SOLAR THERMAL CONTRIBUTION TO THE EU STRATEGY FOR HEATING & COOLING

European Solar Thermal Industry Federation

ABSTRACT

The European Solar Thermal Industry Federation welcomes the consultation process initiated by the European Commission on the incoming European Strategy on the Heating and Cooling sector and wants to contribute to the debate with its view on the long term objectives and goals for the sector.

This contribution answers the consultation questions, exploring synergies with other sectors, providing integrated solutions that combine renewables and energy efficiency, and highlighting the role of the solar thermal technology both at central and at decentralised level. It shows that solar thermal has the potential to cover an important share of the European low temperature heating needs and that it can do so in a increasingly competitive way.

Yet, the sector is underperforming and will struggle to reach its – not so ambitious - 2020 targets. In order to avert such an outcome, barriers are being identified and must be tackled comprensively in the Strategy. These barriers similarly affect other renewable heating and cooling technologies, and most of them are also factors hindering the development of the energy efficiency sector. Specific actions to remove these barriers are thus needed and must be initiated within the Heat Strategy to bring the sector back on track. Some proposals to achieve this objective are thus presented here.

This course of action must be undertaken to fully grasp the significant benefits that solar thermal can bring to the EU energy policy, both in terms of decarbonisation and environmental impacts, and in terms of local economic growth, job creation, energy security and competitiveness.

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Introduction

The EU Strategy on Heating and Cooling is the result of an increasing positive attention the EU institutions have been giving to the Heating and Cooling (H&C) sector, and is a fundamental step in the recognition of its key role in the overall EU climate and energy objectives. The Strategy has therefore the potential to lay solid and long-lasting foundations for the European H&C sector, and will be a milestone for future policy interventions in the sector.

The European Solar Thermal Industry Federation (ESTIF) is ready to contribute in an open and constructive way to the debate on how to decarbonise the European heating and cooling sector, and is keen to play its part in meeting the challenges faced by the European heating and cooling sector.

The following contribution is structured in order to give ESTIF feedback on the consultation process carried on by the European Commission services in relation to the preparation of the Heat Strategy. This contribution takes into account the different stages of the consultation, including informal ones. Therefore, it will firstly recap what ESTIF has been communicating at the informal consultation debate during the EUSEW, and will then analyse the Commission issue papers prepared for the Consultation Forum of 9 September 2015. Moreover, it will analyse some technical questions specific to the solar thermal sector, raised during bilateral consultation meetings with the Commission: the issues of the potential, costs and barriers in the solar thermal sector will be explored in detail.

Being renewable deployment one of the main axes of the Heat Strategy, an analysis of the solar thermal sector in the light of the EU 2020 targets for renewable energy will be done, taking into consideration the recent Progress Report on the Renewable Energy Directive of the European Commission. This will be important to set the right framework to understand the solar thermal sector position into the Heat Strategy debate. The contribution will finally highlight some of the main objectives for the solar thermal sector to be covered by the Heat Strategy, and propose concrete actions needed to achieve them.

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EUSEW Contribution

What follows is an adjusted transcript of ESTIF Secretary General Pedro Dias intervention during the EU Sustainable Energy Week conference on 'Tapping the Potentials of the Building and the Heating and Cooling Sectors – Review of the Energy Performance of Buildings Directive and an EU Strategy on Heating and Cooling', on the 18th June 2015. This intervention is structured according to the set of questions the Commission established to guide the debate.

- **What are the 'no regret' options to reduce and decarbonise buildings' heating and cooling needs by 2050?**

The combination of energy efficiency and renewables is the real no regret option, as stressed by many speakers during the EUSEW. The only regrets will be when we realise that we were preventing market innovation and that the decisions we made, either for large investments or infrastructure, tipped the energy supply balance in favour of some conventional sources. Thus slowing down the pace of change or coming to the conclusion that those investments were not worth it. We should learn also from experiences in the power sector: who would have thought that nuclear would be considered as non-competitive as it is today? Things are moving very fast. Looking towards 2050, the regret might come from having locked-in options and not letting the various technologies and the market work it out for themselves.

The other issue is to understand the diversity of the market and that the market can develop further if there is competitiveness, as the result of having available in the market various solutions for heating and cooling and several options for energy efficiency. The consumers will then drive the market change and push for innovation and competitiveness. Trying to choose which way they should go is not the right way, we should instead help them to operate these changes.

The other no regret option is therefore to combine forces with the consumers and give them the tools to really make the change in their own houses, or in their neighbourhoods or cities. Here we are not talking about whole countries because this is also what we need to grasp: the big difference with the heating sector is that here we are talking about a decentralised reality, we are talking about the local level. Sometimes this is difficult to understand from Brussels where we always try to bring big solutions

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and try to fit everything in big packages. We also need to understand that one of the key issues here is that there is not one-size-fits-all solution, no silver bullet. The best thing we can do is try to facilitate the change, be it by reducing energy consumption with energy efficiency, or with fuel switch from fossil fuels to renewables.

- **How can synergies be ensured between building level efficiency measures and supply side measures exploiting renewable energies and waste heat?**

There are different benefits for both sectors. In our sector, solar thermal systems are performing better in well insulated buildings, because there is a reduction of the heat demand variation between winter and summer. On the other hand, in what regards domestic hot water, where solar thermal is more competitive, the demand will continue, whether a building is well insulated or not.

Again in this case, the main point is that the energy efficiency and the renewable heating and cooling sectors face very similar barriers in the market, these barriers are the upfront investment and the technical side. The question of installers has already been raised - they require special expertise both for renovations or retrofitting, so we believe that working together is the way forward to arrive at the solution best suited to each situation, location, type of building, type of consumer demands and so on.

- **What policy mechanisms would allow energy savings and decarbonisation of energy supply at district level?**

When people think about district level they think about district heating, while we should also think about decentralised level and demand aggregation. One of the challenges for making a change is that here we are talking about very small investments, and at EU level we like to talk about investments in billions, with EFSI and so on. What we need here is not a few investments of billions of euros, we need millions of investments in thousands of euros, and that is the big difference. This demand aggregation can be done with local authorities. Of course district heating solutions are there and they should be exploited, and we should work as soon as possible on the district heating supply fuel switching into renewables. There are also very good solutions for small networks, we believe that for a group of buildings they will continue to be extremely good solutions. But when we think about district level we

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should think about working with local authorities in creating demand aggregation, in creating programmes that empower neighbourhoods to make the change we are talking about with energy efficiency measures and the inclusion of renewable heating and cooling solutions.

- **How can we harness synergies between buildings and smart electricity networks?**

We hear a lot about this idea of using wind and other renewable power sources for heating. What you might not know is that the solution of using wind for heating is only possible because there is solar district heating systems requiring huge heat storage, and this is where the excess wind energy is stored in the form of heat (transformed using heat pumps). Therefore, for solar thermal, this is also a very interesting combination, we are not talking about replacing one with the other, but making them work together, balancing the grid. In this case, when the storage becomes part of the systems and is not only linked to the investment in solar thermal, our business model improves drastically because all the costs of investment in the district heating network storage are not all solely allocated to solar thermal and serve different technologies. But it is also important to understand that this happens at a decentralised level, at the building and residential level. We need to do it in a balanced way: it should be there that the combination should help manage peak loads and not the opposite, that we do not create too much pressure on the electricity grid, because we just are using too much heating generated by electricity as we already have very clear examples today, as highlighted by the problems already faced by France with such solutions. So it should be achieved in a combined way, finding synergies, instead of one technology overwhelming another in what is the supposed best solution.

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Consultation Papers

This section contains ESTIF position regarding the five issue papers issued by the Commission in relation to the Consultation Forum on the EU Strategy on Heating and Cooling of 9 September 2015. Some general feedback on the papers content will be presented, then the most relevant questions for the solar thermal sector raised at the end of each issue papers will be addressed with a specific answer.

General comments

The five issue papers are overall a very good starting point in the description of the heating and cooling in Europe. In particular, the recognition of the key role decarbonisation and renewables must play in the future of the European heating and cooling sector is encouraging. Moreover, the quest for combined synergies between energy efficiency and renewable energy supply is to be welcomed.

Answers to papers questions

1) What are the trade-offs between and how can we assess the cost-optimal balance of:

- **Measures to reduce energy consumption in buildings;**
- **On-building renewable energy;**
- **Remote low-carbon electricity; and**
- **Waste heat and renewable energy based district heating and cooling**

in decarbonising building heating and cooling?

- One of the main questions is to ensure a pre-existing level playing field in the H&C sector, giving the possibility to renewable heating and cooling, and energy efficiency to compete on an equal basis against fossil fuels, for instance by internalizing the cost of CO_2 emissions.
- Once this is completed, the market should be let free to decide the cost-optimal balance between renewable heating and cooling solutions and energy efficiency measures and other options (be it other energy sources, such as centrally generated electricity, waste heat or other energy efficiency enablers, such as district heating).

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- The cost-optimal balance between the necessary components of the European heating sector cannot be established and determined on a top-down approach and applied everywhere equally across Europe because climate, economic and sourcing preconditions vary strongly.
- What can be done from a top-down perspective is to encourage a holistic approach to the heating and cooling sector, promoting solutions that integrate both renewable heating and cooling, and energy efficiency at the same time.
- The data modelling of the European Commission could be improved better reflecting the reality of the heating and cooling sector, in particular when it comes to the very high discount rates still applied for the energy efficiency and renewable heating and cooling.

2) What would help to improve our understanding of heating and cooling use in industry and in the service sector to better assess the technical potential for energy efficiency and renewable deployment?

- Need to determine a stable scenario describing the desirable future energy mix in order to decarbonise the heating and cooling sector and avoid stranded investments into carbon intensive infrastructure. Those scenarios should be European and differentiated on national level.
- Need to establish a data collection system in partnership with relevant sectorial stakeholders, capable of providing reliable information on the heating and cooling sector on an EU level. In the particular case of industry, there is the need for matchmaking between industrial processes using heat and renewable solutions. This includes understanding different uses of heat, different thermal system configurations and industrial process design and identifying the potential and requirements of suitable renewable energy options.
- The Commission could set up an expert group on heating & cooling to provide expertise and advice on the development of political strategies and specific actions in the H&C sector, aiming towards the improvement of EU energy security and energy efficiency, the development of an EU internal energy market and greater innovation, while decarbonizing the sector. The experts group should include suppliers of energy for heating, equipment suppliers, energy efficiency industry, representatives of local and regional authorities, energy agencies, academic experts, environmental NGOs and industrial and commercial heat consumers' representatives.

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3) **What are the most important barriers for companies to deploy existing energy efficiency and renewable energy solutions and how can these barriers be overcome?**

- Policy discontinuity is among the most important barriers, as it undermines a stable framework for investments and projects development. Reliable, steady and attractive support instruments, as long as no level playing field with fossil sources has been established, are needed.
- Financing is a crucial barrier, as both energy efficiency and renewable heating & cooling have high up-front investment cost which deter consumers from opting to more sustainable options.
- Another important barrier is the lack of consumers' and investors' (such as DH companies) knowledge of the actual technology's costs and benefits. Consumer awareness campaigns targeting the EU wide public, promoted in collaboration with all the sectorial stakeholders, could help overcoming this barrier. Better information would also tackle trust issues towards such technologies. These can also be tackled efficiently promoting standards and certifications, as well as training of installers.

