V_{S,aux})$

"large" installation: $f_{S,Vaux} = 1$

Please note that this correction factor only applies to the standby volume.

Correction for storage temperature $f_{S,\Theta}$

For the correct assessment of the heat gain of the solar system the heat loss of the regular water heater storage tank have to be added. This correction factor is calculated with

$$f_{S,\Theta} = 47 / (50 - \Theta_{u,m})$$

where $\Theta_{u,m}$ is the ambient temperature of the storage tank. The default value indoors is 20°C, whereby $f_{S,\Theta}$ = 47 / (50 - 20) = 1,56.

Correction for operating period $f_{S,t}$

The correction factor for the operating time $f_{S,t}$ = 365/350 = 1,042

Correction for connection to storage tank heat losses f_{San}

For indirect cylinders $f_{S,an}$ = 1/1,2 = 0,83.

Table 10-2. Default values look-up table for solar systems used in Annex C of DIN 4701-10;2003

Variable	Description	Unit	Flat plate collector	Vacuum tube collector
η_0	conversion factor	[-]	0,77	0,71
k_1	heat transmission coefficient	W/m²K	3,5	1
k_2	heat transmission coefficient	W/m²K	0,02	0,009
IAM 50°	irradiation angle at 50o	[-]	0,9	0,99
C	effective heat capacity	kJ/m²K	6,4	11
A_c	collector surface	m²	A_c= 0,09 $A_N^{0,8}$	A_c= 0,066 · $A_N^{0,8}$
	collector inclination	[°]	30	
	orientation (y)	[°]	-20	
L_{sol}	length of solar piping	[m]	40	
$V_{S,aux}$	standby volume of store	[l]	as indirect cylinder: V= 6 $A_N^{0,7}$	
$V_{S,sol}$	solar volume of store	[l]	$V_{S,sol}$ = 2 $A_N^{0,9}$	
$q_{B,s}$	Standing heat losses bivalent storage tank	kWh/d	$q_{B,S} = (0,4 + 0,2 (V_{S,aux} + V_{S,sol})^{0,4} \cdot \{ V_{S,aux} / (V_{S,aux} + V_{S,sol}) \}$	
$q_{B,s}$	Standing heat losses separate solar storage tank	kWh/d	$q_{B,S}$= 0,4 + 0,2$V^{0,4}$	

For electrically heated tanks $f_{S,an}$ = 1.

For the Table Method the following look-up table, referenced several times above, is given.

The Table Method makes no difference between the flat plate collector and a vacuum tube collector. The reasoning is that a vacuum tube collector has less energy losses, but that the collector area will normally be smaller. For instance, for a dwelling of 100 m² the default collector surface A_c is 3,6 m² for a flat plate collector and 2,6 m² for a vacuum tube collector [45].

Basically the Table Method gives a coverage of around 50% if the storage tank is outside and there is a circulation circuit. Without a circulation circuit the coverage is around 60%. If the storage tank is inside the heated building shell these values are 5 percentage points higher (55 and 60%).

[45] Both with a bivalent storage tank with a standby volume 128 litres + solar volume 103 litres.

Table 10-3. ***'Table Method'*** **Solar coverage of hot water demand α (DIN 4701-10; Annex C Table C.1-4a)**

A_c	A_N	tank outside		tank inside	
m²	m²				
3,6	**100**	0,51	0,63	0,55	0,68
5,0	**150**	0,51	0,61	0,54	0,64
6,2	**200**	0,50	0,59	0,53	0,62
8,6	**300**	0,49	0,57	0,51	0,58
13,0	**500**	0,53		0,54	
18,0	**750**	0,50		0,51	
22,6	**1000**	0,48		0,49	
31,3	**1500**	0,45		0,46	
47,1	**2500**	0,42		0,43	
54,4	**3000**	0,41		0,42	

10.6 Hot water generation losses

To assess the generation losses for sanitary hot water DIN 4701-10 determines the 'Aufwandszahl'[46] $e_{TW,g}$ [-] as follows:

$$e_{TW,g} = (1 + (1/\varphi_{TW} - 1) * (1 - t_{HP}/ t_{TW}) * q_{B,\Theta}) / \eta_{100\%}$$

Where t_{HP}/ t_{TW} is the ratio between heating season [180 d] and hot water period [350 d] . The hot water load factor φ_{TW} of a heat generator covering a share of $\alpha_{TW,g}$ of the total demand can be expressed as the ratio between the total hot water energy demand [kWh] and the maximum energy that the heat generator can supply in a year [kWh] or

$$\varphi_{TW} = t_{100\%} / t_{TW}$$

$$= \{ (q_{TW} + q_{TW,ce} + q_{TW,d} + q_{TW,s}) * A_N * \alpha_{TW,g} \} / (Q_n * t_{TW} * 24)$$

For the standby-losses of the heat generator (boiler) $q_{B,\Theta}$ at average boiler temperature $\Theta_{K,m}$ the equation is

$$q_{B,\Theta} = q_{B,70} (\Theta_{K,m} - 20) / (70 - 20),$$

where $q_{B,70}$ are the standby losses at an average boiler temperature of 70°C.

For the average boiler temperature $\Theta_{K,m}$ the following values apply:

- Standard boiler: ΘK,m = 70°C
- Combi-boiler: ΘK,m = 35°C + 0,002 AN
- Low temperature and condensing boiler: ΘK,m = 35°C + 0,002 AN

The auxiliary electric energy is to be calculated multiplying the electric power consumption of the boiler with the operating time.

For the Table Method the DIN 4701-10 assumes the following values for the boiler efficiency at 100% load $\eta_{100\%}$:

- Standard boiler: $\eta_{100\%} = (85 + 2 * \log Q_n) / 100$
- Low temperature boiler: $\eta_{100\%} = (88,5 + 1,5 * \log Q_n) / 100$
- Condensing boiler: $\eta_{100\%} = (92 + 1 * \log Q_n) / 100$
- Improved condensing boiler: $\eta_{100\%} = (94 + 1 * \log Q_n) / 100$

These first three are mandatory minimum values according to directive 92/42/EC.

[46] Aufwandszahl is the inverse of the efficiency, e.g. Aufwandszahl 2 → efficiency 50%

The nominal performance Q_n [kW] is

$Q_n = 0{,}42\ A_N^{0{,}7}$ or for combi-boilers $Q_n = 24$ kW

The default standby losses $q_{B,70}$ are

- Standard boiler: $q_{B,70} = 0{,}12 * (Q_n / 0{,}42) - 0{,}4$
- Low temperature and condensing boiler: $q_{B,70} = 0{,}06 * (Q_n / 0{,}42) - 0{,}4$
- Combi-boiler instantaneous with preheat store ($2 < V < 10$): $q_{B,70} = 0{,}012$
- Combi-boiler instantaneous ($V < 2$): $q_{B,70} = 0{,}022$

If the total hot water energy demand of a building is unknown, it can also be estimated as follows

$$Q_{TW\ total} = 70{,}56\ A_N^{0{,}7} + 2{,}12\ A_N^{1{,}2}$$

Likewise, the electric power consumption of the boiler is estimated as $P_{HE} = 0{,}045\ Q_n^{0{,}48}$. For instance for a Q_n =24 kW boiler this would be 207 W.

Note that instantaneous gas heaters are treated as low temperature boilers in terms of default values.

Electric heat pump combi appliances (both space heating and hot water) the generation efficiency is calculated as with space heating. Assumed is a 45/55°C regime for soil-water and brine-water heat pumps. For air-water heat pumps (incl. Ventilation air) a 28/35°C regime is assumed.

For dedicated electric heat pump water heaters the standard defines two types: one using the used ventilation air and the other using the air from the cellar. We will discuss only the former, where the 'Aufwandszahl' $e_{TW,g} = 1 / \varepsilon_N * F_1 * F_2$

Here ε_N is the COP [47] according to EN 255/3 (default $\varepsilon_N = 3{,}8$) . F_1 is a correction for the water temperature at draw-off (varies between F_1=0,95 at 45°C and F_1=1,15 at 65°C with intermediate values through linear interpolation). F_2 is a correction factor, where F2=1 for heat pumps using only the heat in the outgoing ventilation air of a mechanical ventilation system. In case of a heat pump in a balanced ventilation system with waste heat recovery, the heat remaining for hot water heating is some 10-15% less (e.g. F_2=0,88 according to formula in standard). The storage losses of this heat pump are calculated as for indirect cylinders (see there).

For all electric water heaters (storage and instantaneous types) the generator efficiency is assumed to be 100% and the auxiliary energy zero.

For dedicated gas water storage heaters the efficiency shall be measured according to DIN 3377. If unknown a default efficiency of 82% is assumed (Aufwandszahl = 1,22) . The auxiliary energy is assumed zero.

Solar water heaters are mainly discussed in the previous paragraph. Only for the pump energy it can be mentioned that the Table Method assumes an operating time of 1750h and a pump power of $30 + 0{,}05 * A_N$.

[47] Coefficient of Performance = efficiency

11 AUSTRIA

Austria has delegated the energy performance of buildings legislation to the regional level ('Länder'). This means that some 6 or 7 pieces of legislation have been investigated for specific water heater requirements, directly or indirectly. In the legislation of the Länder there is no specific minimum energy efficiency requirement for water heaters.

For the emissions of NO_x, CO, dust, etc. the fossil fuel fired water heaters are considered *'Kleinfeuerungsanlagen'* and limit values given in the table below apply. OGC is the emission of hydrocarbons C_xH_y measured as carbon.

