IEA ECBCS Annex 36: Retrofitting in Educational Buildings – Energy Concept Adviser for Technical Retrofit Measures

SUBTASK A

Overview of Retrofitting Measures

edited by:
Tomasz M. Mróz
Poznan University of Technology, Poznan, Poland

December 2003

IEA ECB&CS Annex 36
Retrofitting in Educational Buildings
Energy Concept Advisor for Technical Retrofit Measures

Chapter 3

Heating systems

by Raphael Haller, Radek Gorzenski

Table of contents

3.3. Domestic Hot Water installations

3.3.1. Introduction

Domestic hot water (DHW) system is required in buildings for showering, bathing, hand washing, clothes and dish washing, etc It makes use of two resources, water and energy, and therefore retrofitting efforts should respect proper DHW system installation.
Average hot water demand in educational building operated 250 days a year runs at 5-15 litres a day and person in schools without showers and 30-50 litres in schools with showers at 45^{o}C. Average lifetime of DHW equipment is 10-15 years. Most of DHW systems in European Union make use of gas and oil as an energy source, 30% are powered by electricity.
Proper systems should meet the following requirements:

- continuous and instantly water flow at desired volume and given temperature
- low capital and operation costs
- easy regulation of temperature
- proper water quality
- easy to maintenance and reliable in use
- legionella disaster proof

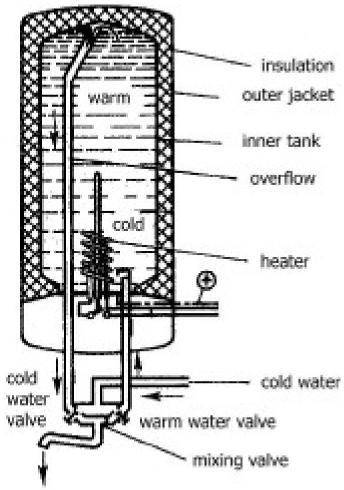

Fig 3.3.1. Low pressure electric storage water heater

3.3.2. Individual systems

Electric:

storage:

- instantly hot water flow allowed without high power demand; low tank capacity power demand; low tank capacity limits the hot water volume

low pressure (Fig 3.3.1):

- heater installed near the tap point
- only one tap point allowed
- capacity 5-100l; power 2-6kW
- no pressure effect; fewer fittings, less complicated
- lever mixing valve required
- tank made of copper, steel, plastic
- immersion and bar heaters
- maximum 20l/min @ 40^{o}C

high pressure (Fig 3.3.2):

- water-pipe network pressure (6-10 bars) effect
- more tap points allowed
- constant temperature
- fittings and safety valves required
- capacity 5-1000l
- more reliable tank required
- tank made of copper, steel
- bar heaters

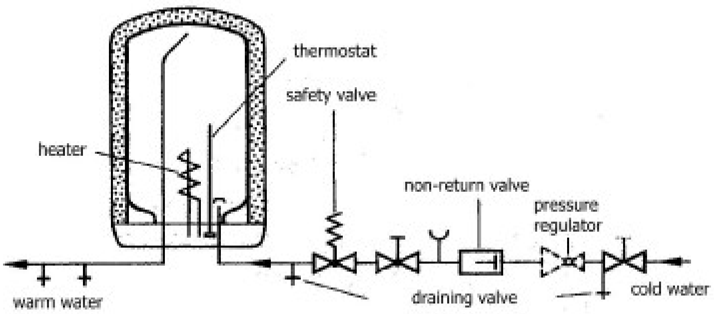

Fig 3.3.2. High pressure electric storage water heater with safety fittings

flow (instantaneous) (Fig 3.3.3):

- instantaneous and continuous heating
- more tap points allowed
- low capital and high energy cost
- high power consumption (1l/min ? t=40-10=30°C P=2.1kW)
- bar heaters, heater wires
- power 12, 16, 18, 21, 24kW
- hydraulic water contact (Venturi tube) P=f(V)
- continuous temperature control
- maximum flow 10l/min

