



# Innovative Applications of Renewable Heating and Cooling

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**Innovative applications of renewable heating and cooling:**

Project “Key Issues for Renewable Heat in Europe” (K4RES-H), EIE/04/204/S07.38607



**Intelligent Energy**  **Europe**

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## **Executive Summary**

Renewable heating and cooling has a potential far bigger than the most typical applications today. While the heating of the built environment (space heating, domestic hot water) will continue to be the most important market segment, other applications will grow to significant market shares.

A few selected applications with a significant potential are highlighted in this document: Renewable heat for industrial processes, for desalination and for cooling. Their success in the market will play a decisive role in transforming the heating/cooling market from conventional – mainly fossil – fuels to clean and secure renewable energy.

Because these applications are not yet widely available, it is important to understand their specific barriers to growth and consequently the best strategies to help overcome these barriers.

The current main barriers for these applications are typical for “early-stage technologies”:

- Higher upfront investment costs
- Lack of awareness amongst decision makers
- Lack of trained professionals
- Lack of mature and possibly standardised products

In order to overcome these barriers, the following recommendations are made:

- Funding for demonstration projects and awareness raising
- Increased funding for R&D on these applications
- Training of professionals (planners, installers)
- Inclusion of these applications in RES-H targets as well as in policy measures, such as the implementations of the Energy Performance in Buildings Directive



## **Introduction**

This document is published within a series of reports on best practice policies to promote heating and cooling from renewable energy (solar thermal, bioheat, geothermal). The project *Key Issues for Renewable Heat in Europe (K4RES-H)*<sup>1</sup> is co-funded by the European Community under their Intelligent Energy-Europe Programme and the author would like to thank the European Commission for the support we receive.

Most policies, which aim at raising the usage level of renewable heating and cooling, are targeted at typical applications available on the market already today. For example, many EU Member States have financial incentive programmes in place, which give financial incentives to the installation of renewable heating systems for domestic hot water production or space heating.

This type of support has been very important for the growth of renewable heating markets. And while the supported technologies move towards the mainstream, it is important to bear in mind that other renewable heating and cooling applications have not yet reached the level of maturity, and are thus sometimes forgotten in promotional programmes.

## **Scope of this document**

This document provides an overview of some of the most promising “innovative” (or: emerging) applications of renewable heating and cooling. It does not try to be all-encompassing but singles out a few technologies, which have a high potential and for which technology is available at least at demonstration stage:

- Heat for industrial processes
- Desalination
- Cooling

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<sup>1</sup> See: [http://www.erec-renewables.org/projects/proj\\_K4\\_RES-H\\_homepage.htm](http://www.erec-renewables.org/projects/proj_K4_RES-H_homepage.htm)

## Industrial process heat

### Introduction

A large part of the heat demand in Europe is due to the built environment: for space heating and to heat domestic hot water. Both are low-temperature heat demands and thus it is not surprising that they are the leading cases for use of solar thermal, bioheat and geothermal.

Another significant user of heat is industry, where heat is used for everything from washing textiles, preparing or preserving food, to distilling chemicals and to smelter metals. And a lot of these cases require heat at low (up to 100°C) and medium (up to 250°C) temperatures, which could be at least partially covered by renewables.

### Examples

#### Solar thermal heat for a container washing plant in Spain

A facility to wash transport containers in Barcelona has a demand of hot water (80°C) of 1.990 MWh/a. Since 2005, 22% of this demand is covered by a solar thermal system based on flat plate collectors with a total capacity of 357 kW<sub>th</sub> (510 m<sup>2</sup> collector area). The remainder is covered by a conventional boiler using natural gas. The solar thermal system, which uses a 40m<sup>3</sup> tank as buffer storage produces 429 MWh/a of useful solar heat, which results in energy costs savings of 12.200 Euro/a (based on current gas prices).

### Specific barriers to growth

- Preference of decision makers for long-proven technologies: Renewable heat in industrial processes has been successfully proven in various demonstration projects. Nevertheless many decision makers prefer traditional systems, because of longer experience with them. If the heat supply is mission-critical for the company, managers will try to avoid down-times at (almost) all cost. This makes it difficult for any new heating technology to enter this market segment.
- Strong emphasis on short payback times: In commercial settings the short term profitability of an investment is even more important than for private house owners. While the house owner often thinks in longer terms (e.g. in typical lifetimes of a heating system), commercial investors typically look for short payback periods. It is typically the conventional technology that wins under such conditions, even if the benefits over the lifetime of the system are substantial.
- Lack of technology: Many industrial processes require higher temperatures than the typical domestic hot water and space heating applications. New designs, sometimes new materials are needed to cater for these higher temperature demands.



## **Recommendations**

- Funding R&D into new designs, materials; monitoring/optimising system over time
- Financial incentives to install RES-H heating system
- Training of professionals
- Awareness raising targeted at industrial decision makers

## Desalination

### Introduction

Lack of access to clean drinking water is a huge and growing problem in many regions of the world. In September 2000, the world's leaders adopted the United Nations Millennium Declaration, which includes the goal to "Halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation."

