Solar Heating and Cooling Technology Roadmap

European Technology Platform on Renewable Heating and Cooling

RHC Renewable Heating & Cooling
European Technology Platform

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Executive Summary

The solar thermal energy sector is at a critical juncture. While solar thermal energy is showing the highest potential among renewable heating and cooling technologies, its share of heating and cooling is still far below 1%. This is against a background of declining or stagnating European solar thermal markets that have ceased growing since 2008. Furthermore, competition from other sources is growing, like electricity being used for heating purposes. Therefore, what will be the future of solar thermal in the European heating and cooling system is an important question.

The solar thermal panel of the RHC-Platform analysed the situation and reached the conclusion that solar thermal energy still offers great potential and has a very realistic opportunity to become a key player in Europe's heating and cooling sector. This is because a significant share of solar thermal energy is needed to develop a secure and sustainable heating and cooling system in Europe, due to the limitations of alternative sources. However, strong technological improvements are definitely prerequisites for the solar thermal sector to make such contribution. This huge technological potential has already been highlighted in the Strategic Research Priorities developed by the solar thermal technology panel and now implementation is needed within the framework of the Horizon 2020 programme. Therefore, research and innovation (R&I) must be accelerated to achieve significant improvements regarding the sector's key objectives, i.e. lower costs for heat production and wider range of applications.

This implementation roadmap presents the key research and innovation actions up to 2020 to develop not only the technological, but also the market potential of the solar thermal energy. Three pathways are identified, which the sector must tackle in parallel: the development of solar compact hybrid systems (SCOHYS) to reduce the solar heat costs by 50% until 2020, technological improvements in Solar-Active-Houses (SAH) as an attractive option to fulfil the requirement of nearly zero-energy buildings and the development of systems supplying solar heat for industrial processes (SHIP) to crack this significant market.

The SCOHYS roadmap pathway is focusing on cost reduction by improving efficiency and lowering the price of components, especially by integrating the solar with the auxiliary heating system, with simpler system design and easier collector installations. R&I is necessary on collectors, storage, hydraulic system, controller and collector mounting in an integrated way for single and multifamily homes. Technological R&I should be accompanied by the development and implementation of standards and quality assurance concepts. It must also include significant progress in socio-economic framework conditions like new business models, support programmes and regulations. To halve the costs of solar heat by 2020 means becoming cost competitive with heat generated by fossil fuels ("fossil fuel parity") in most applications for domestic hot water heating and space heating in Europe. The necessary R&I budget is estimated at 65 Mio € until 2020, which has to be spent by both public and private sectors.

The SAH roadmap pathway is focusing on increasing the share of solar thermal energy for the domestic hot water and space heating demand per building, from about 25% to about 60%, without increasing the solar heat costs. R&I is vital to improve collector arrays, the integration of large storage volumes in the building, hydraulic schemes and control strategies. The system design can be further optimized to increase efficiency, reduce collector surface and storage volume, and, therefore, costs. The first action is to optimize the SAH concept for newly built single family homes, followed by actions to extend the SAH concept to multifamily homes and to the refurbishment of buildings. The technological R&I actions include: basic research on components and system design, prototype development and demonstration, and it should be accompanied by non-technological measures. The total R&I budget is estimated at 74 Mio € until 2020.

The SHIP roadmap pathway is focusing on the standardized and cost optimal solutions to integrate solar thermal technology in all industrial processes, by developing collector structures adapted to industrial buildings, improved large-scale solar collector arrays, and new planning and design tools. A second action is focusing on the development of the next generation of medium temperature collectors for temperatures between 100°C and 250°C. Beside the development of appropriate solutions, the main target of the R&I actions is the significant reduction of solar heat costs to 3-6 €ct/kWh for low and 4-7 €ct/kWh for medium temperature applications. Since the SHIP actions include a large demonstration programme of 700 SHIP systems, the budget is estimated at 450 Mio €.

By implementing this roadmap, the solar thermal sector will be able to play a crucial part in a sustainable energy system as foreseen by the European Union. With reduced solar heat costs as a result of the roadmap implementation, the solar thermal technology will become cost competitive and attractive for customers; therefore contributing to the European goals towards reducing greenhouse gas emissions, stabilizing energy prices and reducing dependency on energy imports. Hence, the sector is calling for a significant increase in R&I support within the framework of Horizon2020.

[1] *European Technology Platform on Renewable Heating and Cooling: Strategic Research Priorities for Solar Thermal Technology, Brussels, 2012*

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Introduction

1 Introduction

1.1 SOLAR HEATING AND COOLING: USE AND OUTLOOK

The future of the energy system will have a dramatic impact on our life and that of coming generations, be it for its impact on climate or on economic growth. It is therefore natural that the European Union is developing scenarios for 2050 aiming at a fundamental transformation of its energy system to achieve a reduction of greenhouse gas emissions of 80% to 95% by 2050. This is while it intensifies discussions on 2030.

Renewable heating and cooling technology will play a vital role among the available options in the sustainable energy system. This has been identified by the European Commission as "no-regret" option in its Energy Roadmap 2050 as it can provide "locally produced" energy. Besides being a decentralized and widely available energy source, it has also an important economic impact: approximately half the investment is allocated to the lower end of the value chain, generating jobs and economic growth at the local level.

Today, about 50% of the final energy demand is used for heating and cooling purposes. In the future, heat demand will be significantly reduced by behavioural changes and efficiency measures e.g. by nearly zero-energy buildings. However, since heat is not only used for space heating, but also for domestic hot water and process heating, roughly 50% of today's heat demand will remain by 2050.

Solar thermal energy, together with biomass and geothermal energy, can be a major source of heating and cooling in Europe. It is an extremely convenient heating source, based on a simple concept enhanced by cutting edge technology. Thanks to technological progress solar thermal has become not only a better option for more traditional applications, such as domestic hot water production, but also an attractive alternative for new and more advanced applications such as industrial process heat.

Solar heating technology can have a strong impact in the market; however, to unlock its potential, technological development is urgently needed. Therefore, experts from the solar heating and cooling sector have gathered together in the Solar Thermal Technology Panel of the Renewable Heating and Cooling Technology Platform and developed this technology roadmap that would help the sector to provide to the market the solutions to critical societal challenges. Hence challenges and solutions are addressed in greater detail in this roadmap.

1.2 CHALLENGES AND OBJECTIVES FOR SOLAR HEATING AND COOLING

Europe has set the goal to increase the share of renewable energy sources (RES) to 20% by 2020. There is good progress in increasing the share of RES in the electricity sector; however, the heating and cooling sector risks missing the indicative target for 2020 by 19.5%[2]. The latest European Commission "Renewable energy progress report" from March 2013 states that the heating and cooling sector *"has experienced slow growth since 2005. Moreover the analysis undertaken for the Commission suggests that the share of renewable energy in the heating and cooling sector may actually decline in the coming years."*

The National Renewable Energy Action Plans of the European Member States describe national targets and policies to contribute to the European 20% RES target. An analysis of the European Solar Thermal Industry Federation (ESTIF)[3] came to the conclusion that the installed capacity of solar thermal collectors must be increased from 27.5 GWth (39.4 Mio m^2) end of 2012 to 120.2 GWth (146 Mio $m^{2)}$ in 2020, to achieve the national goals.