Table 11-1. Emission limits Austria

Burner	CO mg/MJ	NO_x mg/MJ	OGC mg/MJ	Dust 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%.

12 UNITED KINGDOM

12.1 Introduction

Water heater energy consumption is part of the Standard Assessment Procedure SAP 2005, which will be discussed in detail in this chapter. Apart from that there are several initiatives and endorsement labels (e.g. by the Energy Saving Trust, EST).

12.2 Hot water demand and distribution losses

The SAP 2005 calculates the hot water demand and the distribution on the basis of the Total Floor Area TFA of the dwelling [m²], TFA), using the following steps:

1. Calculate
   a. N = 0,035 * TFA - 0,000038 * TFA2, if TFA ≤ 420
   b. N = 8 if TFA > 420
   c. Hot water usage = (25 * N) + 38
2. Energy content of water used = [(61 * N) + 92] * 0,85 * 8,76
3. Distribution loss = [(61 * N) + 92] * 0,15 * 8,76

The above relates to internal distribution losses (inside the house). Please note that for community heating systems (district heating, block heating) the external distribution losses have to be taken into account (see table below).

Table 12-1. Look-up table SAP 2005 hot water demand and distribution losses (SAP2005 Table 1)

Floor area TFA (m²)	(a)Hot water usage Vd(litres/day)	(b)Energy content of water used (kWh/year)	(c)Distribution loss (kWh/year)
30	63	1146	202
40	71	1293	228
50	79	1437	254
60	87	1577	278
70	95	1713	302
80	102	1846	326
90	109	1976	349
100	116	2102	371
110	123	2225	393
120	129	2344	414
130	136	2460	434
140	142	2572	454
150	148	2681	473
200	175	3174	560
250	197	3581	632
300	215	3901	688

Table 12-2. Distribution loss factor for group and community heating schemes (SAP 2005 table 12c.)

Heat distribution system	Factor
Mains piping system installed in 1990 or earlier, not pre-insulated medium or high temperature distribution (120-140ºC), full flow system	1,20
Pre-insulated mains piping system installed in 1990 or earlier, low temperature distribution (100ºC or below), full flow system.	1,10
Modern higher temperature system (up to 120ºC), using pre-insulated mains installed in 1991 or later, variable flow system.	1,10
Modern pre-insulated piping system operating at 100ºC or below, full control system installed in 1991 or later, variable flow system	1,05

Note:
A full flow system is one in which the hot water is pumped through the distribution pipe work at a fixed rate irrespective of the heat demand (usually there is a bypass arrangement to control the heat delivered to heat emitters). A variable flow system is one in which the hot water pumped through the distribution pipe work varies according to the demand for heat.

12.3 Hot water storage losses & primary circuit losses

The SAP 2005 requires the assessment of the hot water storage loss factor (kWh/litre/day).

If the manufacturer's declared loss is available, the temperature factors in the SAP Table 2b on the next page applies. In the absence of manufacturer's declared cylinder loss, the loss factor L from SAP Table 2 is multiplied by the cylinder volume in litres, by the volume factor from SAP Table 2a, and by the appropriate temperature factor from SAP Table 2b, to obtain the loss rate. The relevant tables are given on the next page.

Table 12-3. Cylinder loss factor (L) kWh/litre/day (SAP 2005 Table 2)

Insulation thickness	Cylinder loss factor (L) kWh/litre/day	
in mm	Factory insulated cylinder	Loose jacket
0	0,1425	0,1425
12	0,0394	0,0760
25	0,0240	0,0516
35	0,0191	0,0418
38	0,0181	0,0396
50	0,0152	0,0330
80	0,0115	0,0240
120	0,0094	0,0183
160	0,0084	0,0152

Note:
Alternatively the heat loss factor, L, may be calculated for insulation thickness of t mm as follows:
1) Cylinder, loose jacket L = 0,005 + 1,76/(t + 12,8)
2) Cylinder, factory insulated L = 0,005 + 0,55/(t + 4,0)

Table 12-4. Volume factor for cylinders and storage combis (SAP 2005 Table 2a)

Volume Vc	Volume Factor VF
40	1,442
60	1,259
80	1,145
100	1,063
120	1,000
140	0,950
160	0,908
180	0,874
200	0,843
220	0,817
240	0,794
260	0,773
280	0,754

Note:
1) When using the data in Table 2, the loss is to be multiplied by the volume factor
2) Alternatively, the volume factor can be calculated using the equation
$VF = (120 / Vc)^{1/3}$
Where:
V c– volume of cylinder or storage, litres

These data apply to cylinders heated by gas, oil and solid fuel boilers and by electric immersion, and to stores within combi boilers. For community heating systems with no cylinder in the dwelling, use loss factor for 50 mm factory insulation and a cylinder size of 110 litres. For an electric CPSU, the loss is 0,022 kWh/litre/day. For the primary circuit losses, i.e. the heat loss from the piping between boiler and hot water storage tank, have to be added. Values are in SAP Table 3.

For combi-boilers with a keep-hot facility or a store, some other losses have to be added. Values are in SAP Table 3.

Table 12-4. Correction factors for types of hot water storage (SAP Table 2b)

Type of water storage	Temperature Factor: For manufacturer's declared loss	Temperature Factor: For loss from Table 2
Cylinder	0,60 [a) b)]	0,60 [a) b)]
Storage combi boiler, primary store	n/a	Store volume ≥ 115 litres: 0,82 Store volume < 115 litres: 0,82 + 0,0022 $\cdot$ (115 – Vc)
Storage combi boiler, secondary store	n/a	Store volume ≥ 115 litres: 0,60 Store volume < 115 litres: 0,60 + 0,0016 $\cdot$ (115 – Vc)
Hot water only thermal store	0,89 [c)]	1,08 [c) d)]
Integrated thermal store and gas-fired CPSU	0,89 [c)]	1,08 [c) d)]
Electric CPSU, with winter operating temperature		
85°C	1,09	
90°C	1,15	1,00
95°C	1,21	

Notes:

a) Multiply Temperature Factor by 1,3 if a cylinder thermostat is absent

b) Multiply Temperature Factor by 0,9 if there is separate time control of domestic hot water (boiler and heat pump systems only)

c) Multiply Temperature Factor by 0,81 if the thermal store or CPSU has separate timer for heating the store

d) Multiply Temperature Factor by 1,1 if the thermal store or CPSU is not in an airing cupboard

Table 12-5. Primary circuit losses* (SAP 2005 Table 3)

System type	kWh/year
Electric immersion heater	0
Boiler with uninsulated primary pipework* and no cylinder thermostat	1220
Boiler with insulated primary pipework and no cylinder thermostat	610
Boiler with uninsulated primary pipework and with cylinder thermostat	610
Boiler with insulated primary pipework and with cylinder thermostat	360
Combi boiler	0
CPSU (including electric CPSU)	0
Boiler and thermal store within a single casing (cylinder thermostat present)	0
Separate boiler and thermal store connected by no more than 1,5 m of insulated pipework	0
Separate boiler and thermal store connected by:	
- uninsulated primary pipe work	470
- more than 1,5 m of insulated primary pipe work	280
Community heating	360

Note:

* 'primary pipework' means the pipes between a boiler and a hot water tank

Table 12-6.Additional losses for combi boilers (SAP 2005 Table 3a)

Combi type	kWh/year
Instantaneous, without keep-hot facility*	600 a)
Instantaneous, with keep-hot facility controlled by time clock	600
Instantaneous, with keep-hot facility not controlled by time clock	900
Storage combi boiler** store volume V c ≥ 55 litres	0
Storage combi boiler** store volume V c < 55 litres	600 – (Vc– 15) ·15 a)

'keep-hot facility' is defined in Appendix D, section D1.16. The facility to keep water hot may have an on/off switch for the user, or it may be controlled by a time switch. If the store is 15 litres or more, the boiler is a storage combination boiler.

In the case of keep-hot:

1) If the keep-hot facility is maintained hot solely by burning fuel, use the appropriate loss for combi boiler from the Table 3a and proceed with the calculation as normal.

2) If the keep-hot facility is maintained by electricity:

a) include appropriate combi losses from Table 3a in box (49)

b) calculate energy required for water heating as [(51) – (49)] x 100 / (86) and enter in box (86a). See also Table 4f.

3) In the case of an electrically powered keep-hot facility where the power rating of the keep-hot heater is obtained from the Boiler Efficiency database, the electric part of the total combi loss should be taken as: LE =8,76 x P (kWh/year) (subject to maximum of the value from Table 3a) where P is the power rating of the heater in watts with the remainder (either 600 – LE or 900 – LE) provided by the fuel.

12.4 Coverage solar energy

Appendix H of SAP 2005 gives a calculationm method for solar water heating. It distinguishes three types of collectors: unglazed (high thermal loss), glazed flat plate and vacuum tube collector.

The SAP 2005 assumes a lay-out whereby Water from the cold supply is either fed (directly or via a cold feed cistern) to the preheat zone where it is heated by solar energy. Then the water passes to the domestic hot storage (separate hot water cylinder or upper part of combined cylinder) which is heated to the required temperature by a boiler or an electric immersion.

