2020 – 2030 – 2050

Common Vision for the Renewable Heating & Cooling sector in Europe

European Technology Platform on Renewable Heating and Cooling

RHC Renewable Heating & Cooling
European Technology Platform

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Cataloguing data can be found at the end of this publication.

Luxembourg: Publications Office of the European Union, 2011

ISBN 978-92-79-19056-8
doi:10.2788/20474

Design and lay-out: www.altitude.be

Printed in Belgium
Photo credits for the cover page: Sakir Simsek; Peter Rechberger; www.wagner-solar.com

Printed on process chlorine-free recycled paper (PCF)

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European Technology Platform on Renewable Heating and Cooling

Renewable Heating & Cooling
European Technology Platform

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LINGUISTIC VERSION

Original: [EN]

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Manuscript completed in January 2011.

This document is available on the Internet at: www.rhc-platform.org

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Foreword

Renewable energies constitute a basic pillar in the strategy supported by EU to reinforce the sustainable development of our economies and citizens' welfare. The main EU Energy challenges can be summed up with three principle objectives: reduce the greenhouse gas emissions - diversify and improve the security of our energy supply - maintain our industry as world leader in clean technologies. These targets, highlighted in the renewable energy directive, are the basic components of the EU regulation in that field.

The European Strategic Energy Technology Plan provides a framework to develop new industrial initiatives. In this view, the Technology Platform on Renewable Heating and Cooling is expected to provide the right impulse to ensure the deployment of future cost effective technologies in the renewable heating and cooling sector.

The current "Vision Document" provides a description of the potential deployment of the sector. The next step should consolidate the Vision with the definition of a powerful Strategic Research Agenda and a dedicated Implementation Plan. These major next steps are real opportunities for the Technology Platform to provide the right supply of heating/cooling applications which are expected by EU citizens and economic actors. The Commission has endorsed the set-up of this important Technology Platform in November 2008 and considers it an essential forum that gathers the main EU stakeholders in this field.

I am confident that the objectives indicated previously can be met by the Technology Platform and that together we can make the difference.

Marie C. Donnelly

Marie Donnelly
Director for New and Renewable Sources of Energy,
Energy Efficiency and Innovation
European Commission

1. Introduction

Photo: Sakir Simsek

At present, almost **50% of the total energy consumed in Europe is used for the generation of heat** for either domestic or industrial purposes. The vast majority of this energy is produced through the combustion of fossil fuels such as oil, gas and coal – with a damaging environmental impact arising primarily from the associated greenhouse gas emissions and also from the resource extraction process. Cooling is, with few exceptions, achieved by processes driven by electricity, which is still also predominantly produced from fossil fuels. The social, environmental and economic costs of climate change are such that we must move swiftly towards a more sustainable energy economy based on renewable energy sources.

For these reasons, energy scenarios often suppose a very substantial contribution of renewable energy penetration in the heating and cooling sector towards the targets set out in the **Renewable Energy Sources Directive** ("RES Directive", 2009/28/EC).

The European **Strategic Energy Technology (SET) Plan** – intended by the European Commission to accelerate the deployment of low-carbon energy technologies – recognises the essential role of renewable energy sources (RES) for heating and cooling as part of the EU's strategy to improve the security of energy supply and to create markets for highly innovative technologies that are useful to society and where European industry can lead.

European Technology Platforms (ETPs) focus on strategic issues where achieving Europe's future growth, competitiveness and sustainability depends on major technological advances. They bring together stakeholders from industry and research to define short- to long-term research and technological development objectives and lay down targets to reach by certain dates.

Climate change, energy security, and the sustainable provision of heating and cooling are three major challenges that European society faces in the 21st century, all requiring a multi-disciplinary approach and the coordination of efforts - typical work for an ETP.

The **European Technology Platform on Renewable Heating & Cooling** (known, for short, as the RHC-Platform) brings together stakeholders from all renewable energy sources concerned and related industries including in cross-cutting technologies such as heat pumps, thermal energy storage and district heating to agree a joint strategy for increasing the use of renewable energy sources for heating and cooling.

Building on the work of the European Solar Thermal Technology Platform (ESTTP, in existence from 2005-2008), four major European organisations – **EUREC Agency** , **AEBIOM**, **EGEC** and **ESTIF** – through the Secretariat of the RHC-Platform are together coordinating the definition of a **Common Vision and Strategic Research Agenda** for the renewable heating and cooling (RH&C) sector.

This vision report has been prepared by the **Horizontal Working Group on the Common Vision** of the RHC-Platform, with the aim to assist the rapid development and deployment of world-class, cost–competitive renewable energy technologies for sustainable production of heating and cooling.

The report identifies major technological and non-technological challenges to the uptake of the RH&C systems and assesses the potential of renewable energy sources to contribute to the European and national energy needs and targets.

Participants in the RHC-Platform are convinced that the use of renewables in heating and cooling is a necessary and integral component of the "third industrial revolution". It is now the responsibility of citizens, policy makers and legislators to ensure that renewable energy sources become a major part of our energy mix.

2. European Heating and Cooling Demand

Photo credits: www.wagner-solar.com

2.1 Heating Demand in Europe

In 2007, 48 % of the final energy consumption in EU 27 took the form of heat. Heat accounted for 86 % of the final energy consumption in households, 76 % in commerce, services and agriculture, and 55 % in industry.

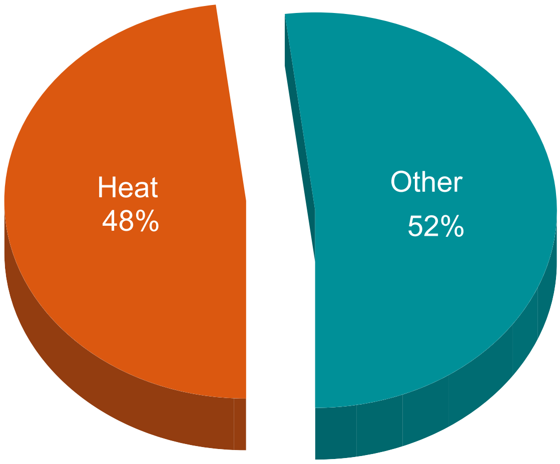


Figure 1 – Form of final energy consumption in the EU

A thorough investigation[1] based on data for the year 2006, identified the different ways in which heat is used in EU 27 (ESTIF 2009). Supplied heat needs to be well matched with demand: The heat source must be near the heat demand and the temperature of supply must meet the required temperature. Heat users quite often have a specific demand profile – so different forms of energy supply technologies are required to cover all types of heat demand. For the renewable energy sources this is a major challenge, which can only be met when all RES contribute with their respective advantages.

The demand for high temperature ("high" meaning above 250 °C) heat is not analysed in this publication. The needs of high-temperature industrial heat users, which make up 30% of the heat market (Fig 2), will be explored by the RHC-Platform in future work. Industries requiring heat above 500 °C (such as cement and glass) pose a particular challenge to renewable energy technologies. Figure 3 shows the distribution of heat users within the low temperature range for the year 2006.

[1] Weiss, W., Biermayr. P.: Potential of solar thermal in Europe, ESTIF 2009, www.estif.org

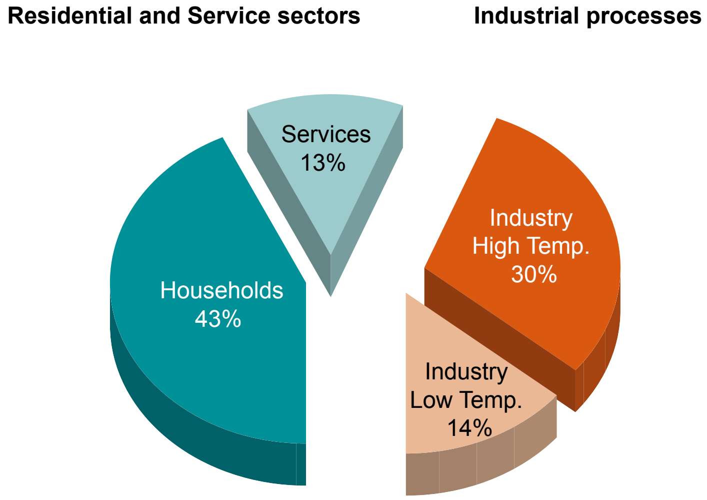


Figure 2 – Distribution of heat by use types in the EU (2006)[2]

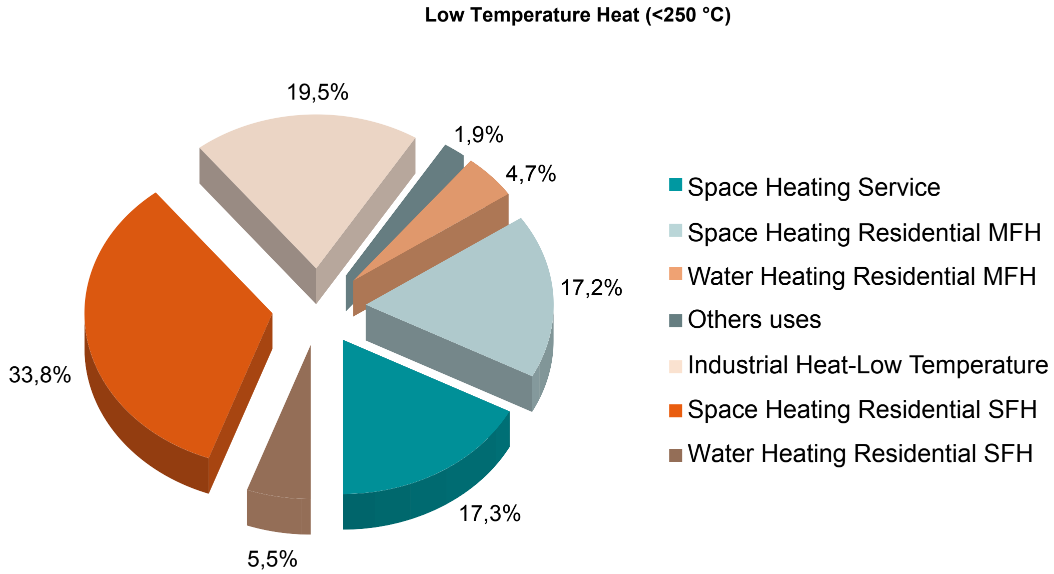
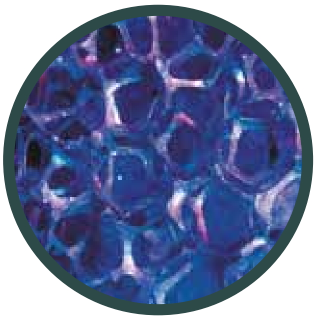


Figure 3 – Distribution of low-temperature heat by use types in the EU (2006)[3]



[2] "Low Temperature heat" refers to heat up to 250 °C. "High Temperature heat" refers to heat above 250 °C.

[3] In Figure 3, MFH and SFH are respectively abbreviations for "Multi-family houses" and "Single-family houses".

Forecasts of future heat demand in EU 27 are sensitive to increases in efficiency:

- in the insulation of the building envelope;
- in the conversion of the respective heat-supply technology;
- and in distribution of energy.

If efficiency gains could be realised in each of these realms, they would allow a considerable reduction in the heat demand. Figure 4 and 5 show the evolution of both high and low temperature heat demand in EU 27 under a "Business as Usual Scenario"[4] and a "Full Research, Development and Policy Scenario"[5] in EU 27.

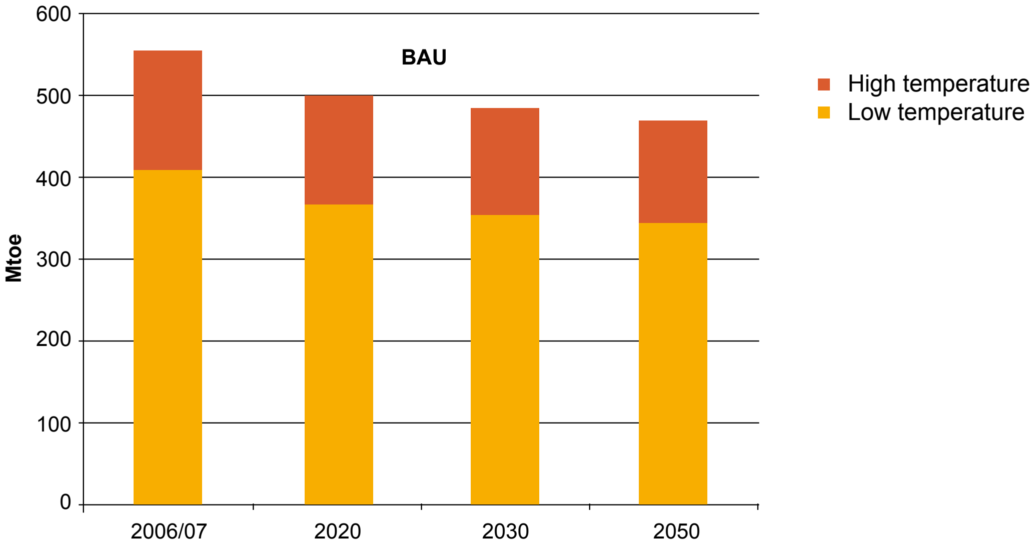


Figure 4 – Heating demand in EU under the "BAU" scenario

[4] The "Business as usual Scenario" (BAU) is based on the following assumptions:

- Moderate reduction of the heating demand compared with 2006 (on average: -5% by 2020, -10% by 2030 and -20% by 2050).
- Policy support: RE obligations only for new residential buildings; subsidies for existing residential, service and commercial buildings as well as for industrial applications (subsidies: 10 - 30% of the system cost) or constantly moderate rising energy prices of fossil energy.
- Medium R&D rate and therefore solutions for high energy density heat stores and new collector materials; sufficient and cost competitive solutions for solar thermal cooling by the year 2020.
- Medium growth rate of RHC installed capacity (10-15% per annum until 2020).