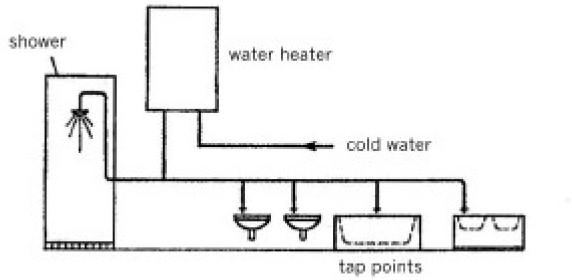

Fig 3.3.3. Single flat central hot water delivery with flow water heater

mixed storage/flow:

central heating cooperated with dectric domestic water heaters:

heat pumps (Fig 3.3.4):

- high capital cost and low energy consumption
- air finned evaporator
- coil or tube condenser
- single family flat 300l; 0.35kW t=50-55°C
- profitable with use of waste, technology heat source (or use of evaporator as a cooler/refrigerator)
- reserve electric heater 2kW
- in European Union common only in new houses with the use of mechanical ventilation (used for heat recovery from exhaust air)

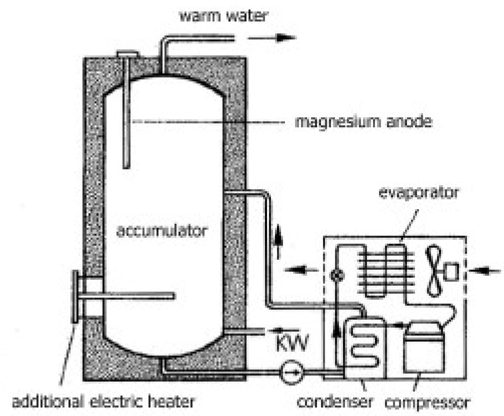

Fig 3.3.4. Heat pump as a separate domestic hot water system component

Gas-fired:

flow (instantaneous) (Fig 3.3.5):

- instantly high volume of hot water allowed
- water heated with combustion gases
- 5-16l/min, 10-35°C, 9-28kW
- pilot flame or piezo electric igniters; gas savings with piezo although electric installation required
- open combustion chamber disadvantages: chimney, low emission of combustion gases, leakiness, boiler room cubature, heat loss
- close combustion chamber - no cubature requirements, disadvantages: fittings and price,
- gas flow controller (Venturi tube) with gas valve needed
- fluent power modulation allowed

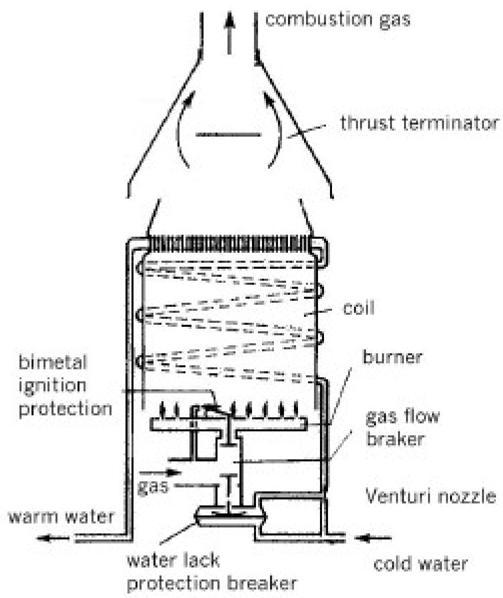

Fig 3.3.5. Gas-fired water flow heater with open combustion chamber

storage (Fig 3.3.6):

- low and high pressure
- higher capital costs
- 5-300l
- circulation pump needed
- single family flat 100-150l

central heating cooperated with gas-fired DHW heaters (Fig 3.3.7, 8):

- in most cases central heating inertia allows for short-time switching off for domestic water heating; one boiler for both systems without major discomforts
- types: flow heaters (direct and indirect), storage heaters

