Solarthermie - F&E Schwerpunkte und deren Implementierungsstrategie

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ETP RHC Basisdokumente
State of the art in Europe

Annual installed capacity of flat plate and evacuated tube collectors from 2000 to 2011
IEA Roadmap vision of solar heating and cooling by sector (EJ/yr)

- Solar water heating: 8.9 EJ/a
- Solar space heating: 7.2 EJ/a
- Solar industrial process heat (low temp): 1.5 EJ/a
- Solar space cooling: 0.4 EJ/a

Total capacity of glazed flat plate and evacuated tube collectors in operation in kWth per 1,000 inhabitants by the end of 2011

Source: IEA Technology Roadmap – Solar Heating & Cooling
Vision of the sector

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.
F&E priorities for residential buildings

Energy costs in €-cent / kWh

- Useful heat from electricity
- Useful heat from natural gas
- District heating
- Central Europe
- Industrial process heat
- Combi-systems
- Central /...
- DHW forced circulation
- DHW thermosiphon

EU27 average: €-cent 7.7

Quelle: ETP RHC (2013)
The overall goals by 2020 are to increase the already high system performance by 10% and to reduce the system costs by 50%. These targets can be achieved by focusing R&D on the following topics:

**ST.1**

**Objective**
- New surfaces, coatings, materials, construction designs, and manufacturing technologies for solar thermal collectors.
- The objective of collector development is the reduction of costs, increase of efficiency, and enhancement of reliability. This will be achieved by transparent cover materials with anti-reflection coatings for high optical transmission, switchable coatings that reduce the stagnation temperatures, highly reflective, light materials for reflectors; new absorber materials with low-emission coatings and optimized heat transfer; temperature-resistant and switchable super insulating materials and alternative medium and high temperature materials like polymers or rubber for collector parts.
- Efficiency can be increased and costs can be reduced by further development of photovoltaic-thermal (PV/T) hybrid collectors, all collectors and low temperature process heat collectors. Also evacuated flat plate and tube collectors with high efficiency can reduce costs in some applications.
- Finally, a continued improvement in the collector construction design and manufacturing processes, focusing on mass production of tailored systems and systematic recycling of materials, will lead to further cost reduction of solar thermal collectors.

**State-of-the-art**
- Today, flat plate collector modules, with about 3.5 m² area, are most commonly used. With special selective absorber coatings, they achieve absorption values of 95% limit inlet emittance to 10%. Sometimes even cover glass with antireflection-coating is used.
- They are used as all-purpose collector modules, since they are produced in relatively high numbers. However, the further reduction of costs requires a change in materials from expensive to cheaper metals, e.g., aluminum, i.e., only for the absorber sheet but also for the piping, or polymers in combination with construction design and coatings and surfaces, which protects the collector against overheating or aggressive environment, and increases reliability.

**Target**
- 50% cost decrease by 2020 for solar collectors inclusive mounting rack and installation.

**Type of activity**
- 40% Research / 50% Development / 10% Demonstration

**ST.2**

**Objective**
- Cost effective solar based hybrid systems able to satisfy the entire building heating demand.
- The objective is to develop solar-based hybrid systems, which provide a full heat supply for small and multifamily residential buildings by combining the solar thermal components with a backup heater in one compact unit including a smart controller. This solution will be particularly suited for the retrofitting of existing systems. This will enable cost reduction of “plug and function” systems for material and installation labour time significantly, since the complexity of the system is limited to the prefabricated inner part of the hybrid unit. The performance will be increased and trouble-free operation of the hybrid heating unit will be achieved. These systems will cover at least 30% of the overall heat demand in residential buildings.
- Innovative system concepts and storage tanks will be developed, which will allow optimal combination of the heat sources. Improved hydraulic designs and components will reduce losses and new controllers will manage the heat flows in an optimal way.

**State-of-the-art**
- Often installers combine a solar thermal system with a backup heater with often suboptimal system designs and hydraulics, a big effort in designing and building the system with a lot of hydraulic connections, and the risk of failures. Often the controllers of both heat sources are not coupled with the risk that they have contradictory control strategies.

**Targets**
- A 50% lower price for the ready installed full heat supply hybrid units as compared to the total investment of a solar thermal system plus a backup heater, which will be replaced by the hybrid unit. The system performance will be enhanced by 30% by increasing the solar yield and reducing system losses.

