Scoping Study for Residential Water Heaters Mapping and Benchmarking Project

Final report

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01 Introduction

This report was prepared by Waide Strategic Efficiency Ltd (UK), ARMINES (France), Lawrence Berkeley Laboratory (the USA) and CEIS (Spain) as the deliverable for the CLASP project RFP#12-13 "Scoping Study for Residential Water Heaters Mapping and Benchmarking". It aims to supply information that could inform the design of a full mapping and benchmarking study for water heaters in accordance with the scope of work specified below.

Scope of work

The scoping study covers residential water heaters –including electric, gas and solar powered appliances, tank, tankless, and heat pump types in the economies of: Australia, Brazil, Canada, China, the EU, India, South Korea and the USA. The study is divided into three tasks as indicated below with their associated sub tasks and the sections of the report where the information is presented.

Task 1 addresses product definition and covers the following elements:

- definition of relevant product classes or categories, discussed in section 2
- listing and assessment of country data sources i.e. a listing of test procedures and regulations, presented in sections 3-10 by economy. Market data sources are given in Appendix A.

Task 2 addresses mapping and covers the following elements:

- mapping of product characteristics in selected countries, presented in section 11
- mapping of existing standards and labelling initiatives and a description of their characteristics, presented in section 12
- Identification and initial comparison of test procedures, presented in section 13.

Task 3 concerns benchmarking and covers the following elements:

- identification of potential issues in test results comparison that would need to be addressed in a full benchmarking study, presented in section 14
- analysis of knowledge gaps that need to be addressed in a full benchmarking study, discussed in section 15.

Overall it is intended that the information presented in this study will facilitate CLASP and their partners to identify future research needs that will lead towards the successful benchmarking of policy settings for this important energy end-use and will thereby support policymakers in better understanding their options to improve water heater energy efficiency.

A note on how to read the report. In order to facilitate comparison and for completeness tables by economy are mostly presented in a common format that shows the relevant parameter (e.g. energy performance test procedure or regulation) for each type of water heater considered by the study. If cells are empty it indicates that there is no such test procedure, regulation or other requirement for that product type within the specified economy.

General context

In most economies sanitary water heating is one of the two largest energy end uses and typically accounts for from 15% to 25% of delivered energy. Globally heating water in the residential sector may use as much as 11 petajoules per year. This makes it one of the most important areas of energy use and CO_2 emissions.

Water heaters may be gas, electric or solar powered. They can be instantaneous, typically positioned close to the point of demand, or they may use storage tanks connected to the points of demand by a distribution system. Electric water heaters may use heat pump technology (usually air-source) to increase the overall efficiency or they may be more conventional designs that simply use electric resistance heaters. In some economies, most notably Europe, water heating can also be provided by the same device used to provide the space heater through a "combi-boiler" design that has one heating loop for sanitary hot water and another to supply water into a hydronic heating system; however, these systems are beyond the scope of the current call which is limited to pure water heating devices.

MEPS and labelling schemes developed for water heaters around the world have traditionally been based on a specific set of standards and metrics differentiated by water heater type. For each subtype (with/without storage, energy source, controls, and so on), there are specific energy performance metrics that express the ratio of heating energy delivered to the energy consumed. In the USA these are known as the "energy factor". These numerous differentiated classifications reveal the difference in performance of products within the same technology sub-class. At the same time, they can actually act as a barrier to energy efficiency improvement through inhibiting comparison across water heater technology classes. This is especially true for water heaters where there is far greater energy savings potential from adopting an alternative high efficiency water heater technology (e.g. solar or heat pump based instead of storage tanks heated by electric resistance) than there is from choosing an incrementally higher efficiency product from within one of the conventional technology classes (e.g., better insulated electric resistance storage tanks). Thus the propagation of efficiency definitions within technology "silos" has encouraged a conservative market.

The most interesting international policy development in recent years has occurred in Europe, where the Ecodesign Lot 2 process, which began in 2006 and built firmly on earlier work looking at efficiency within technology classes, recognized the need to develop a means of putting all water heater technologies on a single scale. The intention was to allow end-users to compare different technologies and their energy performance on a single efficiency scale e.g. an electric storage water heater and a condensing boiler with storage. After 7 years intensive work and policy development the new regulation on water heaters was adopted in 2013. The approach used gives a much larger potential in terms of energy efficiency improvement from MEPS and labelling because the differences in energy efficiency between the different technologies are much larger than within the same technology type.

We believe that consideration of this functional approach (as opposed to a technological approach) is an essential element for the proposed global benchmarking study on water heating technology if the CLASP project is to foster the development of the most efficient technologies rather than solely encouraging within technology type benchmarking. In consequence the work aims to dive deeply inside the various international test methodologies and standards in order to ensure all technologies are fairly considered but also that both within class and between class comparison options are addressed. This additional element requires comparison of water heaters using different types of energy sources on a common scale and then consideration of the definition of default conversion factors between electricity, thermal (e.g., natural gas) and solar energy sources.

02 Definition of relevant product classes or categories

A broad overall definition of a water heater

The recent EU Ecodesign and energy labelling regulations provide a broad definitional scope of domestic water heaters as follows[1]:

"1. This Regulation establishes requirements for the energy labelling of, and the provision of supplementary product information on, water heaters with a rated heat output ≤ 70 kW, hot water storage tanks with a storage volume ≤ 500 litres and packages of water heater ≤ 70 kW and solar device."

The EU regulations do not apply to:

- water heaters specifically designed for using gaseous or liquid fuels predominantly produced from biomass
- water heaters using solid fuels
- certain kinds of combination heaters
- water heaters designed for making hot drinks and/or food only.

The EU regulations clarify the meaning of some of these terms through the following set of definitions:

"(1) 'water heater' means a device that:
(a) is connected to an external supply of drinking or sanitary water;
(b) generates and transfers heat to deliver drinking or sanitary hot water at given temperature levels, quantities and flow rates during given intervals; and
(c) is equipped with one or more heat generators;
(2) 'heat generator' means the part of a water heater that generates the heat using one or more of the following processes:
(a) combustion of fossil fuels and/or biomass fuels;
(b) use of the Joule effect in electric resistance heating elements;
(c) capture of ambient heat from an air source, water source or ground source, and/or waste heat;
(3) 'rated heat output' means the declared heat output of the water heater when providing water heating at standard rating conditions, expressed in kW;
(4) 'storage volume' (V) means the rated volume of a hot water storage tank, expressed in litres;
(5) 'standard rating conditions' means the operating conditions of water heaters for establishing the rated heat output, water heating energy efficiency and sound power level, and of hot water storage tanks for establishing the standing loss;
(8) 'fossil fuel' means a gaseous or liquid fuel of fossil origin;
(9) 'hot water storage tank' means a vessel for storing hot water for water and/or space heating purposes, including any additives, which is not equipped with any heat generator except possibly one or more back-up immersion heaters;
(10) 'back-up immersion heater' means a Joule effect electric resistance heater that is part of a hot water storage tank and generates heat only when the external heat source is disrupted (including during maintenance periods) or out of order, or that is part of a solar hot water storage tank and provides heat when the solar heat source is not sufficient to satisfy required comfort levels;
(11) 'solar device' means a solar-only system, a solar collector, a solar hot water storage tank or a pump in the collector loop, which are placed on the market separately;

[1] http://www.eceee.org/ecodesign/products/water_heaters/Water_heaters_Ecodesign_Reg_814_2013.pdf

(12) 'solar-only system' means a device that is equipped with one or more solar collectors and solar hot water storage tanks and possibly pumps in the collector loop and other parts, which is placed on the market as one unit and is not equipped with any heat generator except possibly one or more back-up immersion heaters;
(13) 'package of water heater and solar device' means a package offered to the end-user containing one or more water heaters and one or more solar devices;
(14) 'water heating energy efficiency' (η_{wh}) means the ratio between the useful energy provided by a water heater or a package of water heater and solar device and the energy required for its generation, expressed in %;
(16) 'standing loss' (S) means the heating power dissipated from a hot water storage tank at given water and ambient temperatures, expressed in W;
(17) 'heat pump water heater' means a water heater that uses ambient heat from an air source, water source or ground source, and/or waste heat for heat generation."

A priori we consider the scope and definitions of water heaters to be considered in this project to be the same. However, we impose the following additional exclusions:

- combi-boilers, i.e. those that have a dual purpose of providing space heating and sanitary hot water heating
- devices using biomass
- devices using solid fuels.

We note that despite the broad definition applied here most regulations and test procedures distinguish by type of water heater according to the characteristics previously described. We will therefore need to assess within and across type for the subsequent work.

The remaining text in this section considers distinctions between types of water heaters, water heater characteristics, their methods of test and the types of energy performance metric used.

Product classifications and configurations

Defining types of water heaters entails defining their classifications and this in turn requires their service and features to be characterised.

Water heaters can be classified in terms of:

- capacity
- fuel type
- whether they are of an instantaneous or storage type
- whether they are unitary or split into components
- whether they have more than one form of heating the water or not.

Capacity

Capacity can be defined in terms of rated power (either output heating power, or rated input heating power) or rated storage capacity (storage volume) for storage type heaters. A rated output heating power seems to be the most encompassing and logical approach because it embraces both storage and instantaneous types and it is defined in terms of the service delivered rather than the input power required. Domestic water heaters are usually defined to be those intended for domestic use, i.e. to supply sanitary hot water for domestic washing and bathing purposes, and thus they are typically constrained to smaller capacity units. Nonetheless the capacity ranges found in regulations can be quite large. For example the EU and Korean regulations set a limit at those units

with a rated heat output ≤ 70 kW. The EU also specifies that in the case of storage tanks they should have a storage volume capacity of ≤ 500 litres.

Note that the definition of storage capacity is sometimes linked with the water storage temperature, which makes comparison across models and economies very difficult. In Europe the introduction of a new "MW40 : mixed water at 40 °C" classification means that effective storage capacity can be increased beyond the actual tank volume by storing water at a higher temperature than 40 °C and mixing in cold water to reduce the delivered temperature to 40°C and thereby increasing the effective rated capacity.

Energy source

All water heaters have a principal energy source used to generate hot water. In practice this can be:

- gas
- electricity
- oil
- solar energy
- solid fossil fuels
- biofuels.

Gas-fired water heaters often use electricity for ignition, controls, fans, etc. The electricity should be included as an energy input. The conversion of electricity to a common energy basis can be done either at site or can include considerations of source efficiency of the electricity generation.

Instantaneous or storage types

Water heaters may deliver instantaneous hot water on demand, i.e. water that is heated and supplied on demand, or they may heat off demand and store the water for use when demanded. The former are known as instantaneous water heaters and the latter storage type water heaters. Storage type water heaters will lose energy in the form of standing losses (thermal losses while waiting for demand), however, they can heat more slowly and hence require less heating power, which can bring benefits for solar water heaters or electric water heaters.

Sometimes instantaneous water heaters are designed to be smaller and to simply supply hot water requirements at a single point of demand. Storage type systems are usually plumbed into a network of demand points and are designed to meet all the water needs at the various demand points. This solution has the benefit of minimising the number of individual water heaters required but does entail additional energy losses in the water distribution network as the water heater cannot be so proximal to each point of demand.

Configuration: unitary or split systems

Water heaters may be sold as unitary units or as assemblies of components. For example, in the case of heat pump water heaters (HPWH) this can include:

- unitary (refrigeration unit and water storage tank in the one cabinet)
- split – heat pump connected to tank by refrigerant lines, condenser inside water tank
- split – heat pump connected to tank by water lines, condenser housed in same cabinet as evaporator. This configuration may be designed as:
  - single pass (‘one time’) – water heated to desired temperature in one pass; and

- multi-pass ('circulated') – water heated to desired temperature in stages.

The way in which HPWHs are defined varies significantly between standards. This means that products which are grouped together for testing under one standard may need to be separately tested under a second standard, because of some design difference that may not even be defined under the first standard. Furthermore, a product type defined in one standard may not even be testable under other standards, because there is no provision for them. For example, the European Standard EN16147 does not appear to provide for the testing of a unitary HPWH designed to be installed outside, whereas this product type is common in Australia.

Multiple heating options

While most water heaters have a single source of energy generators there are a number of possible combinations found in practice. Several of these are designed to take advantage of an intermittent renewable energy source and hence have a secondary heating source as a backup (auxiliary). Configurations include:

- Solar + Electric
- Solar + Gas
- Gas + Electric Heat pump
- Electric + Electric heat pump
- Biofuel + electric
- Biofuel + gas.

Controls

Water heaters are now being designed with control logic that can adapt to the pattern of household hot water use. For example, if the controller observes that hot water demand is concentrated at a certain time of day it can adapt reheat times to minimise heat loss or to make use of cheaper electricity rates (assuming that there is a capability for the controller to have tariff times programmed into it, or to monitor them in real time).

The proposed European regulations for the energy labelling of water heaters (including HPWHs) allows models with 'smart controls' to obtain a rating one grade higher than would be indicated by energy efficiency alone (EC 2013). It defines 'smart control' as 'a device that automatically adapts the water heating process to individual usage conditions with the aim of reducing energy consumption'.[2]

While 'smart' controls may enable a water heater to reheat at times when electricity tariffs are lower use, and so reduce running costs, they complicate energy efficiency testing because the water heater may behave differently after 'learning' the draw-off patterns used in the first stages of a test.

Description of test types and energy performance metrics

Throughout the study, reference is made to the principal test types and performance metrics. Most of these tests and metrics are described briefly below. In addition, some terms particular to a given economy are described in the text.

[2] Some new water heaters have the capability to change their mode of operation (i.e. to turn off, reduce load or turn on) in response to signals sent from the utility or other 'remote agent'. This is a separate capability that may have different impacts on energy consumption or energy-efficiency.

Metrics

- **Energy efficiency**: means the ratio between the useful energy provided by a water heater and the energy required for its generation, expressed in %. It can be used for steady state behaviour, for tapping cycles, on a daily or yearly basis, etc. The energy used for hot water generation can be gas, oil, electricity, or may be referred to primary energy using primary energy conversion factors (primary energy factor) given in regulations or test standards. It may be determined via a single test, or be obtained by calculation from the results of several tests.
  It may also be called water heating energy efficiency, thermal efficiency, or energy factor.
  It may be denoted by the following symbols: η, η_{wh}, EFF, EE, COP, PER, EF, COP_{DHW}
  Units: %
  Note: In some cases it may be a seasonal performance factor, like for heat pump (SCOP = seasonal coefficient of performance) or solar water heaters.

- **Annual gas usage**: calculated for a given daily water usage, using the measured values of thermal efficiency, start-up heat capacity and pilot gas consumption. For the purposes of energy labelling, it may be compared with the annual gas consumption of a reference storage water heater to give the relative performance.

- **Standby losses**: applies to storage water heaters. It is the energy or the power required to maintain a constant water temperature inside the tank when no hot water is being drawn off.
  It may also be called maintenance gas consumption, standing heat losses, tank standby losses, standing loss.
  It may be denoted by the following symbols: M, Q, S,
  Units: W, kWh/L-month, kWh

- **Hot water delivery capacity**: The volume of hot water a storage heater is able to deliver starting with the water in the tank at its standard hot temperature, referenced to a given temperature (generally 40ºC or 45ºC).

- **Pilot gas consumption:** gas consumption when there is no demand for heating.

- **Monthly specific energy production:** solar water heaters (PMEe).

Tests

- **Stationary (or steady-state)**: measurement of the energy input in steady-state conditions, in different conditions of water flow, water inlet temperature, water outlet temperature, standard energy consumption, used to measure the efficiency. Several tests may be performed to get the average results. It may include a reduced capacity test. It can be used for instantaneous heaters, or with the heating part of a split storage heater.

- **Standby energy consumption**: the electrical power input measurement while there is no heating demand.

- **Start-up heat capacity** (or steady-state warm-up, cold-start heat-up): for instantaneous heaters, the energy or the capacity necessary to rise the cold water temperature up to a given percentage (generally 90%) of the steady-state temperature rise. For a storage heater, it is the energy required to raise the temperature of the water in the tank from the cold water temperature up to a given temperature, defined in the standard or given by the manufacturer.

- **Hot water delivery capacity** (or diffusion test): for storage heaters. The test starts just after a recovery. Hot water is drawn off at a constant water flow rate or a constant energy rate until

the outlet water temperature reaches a given value. Water inlet temperature is constant and the heater is connected. Water volume drawn off during the test is measured together with its temperature. The final result is the volume of water referred to a given temperature.

- **Tapping cycle** (or draw): test simulating "real" use of the hot water, with several hot water draw-offs at a given water flow rate, during a given time or until reaching a given energy. For storage heaters, this test starts after a recovery and a last recovery shall end the test after a 24h period. The number of draw-offs varies between countries (roughly between 6 and 20 per 24 h) and the draw-off characteristics may or may not be identical.

- **24 hour simulated use test**: simulated composite 24 hours using results of different tests. This can be made by calculation or by the use of full simulation from component testing using TRNSYS software.

- **Pilot gas consumption**: gas consumption when there is no demand for heating.

- **Steady-state standby loss test**: this test starts when the water temperature in the tank is steady at a given hot water temperature, as defined in the standard or given by the manufacturer. During 48 h to 72 h depending on the test procedure, energy consumption is measured while the control device of the heater maintains a constant temperature within the tank.

- **Coefficient of Thermal Performance**: a measure of efficiency used for solar water heaters.

- **Stationary, COP** (coefficient of performance) at different outdoor temperatures/water inlet temperatures, constant outlet temperature. Weighted to a seasonal COP (SCOP) value.

03 Listing and assessment of country data sources: Australia

Test procedures

The following test procedures apply for water heaters in Australia.

Table 3.1 Test procedures in Australia

Water heater type	Exist. std (Y/N)	Standard reference	Status	Comments
Gas				
Gas storage	Y	AS/NZS 4552.2:2010 AS 4552-2005	Current	Test methods of AS 4552 used until publication of AS/NZS 4552.3
Gas instantaneous	Y	AS/NZS 4552.2:2010 AS 4552-2005	Current	Test methods of AS 4552 used until publication of AS/NZS 4552.3
Combi-boilers				
Gas + solar				
Gas + electric heat pump				
Electric				
Electric storage	Y	AS/NZS 4692.1:2005 AS/NZS 4692.2:2005 AS 1361-1995	Current	Use of AS 1361 is still allowed. In the near future, only the AS/NZS 4692.1 test method will be used, although no date has been decided yet..
Electric instantaneous	Y	AS/NZS 4692.1:2005 AS/NZS 4692.2:2005 AS 1361-1995	Current	Use of AS 1361 is still allowed. In the near future, only the AS/NZS 4692.1 test method will be used, although no date has been decided yet...
Electric heat pump	Y	AS/NZS 5125.1:2010 AS/NZS 2712:2007 AS/NZS 4234:2008	Current	
Oil				
Any				

Table 3.1 Test procedures in Australia (continued)

Water heater type	Exist. std (Y/N)	Standard reference	Status	Comments
Solar				
Solar water heater system	Y	AS/NZS 2712:2007 AS/NZS 4234:2008 AS/NZS 4445.1:1997 (R2013) AS/NZS 2535.1:2007 (ISO 9806-1:1994)	Current	
Solar collector	Y	AS/NZS 2535.1:2007 (ISO 9806-1:1994)	Current	
Solar tank				
Tank				
Unvented				

Regulations

The following regulations apply for water heaters in Australia.

Table 3.2 MEPS in Australia

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current	Minister for Resources, Energy and Tourism	Determination: Greenhouse and Energy Minimum Standards (Gas Water Heaters) Determination 2013	http://www.comlaw.gov.au/Details/F2013L00729
Gas instantaneous	Current	Minister for Resources, Energy and Tourism	Determination: Greenhouse and Energy Minimum Standards (Gas Water Heaters) Determination 2013	http://www.comlaw.gov.au/Details/F2013L00729
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Current	Minister for Resources, Energy and Tourism	Determination: Greenhouse and Energy Minimum Standards (Electrical Water Heaters) Determination 2012	http://www.comlaw.gov.au/Details/F2012L02125
Electric instantaneous	Current	Minister for Resources, Energy and Tourism	Determination: Greenhouse and Energy Minimum Standards (Electrical Water Heaters) Determination 2012	http://www.comlaw.gov.au/Details/F2012L02125
Electric heat pump	Under study	Minister for Resources, Energy and Tourism		-
Oil				
Any	None			
Solar				
Solar water heater system	Under study	Minister for Resources, Energy and Tourism		
Solar collector	None			
Solar tank	None			

Table 3.3 Mandatory labels in Australia

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	None			
Gas instantaneous	None			
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Under study	Minister for Resources, Energy and Tourism	Equipment Energy Efficiency (E3) Program (Not decided yet whether it will be mandatory or voluntary)	
Electric instantaneous	Under study	Minister for Resources, Energy and Tourism	Equipment Energy Efficiency (E3) Program (Not decided yet whether it will be mandatory or voluntary)	
Electric heat pump	Under study	Minister for Resources, Energy and Tourism	Equipment Energy Efficiency (E3) Program (Not decided yet whether it will be mandatory or voluntary)	
Oil				
Any	None			
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			

Table 3.4 Voluntary labels in Australia

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	None			
Gas instantaneous	None			
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Under study	Minister for Resources, Energy and Tourism	Equipment Energy Efficiency (E3) Program (Not decided yet whether it will be mandatory or voluntary)	
Electric instantaneous	Under study	Minister for Resources, Energy and Tourism	Equipment Energy Efficiency (E3) Program (Not decided yet whether it will be mandatory or voluntary)	
Electric heat pump	Under study	Minister for Resources, Energy and Tourism	Equipment Energy Efficiency (E3) Program (Not decided yet whether it will be mandatory or voluntary)	
Oil				
Any	None			-
Solar				
Solar water heater system	Under study	Minister for Resources, Energy and Tourism	Equipment Energy Efficiency (E3) Program (Not decided yet whether it will be mandatory or voluntary)	
Solar collector	None			
Solar tank	None			

04 Listing and assessment of country data sources: Brazil

Test procedures

The following test procedures apply for water heaters in Brazil.

Table 4.1 Test procedures in Brazil

Water heater type	Exist. std (Y/N)	Standard reference	Status	Comments
Gas				
Gas storage	Y	ABNT NBR 10542:1988	Current	
Gas instantaneous	Y	ABNT NBR 8130:2004	Current	
Combi-boilers	N			
Gas + solar	N			
Gas + electric heat pump	N			
Electric				
Electric storage	N			
Electric instantaneous	Y	ABNT NBR 14015:1997	Current	
Electric heat pump	N			
Oil				
Any	N			
Solar				
Solar water heater system	Y	ABNT NBR 15569:2008	Current	
Solar collector	Y			
Solar tank	N			
Tank				
Unvented	N			

Regulations

The following regulations apply for water heaters in Brazil.