4) **Are there technical limitations to substitute fossil fuels with biomass in heating and cooling supply in industry? Are there environmental and economic limitations?**

N/A

5) **Ditto for other alternative energy sources.**

- The most important technical limitation to substitute fossil fuels with solar thermal in heating and cooling supply in industry is related to the technological potential of solar thermal. In fact, solar thermal can provide heat only into a limited temperature range (up to approx. 250 degrees centigrade) and performs best on low level temperatures. However, medium and low temperatures cover a large part of the industrial heat demand, thus leaving room for a considerable solar thermal deployment potential.
- There are no foreseeable environmental limitations to the use of solar thermal in the industry sector. Solar thermal has a very low negative externality (concentrated in the

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minerals extraction phase)[1], and does not involve the use of toxic chemicals or materials, neither it produces combustion gases. There are also no reports of solar thermal heat impacting on the local biosphere.

- Economic limitations to the deployment of solar thermal in the industry sector stem from the competitiveness of the technology, which is hampered by the inexistence of a level-playing field with traditional fossil fuel alternatives.
- Restrictive investment viability considerations (on payback period, e.g.) by industrial end-users impairing viable investments on a Net Present Value based analysis, as is often the case with solar thermal.

6) What are the areas where industrial and tertiary sectors would need support from national and local authorities and what are the mechanisms to establish better cooperation and coordination between companies and national and local authorities?

- National and local authorities can contribute actively to the deployment of renewable heating and cooling, by creating positive and stable frameworks in which those technologies can flourish. Several actions can be taken at the local level, from the simplification of the authorisation procedures, to the mandatory integration of renewable heating and cooling solutions in buildings, starting from the public sector. National and local authorities should adopt a comprehensive approach to urban planning including decarbonisation of the heating and cooling supply measures, in order to maximise active and passive solar gains, and allow the deployment of solar thermal solutions that require appropriate areas for collectors and storage. Promoting the development of ESCO's, that can specialise on energy contracts combining energy efficiency measures and renewable energy options.

7) What are the best practices of an enabling framework which facilitates the uptake of short and long-term efficiency solutions in heating and cooling in enterprises?

N/A

8) What are the best practices of industrial networks/clusters which facilitate the uptake of short and long-term efficiency solutions in heating and cooling in enterprises?

[1] See Ecofys study 'Energy subsidies and costs in Europe', 2014.

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N/A

9) What is needed to accelerate the deployment of energy efficient and renewable heating and cooling technologies in buildings?

- Reliable, steady and attractive support measures to promote renewable solutions.
- Improve access to financing for consumers. Promote new financial tools and improve knowledge of existing opportunities.
- Promotion of integrated solutions combining renewables with energy efficiency measures (see Annex I).
- Awareness raising among consumers on available technologies, their real cost and benefits.
- Disseminate information and personnel training in local planning and permitting authorities.
- Installers training (rooftop installations) and incentivation to promote RES-HC technology.
- Renewable and efficiency obligations for existing buildings.

10) What is needed to secure the buy-in of installers, builders and architects of the most efficient and renewables technologies?

- Installers, builders and architects should be informed about the advantages of the renewable technologies, for consumers and for their activity. Simplified training mechanisms should be in place to facilitate the adoption of these technologies, in particular for those professionals used to deal mostly with conventional solutions, using fossil fuels. Specific support mechanisms, making it more attractive for these professionals (installers, builders and architects) to opt for solutions promoting a fuel switch should also be considered.

11) How can the deployment of energy efficient and renewables heating and cooling technologies in industry be facilitated?

- Reduce cost privileges for industrial heat supplied by fossil sources.
- Promote awareness and information on existing renewable solutions, real costs over the lifespan of the technology, and its benefits. Promote the sharing of best practices.
- Foster R&D targeting in particular system integration and mid-to-high level temperatures.
- Implement the RHC European Technology Platform Solar Heating and cooling Technology Roadmap, in particular the pathway on solar heat for industrial processes. The main targets here should be the achievement of cost optimal solar heat for industrial process

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systems, their integration into relevant industrial applications, the development of next generation systems with increased solar fraction, and the adaptation of solar heat for industrial process systems to industry machinery standards and development of new ways to feed in solar heat into the industrial processes.

- Promote energy intensity/renewable energy labelling schemes for industrial production in different industrial branches (e.g. food & beverages, textile, etc).

12) Are there technical limitations to substitute fossil fuels with renewable energy, including biomass, or other alternative energy sources in heating and cooling in industry? Are there environmental and economic limitations?

See question number 5

13) How can the conditions for financing for the transition to a renewable dominated and more energy efficient heating and cooling systems be made more attractive?

- As a transition towards bankability of RES-H&C projects, governments should support the sector by providing guarantees mechanisms lowering the interest rates for private and commercial investments into renewable heat and energy efficiency.
- Knowledge of the benefits, long term gains and reliability of the technology must be promoted among the financing community.
- Consumers' aggregation tools should be explored and promoted.
- ESCOs should be incentivised to switch to renewable heating and cooling.
- Tools promoting long term period financing (over 10 years or more) must be promoted.
- Integrated solutions, including energy efficiency measures and renewable heating and cooling at the same time, should be promoted, and deployed as off-the-shelf packages, which should be easier to get financed (see Annex I). Best practices and data from such solutions should be disclosed, in order to promote knowledge of their bankability in the financial community.
- Facilitate access to third-party financing mechanisms supported on a clear and stable securitization framework (Guarantee of Results, heat Purchase Agreements, Insurance, Definition of liabilities, etc).

14) What steps to take to link heating and cooling and electricity systems?

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- Caution must be the underlining principle when tackling the electrification of the heating sector. A certain amount of efficient electrification is necessary, in particular in the high range temperature needs, in the path towards the decarbonisation of the European heating sector. However, the idea of using the heating sector to absorb excess electricity from inflexible or intermittent sources is the result of a wrong market design and lack of flexibility, which lead to overcapacity and inefficiencies. A wild electrification of the heating sector is not desirable, as it is an inefficient energy form, in terms of exergy, to cover the mostly low temperature demands of the heating sector – in brief, it is a waste to use electricity for low temperature heat. Moreover, massive electrification of the heating sector might be non-affordable, as the electricity prices are set to raise in the future[2], while alternatives such as renewable heating and cooling are costing less and less. The electrification of the heating sector puts under stress the power grids, while also putting the decarbonisation of the sector at risk, as in many EU countries, the bulk of the power production is still concentrated into heavily pollutant fossil fuels such as coal.
- The European Commission should therefore examine cautiously the heating and cooling sector to find areas where an electrification through highly efficient systems can be applied, and reject a massive, wild electrification in sectors where more sustainable solutions are already existing, and are becoming more and more competitive.

15) How cost-effective is thermal storage?

- Thermal storage is probably the cheapest form of energy storage available today[3]. In combination with solar thermal systems, thermal storage can be a very efficient way to improve the performance of the system, both at a small scale, residential level, and at a large scale level. There storage can increase its competitiveness, as it can provide seasonal storage, and it can integrate different sources such as excess variable power supply via efficient heat pumps, making it even more cost effective.

[2] Commission Staff Working Document (SWD(2014)15) - Impact Assessment Accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A policy framework for climate and energy in the period from 2020 up to 2030, pp.28-29.
[3] Cfr. https://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20E17%20Thermal%20Energy%20Storage.pdf

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16) How dependant is an integration of heating and cooling and electricity on collective solutions (CHP, district heating)?

- One of the potential solutions for the use of excess renewable power generation is to store it in the form of heat in seasonal heat stores. Several solar thermal plants providing heat to district heating networks use very large heat stores, making it easier to integrate power to heat solutions, making use of RES variability and excess power in the grid. On the other hand, new large heat stores can be added to existing district heating networks, to use both solar thermal energy or take advantage of excess power from RES. In such case, the additional investment in a solar thermal solution would be even lower, making this option even more economically attractive.
- Another interesting solution, already considered in several district heating systems, is to use solar thermal during spring and summer, when the solar resource is abundant but the heat demand is drastically reduced. In such cases, it is possible to shut-down heating plants or CHP plants that are not efficient at a low level of heat generation.

17) What should the key features of the heating and cooling system in 2050 be?

- The EU heating and cooling system in 2050 should be on track towards a full decarbonisation.
- Renewable heating and cooling technologies are the most competitive solutions and are the majority of the market, replacing old equipment using fossil fuels, since the right framework to ensure a level playing field has already been set.
- Renewables for heating and cooling and renewables for power generation are main elements of smart cities, where power grids, heat networks and decentralised generation of renewable heating and of renewable electricity are integrated in an efficient way, providing cost-optimal solutions.
- Carbon emissions from traditional fossil fuels heating appliances are subject to carbon tax, and thus heavily discouraged.
- District heating systems should be expanded wherever feasible, efficient and competitive, and all existing ones should be turned to renewable energy sources and upgraded to the highest efficiency standards. Solar thermal could be used, in combination with other renewable sources, to cover large part of the demand of the European district heating networks.

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18) What can be the benefits of an integrated approach to set pathways for the transformation of heating and cooling?

- An integrated approach to the decarbonisation of the heating and cooling, combining its two most important elements, energy efficiency and renewables for heating and cooling, is crucial as it allows for a maximisation of synergies and benefits resulting from each element. An integrated approach allows:
    - Better policy interventions, as those elements face similar barriers and constraints;
    - Better urban planning, as combined interventions reduce inconveniences
    - Better access to financing
    - It would prevent the creation of lock-in effects, i.e. when the consumer decides to invest either in energy efficiency or in renewable heating and cooling to the detriment of the other one. At domestic level, usually once end-users have carried out major works in their homes, they are loath to start other works for many years afterwards.

19) What elements does such an integrated approach need to consider in terms of the options of demand reduction and the deployment of renewable energies, e.g. the share of electricity in heating, the balance between reducing demand in buildings and industry and the deployment of renewable supply sources, the role of district heating and cooling, technologies deployment, and the roll-out of smart energy networks, the empowerment of consumers?

- The balance between reducing heat demand in buildings and industry and the deployment of renewables cannot be struck once and for all from a top-down perspective. This balance is subject to different variables in different geographic, social and economic locations across Europe. What can be done from a top-down level is to ensure a level-playing field with traditional fossil fuels, and ensure a proper legislative framework is in place and implemented to promote both energy efficiency and renewable heating and cooling. There are also certain heat demand segments where energy efficiency can hardly replace clean production of heat, as it is the case of domestic hot water, which demand is not greatly reduced by energy efficiency measures.

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- The share of electricity in heating must be cautiously analysed, in order to avoid scenarios where massive, wild electrification of the heating sector is carried on, forging ahead to solve imbalances in the power market (see question 14).
- District heating can have an important role to play in the decarbonisation of the heating sector, insofar as they are based on renewable energy, and are planned in a participated way, involving consumers, instead of being imposed on a top-down approach. District heating networks are a smart delivery solution, but cannot cover the full heat demand in Europe, not even in urban landscapes. They should be promoted whenever feasible, competitive and sustainable, but should not be considered as the silver bullet for European cities, as in many cases they simply cannot replace decentralised installations.
- The change in the energy system and in particular in heating and cooling needs to be done at decentralised level, mostly in private homes, companies and institutions. The change can only be done if consumers are engaged and empowered. The empowerment of consumers must be a transversal basis for an integrated approach to the heating sector. There is no policy, no regulating framework, no financing measure that can properly work without citizens' involvement and consumers' empowerment.

20) At what level should such integrated approach be applied, i.e. EU, national or local levels?

- Since the European heating and cooling sector is mostly a decentralised sector, solutions must also be applied at a decentralised, local level.

21) What are the best practices of integrated mapping for heating and cooling at local and national level?

- Solar roof cadastre of City of Graz[4]: The "Graz solar roof cadastre", created in collaboration with the municipal statistical office and the environmental office and the industry, aims at helping individual citizens, property developers, real estate developers, construction companies or the building authorities to assess whether solar installations are competitive and effective in specific locations in Graz.