Unfortunately, today's annual installed solar thermal capacity in Europe is not sufficient to achieve these goals and even worse, it has been declining since 2009. This trend must be reversed to achieve the European and national targets.

[2] *Renewable energy progress and biofuel sustainability, ECOFYS et al, 2012*
[3] *Solar Thermal Markets in Europe – Trends and Market Statistics, ESTIF, 2013*

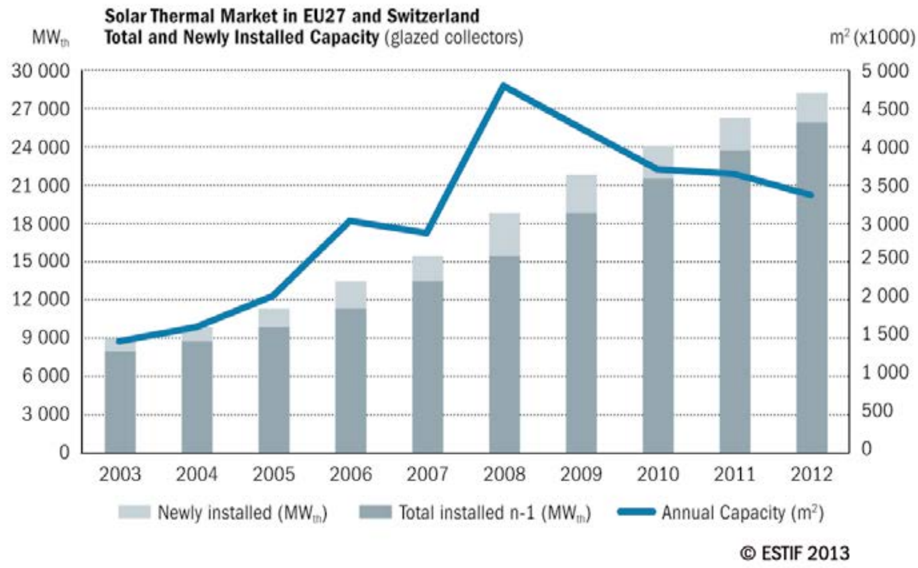

Figure 1: Solar Thermal Market in EU27 and Switzerland. Total and New Installed Capacity

The Roadmap is essentially market oriented to make SHC more competitive and, thus, develop the full potential of social and environmental benefits inherent to solar thermal technologies.

In this roadmap Research & Innovation (R&I) actions are identified to improve significantly the competitiveness of solar heating and cooling technology. Table 1 describes the objectives of the roadmap, which will be achieved in response to the societal challenges.

Challenge	Objective
Increase the competitiveness of solar heating and cooling	Price reduction of solar heat by 50% (in comparison with 2013)
Simplification of the entire heating system including the solar thermal part	Development of easy-to-install compact solar hybrid heating systems with increased reliability and user-friendliness
Major role of solar energy to the heating demand of buildings	Increase the solar fraction (share of solar energy on the overall heat demand) from about 25% to 60% in Solar-Active-Houses
Extend the use of solar heat to new market segments	Adapted solar thermal technology for industrial processes and vice versa.

Table 1: Societal challenges for solar thermal technologies related objectives of the roadmap by 2020

1.3 Solar heating and cooling solutions for societal challenges

This technology roadmap is based on the “Strategic Research Priorities for Solar Thermal Technology”, which was published by the Solar Thermal Panel of the RHC-Platform in December 2012, and the “Strategic Research and Innovation Agenda for Renewable Heating and Cooling”, published by the RHC-Platform in April 2013. These publications presented a comprehensive list of relevant research topics for solar heating and cooling technology. While the previous work has been carried out with a wider scope, taking into account a variety of different applications and solutions, this “Solar Heating and Cooling Technology Roadmap” focuses on a limited number of solutions as an answer from solar heating and cooling to societal challenges like sustainable energy supply, security of supply and stable energy costs.

The roadmap incorporates several research topics in three roadmap pathways, each dedicated to a specific type of SHC application. It aims to identify the actions and tasks to be addressed until 2020 in order to accelerate R&I to achieve concrete results towards a greater deployment of the SHC technology.

Therefore, the roadmap focuses on the timeframe of the European Framework Programme for Research and Innovation “Horizon 2020”. However, together with delivering results with an impact on the market by 2020, there is the need to run basic research projects, which will lead to innovations beyond 2020. These research topics are mentioned as well, but not described in detail.

Thus, the technology roadmap is going to serve as a basis for strategic planning and decision-making related to the SHC sector and as the master plan for the R&I efforts needed until 2020.

1.4 SCOPE AND STRUCTURE OF THE TECHNOLOGY ROADMAP

The roadmap is focusing on R&I actions, which contributes to develop end user solutions and address the main societal challenges related to the sector. It concentrates on the solutions with the most incisive contribution on a wider deployment of the solar thermal technology and on a strong societal impact till 2020.

Thus, the Roadmap is structured in three pathways. For each pathway objectives and R&I actions, which are necessary in order to complete and deploy each one of the solutions, are indicated. The objectives are presented within the time frame 2014-2020 and technological and non-technological R&I actions are described. The technological actions are divided between core technology, materials and enabling technology, and standards and quality. The non-technological ones include socio-economic actions, as well as legal and administrative aspects. Finally, the necessary budgets to implement the R&I actions are estimates.

1.5 TECHNOLOGY READINESS LEVEL (TRL)

For each action the technological readiness levels are identified according the criteria established by the European Commission[4] and presented in Table 2.

Innovation Cycle	Level	Description
Research	TRL 1	basic principles observed
	TRL 2	technology concept formulated
	TRL 3	experimental proof of concept
Development	TRL 4	technology validated in laboratory
	TRL 5	technology validated in relevant environment
Demonstration	TRL 6	technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
	TRL 7	system prototype demonstration in operational environment
	TRL 8	system complete and qualified
	TRL 9	actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

Table 2: Definition of Technology Readiness Levels (TRL)

[4] *Based on European Commission, Horizon 2020 Work Programme 2014-2015; http://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf*

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The technology roadmap

❷ The technology roadmap

To meet the main short to mid-term challenges for a significant increase of solar thermal market share three pathways were identified:

- Development of **Solar Compact Hybrid Systems** (SCOHYS)
- Development of **Solar-Active-Houses** (SAH)
- Development of systems for **Solar Heat for Industrial Processes** (SHIP)

The three pathways of the roadmap are intended to increase the competitiveness of the solar heating technology significantly. How they are influenced by the societal challenges and the R&I actions is shown in Figure 2. The R&I actions are selected from the research priorities which are described in detail in the document "Strategic Research Priorities for Solar Thermal Technology".

