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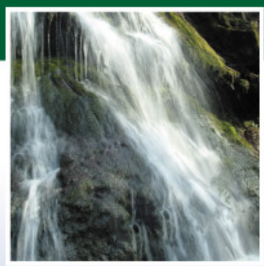

Chapter 4
Solar Geothermal

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4 Geothermal Energy & Heat Pumps

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4.1 Objectives

Having completed this section of the training course and manual, learners should:

- Understand the concepts of geothermal energy
- Be familiar with heat pump technology at its application

4.2 Introduction to Solar Energy

It is obvious that solar energy refers to energy whose source is the Sun. What is not so obvious is the ways in which this energy manifests. With the exceptions of nuclear energy, the lunar component of tidal energy and true geothermal energy (heat energy originating in the Earth's core) the sun is responsible for all other forms of energy. It is responsible for solar heating and solar electricity and is also directly and indirectly responsible for geothermal applications. In addition it is indirectly responsible for wind, hydro, biomass, ocean current (expected to become an important resource in a decade or so) and even fossil fuel energy sources. The purpose of this chapter is to focus on solar geothermal and heat pump applications.

4.3 Introduction to Geothermal Energy

Geothermal energy is a term used to describe the energy available from the earth. Geothermal energy can generally be divided into two forms

- high temperature/deep geothermal
- low temperature

This section will only deal with low temperature geothermal and in particular with the technology of heat-pumps. High temperature geothermal systems typically use the high temperatures available in the earths crust to produce hot water or steam directly. This can then be used for space heating, process heating or electricity generation. Studies of high temperature or deep geothermal resources have been carried out across the EU. A sample of a geothermal map can be found at http://esb2.net.weblink.ie/SEIGeoThermal/

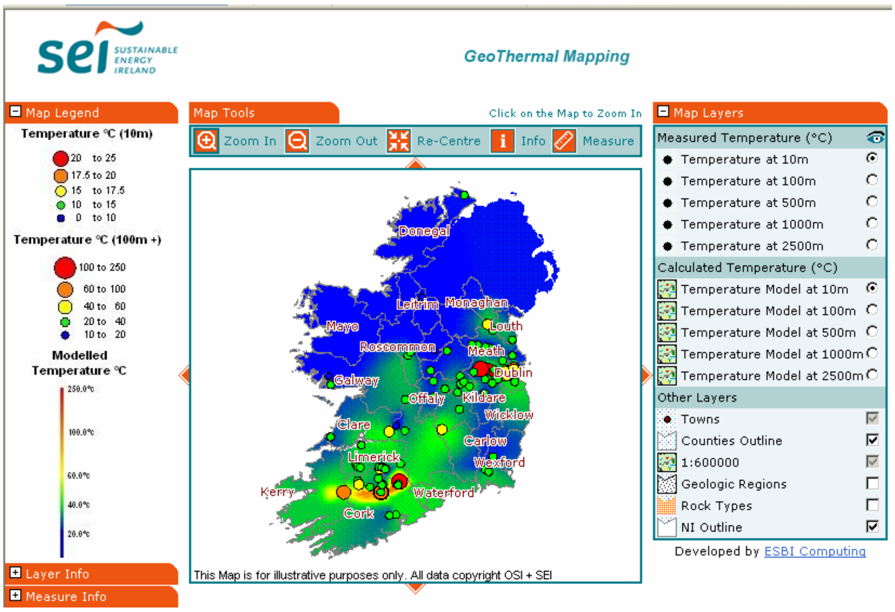

Figure 4.1 Deep Geothermal Map for Ireland
(SEI, 2006)

Low temperature geothermal normally requires the use of heat pump technology to upgrade the heat available and the typical application is for water or space heating. Heat pumps can draw their energy from the ground, water or air.

4.4 Heat Pump Technology and Applications

4.4.1 How do heat pump systems work?

All types of heat pump systems function similarly. Low grade heat is collected from the ground, water or air, and compressed by the heat pump to a higher temperature heat, suitable for space heating and domestic hot water pre-heating. With a ground or water source heat pump, the heat is best distributed using an underfloor heating system or fan-coil radiators. Heat pumps operate using one of two main principles Vapor compression or Absorption. The majority of systems are Vapor Compression systems and are normally driven by an electric motor.