[4] http://www.geoportal.graz.at/cms/ziel/5163127/DE/

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Potential of Solar Thermal

This section provides a non-exhaustive analysis of three issues related to solar thermal, the technology potential, costs and barriers. The understanding of those issues is key in order to ensure a proper deployment of the technology.

Potential

Defining the potential of solar thermal in Europe is a difficult yet crucial task. Definitions can vary according to methodology, thus affecting the perceived outcome of the analysis. At least five different definitions can be identified[5]:

1. Theoretical potential: The highest level of potential is the theoretical potential. This potential only takes into account restrictions with respect to natural and climatic parameters.
2. Geographical potential: Most renewable energy sources have geographical restrictions, e.g. land use, land cover, reducing the theoretical potential. The geographical potential is the theoretical potential limited by the resources at geographical locations that are suitable. For the solar thermal, it is the solar radiation.
3. Technical potential: The total amount of energy (final or primary) that can be produced taking into account the primary resources, the socio-geographical constraints and the technical losses in the conversion process.
4. Economic potential: The technical potential at cost levels considered competitive.
5. Market potential: The volume that solar thermal can reach taking into account the demand for energy, the competing technologies, the costs and subsidies of renewable energy sources, and the barriers.

The limitations to the theoretical and geographical potential caused by solar radiation are not affecting solar thermal as much as it is generally conceived. Most of solar thermal systems are equipped with storage to deliver during the night, and seasonal storage to deliver during winter is being developed more and more. Moreover, solar thermal systems usually run with a backup system as auxiliary heat

[5] The section below is an adaptation from ESTIF, UNEP publication 'Guidelines for policy and framework conditions', under the Global Solar Water Heating Market Transformation and Strengthening Initiative.

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generator. Even when it cannot satisfy the total heat demand, solar thermal brings several benefits, such as allowing the backup heater to work at higher efficiency thanks to pre heated water. The fact that solar radiation is not such a strong limitation to the potential of the technology is self-evident considering that most well developed solar thermal markets are located in central Europe for space heating and in northern Europe for district heating, where solar thermal systems can be totally competitive and effective.

The technical potential of solar thermal technology is analysed in depth in the ESTTP publication 'Solar Heating and Cooling for a Sustainable Energy Future in Europe' [6], where, based on purely technical perspective, solar thermal is estimated as being able to cover up to 50% of the heating demand in Europe on the long term.

The economic potential takes into consideration the costs of the technology, which are going to be discussed in more depth in the next section. The market potential is resulting from the interaction of the economic potential with the given framework conditions, i.e. the heating and cooling and market development, the public acceptance and awareness of solar thermal, the national and local energy mix, the research and testing capacity, the qualification and training, and the regulatory and policy framework. As opportunities are included as well as barriers, the market potential may in theory be larger than the economic potential, but usually the market potential is lower because of all kind of barriers.

In 2008, ESTIF commissioned a study on the potential of solar thermal technology in Europe to the Vienna University of Technology and the Institute for Sustainable Technologies- AEE-Intec[7]. Although the European energy landscape has evolved since then -not always positively for the solar thermal sector- and some of the assumptions underpinning the study were made in a slightly different context, most of the results of the study can still be looked as relevant in the identification of the solar thermal medium-to-long term market potential in Europe. The main results are presented below.

[6] http://www.estif.org/fileadmin/estif/content/projects/downloads/ESTTP_SRA_RevisedVersion.pdf
[7] http://www.estif.org/fileadmin/estif/content/publications/downloads/Potential%20of%20Solar%20Thermal%20in%20Europe_Full%20version.pdf

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The study identified three different scenarios, and compared the results on a 2020, 2030 and 2050 perspective. The scenarios are Business as Usual (BAU), Advanced Market Development (AMD), and Full R&D and Policy (RDP). In 2011, ESTIF noted that the NREAP's projections for solar thermal deployment in 2020 were closely matching the intermediate AMD scenario of the 2008 study (see table below), thus corroborating the validity of the study projections. The study main findings have also been endorsed by the European Solar Thermal Technology Platform – ESTTP.

Solar Thermal in 2020: Comparative Scenario

			2020				
		2006	BAU	AMD	NREAPs	RDP
Spec. Collector Area	kW_{th}/inhab	0.03	0.14	0.21	0.2	0.56
	m²/inhab	0.04	0.2	0.3	0.29	0.8
Total Installed Capacity	GW_{th}	14.17	67.9	101.9	102.2	271.6
	Million m²	20.25	97	145.5	146	388
Solar Yield (ST energy production per year)	TWh/a	0.05	0.9	1.7	-	2.7

BAU: Business as Usual scenario
AMD: Advanced Market Deployment scenario
NREAP: National Renewable Energy Action Plan
RDP: Full R&D and Policy scenario

The study particularly looks into the composition of the heat demand in Europe, and highlights the high potential for solar thermal in the low temperature segments of the heat demand. In the baseline year of the study, 2006, the total heat demand in the EU-27 was 6 668 TWh and the low temperature heat accounted for 4 640 TWh, which was 34% of the total final energy consumption. The low temperature heat consumption shows therefore the theoretical potential for solar thermal.

The figure below shows the low temperature heat demand by sector in the EU-27 in 2005. It is to be noted that these figures did not change significantly in the last decade[8], and are therefore still relevant[9]. Of this breakdown, 61% of the overall low temperature heat is used in the households sector. The remainder accounts for low temperature process heat (<250° C) industry, 20% and the service sector, 19%. This clearly shows the huge potential for solar thermal applications in the households sector. Another important sector with considerable potential is low temperature process heat for industry. 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

[8] See for instance JRC https://setis.ec.europa.eu/system/files/3.HCDemandandMarketPerspective.pdf
[9] The incoming study "Mapping and analyses of the current and future (2020 - 2030). heating/cooling fuel deployment (fossil/renewables)" ENER/C2/2014-641, Fraunhofer and alia, 2015, should confirm these data. The lack of articulated sectorial studies between 2008 and 2015 is a symptom of the difficulties in data collection the sector is facing.

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around 60%. Tapping into this potential would provide a significant solar contribution to industrial energy requirements[10].

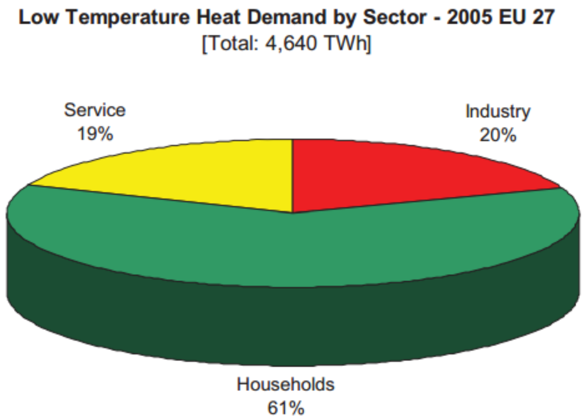

Figure 7-3: Low temperature heat demand by sector in EU 27.

The table below shows data for the baseline year 2006 and the potential solar thermal contribution to the low temperature heat demand of the EU-27 countries under the three scenarios. Depending on the scenario, in 2020 the contribution of solar thermal to the low temperature heat demand of the EU-27 will be between 0.8% (BAU) and 3.6% (RDP). The corresponding annual solar yields would be 38 TWh (BAU) and 155 TWh (RDP). The specific collector area needed to reach these goals would be between 0.2 m² (BAU) and 0.8 m² (RDP) per inhabitant. The resulting total collector area will be between 97 million m² (BAU) and 388 million m² (RDP). In comparison, the 2006 baseline data is 0.04 m² collector area per inhabitant and a total collector area in operation of 20.3 million m², which - corresponds to an installed capacity of 14.2 GWth. According to the scenarios for 2020 a reduction of 0% (BAU) and 9% (RDP) of the low temperature heat demand compared with 2006 is assumed. To reach the goals of the RDP scenario a 26% average annual growth rate of the European solar thermal market is needed until 2020. The goals of the AMD scenario would require a 15% average annual growth rate and the goals of the BAU scenario a 7% growth rate.

[10] See the RHC Platform Solar Heating and Cooling Technology Roadmap, 2014. http://www.rhc-platform.org/fileadmin/user_upload/Structure/Solar_Thermal/Download/Solar_Thermal_Roadmap.pdf

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Table 7-3: Solar thermal contribution to the low temperature heat demand of the EU-27

		BAU	AMD	RDP
2006 Baseline				
Specific collector area	m²/inhab.	0,04	0,04	0,04
Total collector area	Mill m²	20,25	20,25	20,25
Total installed capacity	GWth	14,17	14,17	14,17
Solar yield	TWh/a	8,5	8,5	8,5
Total low temperature heat demand 2006	TWh	4.715	4715	4715
Solar fraction	[%]	0,2%	0,2%	0,2%
Number of jobs EU 27		31.400	31.400	31.400
2020				
Specific collector area	m²/inhab.	0,2	0,3	0,8
Total collector area	Mill m²	97,0	145,5	388,0
Total installed capacity	GWth	67,9	101,9	271,6
Solar yield	TWh/a	38	59	155
Total low temperature heat demand 2020	TWh	4.715	4.506	4.297
Reduction of low temperature heat demand compared to 2006	[%]	0,0%	4,4%	9%
Solar fraction	[%]	0,8%	1,3%	3,6%
Number of jobs EU 27		46.900	103.200	470.000
2030				
Specific collector area	m²/inhab.	1,0	2,0	3
Total collector area	Mill m²	485	970	1.455
Total installed capacity	GWth	340	679	1.019
Solar yield	TWh/a	198	394	582
Total low temperature heat demand 2030	TWh	4.715	4.251	3.787
Reduction of low temperature heat demand compared to 2006	[%]	0,0%	10%	20%
Solar fraction	[%]	4%	9%	15%
Number of jobs EU 27		306.800	770.400	1.300.000
2050				
Specific collector area	m²/inhab.	2,0	5,3	8
Total collector area	Mill m²	970	2.571	3.880
Total installed capacity	GWth	679	1.799	2.716
Solar yield	TWh/a	391	1.047	1.552
Total low temperature heat demand 2050	TWh	4.715	3.993	3.271
Reduction of low temperature heat demand compared to 2006	[%]	0,0%	15%	31%
Solar fraction	[%]	8%	26%	47%

BAU = Business as Usual; AMD = Advanced Market Deployment; RDP = Full R&D and Policy Scenario

In 2030, the contribution of solar thermal to the low temperature heat demand of the European Union (EU 27) will be between 4% under the BAU scenario and 15% under the RDP scenario. The corresponding annual solar yields are 198 TWh (BAU) and 582 TWh (RDP). The specific collector area needed to reach these goals will be between 1 m² (BAU) and 3 m² (RDP) per inhabitant. The resulting total collector area will be between 485 million m² (BAU) and 1.45 billion m² (RDP). According to the scenarios for 2030 a reduction of 0% (BAU) and 20% (RDP) of the low temperature heat demand compared to 2006 is assumed.

In 2050, the contribution of solar thermal to the low temperature heat demand of the European Union (EU-27) will be between 8% under the BAU scenario and 47% under the RDP scenario. The

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corresponding annual solar yields are 391 TWh (BAU) and 1552 TWh (RDP). The specific collector area needed to reach these goals will be between 2 m² (BAU) and 8 m² (RDP) per inhabitant. The resulting total collector area will be between 970 million m² (BAU) and 3.88 billion square metres (RDP). According to the scenarios for 2050 a reduction of 0% (BAU) and 31% (RDP) of the low temperature heat demand compared to 2006 is assumed.