**Type of activity**
- 25% Research / 50% Development / 25% Demonstration
F&E priorities for non residential buildings
### ST.6 Multifunctional building components, including façade and roof integrated collectors, for new and existing buildings

**Objective**
Solar thermal systems will be integrated into the building envelope by means of multifunctional components. Collectors, storage and other components will become structural elements fulfilling multiple functions in the building, such as heat generation, storage and distribution as well as static function. They will optimise the use of passive and active solar energy in the building, generating heat, adjusting the building temperature, distributing and storing heat.

Some building components will become part of the heating and cooling systems, improving aesthetics and integration of multifunctional components within buildings regarding security and maintenance.

**State-of-the-art**
Today, solar thermal systems are separated from the building structure and heat distribution is increasingly becoming a part of the roof tiles, however it is not common to have functionality, such as ventilation, built into the roof. Considering the outside, a heat distribution network is commonly used. The use of solar technologies in buildings is still in its infancy.

**Targets**
Development of multifunctional building components, e.g. solar collectors as roof and wall components, with high flexibility and low maintenance costs by 2020. Availability of practical demonstration of existing buildings.

**Type of activity**
90% Research / 10% Development

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### ST.7 Highly efficient solar assisted cooling systems combining heating and cooling

**Objective**
The main research regarding cooling components will focus on developing technical solutions to make the systems more economically attractive and well performing on a long-term basis. For the first criteria, plug and function systems will be developed so as to decrease installation costs. These systems will require hydraulic configurations as simple as possible when at the same time leading to very low primary energy consumption when coupled with back-up.

Specific building applications will be identified so as to maximise the solar energy usability all year round as well as cooling at heating (space and DHW). Specific developments are expected on the adaptation of solar to low parasitic consumption through new heat rejection concepts and on system architecture leading to very low cost for operation and maintenance.

Finally lots of effort should be devoted to the development of packaged solutions reducing installation hassle and increasing the level of standardisation of solar cooling systems, either they are small, medium and even large capacity.

**State-of-the-art**
In 2013 about 700 solar cooling systems were installed worldwide, including installations with small capacity (less than 10kW)

Due to the large number of system components, i.e. cooling equipment, solar collectors and heat storage appliances, which are not optimised yet, the investment costs are high and solar thermal cooling systems are not yet cost competitive with conventional electricity driven cooling systems.

**Targets**
Overall efficiency (in equivalent power consumption) of the solar system for heating and cooling of more than 10 (COP) and solar cooling system costs halved by 2020.

**Type of activity**
30% Research / 40% Development / 30% Demonstration

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F&E priorities for industrial processes

Cost of Solar Heat in Europe

Useful heat from electricity
Useful heat from natural gas
District heating
Central Europe
Industrial process heat...
Combi-systems
Central /...
DHW forced circulation...
DHW thermosiphon...

EU27 average: €-cent 7.7
EU27

Quelle: ETP RHC (2013)
### ST.10 Medium temperature collectors developed and demonstrated in industrial applications

**Objective:** Using solar thermal collectors in medium and high temperature (100°C–400°C) systems imposes constraints on collectors.

Applied research should result in the development of new, high temperature-resistant materials, as well as new collector designs. The following aspects are particularly important:

- Adapting and improving collector technology (flat-plate and evacuated tube) which is currently used in low-temperature applications (e.g., either through better insulation or noble gas atmospheres).
- Developing specific concentrating collectors using light-weight, stable, highly performing and dirt-proof or self-cleaning reflectors which are resistant to degradation due to mechanical cleaning and weathering.

Moreover, cost-effective hybrid systems are needed for specific installation and maintenance requirements of large-scale applications.

**State-of-the-art**

Pilot solar systems used for industrial process heat are available in Europe. Many systems for industrial heat are configured to work at higher temperatures than the process would require. Today, arrays of flat plate collectors constitute the majority of the installed capacity due to cost, reliability and modularity reasons. However, the use is limited to low temperature processes.

**Targets**

- 50% cost reduction on installed collector with increased reliability (lower O&M costs).