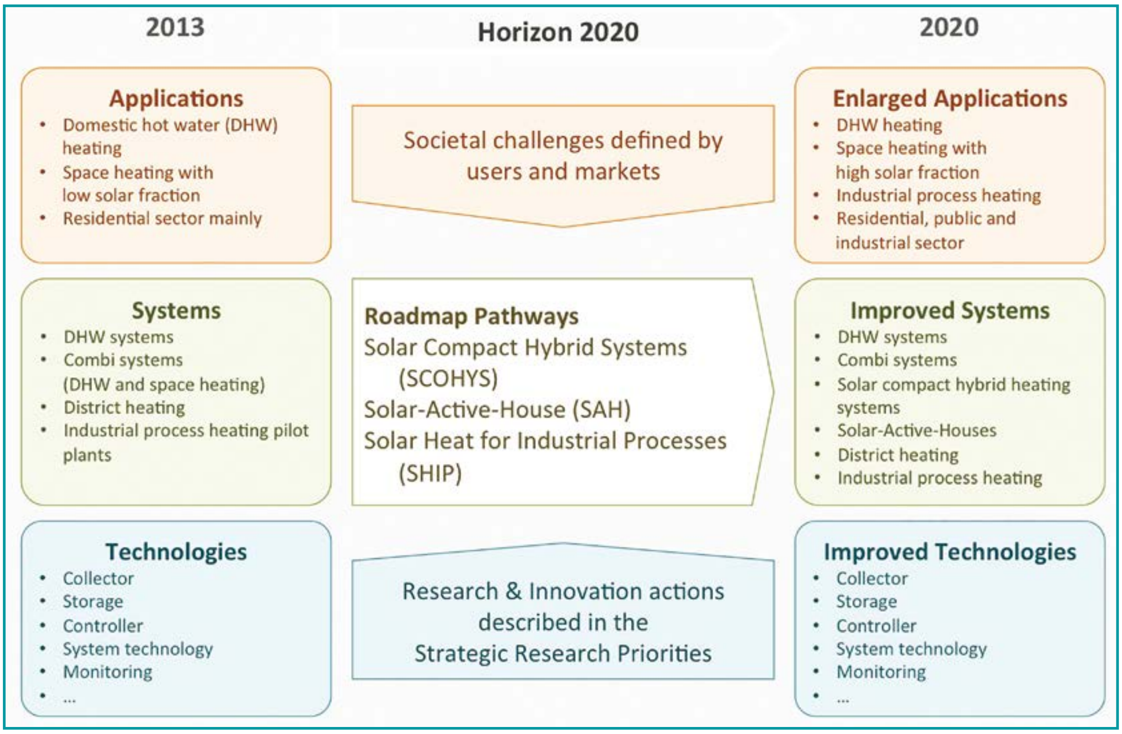

Figure 2: The technology roadmap is focusing on system solutions in three pathways as a response to the challenges defined by users and markets (application oriented) and by implementing R&I actions for technology development described by the Strategic Research Priorities

2.1 ROADMAP PATHWAY 1: SOLAR COMPACT HYBRID SYSTEMS (SCOHYS)

2.1.1 Motivation and objectives

House owners do not want to buy heating components separately, like solar collectors, water storage, backup-heater and other equipment. They want to buy a solution for domestic hot water (DHW) and space heating (Combi systems). This heating solution should be reliable, cost competitive, compact, user and environmentally-friendly, and sustainable.

Twenty years ago, solar heating systems were mainly designed in tailor-made fashion by installers, which combined different components from different manufacturers individually. Today, manufacturers are selling solar systems as units with a high grade of prefabrication. But usually several components of the solar heating systems must still be installed and combined with an external backup-heater by the installer on-site. Usually, manufacturers offer solar systems which can be combined with a huge variety of heating system designs. However, this diversity increase complexity, costs and risk of faults at the time of installation and the risk of suboptimal operation due to conflicts between the controller of the solar system and the backup-heater.

This challenge can be solved by the Solar Compact Hybrid System (SCOHYS), which includes the solar system and the backup-heater in one compact unit. SCOHYS will be a compact solution at reduced costs due to simplified design, only one controller, high grade of prefabrication and reduced installation effort. Due to optimized combination of components and prefabrication the performance and reliability will improve.

The objectives of the SCOHYS roadmap pathway are:

- reduction of the solar heat costs by 50%,
- increased compactness with reduced space requirements and installation time, and
- improved reliability and performance

2.1.2 The SCOHYS roadmap pathway

SCOHYS are compact heat supply systems including a solar and a backup heating source (e.g. based on bio energy or heat pumps) with a solar fraction of at least 50% in the case of DHW SCOHYS systems, which deliver only domestic hot water and of a solar fraction of at least 25% in the case of combi SCOHYS systems, which deliver both, domestic hot water and space heating. The solar fractions are related to typical usage and buildings in central Europe with average heat demand.

The SCOHYS roadmap pathway involves R&I actions for three applications:

- SCOHYS for single family homes (DHW and combi systems),
- SCOHYS for multifamily homes (DHW), and
- SCOHYS for multifamily homes (combi systems).

For the two first applications R&I actions are divided in an applied research phase **(ACTION I)** and a demonstration phase **(ACTION II)**. For the third application development and demonstration is combined in one action **(ACTION III)**. The R&I actions include research tasks on different components and technical aspects and combine them to a holistic approach. In addition, the roadmap identifies actions in the field of enabling technologies, standards and quality, socio-economic framework and legal and administrative aspects. The SCOHYS roadmap pathway and its sub-tasks are shown in Figure 3.