[5] The "Full Research, Development and Policy Scenario" (RDP) is based on the following assumptions:

- Significant reduction of the heat demand compared with 2006 (depending on the country but on average: -10% by 2020, -20% by 2030 and -30% by 2050).
- Full policy support: RE obligations for all new and existing residential, service and commercial buildings as well as for low-temperature industrial applications or high energy prices of fossil energy.
- High R&D rate delivers solutions for cost efficient high energy density heat stores and new collector materials; sufficient and cost competitive solutions for solar thermal cooling available by 2020.
- High growth rate of RH&C installed capacity (approx. 25% per annum until 2020).

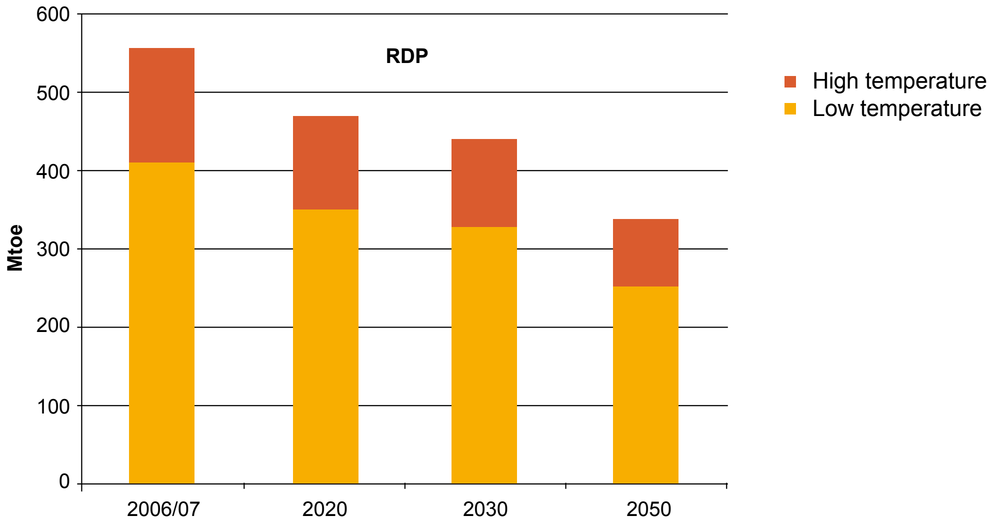


Figure 5 – Heating demand in EU under the "RDP" scenario

2.2 Cooling Demand in Europe

Cooling is defined as the decrease in temperature of indoor air for thermal comfort. "Cooling demand" is the demand for energy to keep the temperature in certain areas characterised by human presence (houses, shops, offices, etc.) below a defined maximum limit. Further decreasing the air temperature in enclosed spaces below human standards for thermal comfort (e.g. for storing or freezing food), is refrigeration and is not considered in this publication.

The evolution of energy consumption for cooling is expected to follow a markedly different trend to that of heating: an increase of demand can be expected rather than a decrease. Climate change and a growing feeling among people that, concerning their comfort or productivity in hot weather "cooler is better", are driving growth in the cooling market. The architecture and technical equipment of large commercial buildings also generates a necessity for more and more active cooling. The share of commercial buildings in Europe equipped with cooling devices is expected to rise to at least 60% by 2020. An upper limit on the size of the market in Europe, if 100% of all useful space were air-conditioned, is estimated to be 1400 TWhc (120 Mtoe) annually.

To reverse these trends appears to require unrealistically high changes in the public's tastes concerning thermal comfort and commercial building design.

Governments have been slow to spot the trend of increased cooling demand, partly because cooling needs are traditionally being met by electrical air conditioners, hiding the cooling element within the building's overall electricity consumption. Air conditioners are signalling their increasing presence on the grid through a shift in the time of year when electricity networks experience peak demand. This used to occur in winter but now, increasingly, occurs in summer.

The technologies to supply this active cooling will have to be as green as possible. Renewable cooling technology less reliant on electricity can help to check the growth in electricity demand. Such technology exists and new technology is under development but this area is not as advanced as renewable heating technology (see further in section 3.4).

The impact on energy consumption of cooling demand is difficult to assess accurately as it is hidden in data for the electricity demand of the residential and service sectors. However, on the basis of the existing literature and by extrapolating relevant data from databases of European statistics, estimates have been made (Fig 6)[6].

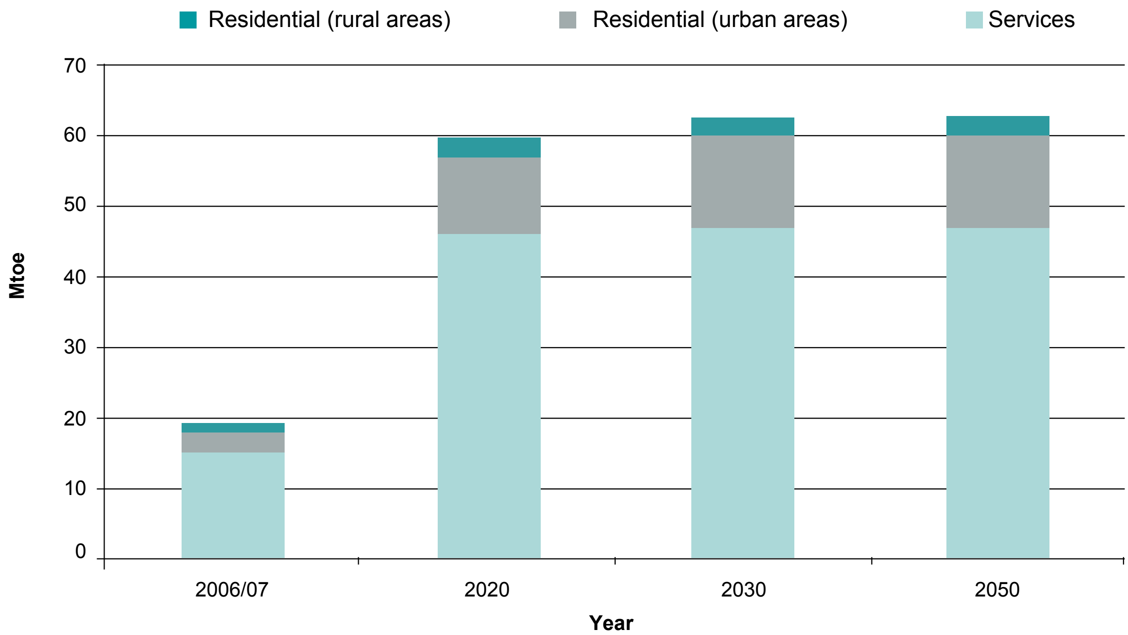


Figure 6 – Expected evolution of cooling demand in EU

[6] The scenario presented in this section is based on the following literature references (complete details available in "Appendix 3: References"): ARMINES 2003; EUROHEATCOOL 2006; ADEME 2009; ESTIF 2009; SUMMERHEAT 2009; EU 2010. For convenience, some key assumptions are summarised here:

· We assume that 80% of cooling demand for residential uses is in high- and medium-density areas (73% for heating).

· A very steep increase in cooling demand is expected by 2020, based on the fact that the amount of useful floor area that is cooled and/or air conditioned has increased in the past few years and this trend will continue for at least the next ten years. From 2007 till 2020 we assume a 82% increase of cooling demand in the residential sector and a 60% increase in the service sector.

· At this point in time the European saturation rate of 60% for the service sector and 40% for the residential sector is reached. Any further expansion will be due to an increase in occupied overall floor space, climate changes, additional technical installations, building standards (have an impact in the opposite way) and social behaviour. On this basis, following the strong growth from now to 2020, only a very slow increase in cooling demand is expected from 2020 to 2030 (6%), and from 2030 to 2050 (1%).

2.3 Demand profiles

Local constraints such as the relative abundance of different forms of renewable energy affect the choice of technology for supplying heating or cooling "renewably". These are some examples:

- The kind of building and the buildings and infrastructure that surround it (Fig 7);
- Local climate and weather patterns;
- Renewable energy resource availability: biomass, sunlight, geothermal potential, or favourable shallow geothermal conditions;
- Proximity to sources of waste heat such as industries or waste incineration plants.

In short, the optimal choice of renewable heating and cooling technology depends heavily on local circumstances.

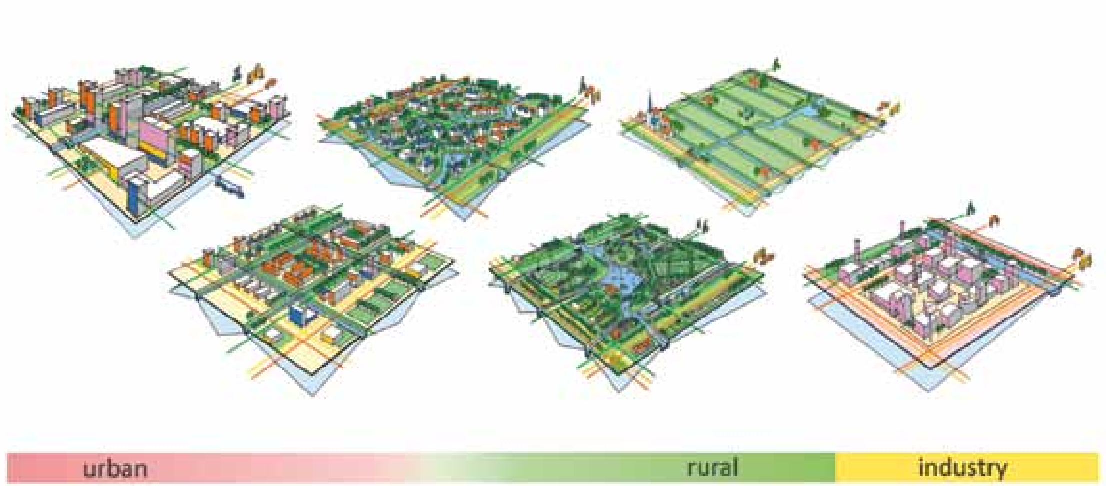


Figure 7 – Profiles of heating and cooling demand

Typically, for spatial planning purposes, 20 to 30 different types of areas are distinguished, but for the purposes of this Common Vision, a three-way categorisation is sufficient: urban areas, rural areas, and industry[7]. These differ in population density, intensity of use, quantity and density of available (energy) infrastructure, availability of local renewable energy sources, etc;

Urban areas (>*500 inhabitants/km^2*)
Urban areas include city centres, suburban areas and village centres. They are characterised by a dense population building density, heterogeneous functionality (living, working, recreation, and transport). They often have higher than average temperatures compared to surrounding areas (making them "heat islands").

This means that there are relatively few possibilities to harness renewable energy sources in urban areas. For example, due to the larger fraction of tall buildings and, in some environments, multi-family houses,

[7] The distinction between urban and rural areas is adapted from the classification currently in use at EUROSTAT:
· Densely populated zones (here defined "Urban areas"): these are groups of contiguous municipalities, each with a population density superior to 500 inhabitant/km².
· Intermediate zones: these are groups of municipalities, each with a density superior to 100 inhabitants/km², not belonging to a densely populated zone.
· Sparsely populated zones: these are groups of municipalities with a density up to 100 inhabitants/km^2.
In this document intermediate zones and sparsely populated zones are collectively called "Rural areas".

the amount of roof space and hence the availability of solar heat per dwelling is limited. The underground space available to each dwelling for storage of geothermal heat is similarly limited. By contrast, the relatively dense network of (energy) distribution infrastructure makes it possible to use remotely-generated renewable energy. High building density also makes distribution through district heating and cooling networks more cost-effective.

Rural areas (*≤500 inhabitants/km²*)
Rural areas include population densities ranging from those of small villages, to garden cities containing lots of green space. The use of these spaces is moderately homogenous and they are used moderately intensively.

In rural areas renewable sources are therefore present in sufficient quantities to meet local needs. In most cases, there is sufficient space on or around buildings to harness, for example solar or geothermal heat, without interfering with neighbouring buildings. Electricity supply infrastructure, however, is usually weak, and distribution networks for heat or cold are often absent. Rural areas will therefore tend toward local, individual generation and use of renewable heating and cooling.

