Heating and Cooling Technologies

In brief

Heating and cooling applications account for almost 50% of total final energy consumption in Europe\(^1\) and, although energy demand for space heating is expected to decline, energy demand for space cooling has continued to increase steadily in both the residential and services sub-sectors over the last decade. The current demand for heating is mainly covered by conventional technology using fossil fuels, while individual electric chillers meet the demand for cooling. Consequently, there is significant potential to increase the share of energy from renewable sources in heating and cooling, in particular biomass, solar and geothermal energy, which can be used as direct sources of heat. The European Renewable Energy Council (EREC) has estimated that renewables will account for a 30% share of total EU heat consumption by 2020, and more than 50% by 2050, compared to 2010, when traditional heating technologies operating on fossil fuels accounted for nearly 72% of energy consumed for space heating.

In addition to the use of renewables, energy efficiency measures will contribute to a decline in the overall heat demand in Europe. In the building sector, a reduction in demand for space heating could account for 25% of potential energy savings in 2050 and improvements in water heating and space cooling systems could together account for an additional 24% in savings.\(^2\)

The technology

The main factors influencing the selection and uptake of heating and cooling technologies include regional climatic conditions, the availability and relative cost of fossil fuel and local renewable resources, proximity to sources of waste heat, and installation and maintenance costs. Conventional fossil fuel-based furnaces and boilers with associated high CO, NO\(_x\) and CH\(_4\) emissions, continue to dominate the European heating market. However, the use of these boilers is expected to decline, with a corresponding increase in the share of alternative heating technologies and gas boilers.

The alternative technologies that will gradually replace fossil-fuel based boilers can supply heat under different conditions: shallow geothermal is best suited for temperatures

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1. Eurostat
2. IEA, 2013
up to 50 °C, and solar thermal up to about 100 °C (with concentrating solar capable of reaching very high temperatures). Deep geothermal heat can supply temperatures in the range of 50–150 °C depending on local conditions, and biomass can supply heat at any temperature below the combustion temperature of the feedstock. Large-scale biomass combustion plants are a mature technology; in many cases, the heat generated is competitive with that produced from fossil fuels. Bioenergy heat can also be produced in cogeneration power plants, achieving overall efficiencies of around 70 to 90 %3.

Solar heating and cooling comprises a wide range of technologies, from mature domestic hot water heaters to new technologies such as solar thermally-driven cooling. Solar cooling is an emerging and attractive technology with zero or very low GHG emissions. Apart from ordinary air conditioning systems driven by solar electricity from PV units, solar thermal cooling can provide cooling needs through a thermally-driven heat pump cycle. As regards heating, solar-assisted District Heating (DH) systems are used to provide low-temperature heat (below 100 °C) on a diurnal or seasonal basis.

Conventional cooling technologies include electrical air conditioners and chillers based on a vapour compression refrigeration cycle. High-efficiency absorption chillers, which use mixtures of water and ammonia (or lithium bromide) with natural gas or cogeneration heat sources, could replace traditional electric chillers in buildings with a high demand for cooling and/or heating and air conditioning.

DHC enables the use of surplus heat from electricity production, industry, waste incineration and renewable sources. Moreover, district cooling networks make direct use of lakes, sea, river water, ice or snow for cooling. The cooling potential of these sources can be boosted with heat pumps.

The industry

Conventional technology currently dominates the European heating and cooling market. Although overall sales of gas and oil boilers...
have decreased in recent years, gas-fired systems still account for nearly 50% of the total energy used in heating. However, the share of renewable technologies in this segment is expected to increase. Heating and cooling technologies based on solar, biomass and geothermal resources are already mature, and other technologies are close to mass-market deployment (small-scale geo-thermal heat pumps) or under development (solar-cooling technologies).

In 2007, the average cost of a solar thermal system was EUR 1 100/kWth for pumped systems installed in central and northern Europe, and EUR 600/kWth for thermo-siphon systems in southern Europe. Should the solar thermal capacity in Europe continue expanding, costs for installed small-scale forced circulation units are expected to decrease to EUR 400/kWth by 2030 in central Europe.4

DHC systems accounted for a 10% market share in 2012. Further improvements in these systems will see the average share of renewable energies in DH increase to at least 25%, with an associated decrease of 2.14 EJ per year in primary energy consumption and the mitigation of 400 Mt of CO2 emissions.5

DH systems in Europe currently supply more than 9% of total European heat demand and district cooling has a market share of about 2% of the total cooling market, corresponding to approximately 3 TWh.

**Barriers**

Financial incentives, stronger regulations supporting the use of energy from renewable sources and an increase in consumer awareness of heating and cooling technologies are needed if we are to see an increase in the share of energy from renewable sources in the heating and cooling sector and more widespread energy efficiency initiatives.

Major barriers to a greater uptake of solar heating and cooling technology, in particular in the building sector, are the high capital costs and long payback time associated with this technology. Furthermore, the cost-competitive deployment of solar heating and cooling is hindered by technical bottlenecks, particularly regarding heat storage and the unavailability of commercialised cooling machines for solar-cooling applications.

**Ongoing research**

Further R&D investment in advanced heating and cooling technologies is needed if these are to reach their full potential. Over the next decade, research and demonstration efforts are required to make geothermal systems commercially available by 2030. Priorities include the development of techniques for resource assessment and the development of more competitive drilling technology.

Regarding solar thermal technology, R&D is required to enable the commercialisation of market-viable products in colder regions requiring freeze protection systems. There is also a need for research into advanced materials, including new polymeric materials and glasses with improved optical properties, as well as novel materials with better insulation properties and better heat-transfer capabilities at high temperatures (up to 250°C). Regarding the storage of heat, additional research is needed on high-density storage media, such as thermo-chemical and phase-change materials capable of storing heat for long periods of time.

Technology for renewables-based cooling is still largely at the research and demonstration stage and the efficiency and flexibility this technology needs to be increased by improving chillers and heat pumps and developing low-cost concentrating collectors for solar cooling. More research is also required to develop free-cooling and hybrid cooling demonstration projects. Existing cooling technologies could be improved by developing variable-speed fans that lower electrical draw, high-efficiency fan motors that use less electricity, improved heat exchangers and more efficient compressors.7

DHC networks need to become more flexible, which will require the development of low-temperature networks, the integration of innovative thermal storage, and interaction with other energy networks. Cost effectiveness should also be enhanced and cooling generation technologies must be improved. Finally, transfer of know-how and optimisation of policies are essential to facilitate market penetration of the technologies.

**Needs**

If heating and cooling technologies are to make a significant contribution to the achievement of Europe’s energy and climate targets, then further investment in R&D will be required. Furthermore, if district heating and cooling is to have a discernible impact on the decarbonisation of the European energy system, then a more favourable financial environment with faster returns on investments will be needed.

Research in the sector should focus on improving efficiency, as a significant improvement in this area is required. This can be achieved through the further optimisation and integration of high-efficiency conventional technologies such as condensing boilers, electric resistance systems, advanced heat pumps and solar thermal technologies, all of which have already proven themselves to be viable on the market.

There is a need for technology to minimise the overall environmental impacts of geothermal exploitation. Finally, novel ground-coupling technologies are needed for geothermal heating and cooling in the residential sector.

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4 EC, 2007
5 EU Handbook, 2012
6 EHPA, 2012