European Solar Thermal Technology Platform

Solar Thermal Vision 2030

Vision of the usage and status of solar thermal energy technology in Europe and the corresponding research topics to make the vision reality

First version of the vision document for the start of the
European Solar Thermal Technology Platform (ESTTP)

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Executive summary

Without any question, solar thermal technology is already a matured technology. 30 years of development have led to efficient and long lasting systems. However, today solar thermal energy is only used in a small percentage of European buildings, usually for domestic hot water heating in private houses. A growing share of the installed systems provide additional support of room heating, covering already typically up to 30% of the total heating requirements of a building in Central Europe. Some large solar thermal systems are installed, which provide domestic hot water for multi-family buildings, hotels, hospitals and similar buildings. A few very large solar energy systems are delivering heat for district heating, sometimes by using huge seasonal storages, which are heated by the solar collectors in summer and which deliver this heat for room heating in winter. There are also some demonstration systems installed to produce high temperature heat for industry or to assist cooling machines up to now.

The most important reason for not using more solar thermal energy today is the low (and subsidized) price for fossil fuels. However, from 1998 to 2005, the oil price increased by 23% p.a. on average. Further there are growing doubts over the security of oil and gas supply since the Russian-Ukrainian gas quarrel at the beginning of 2006. And a growing number of experts are proving evidence that we are near reaching peak-oil, after which oil supply will decline due to physical reasons. In addition, the urgency to reduce the use of fossil fuels in order to reduce emissions of greenhouse gas and to limit climate change becomes more and more obvious. For all these reasons a fast transition to an energy structure based on renewable energy is of utmost importance.

Solar Thermal Energy is an important alternative to fossil fuels with a huge potential. In 2005 approximately 10 GW_{th} of solar thermal capacity were in operation in Europe. This capacity could well be increased to at least 200 GW_{th} by 2030, when solar thermal energy will be used in the majority of European buildings. The typical share of solar thermal energy in meeting the heating and cooling demands of a single building will be increased dramatically to more than 50%, and up to 100%. And new applications will be developed, e.g. solar thermal systems that provide process heat for industrial use.

Although matured solar thermal technologies are available already, there are further developments needed to provide adjusted products and applications, reduce the costs of the systems and increase market deployment. Turning solar thermal into a major energy resource for heating and cooling in Europe by 2030 is an ambitious but realistic goal, which is well achievable – provided the right mix of research & development, industrial growth and consistent market deployment measures is applied.

About 49% of final energy demand in Europe is used for heating and cooling requirements, mainly in buildings. On the basis of a strong reduction of energy demand through energy efficiency measures, solar thermal energy will be the most important energy source for heating and cooling in new buildings and in the existing building stock by 2030. Already today, state-of-the-art buildings are constructed that are fully heated by solar thermal energy.

Solar thermal systems will look very different in the future. Solar thermal collectors will cover, together with photovoltaic modules, the entire south-oriented roof area of buildings. Roof windows will be integrated. The storage tank will be able to store the solar heat over weeks and months, but will not be too large. The solar thermal energy system will provide domestic hot water, room heating in winter and room cooling in summertime, thus greatly increasing the overall comfort of the building.

Important further solar thermal applications will be available: large systems for multi-family houses, hotels, hospitals etc. In small cities, every building will have its own solar thermal system; in large cities, solar thermal energy will be used within district heating systems. Solar thermal systems will provide process heat of up to 250°C for industrial requirements. Solar thermal sea water desalination will be important, e.g. for the Mediterranean countries.

In a few years, solar thermal systems will be cost competitive, due to reduced costs for solar heat and increased prices for fossil fuels. The effect of large-scale use of solar thermal will decrease greenhouse gas emissions as well as the high European dependency on imported fuels. Solar thermal energy will consequently help to keep the energy costs within acceptable limits for consumers and industries. In addition, a large number of new and future-oriented jobs will be created mainly in small and medium size enterprises, due to the decentralised nature of the technology.

The European Solar Thermal Technology Platform (ESTTP) will play a very important role in the future development of solar thermal in Europe by:

- specifying the vision of the use of solar thermal energy in 2030
- working out a strategic research agenda which is necessary to achieve the vision
- accelerating the technological and market development of solar thermal technologies
- advising industry, researchers and politicians about the most appropriate and effective steps to develop the technology, industry and markets for solar thermal in order to implement the vision and the strategic research agenda

The goal of the ESTTP is to help the industry, the research community as well as public funding bodies to focus on high-impact topics with the aim of sustaining the European solar thermal sector's global technological leadership.