Three arrangements are given:

- A separate solar storage tank that feeds into a regular indirect cylinder heated by a boiler
- A twin-coil storage tank where the lower part is heated by the solar collector and the upper part by the boiler
- A separate solar storage tank, combined with an instantaneous combi-boiler

The solar contribution to domestic hot water is given by

$$Q_s = S * Z_{panel} * A_{ap} * \eta_o * UF * f(a_1/\eta_o) * f(V_{eff} / V_d)$$

where

Q_s = solar input, kWh/year

S = total solar radiation on collector, kWh/m²/year

Z_{panel} = overshading factor for the solar panel

A_{ap} = aperture area of collector, m²

η_o = zero-loss collector efficiency

UF = utilisation factor

a_1 = linear heat loss coefficient of collector, W/m²K

$f(a_1/\eta_o)$ = collector performance factor = 0,87 - 0,034 (a_1/η_o) + 0,0006 $(a_1/\eta_o)^2$

V_{eff} = effective solar volume, litres

V_d = daily hot water demand, litres

$f(V_{eff}/V_d)$ = solar storage volume factor = 1,0 + 0,2 ln (V_{eff}/V_d) subject to $f(V_{eff}/V_d) < 1{,}0$

The collector's gross area is the projected area of complete collector (excluding any integral means of mounting and pipework). The aperture area is the opening through which solar radiation is admitted. The preferred source of performance data for solar collectors is from a test on the collector concerned according to BS EN 12975-2, *Thermal solar systems and components - Solar collectors - Part 2: Test methods*. The aperture area and the performance haracteristics η_o and a_1 related to aperture area, are obtained from the test certificate. If test data are not available (e.g. for existing installations), the values in Table H1 may be used.

The effective solar volume is:

- in the case of a separate pre-heat tank (such as arrangements a) or c) in Figure H2), the volume of the pre-heat tank
- in the case of a combined cylinder (such as arrangement b) in Figure H2), the volume of the dedicated solar storage plus 0,3 times the volume of the remainder of the cylinder.
- in the case of a thermal store (hot water only or integrated as defined in Appendix B) where the solar coil is within the thermal store, the volume of the dedicated thermal storage.

Table 12-7. Solar energy systems SAP defaults (Tables H1, H2 and H3 of SAP 2005)

Table H1: Default collector parameters

Collector type	η0	a1	Ratio of aperture area to gross area
Evacuated tube	0,6	3	0,72
Flat plate, glazed	0,75	6	0,90
Unglazed	0,9	20	1,00

Table H2: Annual solar radiation, kWh/m²

	Orientation of collector				
Tilt of collector	South	SE/SW	E/W	NE/NW	North
Horizontal	933	933	933	933	933
30°	1042	997	886	762	709
45°	1023	968	829	666	621
60°	960	900	753	580	485
Vertical	724	684	565	427	360

Table H3: Overshading factor

	Overshading % of sky blocked by obstacles.	Overshading factor
Heavy	>80%	0,5
Significant	60-80%	0,65
Modest	20-60%	0,8
None or very little	<20%	1

12.5 Hot water generation losses

In principle the same generation efficiency applies for space heating and water heating when hot water is supplied from a boiler system. The seasonal efficiency values are supplied by the SEDBUK database. If the efficiency is unknown then the values can be taken from table below (SAP Table 4b).

Table 12-8. 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

For heat pumps and dedicated water heaters the following (fixed) efficiency values are given.

Table 12-9. Efficiency of heat pumps and hot water only systems (selection of SAP Table 4a)

HEAT PUMPS (to water)*	Efficiency
	%
Ground-to-water heat pump (electric)	320
Ground-to-water heat pump with auxiliary heater (electric)	300
Water-to-water heat pump (electric)	300
Air-to-water heat pump (electric)	250
Gas-fired, ground or water source	120
Gas-fired, air source	110
HOT-WATER-ONLY SYSTEMS	
If water heating from main system, use efficiency of main system.	
Electric instantaneous at point of use	100
Electric immersion (on-peak or off-peak)	100
Back boiler (hot water only), gas	65
From a circulator built into a gas warm air system, pre 1998	65
From a circulator built into a gas warm air system, 1988 or later	73
Single-point gas water heater ((instantaneous at point of use)	70
Multi-point gas water heater (instantaneous serving several taps)	65

* If the heat pump supplies 100% of domestic hot water then the above values have to be multiplied with a factor 0,7. In case the heat pump supplies 50% of domestic hot water a factor 1,0 applies according to SAP 2005 Table 4c.

For the auxiliary electric energy of the system the following values apply

Table 12-10. Electricity for fans and pumps and electric keep-hot facility (SAP 2005 Table 4f, selection)

Equipment	kWh/year
Central heating pump (supplying hot water to radiators or underfloor system)	130 a)
Oil boiler b)- pump (supplying oil to boiler and flue fan) c)	100 a)
Gas boiler - flue fan (if fan assisted flue)	45
Keep-hot facility of a combi boiler	
Electricity for maintaining keep-hot facility e,f)	
- keep-hot facility, controlled by time clock	600
- keep-hot facility, not controlled by time clock	900
solar water heating pump	
-electrically powered	75
-PV powered	0

Notes:

a) Multiply by a factor of 1,3 if room thermostat is absent.

b) Applies to all oil boilers that provide main heating, but not if boiler provides hot water only.

c) The same motor operates both the pump and the flue fan.

d) See notes to SAP2005 Table 3a for the definition of keep-hot facility.

e) In the case of an electrically powered keep-hot facility where the power rating of the keep-hot heater is obtained from the Boiler Efficiency database, the electricity consumed for maintaining the keep-hot facility should be taken as in footnote 3) to SAP2005 Table 3a.

12.6 Primary energy factor and CO_2

The final step in the SAP calculation is the multiplication with a CO_2 emission factor and a primary energy factor. These are give in the table below.

Table 12-11. 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
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)

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.

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.

13 IRELAND

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.

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].

[48] see www.epbd.ie

14 SPAIN

14.1 General requirements

For heating equipment, including water heaters, the new Spanish Building Code CTE of March 2006 refers to the RITE. The Royal Decree 1751/1998 approves the Regulations of Thermal Installations in Buildings (RITE) and its Complementary Technical Instructions (ITE) and creates the Consultant Committee for Thermal Installations in Buildings. In 2002 the RITE has been amended.

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. (02.5.1)
- Generators. The choice of the generator equipment has to be based in 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.) (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.

Regarding consumption levels, 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 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.

14.2 Solar water heating

14.2.1 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. A further step has been taken by the Barcelona Local Government, and a regulation about solar panels for hot water has been established in 1999. This regulation states as mandatory for almost all the new dwellings to install solar panels, so that they provide at least 60% of the global annual energy consumption related to hot water.

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.

14.2.2 Barcelona

The Barcelona Local Governement was thereby the frontrunner in Spain, followed recently at regional level, e.g. in the *Decree from the Generalitat de Catalunya for Sustainable Buildings*, and soon to be followed at national level with the imminent CTE.

The climatic conditions of Barcelona are suitable for the use of solar energy. Actually the solar radiation is assessed to be 14,5 MJ/(m² day), whereas e.g. in The Netherlands it is 9,92 MJ/(m² day)[49]. This, and the energy and money saving possibilities, led to the local government to established a new regulation in 16 July 1999 with the name "*Ordenanza sobre la Incorporación de Sistemas de Captación de Energía Solar en los Edificios"* (Decree on the Installation of Solar Panels in Buildings).

Article 8 states the main technical guidelines to be followed by this kind of installations:

- Cold water temperature: 10°C
- Minimum temperature of the hot water: 45°C
- Percentage accounted by the solar energy (DA) of the total annual energy consumption related to the hot water generation: 60%. DA is calculated by means of this expression: DA = [A / (A+C)] x 100, where A is the solar energy used for the water heating and C is the additional thermal energy used for water heating.
- DA must be 60% also for water heating systems in swimming-pools.

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[49] "Statistisch Jaarboek 2001", Centraal Bureau voor de Statistiek

- Depending on the circumstances, the Major could increase the DA value to 80%.

This is to be complied by all the buildings, located in Barcelona, with these three features:

- new buildings or those which are completely renovated.
- the building is a: dwelling building, hospitals, sport centre, tertiary sector site, industrial building, swimming-pools (more than 100 m^3) or any other with kitchens, canteen or laundry.
- The average of the annual energy demand related to the hot water generation must exceed 292 MJ.

The regulation also states the minimum hot water consumption to be considered in the buildings projects. This value, known as "**Ci**" with litres/day as units, depend on the characteristics of the building:

- Dwellings:
- Individual systems: Ci = 140 * P/4, where P is the number of persons living in the house.
- Non-Individual systems: C = f * ΣCi, where f is defined by this table:

Table 14-1. "f" value

f	Number of dwellings
1	≤ 10
1,2 x (0,02 x n)	10 < n < 25
0,7	n ≥ 25

- Others: defined by the European average hot water consumption, listed in the next table:

Table 14-2. Hot Water Consumption per person defined in the Solar Systems Decree

Hospitals	60 l/bed
Schools	5 l/person
Barracks	30 l/person
Factories	20 l/person
Offices	5 l/person
Camping Sites	60 l/tent
Hotels	100-160 l/room
Sport Centres	30-40 l/person
Laundries	5-7 l/kg of clothes
Restaurants	8-15 l/client
Cafes	2 l/client

The regulation also states the orientation of the solar panels, the parts of the hot water system or the control system. Concerning the exceptions, the decree identifies three possible situations:

- when it is technically impossible that solar energy accounts for 60% of the energy consumption of the hot water generator system
- when there is not at least 5 m^2 available per dwelling in the roof of the building. If the solar energy can only account for 25% of the energy consumption, then it could not be used at all.
- when at least 40% of the total energy consumption is provided by cogeneration, gas-fired heat pump or a heat recovery system. The rest of the energy demand will be provided by solar panels.