Table 4.2 MEPS in Brazil

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current	CGIEE	Portaria Interministerial 324/2011	http://www.mme.gov.br/mme/galerias/arquivos/conselhos_comite/cgiee/Portaria_Interministerial_nx_324_2011.pdf
Gas instantaneous	Current	CGIEE	Portaria Interministerial 324/2011	http://www.mme.gov.br/mme/galerias/arquivos/conselhos_comite/cgiee/Portaria_Interministerial_nx_324_2011.pdf
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	None			
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Any	None			
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			

Table 4.3 Mandatory labels in Brazil

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current	INMETRO	Portaria INMETRO / MDIC número 182 de 13/04/2012	http://www.inmetro.gov.br/legislacao/rtac/pdf/RTAC001812.pdf
Gas instantaneous	Current	INMETRO	Portaria INMETRO / MDIC número 182 de 13/04/2012	http://www.inmetro.gov.br/legislacao/rtac/pdf/RTAC001812.pdf
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	None			
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Any	None			
Solar				
Solar water heater system	Current	INMETRO	Portaria Inmetro nº 301 de 14/06/2012	http://www.inmetro.gov.br/legislacao/rtac/pdf/RTAC001845.pdf
Solar collector	None			
Solar tank	None			

Table 4.4 Voluntary labels in Brazil

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current	Conpet	Conpet for water heaters	http://consultaaquecedores.petrobras.com.br/Forms/TabelaConsumo.aspx
Gas instantaneous	Current	Conpet	Conpet for water heaters	http://consultaaquecedores.petrobras.com.br/Forms/TabelaConsumo.aspx
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	None			
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Any	None			
Solar				
Solar water heater system	Current	PROCEL	Regulamento de Sistemas e Equipamentos para Aquecidmento Solar de Agua REGULAMENTO ESPECÍFICO P/ USO DA ENCE	http://www.eletrobras.com/elb/procel/services/DocumentManagement/FileDownload.EZTSvc.asp?DocumentID={5A25AC07-9BA4-4110-9AD8-9C40964CBD68}&ServiceInstUID={AEBE43DA-69AD-4278-B9FC-41031DD07B52}
Solar collector	None			
Solar tank	None			

05 Listing and assessment of country data sources: Canada

Test procedures

The following test procedures apply for water heaters in Canada.

Table 5.1 Test procedures in Canada

Water heater type	Exist. std (Y/N)	Standard reference	Status	Comments
Gas				
Gas storage	Y	CSA P.3-04	current	
Gas instantaneous	Y	CSA P.7-10	current	
Combi-boilers	Y	CSA-P.9-11	current	applies to forced-air packaged combo systems
Gas + solar				
Gas + electric heat pump	N			
Electric				
Electric storage	Y	C191-13	current	standing loss test
Electric instantaneous	N			
Electric heat pump	Y	CSA-C745-03 (R2009)	current	references 10CFR430, appendix E, subpart B
Oil				
Storage	Y	CSA B211-00	current	
Solar				
Solar water heater system	Y	CSA-F379 SERIES-09 (R2013)	current	
Solar collector	N			
Solar tank	N			
Tank				
Unvented	N			

Regulations

The following regulations apply for water heaters in Canada.

Table 5.2 MEPS in Canada

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current, updates proposed	NRCan	Energy Efficiency Regulations (SOR/94-651) Schedule I (Subsection 2(1) and section 4) Energy Efficiency Standards Part 1	http://laws-lois.justice.gc.ca/eng/regulations/SOR-94-651/page-12.html#h-13 http://www.nrcan.gc.ca/energy/regulations-codes-standards/bulletins/7191
Gas instantaneous	Proposed	NRCan	Water Heaters - June 2010, Bulletin on Proposed Regulations	http://www.nrcan.gc.ca/energy/regulations-codes-standards/bulletins/7191
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Current, updates proposed	NRCan	Energy Efficiency Regulations (SOR/94-651) ENERGY EFFICIENCY ACT Energy Efficiency Regulations Technical Requirements for Energy-Using Products Gas water heaters SCHEDULE I(Subsection 2(1) and section 4)ENERGY EFFICIENCY STANDARDS, PART 1	http://laws-lois.justice.gc.ca/eng/regulations/SOR-94-651/page-12.html#h-13 http://www.nrcan.gc.ca/energy/regulations-codes-standards/bulletins/7191
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Storage	Current, updates proposed	NRCan	Energy Efficiency Regulations (SOR/94-651) ENERGY EFFICIENCY ACT Energy Efficiency Regulations Technical Requirements for Energy-Using Products Gas water heaters SCHEDULE I(Subsection 2(1) and section 4)ENERGY EFFICIENCY STANDARDS, PART 1	http://laws-lois.justice.gc.ca/eng/regulations/SOR-94-651/page-12.html#h-13 http://www.nrcan.gc.ca/energy/regulations-codes-standards/bulletins/7191
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			

Table 5.3 Mandatory labels in Canada

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current	NRCan	Energy Efficiency Regulations (SOR/94-651), Part IV, Verification Mark Labelling	http://laws-lois.justice.gc.ca/eng/regulations/SOR-94-651/page-8.html#h-8
Gas instantaneous	None			
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Current	NRCan	Energy Efficiency Regulations (SOR/94-651), Part IV, Verification Mark Labelling	http://laws-lois.justice.gc.ca/eng/regulations/SOR-94-651/page-8.html#h-8
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Storage	Current	NRCan	Energy Efficiency Regulations (SOR/94-651), Part IV, Verification Mark Labelling	http://laws-lois.justice.gc.ca/eng/regulations/SOR-94-651/page-8.html#h-8
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			

Table 5.4 Voluntary labels in Canada

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current	NRCan	EnerGuide label	http://www.nrcan.gc.ca/energy/products/energuide/label/reading/13722
Gas storage	Current	US EPA	ENERGY STAR®	http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters
Gas instantaneous	Current	US EPA	ENERGY STAR®	http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Current	NRCan	EnerGuide label	http://www.nrcan.gc.ca/energy/products/energuide/label/reading/13722
Electric instantaneous				
Electric heat pump	Current	US EPA	ENERGY STAR®	http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters
Oil				
Storage	None			
Solar				
Solar water heater system	Current	US EPA	ENERGY STAR®	http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters
Solar collector				
Solar tank				

06 Listing and assessment of country data sources: China

Test procedures

The following test procedures apply for water heaters in China.

Table 6.1 Test procedures in China

Water heater type	Exist. std (Y/N)	Standard reference	Status	Comments
Gas				
Gas storage	Y	GB 18111-2000	Current	
Gas instantaneous	Y	GB 6932-2001 CJ/T 336-2010	Current	Separate test methods for condensing and non-condensing
Combi-boilers	Y	GB 25034-2010 CJ/T 395-2012 JJF 1261.9-2013	Current	Separate test methods for condensing and non-condensing
Gas + solar				
Gas + electric heat pump				
Electric				
Electric storage	Y	GB 21519–2008 GB/T 20289 – 2006	Current	MEPS, labels, and test procedure in same document
Electric instantaneous	Y	GB/T 26185-2010	Current	Labels and test procedure in same document
Electric heat pump	Y	GB/T 23137-2008	Current	

Table 6.1 Test procedures in China (continued)

Water heater type	Exist. std (Y/N)	Standard reference	Status	Comments
Oil				
Any				
Solar				
Solar water heater system	Y	GB/T 18708-2002 JJF 1261.11-2013	Current	
Solar collector				
Solar tank				
Tank				
Unvented				

Regulations

The following regulations apply for water heaters in China.

Table 6.2 MEPS in China

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current		GB 18111-2000?	http://webstore.ansi.org/RecordDetail.aspx?sku=GB+18111-2000
Gas instantaneous	Current		GB 6932-2001? CJ/T 336-2010?	http://webstore.ansi.org/RecordDetail.aspx?sku=GB+6932-2001
Combi-boilers	Current		GB 20665-2006	
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Current		GB 21519–2008	
Electric instantaneous	Current		GB/T 26185-2010	
Electric heat pump	Current		GB 29541-2013	
Oil				
Any	None			
Solar				
Solar water heater system	Current		GB26969-2011	
Solar collector	None			
Solar tank	None			

Table 6.3 Mandatory labels in China

Type	Status	Organisation	Standard	Link
Gas				
Gas storage				
Gas instantaneous				
Combi-boilers	Current		GB 20665-2006	http://www.energylabel.gov.cn/en/LabelNews/LabelRelatedActivities/detail/551.html
Gas + solar				
Gas + electric heat pump				
Electric				
Electric storage	Current		GB 21519–2008	http://www.energylabel.gov.cn/en/LabelNews/LabelRelatedActivities/detail/554.html
Electric instantaneous				
Electric heat pump	Current		GB 29541-2013	
Oil				
Any	None			
Solar				
Solar water heater system	Current		GB26969-2011	
Solar collector	None			
Solar tank	None			

Table 6.4 Voluntary labels in China

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current		GB 18111-2000	
Gas instantaneous	Current		GB 6932-2001 CJ/T 336-2010	
Combi-boilers	Current		GB 20665-2006	
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Current		GB 21519-2008	
Electric instantaneous	Current		GB/T 26185-2010	
Electric heat pump	Current		GB 29541-2013	
Oil				
Any	None			
Solar				
Solar water heater system	Current		GB26969-2011	
Solar collector	None			
Solar tank	None			

07 Listing and assessment of country data sources: European Union

Test procedures

The following test procedures apply for water heaters in the EU.

Table 7.1 Test procedures in the EU

Water heater type	Exist. Std (Y/N)	Standard reference	Status	Comments
Gas				
Gas storage	Y	EN 89:1999/A4:2006 EN 13203-1:2006 EN 13203-2:2006	Rev planned 2015 (Ecodesign)	The revised metrics to compute energy efficiency ratings are described in the Ecodesign regulation, as well as required changes to the existing standards. This means that even if the revised standards are not yet available, it is already possible to anticipate what the impact of their revision will be.
Gas instantaneous	Y	EN 26:1997/A3:2006	Rev planned 2015 (Ecodesign)	As above.
Combi-boilers	Y	EN 625:1995	Rev planned 2015 (Ecodesign)	As above.
Gas + solar	Y	EN 13203-3:2010	Rev planned 2015 (Ecodesign)	As above.
Gas + electric heat pump	Y	PR EN 13203-5:2013	Rev planned 2015 (Ecodesign)	As above.
Electric				
Electric storage	Y	EN 60379: 2004	PR EN 50440:2010 (standard project revision) Rev planned 2015 (Ecodesign)	As above.
Electric instantaneous	Y	EN 50193:1997	Revision project ed. 2014 Rev planned 2015 (Ecodesign)	As above.
Electric heat pump	Y	EN 16147:2011	Rev planned 2015 (Ecodesign)	As above.

Table 7.1 Test procedures in the EU (continued)

Water heater type	Exist. Std (Y/N)	Standard reference	Status	Comments
Oil				
Any	NA			
Solar				
Solar water heater system	Y	EN 15332:2008 EN 12976-2:2006 EN 12977-2:2013	Rev planned 2015 (Ecodesign)	As above.
Solar collector	Y	EN 12975-2:2006	Rev planned 2015 (Ecodesign)	As above.
Solar tank	Y	EN 12977-3:2013	Rev planned 2015 (Ecodesign)	As above.
Tank				
Unvented	Y	EN 15332:2008 EN 12977-3:2013 EN 12897:2006	Rev planned 2015 (Ecodesign)	As above.

Regulations

The following regulations apply for water heaters in the EU.

Table 7.2 MEPS in the EU

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Gas instantaneous	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Combi-boilers	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 813/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for space heaters and combination heaters	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0813:EN:NOT
Gas + solar	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Gas + electric heat pump	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Electric				
Electric storage	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Electric instantaneous	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Electric heat pump	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Oil				
Storage	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT

Table 7.2 MEPS in the EU (continued)

Type	Status	Organisation	Standard	Link
Solar				
Solar water heater system	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Solar collector	None			
Solar tank	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT
Tank				
Unvented	takes effect 26 Sep, 2015	DG ENERGY	Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0814:EN:NOT

Table 7.3 Mandatory labels in the EU

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Gas instantaneous	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Combi-boilers	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 811/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of space heaters, combination heaters, packages of space heater, temperature control and solar device and packages of combination heater, temperature control and solar device - OJ L 239, 06.09.2013, p. 1–82	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0812:EN:NOT
Gas + solar	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Gas + electric heat pump	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Electric				
Electric storage	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Electric instantaneous	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Electric heat pump	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT

Table 7.3 Mandatory labels in the EU (continued)

Type	Status	Organisation	Standard	Link
Oil				
Storage	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Solar				
Solar water heater system	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Solar collector	None			
Solar tank	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT
Tank				
Unvented	takes effect 26 Sep, 2015	DG ENERGY	Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135	http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32013R0811:EN:NOT

Voluntary labels

There are no voluntary labels for water heaters organized at the EU level (no Ecolabel as yet), but some of the technologies are covered by national labelling/incentive schemes like the Blue Angel label (Germany), the Nordic Swan label (Scandinavia), the UK's Enhanced Capital Allowances scheme (UK), among others. However, these schemes will need to be reviewed following the legislative changes at EU level, expected to occur before the enforcement of the EU energy label and Ecodesign requirements on September 26th, 2015.

08 Listing and assessment of country data sources: India

Test procedures

The following test procedures apply for water heaters in India.

Table 8.1 Test procedures in India

Water heater type	Exist. std (Y/N)	Standard reference	Status	Comments
Gas				
Gas storage	Y	IS 5115-1969	Current	for use with LPG
Gas instantaneous	Y	IS 15558-2005	Current	for use with LPG
Combi-boilers	N			
Gas + solar	N			
Gas + electric heat pump	N			
Electric				
Electric storage	Y	IS 2082:1993	Current	
Electric instantaneous	Y	IS 8978-1992	Current	
Electric heat pump	N			
Oil				
Any	N			
Solar				
Solar water heater system	NA			
Solar collector	NA			
Solar tank	NA			
Tank				
Unvented	NA			

Regulations

The following regulations apply for water heaters in India.

Table 8.2 MEPS in India

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	None			
Gas instantaneous	None			
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	None			
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Any	None			
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			

Table 8.3 Mandatory labels in India

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	None			
Gas instantaneous	None			
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	None			
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Any	None			
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			

Table 8.4 Voluntary labels in India

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	None			
Gas instantaneous	None			
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	Voluntary	BEE	Schedule-10	http://220.156.189.29/Content/Files/Schedule_10.pdf
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Any	None			
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			

09 Listing and assessment of country data sources: Korea

Test procedures

The following test procedures apply for water heaters in Korea.

Table 9.1 Test procedures in Korea

Water heater type	Exist. Std (Y/N)	Standard reference	Status	Comments
Gas				
Gas storage	Y	KS B 8110: 2010 KS B 6032: 2006 KS B 8111: 2010	Current Current Current	KS B 8110: 2010 Close storage type gas water heaters. No ISO or IEC references. Instead references: KS B 0221 | KS B 0222 | KS B 2331 | KS B 5202 | KS B 5203 | KS B 5223 KS B 5231 | KS B 5246 | KS B 5302 | KS B 5305 | KS B 5316 | KS C 3101 KS C 3102 | KS C 4004 | KS C 8501 | KS D 3501 | KS D 3503 | KS D 3506 KS D 3507 | KS D 3512 | KS D 3517 | KS D 3518 | KS D 3528 | KS D 3534 KS D 3535 | KS D 3536 | KS D 3544 | KS D 3561 | KS D 3566 | KS D 3576 KS D 3698 | KS D 3702 | KS D 3705 | KS D 3706 | KS D 3752 | KS D 4301 KS D 5101 | KS D 5201 | KS D 5301 | KS D 5545 | KS D 6005 | KS D 6006 KS D 6008 | KS D 6701 | KS D 6713 | KS D 6759 | KS D 6761 | KS D 6763. KS B 6032: 2006 Liquified Petroleum Gas Storage Type Water Heaters. No ISO or IEC references. Instead references: KS 3 512 | KS B 0221 | KS B 0222 | KS B 1002 | KS B 1004 | KS B 1005 KS B 1012 | KS B 1013 | KS B 1014 | KS B 1021 | KS B 1023 | KS B 1024 KS B 1025 | KS B 1026 | KS B 1027 | KS B 1324 | KS B 1325 | KS B 1326 KS B 1336 | KS B 1337 | KS B 5202 | KS B 5203 | KS C 1602 | KS C 1608 KS C 8501 | KS D 3698 | KS D 4301 | KS D 5101 | KS D 5301 | KS M 2150 KS B 8111: 2010 Open storage type gas water heaters. No ISO or IEC references. Instead references: KS B 0221 | KS B 0222 | KS B 2331 | KS B 5202 | KS B 5203 | KS B 5223 KS B 5231 | KS B 5246 | KS B 5302 | KS B 5305 | KS B 5316 | KS C 3101 KS C 3102 | KS C 4004 | KS C 8501 | KS D 3501 | KS D 3503 | KS D 3506 KS D 3507 | KS D 3512 | KS D 3517 | KS D 3518 | KS D 3528 | KS D 3534 KS D 3535 | KS D 3536 | KS D 3544 | KS D 3561 | KS D 3566 | KS D 3576 KS D 3698 | KS D 3702 | KS D 3705 | KS D 3706 | KS D 3752 | KS D 4301 KS D 5101 | KS D 5103 | KS D 5201 | KS D 5301 | KS D 5545 | KS D 6005 KS D 6006 | KS D 6008 | KS D 6701 | KS D 6713 | KS D 6759 | KS D 6761 KS D 6763 |

Table 9.1 Test procedures in Korea (continued)

Water heater type	Exist. Std (Y/N)	Standard reference	Status	Comments
Gas instantaneous	Y	KS B 8116: 2009	Current	KS B 8116: 2009 Instantaneous water heaters. No ISO or IEC references. Instead references: KS B 0221 | KS B 0222 | KS D 5101 | KS D 5301 | KS G 5120 | KS M 2150
Combi-boilers	NA	None found		
Gas + solar	N	None		
Gas + electric heat pump	N	None		
Electric				
Electric storage	Y	KS C 9805: 2013	Current	KS C 9805: 2013 Electric storage water boilers for household purposes and storage tank water heaters
Electric instantaneous	Y	KS B 8116: 2009	Current	KS B 8116: 2009 Instantaneous water heaters. No ISO or IEC references. Instead references: KS B 0221 | KS B 0222 | KS D 5101 | KS D 5301 | KS G 5120 | KS M 2150
Electric heat pump	Draft	Draft (KS B ****)	Under development	
Oil				
Any	Y	KS B 6034: 2010	Current	KS B 6034: 2010 Oil burning water heaters for domestic use. No ISO or IEC references. Instead references: KS B 0222 | KS B 6153 | KS C 3308 | KS C 4004 | KS D 3503 | KS D 3506 KS D 3507 | KS D 3512 | KS D 3698 | KS D 5301 | KS F 4714 | KS G 5126 KS L 2508 | KS L 3201 | KS L 3202 | KS L 9102 | KS M 6576 |
Solar				
Solar water heater system	N	None		
Solar collector	N	None		
Solar tank	N	None		
Tank				
Unvented	N	None		

Regulations

The following regulations apply for water heaters in Korea.

Table 9.2 MEPS in Korea

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current	KEMCO	Based on the article 15 (Designation of machinery and materials subject to efficiency management,) and the article 16 (Post management of machinery and materials subject to efficiency management) of the "Rational Energy Utilization Act"	- 「Regulation on Energy Efficiency Labeling and Standards」(Ministry of Knowkedge Economy Notification No.2011-263. 2011.12.23)
Gas instantaneous	Current	KEMCO	Regulation on Energy Efficiency Labelling and Standards - Ministry of Knowledge Economy Notification No.2011-263. 2011.12.23	- 「Regulation on Energy Efficiency Labeling and Standards」(Ministry of Knowkedge Economy Notification No.2011-263. 2011.12.23)
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	None			
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Storage	None			
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			
Tank				
Unvented	None			

Table 9.3 Mandatory labels in Korea

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	None			
Gas instantaneous	Current	KEMCO	Regulation on Energy Efficiency Labelling and Standards - Ministry of Knowledge Economy Notification No.2011-263. 2011.12.23	- 「Regulation on Energy Efficiency Labeling and Standards」 (Ministry of Knowkedge Economy Notification No.2011-263. 2011.12.23)
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			
Electric				
Electric storage	None			
Electric instantaneous	None			
Electric heat pump	None			
Oil				
Storage	None			
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			
Tank				
Unvented	None			

Voluntary labels

None.

10 Listing and assessment of country data sources: USA

Test procedures

The following test procedures apply for water heaters in the USA.

Table 10.1 Test procedures in the USA

Water heater type	Exist. std (Y/N)	Standard reference	Status	Comments
Gas				
Gas storage	Y	10CFR430—Appendix E to Subpart B	Rev expected in 2014 (DOE)	Revisions expected to cover light duty commercial water heaters as well.
Gas instantaneous	Y	10CFR430—Appendix E to Subpart B	Rev expected in 2014 (DOE)	Revisions expected to cover light duty commercial water heaters as well.
Combi-boilers	N			
Gas + solar	Y	10CFR430—Appendix E to Subpart B	Rev expected in 2014 (DOE)	Tested as gas water heater
Gas + electric heat pump	Y	10CFR430—Appendix E to Subpart B	Rev expected in2014 (DOE)	Tested as gas water heater
Electric				
Electric storage	Y	10CFR430—Appendix E to Subpart B	Rev expected in2014 (DOE)	Revisions expected to cover light duty commercial water heaters as well.
Electric instantaneous	Y	10CFR430—Appendix E to Subpart B	Rev expected in2014 (DOE)	Revisions expected to cover light duty commercial water heaters as well.
Electric heat pump	Y	10CFR430—Appendix E to Subpart B	Rev expected in2014 (DOE)	Revisions expected to cover light duty commercial water heaters as well.
Oil				
Storage	Y	10CFR430—Appendix E to Subpart B	Rev expected in2014 (DOE)	Revisions expected to cover light duty commercial water heaters as well.
Solar				
Solar water heater system	Y	SRCC 300-2013-09	current	Solar Rating & Certification Corporation
Solar collector	Y	SRCC 100-2013-11	current	Solar Rating & Certification Corporation
Solar tank	Y	10CFR430—Appendix E to Subpart B	Rev expected in2014 (DOE)	Tested as electric water heater
Tank				
Unvented	N			

Regulations

The following regulations apply for water heaters in the USA.

