

Water heating systems

Module 6

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Introduction

In the European Union, hot water heating systems account for 14 - 25% of the energy end-use in Households [see module 1.1.1]. It is important therefore to ensure that domestic hot water (dhw) systems are designed and sized in accordance with best practice guidelines.

The following modules examine various system technologies, storage and distribution requirements and controls.

Module 6.1

Water Heating Systems

- **On completion of this module learners will be able to:**
 - Explain the principle of Localised and Centralised systems
 - Identify typical Localised and Centralised systems

Water Heating Systems

Domestic hot water systems can be divided into centralised and localised.

- A **localised system** is one in which the water is heated locally to its needs, e.g. a single-point heater located above a sink. It may be chosen where a long distribution pipe would mean an unnecessarily long wait for hot water to be drawn off at the appliance.
- A **centralised system** is one in which the water is heated and possibly stored centrally within the building, supplying a system of pipework to the various draw-off points.

Water Heating Systems Cont.

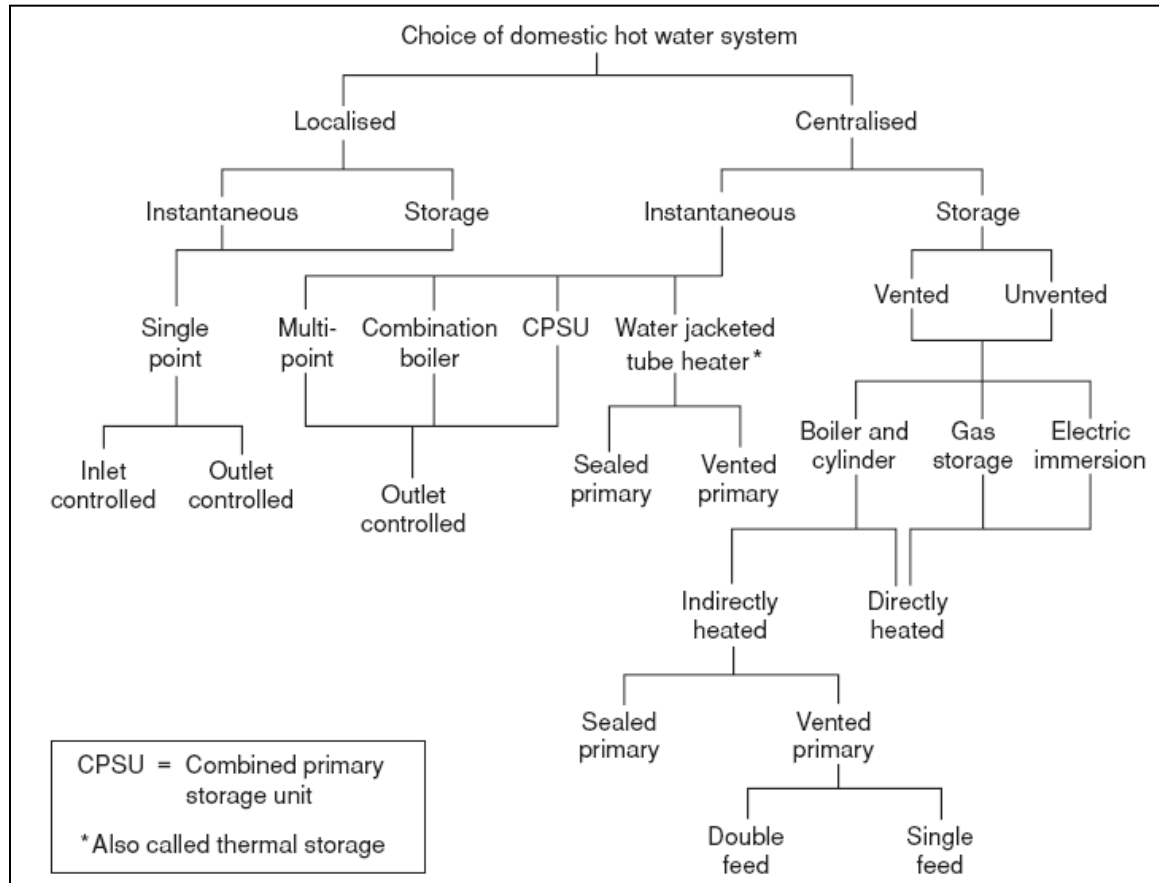


Diagram gives a brief guide to the system designs which are available [5]

Water Heating Systems Cont.