Part of the solution to this challenge must be the desalination of sea or brackish water. Already today, the International Desalination Association (IDA) reports 17.348 desalting units worldwide, having a total capacity of producing 37.750.000 m<sup>3</sup> of desalted water per day.

And the market is on the rise. IDA estimates that between 2005-2015 an additional capacity of 31 million m<sup>3</sup> per day is expected to be commissioned. The largest market will continue to be the Arabic Gulf area, while the largest growth market will be the Mediterranean Rim.

Most of these desalination units use huge amounts of energy (heat and/or electricity): Per ton of water 2-5,5 kWh are typically needed. In many countries this makes the use of desalination technology a big challenge – either because a certain area does not have suitable grid access or because the costs of energy are too high. Customers in such regions are typically supplied by water trucks – if at all.

Here renewable energies can play a decisive role: Solar thermal has been used in "solar stills" since the 19th century to produce fresh water. Today various approaches exist to use solar thermal or geothermal energy much more effectively to desalinate sea or brackish water. By providing energy even in areas without grid-access, the use of solar- or geo-thermal energy can bring drinking water to a large number of people.

### Examples

#### Solar thermal desalination in Saudi-Arabia

In November 2005, a solar desalination system was commissioned in Jeddah, Saudi-Arabia. The system has a fresh water capacity of 5.000 litres per day and is supplied by a 98 kW<sub>th</sub> flat plate collector field (140 m<sup>2</sup>). By using a 10m<sup>3</sup> tank as heat storage, the system can be used 24h a day using only solar thermal energy.

#### Geothermal desalination in Greece

Another recent example – still under construction – is the geothermal desalination plant on the Greek island of Milos. With support from the European Community, a project ("MIDES", NNE5-1999-00041) was started in 2000, which aimed at exploring the use of geothermal energy for desalination and power production. An organic Rankine cycle



plant will generate up to 470 kW of electricity and a MED-TVC plant (Multi-effect Distillation-Thermal Vacuum Compression) will provide 75-80 m<sup>3</sup> of fresh water per hour.

### **Specific barriers to growth**

- Trade-off between efficiency and complexity: Desalination based on renewable energy is mostly attractive in regions where grid access is not available or where conventional fuels are too expensive. These conditions can be found mostly on islands and in developing countries. But especially for the latter circumstances, the current desalination systems based on geothermal or solar thermal energy are often too complex, needing too much know-how and regular maintenance.
- Efficiencies of RES-H driven desalination plants are often lower than plants running on electricity. This typically means that if grid access is available, it is often cheaper to use conventionally produced electricity to desalinate water.
- Existing RES-H components are typically not made for the highly corrosive environment of desalination plants. Different materials and designs are needed to cope with these conditions.

### **Recommendations**

- Funding R&D into new designs, materials; monitoring/optimising systems over time
- Financial incentives to install RES-H desalination plants
- Publicly-owned demonstration plants
- Support for dissemination of success stories

## Cooling

### Introduction

Cooling and air conditioning demand is growing at an ever faster pace. Cars are the prime example for this development: 20 years ago, only luxury cars were equipped with an air-conditioning (A/C) unit in Europe. Nowadays most medium-sized cars and even a rising share of the compact cars offer the comfort of air-conditioning as a standard option. In Japan and the US, 90% of all new cars are already sold with A/C and Europe is on its way to catching up. Demand for cooling is rising also in the built environment. 26 million room air conditioners were sold worldwide in 1998 – and more than 40 million sales are forecasted for 2006.

As most of these machines are single-split machines, which have a strong electricity demand, serious problems arise:

- Environmental problems: The rising cooling demand leads to a vast increase in electricity consumption in summer, with all its related problems such as CO<sub>2</sub>-emissions, nuclear waste etc. Furthermore many conventional cooling machines are based on refrigerants with ozone-depleting potential (mostly older systems) and/or strong global warming potential. Their release through leakages, or at unsuitable destruction, can set them free and pose a risk.
- Rising import dependency: As most fuels used in power stations are imported, an increase in electricity consumption necessarily increases the dependence on imported energies.
- Grid stability: The electricity grids – especially in the warmer, southern parts of Europe – are not laid-out to provide the peak loads nowadays encountered on hot summer days. This results in unstable grid operations and eventually to blackouts. Providing the power supply and grid capacities necessary to satisfy peak demand on a few days in summer would be extremely costly.

While not immediately obvious, renewable heating can be used to drive cooling machines. Such thermally-driven cooling machines are either based on a sorption/desorption cycle or on the principle of desiccant and evaporative cooling (DEC). The technology has been used for decades, mainly in connection with industrial waste heat, which was used to drive the cooling machine.

Ab- or ad-sorption chillers have traditionally come in rather large capacities – most often beyond 100kW cooling capacity. This made them unsuitable for smaller use cases such as in office or residential buildings. Only recently have smaller machines emerged, which could be used in these environments (10-20 kW). And even smaller machines (2-5 kW) are on the horizon.

One of the main benefits of thermally-driven cooling machines is their reduction of electricity consumption for cooling purposes. By using renewable heat, the whole process can furthermore be turned CO<sub>2</sub> neutral.