1 Introduction

A major part of the energy use in the EU is related to applications in heating and cooling which operate at temperatures far below 250°C. Most of this heat could be provided by solar thermal energy.

About 49% of final energy demand in EU25 is used for heating purposes. 80% of that demand is used for applications below 250°C. These figures reflect the enormous potential for solar thermal as the main technology to replace traditional fuels used for heating and cooling.

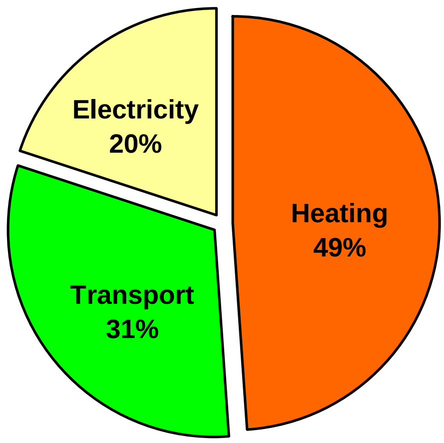

Fig. 1: Breakdown of final energy consumption in Europe

In order to fully utilise the potential of the technology, there must be a structural approach towards research and development along with implementation aspects. Solar thermal will generally be produced on site and not transported over long distances. Therefore, solar thermal needs to "blend" into the existing processes, installations and buildings.

In new buildings, solar thermal energy can cover 100% of heating and cooling requirements. In the existing building stock, solar thermal can cover more than 50% of the heating and cooling requirements, and up to 100%, depending on the specific conditions. For various industrial processes, the solar thermal potential is hardly used today, but this is expected to change drastically once the turning point is reached and price levels of traditional fuels will exceed solar thermal prices.

This vision document describes the goals and targets for solar thermal energy and provides an overview of the technological perspectives and needs of research and development to fully utilise its benefits as a major energy source in 2030. The paper gives some ideas as to the sectors in which solar thermal energy will be used, to what extent, with which technology and in what types of applications.

2 Objectives and scope

2.1 The nature of the task: heating and cooling without the use of fossil fuels

In 2030, it is very likely that due to their limited availability fossil fuels will be too expensive to be used for heating and cooling buildings. The need for drastic reductions in the consumption of fossil fuels for energy requirements in buildings and industrial processes will lead to energy efficiency measures and energy savings in general. However these measures alone will not be sufficient. The large-scale deployment of renewable energies and especially solar thermal is the essential factor to guarantee a sustainable supply of heating and cooling.

Solar thermal energy offers the availability to cover a substantial part of the EU energy use in a cost effective and sustainable way

The proportion of CO_2-neutral heating systems using biomass, and in some regions geothermal, will rise significantly in the future. The existing biomass and geothermal potential will however not be sufficient to cover the entire heating and cooling demands, especially since biomass will also be needed to cover the requirements of the transport and electricity generation sectors.

In the vision described in the following, the efficient use of energy sources, by means of heat insulation of buildings for instance, but also by using passive solar energy through windows, as well as the extensive use of biomass and geothermal energy, is taken for granted and not given specific mention. Therefore only the active solar thermal energy systems, which cover an important part of the remaining energy demand, are described.

2.2 A vision for 2030: solar thermal energy systems will provide up to 50% of low temperature heating and cooling demand

For new buildings, the vision is to establish the completely solar-heated building as a building standard by 2030. This concept already exists and the functionality of such systems has been proven. The only requirements are a sufficiently large area for the solar collector and a seasonal heat storage system that uses the energy obtained in summer to heat the building over the winter months. Already in 1989, a house using solar energy for 100% of its heating requirements was constructed in Oderburg, Switzerland. This was followed by other solar energy houses, for example the Self-Sufficient Solar House in Freiburg in 1991. A growing number of buildings constructed in Europe are heated 50% to 100% by solar thermal energy.

In the future, new compact long term storage technologies will significantly reduce the space demand required of heat storage devices. High-efficiency solar collectors will be developed further, which will increase the energy gained from the winter sun. Additonal components and the design of such systems have to be further improved to allow their use in the widest possible spectrum of applications, as well as their integration in the building and in the energy system.

For the existing building stock the challenges are even greater. The building envelope, the location, orientation and access to energy networks determine the possibilities to reduce the heating demand and to produce the entire heat demand by solar thermal energy. However technologies and products to drastically reduce the energy consumption are already available. The aim of the solar thermal branch is to cover substantially more than 50% of the remaining heating demand with solar thermal energy in refurbished buildings.

Solar thermal energy will not only be the most common type of heating system in residential buildings but also in public, commercial and industrial buildings, and it will supply heat for domestic hot water as well as for room heating and cooling requirements.