There are a number of factors that influence the design and type of hot water system. Much will depend on the type of building that it is to be installed into, availability of fuel types and of course the requirements of the householder. The following factors should be taken into consideration prior to system selection and design:

- Efficiency of the system and fuel cost
- Hot water demand requirements
- Storage and distribution temperature
- Waste of water and energy
- Installation and maintenance cost
- Safety of the User

Water Heating Systems Cont.

Centralised versus Localised - Some of the main advantages and disadvantages are outlined below.

Centralised

Advantages

- Provides large bulk of storage
- Requires less maintenance than several units
- Cheaper fuel can be used
- Easier to integrate renewable technologies

Disadvantages

- Long lengths of secondary pipework which can lead to heat losses

Localised

Advantages

- May be fitted close to the fittings being supplied
- Saving in boiler house space and possible fuel store
- No need for secondary circulation or no problem long dead legs

Disadvantages

- Separate gas or electricity connections required for each heater
- Greater risk of fire inside the dwelling due to more gas or electrical connections

Module 6.2

Water Heating Systems Fuel Types

- **On completion of this module learners will be able to:**
 - Identify the different fuel types
 - Show how fossil fuels and renewable fuels are integrated into water heating systems

Water Heating System Fuel Types

Whilst the provision of domestic hot water is still largely based on the use of fossil fuels such as solid fuel, electricity oil or gas in the majority of current EU housing stock. The EU has been progressively strengthening its measures to increase the use of high efficiency renewable technologies such as:

- Heat pumps (ground, water and air)
- Solid Biomass (logs, wood pellet and wood chip)
- Solar thermal systems

Water Heating System Fuel Types Cont.

Design principles for successful renewable heat integration are:

1. Choose renewable technologies which are best suited to the householder demands, and which use the fuel or energy most readily available.
2. Consider combining technologies, such that the advantages of one cover the weaknesses in the other (eg. solar thermal for DHW spring to autumn, plus biomass for space heating and winter DHW).
3. Incorporate fossil fuel back-up for 'worst case' situations, and for the short periods of maximum demand. This prevents unnecessary and expensive over-sizing, and gives the householder confidence in supply.

Water Heating System Fuel Types Cont.

Heat Pump

Where heat pumps are fitted they are normally integrated into a low temperature heating system. For hot water storage, an auxiliary electric immersion heater or fossil fuel boiler is generally needed to provide a 'boost' facility. It may be more economic to use the immersion or fossil fuel boiler to heat the stored water at temperatures above 45°C, because the efficiency of the heat pump falls as the output temperature rises.

If an immersion is used then the stored water volume should be sized so that virtually all the energy input can be supplied during a reduced rate electricity tariff period [6].

Note: For further information on Heat Pumps see module 9.2

Water Heating System Fuel Types Cont.