Industry
Industrial applications for renewable heating and cooling are typically found in designated industrial zones or ports. Such zones typically have a high building density, and are often monofunctional. Industrial applications of renewable heating and cooling differ from residential or service sector applications in their high energy intensity, higher required temperature levels, and more constant, round-the-clock energy demand.

The technologies that can supply these needs are, for example, high-temperature solar thermal collectors, suitable biomass technology or deep geothermal heat. The high building density and well-developed energy-supply infrastructure favour the use of larger, collective installations, which should, where practicable, convey waste heat to nearby urban areas.

3. Potential of RES for heating and cooling

Photo credits: EGEC

The "RES" Directive 2009/28/EC on the promotion of the use of energy from renewable sources states in art. 2:

> *The following definitions also apply:*
> *a) 'energy from renewable sources' means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases;*

Of the RES listed, only a few are directly relevant for heating and cooling:

- solar thermal
- biomass
- geothermal
- and aerothermal/hydrothermal.

Of course, renewable electricity can be and is used for heating and cooling purposes, but this application of RES-E is beyond the scope of the RHC-Platform.

Each RES for heating can only be used to deliver heat up to a certain temperature, affecting the applications that they can be used for. Shallow geothermal is best suited for temperatures up to 50 °C, solar thermal up to about 100 °C (with the exception of concentrating solar, which can reach 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. The individual sources, their challenges and potential, are discussed in the following pages.

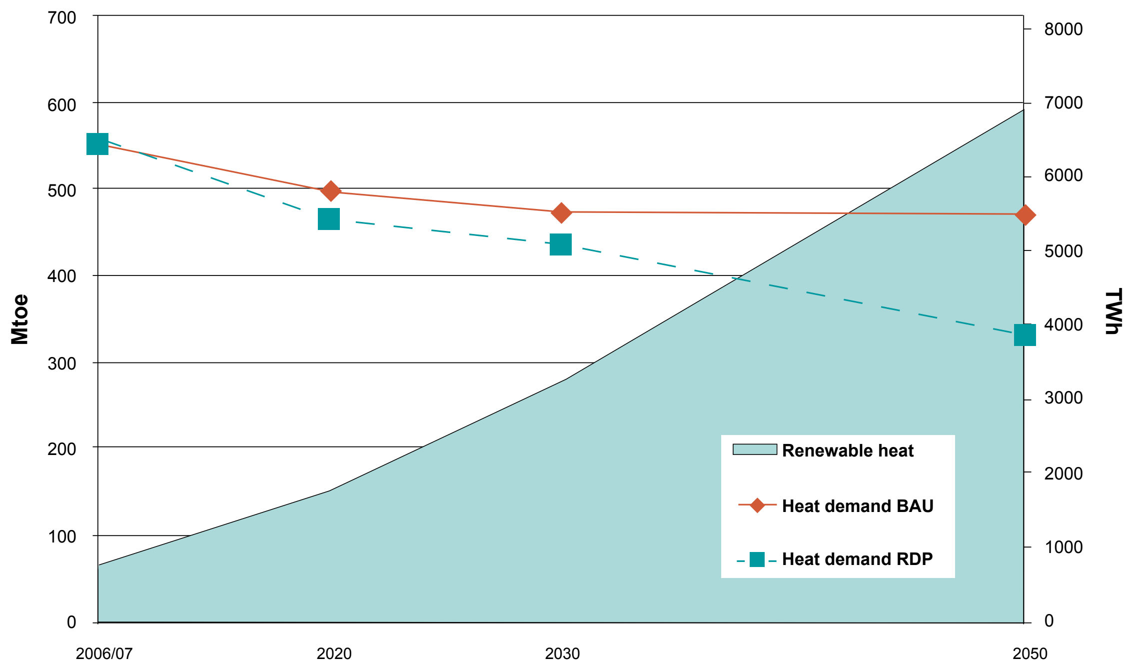


Figure 8 – Heating supply from renewable energy sources in EU

By 2050, the combined potential of RES even exceeds the expected heating demand (Figure 8). The long-term scenario with 100% renewable heat will result in a dramatic reduction in the emissions of greenhouse gases associated with the consumption of fossil fuels.
Figure 9 breaks down aggregate RES heat supply into its components.

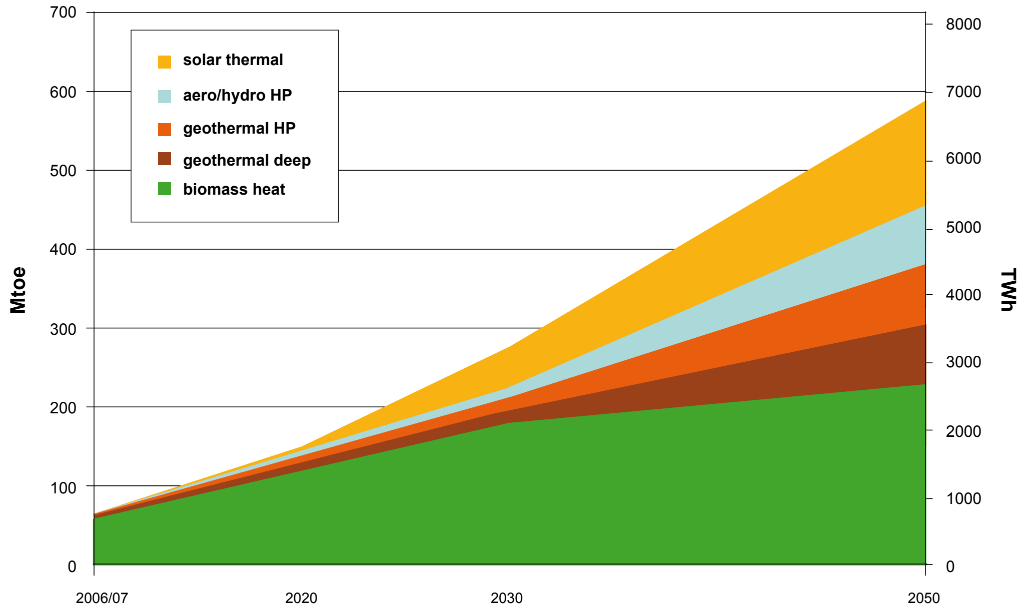


Figure 9 – Heating potential by renewable energy source in EU

When outlining the potential of RES, it is important to use internationally agreed definitions of "primary" and "final" energy.
All figures presented here refer to the potential of RES to meet the EU's **final energy** demand. The terms "primary", "final" and "useful" energy are explained in "*Appendix 1: Glossary of energy definitions*".

Source: www.wagner-solar.com

3.1 Solar Thermal

Description of solar thermal technology

The fundamentals of solar thermal systems are simple: solar radiation is collected and the resulting heat conveyed to a heat transfer medium - usually a liquid but also air in the case of air collectors. The heated medium is used either directly (for example to heat swimming pools) or indirectly, by means of a heat exchanger which transfers the heat to its final destination (for instance space heating or domestic hot water).

State of the art of solar thermal technology

Current key applications of solar thermal technologies:
- Domestic hot water preparation for single- and multi-family houses with typical solar fractions between 40 – 80% (meaning the energy of sunlight meets these shares of demand for this use).
- Space heating of single and multiple family houses with typical solar fractions between 15 – 30%.
- Hot water preparation in the hotel and tertiary sector.

In some European countries (Austria, Denmark, Germany and Sweden) solar-assisted district heating systems are already well established. In recent years the number of solar thermal systems for cooling and air conditioning and industrial process heat has increased considerably, while there is a big untapped

potential in new applications such as sea water desalination and water treatment.
The worldwide market for solar thermal systems has grown 10 - 20% per year since 1999. In Europe, the size of the market has tripled within a few years.

Within the renewable energy technologies for heating and cooling, solar thermal (ST) has specific benefits, as it:

- always leads to a direct reduction of primary energy consumption
- can be combined with nearly all kinds of back-up heat sources;
- does not rely on finite resources, which might be needed for other energy and non-energy purposes;
- does not cause a significant increase of electricity demand. Peak cooling consumption coinciding with peak solar radiation, solar thermal technology is able to reduce the load on existing grids;
- can generate heat nearly everywhere. Current limitations can be largely overcome through R&D;
- provides energy for a predictable price. Most costs are incurred at the moment of investment. There is no exposure to the volatility of oil, gas or electricity prices;
- has an extremely low environmental life-cycle impact;
- creates local jobs – a large portion of the value chain (distribution, planning, installation, maintenance) cannot be delocalised.

Europe's market supports a greater diversity of solar thermal applications than the world's other markets. The increase in the installations of solar thermal combi-systems, providing both domestic hot water and space-heating, is a very promising development enabling greater use of the solar resource.

100% solar-heated buildings (Active Solar Buildings) have already been demonstrated in Central European climates (both detached houses and multi-family buildings). These buildings need very good thermal insulation, space for a large collector area and for a heat store. The key technological challenge is to reduce the volume of the heat storage.

Some district heating systems use solar thermal energy for significant shares of the total heat they supply. There has been a significant increase in the number of such applications and the capacity of what is presently the biggest plant (13 MWth) will soon be doubled in plants being developed in Denmark and Saudi Arabia.

Potential of solar thermal technology

According to the study "Potential of solar thermal in Europe", solar thermal energy could supply 133 Mtoe (1552 TWh) of final energy in the RDP scenario, corresponding to an installed capacity of 2716 GWth. This would lead to energy savings (primary energy) of 217 Mtoe.

Assuming a 9% reduction in overall final energy demand due to energy efficiency measures by 2020 (compared to 2006), in the most ambitious scenario (RDP)[8] solar thermal could provide up to 6,3% of the 20% target for renewable energy in the EU. Considering the European energy mix in 2005 (reference year of the "RES Directive"), solar thermal systems will contribute for a share equivalent to 12% of the total new renewable energy capacity installed by 2020 to meet the EU targets".

Post-2020, the RDP scenario shows contributions of solar thermal to total European low-temperature heat demand of 3.6% in 2020, 15% in 2030 and 47% in 2050.

[8] For reference: Weiss, W., Biermayr. P.: Potential of solar thermal in Europe, ESTIF 2009, www.estif.org. See also assumptions in footnotes 4 and 5.

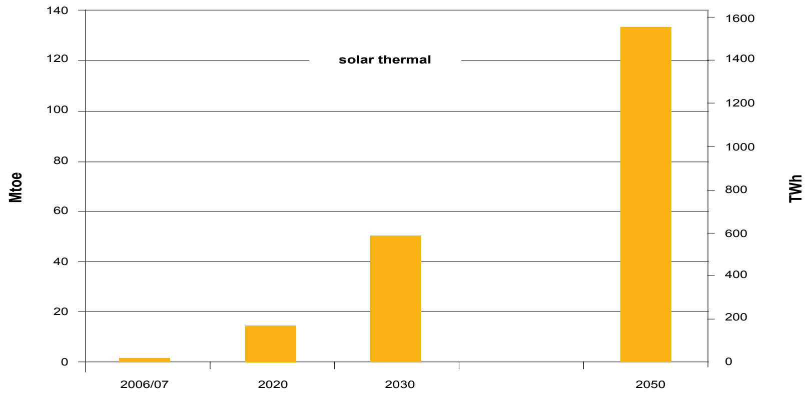


Figure 10 – Heating potential of solar thermal in EU

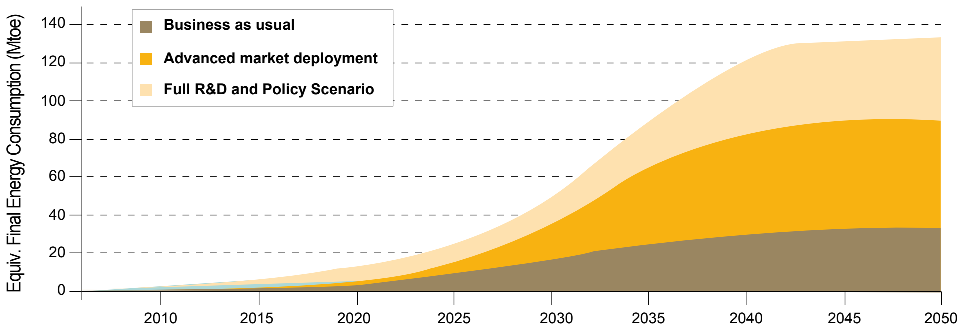


Figure 11 – Solar thermal market scenarios 2010 -2050 [ESTIF, 2009]

3.2 Biomass

Description of biomass technology

When biomass is used for energy purposes, it is most often for heating. Biomass currently covers more than half of the total renewable energy contribution to heating demand in Europe. The development of new technologies will enable the production of high quality fuels; secure, sustainable supplies; clean and effective combustion processes and optimally-integrated solutions for households, industry, and district heating and cooling.