Table 10.2 MEPS in the USA

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current, update takes effect 15 April, 2015	DOE	Code of Federal Regulations, TITLE 10—Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, §430.32 Energy and water conservation standards and their compliance dates (d) Water heaters.	http://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf
Gas instantaneous	Current, update takes effect 15 April, 2015	DOE	Code of Federal Regulations, TITLE 10—Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, §430.32 Energy and water conservation standards and their compliance dates (d) Water heaters.	http://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None	DOE	Code of Federal Regulations, TITLE 10—Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, §430.32 Energy and water conservation standards and their compliance dates (d) Water heaters.	http://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf
Electric				
Electric storage	Current, update takes effect 15 April, 2015	DOE	Code of Federal Regulations, TITLE 10—Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, §430.32 Energy and water conservation standards and their compliance dates (d) Water heaters.	http://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf
Electric instantaneous	Current, update takes effect 15 April, 2015	DOE	Code of Federal Regulations, TITLE 10—Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, §430.32 Energy and water conservation standards and their compliance dates (d) Water heaters.	http://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf
Electric heat pump	Current, update takes effect 15 April, 2015	DOE	Code of Federal Regulations, TITLE 10—Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, §430.32 Energy and water conservation standards and their compliance dates (d) Water heaters.	http://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf
Oil				
Storage	Current, update takes effect 15 April, 2015	DOE	Code of Federal Regulations, TITLE 10—Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, §430.32 Energy and water conservation standards and their compliance dates (d) Water heaters.	http://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf

Table 10.2 MEPS in the USA (continued)

Type	Status	Organisation	Standard	Link
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	Current, update takes effect 15 April, 2015	DOE	Code of Federal Regulations, TITLE 10—Energy, PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS, §430.32 Energy and water conservation standards and their compliance dates (d) Water heaters.	http://www.gpo.gov/fdsys/pkg/CFR-2013-title10-vol3/pdf/CFR-2013-title10-vol3-sec430-32.pdf

Table 10.3 Mandatory labels in the USA

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current	FTC	Code of Federal Regulations, Title 16 - Commercial Practices , Part 305 — Rule Concerning Disclosures Regarding Energy Consumption and Water use of Certain Home Appliances and Other Products Required Under the Energy Policy and Conservation Act (''Appliance Labeling Rule'')	http://www.gpo.gov/fdsys/pkg/CFR-2013-title16-vol1/pdf/CFR-2013-title16-vol1-part305.pdf
Gas instantaneous	Current	FTC	Code of Federal Regulations, Title 16 - Commercial Practices , Part 305 — Rule Concerning Disclosures Regarding Energy Consumption and Water use of Certain Home Appliances and Other Products Required Under the Energy Policy and Conservation Act (''Appliance Labeling Rule'')	http://www.gpo.gov/fdsys/pkg/CFR-2013-title16-vol1/pdf/CFR-2013-title16-vol1-part305.pdf
Combi-boilers	None			
Gas + solar	None			
Gas + electric heat pump	None			

Table 10.3 Mandatory labels in the USA (continued)

Type	Status	Organisation	Standard	Link
Electric				
Electric storage	Current	FTC	Code of Federal Regulations, Title 16 - Commercial Practices , Part 305 — Rule Concerning Disclosures Regarding Energy Consumption and Water use of Certain Home Appliances and Other Products Required Under the Energy Policy and Conservation Act (''Appliance Labeling Rule'')	http://www.gpo.gov/fdsys/pkg/CFR-2013-title16-vol1/pdf/CFR-2013-title16-vol1-part305.pdf
Electric instantaneous	Current	FTC	Code of Federal Regulations, Title 16 - Commercial Practices , Part 305 — Rule Concerning Disclosures Regarding Energy Consumption and Water use of Certain Home Appliances and Other Products Required Under the Energy Policy and Conservation Act (''Appliance Labeling Rule'')	http://www.gpo.gov/fdsys/pkg/CFR-2013-title16-vol1/pdf/CFR-2013-title16-vol1-part305.pdf
Electric heat pump	Current	FTC	Code of Federal Regulations, Title 16 - Commercial Practices , Part 305 — Rule Concerning Disclosures Regarding Energy Consumption and Water use of Certain Home Appliances and Other Products Required Under the Energy Policy and Conservation Act (''Appliance Labeling Rule'')	http://www.gpo.gov/fdsys/pkg/CFR-2013-title16-vol1/pdf/CFR-2013-title16-vol1-part305.pdf
Oil				
Storage	Current	FTC	Code of Federal Regulations, Title 16 - Commercial Practices , Part 305 — Rule Concerning Disclosures Regarding Energy Consumption and Water use of Certain Home Appliances and Other Products Required Under the Energy Policy and Conservation Act (''Appliance Labeling Rule'')	http://www.gpo.gov/fdsys/pkg/CFR-2013-title16-vol1/pdf/CFR-2013-title16-vol1-part305.pdf
Solar				
Solar water heater system	None			
Solar collector	None			
Solar tank	None			

Table 10.4 Voluntary labels in the USA

Type	Status	Organisation	Standard	Link
Gas				
Gas storage	Current, revision process initiated	EPA	ENERGY STAR Residential Water Heaters Specification Version 2.0	http://www.energystar.gov/products/specs/node/241 http://www.energystar.gov/index.cfm?c=water_heat.pr_water_heaters_landing
Gas instantaneous	Current, revision process initiated	EPA	ENERGY STAR Residential Water Heaters Specification Version 2.0	http://www.energystar.gov/products/specs/node/241 http://www.energystar.gov/index.cfm?c=water_heat.pr_water_heaters_landing
Combi-boilers	None			
Gas + solar	Current, revision process initiated	EPA	ENERGY STAR Residential Water Heaters Specification Version 2.0	http://www.energystar.gov/products/specs/node/241 http://www.energystar.gov/index.cfm?c=water_heat.pr_water_heaters_landing
Gas + electric heat pump	None			
Electric				
Electric storage	None			-
Electric instantaneous	None			-
Electric heat pump	Current, revision process initiated	EPA	ENERGY STAR Residential Water Heaters Specification Version 2.0	http://www.energystar.gov/products/specs/node/241 http://www.energystar.gov/index.cfm?c=water_heat.pr_water_heaters_landing
Oil				
Storage	None			-
Solar				
Solar water heater system	Current, revision process initiated	EPA	ENERGY STAR Residential Water Heaters Specification Version 2.0	http://www.energystar.gov/products/specs/node/241 http://www.energystar.gov/index.cfm?c=water_heat.pr_water_heaters_landing
Solar collector				
Solar tank				

11 Mapping of product characteristics in selected countries

Australia

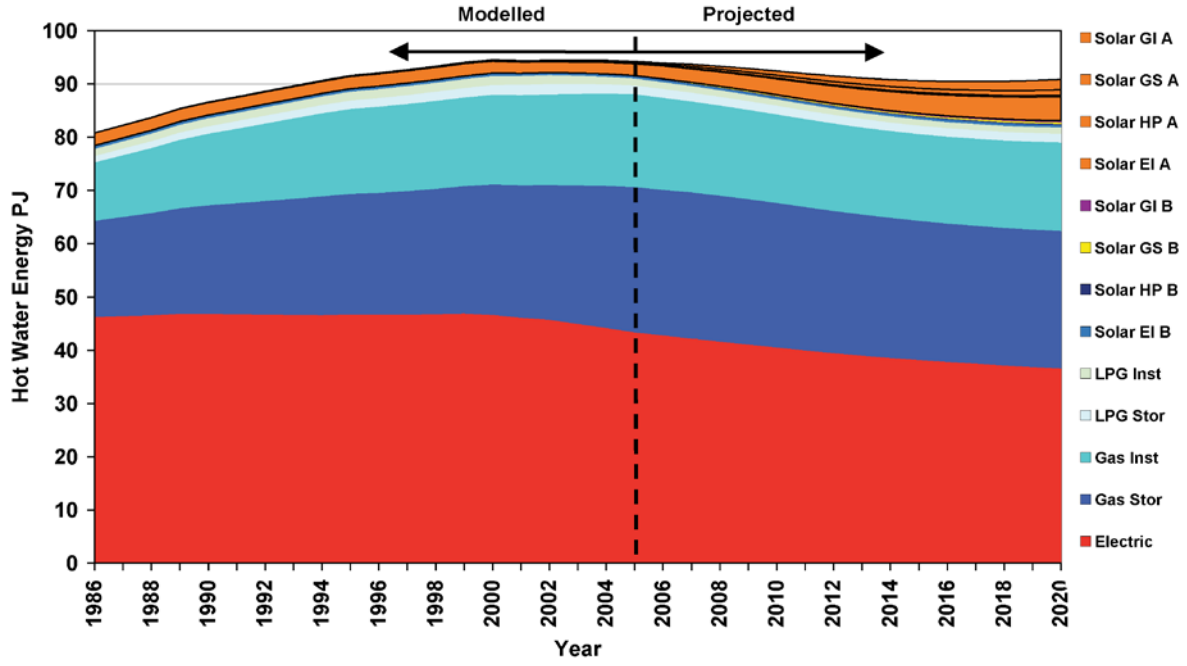
The Australian water heating market conventionally used electric or gas storage water heaters. However, the Australian electric supply has a very high greenhouse gas (GHG) emission factor and water heating accounted for 24% of the total GHG emissions by Australian households in 2010[3]. There has been an effort in recent years to reduce the amount of electricity used to heat water at both the state and federal levels.

The water heater market in Australia is small, with approximately 700,000 units sold each year. With strong governmental support, solar water heaters and heat pumps are the fastest growing segment of the market and accounted for over 30% of the market in 2010.

Gas water heaters

There is little market data for gas water heaters (storage or instantaneous), except a comparison of the energy consumption for all types of water heaters (source: *DEWHA (2008)*).

Figure 11.1 Trends in hot water energy consumption in Australia



Where: Solar GI A are passive solar systems boosted with a gas instantaneous heater, Solar GI B are the corresponding active systems (with water pump), S is for storage, HP is for heat pump and E is for electric.

Conventional electric storage water heaters

In Australia, conventional electric storage water heaters constituted 52% of the residential water heater stock in 2011, solar electric-boosted storage water heaters comprised 9% and heat pump water heaters for around 2% (ABS 2011). The remaining 37% correspond to gas-fired water heating systems. Historically low pressure or gravity fed electric water heaters were installed however mains pressure systems have been the most popular system for several decades. Conventional electric storage water heaters come in a variety of types and sizes. In Australia there is a mixture of continuous and restricted tariff water heaters. Restricted tariffs units tend to be larger in size and installed in the detached

[3] (Ferrari et al. 2012)

house and townhouse market. The electric storage water heaters on a continuous tariff tend to be much smaller units and are often preferred for flats and apartments.

The share of water heaters sales for conventional electric storage water heaters is estimated to be 29% so the proportion of conventional electric storage water heaters in the installed stock is slowly declining. The current estimated electric storage water heaters stock is around 4.2 million units. Australian conventional electric storage water heaters sales in 2009/10 were estimated to be around 280,000 units (derived GWA 2010) and the annual sales volume has been declining. The decline over the last few years is in response to factors such as restrictions on the installation of conventional electric storage water heaters in new Class 1 buildings, the partial phase-out of electric water heaters for existing Class 1 buildings in two States, rebates and incentives encouraging the installation of lower emission water heaters, the increasing cost of electricity and consumer preference for other types of water heaters such as instantaneous gas systems.

Solar and heat pump water heaters

Australia has had a well-established solar water heater manufacturing base for many years. There are now over 50 solar water heater suppliers currently operating in Australia and a wide variety of product types are available. Likewise there has been considerable research conducted in Australia by local suppliers over the last few decades to develop commercially viable, air-sourced heat pump water heaters. There has been development and refinement of these products internationally as well. There are now 18 different suppliers of heat pump water heaters in Australia.

Despite the history of product development and the number of suppliers in Australia, sales of solar water heaters and heat pump water heaters constitute a minority of total water heater sales in Australia. Solar water heaters form around 9% and heat pump water heaters approximately 2% of the installed water heater stock in 2011. Electric boosted solar systems form only part of the total number of solar water heater installations and data provided by the Department of Climate Change and Energy Efficiency (DCCEE) suggest around 65% of installations in recent years are electrically boosted solar systems – with the remaining solar systems using gas to supplement solar heat. This equates to around 4.5% of the total water heater sales in Australia being electrically boosted solar water heaters. Recent regulatory changes at the state and national level have increased the sales of solar water heaters and heat pump water heaters to the new homes market and the initiative to phase out greenhouse gas intensive electric water heaters, if fully implemented, would further increase the market share of solar water heaters and heat pump water heaters in the replacement market. The annual Australian market for heat pump water heaters was under 5,000 units five years ago and had increased to around 65,000 in 2009. In 2010 the total number of heat pump water heaters installed decreased to approximately 20,000. Approximately 65,000 electrically boosted solar systems are estimated to have been installed in 2010 however 80,000 may have been installed in 2011.

Table 11.1 Water heater sales and stock data for Australia

	Sales 2009-10 (2 yrs)		Sales 2011		Installed (2011)	
Australia	**Volume (1000 units)**	**Percent Sales**	**Volume (1000 units)**	**Percent Sales**	**Current Stock (1000 units)**	**Percent Installed**
Gas Instantaneous	N/D	N/D	N/D	N/D	N/D	N/D
Gas Storage	554	N/D	N/D	N/D	N/D	N/D
Electric Instantaneous	N/D	N/D	270	N/D	4439	N/D
Electric Storage	488	N/D				
Oil	N/D	N/D	N/D	N/D	N/D	N/D
Solar	402	N/D	80	N/D	595	N/D
Heat Pump			20	N/D	139	N/D
Total	N/D	N/D	N/D	N/D	N/D	N/D

Sources: Derived from http://ac.els-cdn.com/S1876610212016700/1-s2.0-S1876610212016700-main.pdf?_tid=18bae464-bc42-11e3-b165-00000aab0f6c&acdnat=1396647962_7f731a693aaea9e65ee0d4bc14dc8f0e

Brazil

Brazil is the largest market for overhead electric instantaneous water heaters in the world. These are small instantaneous water heaters mounted directly at the showerhead. In fact, 98% of all water heaters sold in Brazil in 2010 and 2011 were of this type and 68% of the country reported using them to PROCEL in 2005. These units typically are 2-3kW resistance heaters, although 12kW units are on the market. Storage water heaters have had minimal market share due to high upfront cost (storage water heaters are 20x the cost of electric on-demand ones), and the few that are sold are between 125-300 L. These units accounted for less than 1% of sales in 2010-2011, but they also have a longer lifetime than electric instantaneous units. A small fraction (6.2%) of the country reported using gas water heaters, primarily in Rio de Janeiro, which has a residential gas delivery system and gas instantaneous water heaters accounted for 1% of national sales during 2010-2011. As the gas distribution system grows, gas water heaters are expected to increase in market share. The adoption of solar water heating is also growing by the year both in the residential and commercial sectors, particularly as Brazilian energy efficiency laws are starting to foster solar thermal solutions. Some states require all new buildings with two or more bathrooms/dwelling to have 30% of hot water met by solar, and the "Minha Casa Minha Vida" housing program required solar water heating. In some parts of Brazil, primarily in the northeast, custom and climate dictate little to no hot water use. Accordingly, 26% of the country has no form of water heating.

Due to the low penetration of air conditioning in homes, water heating typically constitutes a large proportion of energy consumption in homes, on the order of 30% or more. Also, much of the demand comes during evening peak hours. Thus, as Brazil's economy continues to grow and put pressure on the hydro-dominated electrical grid, there is a growing incentive to reduce the electricity demand of hot water heaters. Solar water heaters are the government backed choice to do this, as there is a high coincidence with solar water availability, hot water demand, and system peak.

Table 11.2 Water heater sales and stock data for Brazil

	Sales 2010-11 (2 yrs)		Installed
Brazil	**Volume (1000 units)**	**Percent Sales**	**Percent Installed**
Gas Instantaneous	516	1%	N/D
Gas Storage	131	0%	N/D
Electric Instantaneous	47,723	98%	N/D
Electric Storage	123	0%	N/D
Oil	N/D		N/D
Solar	N/D		N/D
Heat Pump	N/D		N/D
Total	48,493	100%	

Sources: (Cressotti 2012) (Ghisi, Gosch, and Lamberts 2007)

Canada

Residential water heating is the second largest energy end-use for Canadian households, accounting for approximately 22% of total household energy consumption. Conventional tank water heating systems are by far the most common type installed. In general, new construction use natural gas rather than electricity for domestic water heating and thus the share of electric water heaters has been steadily declining over time, while natural gas has been steadily increasing.

Table 11.3 Water heater sales and stock data for Canada

	Sales 2010-11 (2 yrs)		Installed (2011)	
Canada	**Volume (1000 units)**	**Percent Sales**	**Current Stock**	**Percent Installed**
Gas Instantaneous	N/D	N/D	N/D	N/D
Gas Storage	N/D	N/D	N/D	58%
Electric Instantaneous	N/D	N/D	N/D	N/D
Electric Storage	N/D	N/D	N/D	38%
Oil	N/D	N/D	N/D	3%
Solar	N/D	N/D	N/D	N/D
Heat Pump	N/D	N/D	N/D	N/D
Total	N/D	N/D	N/D	100%

Sources: Derived from http://en.wikipedia.org/wiki/List_of_Canadian_provinces_and_territories_by_population

CREEDAC-Canadian-Residential-Hot-Water-Apr-2005

China

The Chinese water heating market was estimated to be 22.3 million units in 2011, and was growing quickly. In 2011, sales of solar water heating increased more slowly compared to previous years and 2011 also saw government increased support for appliance sales in rural areas. As China is growing quickly and government support has a large effect on markets, more recent data for China should be acquired.

In 2011, electric storage and gas instantaneous accounted for 95% of total water heater sales. There is also a small but growing market for electric instantaneous water heating, but they are considered very expensive to run and there are safety concerns. Gas storage water heaters are not common in China due to large space requirements and complex installation.

Electric storage water heaters are used where there is no gas distribution infrastructure and in multi-story apartment building. In 2011, the most popular models had a capacity between 40 and 100 L, specifically in the 50 to 80 L range. Larger units are popular in the prosperous south and in larger dwellings. Gas instantaneous water heaters are common and growing with China's gas distribution infrastructure. The most popular models have flow rates that vary between 5 and 13 litres per minute and have a fan-assisted open flue.

Water heating in China grew at 10% per year from 2006-2010 and the rate was forecasted to increase at nearly 15% per year between 2011 and 2015.

Table 11.4 Water heater sales and stock data for China

	Sales 2010-11 (2 yr)		Installed (2011)	
China	**Volume (1000 units)**	**Percent Sales**	**Current Stock**	**Percent Installed**
Gas Instantaneous	17,271	33%	N/D	N/D
Gas Storage	193	0%	N/D	N/D
Electric Instantaneous	1,639	3%	N/D	N/D
Electric Storage	21,244	41%	N/D	N/D
Oil	N/D	N/D	N/D	N/D
Solar*	12,000	23%	N/D	N/D
Heat Pump	N/D	N/D	N/D	N/D
Total	52,347	100%		

Sources: (Fritsch 2012), http://www.aceee.org/files/pdf/conferences/hwf/2012/6C-Goetzler-Final.pdf

EU

Water heater market and stock estimates for all technologies in Europe have been derived for energy efficiency studies in 1998 (Save study) and 2006 (VHK, 2007[4]). A robust market and stock estimate for all technologies is thus available for the year 2005 (see Tables 11.5 and 11.6). More recent EU Member states are not included (Bulgaria and Romania integrated in 2007, Croatia in 2013). In addition, data for Cyprus, Malta and Luxembourg are not available. All in all, it means that about 7 % of the EU28 population is missing from the EU22 estimates.

Stock estimates (overall)

In terms of number of units, dedicated water heaters represented about 60 % of the installed based in Europe in 2005. Combined heating and hot water systems represented about 37 % of the installations. The VHK study does not consider individual oil water heaters which are then supposed to account for zero percent of the market. Solar installations appeared to be mainly used in dedicated installations (14 % only in combined systems). Dedicated heat pump water systems were only at their very beginning at that time, with about 10000 units sold in 2005 and the stock in that year is probably negligible.

It is important to note that a large share (about 30 %) of electric instantaneous and storage water heaters (with capacities below 30 L) are for single point hot water needs (for kitchen or bathroom). Hence it is useful to keep in mind the distinction of primary (multi-points) and secondary (single point) hot water systems as proposed by BRG CONSULT and reproduced below.

[4] Van Holsteijn en Kemna (VHK), 2007. Preparatory study on eco-design of water heaters. Available at: 〈http://www.ecohotwater.org/〉

Table 11.5 Total water heater stock data for the EU

	2005	2005
EU22 – stock of water heaters	**1000 units**	**%**
District heating	2 606	1.1%
Linked to boiler (combined)	87 301	37.0%
Dedicated, of which	146 339	61.9%
Gas Instantaneous	29 688	12.6%
Gas Storage	3 769	1.6%
Electric Instantaneous	26 784	11.3%
Electric Storage	84 437	35.7%
Oil	0	0
HP (EHPA)	Unknown	Unknown
Solar*	1 661	0.7%
TOTAL	236 246	100.0%

*solar: +263 installations supposed to be in combined systems

Table 11.6 Primary and secondary water heater stock data for the EU

Installed base of primary water heaters	2005	2005
EU22 – stock of water heaters	**1000 units**	**in % prim**
District heating	2 606	1.5%
Linked to boiler (combined)	87 301	48.9%
Dedicated, of which	88 572	49.6%
Gas Instantaneous (13+ l/m)	19 069	10.7%
Gas Storage	3 769	2.1%
Electric Instantaneous >12 kW	12 713	7.1%
Electric Storage >30 litres	51 360	28.8%
Oil	0	0.0%
HP	Unknown	Unknown
Solar	1 661	0.9%
TOTAL primary	178 479	100.0%

Primary means main source of hot water (multi-point systems)

Installed base of secondary water heaters	2005	2005
EU22 – stock of water heaters	**1000 units**	**in % sec**
Electric Storage (<30 L)	33 077	57%
Electric Instantaneous (<12 kW)	14 071	24%
Gas Instantaneous (5 to 13 L/min)	10 619	18%
TOTAL Secondary	57 767	100%

Market estimates (global)

Market sales of dedicated water heaters were estimated for EU22 by (VHK, 2007) and are given in the tables below, in thousand units and in percentage.

Table 11.7 Water heater sales data for the EU

	1990	1995	2000	2005	2010	2020
EU22 - market data	**1000 units**	**1000s**	**1000s**	**1000s**	**1000s**	**1000s**
Gas Instantaneous	2308	1929	1972	1849	1734	1495
Gas Storage	250	261	291	234	208	126
Electric Instantaneous	1619	1970	2303	2430	2406	2509
Electric Storage	5629	5450	5652	5905	5973	6295
Oil	0	0	0	0	0	0
HP (source EHPA)	0	0	0	11	30	Unknown
Solar	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
TOTAL	9806	9610	10218	10429	10351	10425

Lighter cells in 2010 are forecasts made in 2005 by BRG CONSULT (VHK, 2007).