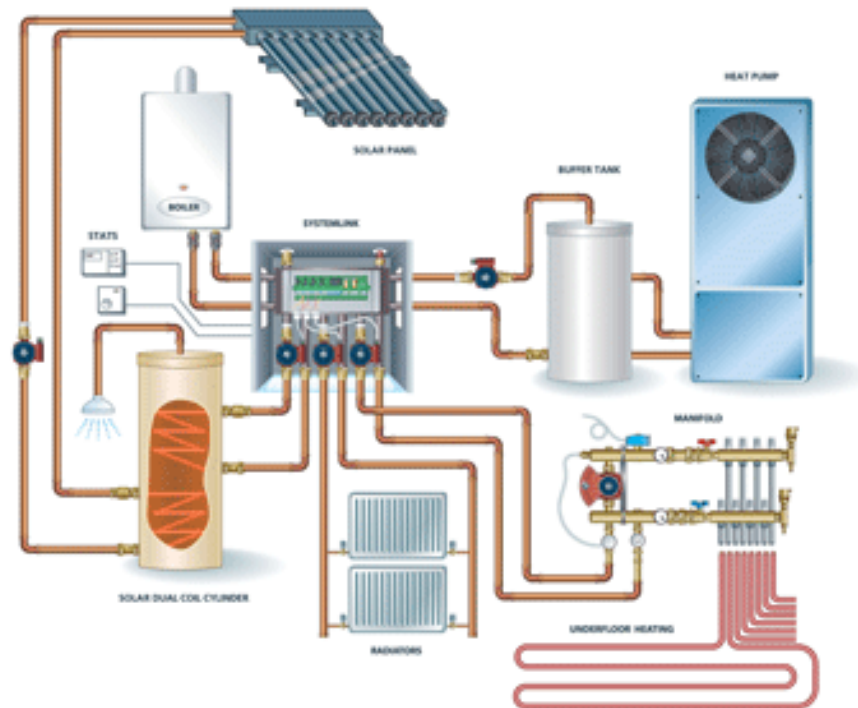
Solar Thermal Systems

A successful solar domestic hot water system requires the solar heat to be stored in a vessel to allow the heat to build-up slowly during the day. Because of the pattern of solar gain, it is very likely that a back-up heat source will also have to be integrated in to the system. Using a single cylinder, as shown in the picture opposite, is the most common solution adopted in the UK and Ireland which is where a cylinder is fitted with two indirect coils, the lower coil is heated by the solar, and the upper coil by a boiler. There may also be an electric immersion heater in the storage cylinder



Note: For further information on Solar Thermal systems see module 9.1

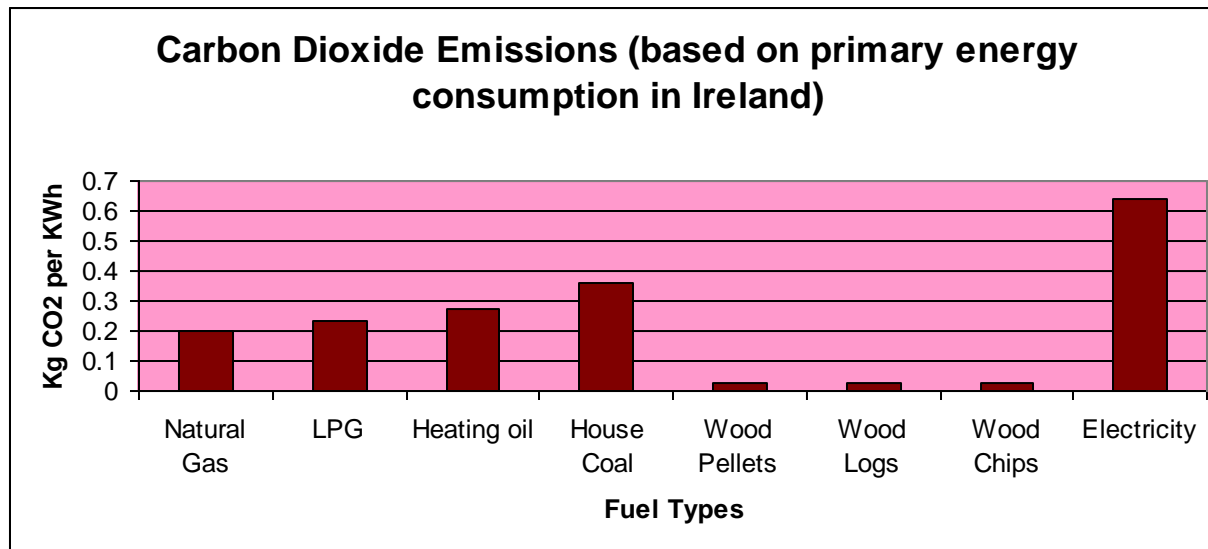
Water Heating System Fuel Types Cont.



Example of integrating a solar thermal system, heat pump, buffer tank, gas/oil boiler, underfloor heating, radiators and dhw cylinder. Source: Systemlink [8]

Carbon dioxide (CO₂) emissions

An increasing concentration of greenhouse gases in the atmosphere has resulted in an **intensifying of the greenhouse effect**. CO₂ emissions are recognised as the most important contributor to this problem.