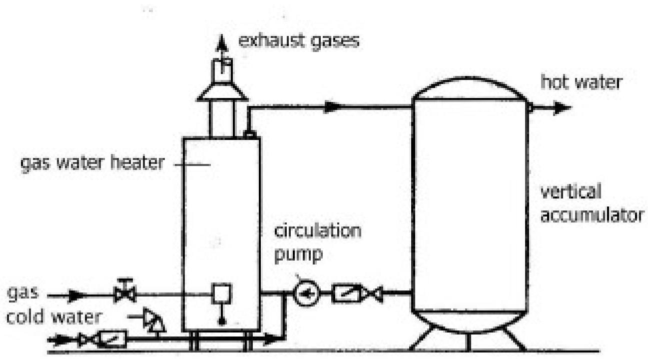

Fig 3.3.6. Gas-fired water storage heater with vertical storage tank and circulation pump

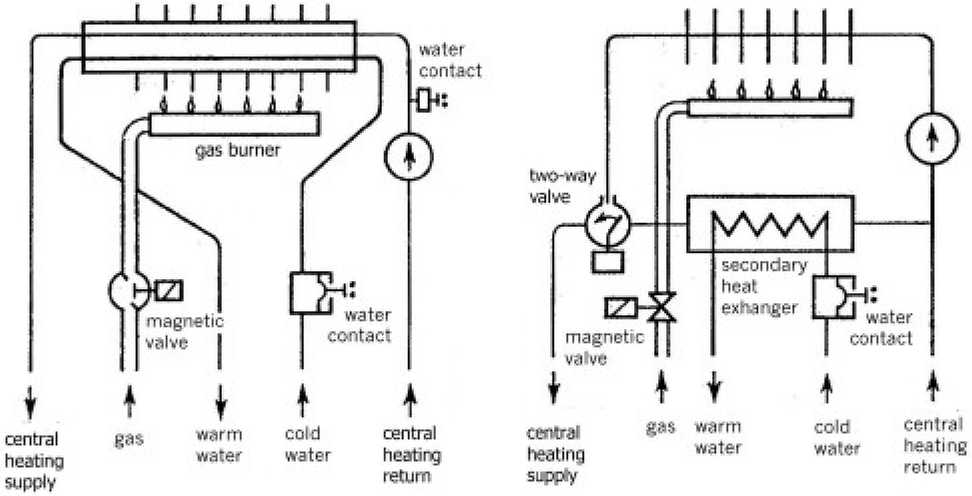

Fig 3.3.7. Combined gas-fired domestic hot water and central heating flow heater: direct DHW heating (left), indirect DHW heating (right)

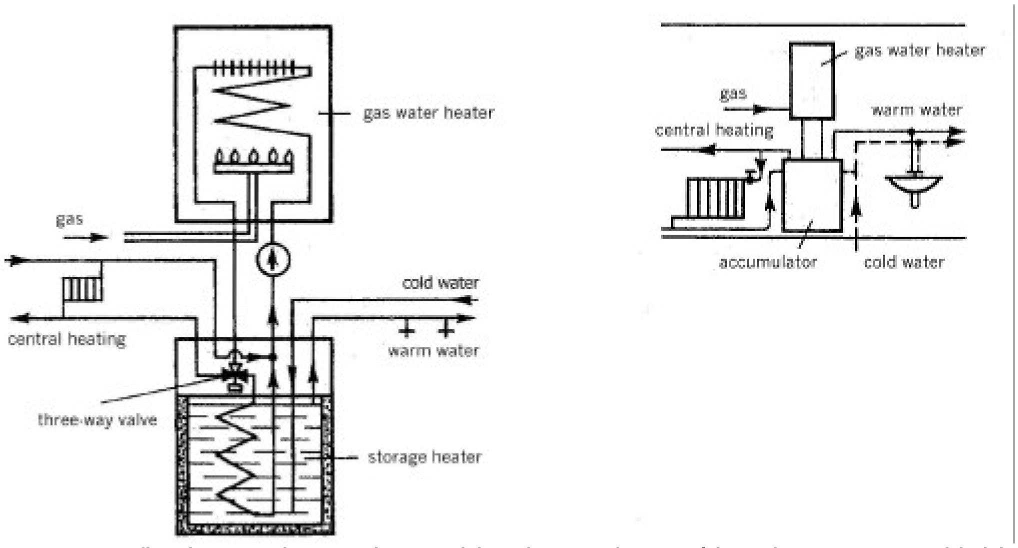

Fig 3.3.8. Gas-fired water heater in combined DHW/central heating system with high pressure water storage tank