Biomass can come from many sources and be converted to many forms of energy . Current sources of biomass include:

- forests, such as fire wood or logging residues
- by-products of the wood industry such as bark, saw dust, shavings, pellets, black liquor etc.
- energy crops (rapeseed, cereals or corn for biofuels; short rotation coppices, energy grass for heat and electricity)
- agricultural by-products (straw, manure, fruit wood)
- Biomass from waste streams including municipal waste

Biomass conversion technologies include stoves (for individual rooms, with typical capacities of a few kW), boilers (capacities of a few tens of kW for homes and on the multi-MW scale for industry and district heating).

Electricity production based on biomass should be concentrated on CHP to maximise the use that can be made of waste heat. Household-scale CHP (so-called “micro-CHP”) has still to be developed. Large boilers can be combined with steam cycle or Organic Rankine Cycle turbines to create a CHP application. A larger system can operate more efficiently but can in many cases needs a new grid to transport away and dissipate its heat.

Other technologies include gasification (where medium- to large-scale units are just beginning to be available commercially), pyrolysis, fermentation, esterification. These different conversion technologies allow biomass to supply heat, electricity or energy stored chemically in liquid, gaseous or solid form.

State of the art of biomass technology

Technology for providing bioheat to households, commerce and industry is available, reliable and efficient but has to compete against well established systems based on fossil fuels. Bioenergy can provide both low-temperature heat and steam, and high temperature heat suitable for industrial processes.

Small-scale heating systems fired with wood logs, chips or pellets offer good ease of use, low operating costs and are replacing oil heating in many European regions. Biomass district heating is of growing importance in Scandinavia, Austria, and other countries where demand for heat by the residential / service sector is high.

Methane production by fermentation is an alternative route suitable for wet raw materials. Biogas can be burned directly in a boiler for heat or in an engine for cogeneration, while upgraded biogas (methane) can additionally be injected into the natural gas grid or as vehicle fuel.

Potential of biomass technology for heating

Biomass’s future development depends to a large extent on the incentives created by the EU Member States. The potential of bioenergy technologies to further penetrate the heating market depends on:

- Sustainability of biomass sources
- Competitiveness of energy or other products from biomass
- Rate of progress of biomass technology

Developing a long term R&D strategy to support the bioenergy industry is therefore key.

The RHC-Platform expects biomass use to more than double by 2020 and to reach around 370 Mtoe of primary energy in 2050 (Figure 12), mostly to meet heat demand. Aquatic biomass has the potential to make a large contribution of this supply in any regions of Europe.

	2007	2020	2030	2050
total primary energy consumption	98	220	300	370
total final energy consumption	78	175	261	357
Made up of:				
Heat (biomass for heat and derived heat)[9]	61	124	182	231
Electricity	9	20	35	56
Biofuels	8	32	45	70

Figure 12 – Potential objectives for bioenergy, including a break-down according to the final form of the energy (in Mtoe)

[9] According to Eurostat methodology, the final energy consumption of biomass equals the energy content of biomass used for heat, except when heat is sold (case of CHP and district heating). This sold heat is called derived heat.

With a 231 Mtoe contribution to heat demand in 2050, biomass could on its own represent 70% of supplied heat if heat demand follows the RDP scenario (Figure 5). The capacity of biomass technology to also satisfy the demand of high-temperature heat for industrial processes plays a significant role in this energy scenario.

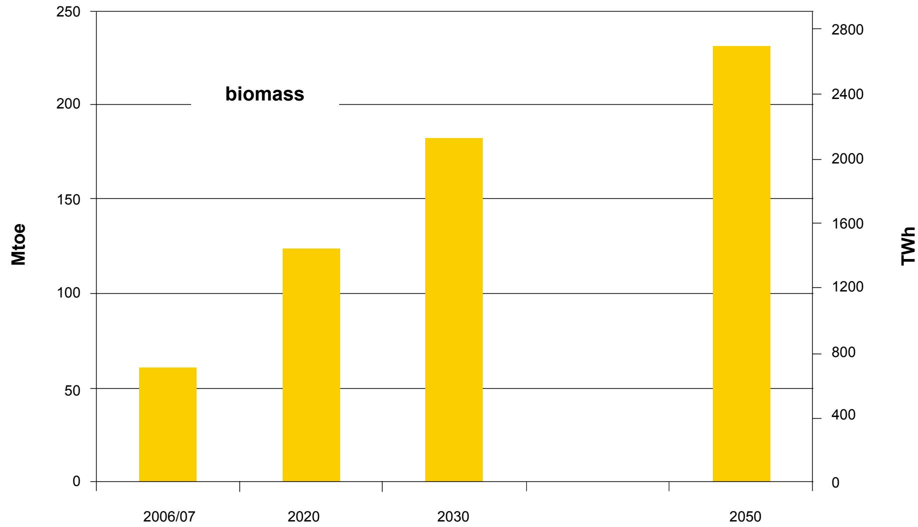


Figure 13 – Potential of biomass for heat and derived heat in EU

3.3 Geothermal

Description of geothermal technology

By definition, geothermal energy is the energy stored as heat beneath the earth's surface. Geothermal heating and cooling is currently provided in two different ways:

- The first one (very low temperature, up to 25°C) is based on the relatively stable groundwater and ground temperatures found at depths of up to 400 m. Typically, but not necessarily, heat pumps are used to raise the temperature to the level required by the hot water, heating or cooling end-use. In certain conditions and configurations, this system can be used to change ground temperatures artificially, in order to use the ground as heat or cold storage. UTES (Underground Thermal Energy Storage) represents a growing market for combined heating and cooling systems mainly for commercial and institutional buildings.

- The second one (low and medium temperature) extracts the heat from the ground and groundwater, typically at higher depths where temperatures are between 25 and 150°C. These temperatures are relevant to agriculture (horticulture, drying, aquaculture), industrial process, and balneology. Heat at this temperature can also be supplied to a district heating network or to a combined heat and power installation, or to drive local sorption heat pumps to provide cooling to a cooling network. District heating (and cooling) may also be supplied from residual heat left over after the production of electricity from a high enthalpy geothermal heat source.

State of the art of geothermal technology

Currently, besides electricity production, geothermal energy is used for district heating and cooling, and to heat and cool single buildings or groups of buildings (offices, shops, houses, schools, greenhouses, swimming pools).

A number of innovative applications of geothermal energy have been developed, of which some have been demonstrated (ice/snow-melting, sea water desalination, etc).

In new construction, shallow geothermal energy (geothermal heat pumps) has already achieved a market share of about 20% in some countries. Most low-temperature energy demand is found in existing houses, and these can be supplied by geothermal district heating systems. .

The key challenge for widespread direct use of geothermal heat will be the ability to reliably engineer the subsurface heat exchangers (using technique known as "EGS" – Enhanced Geothermal System) in a reproducible way to harness the heat flux at the required temperature.

The main challenges can be summarised as follows.

- Shallow geothermal:
  - Integrate a geothermal heat supply as a standard in the building energy system
  - Develop heating and cooling networks that can integrate geothermal heat pumps and geothermal storage (UTES), including hybrid systems where appropriate
  - Develop solutions for retrofitting existing infrastructure for geothermal energy

- Deep geothermal:
  - Exploit the full potential of sedimentary basins suitable for deep conventional geothermal energy
  - Deploy EGS technology

Geothermal potential for heating

The potential of geothermal energy in Europe is huge. At present, deep geothermal technology is only deployable in certain areas (Figure 14). But geothermal heat pumps and EGS, after successful demonstration, can be used virtually everywhere.

The extent of its deployment is therefore limited only by the demand for heat. By 2050, a value in excess of 150 Mtoe of heat production is deemed possible (45% of heat demand under the RDP scenario) (see Figure 15).

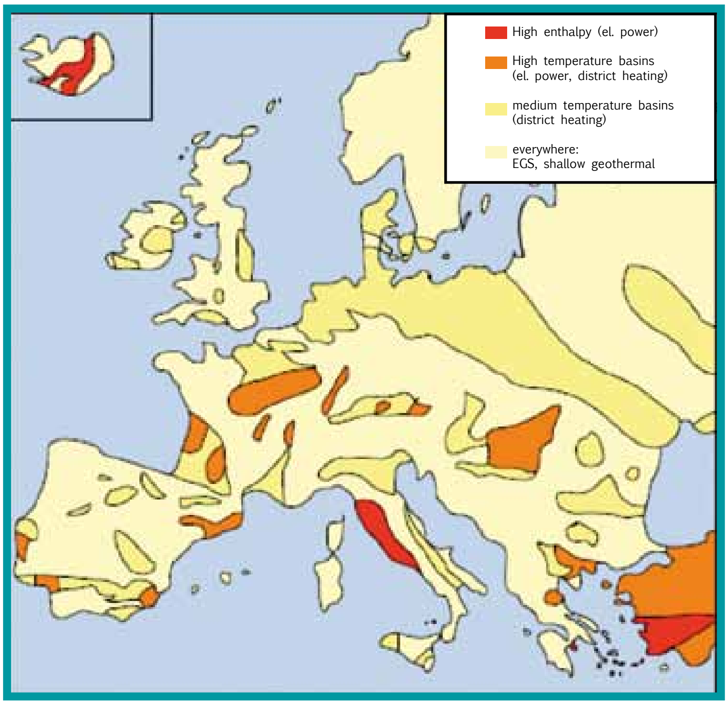


Figure 14 – Availability of geothermal resources

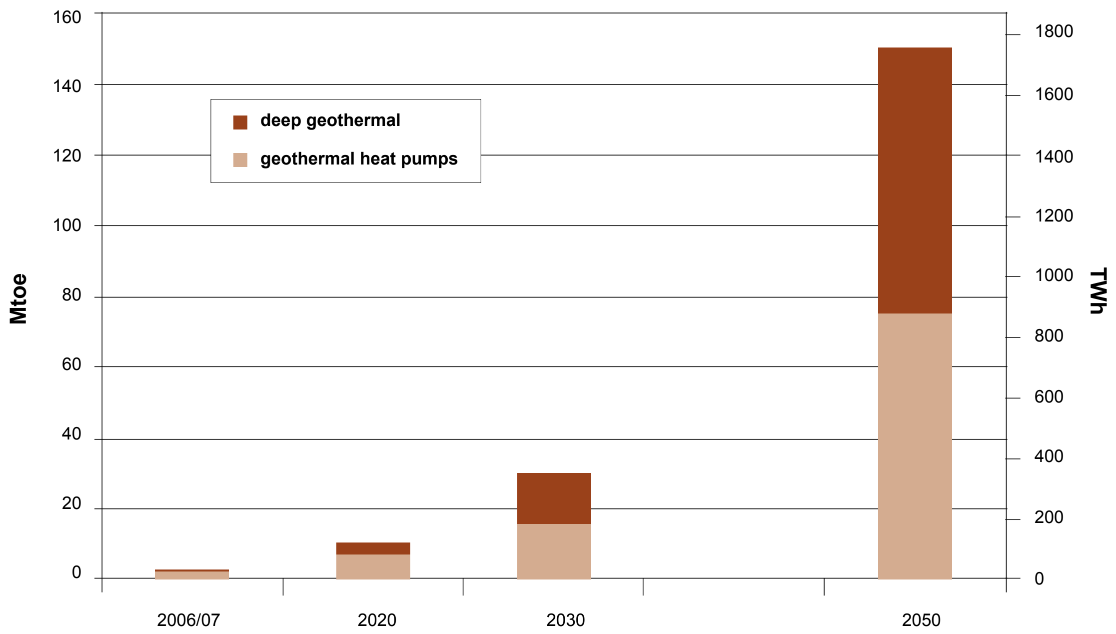


Figure 15 – Heating potential of geothermal energy in EU

3.4 Cooling from renewable sources

Comfort cooling as well as commercial and industrial cooling will account for an increasing part of thermal energy demand. There is little hope that the increase in cooling demand can be stopped or reduced in future – modern buildings, lighting, office technology, etc; require cooling (and any rise in average global temperatures will not make the situation easier).

Today, the demand for cold can be seen in energy statistics as electricity consumption for refrigeration, air conditioners, large chillers etc. In warm climates this results in high demand on summer days occasionally resulting in grid failures.

Of course, sufficient electric power from renewable energy sources could make electricity-driven cooling clean. But there is an alternative, since renewable energy sources can be used without first being converted into electricity.

Sorption cooling allows the use of heat to produce cold (see chapter 4.3 for technical details). The heat, which has to be at a temperature of 70 °C upwards, can come from any available sources, including:

- Solar thermal (in individual collectors, but also in concentrating arrays).
- Biomass (biomass or biogas boilers).
- Geothermal (direct geothermal heat from greater depth or in high-enthalpy areas).

Additionally, waste heat from industry processes, power generation through thermal cycles or waste incineration all offer potential for cooling applications. The heat source might not be renewable, but the heat is generated as a by-product and is today usually dissipated to the environment. The utilisation of this heat for cooling processes onsite or in district networks enhances cold production without the need to exploit other energy sources.

A particular advantage of sorption cooling driven by solar thermal is that the time of the highest availability of sunlight correlates well with the time of highest cooling demand.