Source – DEAP [2]

Module 6.3

Standardised Operation Conditions

- **On completion of this module learners will be able to:**
 - Show the average hot water supply requirements per person
 - Show the average hot water supply requirements per appliance

Standardised Usage per Person

During the design of a hot water heating system for a one family dwelling the following average values can be used for estimating the hot water consumption [3]

Requirement (dwelling)	Quantity 1	Temperature °C	Flow Rate L/S
Stored water	135	60	n/a
Hot water per person per day	35-45	40-60	n/a
Bath per use	100	40 mixed	0.2-0.3
Shower per use	25	32-40	0.05-0.1
Power shower per use	50	32-40	0.2-0.3
Wash basin per use	4.5	40-60	0.1-0.15
Kitchen sink per use	18	60	0.1-0.2

Standardised Usage per Person Cont.

Depending on the appliances in the household, the following average consumption values per person can be calculated (45°C) [4]

- Low Consumption 20-30 litres
- Average Consumption 30-50 litres
- High Consumption 50-70 litres

Module 6.4

Water Heating Systems Losses

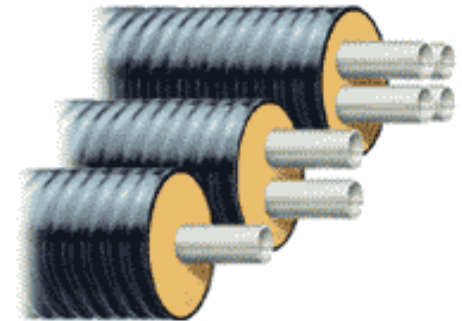
- **On completion of this module learners will be able to:**
 - Outline how to limit heat losses from:
 - The primary circuit
 - The hot water storage cylinder
 - The hot water supply pipe-work

Primary Losses

- The boiler should be positioned as close to the hot water storage cylinder as possible, so that heat losses from the primary flow and return pipes are reduced to a minimum.
- The best practice standard is that the primary pipe-work is insulated throughout its length.
- Fittings and valves should be insulated to provide the same insulation thickness as on the main pipe section (adhesives and jointing tapes are available to ensure a neat joint)
- Pre-insulated or district piping minimises the heat loss when running primary pipe-work underground from a shed / garage (biomass boiler) to the dwelling.



Pipe Insulation



Pre-insulated pipe

Primary Losses Cont.

UK Building Regulations

All the hot water (primary and secondary) pipes connected to the storage vessel should be insulated for at least a metre in length or up to the point at which they are concealed.

Unless the heat loss from a pipe or duct carrying hot water contributes to the useful heat requirement of a room or space, the pipe or duct should be insulated. The following levels of insulation should suffice:

(a) Pipe or duct insulation meeting the recommendations of BS 5422: 2001

or

(b) Insulation with material of such thickness as gives an equivalent reduction in heat loss as that achieved using material having a thermal conductivity at 40°C of 0.035 W/mK and a thickness equal to the outside diameter of the pipe, for pipes up to 40 mm diameter, and a thickness of 40 mm for larger pipes.

Storage Losses

Hot Water Cylinder Insulation

- For newly installed cylinders the best insulating medium is that applied at the factory as part of the manufacturing process, mould-injected rigid polyurethane foam (PU), typically 50-75mm thick.
- For existing cylinders an insulating jacket (at least 75mm thick) may be used, and fitted so that there are no parts of the cylinder wall exposed. Fixing bands should not be over-tightened, as this will reduce insulation efficiency.



Factory applied insulation



Insulating jacket

Primary & Storage Losses

The following table gives approximate costs, savings and paybacks for hot water cylinder jackets and pipe insulation (UK based figures):

	Hot Water Cylinder Jacket	Primary Pipe Insulation
Annual saving per year (£)	Around £35	Around £10
Payback	Less than 6 months	Around 1 year
CO² saving per year	Around 190kg	Around 60kg

Source: Energy Saving Trust UK [7]

Distribution Losses

- Hot water supply pipe-work should not be oversized but be adequate for the pressure and flow requirements
- The best practice standard is that the hot water supply pipe-work is insulated throughout its length.
- Ideally the hot water storage cylinder should be sited to minimise “dead leg” distances especially to the point of most frequent use.

