A Strategic Research and Innovation Agenda for Renewable Heating and Cooling: Key Findings

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ABSTRACT

This paper presents the main findings of the Strategic Research and Innovation Agenda for Renewable Heating and Cooling (RHC-SRA) published in April 2013 by the European technology Platform on Renewable Heating and Cooling (fig. 1). The RHC-SRA provides stakeholders with a structured and comprehensive view of the strategic research priorities which are necessary to increase the share of heating and cooling supplied by Renewable Energy Sources (RES). The contribution of RES to the EU energy targets by 2020 and beyond will be determined by the availability of reliable, efficient and affordable heating and cooling technology.

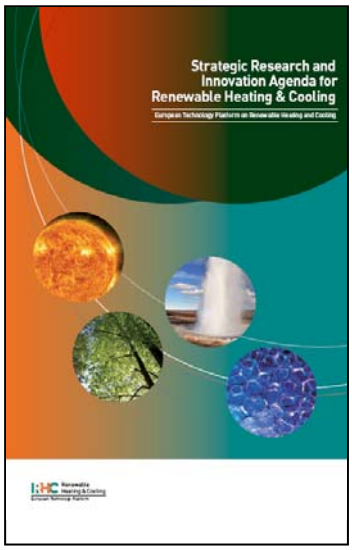

Figure 1: The RHC-SRA document

The RHC-SRA clearly identifies the R&D activities and investment areas needed to make RHC technologies cost-competitive in all market segments (residential, non-residential, and industrial) by 2020 (in some cases by 2030). Specific, measurable targets are identified for each research and innovation priority. These technology-specific targets are often expressed in terms of cost reduction and/or efficiency gain; however the implementation of the RHC-SRA in its entirety requires a system-wide approach to produce innovative integrated solutions.

The total volume of resources required to implement the RHC-SRA by 2020 is estimated at around 4 billion Euro, of which ca. 60% is expected to come from the European industry. For each Euro invested by the public sector (European Commission or Member States), 3 Euros should be committed by the private sector. The RHC-Platform recommends the European Commission to support the implementation of the RHC-SRA by allocating a yearly budget of 114 million Euro to RHC research and innovation projects.

1. INTRODUCTION

Renewable Energy has proven to be a driving force for Europe's economic growth and sustainable long-term prosperity. Renewable energy technologies offer a safe, reliable, clean and increasingly cost-effective solution to all heating and cooling needs, which account for nearly half of the final energy consumption in the European Union.

The vast majority of energy supplied for heating and cooling is however still produced by burning fossil fuels such as oil, gas and coal – with a severe environmental impact arising from the associated greenhouse gas emissions and posing a risk in terms of energy security.

It is against this background that in 2008 the European Commission (EC) supported the establishment of the European Technology Platform on Renewable Heating and Cooling (RHC-Platform) with the aim to create a common framework within which European industry and research stakeholders can define technological research needs and strategic priorities to increase the use of renewable energy sources (RES) for heating and cooling and to consolidate EU technological leadership.

With the publication of the *Common Vision for the Renewable Heating & Cooling sector in Europe* (RHC-Platform 2011), the RHC-Platform proved that

the theoretical and technical potential of renewable energy sources can under the right conditions exceed Europe's total heating and cooling consumption. However, the report also pointed out that discovering how to make such a potential economically viable remains a challenge.

In order to realise the Common Vision, in 2013 the RHC-Platform launched a "Strategic Research and Innovation Agenda for Renewable Heating and Cooling" (RHC-Platform 2013), a key publication which addresses the short, medium and longer term R&D needs in the field of renewable heating and cooling technologies and puts together the strategic research priorities identified for geothermal as well as for the other renewable energy technologies.

