Water Heating Systems

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08/2015

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Abbreviations

ABBREVIATION/ ACRONYM	DESCRIPTION
EE	Energy Efficiency
POET	Performance, Operation, Equipment and Technology
COP	Coefficient of performance
SCOP	Seasonal coefficient of performance
EF	Energy factor

PURPOSE

The objective of this energy efficiency (EE) guide is to provide useful information on the buildings water heating systems.

1 Introduction

Water heating systems may be gas, fuel oil, electric, solar powered or a hybrid of any of these systems. In terms of storage, they can either be instantaneous i.e. positioned close to the point of demand, or they may have storage tanks connected to the points of demand by a distribution system. Electric water heaters either use heat pump technology (usually air-source) to increase the overall EE or the more conventional designs that simply use electric resistance heaters.

This water heating systems EE guide is provided using the performance, operation, equipment and technology (POET) framework. The systems are classified, where possible, in groups of world's best practices, international and national standards. References and standards are cited for further information.

2 Water heating system technology

2.1 Electric storage water heaters

a) **International best available technology/practice** (U.S. Department of Energy, 2001): Hot water using an electric element in the bottom of a storage tank with a capacity of at least 75 liters. They offer a ready reservoir of hot water, although "standby" energy losses are higher than with some other types.
b) **South Africa best available technology/practice**: Same as the international best technology/practice.

2.2 Gas storage water heaters

a) **International best available technology/practice**: Use either reticulated/piped natural gas or LPG to heat water stored in a tank. "Standby" energy losses are also higher than in some other types.
b) **South Africa best available technology/practice**: The heaters use LPG.

2.3 Electric instantaneous water heaters

a) **International best available technology/practice**: They use electricity for heating the water once the water flow is sensed. They do not store any water except for the little amount in the heat exchanger.

b) **South Africa best available technology/practice**: Same as the international best technology/practice.

2.4 Gas instantaneous water heaters

a) **International best available technology/practice**: They use gas as the energy source, initiating heating by sensing water flow.
b) **South Africa best available technology/practice**: N/A

2.5 Heat pump water heaters

a) **International best available technology/practice**: They use heat pump technology by absorbing heat from the surrounding medium and transferring it to water thereby providing cost effective water heating in mild climates.
b) **South Africa best available technology/practice**: Same as the international best technology/practice.

2.6 Solar water heaters

a) **International best available technology/practice**: They consist of a solar collector that uses the energy from the sun's rays to heat water, which then flows to a storage tank, ready for use.
b) **South Africa best available technology/practice**: Same as the international best technology/practice.

2.7 Tank-less coil and indirect water heaters

a) **International best available technology/practice**: Use a home's space heating system to heat water. They are generally applicable in extremely cold climates.
b) **South Africa best available technology/practice**: N/A

Recommendation

International available technology should be used subject to financial and technical suitability in the building.

3 Water heating equipment

3.1 Hot water storage tanks

a) **International best available technology/practice:**
   - Flush the water from the tank after prescribed time
   - Inspect whether the sacrificial anode rod has deteriorated
   - Improve the thermal insulation of the tank to reduce standby losses
   - Check the heating element for signs of rust and leakage
   - Inspect filter screen

b) **South Africa best available technology/practice:** Same as the international best technology/practice.

3.2 Instantaneous water heating

a) **International best available technology/practice:**
   - Check main burner and vent assembly for gas instantaneous heaters
   - Inspect filter screen.
   - Remove any lime scale that has accumulated.

b) **South Africa best available technology/practice:** Only the electric water heating is available

3.3 Heat pump water heating

3.3.1 Types

a) **International best available technology/practice:** Air source heat pump and ground sourced heat pumps, solar thermal-heat pumps.

b) **South Africa best available technology/practice:** Air source heat pump, solar thermal-heat pumps.

3.3.2 Configurations

a) **International best available technology/practice:** Integrated/Compact system where the tank and the compressor are a single unit, and split systems where the tank and the compressor are separate.

b) **South Africa best available technology/practice:** Either compact unit or retrofitting with the existing storage.

3.4 Solar water heating

3.4.1 Direct and Indirect types

a) **International best available technology/practice** (U.S. Department of Energy, 2001): Direct or open loop systems circulate water directly through the collectors. They have no over-heat or freeze protection. Indirect or closed loop systems use a heat exchanger that separate the potable water from the heat transfer fluid (HTF).

b) **South Africa best available technology/practice:** Same as the international best technology/practice.