Note: The kitchen tap is generally supposed to be the most susceptible to draw off losses since typically it is used for short bursts of hot water, compared to the bath tap where a long draw off is more common and an initial cold flow can still be utilised

Distribution Losses Cont.

Secondary circulation with timer and temperature control -

The timer only allows the pump to turn on at certain times. So if hot water is only needed in the morning, the timer is set for 6.00 am to 8.00 am. Then the pump would only recirculate the hot water during that time. The thermostat turns off the pump when the water in the pipes reaches a certain temperature. So once the water in the pipe is hot, the pump turns off. When the timer and thermostatic controls are installed together, in series, the circulator operates only at the preset clock times specified by the user and only when the temperature conditions of the thermostat are met.

Module 6.5

Water Heating System Controls

- **On completion of this module learners will be able to:**
 - Describe the range of controls commonly used in water heating systems.
 - Understand what controls do and their benefits.

Water Heating System Controls

Water heating systems should be effectively controlled so as to ensure the efficient use of energy by limiting the provision of heat energy use to that required to satisfy user requirements.

- **Time Control** - A 7-Day programmable timer allows the heating system to be set to match occupancy patterns on a daily and weekly basis. The **separation of space heating and domestic hot water** controls into zones allows each zone to operate for required periods only. For example: During the summer time the boiler can be set to switch on automatically before the householder wakes up in the morning to heat water for showers without turning on the central heating.

Water Heating System Controls Cont.

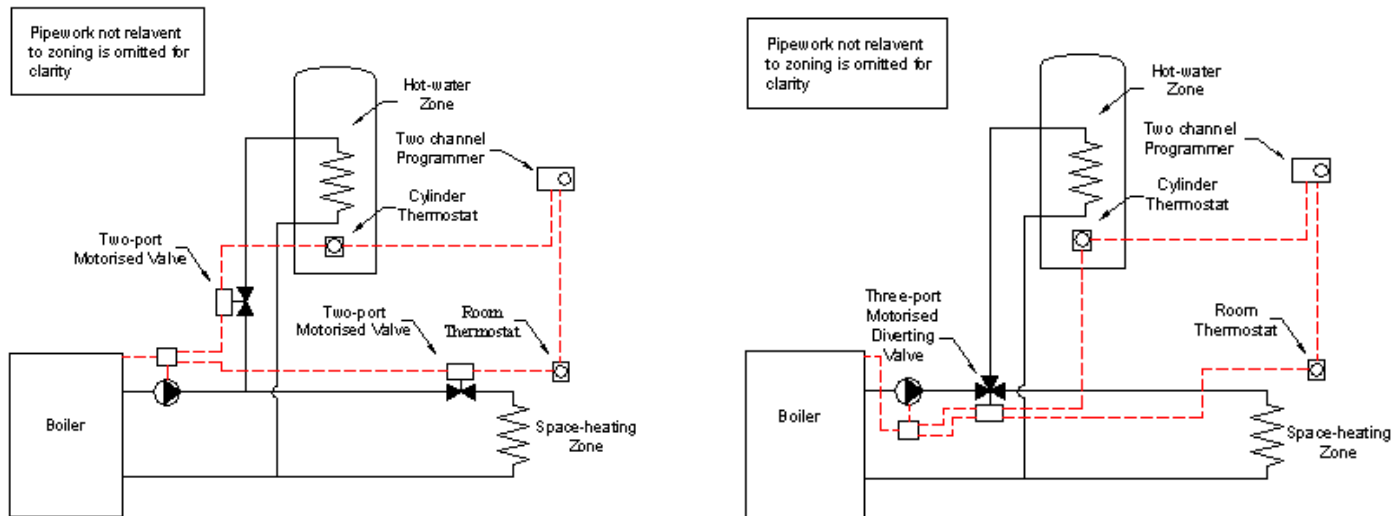
Temperature Control – A Cylinder Thermostat is a temperature sensing device used to control the temperature of the stored hot water within the cylinder whenever the hot water circuit is timed to be on. They should be fitted between a quarter and a third of the way up the cylinder. It is important to have a good, clean contact with the metal cylinder wall when fitting a strap-on thermostat. The recommended temperature for storage of domestic hot water is between **60°C and 65°C**, being high enough to kill off the harmful bacteria in the water, yet low enough to deter the production of scale.