The RHC-SRA sets out the likely directions of technological and organisational changes that will need to be converted into specific research activities over the next years, starting from Horizon 2020 (2014-2020). Furthermore, it aims to facilitate the coordination of other research programmes in and between member states. As market growth to a great extent depends on major technological advances, the implementation of the RHC-SRA, along with appropriate market conditions, will be crucial to realise the shift to a renewable energy system in which European citizens can enjoy affordable and sustainable heating and cooling services.

2. OVERIEW OF THE STRATEGIC RESEARCH AND INNOVATION PRIORITIES

The RHC-SRA distinguishes three profiles of heating and cooling demand: residential sector (Table 1), non-residential buildings (Table 2), and industrial processes (Table 3). Local constraints such as the relative abundance of different forms of renewable energy but also the required temperature, the consumption profile, the thermal demand density, etc. affect the choice of technology.

Table 1: Strategic Research and Innovation Priorities for the Residential Sector (long-term items in *italics*).

Solar Thermal	ST1	New surfaces, coatings, materials, constructions designs, and manufacturing technologies for solar thermal collectors
	ST2	Cost effective solar based hybrid systems able to satisfy the entire building heating demand
	ST3	Optimised heating systems for 'Solar-Active-Houses'
	ST4	*Research on the next generation of the Solar Active House – the Smart Solar Building*
	ST5	*Improving the components of solar thermal cooling systems*
Biomass	BIO1	Improve system design of residential biomass heating systems
	BIO2	Demonstrate the potential of efficient biomass boilers and stoves to improve air quality and reduce energy consumption
	BIO3	Cost-effective micro-CHP systems
	BIO4	*Development of next generation of firewood stoves (and insert appliances and cookers)*
	BIO5	*Fuel flexible residential scale boilers*
Geothermal	GEO1	Optimisation of ground-couple technology (i.e. technology to exchange heat with the ground in an optimal way)
	GEO2	Improving the understanding of the shallow geothermal reservoir
	GEO3	*Research on pipe material for borehole heat exchangers (BHE) or horizontal ground loops*
Cross-cutting	CCT1	Cost competitive heat pump kit for houses with existing boilers
	CCT2	Optimisation of thermally driven heat pumps and their integration in the boundary system
	CCT3	Automation, control and long-term reliability assessment
	CCT4	*Developments of heat pump for near-zero energy buildings (single family house)*
	CCT5	*Next generation of highly integrated, compact hybrid systems*
	CCT6	Next generation of Sensible Thermal Energy Storage
	CCT7	*Improving the efficiency of combined thermal energy transfer and storage*
	CCT8	*Increased storage density using phase change materials (PCM) and thermochemical materials (TCM)*
General	RHC1	Developing standards for the overall system design and for hydraulic and electrical interconnections of different building components
	RHC2	Elaborating standards, tests, and benchmarks for system efficiency

Table 2: Strategic Research and Innovation Priorities for Non-residential Buildings (long-term items in *italics)*.

Solar Thermal	ST6	Multifunctioning building components, incl. façade and roof integrated collectors, fir and existing buildings
	ST7	Highly efficient solar assisted cooling systems combining heating and cooling
	ST8	*Solar Based hybrid systems for 100% renewable heat solutions*
	ST9	*Research on new absorption and adsorption chillers*
Biomass	BIO6	Cost effective solutions to reduce dust emissions
	BIO7	Cogeneration technologies and small scale biomass gasification technologies
	BIO8	*Development of advanced cost-effective high quality solid and liquid biomass fuels from agro-biomass, bio-degradable waste, forestry and aquatic biomass*
Geothermal	GEO4	System concepts and application for geothermal cooling in warm climates
	GEO5	Development of ground coupling technologies and installation techniques for high capacities
	GEO6	*Integration of design of the shallow geothermal system and building energy system with regard to optimum thermal use and operational strategy*
Cross-cutting	CCT9	High capacity heat pump for simultaneous production of cold and hot water for heating/cooling the building
	CCT10	Integration, automation and control of large scale hybrid systems for non-residential buildings
	CCT11	*Sorption cooling systems driven by hot water at moderate temperatures*

Table 3: Strategic Research and Innovation Priorities for Industrial Processes (long-term items in *italics)*.