	1990	1995	2000	2005	2010	2020
EU22 - market data	**%**	**%**	**%**	**%**	**%**	**%**
Gas Instantaneous	24%	20%	19%	18%	17%	14%
Gas Storage	2.5%	2.7%	2.8%	2.2%	2.0%	1.2%
Electric Instantaneous	17%	20%	23%	23%	23%	24%
Electric Storage	57%	57%	55%	57%	58%	60%
Oil	0	0	0	0	0	0
HP	Unknown	Unknown	Unknown	0.1%	0.3%	Unknown
Solar	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
TOTAL	100%	100%	100%	100%	100%	100%

The following projected trends were hypothesized in 2007 for electric and gas dedicated water heaters, although there are no data to check whether this indeed happened.

- Gas storage and instantaneous dedicated water heaters are on the decrease, with sales starting to decrease sharply after 2010.
- Electric instantaneous sales are rather constant after 2005, hiding continuously increasing electric shower (in the UK and in Ireland exclusively) while standard elec. instantaneous heater sales are decreasing.
- Sales of electric storage heaters are slightly on the increase, with a global trend to higher volumes.

Heat pump water heaters

The European Heat Pump Association (EHPA) gives annual statistics of dedicated heat pump water heater sales. Heat pump figures can be used directly as figures are given in number of units and a specific category is available for heat pump water heater. Sales figures are given in the table below for 20 EU countries plus Switzerland (Countries not covered: Bulgaria, Croatia, Cyprus, Greece, Luxembourg, Malta, Romania and Slovenia).

Table 11.8 Heat pump water heater stock data for the EU

	2005	2006	2007	2008	2009	2010	2011	2012
HPWH Market sales (EU 20 + CH)	11253	21594	13840	28518	29223	31558	50917	63 502

Source: Nowak 2013, Heat pump market and statistics report 2013, European Heat Pump Summit 2013, October 15 and 16 2013, Nuremberg, Germany

Solar water heaters

In recent years, European solar and heat pump associations have published regular market figures (see above) which highlight the development of these technologies. However, solar figures are given in m^2 of glazed collector installed or in thermal kW and not in number of installations. In addition, the share dedicated to domestic water heaters is not known. Part of this goes to combined heating and water heating solutions (estimated to be 14 % in 2006 (VHK, 2007)). In recent years, commercial and industrial sales have been growing so that collectors sales used for domestic water heaters only would probably largely overestimate the number of installations.

Consequently, the only reference for dedicated water heater sales available is from the DG ENER Lot 2 Preparatory Study and has been reported above.

Potential issues regarding market and stock data gatherings in Europe

In order to get more recent market sales data it would be necessary to purchase data from commercial concerns, and this data is not available for all countries in Europe but probably only for the main markets. BSRIA and BRG CONSULT are possible firms to consult on this matter.

Apart from the cost, the risk is that a comprehensive set of data at the national level may be required to get a full and accurate picture of EU28 water heater sales and stock data.

India

Water heating in India varies by region and dwelling. In the urban areas it is common to have a water heater – and electric, gas, and solar are all common, depending on the region. In rural areas, hot water is generated by the use of open fires or an electrified hand-held stick (element) that heats water in a bucket. The vast majority of bathrooms do not have hot water piping, nor a bathtub, nor shower.

Overall, there is low penetration of water heaters in India, but the market is growing. In 2010 it grew by more than 10% and by another 6% in 2011. The Indian water heating market is dominated by electric water heaters. Gas water heaters are becoming more popular, but there is little infrastructure and (non-subsidized) gas prices are very high. However, there are constant electricity shortages in India, and gas and solar water heaters are one way to ensure hot water is available, so they are becoming more popular.

Electric storage water heaters are the primary water heating devices in India. Storage water heaters are the most common for large households. Preheated water from a storage heater can be used in case of a power cut. The most common sizes are between 6 and 30 litres and are installed in every bathroom. Larger units are used in commercial settings but their share is small. Big sizes are also used in the luxury residential segment.

Electric instantaneous heaters are the second biggest market segment in India and are mostly smaller units with a capacity of 3kW. Instantaneous heaters are primarily used in large cities, Mumbai being the largest regional market, where power outages are less common. In Mumbai, 4.5 kW units dominate. Larger units of 6, 9, 12 or 15kW are also on the market.

The market is expected to grow further in the years to come in line with the increase of India's GDP, disposable income, and construction market.

Table 11.9 Water heater sales and stock data for India

	Sales 2010-11		Installed
India	**Volume (1000 units)**	**Percent Sales**	**Percent Installed**
Gas Instantaneous	505	13%	N/D
Gas Storage	N/D	N/D	N/D
Electric Instantaneous	970	25%	N/D
Electric Storage	2,400	62%	N/D
Oil	N/D	N/D	N/D
Solar	N/D	N/D	N/D
Heat Pump	N/D	N/D	N/D
Total	3,875	100%	

Sources: Feedback (2014), MNRE (2010)

Korea

Korea has a unique "Ondol (Korean floor heating system, http://en.wikipedia.org/wiki/Ondol)" culture such that almost 100% of households choose under floor heating systems that circulate hot water coming from gas or oil boilers through the floor. This system also provides hot water supply for sanitary use. Thus the vast majority of sanitary hot water is provided through gas- or oil-fired combi-boilers.

Table 11.10 Water heater sales and stock data for Korea

	Sales 2010		Installed (2011)	
Korea	**Volume (1000 units)**	**Percent Sales**	**Current Stock (1000 units)**	**Percent Installed**
Gas Instantaneous (combi)	1079	~80%	N/D	N/D
Gas Storage	N/D	N/D	**N/D**	N/D
Electric Instantaneous	N/D	N/D	N/D	N/D
Electric Storage		**~3%**	**550**	N/D
Oil (combi)	200[1]	~13%	N/D	N/D
Solar*	N/D	N/D	**N/D**	
Heat pump	N/D	N/D	N/D	
Totals		**100%***		**100%**

1) Data for 2012, note the percent sales values shown do not sum to 100% because the remaining sales are N/D (not disclosed).

Source: KEMCO personal communication.

USA

In the USA water heating is the second largest energy use in homes, accounting for 17% of residential energy consumption. The market size is approximately 8 million units per year. Type of water heating installed is dependent on infrastructure, so varies regionally. The majority of installed units are fuelled with natural gas, with electricity being the second most common. A small percentage of homes, primarily in New England and the mid-Atlantic regions, use fuel oil. Solar and heat pumps make up a small but growing sector of the market. Historically, the water heater market in the US grew consistently and was tied to new home construction. During the recession, the market fell by more than 20% from the 2004 peak. It is expected to rebound with the economy. The 2009 American Recovery and Reinvestment Act supported state sponsored appliance rebate programs that promoted both energy efficient conventional units and heat pumps and solar systems.

Table 11.11 Water heater sales and stock data for the USA

	Sales 2010		Installed (2011)	
USA	**Volume (1000 units)**	**Percent Sales**	**Current Stock**	**Percent Installed**
Gas Instantaneous	344	5%	N/D	N/D
Gas Storage	3,182	42%	N/D	48%
Electric Instantaneous	N/D	N/D	N/D	N/D
Electric Storage	3,700	48%	N/D	49%
Oil	268	4%	N/D	3%
Solar*	30	0%	N/D	
Heat pump	161	2%	N/D	
Totals	**7,655**	**100%**		**100%**

Sources: http://www.aceee.org/files/pdf/conferences/hwf/2012/6C-Goetzler-Final.pdf, https://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/water_heaters/Water_Heater_Market_Profile_2010.pdf

12 Mapping of existing standards and labelling initiatives and their characteristics

Australia

Test procedures

Table 12.1 maps which water heaters types are to be tested to which test standards in Australia.

Table 12.1 Water heater test procedures in Australia

Water heater type	Exist. std (Y/N)	Standard reference	Rated Volume	Rated Input	Temperature
Gas					
Gas storage	Y	AS/NZS 4552.2:2010 AS 4552-2005	> 50 l	< 50 MJ/h	< 99 °C
Gas instantaneous	Y	AS/NZS 4552.2:2010 AS 4552-2005	None	< 250 MJ/h and Output > 13,1 kW	< 99 °C
Electric					
Electric storage	Y	AS/NZS 4692.1:2005 AS/NZS 4692.2:2005 AS 1361-1995	Unvented: NA Vented: NA Exchanger: 45 l to 710 l	Unvented and vented: 25 l to 630 l Exchanger: NA	75 °C
Electric instantaneous	N				
Electric heat pump	Y	AS/NZS 5125.1:2010 AS/NZS 2712:2007 AS/NZS 4234:2008			
Oil					
Storage	N				
Solar					
Solar water heater system	Y	AS/NZS 2712:2007 AS/NZS 4234:2008 AS/NZS 4445.1:1997 AS/NZS 2535.1:2007 (ISO 9806-1:1994)			
Solar collector	Y	AS/NZS 2535.1:2007 (ISO 9806-1:1994)			
Solar tank	Y	AS/NZS 4692.1:2005 AS/NZS 4692.2:2005 AS 1361-1995	Unvented: NA Vented: NA Exchanger: 45 l to 710 l	Unvented and vented: 25 l to 630 l Exchanger: NA	75 °C
Tank					
Unvented	Y	AS/NZS 4692.1:2005 AS/NZS 4692.2:2005 AS 1361-1995	Unvented: NA Vented: NA Exchanger: 45 l to 710 l	Unvented and vented: 25 l to 630 l Exchanger: NA	75 °C

NA: not applicable.

Regulations

The following regulations apply for water heaters in Australia.

MEPS

There are two current regulations, for gas and electrical water heaters, and another two are under study, for heat pumps and solar water heaters.

1. Greenhouse and Energy Minimum Standards (Gas Water Heaters) Determination 2013 covers:

- fired with natural gas (NG), liquefied petroleum gas (LPG) or simulated natural gas (SNG), and
- operated using natural draught, or fan assisted, combustion systems.

2. Greenhouse and Energy Minimum Standards (Electric Water Heaters) Determination 2012 covers:

- storage water heaters with rated hot water delivery up to 630 litres, including the storage component of:

  (i) solar water heaters

  (ii) heat pump water heaters, and

  (iii) indirectly heated systems

  or:
- heat exchange water heaters of a heat storage volume up to 710 litres, or
- water heaters that use electric resistive heating as the primary energy source.

Table 12.2 lists the mandatory minimum energy performance standards for water heaters sold in Australia. The MEPS are expressed in terms of the Energy Factor which is determined using the test procedures defined in Table 12.1

Table 12.2 Water heater MEPS in Australia

Type	Status	Standard	MEPS
Gas			
Gas storage	Current	Greenhouse and Energy Minimum Standards (Gas Water Heaters) Determination 2013	$\eta \geq 0.60$ (on yearly basis, daily output 37.67 MJ) $\eta \geq 0.75$ (at nominal gas consumption) $M < 0.42 + 0.02V^{2/3} + 0.006R$ (at 45 K over ambient) (M = maintenance gas consumption in MJ/h, V = nominal capacity in L, R = nominal gas consumption in MJ/h) + requirements on stratification
Gas instantaneous	Current	Greenhouse and Energy Minimum Standards (Gas Water Heaters) Determination 2013	$\eta \geq 0.60$ (on yearly basis, daily output 37.67 MJ) $\eta \geq 0.75$ (at nominal gas consumption)
Electric			
Electric storage	Current AS 1056.1 AS 1361 AS/NZS 4692.1 AS/NZS 4692.2	Determination: Greenhouse and Energy Minimum Standards (Electrical Water Heaters) Determination 2012	un-vented displacement Standing heat losses – See Table 12.3
			vented displacement Standing heat losses – Tested to AS 1361 $\leq 0.255 \times V^{0.4032}$ (V is the hot water delivery of the vented electric water heater) – kWh/day Tested to AS/NZS 4692.1: $\leq 0.2821 \times V^{0.3897}$
			heat exchange Standing heat losses – Tested to AS 1361 $\leq 0.4362 \times V^{0.3235}$ (V is the hot water delivery of the vented electric water heater) – kWh/day Tested to AS/NZS 4692.1: $\leq 0.4057 \times V^{0.3322}$
Electric instantaneous	None		
Electric heat pump	None		

Type	Status	Standard	MEPS
Oil			
Storage	None		
Solar			
Solar water heater system	None		
Solar collector	None		
Solar tank	None		
Tank			
Unvented	None		

Note: Hot water delivery: The quantity of hot water that can be drawn off continuously at a specified flow rate without exceeding a specified temperature drop or, in the case of a heat exchanger water heater, while exceeding a specified cold temperature rise.

Table 12.3 Maximum heat loss for electric storage water heaters (unvented tanks without an attached feed tank) in Australia

Rated Hot Water Delivery (litres)	Maximum Allowable Standing Heat Loss (kilowatt hours/day) October 2005 when tested to AS1056.1	Maximum Allowable Standing Heat Loss (kilowatt hours/day) October 2005 when tested to AS/NZS 4692.1
<25	0.98	1.04
25	0.98	1.04
31.5	1.05	1.11
40	1.12	1.18
50	1.19	1.25
63	1.33	1.39
80	1.47	1.53
100	1.61	1.67
125	1.75	1.81
160	1.96	2.02
200	2.17	2.23
250	2.38	2.44
315	2.66	2.72
400	2.87	2.93
500	3.15	3.21
630	3.43	3.49

Mandatory labels

There is currently no mandatory label in Australia. Labelling is under study for electrical and heat pump water heaters, without any known deadline for the publication of the corresponding act.

Voluntary labels

There is currently no voluntary label in Australia.

Brazil

Test procedures

Table 12.4 maps which water heaters types are to be tested to which test standards in Brazil.

Table 12.4 Test procedures in Brazil

Water heater type	Exist. std (Y/N)	Standard reference	Rated Volume	Rated Input	Temperature
Gas					
Gas storage	Y	Appendix of INMETRO Ordinance No. 182/2012	< 250 L	< 35.0 kW	
Gas instantaneous	Y	Appendix of INMETRO Ordinance No. 182/2012	unknown	< 70.0 kW	
Combi-boilers (1)	N				
Gas + solar	N				
Gas + electric heat pump	N				
Electric					
Electric storage	N				
Electric instantaneous	Y	Instantaneous water heaters and electrical taps - Determination of energy consumption ABNT 14015-1997			
Electric heat pump	N				
Oil					
Storage	N				
Solar					
Solar water heater system	Y	INMETRO Ordinance No. 301/2012 and ISO 9459-2	≤ 1000 L		
Solar collector	Y	INMETRO Ordinance No. 301/2012 and ISO 9459-2			
Solar tank	Y	INMETRO Ordinance No. 301/2012			
Tank					
Unvented	N				

These sections show the mapping of existing standards and labelling initiatives and their characteristics for residential water heaters in Brazil.

Regulations

The following regulations apply to water heaters in Brazil.

MEPS

Brazil has MEPS for all gas water heaters, both storage and instantaneous. Solar tanks less than 1000 L must meet a maximum monthly specific energy loss requirement.

Table 12.5 Water heater MEPS in Brazil

Type	Status	Standard	MEPS
Gas			
Gas storage	Current	Inter-ministerial Ordinance 324/2011	η ≥ 72%
Gas instantaneous	Current	Inter-ministerial Ordinance 324/2011	η ≥ 76%
Combi-boilers	None		
Gas + solar	None		
Gas + electric heat pump	None		
Electric			
Electric storage	None		
Electric instantaneous	None		
Electric heat pump	None		
Oil			
Storage	None		
Solar			
Solar water heater system	None		
Solar collector	None		
Solar tank	Current	INMETRO ordinance 301/2012	maximum specific energy loss in kWh/L-month = = 0.27 for storage tanks ≤ 300L = 0.26 – V/10,000
Tank			
Unvented	None		

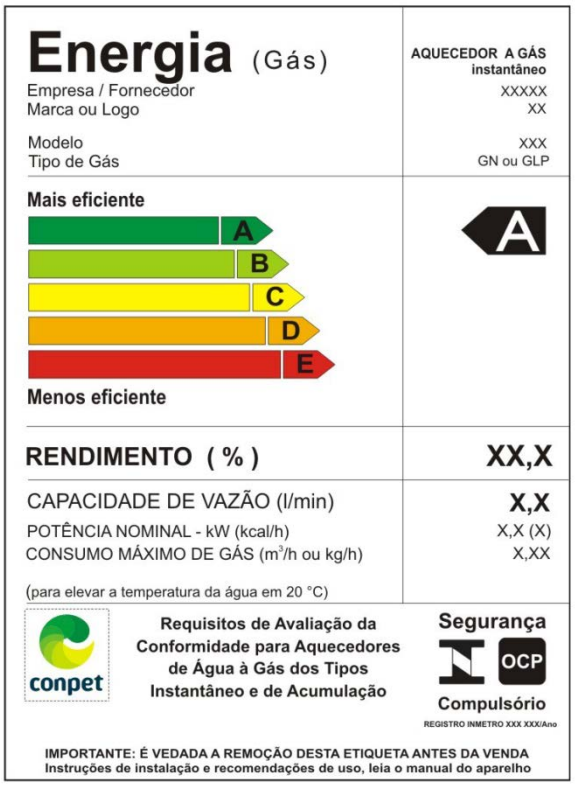
Labels

Brazil has mandatory comparative labels for all gas water heaters and voluntary comparative labels for solar systems. The Energy Conservation National Label (Etiqueta Nacional de Conservação de Energia, ENCE in Portuguese) certifies that the product meets the performance and safety requirements of the INMETRO labelling program. The rating ranges for instantaneous gas water heaters are defined in Table 12.6.

Table 12.6 Instantaneous gas water heater label classes in Brazil

Efficiency η (%)	Range
η ≥ 84	A
84 > η ≥ 82	B
82 > η ≥ 80	C
80 > η ≥ 78	D
78 > η ≥ 76	E

A template of the ENCE label for instantaneous gas water heaters is shown below.

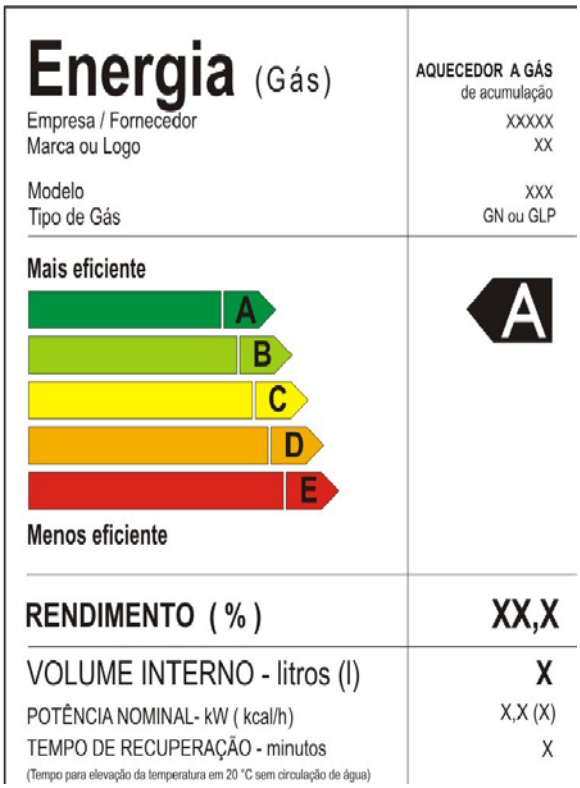


The rating ranges for gas storage water heaters are listed in Table 12.7.

Table 12.7 Gas storage water heater labelling classes in Brazil

Efficiency η (%)	Range
η ≥ 81	A
81 > η ≥ 79	B
79 > η ≥ 77	C
77 > η ≥ 74	D
74 > η ≥ 72	E

An example of the ENCE comparative label for gas storage water heaters is shown below.



The CONPET voluntary seal of energy efficiency is awarded by Petrobras. To earn the CONPET seal, water heaters must be ranked as "A" on their ENCE label.

The voluntary label for solar water heater systems is based on monthly specific energy production (PMEe). The rating ranges for solar water heater systems are listed in Table 12.8.

Table 12.8 Voluntary solar water heater labelling classes in Brazil

PMEe (kWh/m^2-month)	Range
80.3 < PMEe	A
73.3 < PMEe ≤ 80.3	B
66.3 < PMEe ≤ 73.3	C
59.3 < PMEe ≤ 66.3	D
52.3 < PMEe ≤ 59.3	E

Canada

This section shows the mapping of existing standards and labelling initiatives and their characteristics for residential water heaters in Canada.

Test procedures

Table 12.9 maps which water heaters are to be tested to the standards in Canada.

Table 12.9 Water heater test procedures in Canada

Water heater type	Exist. std (Y/N)	Standard reference	Rated Volume	Rated Input	Temperature
Gas					
Gas storage	Y	CSA P.3-04: Testing Method for Measuring Energy Consumption and Determining Efficiencies of Gas-Fired Storage Water Heaters	50 to 454 L	≤ 21.98 kW	< 82 °C
Gas instantaneous	Y	CSA P.7-10: Testing Method for Measuring Energy Loss of Gas-Fired Instantaneous Water Heaters	< 7.57 L	14.7 to 73.2 kW	< 82 °C
Combi-boilers (1)	Y	CAN/CSA-P.9-11 - Test method for determining the performance of combined space and water heating systems (combos)	unknown	≤ 87.9 kW for boiler-based systems ≤ 73.2 kW for water-heater-based systems intended for field assembly.	unknown
Gas + solar	N				
Gas + electric heat pump	N				
Electric					
Electric storage (2)(3)(4)	Y	C191-13 - Performance of electric storage tank water heaters for domestic hot water service	50 to 454 L	not specified	not specified
Electric instantaneous	N				
Electric heat pump	Y	CAN/CSA-C745-03 (R2009) - Energy Efficiency of Electric Storage Tank Water Heaters and Heat Pump Water Heaters	76 to 454 L	≤ 12 kW	< 82 °C
Oil					
Storage	Y	CAN/CSA-B211-00 (R2010) - Energy Efficiency of Oil-Fired Storage Tank Water Heaters	≤ 190 L	≤ 30.5 kW	unknown
Solar					
Solar water heater system	Y	CAN/CSA-F379 SERIES-09 (R2013) - Packaged solar domestic hot water systems (liquid-to-liquid heat transfer)	unknown	Unknown	unknown
Solar collector	N				
Solar tank	N				
Tank					
Unvented	N				

Table 12.9 Water heater test procedures in Canada (continued)

Water heater type	Exist. std (Y/N)	Standard reference	Rated Volume	Rated Input	Temperature
Electric					
Electric storage (2)(3)(4)	Y	C191-13 - Performance of electric storage tank water heaters for domestic hot water service	50 to 454 L	not specified	not specified
Electric instantaneous	N				
Electric heat pump	Y	CAN/CSA-C745-03 (R2009) - Energy Efficiency of Electric Storage Tank Water Heaters and Heat Pump Water Heaters	76 to 454 L	≤ 12 kW	< 82 °C
Oil					
Storage	Y	CAN/CSA-B211-00 (R2010) - Energy Efficiency of Oil-Fired Storage Tank Water Heaters	≤ 190 L	≤ 30.5 kW	unknown
Solar					
Solar water heater system	Y	CAN/CSA-F379 SERIES-09 (R2013) - Packaged solar domestic hot water systems (liquid-to-liquid heat transfer)	unknown	Unknown	unknown
Solar collector	N				
Solar tank	N				
Tank					
Unvented	N				

(1) Forced-air combo systems only.
(2) Standby loss test, loss in watts for 48 hour at a temperature difference of 40 °C.
(3) Diffusion test - at least 90% of the tank capacity shall be delivered before the outlet water temperature drops more than 17 °C.
(4) Delivery test - shall be capable of delivery of specified draw pattern while the average temperature of any withdrawal shall be not less than 44 °C above the supply water temperature.