For the industrial and agricultural needs of process heating and cooling, the challenges are similar. Due to increasing prices of fossil fuels and growing restrictions of greenhouse gas emissions, the industry is increasingly adapting to review its energy-consuming processes. In that respect, there is growing potential which will require further appropriate technical solutions based on solar thermal technology in order to tap the enormous potential for heat at temperatures of up to 250°C.

It is expected that in the coming years solar thermal will become the most important source of energy for heating and cooling buildings and will play an important role in providing (industrial) process heat

Approximately 40% of the final energy consumption in the EU is accounted for by the low-temperature heating segment in new buildings, the existing building stock, and industrial requirements in process heating and cooling. It is in this segment that the European Solar Thermal Technology Platform is operating.

2.3 The potential for innovation has been underestimated

Up to now, solar thermal technology has no high priority in European and national R&D strategies and therefore only very limited financial resources are provided for R&D in this sector. The reason is that in many circles, solar thermal energy systems are regarded as a low-tech technology with little potential for development. But the huge potential of energy production and the huge potential of technical development of solar thermal technology described in this vision document make it evident that solar thermal technology is as yet dramatically underestimated.

Already in recent years, impressive technological developments have been made. All components of solar thermal systems were improved, new concepts, materials and new types of production were developed in order to increase efficiency, quality and life time of the systems, as well as to reduce costs. For example, solar combi-systems (solar thermal systems for combined domestic hot water provision and space heating) have been significantly improved in their level of efficiency and reliability, as well as in the level of integration of collectors into the roof cladding or facades and of the integration of solar energy systems into conventional heating technology.

Now we have to start to fully exploit the great potential for innovation of solar thermal technology in a strategic way. This applies to all components such as solar collectors, storages, controllers, pumps, security equipment etc. as well as system design, integration in conventional heating systems and the building envelope. In addition, the new applications such as process heat and cooling have to be further developed.

2.4 The high variation of geographical conditions has to be considered

The different intensities of solar radiation and the different demands for domestic hot water, room heating and cooling throughout Europe lead to very different solar thermal systems and applications. This represents a major additional challenge for the development of the technology, but also brings more dynamism into the process. Other than electricity, heat cannot be transported over large distances, therefore solar thermal energy has to be produced near the loads, and the applications have to be adjusted to the various existing heating and cooling equipment and structures.

The vision and the strategic research agenda for solar thermal technology have to take into account the geographical and climatic variation across Europe, and have to guarantee that adjusted solutions are developed. Mediterranean heating and cooling installations have different requirements than Scandinavian ones. Covering cooling demand is of priority in the south, and heating demand in the north of Europe.

3 Solar thermal energy in 2030

Highly efficient, innovative and intelligent solar thermal energy systems providing hot water, heating and cooling will be available, and will offer a high level of reliability and comfort

By the year 2030, specific solutions will be developed for new buildings, for the existing building stock, and for other applications such as industrial needs and cooling. Solar thermal energy will be used in stand-alone single family houses as well as in multi-family houses. In urban areas, a growing proportion of buildings will be heated by district heating systems with seasonal storages, which are heated up to 100% by solar thermal energy.

3.1 Solar vision for new buildings: the Active Solar Building

New buildings offer the chance of optimising building architecture by providing a large solar proportion of energy usage, minimum heat loss, efficient ventilation and optimal integration of large solar collector areas. Integrated building planning offers a high level of comfort in room temperature conditioning by using surface heating and solar cooling systems. The Active Solar Building will be fully heated by solar thermal energy.

There are different ways to achieve the goal of fully heated buildings in Southern as well as in Central and Northern Europe. Active solar thermal energy systems could be integrated into the walls, thus efficiently minimising the heating requirements whilst providing an active and efficient flow of heat energy into the building. In summer, the heat energy can be used for cooling, as required. Solar collectors on the roof provide heating of the domestic water. As an alternative to wall-integrated active solar energy systems, large collector fields on the roof and in the facade can feed into seasonal compact heat storage systems that retain the energy for use in the winter months.

Active solar thermal energy systems can also be used for cooling the building. Systems will be adapted to accommodate geographic differences. Buildings in the north of Europe will emphasise the heating aspects, while buildings in the south of Europe will emphasise cooling. Buildings in Central Europe will most likely balance the two aspects in generic approaches.