Direct cooling uses relatively low temperatures found in nearby ground, water and air (at certain times) to provide cold. As the time of highest cold supply (winter, nights) typically does not match the time of highest cooling demand (summer, days), storage devices might be needed. The drawing of cooling from a source at exactly the time it is needed is known as "free cooling". The systems and operational strategies vary according to cold source and to climate:

- For ground (incl. groundwater) and deeper surface water bodies (e.g. deep lakes, seawater) with a relatively constant temperature throughout the year below an average of approx. 12°C, free cooling is possible. In order to maintain the long-term temperature of the cold source, injection of cold into the ground or water might be necessary to replace the heat injected when cooling is drawn from the source. The cold could come from winter air. The same technique of capturing seasonally available temperatures can be used to cool the ground or water of areas with average annual temperatures over 12°C so that they, too, can be used for summer cooling.

- The temperature of air and shallow water at the time of cold demand typically prevents them from offering free cooling. To use the temperatures of these sources, e.g. cool night air to mitigate high daytime temperatures, a form of short-term thermal energy storage is needed.

It is necessary to contain local temperature variations caused by using the environment as a source of cold within acceptable limits and to minimise any other environmental impacts. Small systems can reject heat into the ground or water while cooling without negative effects, but larger installations, as well as continuous cooling processes (industrial application) would need compensatory cold injection.

Rules on how to calculate the contribution of renewable energy in the processes described above (relevant for measuring progress towards national and European targets, for example) have yet to be established. Therefore, at present the RHC-Platform's Common Vision does not assess quantitatively the potential of RES to meet cooling demand.

Not all cold required in future will be supplied from the renewable heat sources described above. A considerable part might still use thermodynamic cycles, either with electrically driven compressors, supplied by power from renewable sources, or with compressors driven by combustion engines running on biofuel or biogas. Together with the cooling options described above, all future cooling demand can be covered with cold supplied by the use of renewable energy sources of different nature.

4. The multiplying effect of cross-cutting technologies

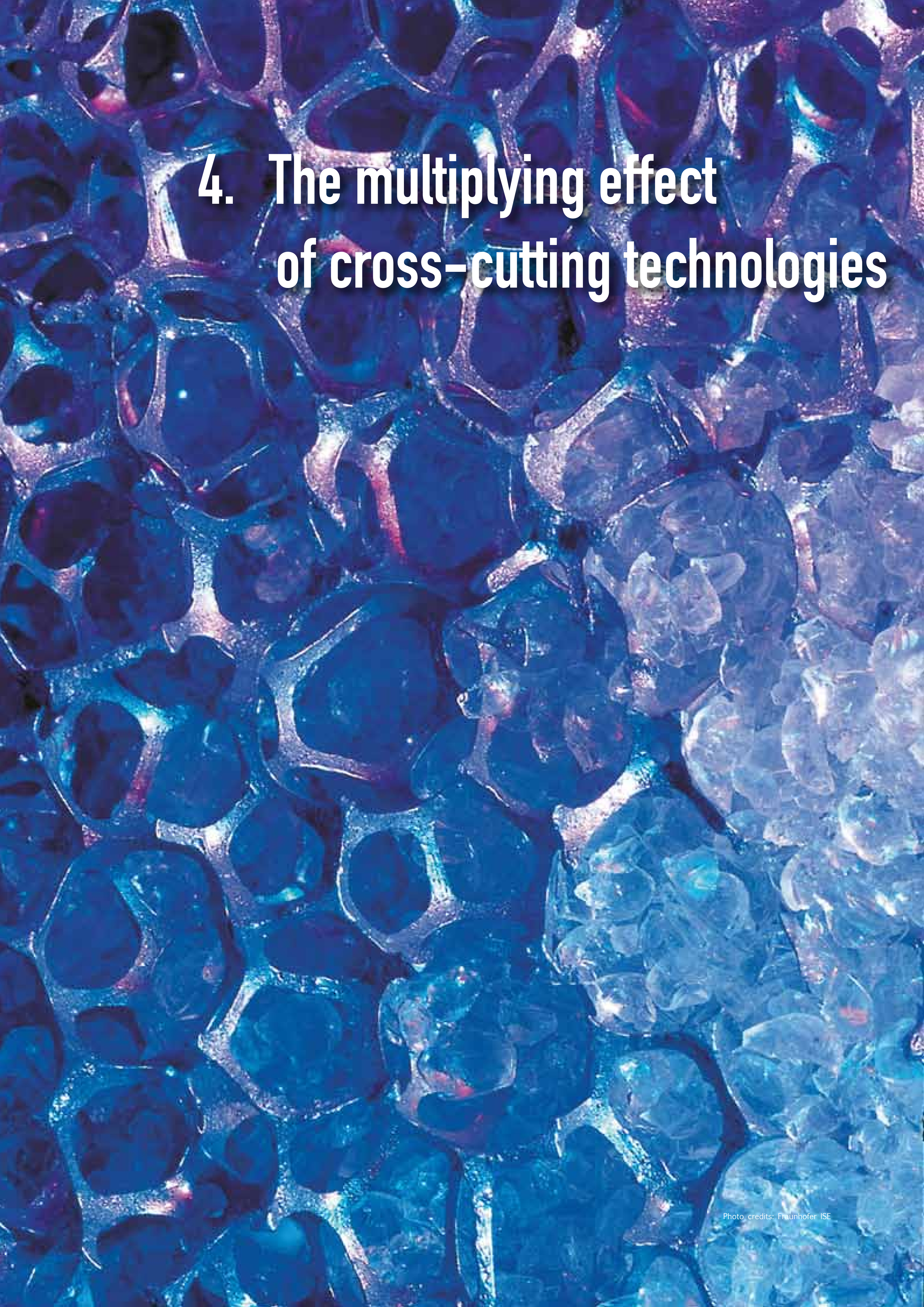


Photo credits: Fraunhofer ISE

Three cross-cutting technologies have been identified that are relevant to solar thermal, biomass and geothermal.

- District Heating and Cooling for Large-Scale integration of RES
- Thermal Energy Storage
- Renewable energy hybrid systems and heat pumps

These cross-cutting technologies can help to utilise the solar thermal, biomass and geothermal resources better, chiefly by sharing, storing or combining them. Figure 16 lists some potential drawbacks of systems based around a single RES and shows how the deployment of a cross-cutting technology can remove that drawback. Cross-cutting technologies must be further developed if heating and cooling from renewable energy is to reach its maximum potential.

Renewable Energy Sources	Examples of problems and cross-cutting technological solutions	Heat demand in buildings and industry
Solar Thermal **Biomass** **Geothermal** (in addition: **aerothermal, hydrothermal)**	<u>**Time difference**</u> Time of peak RES yield is different from peak heat/ cold demand: **Heat or Cold Storage** <u>**Scale difference**</u> Source requires large capacity installation, demand is in smaller units (e.g. buildings): **District Heating and Cooling** <u>**Temperature difference**</u> Temperature levels of source and demand do not match: **Heat Pumps** <u>**Quantity difference**</u> Required capacity, temperature and reliability cannot be met with one RES alone: **Hybrid Systems**	**Buildings**: - Space heating (in colder season) - Space cooling (in warmer season) - Domestic hot water (all year) - Swimming pools etc. **Industry**: - continuous demand - batch processes with intermittent demand - seasonal processes (e.g. sugar refining)

Figure 16 – Examples of cross-cutting technological solutions

District Heating and Cooling allows different renewable energy sources and end-consumers to be brought together in one system. District heating consists of technologies that allow to exploit sources which would be difficult or impossible to use in building specific applications (deep geothermal, wood wastes, residual biomass such as olive stones etc). District cooling networks offer the possibility of directly using lake, sea , river water, ice or snow (free cooling) for cooling. The cooling potential of these sources can be boosted using heat pumps. Alternatively, cooling could be accomplished by using heat from district heating networks in combination with sorption chilling. District networks are viable in areas where end-consumers demanding heating or cooling are concentrated.

Thermal storage is the solution for a real bottleneck against the widespread use of renewable heating and cooling, since the demand for heating or cooling does not coincide with renewable supply in many cases. Different technologies can be used for storages of different specifications (volume, heat release rate, heat capacity) and have their own specific benefits. Broadly speaking, these are sensible, latent, sorption and thermochemical storage. Nevertheless, the basic knowledge within the different storage technologies is common to solar thermal, biomass, geothermal, and heat pumps.

Heat pumps can use aerothermal, hydrothermal and geothermal energy sources to provide heating and cooling - and can be combined with heat coming directly from other renewable energy sources in hybrid systems.
Heat pumps can be driven by electricity or by thermal energy.

- In electrically-driven heat pumps, the electric motor activates a compressor. The necessary components are mass-produced and proven. Electric heat pumps switched on an off by controllers reacting to the price of electricity on the grid (smart grids), can help energy generation capacity to operate at optimum load.

- Thermally-driven heat pumps (sorption chillers) can make use of heat above 70°C for the production of cold for air conditioning or, with driving temperatures >100°C, for refrigeration purposes. In heat pump mode they allow to enhance the coefficient of performance of the heating system through the exploitation of low temperature (renewable) heat sources. Sorption chillers can be directly connected to heat produced by renewable sources but can as well use waste heat from renewable and non renewable industry or power generation processes. They can be installed in single energy appliances as well as in large energy systems and DHC.

Hybrid systems, combining two or more energy sources into a single system, can overcome the limitations of individual technologies. This is true for small-scale systems like heating and cooling systems for single family houses as well as for large-scale applications suitable for district heating and cooling or industrial processes.

Where a single renewable energy source cannot provide alone 100% of heating or cooling demand, additional sources must be combined efficiently in systems. This makes control and automation strategies a very important part of renewable energy system research. Climatic modelling, user behaviour and systems hydraulics are also targets for research. For cross cutting technologies to reach their full potential, research on the level of single components, as well as research on the smart integration in systems is necessary.

As the issues discussed above are common to all renewable heating and cooling technologies, it is important to consider them within the RHC-Platform for the following reasons:

- Scientific and technological challenges must be overcome for the growth of renewable heating and cooling, and improvements in cross-cutting technologies are expected to yield major overall improvements.

- Solar thermal, biomass, geothermal, aerothermal, and hydrothermal are on their own often unable to satisfy 100% of energy demand, but can if combined. Research in combining technologies is necessary.

- Research is needed on components that qualify as cross-cutting technologies: enhanced thermal storages, improvements on thermally and electrically driven heat pumps, and heat sinks.

- In order for cross-cutting technologies to roll-out their multiplication potential to the energy sources considered in the RHC-Platform's Panels, they must be optimised both at the level of single components, and enhanced as tools for building integrated systems.

Optimising renewable energy systems will help to make 100% RES for heating and cooling a reality.

4.1 District Heating and Cooling integrating RES

Main challenges:

Modern district heating and cooling can be improved in many ways. Better materials, equipment and processes will boost efficiency, cost-effectiveness and improve the end-customer's experience of the technology.

To reach high penetrations of RES in district heating requires the development of source systems that can draw on a variety of heat and cold sources to meet customer demand at any time. New information and communication technologies such as real-time smart metering devices and plug-and-play intelligent substations for individual customers, will be needed to regulate energy inputs and outputs in order to optimise the interaction between sources of energy supply and the various temperature demands of customers (see 4.2 – thermal energy storage).

The network, especially if it includes efficient and inexpensive hot and cold stores, can operate as storage opportunity for the various renewable energy sources dependent on fluctuations in natural circumstances. This presupposes the effective accommodation of different energy sources at different temperatures. Solutions to be explored include the adaptation of operational temperature levels throughout the entire network and applying innovative types of pipeline configurations.

Older, less efficient networks must be upgraded with the know-how found in the most modern systems. By 2020 every system in Europe should reach performance levels comparable to the levels attained by the best performing systems deployed in 2012. This requires consistent and flexible quality assessment tools and best-practice transfer. Upgrading production facilities to renewable sources without acting on customer installations, distribution and transport infrastructure would lead to suboptimal results.

To achieve a substantial penetration of RES in urban areas for both heating and cooling will also require a significant expansion of networks based upon integrated planning of energy generation and heat recycling at local levels.

As regards District Cooling, technological progress should lead to the use of a greater variety of natural cooling sources situated at greater distance from the customer. Further enhancements in the efficiency of cooling cycles and ice slurry technology need to be pursued. Pilot demonstration sites are necessary for testing the large-scale deployment of innovative systems. The use of on-site sorption chillers to supply cooling using District Heat should also be tested at large scale.

The European DHC industry is highly developed in operation and surveillance, but is still a labour intensive industry in the expansion phase. This emerging situation is partly shared with the construction industry. This gives a need to increase the expansion of productivity, especially in the connecting phase (putting pipes into the ground, connecting substations etc.) and in the manufacturing of substations. This challenge can be met by a higher degree of standardisation of working methods and system parts.