Sol. Th.	ST10	Medium temperature collectors developed and demonstrated in industrial applications
	ST11	*Turn-key solar thermal process heat systems*
Biomass	BIO9	Development of highly efficient large scale or industrial CHP with enhanced availability and high temperature heat potential
	BIO10	*Development of high efficient biomass conversion systems for tri-generation (heating cooling and power)*
Geo-thermal	GEO7	Geothermal Heat for industrial processes up to 250C
	GEO8	Production pump technology for temperatures >180C
	GEO9	*Unconventional resources and very high temperatures*
Cross-cutting	CCT12	Enhanced industrial compression heat pumps
	CCT13	Process integration, optimisation and control of industrial heat pumps
	CCT14	*Improvements in Underground Thermal Energy Storage (UTES)*
	CCT15	*Improvement of sorption cooling from renewable energy sources*
	CCT16	*New Concepts for industrial heat pumps*

Alongside the description of demand characteristics, the RHC-SRA presents the strategic research and innovation priorities for renewable energy technologies able to meet these diverse profiles of demand in the short-term (by 2020), and medium- to long-term (2030 and beyond). Priorities for District Heating and Cooling (Table 4) are presented separately because advancements are likely to bring benefits to all types of users and to have a positive impact on the entire range of renewable energy supply technologies. Other cross-cutting technologies (CCT) like energy storage, hybrid systems and heat pumps are looked at within the priorities defined for the three demand profiles.

The RHC-SRA is complemented by four individual documents detailing more the R&D-priorities of the three RHC sectors and of Cross Cutting Technologies. These reports were published in April 2012 and provide the sectorial reference to the RHC-SRA. The document on geothermal technology (figure 2) has a section on shallow geothermal and on deep geothermal, respectively. Within the deep geothermal part, a special chapter on R&D for EGS is included. The geothermal R&D priorities have been collected by the Geothermal Panel of the RHC-platform at several larger meetings, working meetings of author groups, and consultation rounds for final verification, over a period from 2010-2012.

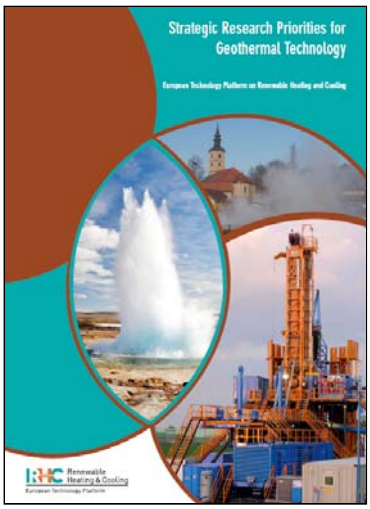

Figure 2: The Strategic Research Priorities for Geothermal Technology of April 2012

3. ENABLING TECHNOLOGIES AND NON-TECHNOLOGICAL PRIORITIES

All R&D activities on RHC technologies must be accompanied and supported by additional research on Information and Communication Technology (ICT) and materials science. As heating and cooling applications become more intelligent, the flexibility available to the energy system is increased and the associated costs lowered. ICT plays an increasing role in reducing the energy intensity of our applications, therefore enabling renewable heating and cooling systems to satisfy a higher share of the energy demand. Materials research is at the core of sustainable technologies for and solutions to our thermal energy needs. Research and development of new materials as well as the understanding and use of their properties is crucial to enable scientists and engineers to enhance energy systems and to realise the full potential of RHC technologies.

In Table 5 an example for material needs is given, with the items for the geothermal sector as listed in the overall materials table in the RHC-SRA. There are two topics from the shallow and one from the deep geothermal sector. Of particular importance in deep geothermal energy is the availability of adequate materials for drilling and production under high temperature and high pressure, and in corrosive environment.