Solar collectors (Fig 3.3.9):

- climate and weather dependent
- ~2kWh/m^2, average 2m^2 and 100-150l/person; savings 300kWh/m^{2}a
- efficiency up to 80% in summer and 20% in winter of energy demand
- circulation pump and addition back-up electric heater needed
- high capital cost, difficult to amortization with high electricity costs and without government help

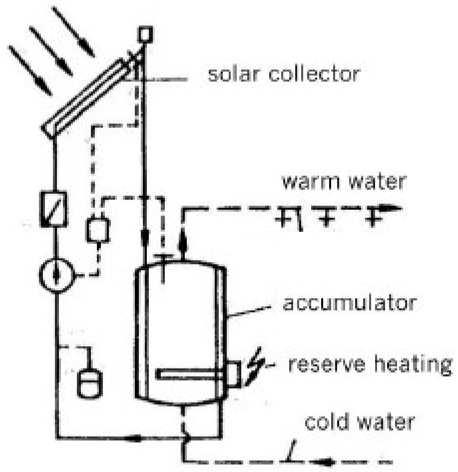

Fig. 3.3.9. Solar energy water heating with additional reheating in boiler

3.3.3. Central systems

- circulation system needed
- high pressure up to 10 bars

<u>storage (Fig 3.3.10):</u>

- heat transfer through the water heat jacket or coil heater
- advantages: peak load equalization with storage tank, high water volume in short time, easy water temperature regulation, high water capacity with small boiler
- disadvantages: scale and corrosion in accumulator, higher capital cost compared with flow heater, heat loss, low heat-transfer coefficient

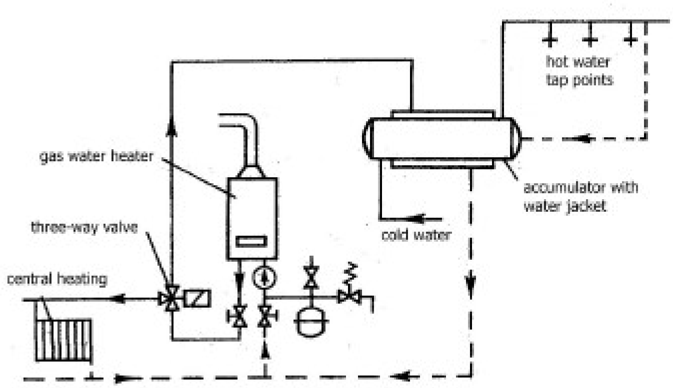

Fig 3.3.10. DHW system with circulation water gas heater and accumulator with double jacket

<u>flow (instantaneous) (Fig 3.3.11, 12):</u>

- types: heat exchanger built in storage tank (coil or plate exchanger), heat exchanger built in a boiler (high water boiler volume, less profitable with large water draft inconsistent)
- advantages: always fresh hot water, higher heat transfer coefficient
- disadvantages: boiler scale, difficulties with water temperature regulations
- without prospects