**Type of activity**

- 10% Research / 50% Development / 40% Demonstration

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### Research and Innovation Priorities

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<thead>
<tr>
<th>Research and Innovation Priorities</th>
<th>Predominant type of activity</th>
<th>Impact</th>
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</thead>
<tbody>
<tr>
<td>ST.10 Optimize large-scale solar collector arrays for uniform flow distribution and low pumping power</td>
<td>Development</td>
<td>By 2020</td>
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<tr>
<td>ST.11 Turn-key solar thermal process heat systems</td>
<td>Research</td>
<td>By 2025</td>
</tr>
</tbody>
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**www.rhc-platform.org**

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**European Technology Platform**
F&E priorities for district heating and cooling

Cost of Solar Heat in Europe

Useful heat from electricity
Useful heat from natural gas
District heating Central Europe
Industrial process heat
Combi-systems
Central /...
DHW forced circulation...
DHW thermosiphon...

Heat costs in €-cent / kWh

Quelle: ETP RHC (2013)
ST.12 Optimize large-scale solar collector arrays for uniform flow distribution and low pumping power

Objective
Development of large-scale collectors and advanced hydraulic concepts, which are especially designed for large collector arrays. Basic theoretical computational approaches should be developed and validated by means of adapted methods (CFD, laboratory measurements, and measurements at large real solar collector fields). Particularly, the flow and temperature distribution, as well as the total efficiency and the electricity consumption of pumps and the related friction pressure loss at all hydraulic levels have to be considered. These advanced large-scale collectors, hydraulic concepts, calculation and simulator tools have to provide uniform flow distribution, reduced pumping power and favourable stagnation behaviour. Furthermore, also cost-effective fixing systems are needed.

State-of-the-art
Due to their size and the need to adapt to each specific application, large-scale systems for solar district heating, industrial process heat, agricultural and water treatment applications are tailor-made. This implies more complex design, such as planning system hydraulics. State-of-the-art collector costs around € 200/kWh (€ 200/ m² when ground mounted) and € 300/kWh (€ 250/ m²) when mounted on flat roofs. Currently, the main challenge is to achieve a theoretically correct design of a large-scale collector field, as well as modelling parallel connections comprising multiple hydraulic levels (collectors, zones, groups).

Targets
Cost reduction of 50% compared to the field cost of state-of-the-art collectors.

Type of activity
50% Research / 30% Development / 20% Demonstration.

Research and Innovation Priorities

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<tr>
<td>ST.12 Optimize large-scale solar collector arrays for uniform flow distribution and low pumping power</td>
<td>Research</td>
<td>By 2020</td>
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<tr>
<td>ST.13 Advanced solutions for the integration of large solar thermal systems into smart thermal/electric grids</td>
<td>Research</td>
<td>By 2020</td>
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Implementing Roadmaps

1. Solar Active House
2. Solar based compact hybrid heating systems
3. Solar heat for Industrial Processes

Thank you for your Attention
Objectives
The main objective of the SHIP Roadmap is to reduce significantly the cost of solar heat, to overcome technical and non-technical barriers and to contribute to the significantly increased use of solar heat in industrial processes.

Scope
The scope of the SHIP Roadmap are all industrial applications with process temperatures up to 250°C.
Technologies

• Flat plate collectors (covered and uncovered)
• Evacuated tube collectors
• CPC collectors
• All kinds of concentrating collectors (parabolic trough, Linear fresnel...)

Applications

• All industrial processes with temperatures up to 250°C (sectors: food and beverage industry, textile, metal surface treatment, agro industry; automotive sector...)
• Integration of the solar thermal system on the process level
• Integration of the solar thermal system on the supply level
Size of systems

>500 m² collector area or 350 kW_{th} (0.35 – 10 MW_{th})

The specific objectives of the SHIP Roadmap are:

- Development and demonstration of the next generation of solar thermal process heat-systems (2017 – 2020)
- About 600 SHIP systems installed in different climatic zones and for all relevant industrial applications by 2020
Phase I 2014 - 2017

Demo Phase I

<table>
<thead>
<tr>
<th>Milestones</th>
<th>2014 - 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications up to 100°C using non-concentrating collectors</td>
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<tr>
<td>System price including storage and installation</td>
<td>€350/m²</td>
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<tr>
<td>Solar heat cost</td>
<td>5 - 8 €cent/kWh</td>
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<td>Applications up to 250°C using concentrating collectors</td>
<td></td>
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<tr>
<td>System price including installation but excluding storage</td>
<td>€400/m²</td>
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<tr>
<td>Storage</td>
<td>100Km²</td>
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<tr>
<td>Solar heat cost</td>
<td>6 - 9 €cent/kWh</td>
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**Demonstration phase 1:**

**Solar heat price:**
- 5 - 8 €cent/kWh for low temperature applications
- 6 - 9 €cent/kWh for medium temperature applications by 2017

**System price reduction to:**
- € 350/m² (low temp. applications)
- € 400/m² collector area (medium temp.) for systems bigger 1000 m² (including storage and installation).