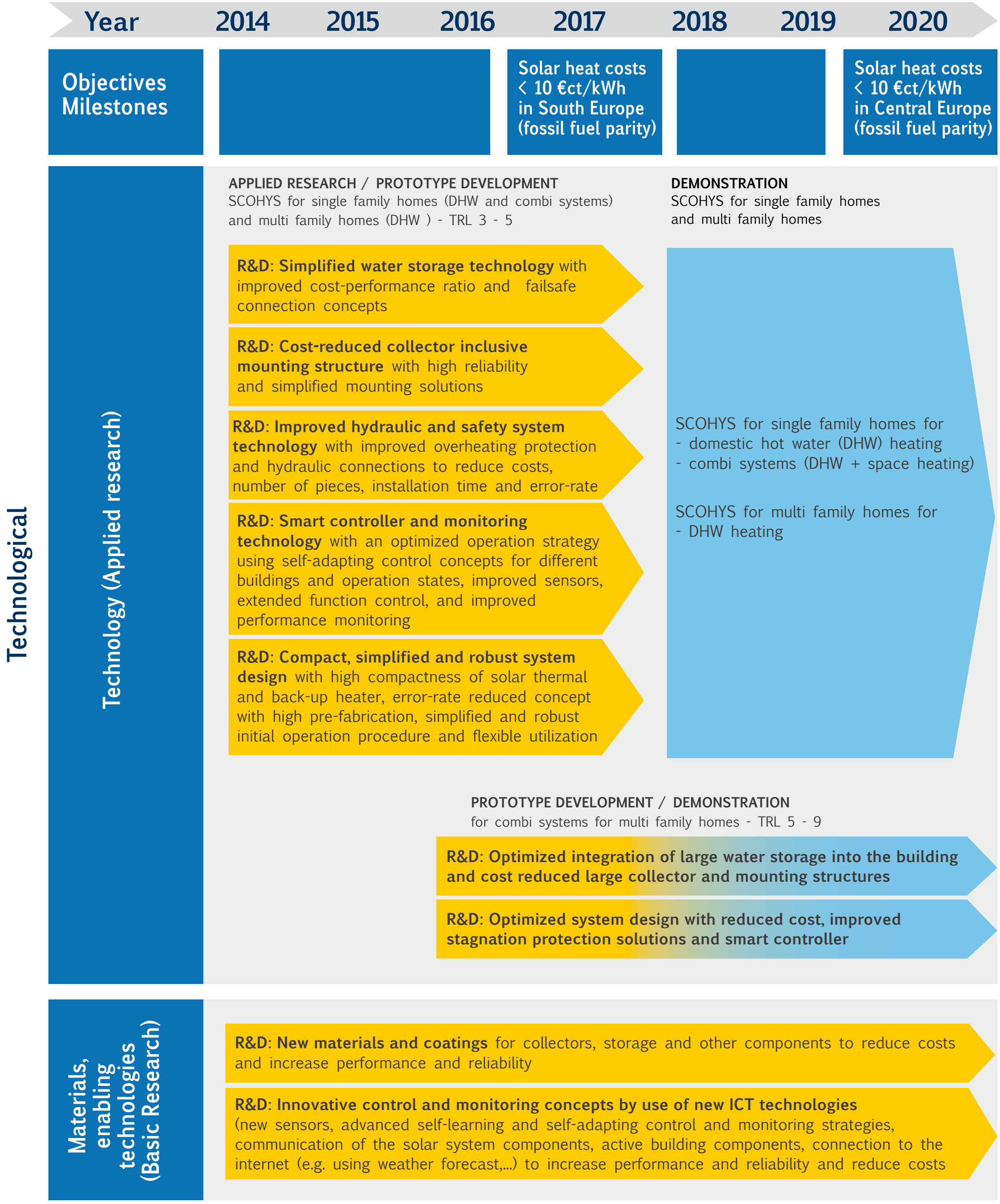

Figure 3: Roadmap pathway for Solar Compact Hybrid Systems (SCOHYS) – part 1

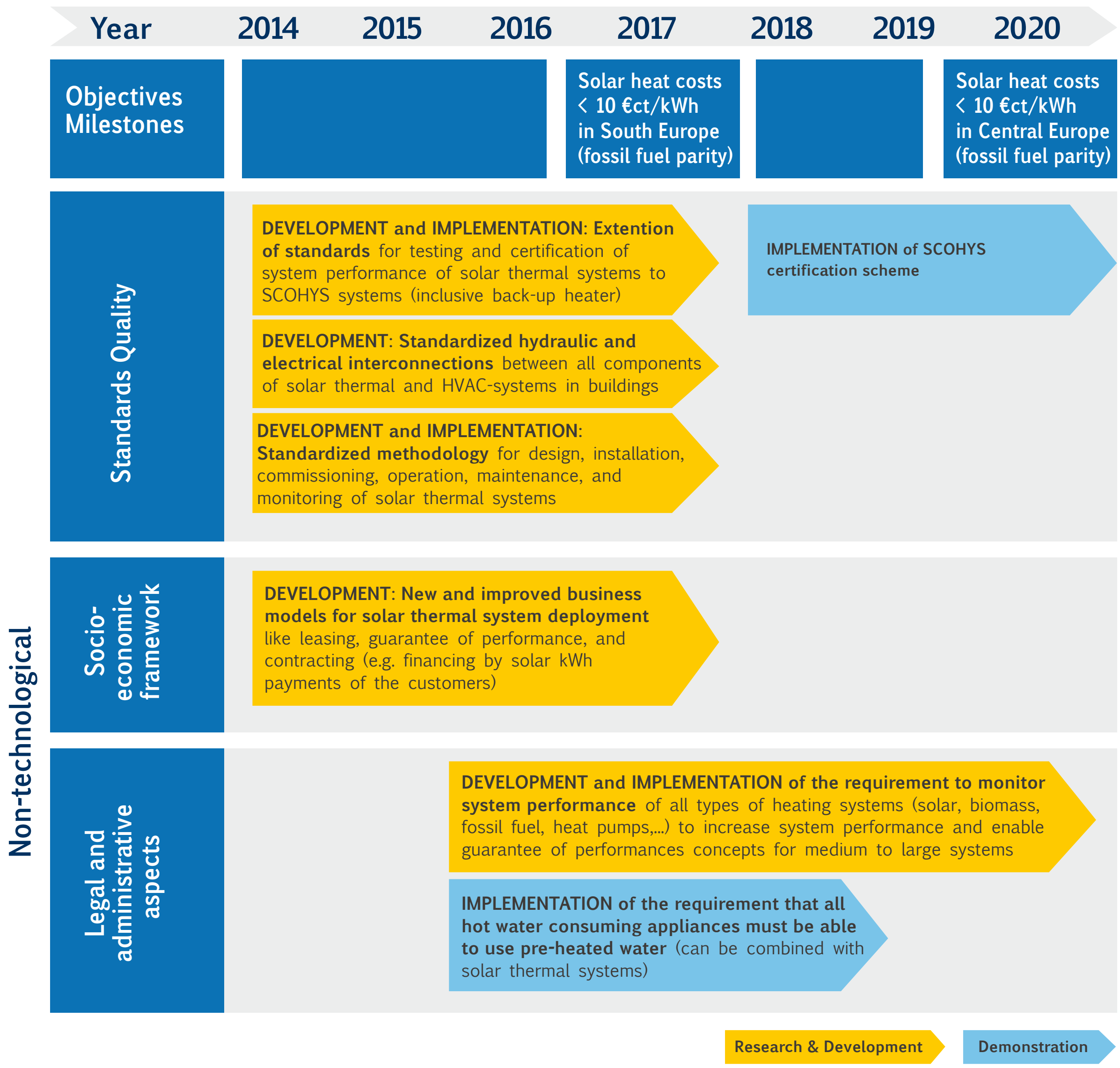

Figure 3: Roadmap pathway for Solar Compact Hybrid Systems (SCOHYS) – part 2

2.1.3 Research actions and budget

Objective	SCOHYS integrates the solar system and the backup-heater in one compact unit to reduce solar heat costs by 50% due to a simplified design, reduced number of components and installation effort. This will further result in an improved performance and reliability due to optimized combination of components and prefabrication and reduced space requirements and especially installation effort. The objectives will be achieved by innovations and improvements in the collector, storage, hydraulic and safety system, controller, and system design technology, partly using new materials and coatings. In addition, innovative control and monitoring concepts with new ICT technologies will be used.
State-of-the-art	Today, most of the solar heating systems are built using system packages provided by manufacturers and system vendors, which are combined with different back-up heaters by the installer on site.
Targets & KPIs	By 2017, SCOHYS will be available as prototype for single family homes (DHW and combi systems) and for multifamily homes (DHW) with solar heat costs reduced by 35% in comparison to 2013, leading to fossil fuel parity in South Europe (< 10 €ct/kWh). By 2020, SCOHYS for multifamily homes will be available as combi systems as well and the SCOHYS systems will be ready for broad market deployment with solar heat costs reduced by 50% in comparison to 2013, accomplishing the fossil fuel parity target for Central Europe.
Type of activity and TRL	The actions on SCOHYS for (DHW and combi systems) in single family homes and for DHW only in multifamily homes combine applied research and prototype development (Action I: TRL 3-5) with an extensive prototype and demonstration phase (Action II: TRL 6-9). The action on SCOHYS for multifamily homes (combi systems) is building up on the experiences of Action I and combines development and demonstration (Action III: TRL 5-9).
Estimated Budget	Action I: 15 Mio EUR / public: 70%, private: 30% (development of 6 different prototypes for different applications/regions including potentially for each several different technical improvements) Action II: 30 Mio EUR / public: 50%, private: 50% (demonstration of 30 SCOHYS systems for different applications in Europe including elements preparing the future commercialisation (certification and labelling, marketing analysis) Action III: 20 Mio EUR / public: 70%, private: 30% (development of 2 prototypes and demonstration of 10 systems) Demonstration includes monitoring and certification scheme implementation

2.2 ROADMAP PATHWAY II: SOLAR-ACTIVE-HOUSES (SAH)

2.2.1 Motivation and objectives

Today, in Central and North Europe space heating is responsible for more than 80% of the heat demand in residential buildings, less than 20% is needed for DHW heating. The space heating demand will decrease due to better insulation and improved façade air tightness after refurbishment, as well as in new buildings. However, if the demand on space heating would be reduced by 75% it is still in the same size than the demand for DHW heating. Since biomass resources are limited and the availability of electricity from renewable energy (which could be used to run heat pumps) is limited during the heating season, solar thermal has a great chance to contribute significantly to space heating in the future energy system as sustainable heating source.