3.2 Solar vision for the existing building stock: Active Solar Renovation

In the future, the energy-related renovation of the existing building stock will be a much bigger task than the construction of new buildings. All throughout Europe, active solar thermal energy systems offer excellent options for carrying out energy-related renovation of buildings, with sustainable emission-free heating and air-conditioning systems. Huge synergy effects can be used by combining active solar thermal systems with insulation measures.

The Active Solar Building which is 100% heated and cooled by solar thermal energy will be the building standard for new buildings

Active Solar Renovation could mean that compact facade or roof units containing active solar elements will be placed on top of existing facades for insulation and energy production purposes. Various solar facade and roof modules will be available, for example solar thermal collectors for water or air heating, photovoltaic modules for electricity generation, as well as modules with transparent insulation for directly heating the walls.

Facade elements used for heat insulation of existing buildings will be significantly thinner and, at the same time, offer greatly improved insulation characteristics, for example through the use of vacuum insulation. The elements will be offered in a wide range of standard raster sizes and will offer the architect all possibilities for adding full-surface solar facades to the building. The ability to combine solar and opaque elements with any desired surface will extend the architectural design possibilities and offer the chance of providing a complete solar energy solution.

Other facade elements could be directly coupled to the existing wall. The wall will be able to efficiently absorb solar energy and direct the heat into the building in a controlled manner. Layers within the wall will be able to regulate the heat flow into the building efficiently for heating the building in winter through the wall and insulating it against external heat outside the heating period. Buildings could be largely heated by the walls using this technique.

In summer, the solar heat will be used for cooling the building. Cooling machines driven by solar heat will be much smaller than today and highly

Active solar renovated buildings will be heated and cooled by at least 50% with solar thermal energy; Active Solar Renovation will be the most cost-efficient way to renovate buildings

integrated. As a result, the thermal comfort of the buildings will be much higher than today.

3.3 Solar vision for other applications

3.3.1 Block and district heating

In cities with dense building areas, **block and district heating systems** must significantly increase their share of heat from solar thermal energy, biomass and geothermal. By 2030, the use of fossil fuels will be replaced by renewable heating systems in existing block and district heating plants, e.g. in Sweden and Poland, where they are common. In other countries in South, Central and Northern Europe, new block and district heating systems will be built, because such systems make it possible to heat buildings in dense building areas with renewable energy. Solar thermal energy is available everywhere and will cover a large proportion of the energy demands of these block and district heating systems.

3.3.2 Solar assisted cooling

The world air-conditioning market is expected to grow exponentially in the next decades and the demand for building air-conditioning will definitely also increase in the European and Mediterranean countries. Although intelligent architecture will significantly reduce the cooling loads, and the use of environmental heat sinks such as soil or air will save energy and cover some of the cooling requirements, the rising demand for comfort and increasing summer temperatures will still cause a rapid growth in space cooling loads.

Solar assisted cooling (SAC) machines will cover a large share of the cooling demand. Due to the simultaneity of cooling demand and solar radiation, solar assisted cooling technology is highly likely to cover a large share of demand. An important reason for using SAC is the need to avoid a totally unbalanced peak in electricity production during the summer period.

3.3.3 Solar thermal desalination

One of the most urgent global tasks to be solved in the future will be to supply people with clean drinking water. It is necessary to accelerate the development of novel water production systems from renewable energy. Keeping in mind the climate protection targets and strong environmental concerns, water desalination and water treatment around the world will be increasingly powered by solar, wind and other clean natural resources in future. Often very favourable meteorological conditions exist for the application of solar thermal systems exactly in those areas with a high level of drinking water scarcity. Solar thermal desalination and water treatment systems will provide excellent possibilities to cover that need in a sustainable and cost-effective way.

Solar thermal energy will play an important role in all segments where heat of up to 250 °C is used

3.3.4 Process heat for industrial needs and new applications

28% of the end energy demand in the EU25 countries originates in the industrial sector. Many industrial processes require heat on a temperature level below 250°C. By 2030, solar thermal systems will be widely used to serve that market segment. Important areas for solar thermal systems exist in the food and drink industries, the textile and chemical industries and in washing processes. Production halls, office buildings, shopping centres etc will also be heated and cooled using solar thermal energy in the future.

The availability of high temperature collectors will lead to the development of other new solar thermal applications, e.g. solar thermal driven refrigerators, steam-sterilisers, solar cookers or compact solar air-conditioning systems.