Besides of decree, a subsidy is granted by the City Council to the solar energy systems that comply with it. Moreover, in order to promote the understanding of the regulation, the web of the City Council of Barcelona has created an specific web page where it is possible to make a first estimation of the features of the system. The number of people in the dwelling, the orientation of the main façade and the angle drawn by the panel with the floor are asked and then a tentative estimation of the system is given: panels surface, storage tank capacity, price (with and without subsidy), percentage of the total energy consumption provided by the equipment and energy generated by the system in one year.

14.2.3 Catalonia

The exceptions to these rules are the same as in Barcelona.

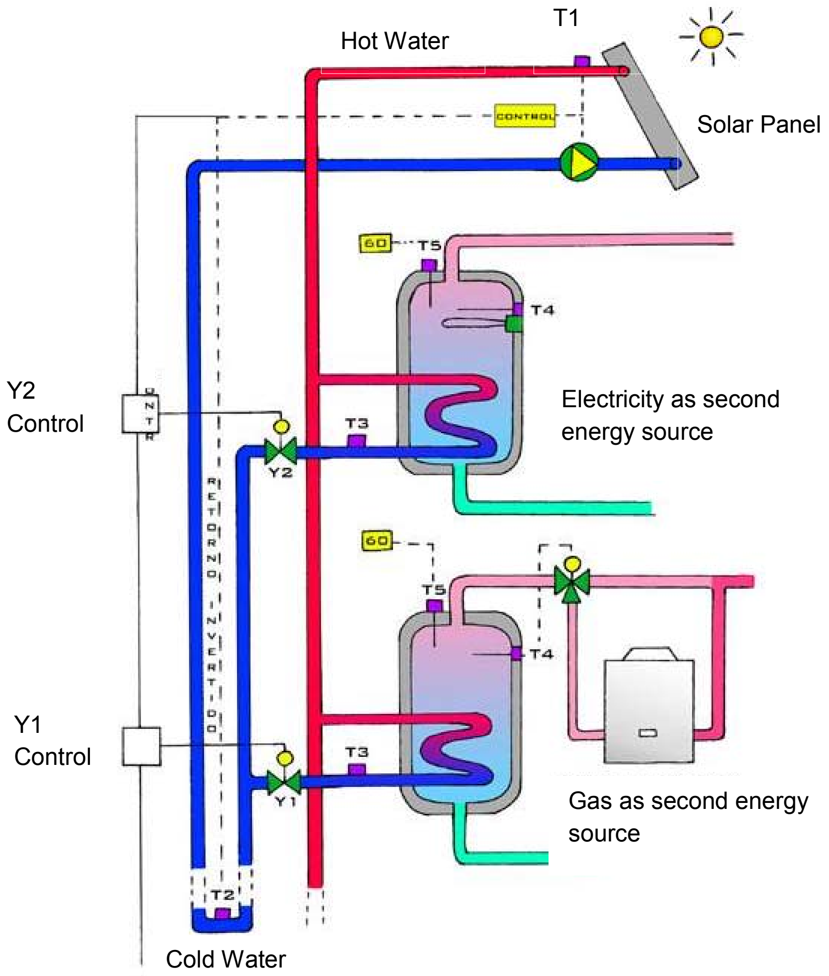
If the hot water installation uses electric resistence heaters ("Joule effect") then the solar coverage should be at least 70% in all cases, unless the building is not connected to the gas distribution network or the electricity comes from renewable energy sources (e.g. PV).

In February 2006, the whole region of Catalonia adopted mandatory solar water heating for sustainable buildings through the Decree 21/2006. For buildings/apartments that are using -according to tables in the annex-more than 50 litres of hot water (60°C) per day it is mandatory to use solar energy for a percentage that is depending on the climate zone, also indicated in a table in the annex. The most common situation is a residential dwelling, where the water use per person is set at 28 litres of 60°C per day. The number of persons is then dependent on the number of rooms: A single room dwelling counts for 1,5 persons, a two room dwelling counts for 2 persons and every extra room counts for 1 person extra. Catalonia has three Spanish climate zones in its territory II, III and IV and the minimum solar coverage of the hot water need in these zones is respectively 40, 50 and 60% for an annual water use of up to 5000 litres per day. For very large water quantities, e.g. at collective showers in swimming pools, the solar energy should cover 70% of the hot water need.

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 14-1.
Hot water system based on solar energy
Source: www.arrakis.es/~jji/Acudis.htm



14.3 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 14-3. 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 14-2.

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.

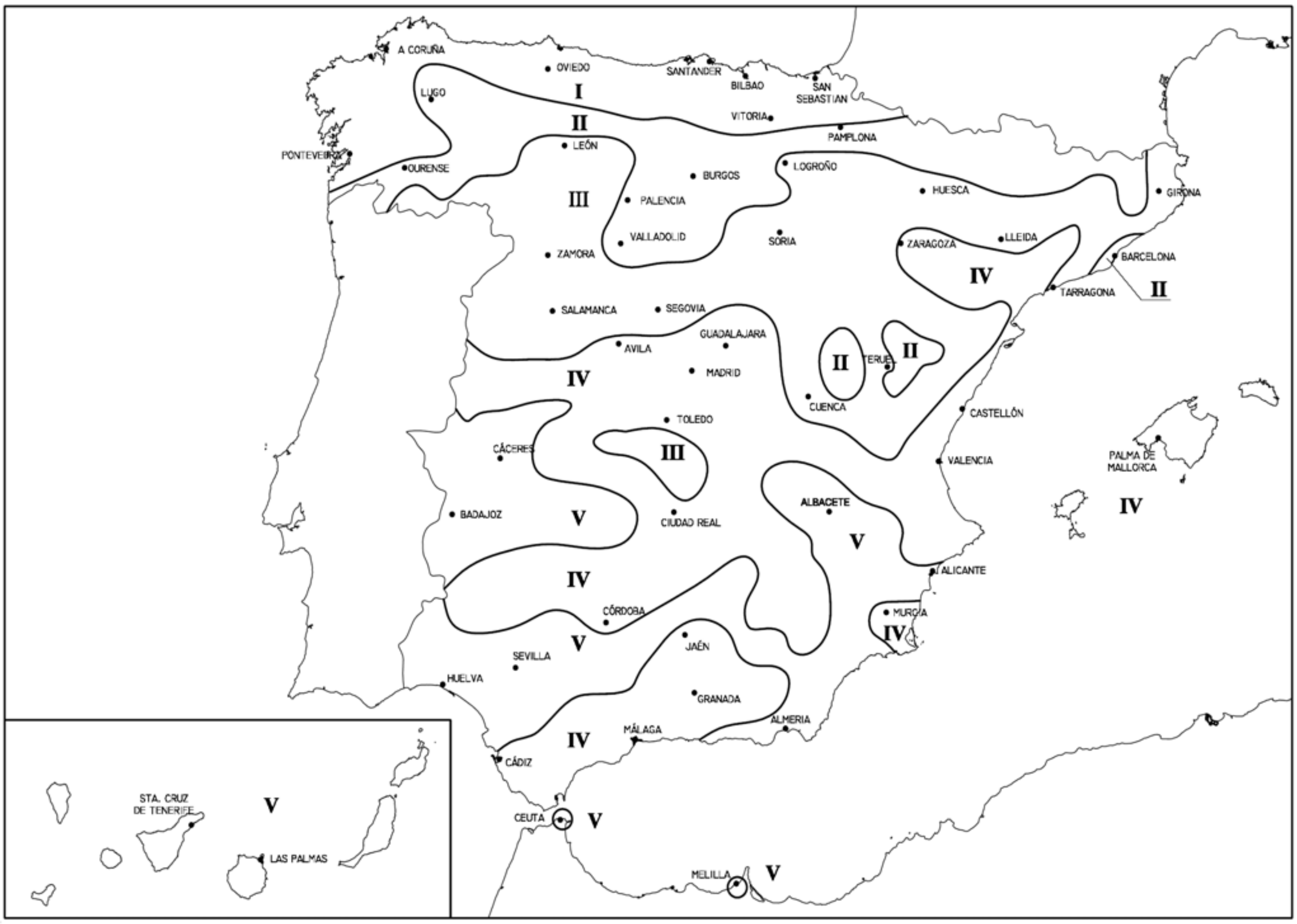


Figure 14-2. Climate zones in Spain

The builder has to submit a plan, incorporating the expected hot water demand and the installation, to show that the minimum solar contribution requirements are met.

Table 14-4. 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.

The hot water demand is determined through the look-up table above, which is similar but not identical to the one used in Barcelona.

The values in the table above 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 [50]. 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).