Regulations

Canada has MEPS for gas, electric, and oil storage water heaters. MEPS for gas instantaneous water heaters are proposed to take effect in 2016. Water heaters for which a MEPS exists must have an efficiency verification label.

MEPS

Table 12.10 lists the mandatory minimum energy performance standards for water heaters sold in Canada. The MEPS are expressed as Energy Factor which is determined using the test procedures defined in Table 12.9.

Table 12.10 Water heater MEPS in Canada

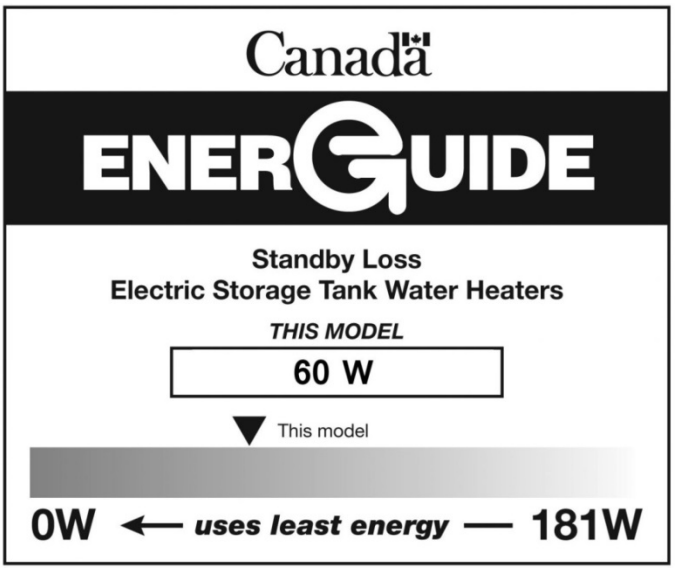
Type	Status	Standard	MEPS
Gas			
Gas storage	current	CSA P.3-04	EF = 0.67 - 0.0005 Vr Vr is rated volume
	proposed January 1, 2016		EF = 0.80
Gas instantaneous	proposed January 1, 2016	CSA P.7	EF = 0.80
Combi-boilers	None		
Gas + solar	None		
Gas + electric heat pump	None		
Electric			
Electric storage	current	CSA C191-04	maximum standby loss in W = (a) for tanks with bottom inlet: (i) 40 + 0.2 V for tanks with V ≥ 50 L and ≤ 270 L (ii) 0.472 V - 33.5 for tanks with V > 270 L and ≤ 454 L (b) for tanks with top inlet: (i) 35 + 0.2 V for tanks with V ≥ 50 L and ≤ 270 L (ii) 0.472 V - 38.5 for tanks with V > 270 L and ≤ 454 L V is volume
Electric instantaneous	None		
Electric heat pump	None		
Oil			
Storage	current	CSA B211-00	EF = 0.59 - 0.0005 Vr
	proposed April 16, 2015		EF = 0.68-0.0005 Vr
Solar			
Solar water heater system	None		
Solar collector	None		
Solar tank	None		
Tank			
Unvented	None		

Labels

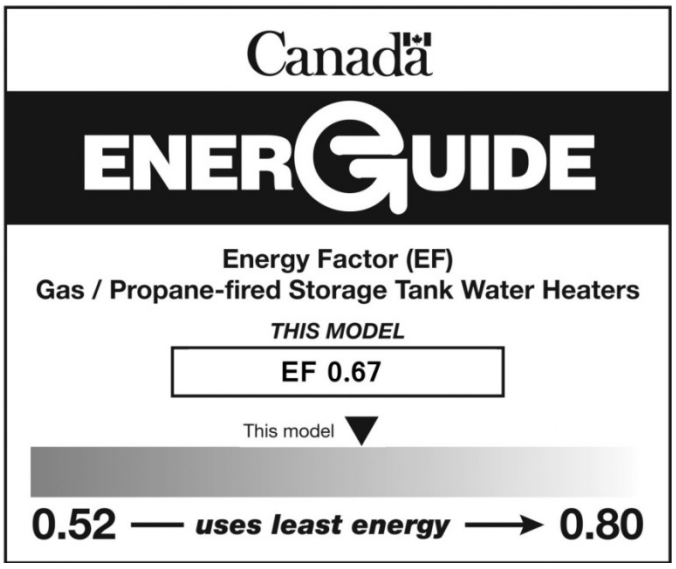
In Canada all regulated water heaters must have efficiency verification labels that indicate a third party has verified the ratings.

Voluntary labels
The EnerGuide label is voluntary for water heaters. Water heater manufacturers that are members of the Canadian Institute of Plumbing & Heating (CIPH) are using the voluntary EnerGuide label as a verification label.[5]

The EnerGuide label for electric storage water heaters shows standby loss in watts.



The EnerGuide label for gas storage water heaters displays Energy Factor.



If a storage gas water heater meets the Energy Star criteria, a manufacturer may display that label as well.

[5] August 15, 2013, CIPH and HRAI Partner with NRCan to add Water Heaters to the HVAC EnerGuide Program. http://myemail.constantcontact.com/CIPH-and-HRAI-Partner-with-NRCan-to-add-Water-Heaters-to-the-HVAC-EnerGuide-Program.html

China

Test procedures

In China the test procedures for rating the efficiency of water heaters are included in the MEPS and labelling documents. Table 12.11 maps which water heaters types are to be tested to which test standards in China.

Table 12.11 Water heater test procedures in China

Water heater type	Exist. std (Y/N)	Standard reference	Rated Volume	Rated Input	Temperature
Gas					
Gas storage	Y	GB 18111-2000		<100kW	82°C
Gas instantaneous	Y	GB 20665-2006			
Combi-boilers	Y	GB 20665-2006			
Electric					
Electric storage	Y	GB 21519-2008			
Electric instantaneous	N				
Electric heat pump	Y	GB 29541-2013			
Oil					
Storage	N				
Solar					
Solar water heater system	Y	GB 26969-2011			
Solar collector	N				
Solar tank	N				
Tank					
Unvented	N				

Regulations

MEPS

China has mandatory MEPS and labelling requirements for gas-fired instantaneous water heaters and hot water combi-boilers, electric storage water heaters, heat pump water heaters, and solar water heating systems. The MEPS are shown in Table 12.12.

Table 12.12 Water heater MEPS in China

Type	Status	Standard	MEPS
Gas			
Gas storage	None		
Gas instantaneous	current	GB 20665-2006	thermal efficiency(η) ≥ 84% at rated load
Combi-boilers	current	GB 20665-2006	water heating thermal efficiency η ≥ 84% at rated load space heating thermal efficiency η ≥ 84% at rated load
Gas + solar	None		
Gas + electric heat pump	None		
Electric			
Electric storage	current	GB 21519-2008	Rated Capacity (L) 24 hour standing loss (kWh) $0<C_R\leq30$ Q=0.024C+0.6 $30< C_R \leq100$ Q=0.015C+0.8 $100< C_R \leq200$ Q=0.008C+1.5 $C_R>200$ Q=0.006C+2.0 C_R is rated capacity. C is measured capacity
Electric instantaneous	None		
Electric heat pump	current	GB 29541-2013	COP standard temperature, add-on HP 3.70 standard temperature, integral HP 3.40 low-temperature, 3.00
Oil			
Storage			
Solar			
Solar water heater system	Current	GB 26969-2011	Coefficient of Thermal Performance CTP≥0.10
Solar collector	None		
Solar tank	None		
Tank			
Unvented	None		

Mandatory labels

Labels are mandatory for all water heater types which have MEPS. The lowest grade on the energy label corresponds to the MEPS level.

Gas instantaneous water heaters and combi-boilers are divided into three grades of energy efficiency, of which Grade 1 represents the highest energy efficiency. The minimum allowable values of heat efficiency for each grade are listed in Table 12.13.

Table 12.13 Water heater energy efficiency grades for instantaneous gas water heaters and combi-boilers in China

Type		Heat Load	Minimum Heat Efficiency Value (%) Energy Efficiency Grade		
			1	2	3
Water heaters		Rated Heat Load	96	88	84
		≤50% Rated Heat Load	94	84	--
Combi-boilers	Heating	Rated Heat Load	94	88	84
		≤50% Rated Heat Load	92	84	--
	Hot water	Rated Heat Load	94	88	84
		≤50% Rated Heat Load	92	84	--

An example of the mandatory label for a combi-boiler is shown above.

Electric storage water heaters are divided into five grades of energy efficiency, of which Grade 1 represents the highest energy efficiency. The required standing loss per 24 h and hot water output rate for each grade of electric water heater are shown in Table 12.14.

Table 12.14 Electric storage water heater energy efficiency grades in China

Energy Efficiency Grade	Standing Loss per 24 h Coefficient (ε)	Hot Water Output Rate (μ)
1	≤0.6	≥70%
2	≤0.7	≥60%
3	≤0.8	≥55%
4	≤0.9	≥55%
5	≤1.0	≥50%

Solar water heating systems

Solar water heating systems are divided into three grades of energy efficiency, of which Grade 1 represents the highest energy efficiency. The required coefficient of thermal performance for each grade of solar water heating system is shown in Table 12.15.

Table 12.15 Domestic solar hot water system energy efficiency rating in China

Domestic solar hot water system type	Coefficient of Thermal Performance (CTP) Energy Efficiency Grade		
	1	2	3
Compact	CTP≥0.50	0.32≤CTP＜0.50	0.10≤CTP＜0.32
Separate direct (split single loop)	CTP≥0.48	0.30≤CTP＜0.48	0.10≤CTP＜0.30
Separate indirect (split dual circuit)	CTP≥0.45	0.28≤CTP＜0.45	0.10≤CTP＜0.28
Integral	CTP≥0.60	0.40≤CTP＜0.60	0.10≤CTP＜0.40

Voluntary labels

China applies a certified quality label to water heaters as operated by China Energy Label Center (CELC), part of the China National Institution of Standardization (CNIS). A voluntary label programme has been implemented for ultra-high energy efficiency electric storage water heaters.

EU

Test procedures

Existing procedures for the different types of water heaters are to be revised by 2015 with the entering into force of the Ecodesign and labelling regulations. In Europe, regulations do not refer precisely anymore to existing standards.

Regulations define the metrics and testing conditions references that are then communicated to the European Committee for Standardisation (CEN) via mandate. When standards have been updated and do comply with the regulation, they become harmonized and may be referred to for the application of the regulations. This is notified in the Official Journal of the European Union.

Hence the main lines of the testing procedure (size, tap water profile by size, metrics definition) are defined in the regulation. An additional document (here a Communication from the Commission) specifies acceptable transitional methods, which are based on existing test standards plus notified modifications of the test procedures. These modifications should normally be integrated in the revised test standards.

Regulations

Two regulations were enforced in 2013 for water heaters: a MEPS (Ecodesign) regulation and a Labelling regulation:

- Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for water heaters and hot water storage tanks
- Commission Delegated Regulation (EU) No 812/2013 of 18 February 2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to the energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device - OJ L 239, 06.09.2013, p. 83–135.

MEPS

MEPS are defined in the Ecodesign regulation. Combination water heaters are included in the space heating regulation. Solid fuel water heaters and "water heaters specifically designed for using gaseous or liquid fuels predominantly produced from biomass" are excluded.

The same requirements do apply for all types of water heater with a rated output lower than or equal to 400 kW and a storage volume lower than or equal to 2000 L.

Requirement are defined in terms of 'water heating energy efficiency', which means the ratio between the useful energy provided by a water heater and the energy required for its generation, expressed in %.

For electric and fuel water heaters:

$$\eta_{wh} = Q_{ref} \;/\; [(Q_{fuel} + CC.Q_{elec})\cdot(1 - SCF.smart) + Q_{cor}]$$

With:

- Q_{ref}: sum of the useful energy content of water draw-offs, expressed in kWh. Useful means the energy content of hot water, expressed in kWh, provided at a temperature equal to, or above, the useful water temperature, and at water flow rates equal to, or above, the useful water flow rate. Useful temperatures and flows to reach are specified in the water profiles supplied in the regulation
- Q_{fuel}: fuel consumption
- CC: primary energy factor of 2.5

- Q_{elec}: electricity consumption
- SCF: smart control factor, performance increase measured on two consecutive weeks, the first week without the smart control enabled and the second one with the smart control enabled
- smart: indicator of smart compliance (0 if SCF < 0.07, or 1)
- Q_{cor}: standby correction term (negative).

For solar water heaters:

$\eta_{wh} = 0.6 \cdot 366 \cdot Q_{ref} / Q_{tota}$; with $Q_{tota} = Q_{nonsol} / (1.1 \cdot \eta_{wh,nonsol} - 0.1) + Q_{aux} \cdot CC$

With:

- Q_{nonsol}: 'annual non-solar heat contribution' means the annual contribution of electricity (expressed in kWh in terms of primary energy) and/or fuel (expressed in kWh in terms of GCV) to the useful heat output of a solar water heater, taking into account the annual amount of heat captured by the solar collector and the heat losses of the solar hot water storage tank
- $\eta_{wh,nonsol}$: 'heat generator water heating energy efficiency' means the water heating energy efficiency of a heat generator which is part of a solar water heater, expressed in %, established under average climate conditions and without using solar heat input
- Q_{aux}: 'auxiliary electricity consumption' means the annual electricity consumption of a solar water heater that is due to the pump power consumption and the standby power consumption, expressed in kWh in terms of final energy.

Solar water heaters shall be tested component by component but can also be tested as a water heater if this is not possible. Calculations should then be used to calculate Q_{nonsol}.

Water heater sizes are defined in terms of storage volume (SV) or 'mixed water at 40 °C' (V40), which means the quantity of water at 40 °C, which has the same heat content (enthalpy) as the hot water which is delivered above 40 °C at the output of the water heater, expressed in litres.

Table 12.16 Water heater size categories in the EU

Declared load profile	3XS	XXS	XS	S	M	L	XL	XXL	3XL	4XL
from 2015 onwards	SV	SV	SV	SV	V40	V40	V40	V40	V40	V40
L (litres)	<= 7	<= 15	<= 15	<= 36	>= 65	>= 130	>= 210	>= 300	>= 520	>= 1040

Table 12.17 lists the mandatory minimum energy performance standards for water heaters sold in the EU. The MEPS are expressed as Water heating energy efficiency, which is determined in the test procedure part above.

Table 12.17 Water heater MEPS in the EU

Declared load profile	3XS	XXS	XS	S	M	L	XL	XXL	3XL	4XL
MEPS 2015 (Sept 26th)	22%	23%	26%	26%	30%	30%	30%	32%	32%	32%
MEPS 2015 (Sept 26th) with smart control	19%	20%	23%	23%	27%	27%	27%	28%	28%	28%
MEPS 2017 (Sept 26th)	32%	32%	32%	32%	36%	37%	37%	37%	37%	38%
MEPS 2017 (Sept 26th) with smart control	29%	29%	29%	29%	33%	34%	35%	36%	36%	36%

In addition to system MEPS, maximum tank standby losses are defined as well as:

$S \leq 16.66 + 8.33 \cdot V^{0.4}$ (in Watts)

Mandatory labels

The scope of the EU label for water heaters is less extended than the Ecodesign scope, with the idea that larger products are rather business-to-business (B2B) products than business-to-consumer (B2C). The label is required for all types of water heaters with a rated output lower than or equal to 70 kW and a storage volume lower than or equal to 500 L. Solar devices (solar components not included in solar water heating packages) are not included. There are 5 different versions of the label, for conventional generators (gas or electric), solar water heaters, heat pump water heaters, packaged water heaters containing at least one conventional generator and one solar generator, and hot water storage tanks. For heat pump and solar water heaters, consumption has to be given for the average climate and two supplementary climates; a cold and a warm climate.

Energy efficiency classes from A+++ to G are defined by size of water heater. Energy efficiency classes from A+++ to G are given in Table 12.18.

Depending on the year (2015 or 2017) and water heater type, the permitted labelling classes to be included in the label vary:

- for all generator types except packages of solar and conventional water heaters, the present regulation specifies that in 2015 only classes A to G will be used and that in 2017, only classes A+ to F will be used
- for packages of solar and conventional water heaters, the full extent of the efficiency scale, from A+++ to G, may be used from 2015.

The EU mandatory energy label for water heaters

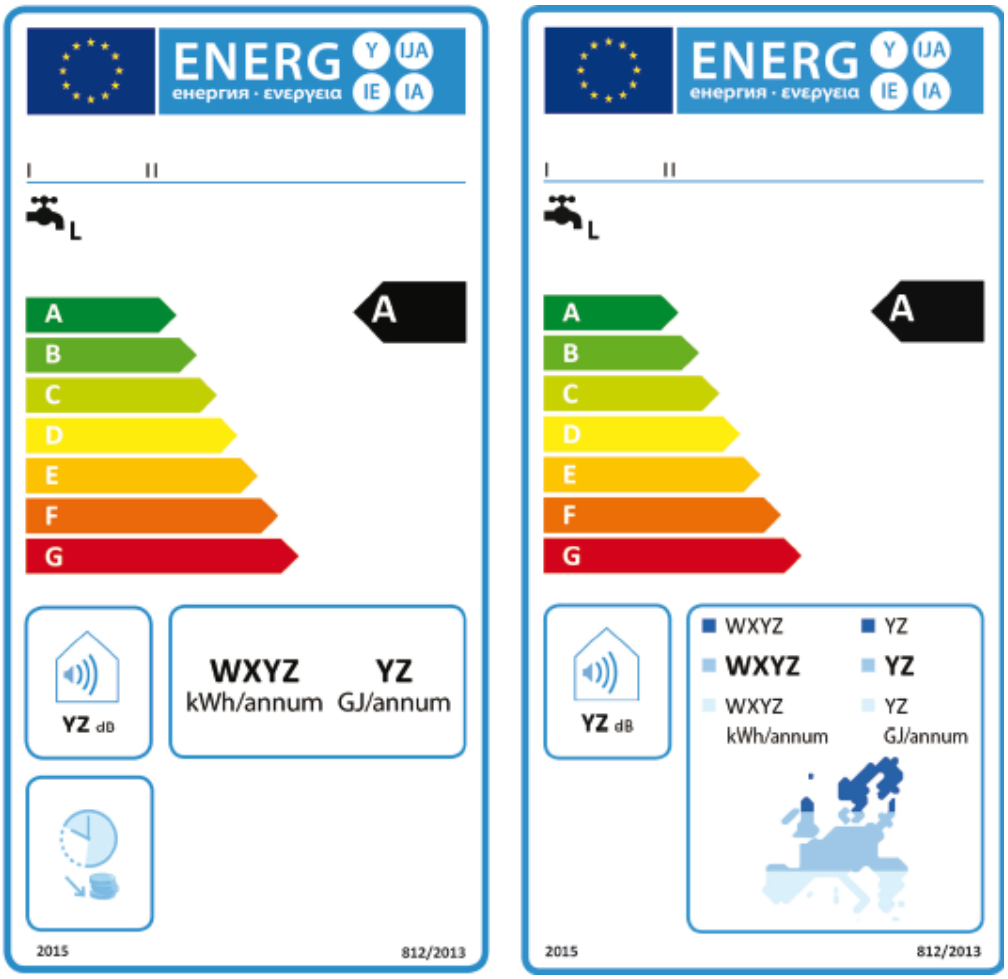


Table 12.18 Water heater energy efficiency classes in the EU

Declared load profile	3XS	XXS	XS	S	M	L	XL	XXL
A+++	ηwh > 0.62	ηwh > 0.62	ηwh > 0.69	ηwh > 0.9	ηwh > 1.63	ηwh > 1.88	ηwh > 2	ηwh > 2.13
A++	0.53 < ηwh ≤ 0.62	0.53 < ηwh ≤ 0.62	0.61 < ηwh ≤ 0.69	0.72 < ηwh ≤ 0.9	1.3 < ηwh ≤ 1.63	1.5 < ηwh ≤ 1.88	1.6 < ηwh ≤ 2	1.7 < ηwh ≤ 2.13
A+	0.44 < ηwh ≤ 0.53	0.44 < ηwh ≤ 0.53	0.53 < ηwh ≤ 0.61	0.55 < ηwh ≤ 0.72	1 < ηwh ≤ 1.3	1.15 < ηwh ≤ 1.5	1.23 < ηwh ≤ 1.6	1.31 < ηwh ≤ 1.7
A	0.35 < ηwh ≤ 0.44	0.35 < ηwh ≤ 0.44	0.38 < ηwh ≤ 0.53	0.38 < ηwh ≤ 0.55	0.65 < ηwh ≤ 1	0.75 < ηwh ≤ 1.15	0.8 < ηwh ≤ 1.23	0.85 < ηwh ≤ 1.31
B	0.32 < ηwh ≤ 0.35	0.32 < ηwh ≤ 0.35	0.35 < ηwh ≤ 0.38	0.35 < ηwh ≤ 0.38	0.39 < ηwh ≤ 0.65	0.5 < ηwh ≤ 0.75	0.55 < ηwh ≤ 0.8	0.6 < ηwh ≤ 0.85
C	0.29 < ηwh ≤ 0.32	0.29 < ηwh ≤ 0.32	0.32 < ηwh ≤ 0.35	0.32 < ηwh ≤ 0.35	0.36 < ηwh ≤ 0.39	0.37 < ηwh ≤ 0.5	0.38 < ηwh ≤ 0.55	0.4 < ηwh ≤ 0.6
D	0.26 < ηwh ≤ 0.29	0.26 < ηwh ≤ 0.29	0.29 < ηwh ≤ 0.32	0.29 < ηwh ≤ 0.32	0.33 < ηwh ≤ 0.36	0.34 < ηwh ≤ 0.37	0.35 < ηwh ≤ 0.38	0.36 < ηwh ≤ 0.4
E	0.22 < ηwh ≤ 0.26	0.23 < ηwh ≤ 0.26	0.26 < ηwh ≤ 0.29	0.26 < ηwh ≤ 0.29	0.3 < ηwh ≤ 0.33	0.3 < ηwh ≤ 0.34	0.3 < ηwh ≤ 0.35	0.32 < ηwh ≤ 0.36
F	0.19 < ηwh ≤ 0.22	0.2 < ηwh ≤ 0.23	0.23 < ηwh ≤ 0.26	0.23 < ηwh ≤ 0.26	0.27 < ηwh ≤ 0.3	0.27 < ηwh ≤ 0.3	0.27 < ηwh ≤ 0.3	0.28 < ηwh ≤ 0.32
G	ηwh < 0.19	ηwh < 0.2	ηwh < 0.23	ηwh < 0.23	ηwh < 0.27	ηwh < 0.27	ηwh < 0.27	ηwh < 0.28

Voluntary labels

None in place at either EU or country level.