The figure below illustrates the solar thermal potential in the EU-27 based on three scenarios. As can be seen in this figure even the BAU scenario shows moderate growth rates of the annually installed capacity until 2035. Around 2035 a saturation of the installed capacity can be observed. This is mainly due to the fact that under this scenario the main application of the solar thermal systems is hot water preparation and solar combi-systems with low solar fractions. By 2030 nearly the full potential for these applications will be exploited and the annually installed capacity will be reduced mainly to the replacement of old systems.

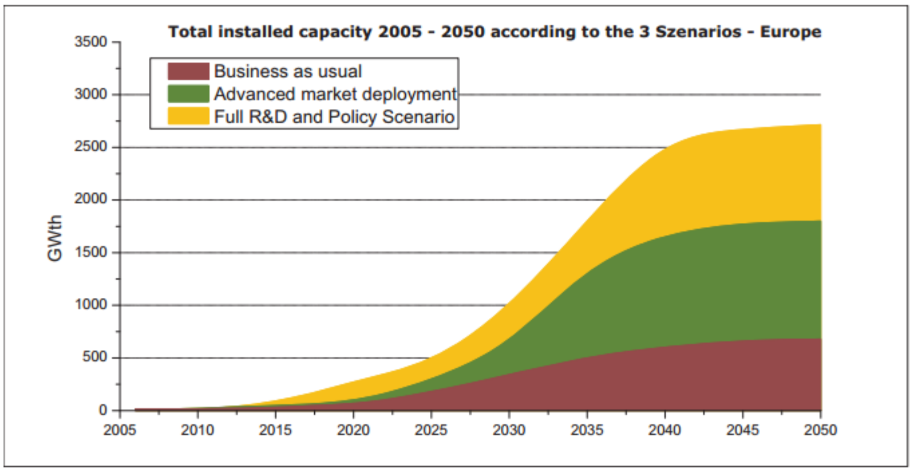

Figure 7-5: Solar Thermal potential in the European Union (EU 27) based on three Scenarios[16]

Both the RDP scenario and the AMD scenario are based on the assumption that the main focus is on the space heating (solar combi-systems) systems in the residential and service sectors in central and northern European countries and on combined systems providing space heating, hot water and air conditioning in the Mediterranean countries.

In addition, a moderate to substantial market diffusion in the other sectors is assumed. Solar combi-systems will provide heat for hot water and space heating (also cooling where needed) and will have the

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ability to switch to high density energy storages when available without changes to the collector area. Using high density energy storages would increase the solar fraction significantly.

The figure below shows the contribution of solar thermal to the European Union heating and cooling demand by sector in comparison with the development of the overall heating and cooling demand from 2006 to 2050. The figure is based on the assumptions of the RDP scenario. The 2006 baseline shows the total heating and cooling demand of 4715 TWh in the EU 27 countries. In 2006, 0.2% of this demand was provided by solar thermal systems.

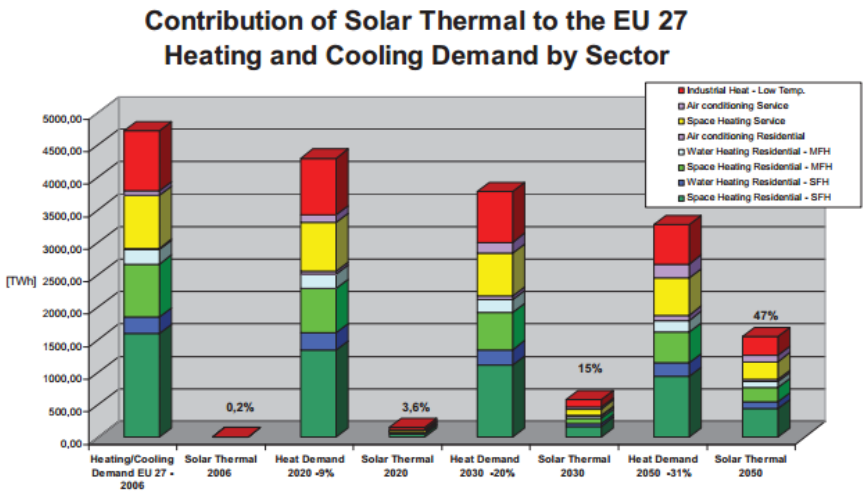

Figure 7-6: Total heating and cooling demand of EU-27 and contribution of solar thermal by sector according to the Full R&D and Policy Scenario (RDP)

Taking energy efficiency measures of 9% into account until 2020 would result in a reduced heating and cooling demand of 4297 TWh. Based on this reduced demand and the additional collector area the solar fraction would be 3.6% by 2020.

In the medium-term (2030) the solar fraction will be 15%, based on a 20% reduction of the demand compared with the 2006 level. And, in the long-term (2050) the solar fraction will be 47%, based on a 31% reduction of the demand compared with the 2006 level.

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Costs

Solar thermal technologies are usually referred to as sleeping giant, since their market potential is not yet unlocked, and their costs are often perceived as uncompetitive. Yet, solar thermal is already competitive today in many market segments, and can be cheaper than fossil fuel alternatives for some applications in some European regions.

There are two reasons, why people usually do not have a clear picture of the competitiveness of solar thermal energy[11]. Firstly, there is not 'one price' for solar thermal heat, since solar thermal systems vary greatly, reflecting different system types, qualities, and standards by the integration into the building[12]. Additionally, the yield of a solar thermal system depends on the insolation (solar radiation) intensity at the installation site, a solar thermal system in Southern Europe has the same energy yield than a system with a 50% larger collector area in Northern Europe. The prices for heat from fossil fuels and electricity vary a lot across Europe. Therefore, competitiveness must be calculated for each system type, for each installation, and in comparison with the specific heat costs of the alternative heat source.

Secondly, costs for solar thermal heat are usually incorrectly compared with today's prices for fossil fuels or electricity, as the two types of costs differ considerably. The investment costs plus the operating and maintenance costs during the lifetime of a system, e.g. 20 years, are taken into account to calculate solar heat costs, these are then divided by the solar heat generated during that period. These costs represent the average costs for solar heat per kWh over the entire lifetime. To achieve a fair comparison with costs for heat from fossil fuels or electricity, their average costs should be calculated over the next 20 years as well. Since oil and gas prices vary a lot, the costs comparison depends greatly on the assumption made for the energy price growth rate over the next 20 years, which is highly unpredictable. However, generally consumers do not calculate average fossil heat prices over 20 years, but are only aware of today's fossil heat prices. Therefore, they systematically underestimate the competitiveness of solar thermal energy, since there is a high probability that fossil and electricity energy prices will rise significantly.

[11] The section below is an adaptation from ESTIF, RHC Technology Platform Strategic Research Priorities for Solar Thermal Technology.

[12] E.g. it is much easier to install a compact thermosyphon system on a flat roof in Southern Europe than to install a collector on a pitched roof with the solar storage in the basement which is usually the case in Central and Northern Europe.

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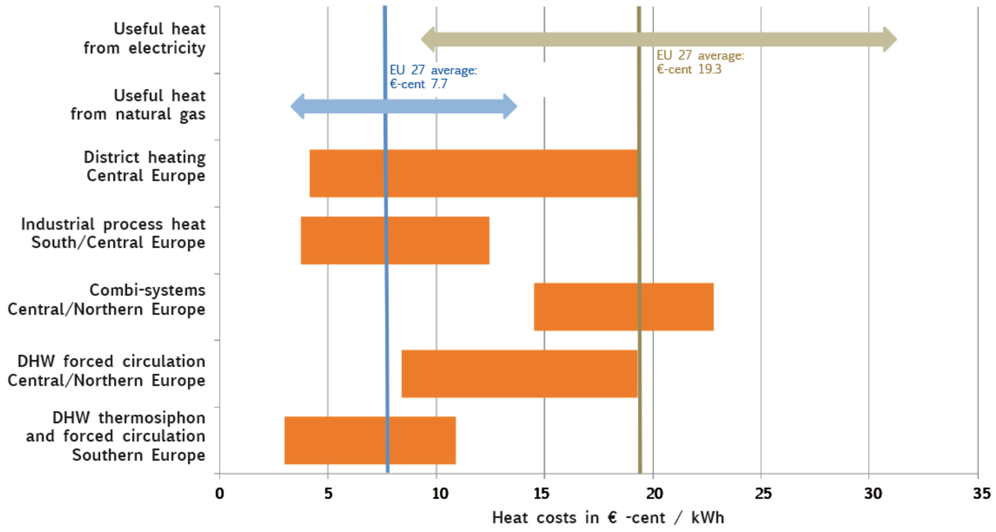
The figure below shows typical ranges of solar heat costs for different solar thermal systems in different European regions, representing average heat costs over the lifetime of the systems of typically 20 years, compared with the costs for useful heat produced by natural gas and electricity in the year 2011[13]. Even though this is an unfavourable comparison for solar thermal, as average solar thermal energy costs over lifetime are compared with today's gas and electricity prices, solar thermal energy is already in some cases cheaper than heat from natural gas and is in most cases cheaper than heat from electricity. However, for combi-systems in central Europe, where the large solar thermal markets are located, solar thermal heat costs are significantly higher than the price for heat from natural gas, which is mainly used as an alternative. Since industry is usually expecting a short payback time for investments, competitiveness of solar thermal process heat is only given, if it is significantly cheaper than heat from fossil fuels which is usually not yet the case.



Solar thermal heat costs are mainly determined by the upfront investment consisting of: the solar collector, storage, plumbing, pumps, controller as well as other components, and the installation costs. The investment depends on the type and size of system used, varying from below 300 EUR per kWth for large-scale district heating systems up to 1700 EUR per kWth for a combi-system. In addition,

[13] Range of solar thermal heat costs for various types of solar thermal systems in different European regions (average costs over lifetime), compared with the range of costs for useful heat. Useful heat takes into account losses by converting natural gas and electricity into heat. The conversion efficiency of 85% for gas and 95% for electricity is assumed. Heat costs from natural gas and electricity are taken from 2011 and include VAT. Solar cooling systems are not included since cooling and heating prices are not comparable and a matured solar cooling market does not yet exist. However, cooling costs of about 45 Eurocent per kWh were achieved in solar cooling pilot plants and average costs for heating and cooling of about 20 Eurocent in combined heating and cooling pilot plants. Source: ESTTP, Eurostat (for natural gas and electricity).

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financing investment costs, operation and maintenance (O&M) costs over the lifetime of 20 years (15 years for low price thermosyphon systems) are taken into account by calculating the average solar thermal heat costs over the lifetime of the system. Based on these assumptions, the ranges of costs for solar thermal systems are as follows: between 3 and 11 Eurocents per kWh for small solar domestic hot water (DHW) thermosyphon systems in Southern Europe; between 5 and 10 Eurocents per kWh for larger solar forced circulation DHW systems in Southern Europe; between 8 and 19 Eurocents per kWh for small and collective solar DHW in Central and Northern Europe; between 14 and 13 Eurocents per kWh for solar combi systems for DHW and space heating in Central and Northern Europe; between 4 and 12 Eurocents per kWh for solar industrial process heat systems in Southern and central Europe; and between 4 and 19 Eurocents per kWh for solar district heating systems both without storage and with very large seasonal storage[14].

The table below shows a range of prices for heat generated by a solar thermal system and the price projected for 2030[15].

Cost in €-cent per kwh				
	Today		2030	
	Central Europe	Southern Europe	Central Europe	Southern Europe
Solar thermal	7 - 16	5 - 12	3 – 6	2 - 4

The spread is wide, because the total costs vary strongly, depending on factors such as quality of products and installation, ease of installation, available solar radiation (latitude, number of sunny hours, orientation and tilting of the collectors), ambient temperature, and patterns of use determining the heat load.