For the future, district heating and cooling can offer Europe:

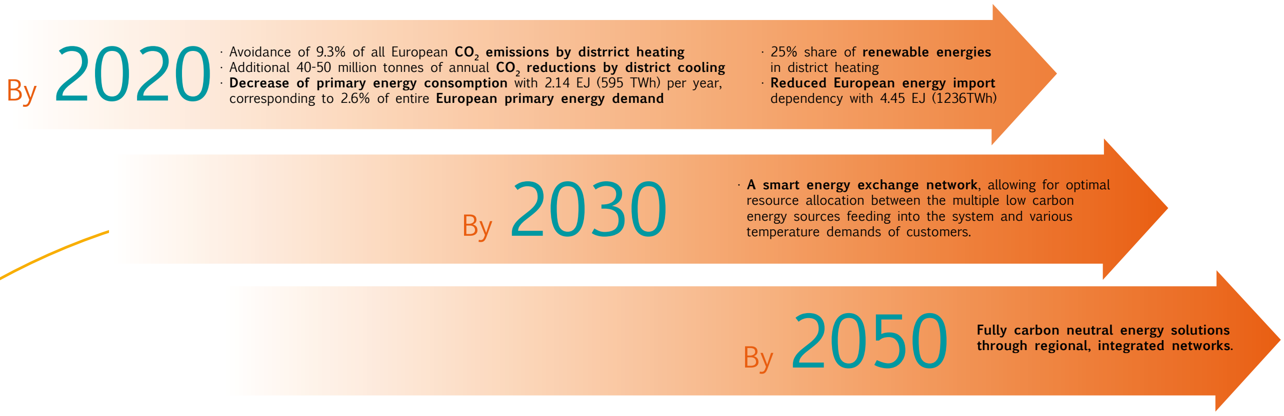


Figure 17 – Potential contribution of district heating and cooling

- In order for cross-cutting technologies to roll-out their multiplication potential to the energy sources considered in the RHC-Platform's Panels, they must be optimised both at the level of single components, and enhanced as tools for building integrated systems.

Optimising renewable energy systems will help to make 100% RES for heating and cooling a reality.

4.2 Thermal Energy Storage

Main challenges:

A key enabler in improving the overall output of renewable heating and cooling technologies is thermal energy storage. Storage allows a greater fraction of the output by the system to be used.

For example, in the case of solar thermal systems, the solar fraction can be increased from 50% to 100% through the use of seasonal storage. This means that without changing the installed collector area, the effective yield of collector systems can be doubled.

For biomass boilers and heat pumps, the number of start/stop cycles can be greatly reduced by using thermal storage. Because by far the largest part of the carbon monoxide and hydrocarbon emissions of biomass boilers occur during these periods, the total emissions of these substances can be reduced by up to 80% assuming a typical operating pattern.

For district heating and cooling networks as well as large-scale renewable heating plants such as geothermal or large biomass plants, the integration of an effective heat storage solution both enhances system performance and enables better utilisation of the system's other assets, potentially reducing costs.

The following key priorities are identified:

I. Storage systems for daily demand-supply matching:

- Enable the exchange of thermal energy at district level between supply and demand nodes at building level (smart thermal grids), where the centralised and decentralised storage system can provide buffering capability of 1-7 days.
- Optimise system performance by using cold storage in cooling and refrigeration applications.
- Store heat decentrally in the form of heat-storing plastering material and storage walls.

II. Storage systems for seasonal demand-supply mismatch for thermal energy needs:

- Further develop large, centralised thermal storage systems, including UTES systems.

- Bring to the market a seasonal heat storage system with an energy density 4-8 times that of water.

III. Integration aspects of storage technologies:

- Integration into energy production/supply systems, building elements, district systems and industrial applications. The target is to minimise system costs, simplify installation, increase the scope of application from new to existing buildings and districts.

In order to achieve these goals, R&D in storage technology must have a high priority. Fundamental research is required to bring about a significant breakthrough in compact, efficient storages. New approaches, like thermochemical storage concepts, need to be explored. Separate development paths are required to try out different concepts since there is no clear winner at present.

4.3 Renewable energy hybrid systems and heat pumps

A “hybrid system” is a system combining two or more energy sources to provide heating, cooling and hot water to buildings or industrial processes.

Today renewable sources can augment existing fossil systems or newly installed renewable systems can be augmented by non-renewable sources. Both qualify as hybrid systems.

In the long term, for optimal sustainability, hybrid systems should be based only on the combination of different renewable energy sources.

Already now, several options exist to cover 100% of the demand for heating and cooling in a building from renewable sources. Hybrid systems are particularly appropriate for the renovation of existing houses. However, most of these solutions have not reached the mass market, which still is dominated by single (fossil) fuel burners and electrically driven air conditioners.

At community level, an increasing number of cities and regions are committed to abandoning the use of fossil fuels altogether, thus forming community hybrid systems for heating, cooling and electricity generation.

Electrically driven heat pumps transform thermal renewable energy at low temperatures from the air, ground or water to heat at higher temperature. They can also use waste energy from industrial processes and exhaust air from buildings, saving energy compared to conventional heating systems and increasing thereby the share of renewable energy in total final energy consumption. A heat pump consists of a heat source, the heat pump unit and a distribution system to heat/cool the building or industrial process. A transfer fluid transports the heat from a low-temperature source to a higher temperature sink. The electrical energy needed to run the compressor and the pumps can be reduced by reducing the temperature gap between the heat source and the heat sink. Therefore low-energy heat distribution systems play a major role in allowing heat pumps to work efficiently. The direction of the cycle can be switched so the same machine can be used for heating and cooling giving it an additional economic advantage in cases where both processes are needed.

In **thermally driven heat pumps** (sorption chiller) the compressor is replaced by a thermal sorption cycle. Therefore thermal energy is needed to drive the cycle and electricity is needed only for auxiliary components like pumps to circulate the working fluid. Thermally driven heat pumps are mainly used for cooling purposes in combination with waste heat or heat produced by renewable sources. Sorption chillers can be used for air conditioning of buildings with driving temperatures between 70°C and 100°C, or for refrigeration purposes, where driving temperatures of over 100°C are needed to reach temperatures below 0°C in the chiller. They can be realised in single, double or triple effect leading to enhanced coefficient of performances and achieving driving temperatures up to 250°C. A wide range of renewable energy source and technology combinations can reach a wide range of possible driving temperatures.

The future of heating and cooling systems will consist of hybrid systems. These systems will have to offer high efficiencies, be reliable, meet end-users' expectations and successfully combine their source energy inputs, which might be available stochastically (sunlight), might have been stored, or originate from non-renewable sources. In order to do so, individual components have to be optimised (see Chapter 3). On the other hand, an in-depth understanding of the system approach is crucial and specific research on integration is needed. In fact, in many cases the system performance of complex systems appears less than the sum of their parts because of sub-optimal hydraulic solutions, a poor choice of supporting components or a bad control strategy. Specific simulation, demonstration and monitoring of research projects is needed to beat the problems associated with complexity. We expect a boom in the number of hybrid systems on the market if these problems can be solved.

The following technological barriers should be addressed to successfully implement hybrid systems:

- **Small scale applications:** Research should be undertaken with the aim of reducing the size of hybrid systems, to improve their reliability and efficiency as whole systems (i.e. they should be available as turn-key products) as well as focusing on the reduction of cost to make them competitive with existing solutions. Systems should be designed on the assumption that buildings and industrial processes will be more energy efficient.

- **Large-scale applications:** With regard to district heating and cooling technology, research should focus on the best combination of RES at the centralised and decentralised level (for example, small "cold source" networks centrally fuelled from solar thermal, biomass, geothermal and other sources, and connected to decentralised, independent heat pumps). Large-scale applications must also address industrial processes.

- **Control and automation of systems:** one major challenge that should be tackled is related to the control and automation of systems. As an hybrid system is not simply an addition of two (or more) separate systems, specific research should be carried on the best way to control the combined system taking into account the stochastic nature of sunlight availability (if it is used in the hybrid system) as well as climate conditions, heating and/or cooling demand forecasting. This research should also address energy performance monitoring as well as early fault diagnosis for continued high performance over the system's lifetime.

- An integrated and adapted control system is necessary for an optimised system. So are a specific **hydraulic scheme** and **optimised auxiliary components** (e.g. heat rejection and water treatment units, pumps, fans).

- **Heat Pump:** Next-generation heat pump technologies (electrically-driven heat pumps using alternative refrigerants, improved sorption heat pump technologies) as well as intelligent system integration of heat pump technologies should be developed and deployed.

In order for renewable energy sources to grow strongly, cross-cutting technologies such as those presented in Chapter 4 will play a major role. The respective influence of each cross-cutting technology has not been quantified. Qualitatively, however, we can say the following:

- For solar thermal, storage of heat is a major bottleneck. Further advances in seasonal and compact storage will have a major impact on the use of solar thermal energy.

- Bioenergy markets will be influenced by the presence of heating and cooling networks as well as by the availability of new intelligent solutions to couple biomass with other RE technologies.

- Almost all applications of deep geothermal use and will use district heating networks. District heating networks are therefore a key enabling technology.

When outlining the potential of renewable energy sources, it is important to distinguish between *the technical potential and the economic potential*.

The technical potential derives from the physical parameters of the system under consideration (e.g. the flow of energy that hits the surface of the earth from the sun, the conversion efficiency of a technology, the space available for energy generation, and the availability of raw material to build the technology). The economic potential is that part of the technical potential that can be realised economically, meaning at a price competitive with relevant alternatives.

This *Common Vision* presents the economic potential of renewable heating and cooling, assuming a CO_2 price of 41 €/t CO_2 in 2020, 45 €/t CO_2 in 2030 and 100 €/t CO_2 in 2050 and oil prices of 100 $/barrel in 2020, 120 $/barrel in 2030 and 200 $/barrel in 2050[10].

[10] This scenario is based on the set of assumptions presented in the publication "RE-Thinking 2050. A 100% Renewable Energy Vision for the European Union" (EREC, 2010).

5. Outlook on the Research needs

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While the European Solar Thermal Technology Platform (now superseded by the RHC Platform) and some other renewable energy Technology Platforms or associations have published research agendas concerning their individual technologies, a joint discussion is being attempted in the RHC-Platform, and this is new.

The RHC-Platform's next work, building on this Common Vision will be to produce a Strategic Research Agenda. Already now, however, some research needs have been identified:

Solar thermal

- Solar collectors:
    - Improvement of cost and performance of low temperature collectors
    - Create a mass market in process heat collectors with working temperatures up to 250°C
- Compact, high density heat storage

- Thermally driven cooling and refrigeration

- Multi-functional building elements like fully integrated façade and roof collectors

- System designs for industrial applications

Biomass

- Improvement of agricultural and forest practices to make them more efficient and better for the environment, with a focus on improving the logistics of biomass supply from crop residues and other additional unexploited biomass sources

- System analysis of the effects of sustainability criteria on production and market potential if implemented at national / local level. Analysis of the impact on bioenergy supply of competition from other end-uses

1. Development of cost-efficient, high-quality and high-energy-content fuels from various biomass sources – e.g. via pre-treatment (biochar for example), blending, compacting, etc
2. Increase system efficiency of and reduce emissions (e.g. particulate emissions) from stoves, boilers and CHP plants from micro to large scale
3. Training of plumbers/installers of new biomass and combined RES systems

Geothermal

- Combined Heat and Power: cogeneration with Enhanced Geothermal Systems and low temperature power plants, micro cogeneration

- Develop commercial deep geothermal projects for industrial use and agriculture, desalination and innovative applications

- Development of large integrated District Heating and Cooling systems in which geothermal energy is flexibly used in different forms, individually or in combination with other RES

- Heat pump performance improvement will also help to increase shallow geothermal efficiency.

- Devices for ground testing and improved design methods for shallow geothermal underground systems

- Measuring consequences on the environment

Some important research topics have also been already identified for cross-cutting technologies:

District Heating and Cooling and large-scale integration of RES

Multidisciplinary research is needed in three thematic areas: competitive technology, sustainable products and intelligent systems. In particular, DHC can benefit from scientific research on:

- Developing the next generation of district heating networks. In order to fully and efficiently realise the energy potential of RES, new system designs for lower temperatures will have to be explored.
- Rationalise the manufacturing of substations by means of harmonising the technical functionalities required.
- Fundamental research is still needed for district cooling, ranging from new cooling sources, conversion technologies, systems design and demonstration installations.