These *cost optimal solar thermal process heat-systems have to be based on the R&D achievements of FP7 projects and results obtained in member states in the years 2010 – 2013.*
Demonstration phase 1:

Number of Systems to have an impact on the market:
200 systems with a total collector area of 300,000 m² in low temperature (up to 100°C process temperature) SHIP applications

100 systems with a total collector area of 150,000 m² using concentrating collectors have to be installed.

Investment
€ 165 Mill. For all systems
If a subsidy rate of 40% is assumed for the demonstration systems – a broad demonstration system program would require a total budget of € 66 Mill.

Accompanying R&D program
An accompanying R&D program for system development and monitoring would be in the range of additional 22 Million.

Funding
If these programs are split between HORIZON 2020 and the member states an budget of € 50 Mill would be required from EU funds for the time period 2014 – 2017 (annual € 12.5 Mill)
Focused R&D projects
Focused R&D projects

In parallel to the 1st demonstration and market implementation program *focused R&D projects* based on the R&D priorities as outlined in the Strategic Research Priorities for Solar Thermal have to be carried out in the timeframe from 2014 – 2017 in order to be able to achieve a further reduction of the solar heat price and to demonstrate the next generation solar thermal process heat-systems in the timeframe from 2018 – 2020.

**Focused R&D projects**

*Focused R&D projects shall focus on the following topics:*

- Next generation medium temperature solar collectors
- Development of self-carrying collector structures for installation on industrial buildings
- Optimized large-scale solar collector arrays for uniform flow distribution and low pumping power
- Development of the standardized integration solutions for all relevant industrial processes.

[Link to RHC Platform: www.rhc-platform.org]
Next generation solar thermal process heat-systems (2018 – 2020)

<table>
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<tr>
<th>2018-2020</th>
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<tbody>
<tr>
<td>Applications up to 100°C using non-concentrating collectors</td>
</tr>
<tr>
<td>System price including storage and installation €250/m²</td>
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<tr>
<td>Solar heat cost: 3–6 €cent/kWh</td>
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</tbody>
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Next generation solar thermal process heat-systems
Demonstration phase 2:
Next generation solar thermal process heat-systems (2018 – 2020)

Solar heat price:
3- 6 €cent/kWh for low temperature applications
4 - 7 €cent/kWh for medium temperature applications by 2020

System price reduction to:
€ 250/m² (low temp. applications)
€ 300/m² collector area (medium temp.) for systems bigger 1000 m²
(including storage and installation).

The next generation of solar thermal process heat-systems has to be based on the R&D achievements of HORIZON 2020 projects which are carried out in the timeframe from 2018 -2020

Number of Systems to have an impact on the market:
220 systems with a total collector area of 400,000 m² in low temperature (up to 100°C process temperature) SHIP applications

120 systems with a total collector area of 360,000 m² using concentrating collectors have to be installed.

Investment
€ 228 Mill. For all systems
If a subsidy rate of 40% is assumed for the demonstration systems – a broad demonstration system program would require a total budget of € 91 Mill.
Demonstration phase 2:
Next generation solar thermal process heat-systems (2018 – 2020)

Accompanying R&D program
An accompanying R&D program for system development and monitoring would be in the range of additional 44 Million.

Funding
If these programs are split between HORIZON 2020 and the member states an budget of € 66 Mill would be required from EU funds for the time period 2014 – 2017 (annual € 22 Mill)

Results
Cost reduction:

Low temperature applications
10 €cent/kWh  →  3- 6 €cent/kWh by 2020
15 €cent/kWh  →  4 - 7 €cent/kWh by 2020

Demonstration Systems
700 systems
1.2 Mill m² = 1.9 GWth installed

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