A relevant contribution of solar energy to space heating requires an increase of the solar fraction per building, which is the share of solar energy on the overall heat demand for DHW and space heating. Today, in Central Europe, combi systems for DHW and space heating have a size of typically 10 to 15 m^2 collector area and can provide a solar fraction of about 25%, depending on the size and the efficiency of the building and the climate conditions on site. Since in Central and North Europe, the level of solar radiation is much lower in winter time than in summer time, a solar fraction close to 100% requires the shift of a significant amount of solar heat generated during the summer to the heating season and the installation of a very large seasonal storage water tank. However, based on improved insulation standards for buildings and improved solar heating technology, the Solar-Active-House with a solar fraction of about 60% was developed as a good compromise of high solar fraction at acceptable storage volume. In Central Europe a typical single family Solar-Active-House needs a collector area of 30 to 40 m^2 and a water storage tank of only 5 to 10 m^3. More than 1300 of such Solar-Active-Houses are already built.

Based on this experience, the SAH roadmap pathway is focusing on cost reduction as well as optimization and standardization of the technology for Solar-Active-Houses with about 60% solar fraction with the aim, to develop Solar-Active-Houses as competitive solution for nearly zero-energy buildings, which are required by the European Union by 2020.

The objectives of the SAH roadmap pathway are:

- reduction of solar heat costs of SAH with solar fraction of over 60% to the same level of solar heat costs of today's combi systems with 25% solar fraction and
- development of the SAH concept, the design and the construction methods to a standard which can be used by the whole construction sector as nearly zero-energy building concept.

2.2.2 The SAH roadmap pathway

The Solar-Active-House (SAH) roadmap pathway includes actions for new built single family homes, new built multifamily homes and refurbishment of existing buildings and is shown in Figure 4.

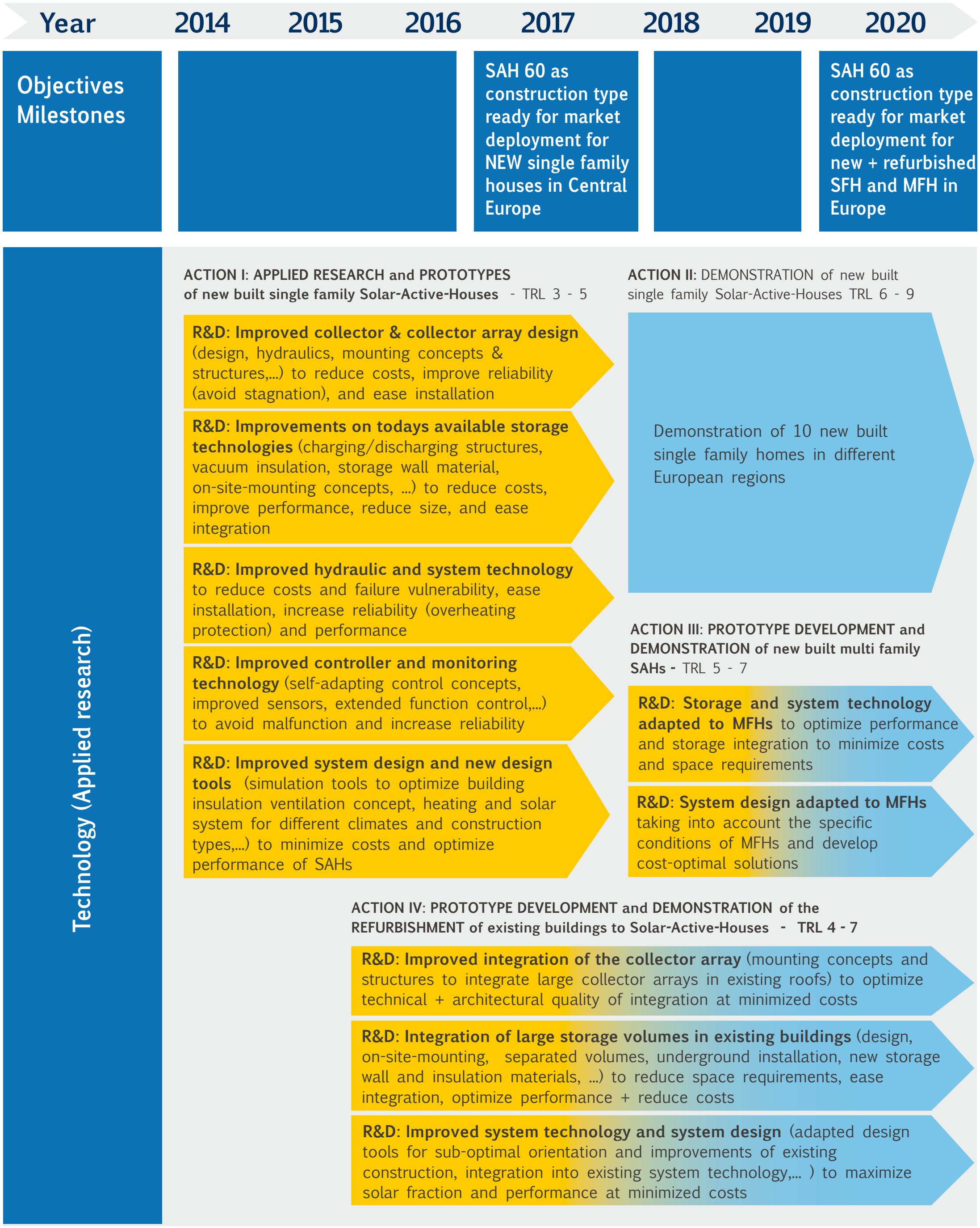

Figure 4: Roadmap pathway for Solar-Active-Houses with solar fraction of 60% (SAH60) – part 1