Thermal Energy Storage

- 24-hour-capacity thermal energy stores
- Seasonal thermal energy stores
- System integration of thermal energy storage

Renewable energy hybrid systems and heat pumps

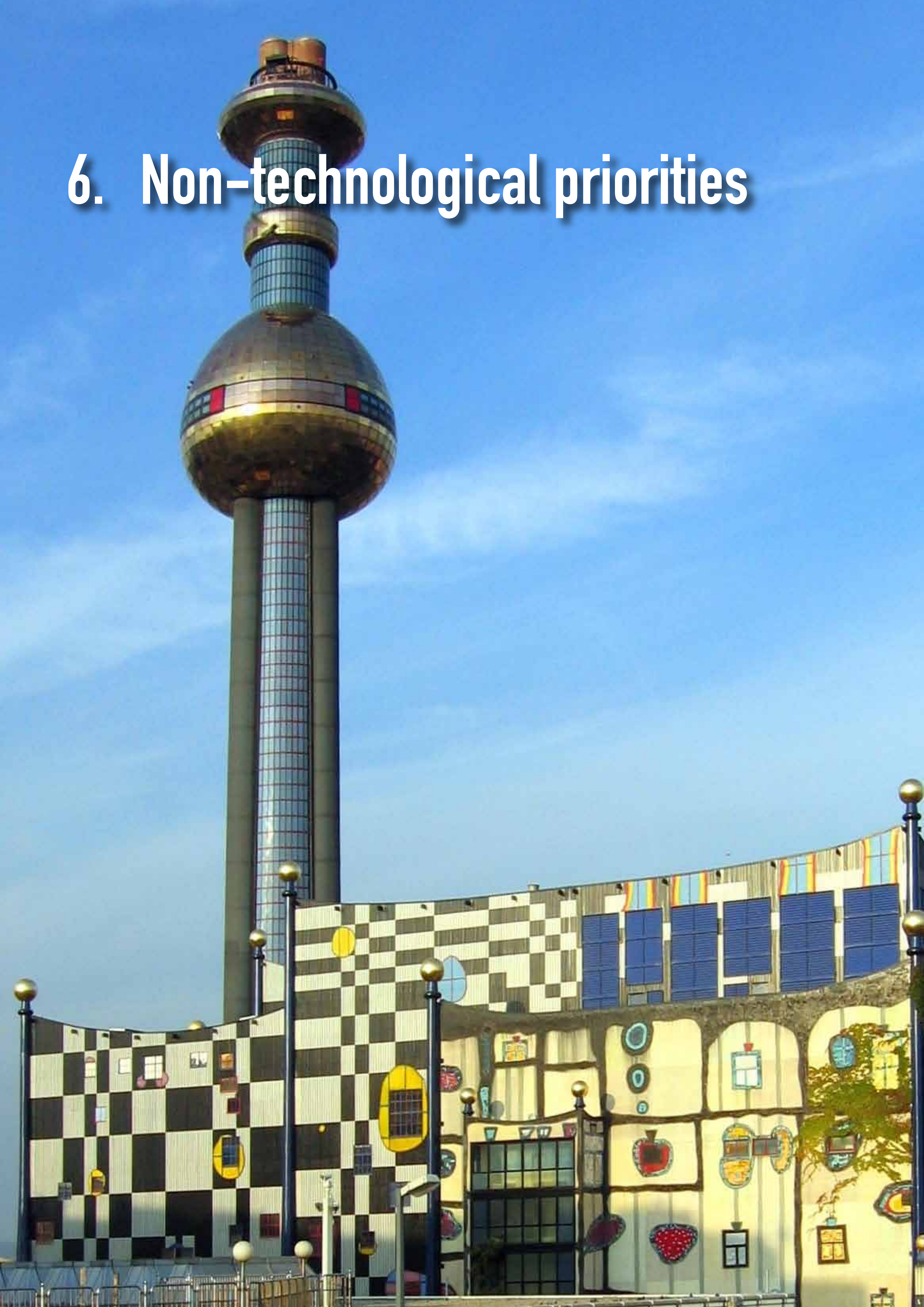
In order to realise the full potential of RH&C, R&D must be carried out in the field of **hybrid systems**. Fundamental research, as well as technological research, is required for high performance level hybrid systems that are optimised at the system-level for different applications.

- Simplified and intelligent hydraulic schemes
- Optimised control systems using each single source in the most efficient way
- Predefined turnkey solutions for RES hybrid systems for single- and multi-family houses

For **heat pumps**, the focus of R&D should be on performance improvement, cost reduction, improvement of environmental performance, both looking at the individual heat pump unit ("next generation heat pumps") and at the intelligent integration of heat pump technology into heating and cooling systems. The topics include:

- advanced control systems
- interface development for the integration of heat pump systems into "smart grids" and "smart cities"
- more efficient compressors and heat exchangers
- heat pumps with low refrigerant charge and refrigerants with a lower Global Warming Potential
- heat pumps with higher temperatures (70-90°C)
- cost and size optimisation of thermally driven heat pumps (economies of scale will certainly help)
- optimisation of support components of thermally driven heat pumps/chillers (heat rejection units, pumps, ...)
- enhancement of efficiency and temperature levels of sorption cycles
- highly integrated, easy to install units for error free installations.

6. Non-technological priorities



Renewable heating can contribute in a big way to Europe's goals for energy efficiency, renewable energy and climate protection. The development of this sector can be spurred not only through technological advancement, but also by the regulatory framework, which has stimulated Europe's renewable electricity sector. Revenue support schemes for renewable electricity have been an effective instrument, in part because the production of electricity could be easily and accurately measured and also because of the small number of parties involved in the sale of electricity: one producer and one counterpart accepting the electricity.

The market for renewable heating and cooling is different: diffuse, with many diverse participants. The heat or cold itself can come in a large range in "energy-quality", or temperature. Application of renewable heating and cooling can be technically fairly complex, needing the replacement of existing infrastructures based on fossil fuels. This makes the development of this market much more complex. The non-technological framework conditions needed to exploit the full potential of renewable heating and cooling can be grouped into five main categories, each containing different conditions:

Policy and Legislation

- Effective and full implementation of the RES Directive (28/2009/EC) in all Member States. Binding energy efficiency targets and renewable energy obligations[11] in both new and existing buildings are essential. In addition, "electricity-only" generation from biomass should be discouraged, with regulation providing an incentive for cogeneration.
- Governments should lead by example and deploy 100% RES in public buildings wherever possible, in particular in buildings visited by large numbers of people (such as schools and other education institutions, trade fairs, public administration buildings).
- More and better quality statistical data related to renewable heating and cooling demand and supply (including the temperature of the supplied heat) should be made available. The RH&C labour market should be monitored. An observatory for the RH&C market would be very useful.
- Authorisation procedures associated with the deployment of RH&C technologies should be streamlined without compromising environmental standards. The costs of obtaining permits should be brought down.

Stimulation / financial support

- The real cost of producing energy from fossil sources should include the environmental and health impact associated with these sources. If these environmental costs were internalised and, at the same time direct and indirect subsides to fossil fuels and nuclear power were removed, many RES would not need subsidies themselves. Until then, specific subsidies/incentives are required for renewable heating and cooling to offset the market failures.
- Renewable energy technologies such as solar thermal and geothermal energy have very low running costs but require a high upfront investment. Financial support is required to reduce the barrier of these high investment costs.
- Increased funding for R&D - from both private and public sources - is crucial for driving down the cost of renewable heating and cooling systems. Large-scale demonstration and dissemination projects, creating critical mass, should also be supported.
- Measures to overcome the "owner-tenant dilemma"[12] are needed for the sector to reach its full potential, in parallel with ongoing support for energy efficiency and renewable energy solutions based on the "energy service company" (ESCO) business models.

[11] Other policy options that can have equivalent or even larger effect include price and quota systems as well as fiscal and financial incentives.

[12] In many buildings, both residential and tertiary, those who pay the bill are not the decision-makers on infrastructure investments. Owners have to be encouraged to make the necessary investments and to be able to benefit from the measures implemented.

Standardisation

- In a global market, the main competitive strength of the European RH&C industry is the high quality of its products. Measures to enforce EU-wide CEN standards[13], certification and quality labels for renewable heating and cooling equipment and systems are therefore required.
- A comprehensive framework for the certification and accreditation of installers should be put in place in order to ensure quality standards are met and customers are kept satisfied. This will in turn spur further market deployment.
- Specifically for bioenergy, an increased focus is needed on the sustainability of the whole chain from biomass production and supply to conversion and use, leading to a unified, transparent EU bioenergy market.

Education / Training

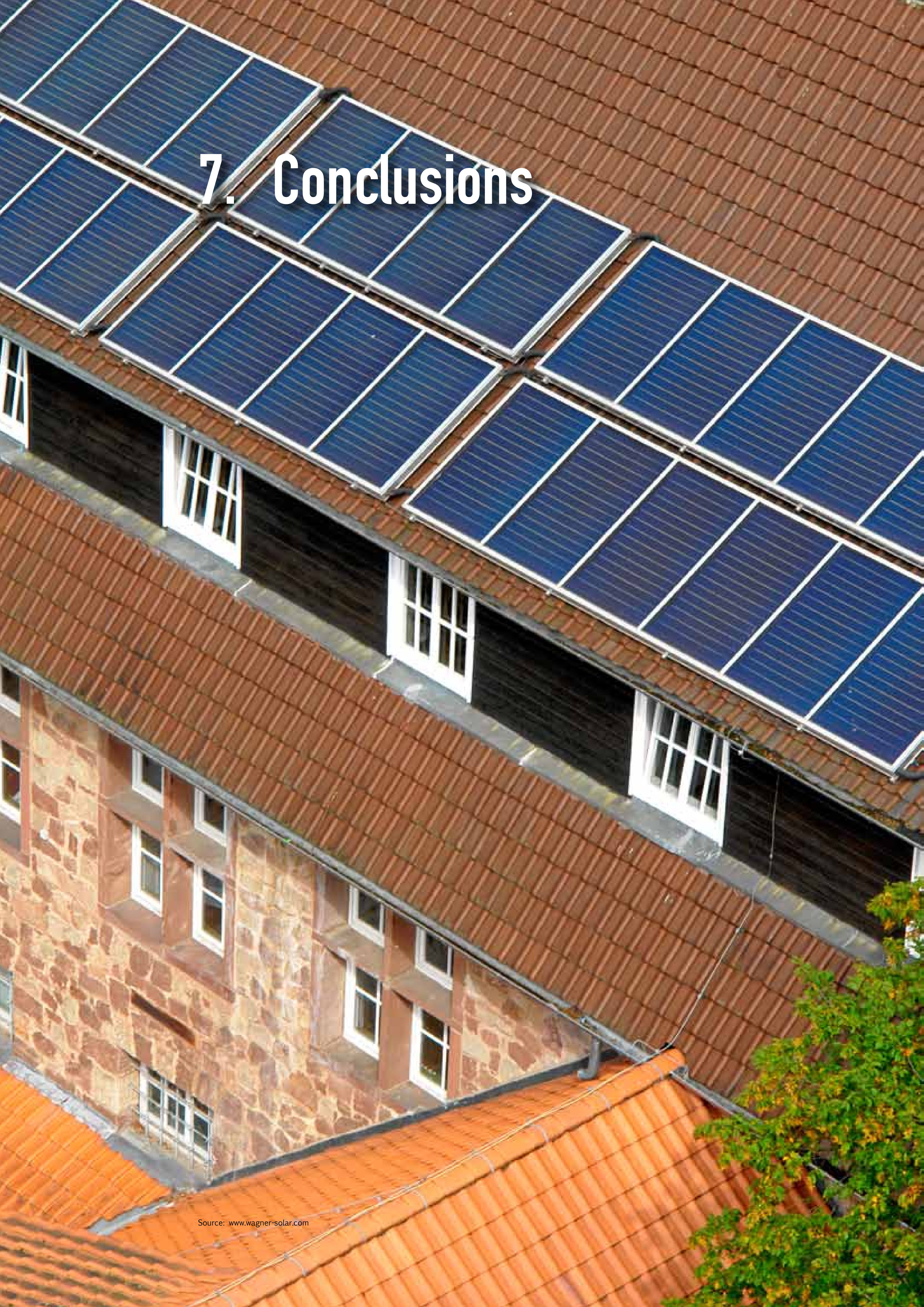
- Knowledge of renewable heating and cooling technologies and equipment should become a standard at all levels of energy education.
- The quality and accessibility of vocational training programs in RH&C technologies will have to be enhanced. From the installers of RH&C systems to agriculture and forestry experts, a variety of high-quality jobs could be created, often in areas that might be suffering from high unemployment. Accelerating uptake of technological innovation in these service providers is also a strategic priority.
- For the renewable heating and cooling industry, an infrastructure / network for knowledge exchange, e.g. as a joint Heating and Cooling Laboratory, is necessary to make sure the latest technological expertise is shared.

Communication

- Renewable heating and cooling technologies are still unfamiliar to many. A communication campaign is needed informing different groups of decision makers (end-users, advisers, authorities, etc;) of the potential of RH&C. This campaign should focus on the actual costs, benefits and risks associated with renewable heating and cooling technologies, provide comprehensive information on the potential of hybrid systems and promote the advantages of ESCO or contracting schemes.
- Public support is of the utmost importance. In parallel, politicians must be convinced that RH&C can play a key role in reaching the 2020 targets for renewable energy.

[13] The European Committee for Standardisation (CEN) is responsible for the planning, drafting and adoption of European Standards and technical specifications.

7. Conclusions


Source: www.wagner-solar.com

The objective of this report was to set a short-, medium- and long-term vision for the heating and cooling systems in the European Union, taking into account on one hand the expected trend of energy demand and consumption patterns, and on the other the potential of renewable energy sources to provide a secure and sustainable supply of heating and cooling.

Heating accounts for a significant proportion of Europe's energy demand. Efficiency gains are required in both residential heating and industrial processes, better use of thermal energy being crucial for meeting the 2020 renewable energy targets and Europe's 2050 target of a 80-95% reduction in GHG emissions. Cooling demand is expected to rise significantly in the next years in spite of greater use of energy-saving measures like insulation.