Table 14-5. 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

At 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 14-6. Global solar radiation (CTE, 2006)

Climate zone	MJ/m².day	kWh/m².day
I	H < 13,7	H < 3,8
II	13,7 ≤ H < 15,1	3,8 ≤ H <4,2
III	15,1 ≤ H < 16,6	4,2 ≤ H < 4,6
IV	16,6 ≤ H < 18,0	4,6 ≤ H < 5,0
V	H ≥18,0	H ≥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 [51]. 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 Wm²/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 m²) and the storage volume V (in litres) is given by
- 50 < V/A < 180

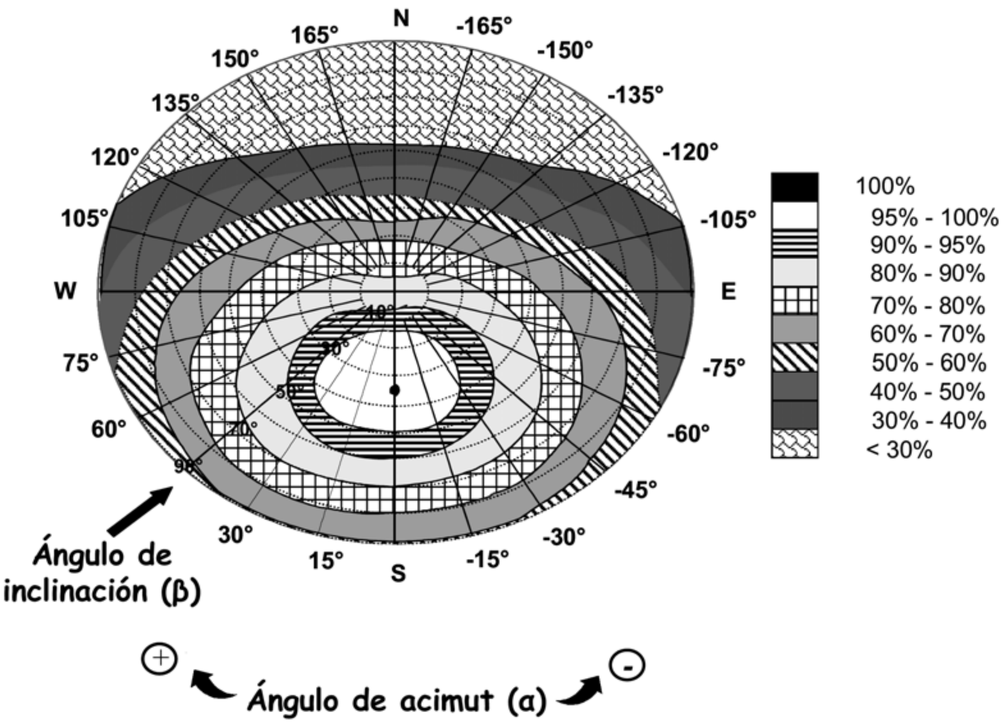
[50] Please note that the calculation was done in UNE 94002;2005 with a temperature of the solar storage tank of 45°C, but this value was recalculated to 60°C.

[51] 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

- The minimum capacity P of the heat exchanger inside the solar storage tank: P ≥ 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[52]
- 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. 14-3)
- For the shading factor, another diagram is given but the same look-up table applies (Annex B).

Figure 14-3.
Look-up diagram for orientation (azimuth) and inclination of collector Spain (CTE, 2006)



[52] Note that ESTIF calculates with 0,7 kWth/m² of collector area for statistical purposes.

15 PORTUGAL

15.1 Introduction

On 4 April 2006, the Official Journal published three Decrees regarding the transposition of the EPBD in national law [53]:

- 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).

Requirements for existing non-residential buildings larger than 1000 m²

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[53] Source: Maldonado, E (University of Porto), Nascimento, C. (ADENE), Implementation of the EPBD in Portugal: Status and Planning, paper P08 for www.buildingsplatform.eu.

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.

15.2 Maximum 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 15-1. 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 $Q_a/\ \eta a$ 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 [54].

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.

15.3 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.

[54] 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

16 ITALY

In 1993 Italy was one of the first countries to implement minimum building installation standards with the Decreto di Legge (DLg) 412 [55]. 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.

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 all clear.

In any case, the DLg 192 prescribes that for new buildings the installation of solar energy systems should be investigated. In case of public buildings –regardless of most circumstances—a solar energy system covering 50% of the sanitary hot water energy demand is always mandatory. Please note that the general obligation –within certain boundary conditions— to install solar energy systems was already part of the 1993 DLg 412 and did not have any noticeable effect: Italy is a country with relatively low penetration of solar energy systems.

In this respect, there is more activity at the regional level. Already some years ago some regions bordering with Austria, like *Bolzano* [56], have more stringent requirements. Also the Provincia di Milano has recently published (15 July 2006) guidelines for the new Regolazione Edilizio Tipo. According to these guidelines all buildings –within certain boundary conditions regarding the building construction and orientation— should have active solar systems that must produce at least 50% of the hot water need [57].

There are no minimum emission or energy standards for dedicated water heaters.

[55] 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.

[56] Provincia di Bolzano, Bollettino Ufficiale n. 44/I-II del 22.10.2002, allowing 50 to 70% subsidy for solar systems

[57] More information at www.anit.it and www.provincia.milano.it

17 CYPRUS

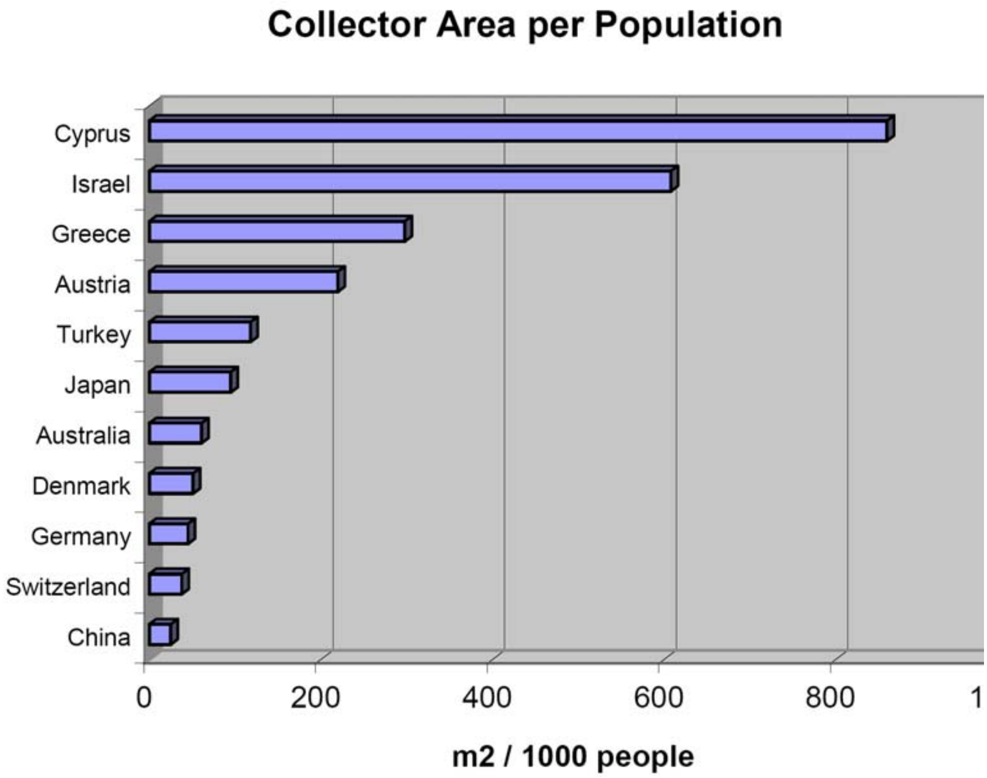
Cyprus is completely dependent on imported fossil fuels, which is strenuous on both the economy and the environment. In 1997, energy imports corresponded to 61 percent of the country's total domestic exports and 9,1 percent of the total imports for home consumption. For this reason, the use of solar 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[58]. 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 percent of total CO_2 emissions are avoided, which is approximately 286 tons of CO_2/year.

[58] source: UN DESA SIDS Network: Cyprus, Success Stories. (www.sidsnet.org)

Figure 17-1.
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)



18 GREECE

As a result of the government programmes started in the early 1980's, 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[59]. 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.

[59] Greek Experience – Solar Thermal Programme Results and lessons (source: -Sun in Action II - a Solar Thermal Strategy for Europe)

19 DENMARK

19.1 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 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.

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 1000 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.

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).

19.2 Energy & CO_2

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 gas- and oil-fired central heating boilers ('Kedler')[60], but not for sanitary hot water installations. This may be due to the fact that the typical Danish fossil-fuel fired water heater is in fact a relatively modest boiler combined with a separate indirectly heated cylinder.

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 20000 kWh heat + 2000 kWh hot water. Electricity consumption is weighted with a factor of 2,75 and the gas consumption with a factor of 1 .

Table 19-1: 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 20,000 kWh. The calculation is based on an 8 kW heating installation, dimensioned for an average temperature on the water side of 55°C and $\Delta T = 15°C$ at an outdoor temperature of -12°C. It is assumed that the boiler runs at minimum load when

[60] 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. 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. 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

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 19-1.