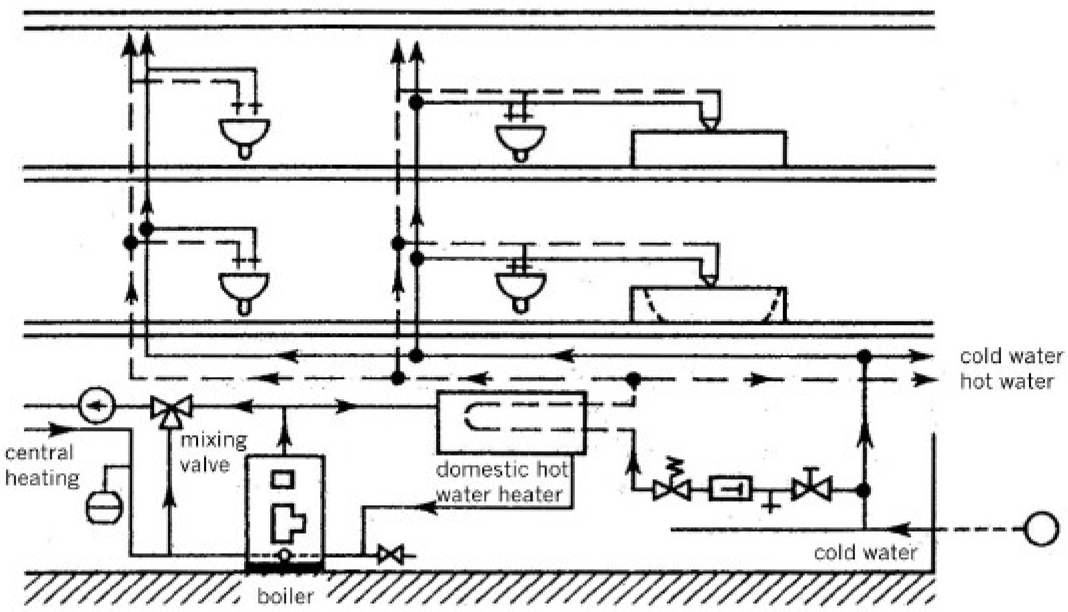

Fig 3.3.11. DHW system with flow heater

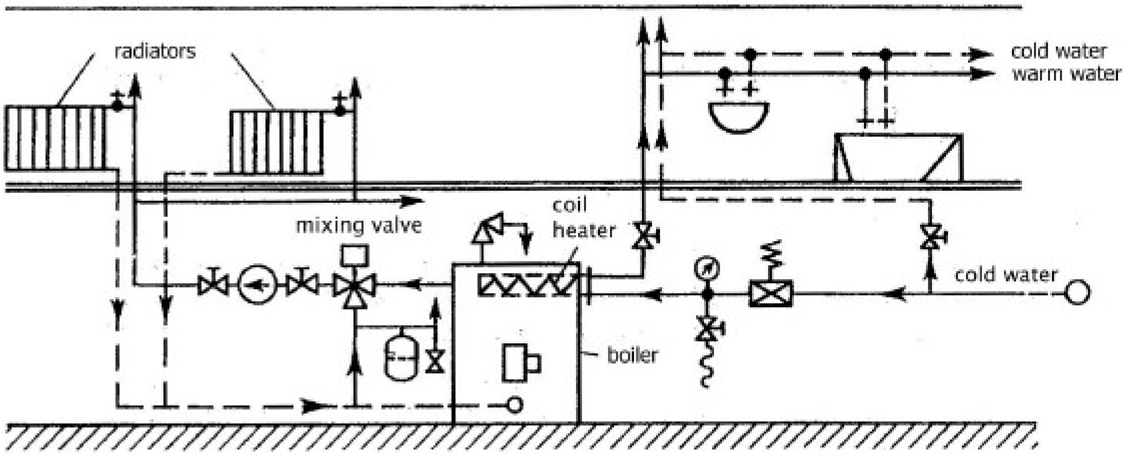

Fig 3.3.12. DHW system with flow heater built in the boiler

3.3.4. Distribution network of domestic hot water

Temperature

Due to energy savings, boiler scale and corrosion protection DHW temperature is limited to maximum 60°C in pipe network. On the other hand, the real danger is the *Legionella pneumophila*, bacteriums causing pneumonia and Pontiac fiver. The following conditions improve the legionella reproduction: hot water @ 32-42°C, vertical thermal gradient in storage water heater, water stops, boiler mud. Water @ 60-65°C effectively kills legionella; short time overheating is apply.