[14] The figures given are representing the costs for solar heat produced by the collector (at the collector outlet) including VAT.

[15] The cost of heating equipment is not taken into account, as this is deemed to be a necessary back-up for a solar thermal system. To reduce the effect of outliers, the cheapest and the most expensive countries have not been taken into consideration. It should also be stated that larger customers, such as big business, are able to obtain lower prices and do not pay VAT. The costs of solar heat include all taxes, installation and maintenance.

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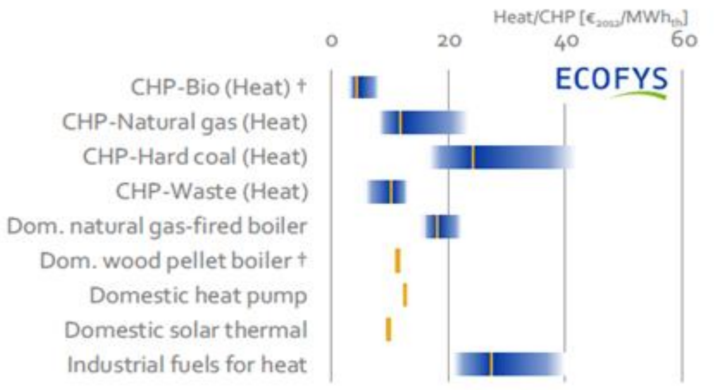
An Ecofys study for the European Commission on Energy Subsidies and Costs in Europe[16] shows that the Levelised Cost of Heating and Cooling for solar thermal varies between €60 and €80/MWh (depending on climatic conditions). Therefore, solar thermal is competitive with similar heating technologies. External costs are estimated at 9€ per MWhth in the same study, among the lowest of the technologies analysed.



There are three main issues that combine to determine the competitiveness of a solar thermal collector system for domestic hot water in single family houses: the initial cost of the system, the maintenance cost, and the compared cost of alternative systems[17]. The initial cost of the system varies depends on the quality of the system and on the specific market, including labour costs, and geographic location. It can vary significantly from country to country (see Annex II). The cost of solar thermal systems is cheaper than natural gas and electricity heating and cooling in several European countries, namely in Southern Europe. While the costs of the energy produced with solar thermal energy are competitive, these take mostly the form of upfront investment (as operation and maintenance costs are low and there aren't fuel costs). The learning curve for the solar thermal sector is estimated at 23% (see graph below[18]), meaning that per every doubling of the solar thermal market, prices go down 23%.

[16] https://ec.europa.eu/energy/sites/ener/files/documents/ECOFYS%202014%20Subsidies%20and%20costs%20of%20EU%20energy_11_Nov.pdf

[17] See IRENA, Solar Heating and Cooling for Residential Applications, 2015. http://www.solarthermalworld.org/sites/gstec/files/news/file/2015-02-27/irena-solar-heating-and-cooling-2015.pdf

[18] Collector production costs development for high-efficient flat plate collector panel of about 2.2 to 2.5 m² gross collector area manufactured in Europe (Source: solrico & trenkner consulting). Cost reduction projections are calculated up to 2020 based on market expectations of the NREAPs.

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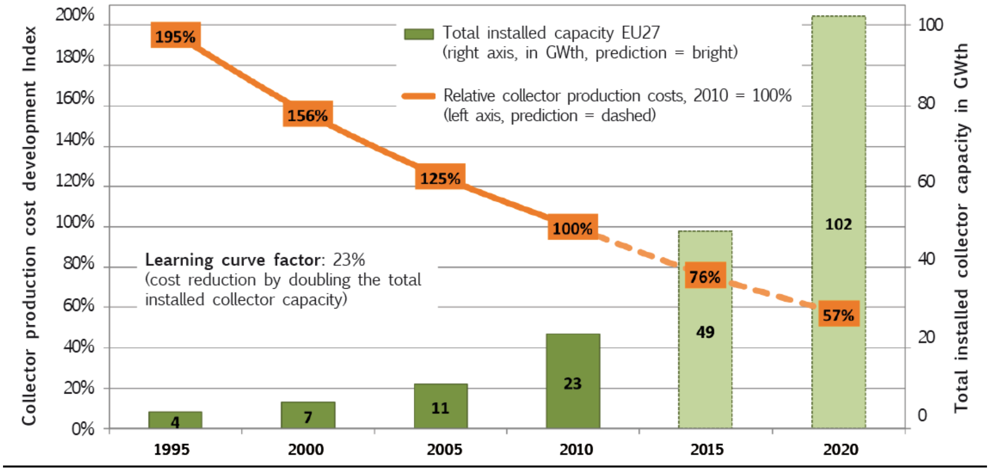

However, improved competitiveness is necessary for moving from early markets to mass markets[19]. Under positive boundary conditions, solar domestic hot water is often already cost-competitive with fossil-fuel based technologies, if considered over the lifetime of the solar system. Applications for space heating in multi-family houses are also close to competitiveness. These applications have the potential for short payback times. They are reliable, but their higher initial investment costs means they appear more expensive to potential purchasers when compared with conventional heating systems. However, this is not the case if costs are compared over a full life cycle.

Overall, cost competitiveness does not automatically lead to a mass market. In economic terms, this may be due to incorrect information about the perceived transaction costs. In practical terms, it may be due to inertia, lack of information, lack of financial resources and other priorities, or the effects of publicity. This means that cost competitiveness does not necessarily create a mass market for a product. However, it can be assumed that moving towards a mass market will be easier, as return on investment times become shorter.

By 2030, it is assumed that technological progress and economies of scale will lead to around a 60% reduction in costs. While important cost reductions in solar thermal can be achieved through R&D and economies of scale, the priority is to enable the large-scale use of solar thermal energy through the

[19] This section is an adaptation of the ESTTP, ESTIF study on Solar Heating and Cooling for a Sustainable Energy Future in Europe.

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development to mass market of new applications, such as Active Solar Buildings, solar cooling, and Solar Heat for Industrial Processes.

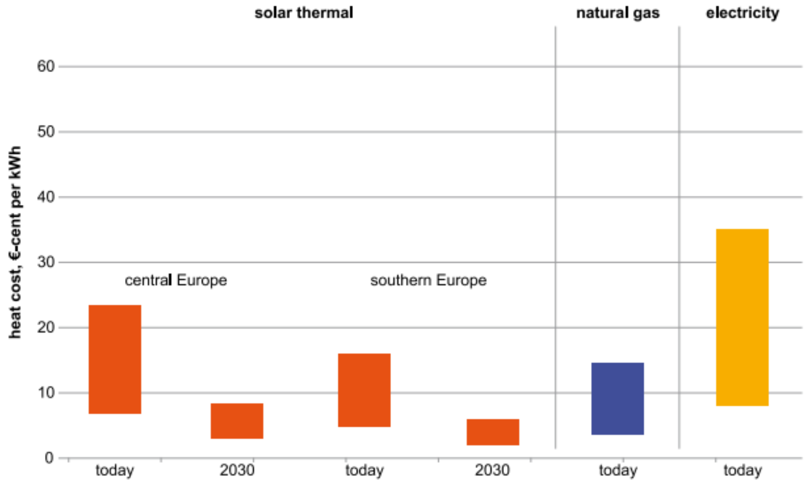

Figure 13: Typical cost ranges of domestic water/space heating with solar thermal, gas and electricity (Source: ESTIF, 2008)

Combi-systems in particular have benefited from these cost reductions, and have increased their market share. Further RD&D investment can help to drive these costs down further. Cost reductions are expected to stem from direct building integration (façade and roof) of collectors, improved manufacturing processes, and new advanced materials, such as polymers for collectors. Furthermore, cost reduction potential can be seen in increasing productivity by the mass production of standardised (kit) systems, which reduce the need for on-site installation and maintenance works.

Advanced applications, such as solar cooling and air conditioning, industrial applications and desalination/water treatment, are in the early stages of development, with only a few hundred of first generation systems in operation. Considerable cost reductions can be achieved if R&D efforts are increased over the next few years.

The competitiveness of solar thermal systems is more obvious when the analysis is based on life cycle costs. In this respect the concept of cost optimality introduced by the EPBD is essential to identify the best solutions for reducing CO2 emissions in a cost effective way. Taking into account the requirements set in the EPBD, we can observe that solar thermal is part of cost-optimal solutions already today. Furthermore, with reduced loads in nZEB (nearly zero-energy buildings), the solar thermal yield can easily increase, improving its competitiveness.

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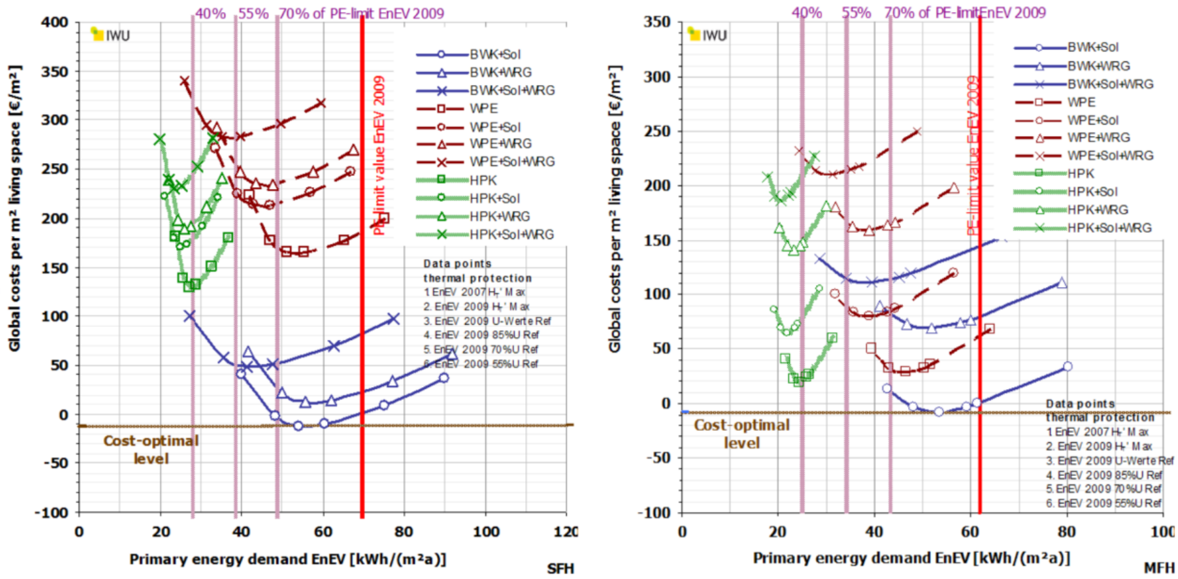

Global costs for SFH and MFH for all heat supply systems (baseline scenario, medium energy price development). Source: BPIE, 2013

The figure above shows the global costs per living space square meter versus the primary energy demand for the single-family houses (SFH) and multi-family houses (MFH) for all heat supply systems, considering a medium energy price development scenario, in Germany, resulting from an independent study from the Building performance institute (BPIE), as an attempt to benchmark different energy efficiency measures using the EPBD Cost-optimality criteria[20].

In this study it is shown that solar heating systems are part of the cost-optimal solutions, both for SFH and MFH, combined with a condensing boiler within a package including also standard thermal insulation, attaining with a primary energy demand of approx. 53-54 kWh/m²a. Furthermore, we can also find other interesting options using solar thermal, in combination with pellets or heat pumps, with lower primary energy consumption.