3.4.2 Passive or active system

c) **International best available technology/practice:** Passive systems rely on heat driven convection in the pipes to circulate the water or HTF in the system. Active systems use one or more pumps to circulate water and/or the HTF.

d) **South Africa best available technology/practice:** Active system

3.4.3 Collector types

e) **International best available technology/practice:** Flat plate, batch, unglazed and evacuated tube collectors used.

f) **South Africa best available technology/practice** (Chang, Lin, Ross, & Chung, 2011): Flat plate collectors commonly available

3.4.4 System configuration

a) **International best available technology/practice:** Thermo-siphon and split systems

b) **South Africa best available technology/practice:** N/A

3.4.5 Auxiliary energy source

a) **International best available technology/practice:** Gas (natural or LPG) and electric

b) **South Africa best available technology/practice:** Electric

3.5 Water heaters lifetime

a) **International best available technology/practice** (Maguire, Fang, & Wilson, 2013):

1. Gas Storage: 13 years;
2. Gas Tankless: 20 years;
3. Electric Storage: 13 years;
4. Electric Tankless: N/A;
5. Heat pump water heater: 13 years;
6. Solar-Electric Hybrid: 30 years;

b) **South African available practice:** The National Standard- SANS 941: Class A is used.

Recommendation

International available practice (Energy Star rating) and National Standard shall be used due to a sustained energy performance. The suitable energy efficient water heating system with longest lifetime should be considered subject to financial feasibility.

4 Water heating operation

4.1 Operating region

a) **International best available technology/practice:** All hot water heaters heat the water to a maximum controlled temperature of 82 oC.
b) **South Africa best available technology/practice:** Same as the international best technology/practice.

4.2 Control gear

a) International best available technology/practice:

- Storage water heaters and heat pumps use thermostats and/or timers.
- Instantaneous water heaters are either ON or OFF only relying on the water flow rate to regulate the temperature. More modern ones using thermostatic control.
- Solar water heaters
    - Direct and passive indirect solar water heaters have no overheat or freeze protection
    - Active indirect have one or more pumps to circulate the water and/or heating fluid. They offer more control possibilities including integration with other heating methods.

b) **South Africa best available technology/practice:** Same as the international best technology/practice.

4.3 Water heaters capacities

a) International best available technology/practice:

- Electric storage water heaters: 76-450 liters.
- Gas storage water heaters: 76-380 liters.

- Heat pump water heaters: max 450 liters.
- Instantaneous water heaters: less than 7.6 liters.

b) **South Africa best available technology/practice:** N/A

4.4 Water heater nominal power

a) International best available technology/practice:

1. Electric storage water heaters: max 12 kW.
2. Gas storage water heaters: max 79 MJ/h.
3. Heat pump water heaters: max 24 A, 250 V.
4. Oil storage type water heaters: max 110 MJ/h.
5. Gas instantaneous water heaters: 53 MJ/h- 210 MJ/h.

Recommendation:

International Standard (Energy star rating) can be used.

5 Water heating system performance

5.1 Heating efficiency

a) **International best available technology/practice:** Energy star rating
Energy efficiency when using gas, oil and electricity is given by water heating energy efficiency, thermal efficiency, or energy factor (U.S. Department of Energy, 2015).
In heat pumps, coefficient of performance (COP) is used, while solar water heaters use seasonal coefficient of performance (SCOP).

- Gas storage: 0.67
- Electric storage: 0.96
- Gas instantaneous: 0.90
- Electric instantaneous (Milward & Prijyanonda, 2005): 0.93
- Combined solar and electric: 1.8
- Heat pump water heater : 2.5

b) **South African available practice:** National Standard-SANS 941 (Alissa K. Johnson, James D. Lutz, Michael A. McNeil, & Theo Covary, 2013): Class A.

5.2 Application of high efficiency water heaters

a) **International best available technology/practice:**

1. Gas storage tank:
    - Replacing an old inefficient gas storage tank
    - Major design changes not required
    - High reliability requirement
2. Gas instantaneous:
    - In a new home or major redesigning taking place
    - There is limited installation space
    - About 30% higher capital cost to be incurred.
    - Reliable piped natural gas supply
    - Have space to accommodate special condensate drain and special venting
3. Electric tankless
4. Heat pump:
    - Replace and/or retrofit existing electric water heater
    - About 50% higher capital cost to be incurred.
    - Sufficient space to accommodate condensate drain
5. Solar water heating:
    - Have dependable sunshine
    - High reliability requirement
    - Install or use an existing auxiliary electric or gas storage for a cloudy or rainy days.

Recommendation:

National standard (SANS 10400X & XA): *"50% (volume fraction) of the annual average hot water heating requirement shall be provided by means other than electrical resistance heating including but not limited to solar heating, heat pumps, heat recovery from other systems or processes and renewable combustible fuel"* **(Standards South Africa, 2011).**

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Supported by:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

based on a decision of the German Bundestag

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