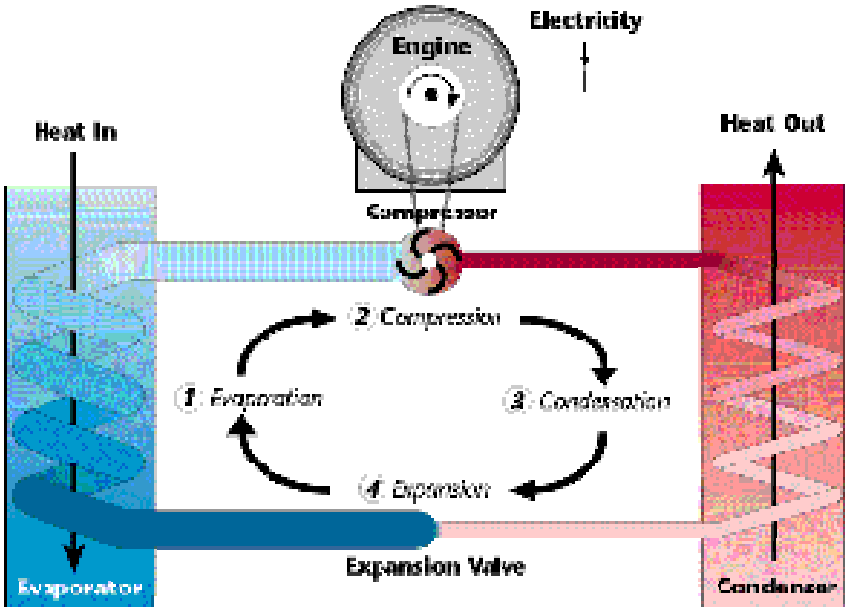

Figure 4.2 Electric motor driven vapour compression heat pump
(IEA, 2006)

Air source collectors can directly heat the air in a ducted air heating/ventilation system. It can also heat water using an integrated air to water heat exchanger for underfloor or fan-coil heating.

Figure 4.3 Air Source and Ground Source Heat Pumps
(AIEA, 2006)

4.4.2 Coefficient of Performance

The efficiency of a heat pump is usually expressed as the Coefficient of Performance (COP). This relates to the amount of heat energy provided for each unit of electricity used to run the pump (Formula 4.1).

COP = Heat output/Electricity Consumption

Formula 4.1 Coefficient of Performance

A heat pump should provide between 3 and 5 kWh of heat for each kWh of electricity consumed. The measurement of COP should comply with European Quality Standard EN255. Figure 4.4 shows the COP for an ideal heat pump as a function of temperature lift, where the temperature of the heat source is 0°C. Also shown is the range of actual COPs for various types and sizes of real heat pumps at different temperature lifts.