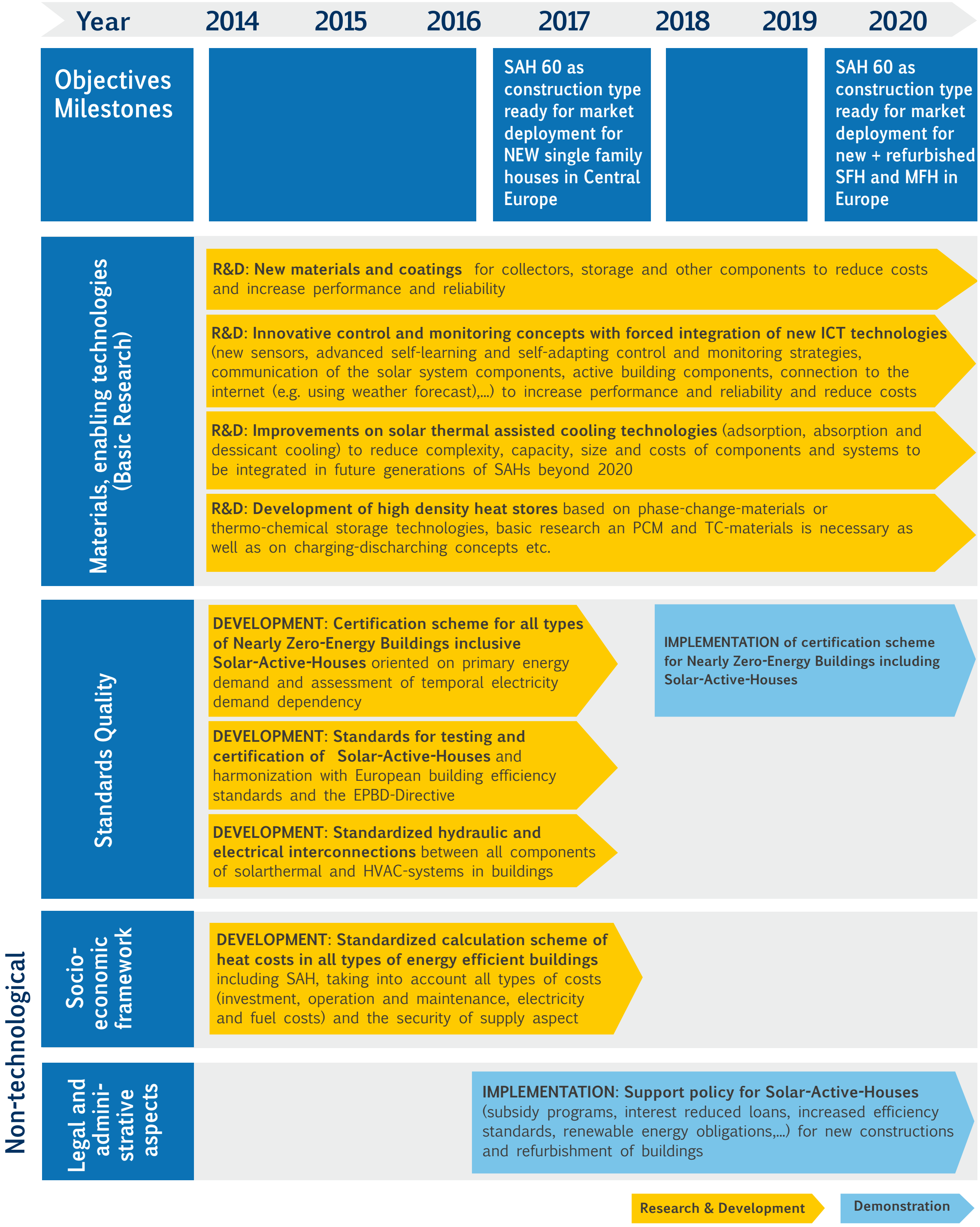

Figure 4: Roadmap pathway for Solar-Active-Houses with solar fraction of 60% (SAH60) – part 2

2.2.3 Research actions and budget

Objective	SAH60 will become a cost-competitive solution for new built single and multifamily homes as well as for refurbished homes in Central Europe in comparison with other nearly zero-energy buildings. Applied research and demonstration will lead to performance improvements and cost reduction on component and on system level including smart control technologies and optimized design tools. Cost reduction will also be achieved by the development of standardized solutions.
State-of-the-art	More than 1300 Solar-Active-Houses with solar fractions between 50% and 100% are already built in Central Europe. However, they are designed and built mainly on the basis of personal practical experiences of the planner since there is a lack of mature design tools, validated monitoring results of existing buildings, systematic optimization procedures on component and system level as well as standardized solutions offered to interested experts and customers. Since most of the existing Solar-Active-Houses are new built single-family homes, the technology must be adapted to the refurbishment of buildings and multifamily homes, since their roof area for collector installation and room for installation of a large storage tank is limited. However, first projects show the feasibility of the concept also for multifamily homes.
Targets & KPIs	By 2017, SAH60 for new built single-family homes will be ready for the market as a standardized solution, which can be applied by all professional planners and construction companies based on sophisticated design tool. By 2020, SAH60 for small multifamily homes and refurbished buildings will be a standardized solution as well. The SAH60 will be cost-competitive with other nearly zero-energy buildings and will provide solar heat at costs comparable to today's combi systems in central Europe (between 15 and 20 €ct/kWh).
Type of activity and TRL	Action I for new built single-family SAH combines applied research and small-scale prototype development (TRL 3-5) followed by a demonstration phase with action II (TRL 6-9). SAH for multifamily homes needs prototype development and demonstration in action III (TRL 5-7). Action IV includes prototype development and demonstration for refurbished buildings (TRL 4-7).
Estimated Budget	Action I and II: 17 Mio EUR / public: 70%, private: 30% (incl. 10 demonstration buildings for new built single-family SAH60), Action III: 16 Mio EUR / public: 50%, private 50% (incl. 10 demonstration buildings for new built multifamily SAH60) Action IV: 21 Mio EUR / public: 70%, private: 30% (incl. 10 demonstration buildings for refurbished SAH60)

Results of the SCOHYS and SAH roadmap pathways

The final goal for the residential sector is to provide Solar-Active-Houses at low solar heat costs. The SCOHYS and the SAH roadmap pathways are different paths to achieve this goal by 2030. Figure 7 shows the SCOHYS roadmap pathway (SCOHYS rm) and its result (cost reduction by 50% for the same solar fraction) and SAH roadmap pathway (SAH rm) and its result (increased solar fraction at the same solar heat costs) for the year 2020 in the solar fraction to solar heat cost diagram. Based on the technological progress beyond 2020, until 2030, the goal of a Solar-Active-House with low solar heat cost and high solar fraction can be achieved.