Figure 19-1:
Criteria for choice of hot water tank

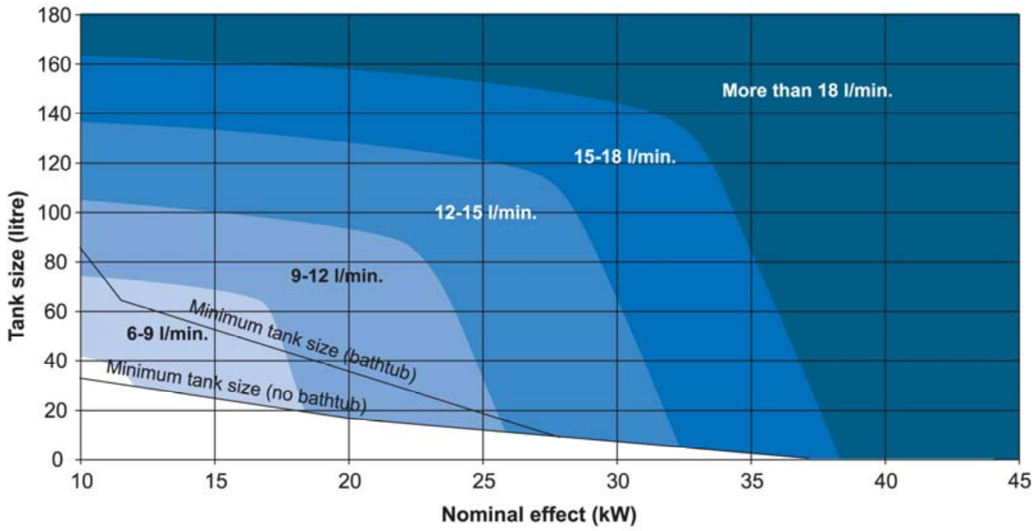


Table 19-2 shows the definition of the number of taps.

Table 19-2. 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.

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.

19.3 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.

20 SWEDEN

20.1 Introduction

Gas- and oil-fired water heaters, as well as new sales of electric resistance water heaters are rare in Sweden. Most water heating comes from heat pump water heaters (e.g. using waste heat from ventilation air) and district heating. In the country-side, multi-fuel solutions (wood/oil) may exist. Sweden is a pioneer in electric heat pumps.

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.

20.2 Energy & CO_2

There is no knowledge of minimum efficiency requirements for gas- or oil-fired water heaters or a holistic approach that would push energy efficiency upwards, other than the obvious transposition of the EU Boiler Directive. Legislation for heat pumps may be relevant. Furthermore, the ENPER project reports that electric resistence heaters are forbidden in Sweden.

20.3 NO_x, CO, C_xH_y, SO_2, PM10 emissions

There are no specific limits regarding NO_x emissions for water heaters.

20.4 Labelling and incentives

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 water heaters as a subject. There are incentives (subsidies) to promote the transition from fossil fuel fired appliances and electric resistance heating systems towards heat pumps and 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.

21 FINLAND

21.1 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 [61].

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.

21.2 Energy & CO_2

Details of building regulations as far as gas-, oil- or electric water heaters are concerned are not known. 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.

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.

[61] 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

21.3 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 water heaters 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 and gas- or oil-fires water heaters are apparently too rare for special legislation.

21.4 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.

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); glassing 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 [62]. 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 [63].

22.3 Latvia

The Latvian Convergence Programme 2004-2007 [64] 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.

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[62] 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.

[63] 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.

[64] 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 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. 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 ([65]) 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)

[65] 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	$mg(NO_x)$ / m^3 (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)

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.

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.

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[66]. 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.

[66] 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 [67], 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 [68].

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)[69] 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.

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[67] www.energie.ch/themen/bautechnik/minergie/index.htm

[68] www.clasponline.org

[69] Pers. Comm.. DiPrenda, 2006.

Table 24-1. Maximum 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

Dedicated storage water heaters are the pre-dominant type of water heaters in the US. Combi-boilers and electric instantaneous heaters are rare. Instantaneous gas-fired water heaters are just starting up as they are being promoted by the authorities as energy efficient. According to an extensive survey by the US government (EIA 2001) some 58% of residential water heating energy comes from natural gas, 41% is electric, whereas oil and LPG each account for 3-4%. The average US household consumes over 5000 kWh per year for water heating, which is twice as much as in Europe. Hot water is used not just for cleaning and personal hygiene, but also for laundry washing ('hot-fill' washing machines) and also for ('hot fill') dishwashers.

25.2 Federal: Energy & CO_2

The US has had federal minimum energy efficiency standards for water heaters since the 1980's. 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 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
electric storage water heaters	0,97 – 0,00132 * 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
electric instantaneous water heaters	0,93 – 0,00132 * 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 24h 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 [70] 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 electric storage water heaters this means that the minimum energy factor is 0,93 (storage < 60 gallons) or 0,91 (storage > 60 gallons) [71]. With gas storage water heaters smaller than 50 gallons the energy factor should be higher than 0,62.

[70] www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/wtrhtr.pdf

[71] www.eere.energy.gov/femp/procurement/eep_electric_waterheaters.cfm#performance

25.3 California: Energy and CO_2

The 2006 Appliance Efficiency Regulations, (California Code of Regulations, Title 20, Sections 1601 through 1608) dated July 2006, were adopted by the California Energy Commission on May 24, 2006, and approved by the California Office of Administrative Law on June 23, 2006.[72] For small water heaters (<20 gallons) the federal standards 2004 (see EF values above) apply. For large water heaters separate minimum values for combustion efficiency and standby-loss are applicable, effective as of Oct. 2003 The minimum combustion efficiency is 78% (most oil) to 80% (gas and small oil). The maximum standby loss for all large gas- and oil-fired water heaters is

$$Q/800 + 110\sqrt{V} \text{ (in Btu/hr)},$$

Where

Q= rated heat input (in Btu)

V= storage tank volume (in gallon, 1 gallon = 3,8 litres)

Example: For a 10 kW (32400 Btu) water heater with a 114 litre (30 gallon) tank the maximum standby loss is $32400/800 + 110 * \sqrt{30} = 40{,}5 + 110 * 5{,}47 = 642$ Btu/hr = 200 W (4,8 kWh/24h) [73].

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 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 specific plans for appliance regulations are known in any other states, including Michigan, Massachusetts and New Jersey (P George, personal communication).

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/hr $\leq$ ca. 120 kW) and Type 2 (400 000 to 2 million Btu/hr = 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.

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. 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,*

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[72] www.energy.ca.gov/2006publications/CEC-400-2006-002/CEC-400-2006-002-REV1.PDF

[73] Compare: EU practice ca. 1,5 - 2 kWh/24 h. In other words the limit values for standby of larger (California regulated) water heaters do not seem extremely stringent. In fact, the water heater from this example would have a standby loss of 1752 kWh/yr and a heating loss of 1277 kWh and would barely be more efficient than with the minimum federal rules.

excluding direct-vent, power-vent and power direct-vent water heaters[74]*; 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 ppmv 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. As of April 30, 2005, the AQMD has available $ 1 227 743 from emission mitigation fees collected under Rule 1121.

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 and San Diego (Benedek and Goodman, 1994).

[74] '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.

26 CANADA

Regarding MEPS for water heaters, an amendment to the Energy Efficiency Regulations was approved in late August and registered on September 1, 2004.[75] 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. Electric storage water heaters are the exception where Canada does not use the US the minimum requirement, but gives (slightly less stringent) maximum standby losses. Furthermore, Canada adds a category of electric storage water heaters with bottom outlet, which are allowed an extra 5 W loss with respect of the conventional product.

This regulation applies to natural gas and propane gas storage-type water heaters having an input of 75000 Btu/h (21,98 kW) or less and a storage capacity of 20 to 100 US gal. (76 to 380 litres).

This regulation applies to oil-fired storage tank water heaters with an input rating of 107000 kJ/h or 30,5 kW or less and manufacturer's specified storage capacity of 190 litres (50 U.S. gal.) or less.

This regulation applies to electric storage tank water heaters with volumes of 50 to 454 litres (11 to 100 Imperial gal.).

Table 26-1. Canada MEPS 2004: Maximum Standby Loss or Minimum Energy Factor (EF)

Electric storage water heaters	Standby loss (watts) less than or equal to: 35 + (0,20V) (50 to 270 litres) (0,472V) - 38,5 (>270 to 454 litres) or with bottom inlet * 40 + (0,20V) (50 to 270 litres) (0,472V) - 33,5 (>270 to 454 litres)
Oil-fired storage water heaters	EF greater than or equal to: 0,59 - 0,0005V
Gas-fired storage water heaters	EF greater than or equal to: 0,67 - 0,0005V

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 electric water heaters, the test standard is CAN/CSA-C191-00, "Performance of Electric 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".

[75] The amendment has been published in the Canada Gazette Part II: http://canadagazette.gc.ca/partII/2004/20040922/html/sor191-e.html

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.

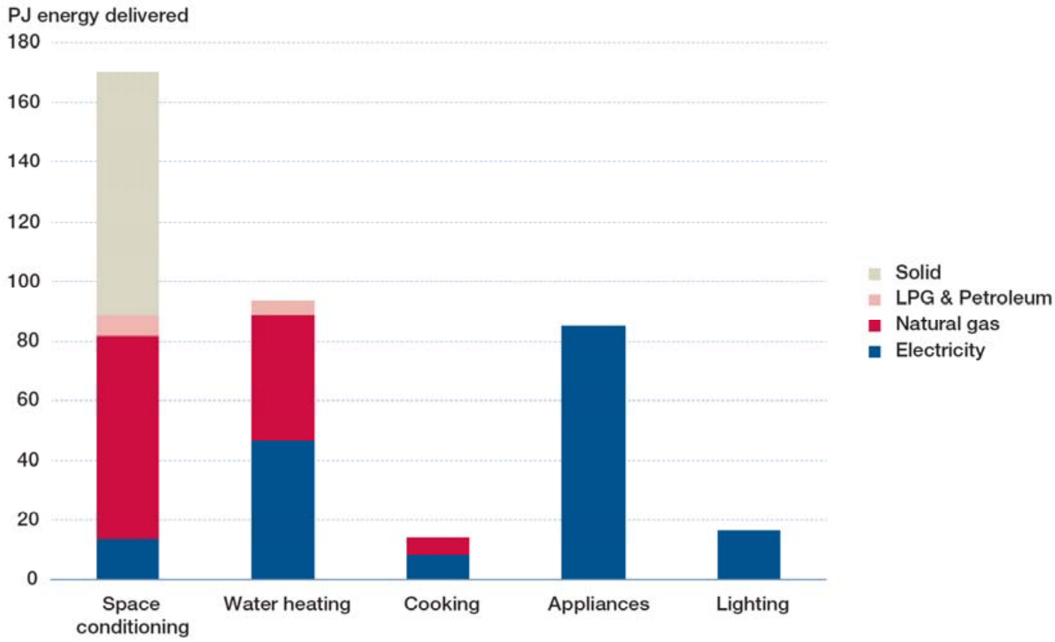
27 AUSTRALIA

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. Gas water heaters are 47% of the stock (28% storage, 19% instantaneous). The graph below shows the fuel use in PJ for water heaters and other appliances. In terms of energy use (in PJ) water heaters rank second after space conditioning equipment (see graph below).