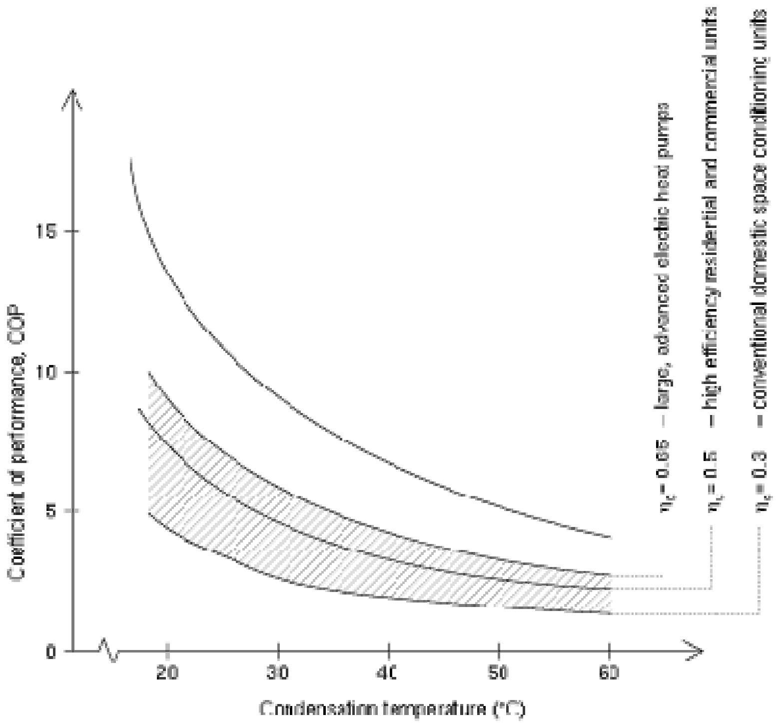

Figure 4.4 COP for Ideal and typical heat pump installations
(IEA, 2006)

4.5 Types of Collectors

4.5.1 Ground Source Horizontal collectors

Ground Source Horizontal collectors are currently the most common collector type for heat pump systems. The pipes are buried in the soil at a depth of between 1 – 2m. A direct expansion (DX) system requires an area of approximately 25m^2 per kW installed. Where overlapping coils known as Slinky pipes are used, an area of 10m x 0.3m per kW installed is necessary.

4.5.2 Ground Source Vertical collectors

Vertical collectors are used where land area is limited. They are inserted as U-tubes into pre-drilled boreholes generally 100 - 150mm diameter, 5m apart and between 15 - 120m deep. About 30m of pipe is necessary per kW installed. Vertical collectors are more expensive than horizontal ones but have higher efficiency and require less overall pipe length and pumping energy.

Figure 4.5 Ground source collectors
a) horizontal standard, b) horizontal 'slinky' c) vertical
(AIEA, 2006)

4.5.3 Water to Water Collector

A Water to Water collector uses ground water from a conventional well as a heat source. A well must be able to deliver about 6 litres of fresh water per minute per kW installed. Water source systems can offer better efficiency and lower installation cost than ground source systems but are limited to where a suitable ground water source is available.

4.5.4 Air Source Systems

Air source heat pumps recover heat from outside air, notably the moisture in the air, rather than from the ground or water. They are also ideal as part of a ventilation with heat recovery system. While slightly less efficient than ground or water source collectors when taking air from outside, air source heat pumps have the advantage of being cheaper and more straightforward to install and have a faster response time.

4.6 System Components

Heat pump systems are generally not suitable for direct replacement of conventional radiator based heating systems as these require water temperatures of 80-90^{o}C; higher than most heat pumps can efficiently generate.

Because a heat pump operates most effectively when the temperature difference between the heat source and heat sink (distribution system) is small, the heat distribution temperature for space heating heat pumps should be kept as low as possible during the heating season.

Table 4.1 shows typical COPs for a water-to-water heat pump operating in various heat distribution systems. The temperature of the heat source is 5°C, and the heat pump Carnot efficiency is 50%.

Heat distribution system (supply/return temperature)	COP
Conventional radiators (60/50°C)	2.5
Floor heating (35/30°C)	4.0
Modern radiators (45/35°C)	3.5

Table 4.1 Example of how the COP of a water-to-water heat pump varies with the distribution/return temperature
(IEA, 2006)

Most systems require a buffer tank (60-150L) to optimise running time and reduce wear on the compressor by preventing rapid on/off cycling.

Heat pumps can efficiently heat water to about 40°C. To bring Domestic Hot Water up to 65°C, the normal temperature for DHW storage, most heat pump systems incorporate an immersion heater. However, some advanced systems can now achieve temperatures of 65°C with minimal COP reduction.

4.7 Maintenance and operation

Heat pump systems have relatively few mechanical components resulting in little maintenance requirements. Servicing is recommended once a year as per conventional boiler systems. The life expectancy of a typical heat pump is around 20 years while a collector system can have a lifetime of many times this.

Figure 4.6 Horizontal collector installation at domestic dwelling (Dunstar, 2006)

4.8 Sources of further information

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