Water Heating System Controls Cont.

Motorised Valves

Electrically operated valves to permit, prevent or direct the water flow within a system. Both 2 and 3 port valves are commonly used to provide separate heating and hot water circuits. Auxiliary switches on valves are wired to switch the boiler/pump off when there is no demand for heat or hot water (boiler interlock).



Drawings illustrate 2 and 3 port valves providing separate heating and hot water circuits.

Water Heating System Controls Cont.

Short Cycling

Boiler short cycling occurs when a boiler subject to its own internal thermostat 'fires up' - starts operating when the thermostat detects that the water in the boiler has cooled down.

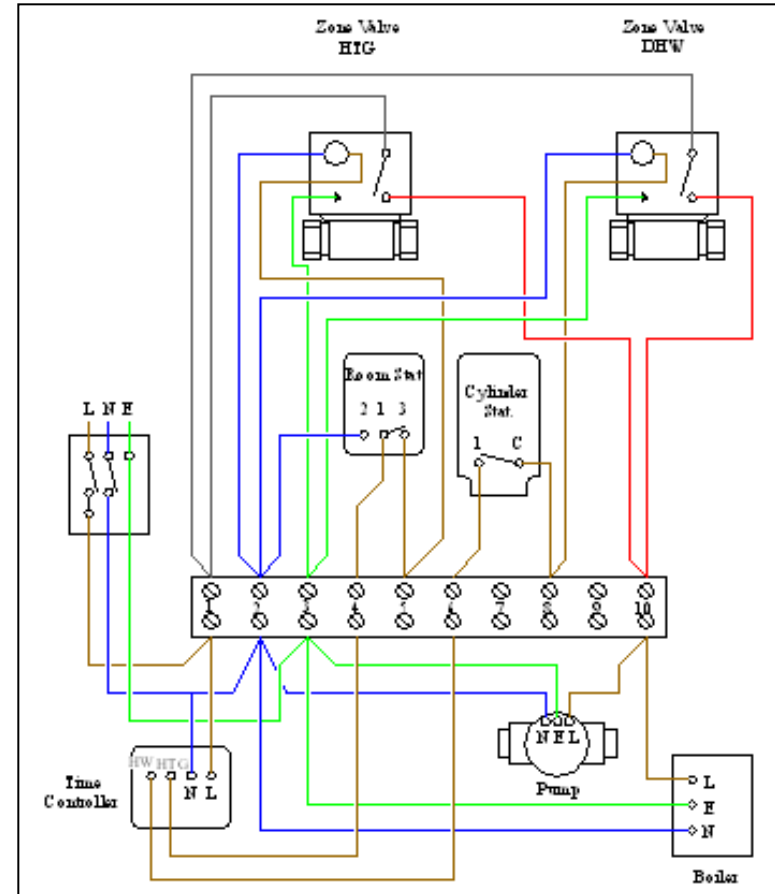
For example: When the water heating system does not require the boiler to fire, the heated water in the boiler's heat exchanger will begin to lose heat to the air around the boiler's casing and through the flue. Short cycling is simply the boiler firing up to re-heat the water in its own heat exchanger when that water has cooled down. Because this water heats up quickly, the temperature that the thermostat is set to is also quickly achieved and when this happens the boiler is again shut down. When the boiler is running and not producing heat for the water heating system this short cycling is:

1. Wasting energy
2. Damaging to the boiler's heat exchanger

The term used to prevent boiler cycling is known as **boiler interlock**

Water Heating System Controls Cont.

Boiler Interlock: The essence of a good heating control is to ensure a boiler does not operate unless there is a demand; this is defined as boiler interlock. Boiler interlock is not a physical device but an arrangement of the system controls (room thermostats, programmable room thermostats, cylinder thermostats, programmers and time switches) so as to prevent the **boiler cycling**.



Boiler interlock in a system with two, 2-port valves (this shows the general logic)

Water Heating System Controls Cont.

Time and temperature controls of installed immersion heaters allow householders to set the time period required for water heating and the temperature to which water is heated. This means that water need not be heated for longer than required or to higher temperatures than required. Temperatures for hot water should be set to a maximum of 60°C.



Immersion heater



Time control

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