Figure 27-1. Australia, residential sector 1999 — energy use by end-use and energy type [GWA et al, 2002]



Given the high share of biomass in space heating, water heaters rank first in terms of CO_2 emissions in Australia. For electric storage water heaters mandatory minimum energy efficiency standards and labels, managed under the government's NACEEE programme. For gas appliances the management 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.[76]

[76] *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*

27.2 MEPS Electric water heaters

Since 1 October 1999, unvented (displacement) electric storage water heaters manufactured in or imported into Australia had to comply with Minimum Energy Performance Requirements which are set out in AS 1056 Part 1. The Minimum Energy Performance Standards requirements are set out as maximum allowable standing heat loss values in Amendment 3 dated 5 August 1996 (column 2 in this amendment).

The introduction of more stringent energy efficiency requirements in the US in 2001 prompted the Australian to review of the 1999-standards. The table shows the comparison between the 1999 Australian MEPS values and those of the US MEPS effective of 2004.

Table 27-1. USA New MEPS compared with Present Australian MEPS [NAEEEC review 2002[77]]

Volume (Litres) %	Delivered (Litres)	Aus 1999 MEPS (kWh/day)	New USA 2004 MEPS (kWh/day)	Aus MEPS Exceeds USA New MEPS
90	80	1,67	1,14	-31%
110	100	1,81	1,30	-28%
135	125	1,95	1,50	-23%
180	160	2,16	1,85	-15%
225	200	2,37	2,20	-7%
270	250	2,58	2,55	-1%
360	315	2,86	3,25	14%
450	400	3,07	3,95	29%

Note: All heat loss values converted to an equivalent heat loss under AS1056.1. Note that the above US values
appear to refer to the MEPS for tabletop water heaters (less stringent than normal el. Storage WHs)

On the 1st October 2005 the Australian government has adopted new/amended standards for electric water heaters, known as AS/NZS 4692.2 — MEPS Requirements for Electric Storage Water Heaters [78].

Table 27-2. Australian MEPS 1999 and 2005 for electric storage water heaters

Rated Hot Water Delivery (litres)	Maximum Allowable Standing Heat Loss (kilowatt hours/day)		Rated Hot Water Delivery (litres)	Maximum Allowable Standing Heat Loss (kilowatt hours/day)	
	Oct. 1999	Oct. 2005		Oct. 1999	Oct. 2005
<25	N/A	0,98	125	1,75	1,75
25	1,4	0,98	160	1,96	1,96
31,5	1,5	1,05	200	2,17	2,17
40	1,6	1,12	250	2,38	2,38
50	1,7	1,19	315	2,66	2,66
63	1,9	1,33	400	2,87	2,87
80	1,47	1,47	500	3,15	3,15
100	1,61	1,61	630	3,43	3,43

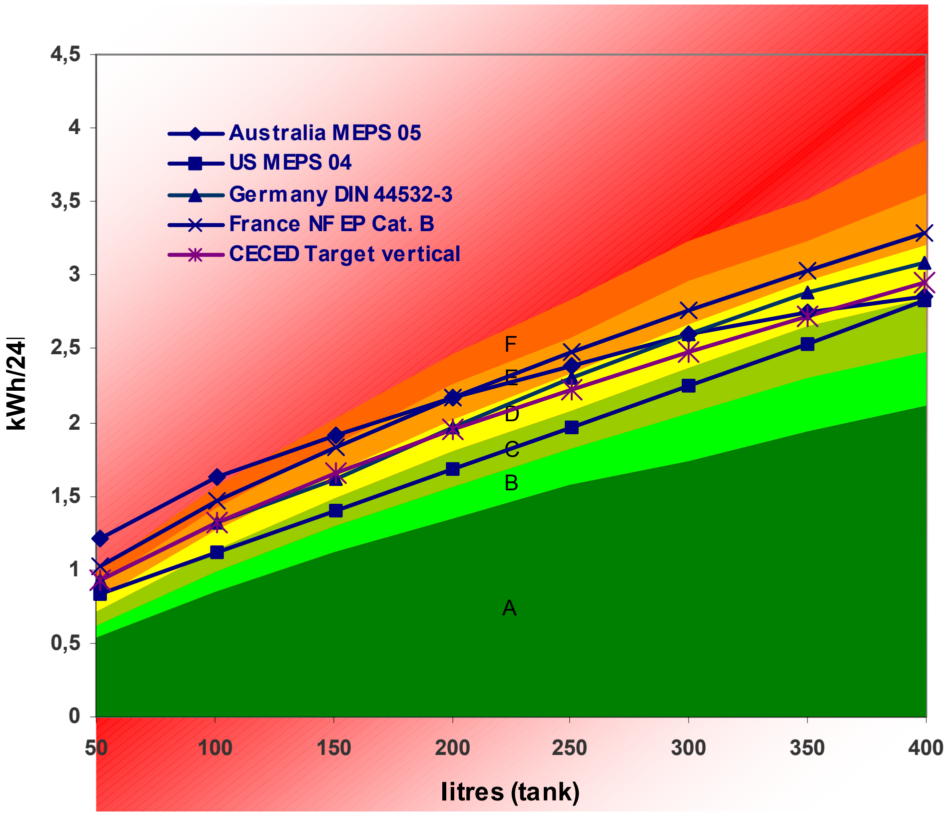
Apart from the unvented water heaters (which is the most common type also in Europe), the new standards also include vented water heaters (MEPS (maximum daily heat loss) = $0{,}255 * V^{0{,}4032}$) .

[77] NATIONAL APPLIANCE & EQUIPMENT ENERGY EFFIC IENCY PROGRAM (NAEEC), Review of the Minimum Energy Performance Standards for Mains Pressure Electric Resistance Storage Water Heaters, 2002.

[78] www.energyrating.gov.au/ewh2.html see also www.clasponline.org

The graph below compares the Australian MEPS 2005 values with the US MEPS 2004 for electric storage water heaters (not tabletops), DIN 44532-3, NF Électricté Performance Cat. B and the CECED targets. In the background of the graph we have given the A-G classification from the prEN 15332; 2006, which is the most recent EU draft standard for (indirectly heated) storage tanks. The US MEPS values have been corrected to reflect the fact that the storage temperature is only 57°C instead of 65°C as with the others.

Figure 27-2.
Comparison between requirements for electric storage water heaters in various countries. Max. storage losses according to Australian MEPS 2005, US MEPS 2004, German DIN 44532-3 (voluntary), the French requirements for the NF Électricité Performance Cat. B cerificate and the CECED target for vertical appliances (voluntary) against a background of A-G rating as proposed in prEN 15332; 2006 for indirect cylinders [analysis VHK 2006]



The graph shows that the US minimum efficiency standards are the most stringent and would equal an average C-rated storage tank according to prEN 15322. The DIN standard equals more or less the line between D- and E-rated appliances. The Australian MEPS 2005 are the least stringent in the lowest volume classes, but the curve is crossing the other two in the higher volume range (>300~400 litres). The CECED targets from the unilateral agreement are comparable to the DIN standard up to 200 litre storage volume and then become slightly more stringent.[79]

27.3 MEPS 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

[79] see www.ceced.org for more background information

The standard (and the labeling) are currently under review[80]. A 2003 discussion paper by the Sustainable Energy Authority Victoria [81]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 x volume (litres).

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[82]. 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/hr. 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.

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[80] 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

[81] Sustainable Energy Authority Victoria, Driving Energy Efficiency Improvements to Domestic Gas Appliances, Discussion Paper July 2003

[82] A similar scheme exists also for electric water heaters

Figure 27-3.
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.

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[83]. All gas water heaters with 5 or 6 stars receive the TESAW label in 2006.

[83] see for more details www.energyrating.gov.au/tesaw-criteria.html

28 NEW ZEALAND

Australia and New Zealand usually have identical or similar requirements in the field of energy policy measures. But in the case of MEPS for electric storage water the New Zealand standard is more stringent. For electric storage water heaters the mandatory Minimum Energy Performance Standard is *NZS 4606.1 - Storage water heaters Part1: General requirements*, which is similar to AS 1056. This standard specifies requirements for electrically heated thermal storage water heaters having capacities within the range 6,5 L to 630 L. Water heaters with copper vessels may also be made to NZS 4602. It does not apply to heat-exchange water heaters or to fixed water boilers.