The theoretical and technical potential of renewable energy sources could exceed Europe's total heating and cooling consumption. Nevertheless, discovering how, economically, to realise such potential is a challenge. The optimal combination of renewable energy technologies to meet the thermal energy needs of a given user depends strongly on local conditions such as population density, intensity of use, quantity and quality of available energy infrastructure and resource availability.

The majority of energy use takes place in urban areas, characterised by higher population density, where district heating and cooling networks represent a critical infrastructure to ensure large scale integration of renewable energy sources.

In **2020** over **25% of heat consumed in the European Union could be generated with renewable energy technologies.** The large majority of renewable heating and cooling will still be produced from biomass sources, although solar thermal is expected to have the highest average growth rate among the renewable energy technologies for heating and cooling in the decade 2010 – 2020. Increasingly competitive geothermal, aerothermal and hydrothermal heat pumps will gain market shares as efficiencies rise. The first Enhanced Geothermal Systems (EGS) drillings will be realised, producing heat at temperature suitable for direct use.

Improved thermally driven cooling systems (eg from solar or heat pump technologies) will make it possible to cover around 5% of cooling demand from the service and residential sectors by 2020.

By **2030 renewable heating and cooling technologies could supply over half of the heat used in Europe.** Improved compact and seasonal thermal energy storage systems will be crucial to meeting the heating and cooling requirements in buildings. In most of Europe, biomass will be used for small-scale heating as well as industrial processes; 2nd and 3rd generation biofuels will also play an important role. Solar thermal will satisfy approx. 15% of the overall European low temperature heat demand and it will be increasingly able to meet the heat demand of medium and higher temperature industrial processes. Geothermal heat pumps and geothermal direct use will be firmly established, especially in agricultural applications and for pre-heating industrial processes requiring heat over 250°C. A smart energy exchange network will enable heat at different temperatures from multiple low-carbon energy sources to be shared efficiently between different customers.

By **2050 biomass could contribute 231 Mtoe, while geothermal could account for 150 Mtoe and solar thermal for 133 Mtoe.** Aerothermal and hydrothermal technologies are expected to provide about 75 Mtoe of heat. Integrated in large- and small-scale hybrid systems and coupled with heat pumps and advanced energy stores, renewable energy sources would not only be able to satisfy **100% of the European heating demand**, but also be cost-competitive with any alternative fossil fuels. Whether these targets are met or not depends on economic growth, the evolution of heat demand and the relative price of alternative fuels, all of which are hard to predict over a 40-year time horizon. Major technical challenges must be overcome to make renewable energy technologies fully cost competitive.

However enormous is the challenge ahead of us, it is not only technological. Tomorrow's energy systems are defined by the policy and legal framework we adopt today, which must provide the right conditions to attract large scale public and private investments.

Public support will increase as the full potential of social benefits such as green jobs is realised. Successful deployment of renewable energy technologies also has to take into account the needs of end-users and of others affected by the technology.

Measures on both the supply and the demand side should be taken to address these challenges. In fact, the large scale deployment of RH&C technologies also requires a change in consumer behaviour.

The cross-cutting dialogue nurtured within the European Technology Platform on Renewable Heating and Cooling can potentially provide the kind of integrated solutions that are sought by civil society. Energy consumers are looking increasingly not only for answers to specific technical problems, but for a systemic approach and answers to large scale issues. By including the full range of diverse users, industries and stakeholders, the RHC-Platform's Vision document is a significant contribution to meeting these expectations.

Appendix 1:

Glossary of energy definitions

In energy statistics, or when describing production and usage of energy , different measures of energy have to be distinguished:

- **Primary Energy** is the quantity of energy in a substance as it is found in nature. Coal, crude oil, natural gas and uranium are forms of primary energy, so too are sunlight, wind or water flows and the geothermal heat flux. In biomass, the concept is slightly more complex, as the actual energy source behind plant growth is sunshine (through photosynthesis), while primary energy in biomass typically is deemed to be the plants harvested; with biogas, this kind of reasoning would become even more complicated.

- **Final Energy** typically is defined as the energy after the first conversion step. In fossil energies, this would be either refining the commodities into usable products (solid, liquid or gaseous fuels), or the conversion into other forms of energy, like electricity. In biomass, the energy content of fuels produced from biomass, like cuttings, pellets, biogas and biofuels is also described as final energy, and generation of biogas and biofuels can be considered in analogy. As renewable energy sources are abundant and, by their very nature, inexhaustible, a primary energy factor of 1 is typically assigned to final energy from renewable sources like water, wind or sunshine. As a consequence, in statistics, the values for primary and final energy for these sources are the same. Final Energy also is known under the term Secondary Energy.

- **Useful Energy** is not yet a well-defined term. It describes the energy that actually meets a certain demand for heat, cold, power, and is used in Annex VII of the RES Directive. Distinguishing between final and useful energy is important when considering energy efficiency in buildings, as final energy is the energy supplied from an external source to the building, while useful energy is the amount delivered to a room (for instance) to warm it up. Additional conversion steps are needed to convert a "final"' form of energy into a "useful" form of energy, like the burning of fuel oil or wood pellets, the release of stored solar heat or the operation of a heat pump. Making conversion more efficient and reducing losses in storage and distribution enables more useful energy to be extracted from a given amount of final energy.

Sources of energy statistics (such as Eurostat) normally quote primary and final energy figures. In the RES Directive, all renewable energy targets are given as final energy. When discussing heat demand for buildings or processes, useful energy is considered. Currently, energy statistics and scenarios do not distinguish sufficiently clearly between final and useful energy. The Common Vision might contain inaccuracies to the use of figures derived under different statistical bases, in particular when comparing biomass with solar thermal and geothermal, or all these energy forms with heat from heat pumps. In the latter case the procedure laid down in the RES Directive has been used to derive figures for useful energy. Further development and better statistics will allow greater consistency in future.

Appendix 2:

Terms and abbreviations

AEBIOM: European Biomass Association
BAU: Business as usual Scenario
CCT: Cross-cutting Technology
CEN: European Committee for Standardisation
CHP: Combined Heat and Power
CO_2: Carbon Dioxide
DHC: District Heating and Cooling
DHW: Domestic Hot Water
EC: European Commission
EGEC: European Geothermal Energy Council
EGS: Enhanced Geothermal Systems
EHPA: European Heat Pump Association
EREC: European Renewable Energy Council
ESTIF: European Solar Thermal Industry Federation
ESTTP: European Solar Thermal Technology Platform
ETP: European Technology Platform
EU27: The 27 Member States of the European Union
EUREC: European Renewable Energy Research Centres Agency
GHG: Greenhouse Gas
HP: Heat Pump
km^2: Square kilometre
kWh: Kilowatt hour
MFH: Multi-family houses
Mtoe: Million tons of oil equivalent
MW: Megawatt
MWh: Megawatt hour
ORC: Organic Rankine Cycle
PCM: Phase Change Material
R&D: Research and Development
RDP: Full Research, Development and Policy Scenario
RES: Renewable Energy Sources
RES Directive: European Directive 2009/28. Reference [EU 2009]
RET: Renewable Energy Technology
RH&C: Renewable Heating and Cooling
RHC-Platform: European Technology Platform on Renewable Heating and Cooling
SET-Plan: Strategic Energy Technology Plan
SFH: Single-family houses
SRA: Strategic Research Agenda
ST: Solar Thermal
TES: Thermal Energy Storage
UTES: Underground Thermal Energy Storage

Appendix 3: References

Reference sources are listed in chronological order.

- [ARMINES 2003] Adnot J. et al. *Energy Efficiency and Certification of Central Air Conditioners (EECCAC) - FINAL REPORT.*
- [FEDERCASA 2006] Federcasa, Italian Housing Federation. *Housing Statistics in the European Union 2005/2006.*
- [EUROHEATCOOL 2006] Euroheat & Power. *The European Heat and cold market study "Euroheatcool".* **www.ecoheatcool.org**
- [OECD/IEA 2007] International Energy Agency. *Contribution of Renewables to Energy Security.*
- [EC 2008] European Commission, Directorate-General for Energy and Transport. *European energy and transport – Trends to 2030 — update 2007.* **http://www.energy.eu/publications/KOAC07001ENC_002.pdf**
- [EGEC 2008] European Geothermal Energy Council. *Geothermal District Heating.*
- [ENERGY POLICY 2008] Bürger, V.; S. Klinski; U. Lehr; U. Leprich; M. Nast and M. Ragwitz (2008): *Policies to Support Renewable Energies in the Heat Market.* Energy Policy, 36(3150-3159).
- [ESTTP 2008] ESTTP - European Solar Thermal Technology Platform. *Solar Heating and Cooling for a Sustainable Energy Future in Europe – Vision, Potential, Deployment Roadmap, Strategic Research Agenda.* **www.esttp.org**
- [OECD/IEA 2008] International Energy Agency. *Deploying Renewables - Principles for Effective Policies.*
- [ADEME 2009] Partners in the ODYSSEE-MURE network. *Energy Efficiency Trends and Policies in the EU 27.* **http://www.odyssee-indicators.org/publications/PDF/publishable_report_final.pdf**
- [DHC+TP 2009] District Heating and Cooling plus Technology Platform. *District Heating and Cooling: a vision towards 2020 - 2030 - 2050.* **www.dhcplus.eu**
- [EC 2009] European Commission COM519 final. *Investing in the Development of Low Carbon Technologies.*
- [EU 2009] European Union. *Directive 2009/28 of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.*
- [EGEC 2009] European Geothermal Energy Council. *Research Agenda for geothermal Energy – strategy 2008 to 2020.*
- [EGEC 2009] European Geothermal Energy Council. *Vision of the Geothermal Technology Panel.*
- [ESTIF 2009] Weiss, W.; Biermayr, P.; *Potential of the Solar Thermal in Europe.* **www.estif.org**
- [EUREC 2009] European Renewable Energy Research Centres Agency. *Research Priorities for Renewable Energy Technology by 2020 and Beyond.*
- [OECD/IEA 2009] International Energy Agency. *World Energy Outlook 2009.*
- [RES-H POLICY 2009] Connor, P.; V. Bürger; L. Beurskens; K. Ericsson and C. Egger; *Overview of RES-H/C Support Options.*
- [RHC-PLATFORM 2009] Geothermal Technology Panel of the European Technology Platform on Renewable Heating and Cooling. *Vision of the Geothermal Technology Panel.*
- [RHC-PLATFORM 2009] Cross-cutting Technology Panel of the European Technology Platform on Renewable Heating and Cooling. *Contribution from Focus Group 2 on "Thermal Energy Storage".*
- [RHC-PLATFORM 2009] Cross-cutting Technology Panel of the European Technology Platform on Renewable Heating and Cooling. *Contribution from Focus Group 3 on "Hybrid renewable energy systems – including heat pumps".*
- [SUMMERHEAT 2009] Berliner Energieagentur GmbH. *Meeting cooling demands in SUMMER by applying HEAT from cogeneration – Final Report.* **http://www.eu-summerheat.net**
- [EHPA 2010] European Heat Pump Association: Outlook 2010. European Heat Pump Statistics.
- [EREC 2010] European Renewable Energy Council. RE-thinking 2050. *A 100% Renewable Energy Vision for the European Union.*
- [ESTIF 2010] European Solar Thermal Industry Federation. *Solar Thermal Markets in Europe Trends and Market Statistics 2009.*
- [EU 2010] European Union. EU Energy in Figures – *Statistical pocketbook 2010.* **http://ec.europa.eu/energy/publications/statistics/doc/2010_energy_transport_figures.pdf**
- [OECD/IEA 2010] Mugnier D.; *Solar cooling economics.* IEA Task38 workshop, Aarhus, April 2010.
- [RHC-PLATFORM 2010] Biomass Technology Panel of the European Technology Platform on Renewable Heating and Cooling. *Biomass for Heating and Cooling – Vision Document.*

Appendix 4:

Secretariat of the RHC-Platform

This document was prepared by the European Technology Platform on Renewable Heating and Cooling (RHC-Platform).

The Secretariat of the RHC-Platform is financially supported by the Seventh European Framework Programme for Research and Technological Development of the European Commission (Grant Agreement n. 268205).

SEVENTH FRAMEWORK PROGRAMME

The Secretariat of the European Technology Platform on Renewable Heating and Cooling is coordinated by:

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European Renewable Energy Research Centres Agency

and managed together with:

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European Biomass Association

EGEC GEOTHERMAL

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ESTIF European Solar Thermal Industry Federation

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European Commission
2020 – 2030 – 2050 – Common Vision for the Renewable Heating & Cooling sector in Europe
European Technology Platform on Renewable Heating and Cooling

Luxembourg: Publications Office of the European Union

2011 - 48 pp. - 21 x 29.7 cm

ISBN 978-92-79-19056-8
doi:10.2788/20474

LB-32-11-644-EN-C

Renewable Heating & Cooling
European Technology Platform

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Publications Office

ISBN 978-92-79-19056-8