Thermally-driven cooling machines are a very good complement to heating systems: Cooling demand – especially air-conditioning – is highest, when heating demand is low or zero. Thus any renewable heating system, which would be unused or not fully used in summer, could drive a cooling machine. This would increase full-load hours of the heating side of the system.

## **Examples**

### **Wood chips heating and cooling in residential building in Italy**

By the end of 2006, the installation of a heating-cooling biomass system will be completed in the Basilicata Region. The system will operate in a 1.000 m<sup>3</sup> building that acts as a Regional "Formative Centre for Bioenergy applications" in the Matera province. Approximately 60t of wood chips will be used per year for domestic hot water preparation and for space heating/cooling in winter and summer respectively. The biomass boiler (60 kW of thermal capacity) provides heat at 90°C, which drives a 40 kW absorption chiller working with a Br-Li water solution. The system is designed to run approximately 2.000h/a in winter (space heating and domestic hot water preparation) and another 2.000h/a in summer (air-conditioning and domestic hot water preparation).

### **Solar thermal air-conditioning in Turkish hotel**

Since 2004, 180 m<sup>2</sup> of solar thermal trough collectors at a hotel in Turkey produce heat at 180°C to drive a thermally driven cooling machine and to provide steam for the hotel laundry. The cooling machine is the first example of a double-effect absorption chiller. It has a cooling capacity of 116 kW and a COP (Coefficient of Performance) of > 1,2. Back-up is provided through a LPG-fired conventional boiler.

## **Specific barriers to growth**

- Small units, which could compete with mobile split-cooling machines, are still in the phase of field testing.
- Lack of experience with different system designs. Practical guidelines for the design and dimensioning of such systems are still rare.
- Upfront investment costs are still higher than for conventional cooling machines. Simulations for various office buildings have shown upfront investment costs in the order of 2-2,5 higher than for mature conventional systems. Over the lifetime of the systems, the costs are still 20-40% higher than for conventional technologies (based on recent energy prices).

## **Recommendations**

- Larger number of demonstration projects – to get more experience and to increase visibility of this emerging technology.

## **Innovative applications of renewable heating and cooling: Cooling**

Project "Key Issues for Renewable Heat in Europe" (K4RES-H), EIE/04/204/S07.38607



- Funding of R&D efforts: Fundamental research into new cycles, new materials and applied research new components, especially in order to develop smaller units.
- Inclusion of cooling into RES-H targets.
- Inclusion of cooling into Energy Performance in Buildings Directive (EPBD) implementation.
- Ban of hazardous substances in conventional cooling machines

## **Conclusions**

The above discussed applications for renewable heat will become mainstream technologies in the future. At the moment, most of them are not yet viable products in the market, but their potential is high and the technology available today proves very promising. These applications will contribute significantly to replacing conventional fuels and to thus help achieve major energy policy goals: Security of energy supply and reduction of greenhouse gas emissions. Furthermore the use of these renewable energy technologies will create value and jobs within Europe.

It is therefore in the public interest to accelerate the development of these applications and help their market introduction. The following recommendations are addressed mainly at policy makers at national or European level but also at other players in the solar thermal sector, such as manufacturers, research institutes, financial institutions, professional associations etc.

## **Typical barriers to growth for upcoming applications**

The current main barriers for these applications are typical for “early-stage technologies”:

- Higher upfront investment costs: The investment into renewable energy technologies is often profitable. But it typically takes several years to recoup the higher initial investments compared with conventional heating equipment.
- Lack of awareness amongst decision makers: Only a few demonstration plants exist so far. Therefore, it is not surprising that many of the decision makers have not heard of them so far. Without awareness of renewable heating technologies and their application in industry, agriculture and the built environment in general they will not be chosen.
- Lack of trained professionals: Most professionals – especially those in the less developed renewable heating markets – know very little about the planning and installation of such systems. And those that have the necessary knowledge in renewables are typically not experts in other industries’ processes and heat demands.
- Lack of mature and possibly standardised products: Some of these applications are still in their infancy, which means that their performance, their ease of use, their costs etc. are most often not competitive with mature conventional products today

## **Recommendations**

In order to overcome these barriers, the following is recommended:

- Funding for demonstration projects and awareness raising should be increased: So far too few people – and especially decision makers – know about the potential of these new applications. By informing them and the general public, an important step to their market success will be taken.
- Increased funding for R&D on these applications: Typical renewable heating applications have had time to develop. They have become attractive products



and more and more consumers choose to buy them. The innovative applications discussed in this document are not yet there. More R&D will have to be undertaken before they can compete in the market. This will help make better products at lower costs.

- Training of professionals (planners, installers): Without trained and motivated professionals, it is impossible to achieve broad market deployment. Although these new technologies are by no means “rocket science” their design and installation comes with a learning curve. It is important to educate and train these professionals as they are gatekeepers to the heating and cooling markets.
- Inclusion of these applications in RES-H targets as well as in policy measures, such as the implementation of the EPBD: Public policies to support domestic hot water and space heating from renewable energy have proven successful in many countries. It is important that new and stronger policies include also the products of tomorrow.