With a temperature difference of 55°C between the water and ambient, the 24 hour heat loss from the heater shall not exceed: For heaters of 90 litres or smaller, 0,0084 L + 0,40 kWh; For heaters of 90 litres or larger, 0,0048 L + 0,72 kWh; rounded up to the nearest 0,1 kWh.[84]

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[84] www.clasponline.org

29 JAPAN

29.1 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 [85]. Although no statistics were found, anecdotal evidence suggests that gas-fired instantaneous water heaters of considerable capacity (34-52 kW) are the dominant type [86]. 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.

29.2 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.

29.2.1 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).

[85] 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)

[86] E.g. see product range of Japanes manufacturers, e.g. Chofu (www.chofu.co.jp/english/gas.htm)

Table 29-1. 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[87] showing that the efficiency is on the Gross Calorific Value (Higher Heating Value) of the fuel. This implies that the Japanese MEPS are around 10%

29.2.2 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.

[87] Kyudae HWANG et al., THERMAL EFFICIENCY ENHANCEMENT ON GAS-FIRED WATER HEATER USING TITANIUM HEAT EXCHANGER FOR LATENT HEAT RECOVERY, Waseda University, Tokyo, Japan.

Table 29-2. Japan minimum energy efficiency targets for Oil-fired Water Heaters (ECCJ, 2006)

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	840
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.

29.3 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 [88]). 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.

[88] www.gas.or.jp/e_kankyo/3_1.html

30 CHINA

Currently, policy measures (MEPS) are under development for gas water heaters in China.[89]

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%).[90] 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%[91]. 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.[92]

Current baseline usage is estimated to be 182 m^3 of natural gas per unit in north China and 146 m^3 natural gas per unit in south China, with an average usage of 161 m^3 per water heater per year.[93] 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 30-1. Annual energy use of water heaters in China (Jiang Lin, 2006)

	Average Efficiency	UEC (m^3/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)[94] 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.[95]

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[89] 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

[90] CNIS (China National Institute of Standardization), unplublished report, cited by Jiang Lin.

[91] Testing report on the energy efficiency of instantaneous gas water heaters, National Quality Supervision and Testing Center for Gas Appliances, 2005

[92] Jiang Lin, ibid

[93] Fu Z., 2005, research note on gas water heaters. In Jiang Lin, ibid

[94] 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)

[95] Jiang Lin, ibid.

31 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/home.php and others.

31.1 Other Asian countries

31.1.1 Hong Kong, China

As part of the The Hong Kong, China energy efficiency program, Hong Kong has a voluntary energy efficiency labeling scheme for electric water heaters references the IEC 60379 test procedures. More information. More information: www.emsd.gov.hk/emsd - (Electrical and Mechanical Services Department)

There is also a voluntary labeling program for gas-fired instantaneous water heaters based on test standards JIA F 031, EN 26;1997, GB 6932.

31.1.2 India

The Government of India launched the voluntary eco-labeling scheme known as `Ecomark' in February 1991 for easy identification of environment-friendly products. The Ministry of Environment of Forests (MoEF), with the technical advice of the Central Pollution Control Board (CPCB), manages the program. Unlike many other international eco-labeling programs that are independent, India's Ecomark is awarded to consumer goods which meet the specified environmental criteria and the quality requirements of the Bureau of Indian Standards (BIS)'s product quality standards. The Ecomark for electric storage water heaters was introduced in 1996. More information: www.cpcb.nic.in/index_ecomark.htm.

31.1.3 Indonesia

The Indonesian government is developing residential appliance efficiency standards and labeling programs. Although no standards currently exist, voluntary standards are being considered for several products, amongst which electric storage water heaters.

31.1.4 Singapore

Electric storage water heaters are one of the products of the voluntary Green Label programme, set up by the government and currently managed by the Singapore Environment Council (SEC) (www.sec.org.sg)

31.1.5 South-Korea

South-Korea has a voluntary EcoLable programme for solar water heaters. More information at www.kela.or.kr/english/cover/cover.asp - Korean Eco Label, Korean Environmental Labeling Association (KELA)

31.1.6 Taiwan

Chinese Taipei (Taiwan) has Performance requirements for household electric storage water heaters (<12 kW), including "energy efficiency" and "heat insulating efficiency", that are specified in CNS 11010-89, According to the Australian evaluation these MEPS are not very stringent. More information: www.moeaec.gov.tw.

31.1.7 Vietnam

The energy standards and labeling program is still in the early stages and there is no S&L program currently under implementation. Electric water heaters are one of the products under consideration for labelling.

31.2 Central & South America

31.2.1 Argentina

Argentina has drafted framework legislation for energy efficiency and began enforcing energy-efficiency labeling requirements in 2000. Until recently, existing appliance and lighting standards have been voluntary in Argentina. Labelling for electric water heaters is being considered under the Programa de Calidad de Artefactos Electricos para el Hogar (PROCAEH).

31.2.2 Brazil

Brazil has a voluntary labeling programme for electric instantaneous water heaters and for solar water heaters. The label lay-out is based on the general EU-label for whitegoods. The test standard for electric water heaters is RESP/002-AAQ (Grupo Tecnico de Conservacao de Energia e Etiquetagem em Electrodomesticos - Aparelhos Eletricos Fixos de Aque-cimento Instantaneo..). The test standard for solar water heaters is RESP/006-SOL . More information at

www.inmetro.gov.br/consumidor/resp002.pdf

For instantaneous gas-fired water heaters there is the voluntary endorsement label CONPET: Programa Nacional da Racionalização do Uso dos Derivados do Petróleo e do Gás Natural (National Program of Rationalization of use of product derived from petroleum and Natural Gas). The test standard for this label introduced in 2005 is RESP 009 Rev 00. Implementing Agency: MINISTÉRIO DE MINAS E ENERGIA PETRÓLEO BRASILEIRO S.A. - PETROBRAS INMETRO. More information can be found at

www.conpet.gov.br/download/pdf/regulamento_selo_conpet.pdf

31.2.3 Chile

CLASP reports that Chile is considering a labeling program for electric storage water heaters based on test standard NCh 2662: 2002, which is based on IEC 60379. More information: www.cne.cl - Comision Nacional de Energia (National Energy Commission) (Spanish) or www.inn.cl - Instituto Nacional de Normalizacion INN (National Standards Institute) (Spanish)

31.2.4 Colombia

Under the Programme for the Rational and Efficient Use of Energy and Other Non-Conventional Energy Forms (Programa de Uso Racional y Eficiente de la energia) Columbia has MEPS for electric storage water heaters using test standards NTC 5106 and NTC 4720, based on IEC 60379. Also there are MEPS for solar water heaters.

Using the same test standard, Colombia also employs a mandatory energy label, based on the EU general example, for water heaters Programa Colombiano de Normalizaci□n, Acreditacion, Certificaci□n y Etiquetado de Equipos de Uso Final de Energ□a (CONOCE). More information: www.upme.gov.co - Unidad de Planeaci□n Minero Energ□tica (UPME) (Ministry of Mines and Energy, Mining Energy Planning)(Spanish) .

31.2.5 Costa Rica

The Ministry of Environment and Energy (MINAE) has spearheaded the development of an S&L regime as a component of the government's Rational Energy Use Program. The program was launched in 1994 with the passage of the Regulations to the Law on the Rational Use of Energy (Ley 7447 Regulación del Uso Racional de la Energía,or "Law No. 7447"), which establishes mechanisms to improve energy efficiency in Costa Rica. The scheme is closely linked with the mandatory energy labeling program (*Plaqueo Energetico*), which requires the MEPS level to be displayed on the efficiency label.

31.2.6 Mexico

Mexico has minimum standards and a label for water heaters. Mexico is working with Canada and the US on a program to harmonise energy labels and standards and e.g. also employs the same mandatory Energy Guide label. Reportedly MEPS exist for gas-fired (and electric?) water heaters based on test standard NOM-003-ENER-2000. The latest 2002 update prescribes a minimal thermal efficiency of 74 (Domestic) and 79% (Commercial) . More information at www.conae.gob.mx - Comision Nacional de Ahorro de Energía (CONAE - National Energy Savings Commission) (Spanish).

31.3 Russia

According to CLASP Russia has MEPS for electric water heaters, approved in 1984. Four agencies were involved in the development of MEPS program: Ministry of Fuel and Energy; GOSTANDART of Russia (the State Committee of Russian Federation for Standardisation and Meteorology, also known as GOST); ZNEENMash (an affiliate of GOST who are responsible for the development of product energy performance regulations), Mintopenergo (responsible for developing and overseeing voluntary energy efficiency requirements and targets). More details at www.gost.ru and www.cenef.ru.

31.4 Israel

CLASPR reports that Israel has a MEPS and a mandatory labelling programme for electric water heaters and for solar water heaters. More information at Standards Institution of Israel (SII) - www.sii.org.il .

31.5 Africa

Although a few African countries employ MEPS (Ghana) and labelling (Ghana, S.-Africa) of products as energy policy instruments. However, water heaters have so far not been included. Apart from economic reasons, it has also to be considered that in large part of Africa the cold water coming from the taps is already warm enough for taking showers.

ANNEX A: TAPPING PATTERNS

PrEN 50440

EN 13203-2

Table A-1

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 A-2

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 A-3. 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 A-4. 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 A-5. 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 A-6. 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 A-7. 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		

TableA-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 A-9. 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: REFERENCES

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