India

Test procedures

The Bureau of India Standards (BIS) has three test procedures for water heaters, IS 2082-1993, Stationary Storage Type Electric Water Heaters (includes standing loss requirement, Table 1, amendment 4); IS 5115–1969, Specification for Domestic Storage Type Water Heaters for use with LPG; (provide a ready supply of hot water at a maximum water temperature of 85°C, having nominal capacities between 6 and 100 litres, thermal efficiency shall be not less than 70 percent) and IS 15558-2005, Mini Domestic Water Heater for use with LPG (nominal useful less than 25 kW, thermal efficiency specified in section 16). These BIS standards are voluntary.

Regulations

MEPS

As of May 2014, India does not have any MEPS for water heaters.

Mandatory labels

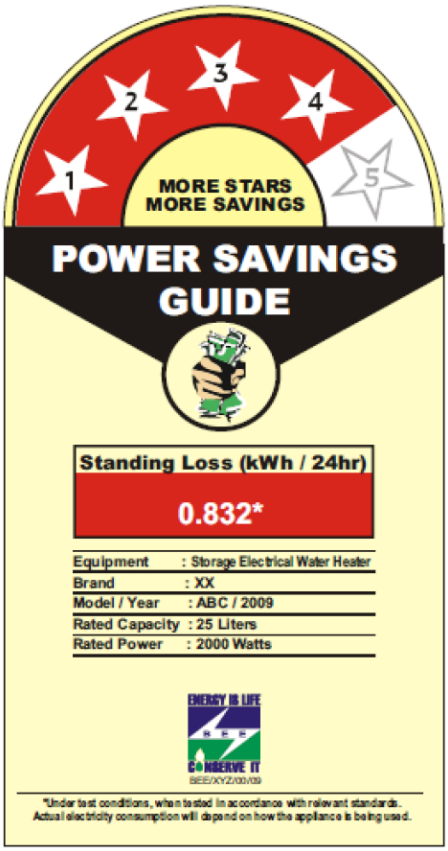
As of May 2014, India does not have any mandatory energy labels for water heaters.

Voluntary labels

The Bureau of Energy Efficiency (BEE) issues voluntary labels for storage electric water heaters. The voluntary label uses a star rating plan based on the standing losses (kwh/24hour/45 °C difference) calculated according to IS 2082:1993. Water heaters are categorized in 10 different rated capacities ranging from 6 to 200 L. The rating ranges from 1 star (the worst) to 5 star (the best) (Table 12.19).

Table 12.19 Water heater energy label efficiency classes in India

Rated Capacity (litres)	1 Star	2 Star	3 Star	4 Star	5 Star
	Standing Losses (kwh/24 hour/45C)				
6	≤ 0.792 & >0.634	≤ 0.634 & >0.554	≤ 0.554 & >0.475	≤ 0.475 & >0.396	≤ 0.396
10	≤ 0.990 & >0.792	≤ 0.792 & >0.693	≤ 0.693 & >0.594	≤ 0.594 & >0.495	≤ 0.495
15	≤ 1.138 & >0.910	≤ 0.910 & >0.797	≤ 0.797 & >0.683	≤ 0.683 & >0.569	≤ 0.569
25	≤ 1.386 & >1.109	≤ 1.109 & >0.970	≤ 0.970 & >0.832	≤ 0.832 & >0.693	≤ 0.693
35	≤ 1.584 & >1.267	≤ 1.267 & >1.109	≤ 1.109 & >0.950	≤ 0.950 & >0.792	≤ 0.792
50	≤ 1.832 & >1.466	≤ 1.466 & >1.282	≤ 1.282 & >1.099	≤ 1.099 & >0.916	≤ 0.916
70	≤ 2.079 & >1.663	≤ 1.663 & >1.455	≤ 1.455 & >1.247	≤ 1.247 & >1.040	≤ 1.040
100	≤ 2.376 & >1.901	≤ 1.901 & >1.663	≤ 1.663 & >1.426	≤ 1.426 & >1.188	≤ 1.188
140	≤ 2.673 & >2.138	≤ 2.138 & >1.871	≤ 1.871 & >1.604	≤ 1.604 & >1.337	≤ 1.337
200	≤ 2.970 & >2.376	≤ 2.376 & >2.079	≤ 2.079 & >1.782	≤ 1.782 & >1.485	≤ 1.485



An example of the BEE star rating label for the storage electric water heaters is shown above.

Korea

Test procedures

Table 12.20 maps which water heaters types are to be tested to which test standards in Korea.

Table 12.20 Water heater test procedures in Korea

Water heater type	Exist. std (Y/N)	Standard reference	Rated Volume	Rated Input	Temperature
Gas					
Gas storage	Y	KS B 8110: 2010	Size limitations	≤ 42 kW (input)	82°C
Gas instantaneous	Y	KS B 8116: 2009		≤ 70 kW (input)	
Combi-boilers	-				
Electric					
Electric storage	Y	KS C 9805: 2013	Size limitations	≤ 30 kW	
Electric instantaneous	Y	KS B 8116: 2009		≤ 70 kW (input)	
Electric heat pump	-	Draft standard	Size limitations	≤ 22 kW (output)	
Oil					
Storage	Y	KS B 6034: 2010		≤ 5800 g/h (~70 kW)	
Solar					
Solar water heater system	N				
Solar collector	N				
Solar tank	N				
Tank					
Unvented	N				

Regulations

MEPS and mandatory labels

The Ministry of Knowledge Economy issued Notification 2011-263, Regulation on Energy Efficiency Labelling and Standards 23 Dec 2011, which contains MEPS and labelling requirements for gas water heaters. This states:

> Rated Thermal Efficiency for water heater: Energy efficiency in household gas water heater is less than the water heating thermal efficiency (hereinafter "Measured thermal efficiency for water heater") measured by "The Liquefied Petroleum Gas safety and business management law" Act Chapter 20, Article 4 or measured in the independent testing laboratory and shall be shown by manufacturers or importers.

The scope of these MEPS and labels is defined as follows.

Gas water heaters

- By KS B 8116 Gas water heater of rated gas consumption of 70.0 kW or less, and the total heat capacity is defined by KS B 8101.
- Energy Efficiency (%) shall be measured by the test method in KS B 8116, which is the heating thermal efficiency for water heaters.

A test report for each item shall show the following results and marking when it is issued: measured thermal efficiency for water heater, gas consumption, standby power, energy efficiency level.

The MEPS applied are specified in Table 12.21

Table 12.21 Water heater MEPS in Korea

Type	Status	Standard	MEPS
Gas			
Gas storage	None		
Gas instantaneous	Current	KS B 8116-	thermal efficiency(η) ≥ 73%
Combi-boilers			
Gas + solar	None		
Gas + electric heat pump	None		
Electric			
Electric storage	None		
Electric instantaneous	None		
Electric heat pump	None		
Oil			
Storage	None		
Solar			
Solar water heater system	None		
Solar collector	None		
Solar tank	None		
Tank			
Unvented	None		

Source: MKE's Notification 2011-263, Regulation on Energy Efficiency Labelling and Standards 23 Dec 2011, Ministry of Knowledge Economy, Korea Energy Management Corporation.

For an instantaneous gas water heater:

$$\text{thermal efficiecny} = \frac{\text{Output}}{\text{Gas consumption}} = \frac{M \times C \times (tw2 - tw1)}{V \times Q} \times \frac{101.3(273 + ta)}{(B + Pm - S) \times 273} \times 100$$

Where:

M : Mass of water, kg

C : Specific heat of Water, 4.19 kJ/kg K

tw2 : temperature at hot water, ℃

tw1 : temperature of supply water, ℃

Q : Total energy, kJ/m^3N

V : gas consumption, m^3

B : barometer, kPa

t_a : temperature at gas meter, ℃

Pm : pressure at gas meter, kPa

S : pressure at t_a

The label thresholds applied for gas water heaters is shown in Table 12.22.

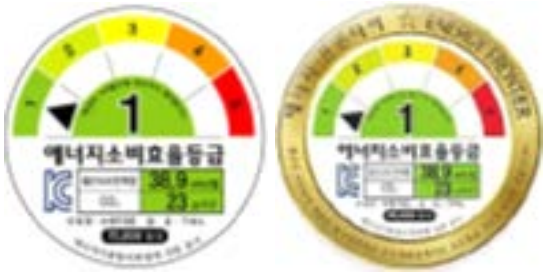
Table 12.22 Gas water heater energy label efficiency classes in Korea

Energy efficiency level R	Standby power (sleep mode)	Level
93.0% ≤ R	≤ 3.0W	1
88.0% ≤ R	N/A	2
83.0% ≤ R < 88.0%	N/A	3
78.0% ≤ R < 83.0%	N/A	4
73.0% ≤ R < 78.0%	N/A	5

Where:

R(Energy Efficiency Level Index) =	Measured thermal efficiency for water heating (%)

And the sleep mode is defined as the reduced power state that the product is not running for a moment, and automatically goes back to run. The Korean energy label is shown below.



Korea's energy efficiency label and energy Frontier's label. The latter is used to designate products that exceed the top class 1 requirements.

Voluntary labels

As of May 2014 Korea does not seem to apply any voluntary energy labels to water heaters.

USA

This section shows the mapping of existing standards and labelling initiatives and their characteristics for residential water heaters in the USA.

Test procedures

Table 12.23 maps which water heaters are to be tested to the standards in the USA.

Table 12.23 Water heater test procedures in the USA

Water heater type	Exist. std (Y/N)	Standard reference	Rated Volume	Rated Input	Temperature
Gas					
Gas storage	Y	10CFR430—Appendix E to Subpart B	76 L to 380 L	< 21.94 kW	< 82 °C
Gas instantaneous	Y	10CFR430—Appendix E to Subpart B	< 7.6 L	14.7 kW to 58.3 kW	< 82 °C
Combi-boilers	N				
Gas + solar	Y	10CFR430—Appendix E to Subpart B	76 L to 380 L	< 21.94 kW	< 82 °C
Gas + electric heat pump	Y	10CFR430—Appendix E to Subpart B	76 L to 380 L	< 21.94 kW	< 82 °C
Electric					
Electric storage	Y	10CFR430—Appendix E to Subpart B	76 L to 450 L	≤ 12 kW	< 82 °C
Electric instantaneous	Y	10CFR430—Appendix E to Subpart B	Reserved	Reserved	Reserved
Electric heat pump	Y	10CFR430—Appendix E to Subpart B	≤ 450 L	≤ 6 kW	< 82 °C
Oil					
Storage	Y	10CFR430—Appendix E to Subpart B	≤ 190 L	≤ 30.56 kW	< 82 °C
Solar					
Solar water heater system	Y	SRCC 300-2013-09			
Solar collector	Y	SRCC 100-2013-11			
Solar tank	Y	10CFR430—Appendix E to Subpart B	76 L to 450 L	≤ 12 kW	< 82 °C
Tank					
Unvented	N				

Regulations

The following regulations apply for water heaters in the USA.

MEPS

Table 12.24 lists the mandatory minimum energy performance standards for water heaters sold in the USA. The MEPS are expressed as Energy Factor which is determined using the test procedures defined in Table 12.23.

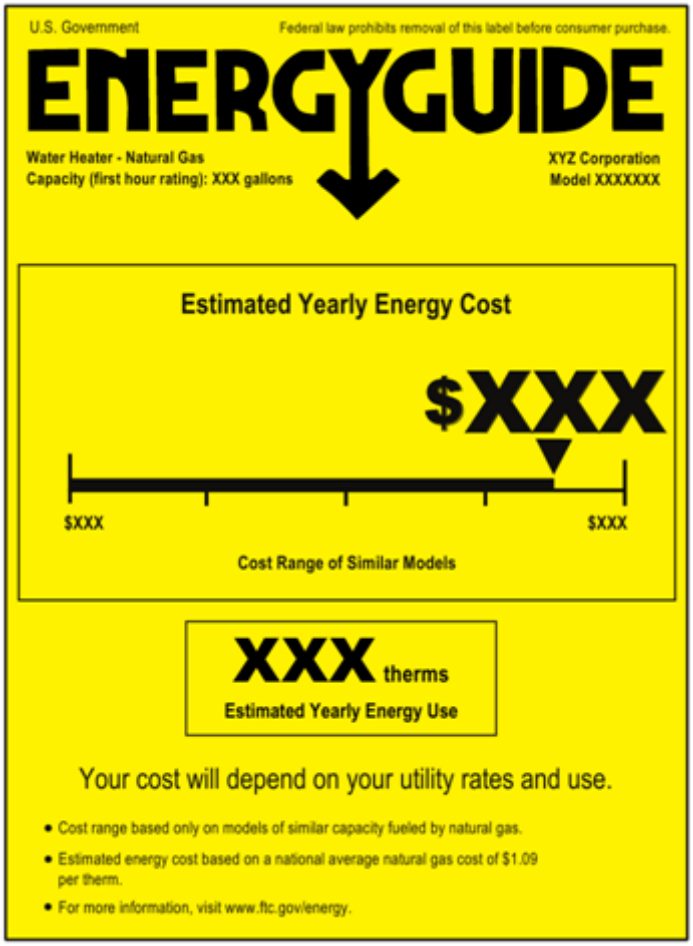
Table 12.24 Water heater MEPS in the USA

Type	Status	Standard	MEPS
Gas			
Gas storage	Current	10CFR430.32 (d)	Energy Factor ≥ 0.67 – (0.0019 × Rated Volume in gallons)
	16 April, 2015		Energy Factor ≥ 0.675 – (0.0015 × Rated Volume, gallons) if ≤ 208.2 L Energy Factor ≥ 0.8012 – (0.00078 × Rated Volume, gallons) if > 208.2 L
Gas instantaneous	Current	10CFR430.32 (d)	Energy Factor ≥ 0.62 – (0.0019 × Rated Volume in gallons)
	16 April, 2015		Energy Factor ≥ 0.82 – (0.0019 × Rated Volume in gallons)
Combi-boilers	None		
Gas + solar	see Gas Storage		
Gas + electric heat pump	see Gas Storage		
Electric			
Electric storage	Current	10CFR430.32 (d)	Energy Factor ≥ 0.97 – (0.00132 × Rated Volume in gallons)
	16 April, 2015		Energy Factor ≥ 0.96 – (0.0003 × Rated Volume, gallons) if ≤ 208.2 L Energy Factor ≥ 2.057 – (0.00113 × Rated Volume, gallons) if >208.2 L
Electric instantaneous	Current	10CFR430.32 (d)	Energy Factor ≥ 0.93 – (0.00132 × Rated Volume in gallons)
	16 April, 2015		
Electric heat pump	see Electric Storage		
Oil			
Storage	Current	10CFR430.32((d)	Energy Factor ≥ 0.59 – (0.0019 × Rated Volume in gallons)
	16 April, 2015		Energy Factor ≥ 0.68 – (0.0019 × Rated Volume in gallons)
Solar			
Solar water heater system	None		
Solar collector	None		
Solar tank	See Electric Storage		
Tank			
Unvented	None		

Mandatory labels

All water heater types with a MEPS listed in Table 12.24 are required to have an attached label at the time of sale to the final consumer. The label contains a graphic display of the relative projected annual energy consumption of the water heater relative to water heaters with similar capacity based on the test procedure. The label also displays an estimated annual energy cost based on national average energy prices. The requirements for size, colour, contents, etc. of the label are fully described in 16CFR 5—Rule Concerning Disclosures Regarding Energy Consumption and Water Use of Certain Home Appliances and Other Products Required Under the Energy Policy And Conservation Act (''Appliance Labelling Rule'') .

A sample EnergyGuide label for a gas storage water heater is shown below.



Voluntary labels

Energy Star is a voluntary endorsement label in the USA. Water heaters meeting the efficiency criteria listed in Table 12.25 are eligible to apply for an Energy Star rating. In addition to the efficiency rating, the water heaters must meet additional warranty criteria.

Table 12.25 Voluntary water heater energy efficiency label requirements in the USA

Type	Standard	Efficiency Requirement
Gas		
Gas storage	ENERGY STAR Residential Water Heaters Specification Version 2.0	EF≥ 0.67
Gas instantaneous	ENERGY STAR Residential Water Heaters Specification Version 2.0	EF≥ 0.82
Combi-boilers	None	
Gas + solar	ENERGY STAR Residential Water Heaters Specification Version 2.0	SEF≥ 1.2
Gas + electric heat pump	None	
Electric		
Electric storage	ENERGY STAR Residential Water Heaters Specification Version 2.0	EF≥ 2.0
Electric instantaneous	None	
Electric heat pump	see Electric Storage	
Oil		
Storage	None	
Solar		
Solar water heater system	ENERGY STAR Residential Water Heaters Specification Version 2.0	SEF≥ 1.8
Solar collector	None	
Solar tank	None	

An example of the Energy Star label is shown below.

13 Test procedure comparison

A full comparison of the differences in test procedures would be part of the work expected in a full mapping and benchmarking study. However, prior to documenting and assessing these specific test and metric details, it's appropriate here to conduct a broader assessment of the differences in the approaches taken to testing water heater energy performance in different economies in order to help identify higher level incompatibilities between the different approaches. This assessment would require additional development in a complete benchmarking study. The parameters considered here are as follows.

- **Scope**: type of water heater (e.g. energy source, instantaneous/storage, etc.) and indication of any size limitations.
- **Size/capacity** classification and limits described in the standard? Y/N. If Y, what is the size metric considered? (For example, volume, flow rate, MW40, etc.)
- **Type of performance tests** used to rate efficiency: stationary, standby, cold/hot start, tested 24-hour tapping cycle, separate tests (standby, cycling, recovery) + simulated composite 24 hours, allows the use of full simulation from component testing (e.g. using TRNSYS software) and so on.
- Do the performance test conditions vary with water heater size (e.g. different draw-off patterns)? Y/N. Give the number of **different tapping patterns in each case**.
- **What is (are) the metric(s)** used to rate efficiency? Name and short definition e.g. EFF, EE, COP, PER (useful to know numerator and denominator and if refers to a specific test). Is it a final or primary energy efficiency indicator? Are electricity and the consumption of fossil fuels accounted separately?
- **Any other product design specifications** in the standard which could affect ratings? Y/N (could be for instance burner specifications for gas appliances, tests with or without storage for HPWH with default tank insulation, and so on).

These parameters are considered for each economy's test procedure below.

Australia

Table 13.1 Description of water heater test procedures in Australia

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Other parameters
Gas						
Gas storage	AS/NZS 4552.2:2010 AS 4552-2005	Gas consumption not exceeding 500 MJ/h (50 MJ/h for MEPS)	Gas consumption not exceeding 500 MJ/h (50 MJ/h for MEPS) (hot water storage capacity < 30 l is not covered by MEPS)	Annual gas usage is calculated for a daily water usage of 200 L at 45°C temperature rise, using the measured values of thermal efficiency, maintenance rate and determined gas consumption	Thermal efficiency, maintenance rate Energy consumption over steady state filling	Test methods of AS 4552 used until publication of AS/NZS 4552.3

Table 13.1 Description of water heater test procedures in Australia (continued)

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Other parameters
Gas instantaneous	AS/NZS 4552.2:2010 AS 4552-2005	Gas consumption not exceeding 500 MJ/h (250 MJ/h for MEPS)	Gas consumption not exceeding 500 MJ/h (250 MJ/h for MEPS) (Heat output < 13.1 kW for MEPS)	Annual gas usage is calculated for a daily water usage of 200 L at 45°C temperature rise, using the measured values of thermal efficiency, start-up heat capacity and pilot gas consumption	Thermal efficiency, start-up heat capacity and pilot gas consumption	Test methods of AS 4552 used until publication of AS/NZS 4552.3
Combi-boilers	None					
Gas + solar	None					
Gas + electric heat pump	None					
Electric						
Electric storage	AS/NZS 4692.1:2005 AS/NZS 4692.2:2005 AS 1361-1995	Water heaters that use electric resistive heating as the primary energy source	rated hot water delivery up to 630 L or nominal capacity up to 710 L	Steady state standby loss test	Electric energy consumed over 24 h	Use of AS 1361 is still allowed. In a near future. Only test methods of AS/NZS 4692.1 will be used.
Electric instantaneous	AS/NZS 4692.1:2005 AS/NZS 4692.2:2005 AS 1361-1995	Water heaters that use electric resistive heating as the primary energy source	rated hot water delivery up to 630 L or nominal capacity up to 710 L	None	None	Use of AS 1361 is still allowed. In a near future. Only test methods of AS/NZS 4692.1 will be used.
Electric heat pump	AS/NZS 5125.1:2010 AS/NZS 2712:2007 AS/NZS 4234:2008	Only air-source HP types Supplied w/wo tank No combi or space heating No size limitation	None	Steady state warm-up test of COP	COP_{DHW} = Q / W Final energy	
Oil						
Storage	None					
Solar						
Solar water heater system	AS/NZS 2712:2007 AS/NZS 4234:2008 AS/NZS 4445.1:1997 (R2013) AS/NZS 2535.1:2007 (ISO 9806-1:1994)	Solar and heat pump hot water supply systems and/or components for household premises	Up to 700L of storage capacity			

Table 13.1 Description of water heater test procedures in Australia (continued)

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Other parameters
Solar collector	AS/NZS 2535.1:2007 (ISO 9806-1:1994)					
Solar tank (1)	None					

Brazil

The Brazilian Conformity Assessment Requirements and the National Energy Conservation Label, ENCE, are specified in ordinances by the National Institute of Metrology, Quality and Technology (INMETRO). The test procedures, which include safety and performance aspects, as well as efficiency ratings, are developed by the Brazilian National Standards Organization (ABNT).