It is important that Member States when performing the pre-assessment and cost optimality studies do include renewable heating solutions, and solar thermal, in particular in countries where such solutions might not be very present on the market today.

[20] Implementing the cost-optimal methodology in EU countries, BPIE 2013, http://bpie.eu/documents/BPIE/publications/cost_optimal_methodology/BPIE_Implementing_Cost_Optimality.pdf

Barriers

Barriers to the deployment of solar thermal to its full potential can be classified in economic and non-economic barriers. Non-economic barriers can vary significantly according to the specific market. Their impact is not to be underestimated, and often economic incentives are not sufficient to overcome them properly. Specific actions are needed to tackle them, once they have been identified. Non-economic barriers can be social and cultural, when they refer to the understanding or use of the technology; geographical, when they are related to supply or servicing bottlenecks; technical, when related to functionality or performance of the technology; political, when related to incentives or market access distortions; environmental, when related to resource supply and waste production. A number of actions are needed to tackle those barriers, ranging from education/information campaigns, to standard and certification measures, to resource and waste management policies, and so on.

Economic barriers relate to prices, costs and competitiveness of solar thermal in the market. This includes the price of the system installation, the price of the heat produced over the life cycle of the system and the comparison with the alternative solutions on the market, in particular with traditional heating devices based on fossil fuels. Economic barriers are thus related to the real and to the perceived price of the solar thermal system, therefore the concepts of pay-back time and initial upfront investment costs are crucial, as their variation directly impacts consumers' choices and preferences. Economic barriers are also related to market distortions such as import tariffs and other taxes on equipment.

The table below provides an overview of the major barriers affecting the solar thermal market, and ways to tackle them.

	What are the main barriers?		How do we solve them?
NON-ECONOMIC	Lack of knowledge of solar thermal technology, of its real costs and benefits among European citizens.	›	✓ Promote information through Europe-wide campaigns, involving the EU institutions, the Member States, the industry, the consumers…
	The solar thermal technology and, more in general, the renewable heating and cooling sector is not well understood even by policy-makers.	›	✓ Produce a comprehensive evaluation of the H&C sector, describing MS markets and different national regulations. Build up a data collection system mapping heat demands in EU!

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	The energy security challenge is being met with large scale solutions, which do not always guarantee effective decarbonisation of the H&C sector, and discourages investments in a mostly decentralised technology such as solar thermal.	✓ The decarbonisation of the H&C sector must be comprehensive and involve the decentralised local level!
	Lack of skilled installers, informed urban planners.	✓ Promote training in the sectorial workforce, identify bottlenecks and improve competition in the installation market!
	Legislation that would solve several problems is already in place, but implementation is not always in place.	✓ EU Institutions should push Member States to proper implement existing legislation in the sector, with a particular focus on the art. 13 and 14 of the RES-Directive!
ECONOMIC	Investments in solar thermal from end-users at local, domestic level are held back by upfront investment costs.	✓ Design and spread specific financing tools that would help citizens overcome the upfront investment!
	Even when the upfront costs are tackled, access to financing is difficult for most consumers in times of economic crisis.	✓ Increase awareness of existing financing opportunities!
	Solar thermal must compete with over-subsidised fossil fuels in an uneven playing field.	✓ Design a roadmap to phase out fossil fuels subsidies, put a price to CO_2 emissions in the H&C sector to take into account the fossil fuels negative externalities and bring a real level-playing field!
	Some EU markets are closed to new entrants or are affected by overregulated prices for dominant conventional fuels.	✓ Promote a competitive market where consumers have choice.
	Lock-in effects can be produced by investments decisions from end-users at local, domestic level in energy efficiency alone.	✓ Promote the smart combination of energy efficiency and solar thermal in the building sector. Share best practices and roll out existing integrated solutions!
	Solar thermal technology potential is not fully explored.	✓ Promote R&D&I, starting from the implementation of the RHC Technology Roadmap!

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Solar Thermal and the EU 2020 targets[21]

In the Renewable Energy Progress Report launched in June 2015, the European Commission mentions that the EU Member States are on track to reach the 2020 targets. However, projections for 2020 show a different scenario with targets not being reached. At first, following the adoption of the Renewables Directive in 2009, the development of renewables was impressive. Afterwards, as support dwindled, there was a dramatic slowdown in renewable energy investments with a lower uptake of renewable technologies.

And, even if the EU Member States combined have exceeded the indicative target for 2014, the results are quite different per country and per technology, highlighting the diversity that characterizes Europe and the different levels of commitment.

Technology Category	Projected deployment 2014	NREAP target 2014	Projected 2020 deployment (max)	2020 target	Deviation 2014	Deviation 2020 deployment (max)
RES total	176.7	172.3	221.5	242.1	3%	-9%
RES heating & cooling	**87.6**	**80.5**	**107.5**	**108.9**	**9%**	**-1%**
RES electricity	72.5	73.3	94.9	103.7	-1%	-9%
RES transport	16.6	18.4	19.1	29.5	-10%	-35%
Solar Thermal	**2.2**	**2.6**	**3.7**	**6.4**	**-15%**	**-42%**

Projected deployment and deviation from planned EU technology deployment 2014 and 2020, Renewable energy progress report, European Commission, June 2015.Values on Mtoe.

[21] This section is an adaptation of the article '2020 targets: a Bermuda Triangle of Lost Opportunities?' on the ESTIF Solar Thermal Market Statistics 2014 publication.
See: http://www.estif.org/statistics/st_markets_in_europe_2014/

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The projection in terms of development per technology shows that, for several technologies, the indicative targets were not met in 2014 and risk not being met by 2020. Solar thermal is one of the most obvious cases where, if intentions are not met with concrete actions, the indicative 2020 targets for this technology will unfortunately be missed. While in 2012, the sector was 1.7% below the indicative target, in 2014 it is already -15.3% and the projections indicate that by 2020, the deviation from the target will be between -41.8% and -45.6%.

The indicative targets for solar thermal proposed by the Member States in the NREAPs were already modest in terms of ambition. A study on the Potential of Solar Thermal in Europe, published in 2009, projected different scenarios (see chapter 4.1): Business As Usual (BAU), Advanced Market Deployment (AMD) and a more ambitious one, Full R&D and Policy Scenario (RDP). Interestingly, the combination of national indicative targets for solar thermal in the NREAPS, published slightly later, were extremely close to the AMD scenario[22].

		2020				
		EU Path	**BAU**	**AMD**	**NREAPs**	**RDP**
Total Installed capacity	GWth	60	68	102	104	272
	Million m²	86	97	146	148	388
Target 2020	Mtoe	3.7	4.2	6.3	6.4	16.7

The current projection presented by the European Commission indicates that Members States are on a 'path' that is below the business as usual scenario presented in the referred study. Clearly, measures being taken by the Member States are not supporting the development of the technology as expected.

The main causes behind the difficulties in the solar thermal market have been broadly discussed. It is, in general, agreed that these include consumer preference for lower investment costs needed for conventional heating solutions, being rather more sensitive to this factor than to the actual energy cost. This effect is enhanced by the current market approach, where the replacement of existing equipment is mostly with an equivalent equipment rather than with a new solution. Other factors are the low fossil

[22] The scenarios on the study on the Potential of Solar Thermal in Europe were developed for EU27 and the current total for the NREAPS is for EU28.

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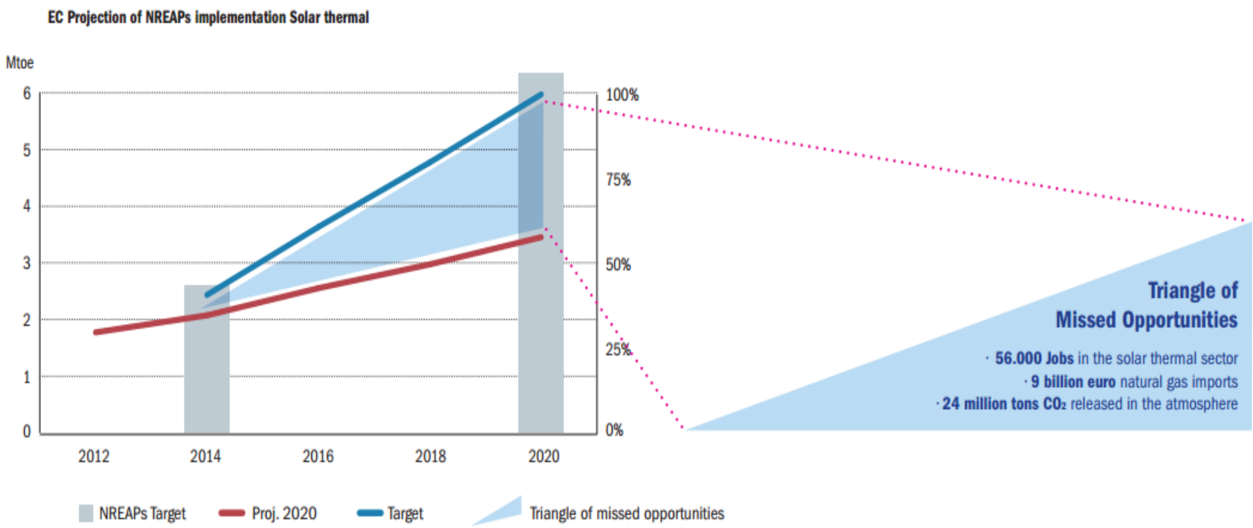
fuel prices (subsidized in several cases) and additional competition in the market provided by alternative renewable energy solutions.

Removal of several of the existing barriers depends on the eventual intervention of public authorities, such as the limited awareness of the technologies, instability in support measures, and lack of regulations promoting the switch from fossil fuels to clean options or scarcity of qualified installers. It is obvious that, in general, Member States are falling short on the implementation of the renewables directive, in particular with regard to 'Administrative procedures, regulations and codes'[23] or 'Information and training'[24], on issues such as building regulations[25], adequate information and awareness raising initiatives at local and regional level[26] or on the certification and qualification of installers[27].



Not meeting the indicative targets for solar thermal also implies a lost opportunity in terms of job creation. Since solar thermal is mostly a decentralized energy source, nearly half the investments in the sector are allocated to the lower end of the value chain. This means that, even when collectors are not

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[23] Art. 13 of the RES-Directive (Directive 2009/28/EC).
[24] Art. 14 of the RES-Directive (Directive 2009/28/EC).
[25] Art 13.6 - By 31 December 2014, Member States shall, in their building regulations and codes or by other means with equivalent effect, where appropriate, require the use of minimum levels of energy from renewable sources in new buildings and in existing buildings that are subject to major renovation. […]
[26] Points 1, 2, 5 and in particular point 6 of Art. 14 of the RES-Directive (Directive 2009/28/EC): Member States, with the participation of local and regional authorities, shall develop suitable information, awareness-raising, guidance or training programmes in order to inform citizens of the benefits and practicalities of developing and using energy from renewable sources.
[27] Art. 14.3 - Member States shall ensure that certification schemes or equivalent qualification schemes become or are available by 31 December 2012 for installers of small-scale biomass boilers and stoves, solar photovoltaic and solar thermal systems, shallow geothermal systems and heat pumps. […]

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produced locally, the installation is done by local companies. This has an important impact on the local economy and thus contributes to local job creation. The local dimension of the solar thermal sector is a major positive externality and a key success factor for the industry. Nonetheless, this potential for job creation is being squandered.

According to the estimation in the study on the Potential of Solar Thermal in Europe, in a Business as Usual scenario (above current EC projections for ST in 2020), the number of jobs in the sector by 2020 would be 46 900. If the indicative targets for solar thermal were achieved, this would represent an additional 56 000 jobs in the solar thermal sector in Europe by 2020, totalling 103 200. Furthermore, it would represent a saving of 9 billion euros in natural gas imports and avoid the release of 24 million tons CO_2 into the atmosphere.