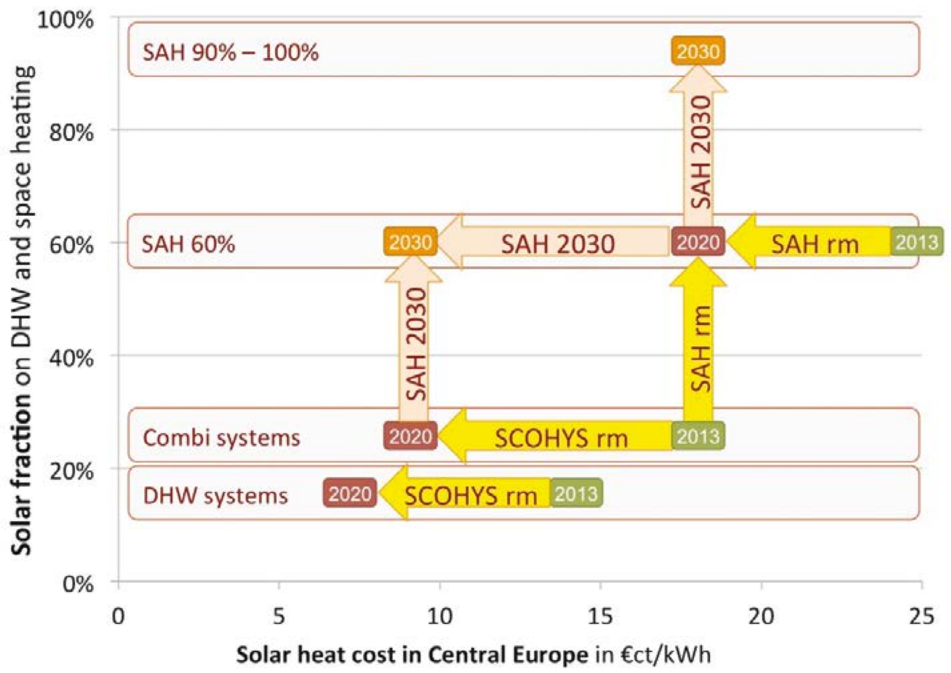

Figure 5: Solar heat costs for different applications in 2013, 2020 and 2030 (the fields with year dates stand for the average heat costs at that year) and the result of the SCOHYS and SAH roadmaps regarding solar heat cost reduction and solar fraction increase for residential applications (costs for typical systems in Central Europe), SAH 2030 represents the roadmap between 2020 and 2030.

2.3 ROADMAP PATHWAY III: SOLAR HEAT FOR INDUSTRIAL PROCESSES (SHIP)

2.3.1 Motivation and objectives

Solar Heat for Industrial Processes (SHIP) is currently at a very early stage of development. Less than 120 operating SHIP systems are reported worldwide, with a total capacity of over 40 MWth (>90,000 m²). Most of these systems are pilot plants with a relatively small size. However, there is great potential for market developments based on innovations, as 28% of the overall energy demand in the EU27 countries originates in the industrial sector and the majority of this heat demand is in the temperature range below 250°C.

According to a study (Ecoheatcool 2006), around 57% of the total industrial heat demand is required at temperatures below 400°C and