Table 13.2 Description of water heater test procedures in Brazil

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Gas						
Gas storage	ABNT NBR 10542:1988	heat input < 35.0 kW storage capacity <250 L	3 sizes in kW <(=) 10.5 kW 10.5 <(=)CAP<(=)21 21 <(=)CAP<(=)35 Inequalities not specified	Stationary, average of 3 tests	Thermal Efficiency	Minimum Thot-Tcold of 20 °C Test gas composition specified depending on pressure
Gas instantaneous	ABNT NBR 8130:2004	heat input < 70.0 kW	3 sizes in kW <(=) 10.5 kW 10.5 <(=)CAP<(=)14 >(=) 14 Inequalities not specified	Stationary, average of 3 tests	Thermal Efficiency	Tolerances +/- 5% CO limits Minimum efficiency 72% Test gas composition specified depending on pressure
Combi-boilers	None					
Gas + solar	None					
Gas + electric heat pump	None					
Electric						
Electric storage	None					

Table 13.2 Description of water heater test procedures in Brazil (continued)

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Electric instantaneous	ABNT NBR 14015:1997	Instantaneous electric heaters and showers in buildings	Minimum flow rate of 0.05 L/s	Stationary 2 tests, one at maximum capacity and one for 10 K difference inlet / outlet	Inferior: flow rate >= 0.05 l/s and Tout-Tin = 10 K El cons = Pelec(W) * 900 s (1800 s for showers) Superior : same procedure but with maximum temperature difference Energy consumption per month	None
Electric heat pump	None					
Oil						
Any	None					
Solar						
System Factory made	INMETRO Ordinance No. 301/2012 and ISO 9459-2		≤ 1000 L			
System Custom built	ABNT NBR 15569:2008	Project design	None	None	None	None
Solar collector	None					
Solar tank	INMETRO Ordinance No. 301/2012					
Tank						
Unvented	None					

Canada

Except for combi-boilers, electric storage and solar systems, the Canadian water heaters are harmonized with the US Energy Factor test. Table 13.3 describes the main facets of the test procedures used in Canada.

Table 13.3 Description of water heater test procedures in Canada

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Other parameters
Gas						
Gas storage	CSA P.3-04	input ≤ 21.98 kW V 50 to 454 L	Tdel < 82 °C	24 hour simulated use test	EF	
Gas instantaneous	CSA P.7-10	input 14.7 to 73.2 kW V < 7.57 L	Tdel < 82 °C	24 hour simulated use test	EF	
Combi-boilers (1)	CAN/CSA-P.9-11	unknown	≤ 87.9 kW for boiler-based systems ≤ 73.2 kW for water-heater-based systems intended for field assembly.	composite space heating efficiency CSHE = (0.1 * Net efficiency at 100%) + (0.6 * Net efficiency at 40%) + (0.3 * Net efficiency at 15%) and water heating performance factor from simulated use test	Thermal performance factor (TPF)	
Gas + solar	N					
Gas + electric heat pump	N					
Electric						
Electric storage	C191-13	V = 50 to 454 L		standby loss 48hr @ ΔT = 40C diffusion test	W % of tank volume	
Electric instantaneous	N					
Electric heat pump	CAN/CSA-C745-03 (R2009	V = 76 to 454 L input ≤ 12 kW	Tdel < 82 °C			
Oil						
Storage	CAN/CSA-B211-00 (R2010)	V = ≤ 190 L input ≤ 30.5 kW				
Solar						
Solar water heater system	CAN/CSA-F379 SERIES-09 (R2013)		unknown			
Solar collector	N					
Solar tank	N					
Tank						
Unvented	N					

(1) Applies to forced-air distribution systems, not hydronic heating systems.

China

The Chinese test procedures for measuring the efficiency of residential water heaters are described in the following table.

Table 13.4 Description of water heater test procedures in China

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Other parameters
Gas						
Gas storage (1)	GB 18111-2000	heat input < 50 kW		Cold Start heat up 72 h standing loss @ ΔT=45K	thermal efficiency standing loss	
Gas instantaneous	GB 6932-2001 JJF 1261.9-2013	heat input < 70.0 kW		Steady draws at full & 50% rated capacity for 15 min @ ΔT=40C	thermal efficiency	
Combi-boilers	GB 6932-2001 JJF 1261.9-2013	heat input < 70.0 kW		Steady draws at full & 50% rated capacity for 15 min @ ΔT=40C	thermal efficiency	
Gas + solar	N					
Gas + electric heat pump	N					
Electric						
Electric storage	GB/T 20289-2006			24 hour standing loss	standing loss	
Electric instantaneous	GB/T 26185-2010			Steady draw 9 min @ ΔT=40C	thermal efficiency	
Electric heat pump	GB/T 23137-2008	input < 10.0 kW		single-pass Steady draw 30 min @ ΔT=40C multi-pass cold start heat up Tin = 15 C, Tfinal = 55 C integrated cold start heat up Tin = 15 C, Tfinal = 55 C	COP	
Solar						
Solar water heater system	GB/T 18708-2002 GB/T 26971-2011 JJF 1261.11-2013	≤ 600 L		8 hour steady state test (4 hours before noon and 4 hours after noon) combined with measured average heat loss factor for tank	Coefficient of Thermal Performance	
Solar collector	N					
Solar tank	GB/T 28745-2012					

(1) GB 18111-2000, gas storage water heaters, references American National Standards ANSI Z.21.10.1:1998 and ANSI Z 21.10.3:1998, Australian National Standards AG 102:1998 and the Japanese Industrial Standard JIS S 2109:1996.

EU

EU standards are to be aligned according to regulations (EU) No 814/2013 and No 812/2013 for MEPS and labelling. Most present standards are not aligned and a communication[6] from the Commission specifies transitional methods, based on existing standards and specifying required modifications in the test procedures. Table 13.5 describes pre-regulation standards. This may be useful to compare existing appliance ratings. However, for future benchmarking, upgraded standards or indications given by the European Commission should be used.

The main modifications are clearly stated and concern the hot water tapping cycles, the performance metrics and the uncertainty of measurement. Nevertheless, performing a benchmarking exercise before the publication of a finalized modified standard might lead to unforeseen complications. This could be the case for electric heat pump water heaters and electric storage water heaters.

Table 13.5 Description of water heater test procedures in the EU

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Gas						
Gas storage	EN 13203-2:2006	heat input not exceeding 70 kW hot water storage capacity (if any) not exceeding 300 l	None	Tapping cycle 5 sizes : S to XXL	Qgas, Qelec Energy consumption over tapping cycle	Design parameters in EN 13203-1:2006
Gas instantaneous	EN 13203-2:2006	heat input not exceeding 70 kW hot water storage capacity (if any) not exceeding 300 l	None	Tapping cycle 5 sizes : S to XXL	Qgas, Qelec Energy consumption over tapping cycle	Design parameters in EN 13203-1:2006
Combi-boilers	EN 13203-2:2006	heat input not exceeding 70 kW hot water storage capacity (if any) not exceeding 300 l	None	Tapping cycle 5 sizes : S to XXL	Qgas, Qelec Energy consumption over tapping cycle	Design parameters in EN 13203-1:2006 Test in summer mode Correction to represent winter and yearly average consumption
Gas + solar	EN 13203-3:2010	heat input not exceeding 70 kW hot water storage capacity (if any) not exceeding 500 l Forced circulation solar system	None	Tapping cycle 5 sizes : S to XXL	Qgas, Qelec Energy consumption over tapping cycle	Design parameters in EN 13203-1:2006 Solar thermal energy input to storage via simulator Solar cycle and temperature included
Gas + electric heat pump	PR EN 13203-5:2013	heat input not exceeding 70 kW hot water storage capacity (if any) not exceeding 500 l Forced circulation solar system	None	Tapping cycle 5 sizes : S to XXL	Qgas, Qelec Energy consumption over tapping cycle	Design parameters in EN 13203-1:2006 Electric HP source temperature

[6] COMMUNICATION FROM THE COMMISSION in the framework of the implementation of Commission Regulation (EU) No 814/2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks, and of the implementation of Commission Delegated Regulation (EU) No 812/2013 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of water heaters, hot water storage tanks and packages of water heater and solar device.

Table 13.5 Description of water heater test procedures in the EU (continued)

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Electric						
Electric storage	EN 60379: 2004 To be replaced by harmonized EN 50440	All except solar tanks, non-insulated tanks, or tanks having more than one heated volume	None	Standby loss test	E Electric energy consumed over 24 h	Does not include standard EU tapping pattern: should be revised before 2015. Pr EN 50440 2006 was a first attempt but tapping cycles do not match the present regulation.
Electric instantaneous	EN 50193:1997 (prEN 50193:2012)	All types Any equipment capable of supplying the labelling regulation profiles	None	Stationary tests for static efficiency. Dynamic tests for start-up losses of each draw-off type in a tapping profile. Tapping patterns 3XS to XXL	Qelec Final energy Computed from test results and tapping profile specification	Y Includes start-up and static losses
Electric heat pump	EN 16147:2011	All HP source types Supplied w/wo tank No combi or space heating No size limitation	None	Tapping pattern 5 sizes : S to XXL Size categories in V40	COP_{DHW} = Q / W Final energy	Y Integration of backup and auxiliaries Correction for pumps / fans pressure loss
Oil						
Any	None					
Solar						
System Factory made	EN 12976-2:2006	Refers to ISO 9459:2 and 5	None	Refers to ISO 9459:2 and 5	QL: energy delivered by the solar heating system fsol %: solar fraction (vs auxiliary heater) Qpar: pump, controller electricity consumption	
System Custom built	EN 12977-2:2013	No phase change, no thermosyphon, integral collector-storage (ICS) systems	None	Component tests (refer to other solar standards) plus yearly simulation	QL: energy delivered by the solar heating system fsol %: solar fraction (vs auxiliary heater) Qpar: pump, controller electricity consumption	

Table 13.5 Description of water heater test procedures in the EU (continued)

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Solar collector	EN 12975-2:2006	Liquid solar collectors	None	Stationary tests	Collector efficiency function parameters	
Solar tank	EN 12977-3:2013	Solar water stores with a nominal volume between 50 l and 3 000 l	None	Conditioning, charge, standby, discharge,	Detailed parameters of the tank in order to enable a tank simulation	
Tank						
Unvented	EN 12897:2006	Separate cylinders maximum capacity of 1,000 l pressure from 0,5 bar to 10 bar temperature of stored water does not exceed 100 °C	None	Stationary and standby tests	Standing heat loss (standby refers to EN60379) Heat exchanger thermal power and performance Pressure loss	N

V40 : 'mixed water at 40 °C' (V40) means the quantity of water at 40 °C, which has the same heat content (enthalpy) as the hot water which is delivered above 40 °C at the output of the water heater, expressed in litres.

India

Currently India has voluntary test procedures for water heaters. Table 13.6 describes the test procedures. IS 2082-1993, Stationary Storage Type Electric Water Heaters (includes standing loss requirement, Table 1, amendment 4); IS 5115–1969, Specification for Domestic Storage Type Water Heaters for use with LPG; (provide a ready supply of hot water at a maximum water temperature of 85°C, having nominal capacities between 6 and 100 litres. Thermal efficiency shall be not less than 70 percent.) and IS 15558-2005, Mini Domestic Water Heater for use with LPG. (nominal useful less than 25 kW, thermal efficiency specified in section 16).

Table 13.6 Description of water heater test procedures in India

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Gas						
Gas storage	IS 5115–1969 (1)	hot water storage capacity 6 to 100 L		Heat up test	Thermal Efficiency	
Gas instantaneous	IS 15558-2005	nominal useful output < 25 kW		Steady state operation	Thermal Efficiency	
Combi-boilers	None					
Gas + solar	None					
Gas + electric heat pump	None					

Table 13.6 Description of water heater test procedures in India (continued)

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Electric						
Electric storage	IS 2082-1993	hot water storage capacity 6 to 200 L		Standing Loss	kwh/24 h/45°C	
Electric instantaneous	None					
Electric heat pump	None					
Oil						
Any	None					
Solar						
System Factory made	None					
System Custom built	None					
Solar collector	None					
Solar tank	None					
Tank						
Unvented	None					

1) Intended for LPG fired, vented tanks.

Korea

Table 13.7 Description of water heater test procedures in Korea

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Gas						
Gas storage	KS B 8110: 2010	Pressurized gas storage water heaters ≤ 42 kW (input)	None for testing	Stationary	Efficiency (thermal capacity over V_0.PCS) V_0 : standardized volume of gas	Eff > 70 % Size limitations

Table 13.7 Description of water heater test procedures in Korea (continued)

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Gas instantaneous	KS B 8116: 2009	<= 70 kW input	None for testing	Stationary	Efficiency (thermal capacity over V_0.PCS) V_0 : standardized volume of gas	Eff > 70 % Size limitations
Combi-boilers						
Gas + solar	None					
Gas + electric heat pump	None					
Electric						
Electric storage	KS C 9805: 2013	<= 30 kW Electric resistance inside the tank or cylinder with integrated heat exchanger	None for testing	Ramping up	Efficiency (thermal) Power consumption over change water thermal capacity from 40 °C to 90 °C	Size limitations
Electric instantaneous	KS B 8116: 2009	<= 70 kW input	None for testing	Stationary	Efficiency (thermal capacity over electric power)	Eff > 70 % Size limitations
Electric heat pump	Draft standard	<= 22 kW output Air source heat pumps for hot water and/or space heating, with or W/O tank	None for testing	Stationary	COP at different outdoor temperatures / water inlet temperatures, constant outlet temperature Weighted to a SCOP value	Size limitations
Oil						
Any	KS B 6034: 2010	Instantaneous and storage <= 5800 g/h (~70 kW)	None for testing	Stationary	Efficiency (thermal capacity over electric power)	Eff > 70 % (inst.) Eff > 90 % (storage)
Solar						
System Factory made	None					
System Custom built	None					
Solar collector	None					
Solar tank	None					

Table 13.7 Description of water heater test procedures in Korea (continued)

Water heater type	Standard reference	Scope	Size/Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Tank						
Unvented	None					

USA

Except for solar water heating systems, the same test procedure is used to rate the efficiency and effective capacity of all types of residential water heaters. The current test procedure is a 24 hour simulated use test with the same stylized draw pattern for all sizes of water heaters. The test procedure is in the process of being revised. The new test procedure is expected to be released in 2014. It will become effective one year after it is released.

The test procedure for solar water heating systems and components is developed by the Solar Rating and Certification Corporation. The method is similar to ISO 9459 in that components are tested and computer simulation is used to develop ratings.

Table 13.8 maps which water heaters are to be tested to the standards in the USA.

Table 13.8 Description of water heater test procedures in the USA

Water heater type	Standard reference	Scope	Size/ Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Gas						
Gas storage	10CFR430—Appendix E to Subpart B	V=76 L to 380 L input < 21.94 kW Tdel < 82 °C		24 h simulated use test First hour delivery capability	EF F_{hr}	
Gas instantaneous	10CFR430—Appendix E to Subpart B V=76 L to 380 L input < 21.94 kW Tdel < 82 °C	V< 7.6 L input = 14.7 kW to 58.3 kW Tdel < 82 °C		24 h simulated use test Maximum flow rate @ΔT=42.8 °C	EF F_{max}	
Combi-boilers	N					
Gas + solar	N					
Gas + electric heat pump	N					
Electric						
Electric storage	10CFR430—Appendix E to Subpart B	V=76 L to 450 L input ≤ 12 kW Tdel < 82 °C		24 h simulated use test First hour delivery capability	EF F_{hr}	

Table 13.8 Description of water heater test procedures in the USA (continued)

Water heater type	Standard reference	Scope	Size/ Capacity limits	Performance test type / size	Metrics	Specific parameters of influence
Electric instantaneous	N					
Electric heat pump	10CFR430—Appendix E to Subpart B	V ≤ 450 L input ≤ 6 kW Tdel < 82 °C		24 h simulated use test First hour delivery capability	EF F_{hr}	
Oil						
Storage	10CFR430—Appendix E to Subpart B	V ≤ 190 L input ≤ 30.56 kW Tdel < 82 °C		24 h simulated use test First hour delivery capability	EF F_{hr}	
Solar						
Solar water heater system	SRCC Standard 300-2013-09 SRCC Document TM-1			24 h simulated use test and modeled using the computer simulation program TRNSYS to calculate the ratings	Solar Energy Factor (SEF_D) solar water heating system components tested to SRCC TM-1 as specified by SRCC 300 depending on type of system	alternative to ISO 9459 test methods. some of the methods have been adapted from the ISO tests.
Solar collector	SRCC Document RM-1				a table of Rating Temperature Differential/Rating Day Combinations	uses ISO 9806-1 or ISO 9806-3
Solar tank	10CFR430—Appendix E to Subpart B or SRCC Document TM-1					
Tank						
Unvented	N					

14 Identification of potential issues in test results comparison

The same type of water heater may be tested according to different test standards in different economies, which therefore gives rise to various rating values, energy performance scales and MEPS values. Depending on the economies in question, test standards may only include a test method description, or may also include a description of the energy performance metrics. In practice, it is likely that only one rated value will be made publicly available in the product's technical specification sheet even if multiple points are recorded during a product test. Insufficient information from which to make energy performance comparisons is then a common issue when developing energy performance benchmarking exercises.

In order to identify the parameters which may lead to significant differences in tests results, test procedures first need to be screened by main water heater type. Any categories which are unique to a single country can be screened out of this process. For instance, instantaneous oil heaters are probably not very common, even in Korea, the only economy with a test standard to rate their performance.

To perform a viable benchmarking assessment, sufficiently reliable conversion formulae need to be determined between test results obtained under different economies' test procedures. This then allows comparison of different MEPS and labelling thresholds.

Differences in energy performance test results can occur due to several factors, some of which have a large influence and hence are critical to be able to normalise for if any comparison is to be viable. This is the case when there are differences in the energy performance metrics used, for instance steady state measurement versus tapping cycles. Differences in permitted measurement uncertainties or test condition tolerances can be important but are less likely to be critical and are more straightforward to factor into any test procedure conversion formula.

It should also be noted that sometimes it can be possible to convert a test result from a given test procedure to the other but the reverse action may not be possible because some critical data was not measured or cannot be deduced from one of the tests. This is the case for the electrical consumption of gas heaters in standby mode, which is measured and included in the energy efficiency calculation in some countries, but not measured in others.

Three techniques can be applied when trying to estimate the impact of a particular test procedure difference:

- sometimes a simple calculation can be applied that requires no additional tests: this is the case, for example, when converting between measurements made using a higher or lower calorific value (HCV of LCV) for gas
- the impact of differences in a physical effect can be modelled. While sometimes this can be done by considering known physical phenomena, in many cases additional testing will be necessary to derive quasi empirical factors to be used in a parametric model
- when data are missing from one of the test procedures and no theoretical relation can be found between both sets of results, the only possibility is to make an estimation of the effect of the missing parameter, using hypothesis or performing measurements and deriving an empirical conversion.

The main factors that have been identified as possible sources of difficulty in elaborating relationships between test results for water heaters are as follows.

- Energy source characteristics: energy supply characteristics can vary between countries and may be a source of differences. These are voltage and frequency for electricity, composition and use of higher

or lower calorific value (HCV of LCV) for gas, and typical weather data for heat pumps and solar (climatic differences). Another difference for electricity is whether the primary or secondary (final) energy value is used in the calculations.

- A major potential issue affecting comparison of the results of different instantaneous heater test types are that tests can be performed in steady state conditions or using specific tapping cycles. Depending on the test procedure, a relationship may be readily derived e.g. in the case of the USA where steady state test results and evaluation of the energy losses at the start and end of a draw-off are used together to calculate the energy efficiency for a tapping cycle, or not.
- The scope of coverage defining which water heaters a test procedure applies to may differ, so that a water heater of a certain storage volume or input capacity may be covered in one country, but not in another.
- There are several types of energy performance metrics used for storage heaters and generally only one is considered within a given S&L regulation. The metrics used include: standby losses of the tank, standby losses of the system, steady state efficiency, tapping cycle efficiency, and heat up duration. The behaviour of this type of water heater is complex and although modelling is generally possible, the parameters required by the model may be difficult to determine with sufficient accuracy, especially if a given test procedure does not generate all the inputs required by the model.
- Impact of control parameters: some water heater control parameters may be determined by the test procedure, or can be set by the manufacturer. In particular for storage water heaters, parameters like the storage hot water temperature or storage water temperature hysteresis have a critical impact on performance factors such as standby losses of the system or the energy efficiency during a tapping cycle. It may be very difficult to compare results between a case where the control setting is given by the standard and a case where the manufacturer can freely choose the value. Control factors that affect the use of a backup heater (gas or electric) are also extremely important to account for if good conversion formulae are to be derived. Another important aspect is how the test procedure accounts for “smart” controls e.g. is the water heater given a chance to “learn” the tapping pattern of the test procedure and to optimise it's performance for that tapping pattern?
- Ambient air temperature and cold and hot water temperatures during test, daily hot water use, tapping patterns used for the test and how load is measured (volume of water or energy delivered) are also possible sources of difficulties when comparing results between different test procedures.
- Measurement uncertainty and test conditions tolerances: In general the effect is much lower than the previously mentioned sources of difference, but their effect has also to be assessed and, if possible, quantified.

After this general review of possible issues in test results comparison, it is relevant to describe in more detail the situation for each type of water heater, as follows.

Gas instantaneous water heaters

- Test type: steady state efficiency, which may include a reduced capacity test, and tapping tests. If a tapping test is used, the manner in which the initial cold water flow at the start of a draw is treated before the water starts being heated is important.
- Performance metrics: efficiency ratings with HCV or LHV, auxiliary energy can be accounted for in the final rated efficiency (e.g. in the EU test procedure).
- Other potential issues: gas composition is usually specified and may differ from one economy to another; differences in flow rates and water temperature requirements; how to account for electricity use as well as gas use; how to account for combined space heating where applicable are all possible issues affecting the comparability of test results.

Gas and oil storage type water heaters

- Test type: steady state losses; heat up duration; tapping cycles; or hot water delivery capacity.

- Performance metrics: standby power (gas/oil + electricity) needed to maintain hot water temperature in the tank; efficiency with tapping (can also be yearly consumption for a given output, or daily efficiency); steady state efficiency (e.g. in Australia); first hour rating or delivery ratio.
- Other potential issues: gas composition is usually specified and may differ from one economy to another; differences in flow rates and water temperature requirements; how to account for electricity use as well as gas use; air temperature.
- For condensing water heaters, the efficiency of water heating depends strongly on the temperature of the water in the tank and thus the efficiency of recovering from standby losses will be different from the efficiency of heating newly incoming cold water. The timing of draws in a tapping cycle can impact the efficiency of the water heater. This issue can also occur with heat pump water heaters.

Electric instantaneous water heaters

- Test type: steady state efficiency, which may include reduced capacity test.
- Performance metrics: thermal efficiency for steady draw.
- Other potential issues: cold and hot water temperatures.

Electric storage water heaters

- Test type: standing losses, may include tapping cycles, hot water delivery capacity .
- Performance metrics: standing losses, first hour rating or delivery ratio.
- Other potential issues: variation in tapping cycles, air temperature.