Table 4: Strategic Research and Innovation Priorities for District Heating and Cooling with RES (long-term items in *italics)*.

Solar Therm.	ST12	Optimize large-scale solar collectors arrays for uniform flow distribution and low pumping power
	ST13	Advanced solutions for the integration of large solar thermal systems into smart thermal/ electrical grids
Bio mass	BIO11	Cost efficient CHP plants using biomass and biogas
	BIO12	*Development of CO2-negative bio-energy systems*
Geothermal	GEO10	Deep Drilling
	GEO11	Production technologies
	GEO12	Surface systems for heat uses in DHC (incl. CHP)
	GEO13	*Enhanced Geothermal Systems (EGS)*
	GEO14	*Resource Assessment for deep geothermal heat use*
Cross-cutting	CCT17	Large scale demonstration of Smart Thermal Grids
	CCT18	Booster Heat Pump for DHC
	CCT19	Develop and roll-out DHC driven white goods and low temperature solution for domestic hot water preparation
	CCT20	*Improved highly efficient substations for both present and future lower temperature networks*
	CCT21	*Optimised integration of renewable energy sources in DHC systems and enhancement of thermal energy storage at system level*

Table 5: Material needs for geothermal technologies as listed in the RHC-SRA.

Geot-hermal	Plastic material for BHE with increased thermal conductivity
	Optimum heat transfer fluid for BHE
	Metal alloys or other material for pumps, pipes, etc. in applications above 180 °C, in high-pressure and highly corrosive geothermal environment

Tomorrow's energy systems are defined by the policy and legal framework we adopt today; these must provide the right conditions to attract large scale public and private investments. The market for heating and cooling systems is characterised by asymmetric information. Policies are required that ensure that prospective customers are provided with standardised information about the technological solution that best meets the thermal energy needs of the individual building, district or industrial process. It is a priority to ensure that building sector professionals are aware of the entire spectrum of RHC solutions to make decisions based on life-cycle cost and benefit analyses which take into account future energy prices and CO2 emissions. It is important to address proactively the shortage of skills and any financial barriers that might set back the progress of RHC technology.

4. OUTLOOK ON THE IMPLEMENTATION OF THE RHC-SRA

The RHC-SRA will be implemented with resources from various sources, depending on the nature of the R&D&D priorities and specific needs of the individual technologies. Three complementary routes are considered to leverage resources required to implement the RHC-SRA priorities:

1. Public funding for R&D at EU level
2. Public funding for R&D at Member State level
3. Investments by the private sector

Figure 3 provides an overview of the total resources required for the successful implementation of this RHC-SRA in Europe. The RHC-Platform estimates that 4,032 million Euro are required for the successful implementation of this Strategic Research and Innovation Agenda in Europe. Over the period 2014-2020, on average 576 million Euro should be allocated annually to RHC research and innovation activities. The information provided is based on a quantitative analysis of funding for RHC research, development and demonstration from the public and private sectors in the period 2007-2012 and the expected funding trends to 2020, which rely on a number of assumptions developed by the RHC-Platform. It must be noted that available data is incomplete and the information concerning public investments in R&D for several Member States was not available.

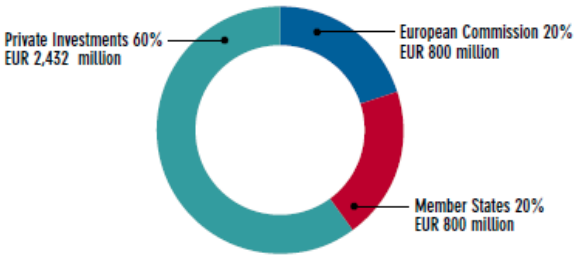

Figure 3: Estimation of total resources required to implement the RHC-Platform's SRA between 2014 and 2020, in million Euro and in %.