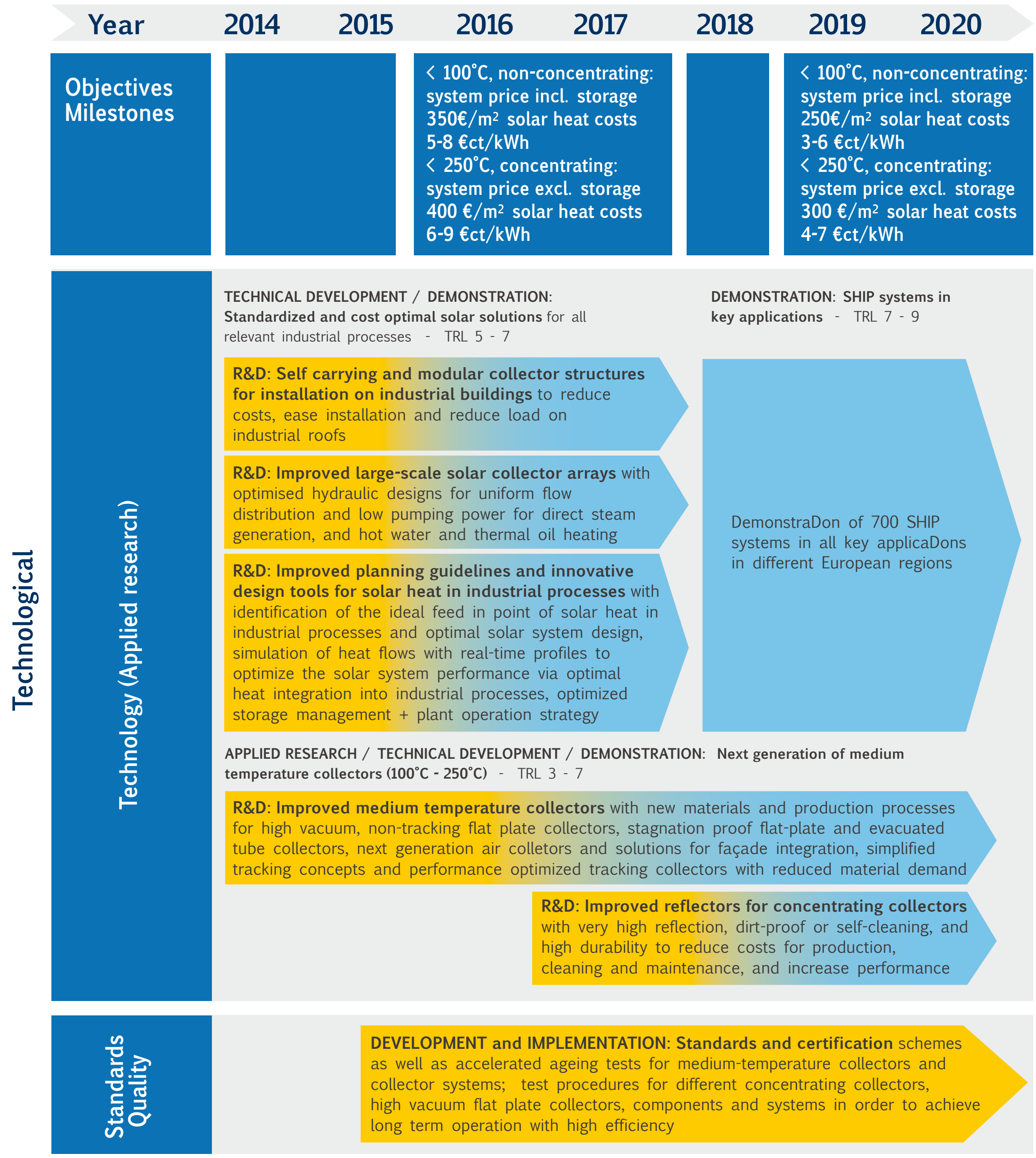

Figure 6: Roadmap pathway of SHIP systems – part 1

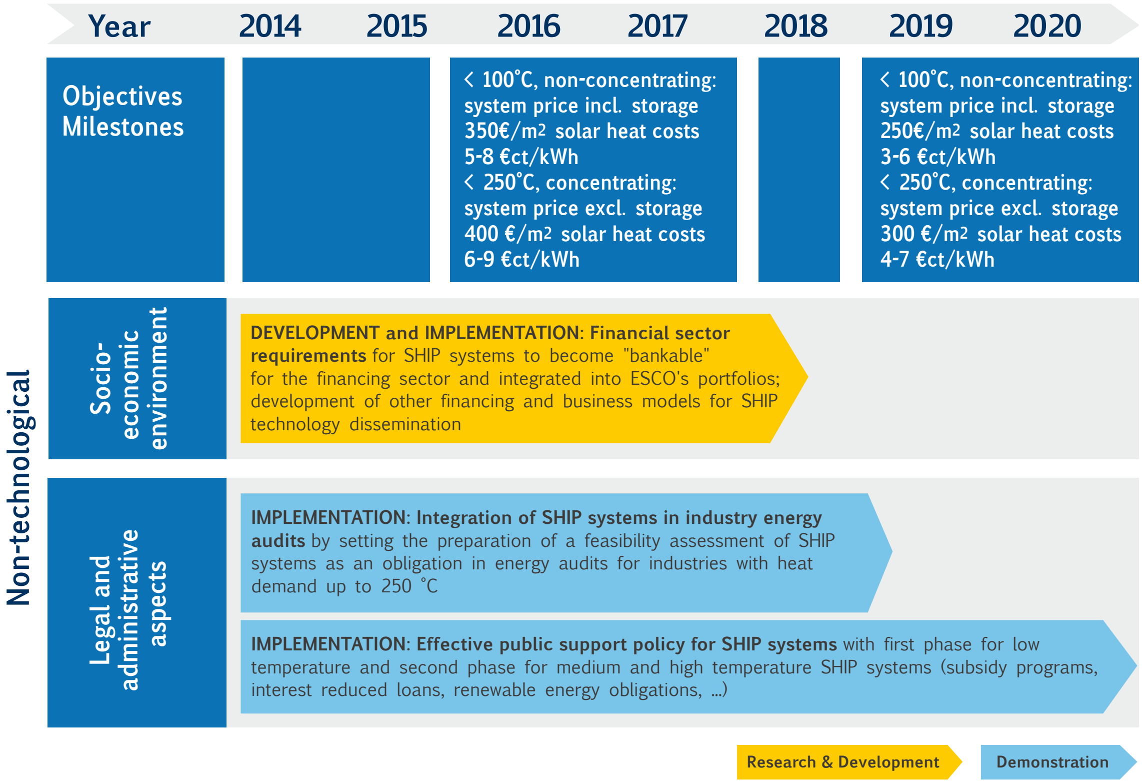

Figure 6: Roadmap pathway of SHIP systems – part 2

30% at temperatures below 100°C. A large share of the heat demand below 100°C can be met with SHIP systems using improved and adopted current technologies, if suitable integration of the solar heating system can be identified. With R&I and technological development, more and more medium temperature applications, up to 250°C, will also become feasible.

The objectives of the SHIP roadmap pathway are:

- Achievement of cost optimal SHIP systems
- Integration of SHIP systems in relevant industrial applications
- Development of next generation SHIP systems with increased solar fraction; and
- Adaptation of SHIP systems to industry machinery standards and development of new ways to feed in solar heat into the industrial processes .

In several specific industry sectors, such as food, wine and beverages, transport equipment, machinery, textiles, pulp and paper, the share of heat demand at low and medium temperatures (below 250°C) is around 60% (POSHIP 2001). Tapping into this potential would provide a significant solar contribution to industrial energy requirements.

2.3.2 The SHIP roadmap pathway

The SHIP roadmap pathway includes all industrial applications with process temperatures up to 250°C, means both low and medium temperature applications and is shown in Figure 6.

2.3.3 Research actions and budget

Objective	SHIP systems will become cost optimal for different temperature ranges and will be adapted to all relevant industrial applications and sectors. Advanced low and medium temperature collectors and optimized concepts to feed in solar heat into industrial processes in an optimized way will be developed. Following results of the R&I actions are expected: · Self carrying collector structures for installation on industrial buildings · Optimized large-scale solar collector arrays for uniform flow distribution and low pumping power · Next generation of medium temperature solar collectors with improved efficiency · Planning and design guidelines, tools for SHIP system integration in relevant processes within key industrial sectors · Standards and certification schemes as well as accelerated ageing tests for medium-temperature collectors and collector systems · SHIP systems in key sectors demonstrated · SHIP systems integrated in ESCO's portfolio and business models
State-of-the-art	Today, there are only about 120 SHIP systems operating worldwide, most of them installed as small-scale experimental or pilot projects. However, over recent years several very large SHIP systems have been installed, for example in the mining industry, opening up a new market segment.
Targets & KPIs	By 2017, SHIP roadmap pathway will achieve solar heat cost in the range of 5-9 €cent/kWh for systems with 10-20% solar fraction, by reducing the investment costs to 350 €/m^2 for low temperature SHIP systems including storage and 400 €/m^2 for medium temperature SHIP systems without storage. By 2020, the solar heat costs will be further reduced to 3-6 €cent/kWh for low temperature applications below 100°C and 4-7 €cent/kWh for medium temperature applications below 250°C. SHIP systems will be scaled up to 0.75-10 MWth and the solar fraction will be increased to 40-50% of the heat demand of industrial process. By 2020, the SHIP roadmap pathway will enable the construction of 700 SHIP systems, with 875 MWth installed thermal capacity (1,250,000 m^2 collector area).
Type of activity and TRL	Action I is focusing on technical development and demonstration (TRL 5-7) and will be continued by action II focusing on demonstration up to post R&I (TRL 7-9). Action III includes applied research, technical development and demonstration (TRL 3-7).
Estimated Budget	Phase I (2014-2017): 33 Mio EUR are estimated for R&I activities (100% public funding) plus 165 Mio EUR for demonstration of 300 SHIP systems (40% public and 60% private funding). Phase II (2018-2020): 44 Mio EUR are estimated for R&I activities (100% public funding) plus 228 Mio EUR for demonstration of 400 SHIP systems (40% public and 60% private funding). Public funding is expected from national governments and European Commission.

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Appendices

Appendix I

ENTITIES ENDORSING THE SOLAR HEATING AND COOLING TECHNOLOGY ROADMAP

Entities endorsing the Solar Heating and Cooling Technology Roadmap can be found at:
http://www.rhc-platform.org/structure/solar-thermal-technology-panel/solar-thermal-technology-roadmap/supporting-organizations-of-the-solar-thermal-technology-roadmap/

Appendix II

ABBREVIATIONS, ACRONYMS AND UNITS OF MEASURE

DHW	Domestic hot water
EPBD	Energy Performance of Buildings Directive
ESCO	Energy service company
ESTIF	European Solar Thermal Industry Federation
ESTTP	European Solar Thermal Technology Platform (or Panel)
HVAC	Heating, ventilation and air conditioning
ICT	Information and communications technology
PCM	Phase-change materials
R&I	Research & Innovation
RD&D	Research, development and demonstration
RES	Renewable energy sources
RHC-Platform	European Technology Platform on Renewable Heating and Cooling
SAH	Solar-Active-House
SAH60	Solar-Active-House with 60% solar fraction
SCOHYS	Solar compact hybrid systems
SHC	Solar heating and cooling
SHIP	Solar heat for industrial processes
SRP	Strategic research priorities
TC	Thermo-chemical
TRL	Technology Readiness Level

UNITS OF MEASURE

°C	Degrees Celsius
€/EUR	Euro
€ct/€cent	Euro-cents
GWth	Gigawatt thermal
kWh	kilowatt-hour
m^2	Square meter
MWth	Megawatt Thermal

Appendix III

SECRETARIAT OF THE RHC-PLATFORM

This document was prepared by the European Solar Thermal Technology Panel (ESTTP) of the European Technology Platform on Renewable Heating and Cooling (RHC-Platform), managed by the European Solar Thermal Industry Federation (ESTIF).

The Secretariat of the European Technology Platform on Renewable Heating and Cooling is coordinate by EUREC and jointly managed with:

European Biomass Association (AEBIOM)

European Geothermal Energy Council

European Solar Thermal Industry Federation (ESTIF)

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Renewable Heating & Cooling

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