Electric heat pump water heaters

- Test type: steady state, standing losses, heat up duration, tapping cycles.
- Performance metrics: the final rating may be a seasonal performance SCOP (or equivalent value in primary energy) or a COP at a given heat source temperature condition. Comparison in that case is difficult if individual test performances are unknown. Performance metrics may include the consumption of auxiliaries. Here again, more data than a single figure of merit is necessary to compare different ratings but this data is generally not available.
- Other potential issues: the performance of heat pumps depends on the temperature of their sources. Different standards may use the same type of test but with different combinations of cold/heat source conditions. For heat up and steady test conditions, corrections may be feasible. To predict tapping performance from steady state tests requires identification of the control parameters of the unit, which may not be practical. Predicting performance becomes more difficult when the heat pump also controls a backup heater (which is generally the case). Some standards (the EU's for instance), allow the manufacturer to determine several settings of the control system, such as: the hot water temperature setting in the tank, hysteresis to restart the heat pump, and the use or not of an existing auxiliary electrical heater during the tests. As there are no constraints in the EU test procedure or the regulations regarding these settings, test results may be very different for the same system tested under different test procedures and making a comparison with test results derived using other economy's test procedures may become almost impossible. This issue may also apply to other storage water heaters using other types of energy.

Solar water heaters

- Test type: laboratory test of system, test of components with computer simulation for annual performance.
- Performance metrics: similar performance issues as with heat pump water heaters, with even more impact from climate.
- Other potential issues: many different types of solar water heating systems, backup heater type together with its control logic.

15 Analysis of knowledge gaps that need to be addressed in a full benchmarking study

Mapping and benchmarking exercises are of greatest value when they inform policy processes and illustrate the opportunities which exist to save energy. There are two principal routes in the case of water heaters:

a) a gap analysis that shows where there is a dearth of existing policy coverage that could produce significant savings were the gap(s) to be addressed

b) a comparative ambition analysis that compares the stringency of existing policy measures of a similar type and illustrates where it is possible to increase stringency through emulation of policy settings in a peer economy.

In addition, best practice policy experience from other economies can also be applied bilaterally in the form of technical assistance. To support this, documenting best practice policy in a given field is valuable, and this can be done by a review of existing international policy practices.

The gap analysis mentioned in (a) can be conducted in a relatively straightforward manner by comparing existing policy coverage by economy and water heater type and in particular overlaying the information on market share by water heater type to see if there are significant policy gaps against preponderant water heater types. Tables 15.1 and 15.2 give an initial illustration of this for MEPS in the eight economies.

Table 15.1 summarises the coverage of water heater MEPS in the eight economies. Some markets like India have no coverage. Others like China, the EU and USA have extensive MEPS coverage. However, most countries only have MEPS for water heater types that are common on their markets (see Table 15.2).

However, while such a gap analysis is useful it is insufficient because it only illustrates gaps by water heater type and does not consider the policy opportunities from encouraging the adoption of the most efficient types of water heater and the migration away from the least efficient.

Table 15.1 Water heater MEPS in the eight economies

Type	Aus	Bra	Can	Chi	EU	Ind	Kor	USA	Total No. Of economies with MEPS
Gas									
Gas storage	Y	Y	Y		Y			Y	5
Gas instantaneous	Y	Y		Y	Y		Y	Y	6
Combi-boilers				Y	Y				2
Electric									
Electric storage	Y		Y	Y	Y			Y	5
Electric instantaneous					Y				1
Electric heat pump				Y	Y			Y	3
Oil									
Storage			Y		Y			Y	3
Solar									
Solar water heater system				Y	Y				2
Solar collector									0
Solar tank		Y						Y	2
Tank									
Unvented									0
Total Types with MEPS (of 11)	**3**	**3**	**3**	**5**	**8**	**0**	**1**	**6**	

Table 15.2 Water heater market shares in the eight economies

	Aus	Bra	Can	Chi	EU	Ind	Kor	USA
Gas Instantaneous	M	1%	N/D	33%	14%	13%	80%	5%
Gas Storage	M	0%	58%	0%	1%	N/D	N/D	42%
Gas Combi	-	-	-	Y	Y	-	Y	-
Electric Instantaneous		98%	N/D	3%	24%	25%	N/D	N/D
Electric Storage	M	0%	38%	41%	60%	62%	3%	48%
Oil			3%	N/D	0	N/D	13%	4%
Solar	M		N/D	23%	NA	N/D	N/D	0%
Heat pump	S		N/D	N/D	NA	N/D	N/D	2%

M = a major part of the market; S = a small part of the market.

Substituting one type for another. Encouraging adoption of the most efficient types of water heaters offers the biggest potential for energy savings in water heaters. Thus the first and most valuable task for a future mapping and benchmarking study could be to analyse the first order savings potentials that would be realised from a shift towards the most efficient water heater types in each economy. This would need to consider long range energy scenarios that mapped movement towards solar and heat pump water heating and would take into account economic considerations, interaction with space heating (e.g. via combi-units where these are prevalent), and any limiting factors. Such an exercise would spell out the full energy value proposition for water heating efficiency policy and would help raise the profile of the topic among target policy making communities and donors alike.

Comparisons within each type. Subsequent to consideration of substitution potential, there is a need to address benchmarking among existing policy settings. This is not a simple task due to the complexity of comparing and analysing differences in the way water heaters are tested and then developing a means to normalise the results so that policy settings can be benchmarked on a common basis. In principle this is more straightforward to do for instantaneous water heaters (more so for electric than gas but both are technically feasible) than it is for storage water heater types. This is because the latter have complex dynamic characteristics which are quite sensitive to the stratification strategy and control strategy adopted in response to the characteristics of the local test procedure. Indeed it is expected that storage water heater designs will be optimised for energy performance under the test procedure used in the market where the product is sold and therefore the designs will be quite sensitive to differences in test procedure characteristics. It will be more straightforward to benchmark differences in policy ambition between storage water heater test procedures that use a simple steady state test with no draw patterns than those that use draw patterns, as the influence of stratification and control optimisation becomes much more pronounced in the latter case; however, this is very difficult to address analytically within any likely project budget.

Heat pump and solar water heaters. The same difficulties apply but are even more pronounced when the case of heat pump and solar water heaters is considered. These are likely to be the most difficult water heater types to benchmark due to the greater number of parameters that come into play and that would need to be normalised for. It becomes very challenging to derive simulation models that could be developed in a sufficient number of cases to represent a market and yet are accurate enough to be useful without: a) extensive test data to prime parametric simulation models, b) detailed information on the product design characteristics and control strategy, or c) the use of complex and labour intensive simulation tools. That said, while the technical challenge and research costs are greater there is more value from being able to compare the performance of some of the more complex water heater types than the simpler because a) the most efficient types are heat pump and solar water heaters, b) there is likely to be greater difference in their performance, c) the use of draw-off patterns is more realistic and hence is good practice. Thus ironically it is technically easier and more affordable to benchmark water heaters at the less diverse and less efficient end of the technology spectrum than it is at the more advanced and policy relevant part of the technology spectrum.

Recommendations. A future study might comprise the following broad elements.

- Completion of any gaps in policy and market information for the economies considered (noting it is recommended that Japan be considered in a future study).
- Derivation of energy, CO_2 and economic savings scenarios from the systematic move towards a more efficient mix of water heater technologies.
- A policy analysis and policy gap analysis that considers not just MEPS and labelling but also policies that stimulate technology switching.
- A more detailed documentation of test procedures taking into account factors mentioned in section 14.

- A detailed first order analysis of the differences in those test procedures and associated efficiency metrics comprising a partially quantitative, partially qualitative analysis of the impact those differences would be expected to have on rated energy performance leading to a simplified first order normalisation for: instantaneous water heaters and storage water heaters under steady state test conditions.
- Round-robin testing for electric storage water heaters in a selection of key markets. To keep costs within an acceptable envelope it is proposed that this could involve taking the most typical electric storage water heater in: China, EU and the USA and testing these under each of the three national test conditions. The data thereby gathered (from a set of nine tests = 3 x 3) would enable the impact of optimisation to the local test condition to be empirically determined but would also allow first order policy benchmarking to be derived (especially if the research is done in such a way that detailed test results can be compared and if the model technical characteristics are known in advance). If more resources become available this round robin testing could be extended to other more efficient water heater types.
- Documentation of the current state of the art of water heater technologies, policy and testing to serve as a guide for policy makers and test procedure designers.

Appendix A Sources of market data

The following market data sources are available for water heaters in Australia.

Table A.1 Market data sources for Australia

Type	Source/ year	Report name	Link	Comments	Can derive UEC?
Gas instantaneous	Department of the Environment, Water, Heritage and the Arts/2008	Water Efficiency Labelling for Instantaneous Gas Water Heaters	http://www.waterrating.gov.au/system/files/publications/2012/10/115/gas-water-heaters.pdf	Some data from AGA directory 2007	No
Gas instantaneous Gas storage	e3/2009	Regulatory Impact Statement Gas Water Heaters	http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Heating/Gas_Water_Heaters/200922-ris-gwh.pdf	Few general data regarding stocks and sales	No
-	AGA/2013	Directory of AGA certified products 2013-12	http://www.aga.asn.au/uploads/292/2013_12.pdf	Very few certified models	No
Electric instantaneous		NO INFORMATION			
Electric storage	e3/2012	Product Profile: Electric Storage Water Heaters	http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Product_Profiles/Water_Heating/Electric_Hot_Water/Public-Product-Profile1.pdf	Very general market data and trends. Also covers solar-electric and heat pumps	No
Heat pumps	e3/2012	Air-Source Heat Pump Water Heaters in Australia and New Zealand	http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Water_Heating/Heat_Pump_Water_Heaters/Heat-Pump-Water-Heater-Product-Profile-June-2012-1.pdf		No
Oil		NO INFORMATION			

Table A.2 presents the market data sources that are available for water heaters in Brazil.

Table A.2 Market data sources for Brazil

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Gas instantaneous	BSRIA 2012	Water heating Brazil 2012	NA	Basic market share information by product type and volume, description of products and range of suppliers	No
Gas storage	BSRIA 2012	Water heating Brazil 2012	NA	Basic market share information by product type and volume, description of products and range of suppliers	No
Electric instantaneous	BSRIA 2012	Water heating Brazil 2012	NA	Basic market share information by product type and volume, description of products and range of suppliers	No
Electric instantaneous	Energy Policy Enedir Ghisi et al. 2007	Electricity end-uses in the residential sector of Brazil	NA	Older data. Estimated penetration by region for electric showers, estimated UEC	
Electric instantaneous	Energy and Buildings Racine T.A. Prado et al. 1998	Water heating through electric shower and energy demand	NA	Older data. Measured electrical on demand energy use	No
Electric storage	BSRIA 2012	Water heating Brazil 2012	NA	Basic market share information by product type and volume, description of products and range of suppliers	No
Heat pumps	NO INFORMATION				
Oil	NO INFORMATION				
Generic	Energy Policy Pacheo et al. 2013	Conversion of Single Family Residential Building to net zero energy buildings in Brazil: Climatic and cultural considerations	http://www.sciencedirect.com/science/article/pii/S0301421513008331#	2007 PROCEL market share data	Market share data only
Generic	PROCEL 2007	Evaluation of the energy efficiency market in Brazil - Base year 2005 - Residential Class - Brazil Report	http://www.eletrobras.com/pci/main.asp?View=%7B5A08CAF0-06D1-4FFE-B335-95D83F8DFB98%7D&Team=&params=itemID=%7BE6AA7196-E64E-4FC0-9567-994B77FB24DE%7D%3B&UIPartUID=%7B05734935-6950-4E3F-A182-629352E9EB18%7D	Original PROCEL report- in Portuguese- has survey information about switching from electricity to solar or gas in addition to penetration info - seems to have complete information for UEC	Yes
Generic	PROCEL 2007	Survey Data		Original Survey data with load and use data	yes

Table A.3 presents the market data sources that are available for water heaters in Canada.

Table A.3 Market data sources for Canada

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Gas instantaneous	No Data				
Gas storage	CBEEDAC/2005	Domestic Water Heating and Water Heater Energy Consumption in Canada	http://sedc-coalition.eu/wp-content/uploads/2011/07/CREEDAC-Canadian-Residential-Hot-Water-Apr-2005.pdf	Older data (2001). General market data by fuel type, total hot water use per capita estimates. Database may be available with more recent data	Yes
Electric instantaneous	No Data				
Electric storage	CBEEDAC/2005	Domestic Water Heating and Water Heater Energy Consumption in Canada	http://sedc-coalition.eu/wp-content/uploads/2011/07/CREEDAC-Canadian-Residential-Hot-Water-Apr-2005.pdf	Older data (2001). General market data by fuel type, total hot water use per capita estimates. Database may be available with more recent data	Yes
Heat pumps	No Data				
Solar	No Data				
Oil	CBEEDAC/2005	Domestic Water Heating and Water Heater Energy Consumption in Canada	http://sedc-coalition.eu/wp-content/uploads/2011/07/CREEDAC-Canadian-Residential-Hot-Water-Apr-2005.pdf	General market data by fuel type, total hot water use per capita estimates	Yes

Table A.4 presents the market data sources that are available for water heaters in China.

Table A.4 Market data sources for China

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Gas instantaneous	BSRIA/2012	Water Heating China	https://www.bsria.co.uk/market-intelligence/market-reports/publication/china-water-heating-world-market-for-heating-2013/	Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Gas storage	BSRIA/2013	Water Heating China	https://www.bsria.co.uk/market-intelligence/market-reports/publication/china-water-heating-world-market-for-heating-2013/	Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Solar	Research In China/2013	Global and Chinese Solar Water Heater Industry Report, 2013	http://www.researchandmarkets.com/reports/2387288/global_and_chinese_solar_water_heater_industry	Key topics: - Development of global solar water heater industry, referring to the industry status quo, market scale, development trends, etc. of the world and major optothermal-using countries. Development of China solar water heater industry, covering industry status quo, market size, business model, competitive features, exportation, sector planning, anticipated future trends, and so forth;	No

Table A.4 Market data sources for China (continued)

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Electric instantaneous	BSRIA/2013	Water Heating China	https://www.bsria.co.uk/market-intelligence/market-reports/publication/china-water-heating-world-market-for-heating-2013/	Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Electric storage	BSRIA/2014	Water Heating China	https://www.bsria.co.uk/market-intelligence/market-reports/publication/china-water-heating-world-market-for-heating-2013/	Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Heat pumps	NO INFORMATION				
Oil	NO INFORMATION				

Table A.5 presents the market data sources that are available for water heaters in the EU.

Table A.5 Market data sources for the EU

Type	Source /year	Report name	Link	Comments	Can derive UEC?
Gas instantaneous	BSRIA 2013	Water heating 2013 for 13 EU countries only	https://www.bsria.co.uk/market-intelligence/	Basic market share information by product type and volume, description of products and range of suppliers	No
Gas storage	BSRIA 2013	Water heating 2013 for 13 EU countries only	https://www.bsria.co.uk/market-intelligence/	Basic market share information by product type and volume, description of products and range of suppliers	No

Table A.5 Market data sources for the EU (continued)

Type	Source /year	Report name	Link	Comments	Can derive UEC?
Electric instantaneous	BSRIA 2013	Water heating 2013 for 13 EU countries only	https://www.bsria.co.uk/market-intelligence/	Basic market share information by product type and volume, description of products and range of suppliers	No
Electric storage	BSRIA 2013	Water heating 2013 for 13 EU countries only	https://www.bsria.co.uk/market-intelligence/	Basic market share information by product type and volume, description of products and range of suppliers	No
"	JRC, 2013	Bertoldi, Hirl, Labanca, Energy efficiency status report 2012	http://iet.jrc.ec.europa.eu/energyefficiency/sites/energyefficiency/files/energy-efficiency-status-report-2012.pdf	Short stock and market description, mostly about electric and solar. Total,no detail by subcategory (volume, efficiency, etc.)	Yes
Heat pumps	EHPA 2012	HP sales in Europe, EHPA statistics compilation	http://www.ehpa.org/market-data/2012/	Yearly sales in volumes per year and per EU country, includes dedicated heat pump water heaters	No
Oil		No specific information, but a priori only combi-boilers or indirect cylinders			
Solar	BSRIA 2013	World renewable 2013, 5 EU27 countries	https://www.bsria.co.uk/market-intelligence/		No
Generic	VHK 2005	Ecodesign study Lot 2, 2006 (2005 sales data and 2010 projection). Most EU27 countries available.	http://www.ecohotwater.org/	Boiler market data and stock of installed dedicated water heaters by size, derivation of UEC from top down analysis, estimates of market shares and technology penetrations	Yes
Generic	CE 2010	Impact assessment of water heater Ecodesign regulation (publication in 2013)	http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2013/swd_2013_0295_en.pdf	Synthesis of Lot 2 report plus market estimates by energy efficiency class. Data matches with Lot 2 report. 2010 data is probably an estimate based on Ecodesign Lot 2 study	Yes

Table A.6 presents the market data sources that are available for water heaters in India.

Table A.6 Market data sources for India

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Gas instantaneous	BSRIA/2012	Water Heating India		Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Gas storage	BSRIA/2013	Water Heating India		Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Solar	MNRE/2010	Solar Water Heaters in India: Market Assessment Studies and Surveys for Different Sectors and Demand Segments	http://mnre.gov.in/file-manager/UserFiles/greentech_SWH_MarketAssessment_report.pdf	Market size and projections by sector	No
Electric instantaneous	BSRIA/2013	Water Heating India		Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Electric storage	BSRIA/2013	Water Heating India		Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Heat pumps	No information				
Oil	No information				

Table A.6 Market data sources for India (continued)

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Generic	Feedback business consulting/ 2014	Opportunity in the Indian Residential Water Heaters Market 2014	http://www.researchandmarkets.com/reports/2392674/opportunity_in_the_indian_residential_water	Includes market size estimates and Market Share Estimates and market size by the following: players, capacities, categories, sub-categories, end user segments, regions	No
Generic	Feedback business consulting/ 2015	Opportunity in the Indian Residential & Commercial Water Heaters Market 2014	http://www.researchandmarkets.com/reports/2339825/opportunity_in_the_indian_residential_and	Product categories include: Electric Water Heaters (Instant, Storage), Gas Water Heaters (Instant, Storage)	No

Table A7 presents the market data sources that are available for water heaters in Korea.

Table A.7 Market data sources for Korea

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Gas instantaneous	BSRIA/2013	South Korea (World Market for Heating 2013)	https://www.bsria.co.uk/market-intelligence/market-reports/publication/south-korea-water-heating-world-market-for-heating-2013/	Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Gas storage	BSRIA/2013	South Korea (World Market for Heating 2013)	https://www.bsria.co.uk/market-intelligence/market-reports/publication/south-korea-water-heating-world-market-for-heating-2013/	Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Solar	None				

Table A.8 presents the market data sources that are available for water heaters in the USA.

Table A.8 Market data sources for the USA

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Gas instantaneous	DOE 2009	2009-01-13 Preliminary Technical Support Document (TSD) Chapter 3	http://www.regulations.gov/contentStreamer?objectId=0900006480c7c942&disposition=attachment&contentType=pdf	Basic market share information by product type and volume, description of products and range of suppliers from 2010 DOE rule making.	yes
Gas instantaneous	D&R International, 2010	Energy Star® Water Heater Market Profile	http://www.drintl.com/publications.aspx#Mark_Prof	Market background for current Energy Star labels	yes
Gas storage	DOE 2009	2009-01-13 Preliminary Technical Support Document (TSD) Chapter 3	http://www.regulations.gov/contentStreamer?objectId=0900006480c7c942&disposition=attachment&contentType=pdf	Basic market share information by product type and volume, description of products and range of suppliers from 2010 DOE rule making.	yes
Gas storage	Appliance Magazine/2014	Appliance Magazine Market Research: Appliance Historical Statistical Review 1954-2012	http://www.appliancemagazine.com/marketresearch/editorial.php?article=2476&zone=108&first=1	factory sales by year	No
Gas storage	D&R International, 2010	Energy Star® Water Heater Market Profile	http://www.drintl.com/publications.aspx#Mark_Prof	Market background for current Energy Star labels	yes
Solar	D&R International, 2010	Energy Star® Water Heater Market Profile	http://www.drintl.com/publications.aspx#Mark_Prof	Market background for current Energy Star labels	yes
Electric instantaneous	NO INFORMATION				

Table A.8 Market data sources for the USA (continued)

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Electric storage	DOE 2009	2009-01-13 Preliminary Technical Support Document (TSD) Chapter 3	http://www.regulations.gov/contentStreamer?objectId=0900006480c7c942&disposition=attachment&contentType=pdf	Basic market share information by product type and volume, description of products and range of suppliers from 2010 DOE rule making.	yes
Electric storage	Appliance Magazine/2014	Appliance Magazine Market Research: Appliance Historical Statistical Review 1954-2012	http://www.appliancemagazine.com/marketresearch/editorial.php?article=2476&zone=108&first=1	factory sales by year	No
Heat pumps	DOE 2009	2009-01-13 Preliminary Technical Support Document (TSD) Chapter 3	http://www.regulations.gov/contentStreamer?objectId=0900006480c7c942&disposition=attachment&contentType=pdf	Basic market share information by product type and volume, description of products and range of suppliers from 2010 DOE rule making.	yes
Heat pumps	D&R International, 2010	Energy Star® Water Heater Market Profile	http://www.drintl.com/publications.aspx#Mark_Prof	Market background for current Energy Star labels	yes
Oil	DOE 2009	2009-01-13 Preliminary Technical Support Document (TSD) Chapter 3	http://www.regulations.gov/contentStreamer?objectId=0900006480c7c942&disposition=attachment&contentType=pdf	Basic market share information by product type and volume, description of products and range of suppliers from 2010 DOE rule making.	yes
Generic	Verify Markets/2010	U.S. Residential Water Heating Market	http://www.researchandmarkets.com/reports/1441323/u_s_residential_water_heating_market	Includes Market overview, drivers/restraints, revenues and forecasts and some distribution trends and market shares for gas tanks, electric tanks, tankless gas, tankless electric, heat pumps	No

Table A.8 Market data sources for the USA (continued)

Type	Source/ year	Report	Link	Comments	Can derive UEC?
Electric instantaneous	BSRIA/2013	South Korea (World Market for Heating 2013)	https://www.bsria.co.uk/market-intelligence/market-reports/publication/south-korea-water-heating-world-market-for-heating-2013/	Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Electric storage	BSRIA/2013	South Korea (World Market for Heating 2013)	https://www.bsria.co.uk/market-intelligence/market-reports/publication/south-korea-water-heating-world-market-for-heating-2013/	Market sales data for electric storage, electric instantaneous, gas storage, gas instantaneous, indirect cylinder	No
Heat pumps	None				
Oil	None				

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