In terms of energy production, it would represent the equivalent to 78 TWh_{th}, while in 2014 the estimated energy generation amounted to 21.9 TWh_{th}, only 28% of the target, with Italy, France and Spain being the countries that are the furthest away from their indicative national targets in absolute terms.

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Solar Thermal and the Heat Strategy

The solar thermal sector, despite covering still a minor fraction of EU heating production, has the potential and the ambition to have a central stage in the Heat Strategy, and more generally in the EU policy for the heating and cooling, insofar as it is a crucial part of the answer the EU must give to the challenges faced by the heating and cooling sector in Europe. Being a flexible, versatile technology, easily deployable at different scales, solar thermal can cover different needs in different contexts, from urban to rural scenarios, from domestic to industrial usages. Having low planning and installation requirements, solar thermal deployment on a larger scale would be extremely rapid, and, with the right incentives and policy framework, it could be ramped up to meet a larger share of the European heating and cooling demand in just a few years.

The Heat Strategy is indeed a very welcomed first step in setting a right framework for such a technology deployment. However, it is just a starting point. Crucial next steps are going to be the review of specific legislation affecting the heating & cooling sector and the setting up of a 2030 governance framework, alongside with the full implementation of the 2020 framework.

General objectives

The main objective of the Heat Strategy should be to define a pathway for the heating and cooling sector to contribute to the overarching goal of reaching a sustainable, competitive and secure energy sector for Europe.

This goal is to be met in two complementary ways: through the decarbonisation of the heat production (by reducing GHG emissions of heat production) and through the reduction of the heat consumption. If energy efficiency measures are clearly the most direct way to reduce heat consumption, renewable technologies for heating and cooling - such as solar thermal - must be the key element for the decarbonisation of the H&C sector! These technologies are fundamental for an efficient and affordable switch from fossil fuels to sustainable alternatives, be it at the residential and tertiary level, or for industrial processes.

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The Strategy should therefore focus on how to promote fuel switch from fossil fuels to renewables in the heating sector, focusing on two key areas: the building and the industry sector. The fuel switch is to be pursued both at a central level, switching large scale installations such as district heating networks, and –most importantly- at a decentralised, local level, switching individual domestic installations from inefficient old heating equipment to small scale renewables.

The Strategy should concretely foster the roll-out of renewable technologies for heating and cooling for a truly efficient decarbonisation of the heat consumption, identifying challenges and barriers to the decarbonisation of the heating & cooling sector via the deployment of renewable technologies for heating and cooling, and finding ways to overcome those barriers.

In brief, for the solar thermal sector, the Heat Strategy should:

- identify barriers to the renewable heating and cooling deployment and ways to overcome them, avoiding medium-to-long term solutions in the heating sector that would lock-in inefficient fossil fuels infrastructure;
- Look at energy efficiency always in combination with renewables for heating and cooling;
- provide a sound basis for all future legislative interventions in the heating sector;
- include a roadmap of how to gradually phase-out fossil fuel subsidies and reach a truly decarbonised heating sector by 2050;
- recognize the importance of meeting heat demand with renewable heat production, limiting the role of electrification of the heating sector to segments where it is truly efficient.

Actions

After identifying the main barriers to an effective decarbonisation of the heating & cooling sector, the Heat Strategy should focus its attention on four main actions, or pillars, which together are capable of tackling most of the existing barriers. For each pillar, several sub-actions can be identified.
Those pillars are:

- **Ensuring a level-playing field in the heating & cooling sector, in particular between renewable technologies for heating and cooling, and fossil fuels.**

- The European Commission should promote transparency as a general principle when it comes to identifying elements hampering the level-playing field, particularly regarding fossil fuels subsidies. The Commission should also provide recommendations to Member States on how to reach a level-playing field in the H&C sector and how to pursue the phasing out of the fossil fuels subsidies, and then monitor actions taken accordingly.
- The Heat Strategy should include a roadmap on how to phase out fossil fuels subsidies, be it direct subsidies, corporate tax breaks, subsidies to consumption when not targeted to fuel switch, or other indirect subsidies.
- The negative externalities of fossil fuels must be taken into account. A carbon price should be fixed for the H&C sector, which mostly falls outside the ETS system. Where a carbon tax is not politically feasible, and in order to offset this market failure, fuel switch to renewable sources of heating should be supported.
- Other measures that foster an uneven playing field must be identified and tackled. It is for instance the case of overregulated markets, where fixed prices of gas forcefully alter the competition with other alternative sources of energy.
- The Heat Strategy should promote a competitive heating & cooling market, where the consumers have real choice. Any forms of restrictions to access clean energy supply must be identified and tackled.
- The Heat Strategy should explore synergies between renewable technologies for heating and cooling, and energy efficiency measures. Those synergies should avoid the creation of lock-in effects, where investments on one of the two pre-empt the development of the other. Once a level-playing field with fossil fuels is reached, a technology neutral approach should be kept: the market should be free to decide the equilibrium between investments in energy efficiency and in renewables for H&C.

➢ **Tackling the issue of access to financing for renewable heating and cooling and energy efficiency measures, in order to promote investments in the decarbonisation of the H&C sector.**

- The Heat Strategy should direct financing in the H&C sector towards the promotion of fuel switch from fossil fuels to renewables, both in centralized installations (district

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heating and CHP) and in decentralised, small scale installations. The Strategy should particularly focus on the fuel switch in the building sector and in the industrial sector, as well as recommending strategic switch in targeted countries highly dependent on external gas supplies.

- The Commission should address as an outmost priority the issue of the upfront investment cost for renewable heating and cooling technologies installed by citizens at local, small scale level. Innovative financing tools must be explored, focusing on decentralised and small scale investments.
- When considering the financing of projects, renewables for heating and cooling and energy efficiency should be addressed at the same time, notably in the building sector, as they face similar barriers and can generate synergies.
- The Commission should increase awareness and transparency on already available financing opportunities to finance the investment cost for renewable heating and cooling technologies in decentralised, small scale installations.
- The forthcoming Smart Financing for Smart Buildings Initiative should explore the synergies between energy efficiency and renewable heating and cooling in the building sector, focusing in particular on integrated solutions combining the two elements.

➢ **Ensuring the proper implementation of the existing legislation.**

- The Heat Strategy should aim at providing a sound basis for all future legislative interventions in the H&C sector, and ensure a correct implementation of the existing legislation. It should foster a new regulatory framework to ensure the integration of RES-H&C in buildings, industry and smart thermal grid.
- Special attention should be paid to the correct implementation of articles 13 and 14 of the Renewable Energy Directive dedicated to renewables in buildings, to the reduction of administrative barriers, to improved information for consumers, and training of installers. Beyond 2020, these measures should be strengthened, boosting the renovation of the existing building stock. The Commission should better monitor Member States actions to implement those key articles, and should be firm in considering eventual infringement procedures.

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- The Heat Strategy should ensure consistency for the incoming revision of the EPBD, EED and RES Directives, and make sure the main pillars outlined here are adequately represented in the revision.

- **Fostering research, development and innovation.**
  - The Heat Strategy should build on the work already accomplished by the RHC Technology Platform, and aim at implementing the Technology Roadmaps[28].
  - R&D&I in RES-H&C technologies should target costs reduction, improvements in the temperature level, the enhancing of system performance and the integration of RES-H&C into existing infrastructure. It should also target the commercialisation phase and should aim at covering additional industrial sectors.
  - The R&D&I should also be targeted towards the development of integrated solutions, combining RES-H&C technologies with energy efficiency interventions.
  - The Heat Strategy should explore ways to foster and mobilize private investment, in combination with EU financing.

Two additional transversal issues on which the Heat Strategy should be based are:

- **Gathering information and promoting knowledge on the heating & cooling sector.**
  - The Heat Strategy should include a comprehensive evaluation of the heating and cooling sector. This should include:
    - A description of the H&C sector in Europe, carefully distinguishing between energy sources (gas, heating oil, coal, biomass, geothermal, solar thermal, aerothermal), enablers (heat pumps, boilers, stoves, district heating, cogeneration), end-users (households, industry, commercial).
    - A description of heating and cooling market in the different MS, including an evaluation of the potential for RES-H&C technologies;
    - An analysis of existing EU-level policies and regulations, which have direct or indirect influence on heating and cooling.

[28] http://www.rhc-platform.org/publications/

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    - A description of different regulations in the heating and cooling sector currently in place in the different MS.
  - The Strategy should propose a permanent data collection system aiming at mapping heat demand and production across Europe, in cooperation with MS, industry, consumers.

- **Involving the citizens as active and informed prosumers.**
  - Citizens' involvement is a transversal issue of the outmost importance, as any other action is likely to fail if it is not sustained by wide public support. The Strategy should therefore strive to involve citizens at all levels, including as small scale investors, consumers, and heat producers.
  - The most direct way to involve citizens is providing them with information and knowledge. Citizens must be involved in their energy choices, and informed about available options. The Strategy should therefore promote campaigns at national and local level both to increase awareness of economic and environmental benefits of switching fuels to RES-H&C in centralized installations, and to inform citizens on available options and relative advantages of RES-H&C in decentralised, small scale installations.
  - In order to give real choices to the consumers, the Strategy should aim at removing relevant bottlenecks in the market, such as lack of skilled installers for RES-H&C technologies. It should therefore promote and increase information and trainings of relevant actors (installers, architects, builders, suppliers of equipment, etc.), fully implementing art. 14 of the RES Directive.
  - Another bottleneck to be removed is the burdensome or problematic authorisation procedure for RES-H&C technologies by local public authorities. This should be done in close cooperation with local authorities and civil society at local level, and according to the measures foreseen in art. 13 of the RES Directive.

Altogether, the structure of the Heat Strategy should look like the image below.

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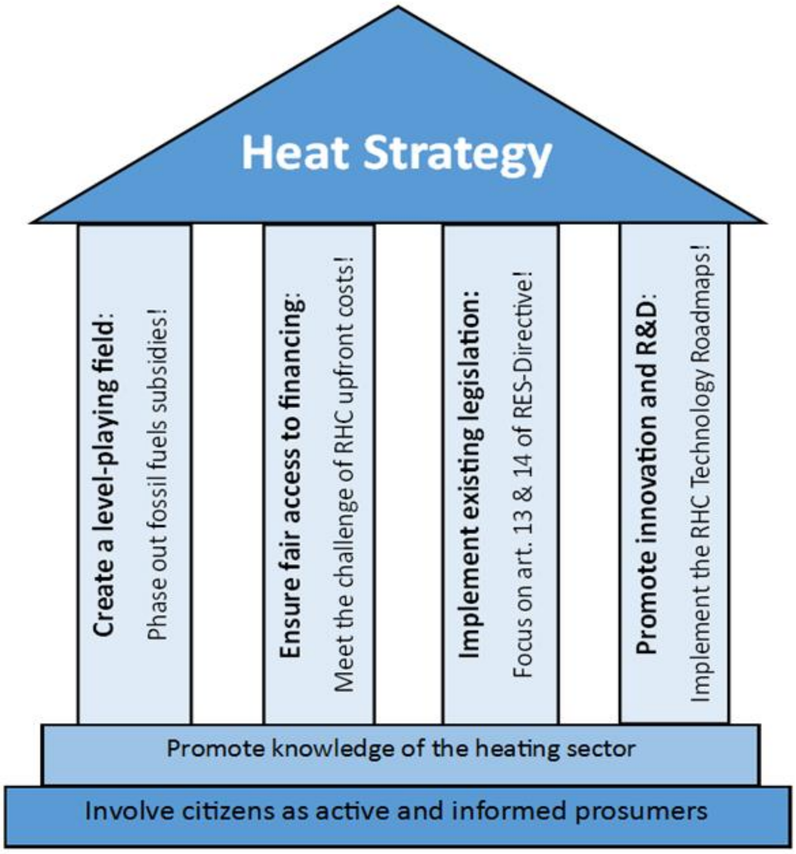

In brief, **the Heat Strategy should**:

- aim at decarbonising the EU H&C sector, giving a central role to the RES-H&C technologies;
- Promote as a goal the fuel switch in the residential, commercial and industrial sectors, particularly focusing on the decentralised, small scale and local level.
- Explore synergies between RES-H&C technologies and energy efficiency measures, promoting integrated solutions that combine both aspects.
- Be sustained by four pillars…
    - creating a level playing field;
    - ensuring fair access to financing;
    - implementing existing legislation;
    - promoting innovation and R&D;
- ...and be based on two transversal issues:
    - Promoting knowledge of the heating sector;
    - Involving citizens as active and informed prosumers.