The EU should put pressure on its Member States to increase their direct national funding for renewable energy research. It should lead by example and, as a first step, increase its RHC research and innovation budget to 114 mln Euro per year. The current economic climate of public spending austerity should not prevent Member States (at aggregate level) to match the EU spending in RHC research and innovation, which also represent an investment in economic growth, job-creation and sustainable development. Finally, as 60% of the required resources should be invested by the private sector, 347 mln Euro is expected to be committed each year by the diverse industrial components of the RHC sector.

Public and private money is required to perform the short, medium and long term research into all parts of the value chain, as well as non-technological priorities. To realise the potential of the RHC-Platform's Common Vision, activities of fundamental research, development and demonstration are necessary depending on the specific technological maturity of the relevant component or system. This paper recommends that the combined spending of the public and private sector should be strategically distributed among topics with commercial relevance in the short, medium and long term, covering the scale of Technology Readiness Levels (TRL) as illustrated in Figure 4.

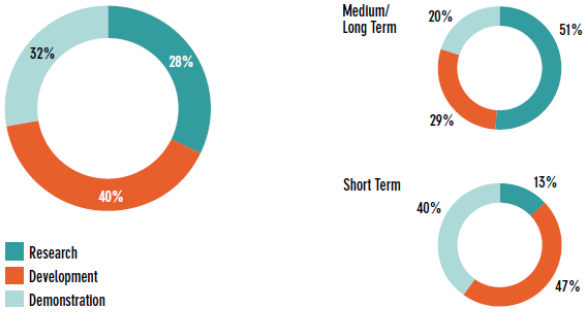

Figure 4: Estimated distribution of resources by type of activity, distinguishing between priorities with impact in the short-term (by 2020), and medium- to long-term (2030 and beyond).

5. CONCLUSIONS

According to the Common Vision for the Renewable Heating & Cooling sector in Europe (RHC-Platform, 2011), the potential of RHC technologies is vast: in 2020 over 25% of heat consumed in the European Union could be generated with renewable energy technologies and by 2030 RHC technologies could supply over half the heat used in Europe. The Strategic Research and Innovation Agenda responds to the need for a detailed analysis of the priorities for Renewable Heating and Cooling technology to take centre stage in the EU energy policy and achieve higher levels of market penetration by 2020 and beyond. Specific objectives and measurable targets are identified for each research and innovation priority;

however the implementation of the RHC-SRA in its entirety requires a systemic approach to produce innovative integrated solutions.

The most important aims, which are common to all RHC technologies, can be summarised as follows:

• Significantly reduce the cost of RHC technologies for different applications and for different capacities.

• Enhance RHC system performance and reliability.

• Reduce RHC system payback time.

Albeit some of the results of the RHC-SRA priorities are expected to be used in commercial applications after 2020 (and in some cases after 2030), it is essential to provide as of today the appropriate R&D support framework to ensure the transition to tomorrow's energy systems. The benefits of strategic planning of investments in research infrastructure usually ripen over a long time frame. A number of technologies such as thermochemical energy storage and EGS which are unlikely to be cost-competitive by 2020, are expected to realise their full potential in the following decade and to become key drivers to realise the RHC-Platform's Common Vision until 2050. Curiosity-driven research in renewable energy technology for heating and cooling, which in the current economic climate has suffered non-negligible budget cuts, holds the potential to lead to a new generation of energy technology options, able to cost-compete with and possibly outperform fossil fuels.

Research and innovation are placed at the heart of the RHC-Platform's agenda as the EU industry competitiveness and ability to create new jobs depends on the capacity to further reduce costs and to improve the quality of energy applications and services. Raising the public-private expenditure for RHC research to the average annual level close to 0.6 billion Euro is crucial to achieve the full RHC industry potential. To this end, support is required at the EU level through different funding instruments, first and foremost HORIZON 2020 which should dedicate to RHC R&D the attention and resources the sector deserves.

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All documents can be downloaded as pdf from the website of the RHC-platform:
http://www.rhc-platform.org

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