Circulation (Fig 3.3.13)

- necessary in large installations, useless in small installations (high heat losses)
- types: natural (with duct drops), forced (circulation pump, continuous or break work; switch on/off depending on water temperature 35-40^{o}C in return pipe correlated with time switches)
- pipe insulation needed
- disadvantages: additional fittings (non-return valves), additional pipes with insulation, electric pump (energy consumption), heat losses in additional pipe network, improper thermal gradient in storage tank

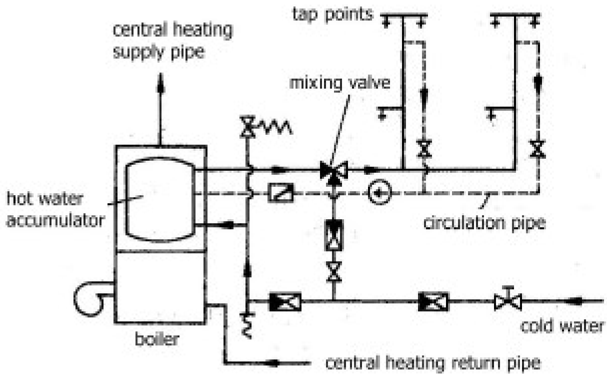

Fig 3.3.13. DHW distribution network with boiler blocked with accumulator and circulation piping

Assisting heating

- substitute for circulation system
- supply pipe network heated with electric strip (belt) heaters
- energy savings about 50-60%, though due to high electricity costs 10-30% higher energy cost compared with circulation systems
- legionella bacterium killing possibility thanks to opportunity of temporary overheating

Pipe network

- overhead, bottom or floor distribution
- pipe made of steel, copper, plastic with proper heat insulation

3.3.5. DHW systems development according to EU Directorate

- inefficient instantaneous electric heaters replacement with systems that will aid peak power management (eg. energy efficient storage-type DHW systems, instantaneous gas heaters, solar-assisted systems)
- equipment improvement, eg. highly efficient instantaneous gas heaters, gas, oil and electric storage heaters, and efficient distribution systems and components
- developing of appliances that minimise hot water use, eg. low flow rate, high pressure showerheads, faucet and showerhead aerators, hot/cold water mixers, optimised volume bathtubs, improved washing machines and dishwashers
- developing kits to facilitate the retrofitting of solar systems onto existing storage-type DHW systems
- developing integrated heat recovery/water heating systems that use warm "grey water" for pre-heating feed water in centralised DHW systems in the residential and non-domestic sectors
- researching and demonstrating units that combine compressive refrigeration with storage-type DHW systems.

Reference:

[1]. DIN EN 832: Thermal performance of buildings – Calculation of energy use for heating – Residential buildings; German version EN 832:1998, Beuth–Verlag, Berlin

[2]. DIN 4108-6: Thermal protection and energy economy in buildings – Part 6: Calculation of annual heat and annual energy use, Beuth–Verlag, Berlin, November 2000

[3]. VDI 2067-11: Economic efficiency of building installations ; Calculation of energy requirements for heated and air-conditioned buildings, Draft version, Beuth–Verlag, Berlin, June 1998

[4]. DIN 4701-10: Energy efficiency of heating and ventilation systems of buildings – Part 10: Heating domestic hot water, ventilation, Beuth–Verlag, Berlin, February 2001

[5]. DIN 4725: Hot water floor heating systems; concepts and general symbols, Beuth–Verlag, Berlin, May 1992

[6]. DIN EN 442-2: Radiators and convectors–Part 2: Test methods and rating; German Version EN 442-2:1996, Beuth–Verlag, Berlin

[7]. VDI 2067-20: Economic efficiency of building installations ; Energy effort of benefit transfer for water heating systems, Beuth–Verlag, Berlin, August 2000

[8]. VDI 2067-1: Economic efficiency of building installations; Fundamentals and economic calculation, Beuth–Verlag, Berlin, September 2000

[9]. DIN 4701-10 Bbl.1: Energy efficiency of heating and ventilation systems of buildings – Part 10: Diagramms and design tools for selected system configurations with standard components, Beuth–Verlag, Berlin, February 2002

[10].Recknagel, Sprenger, Hönmann, Schramek *Ogrzewanie i klimatyzacja. Poradnik,* EWFE Wydanie 1, Gdansk 1994

[11].Domestic Hot Water Overview http://europa.eu.int/en/comm/dg17/atlas/htmlu/hotwater.html

[12].Atlas, EU Thermie

[13].Principle of Hybrid Ventilation Final Report of IEA ANNEX 35 (2002): Chapter 4 – Control Strategies. Technical report: “CO2 sensors for Indoor Air Quality” Ad Van der.