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Conclusions

The EU Strategy on Heating and Cooling is a very welcomed initiative, a first necessary step in the path towards a proper policy framework for the sector. There is still however much to be done, and the solar thermal industry is willing to work together with the EU institutions and the other stakeholders to proceed to a successful decarbonisation of the heating and cooling sector in a sustainable and affordable way.

In this context, the solar thermal sector represents an opportunity for the European Commission to contribute to the aims of the EU Strategy on heating and cooling and, more generally, to the overall goals of the EU energy policy. Solar thermal is a sustainable option that is already competitive today in many market segments, and can become even more competitive on the short term with appropriate measures. Solar thermal can play an important role in the decarbonisation of the heating and cooling sector, being a flexible and easy to deploy technology, adaptable to different contexts and needs.

Solar thermal is also a European industry, which provides European added value and local jobs. Europe cannot afford to lose the opportunities associated to a full deployment of solar thermal technology. Solar thermal is a no-regret option for Europe, and the biggest energy and economic waste today is the untapped free supply of solar energy!

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ANNEXES

I. Factsheet on integrated energy efficiency – solar thermal solution case study

II. Data on solar thermal costs

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BEST PRACTICE EXAMPLE

Pre-fabricated Multifunctional Façade Modules with Integrated Solar Thermal

DESCRIPTION

The aim of this showcase project is to reduce the energy demand, running costs and GHG emissions of a large residential building. This is achieved through a high-performance building envelope renovation, which includes both energy efficiency refurbishment and production of renewable thermal energy. To this end, prefabricated large-scale façade modules with integrated solar thermal collectors were used. These modules are incorporated into the old façade, thus reducing installation time and costs. Residents are also able to continue living in the building during the renovation works. The design and structure of modules can be adapted to different facades, thus incorporating external elements such as windows, balconies, ventilation devices.

REGION

Dieselweg Residential area, Graz, Austria

KEYWORDS

* Solar Thermal
* Integrated solutions
* Energy Efficiency
* Building renovation

KEY BENEFITS

- Higher thermal insulation for the building
- Greater passive solar gains
- Weatherproof building
- New structural components for architecture
- Increased wellbeing for inhabitants
- Lower energy bills
- Decrease in space heating demand >80%
- Reduction of the CO_2-emissions >80 %

Pre-fabricated façade modules

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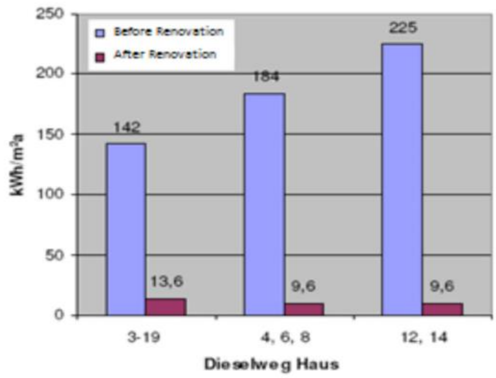
Energy Consumption (space heating)



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KEY DATA

Renovation project: 2008-2010.

- Project costs: 8.8 Mio. EUR.
- Heating running costs (EUR per net floor area per month):
  - Before renovation: approx. € 2.0/m^2
  - After renovation: € 0.11/m^2.
- Domestic hot water running costs (EUR per net floor area per month):
  - Before renovation: approx. € 0.40/m^2
  - After renovation: € 0.10/m^2.
- Energy cost reduction: over 90% (on average, from 183 kWh/m^2 per annum to 11 kWh/m^2 per annum).

Dieselweg 12, 14

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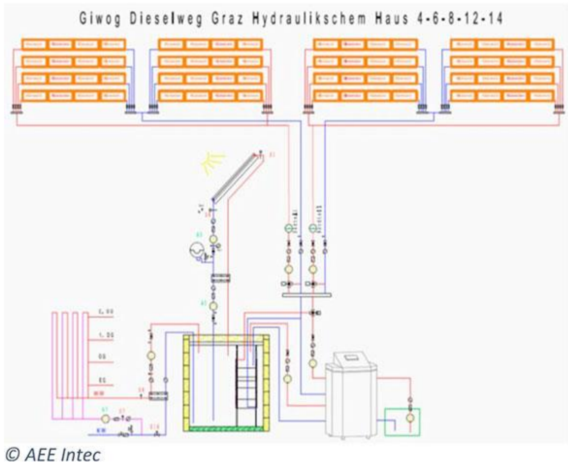
HOW DOES IT WORK

The renovation is based on a concept combining two solutions in one operation: reducing the energy demand by improving the building thermal envelope with prefabricated façade modules and generating renewable thermal energy by integrating solar thermal collectors into the façade modules. The collectors are vertically integrated into the façade modules south facing and also installed on flat roofs and carport (3m^2/apartment). They feed a 40m^3 heat storage tanks system located in the basement, together with a ground water heat pump. New heating and DHW supply systems, and pipes are installed between the façade and existing wall. Control and remote maintenance are via the internet.

Solar Thermal System



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FIND OUT MORE

- www.empa-ren.ch/A50/Annex%2050%20Final%20Publications%20for%20Internet/Graz_Dieselweg_3-19_CaseStudy_ECBCS_A50.pdf
- www.lehr.be/Downloads/10_Geier.pdf

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Data on solar thermal costs

Assumptions for solar heat cost calculations

	Thermosiphon Southern EU	Forced circulation central EU	Forced circulation northern EU	Solar cooling	Large scale EU
Investment costs (USD/kW)	630	850-1 900	1 600-2 400	1 600-3 200	350-1 040
Collector yield (kWh/m²a)	685	395	360	395-685	685
Discount rate	3%-6%	3%-6%	3%-6%	3%-6%	3%-6%
Lifetime (yrs)	15	20	20	20	20
Operation and maintenance	0.5-1.5%	0.5-1.5%	0.5-1.5%	0.5-1.5%	0.5-1.5%

Note: Actual observed system prices can go beyond these ranges.

Source: IEA, Solar Heating and Cooling Technology Roadmap, 2012.

Solar thermal system characteristics and costs for single-family dwellings, 2007

	Single-family dwelling		
	OECD Europe	OECD North America	OECD Pacific
Typical size: water heating (kW_{th})	2.8-4.2	2.6-4.2	2.1-4.2
Typical size: combi systems (kW_{th})	8.4-10.5	8.4-10.5	7-10
Useful energy: water heating (GJ/system/year)	4.8-8	9.7-12.4	6.5-10.3
Useful energy: space and water heating (GJ/system/year)	16.1-18.5	19.8-29.2	17.2-24.5
Installed cost: new build (USD/kW_{th})	1 140-1 340	1 200-2 100	1 100-2 140
Installed cost: retrofit (USD/kW_{th})	1 530-1 730	1 530-2 100	1 300-2 200

Source: IEA Solar Heating and Cooling Implementing Agreement; ESTTP, 2007; Navigant Consulting, Ecodesign Hot Water Task 4; and NEDO, 2009.

Source: IEA, Energy-efficient Buildings: Heating and Cooling Equipment – Technology Roadmap, 2011.

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Solar thermal system characteristics and costs for multi-family dwellings, 2007

	Multi-family dwelling		
	OECD Europe	OECD North America	OECD Pacific
Typical size: water heating (kW_{th})	35	35	35
Typical size: combi systems (kW_{th})	70-130	70-105	70
Useful energy: water heating (GJ/system/year)	60-77	82-122	86
Useful energy: space and water heating (GJ/system/year)	134-230	165-365	172
Installed cost: new build (USD/kW_{th})	950-1 050	950-1 050	1 100-1 850
Installed cost: retrofit (USD/kW_{th})	1 140-1 340	1 140-1 340	1 850-2 050

Source: IEA Solar Heating and Cooling Implementing Agreement; ESTTP, 2007; Navigant Consulting, Ecodesign Hot Water Task 4; and NEDO, 2009.

Source: IEA, Energy-efficient Buildings: Heating and Cooling Equipment – Technology Roadmap, 2011.

Costs	Typical current international values and ranges						
Typical Breakdown Heating (US)	Collector: 51% Storage: 11% BoS Costs: 38%						
Typical Breakdown Cooling (Greece)	Solar loop: 37%; Storage: 8%; Thermal chiller (100kW): 29%; Heat rejection loop: 7%; Services: 18%						
System	Thermo-syphon direct					Thermo-syphon indirect	
Country/Region	Australia	China	India[b]	South Africa	Turkey	Southern Europe	US[c]
Investment costs[a], USD/kW	1100	100-250	130-180	630-650	130	630	2300
Collector yield, kWh/m²a	850	770-860	850	900-1000	770-900	685	550-700
Collector size, m²	3.5	4	2-4	2.5-4	4	2.5-4	6

Costs	Typical current international values and ranges				
System	Pumped Indirect			Pumped Direct	
Country/Region	US[c]	Central Europe	North Europe	US[c]	South Africa[d]
Investment costs[a], USD/kW	2300	850-1900	1600-2 400	1700	760-820
Collector yield, kWh/m²a	550-700	395	360	550-700	900-1000
Collector size, m²	6	4-6	4-6	6	2.5-4

Source: IRENA, Solar Heating and Cooling for Residential Applications - Technology Brief, 2015.

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Table 1: Investment costs of STS in different regions.

	Country/ Region	Investment costs[a] (USD/kW)	Collector yield (kWh/m²a)	Collector size (m²)
Thermo-syphon direct	Australia	1100	850	3.5
	China	100-250	770-860	4
	India[b]	130-180	850	2-4
	South Africa	630-650	900-1000	2.5-4
	Turkey	130	770-900	4
Thermo-syphon indirect	US[c]	2300	550-700	
Pumped direct	US[c]	1700	550-700	
	South Africa[d]	760-820	900-1000	2.5-4
Pumped indirect	US[c]	2300	550-700	6
	Central Europe	850-1900	395	
	North Europe	1600-2400	360	4-6
ICS collector	USA[e]	450-800	700	3-4.5
Solar CS[f]	China	980-1400	580	12
	Germany	1800-	530-622	12
STS district heat	Denmark[g]	350-400	450-480	10000

a without subsidies
b ETC are supposed to be 1/3 cheaper than FPC (Epp, 2013c), exchange rate 1 INR = 0.01661 USD, June '11.
c NREL, 2012
d Exchange rate 1 ZAR = 0.1 USD, June '14
e DoE, 2012
f Personal communication with manufacturers
g IEA, 2012

Source: IRENA, Solar Heating and Cooling for Residential Applications - Technology Brief, 2015.

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