4 Innovation and technological development

The restructuring of the heating sector from fossil fuels to renewable and especially solar energy generation not only fulfils the requirements of sustainability and ecology but is also the optimum direction from an economic point of view. By the year 2030, the costs of solar thermal energy will have been significantly reduced by technological innovation and industrial mass production. On the basis of the simultaneous increase in the cost of fossil fuel energy sources, solar thermal heating and cooling will be the most cost-effective way to generate heat and provide cooling in the described market segments. Due to the great advantages of using solar thermal energy, once it has achieved cost-competitiveness its use will only be limited by the available space to install the solar thermal collectors. Some of the fields of innovation and possibilities for cost reduction are described in following.

4.1 Solar thermal collectors

4.1.1 Integration

By 2030, in most buildings solar thermal collectors and solar electricity modules will cover the entire south-facing roof surface (south-facing means from east, through south, to west). Collectors and modules together with roof windows in a unified design will share the existing surfaces. As well as the dedicated solar thermal collectors, combined solar thermal and electricity collectors (PVT) will be available.

In addition to the roof areas, south-facing facades will also be used as active solar absorption surfaces. The solar collectors will be completely integrated into the building envelope components. A new synergy will occur through compact construction techniques and the intelligent multi-use of construction components.

Standardisation of the installation technology and standardisation of the interface between the collector, the roof or facade and the rest of the installation will significantly reduce the installation time and costs. This will also lead to improvement of architectural design and therefore the acceptance and the possibilities of usage of collectors in the roof and the facade.

A very large innovation potential exists in combining the functions of the building envelope with the heat generation by the collector. Waterproofing, windproofing, heat insulation of the roof and facade, and the static loading requirements of the roof and walls have only been integrated into the collector design in isolated cases up to now. Especially in new buildings, the construction elements and the solar thermal collectors could form a single unit in the future. The collector can even take over the visual presentation of the facade, in the sense of structure and colour.

Solar thermal systems offer a high potential for innovation and cost-cutting, especially when used as the main components in heating & cooling systems

4.1.2 Development

The strong increase of the market for solar thermal collectors and the related types of applications leads to the diversification of specific collector types for different applications. High-temperature collectors will be developed alongside large-scale collector modules, façade-integrated modules and very inexpensive low temperature collectors.

To address the segments in the temperature range of 80°C to 250°C, collectors must be developed that can reach these temperatures at a high level of efficiency. Appropriate technology concepts already exist, for example flat-plate collectors with multiple glazing and anti-reflective coating, stationary CPC (compound parabolic concentrator) collectors or small parabolic collectors. High temperature collectors can also be used for refrigeration services required in industrial processes.

4.1.3 Materials

The materials and processes currently used in the production of solar thermal collectors do not satisfy all the requirements of suitability for mass production. For example, a new generation of plastics can be developed further with respect to the necessary mechanical, electrical and optical characteristics. Natural materials are fundamentally suitable for heat insulation with super-insulating characteristics, or can assume static functions. Ceramics, metal foam and other future materials promise a high potential for innovation in the area of collector technology and will promote the development of new process-oriented heat collectors.

Significant progress in the development of functional glass coatings has been made in recent years, from heat-protection glazing in buildings, to anti-reflective coatings on solar glass, which raise the efficiency of heat collectors by up to 5%. Further progress is to be expected from continuing intensive research and from the latest research results in nanotechnology. For example, dirt-resistant and IR-reflective layers will further increase levels of efficiency over the entire life span of the product. Switchable layers will allow the performance of the solar thermal collector to be dynamically adjusted to suit immediate requirements by adjustment of the level of reflection. Further innovations are seen in improved selective absorber coatings regarding dirt resistance, high-temperature resistance, chemical resistance and performance regulation.

4.1.4 Manufacturing

Great progress has been made in recent years in optimising the technique used for joining the absorber sheets and the absorber pipes. Further great potential for improvement is seen in the use of new materials and production technologies in order to reduce production costs, e.g. with full through-flow volumetric absorbers and frames suitable for industrial production.

4.2 Heat storage for single buildings

The goal is an eightfold increase in the energy density of heat storage by 2030

The fully solar heated building will usually require seasonal storage of the solar heat generated in the summer months which is stored for heating demands in the winter months. Currently, in a well thermally insulated single-family house, the today available water storage systems need a volume of much more than ten cubic metres to provide the necessary capacity. By 2030, new storage technologies will offer a significantly higher energy density and will reduce the required volume drastically. The goal is an eightfold increase in the energy density of storage compared to water as storage medium. In addition, thermal insulation of storage will be greatly improved, e.g. using vacuum insulation that reduces the heat losses of the storage as well as the volume of the insulating layers. The target is a seasonal heat storage system with a volume of only a few cubic metres for single family houses. In addition to a centralised heat storage system, decentralised storage concepts in the form of heat-storing plastering material and storage walls will also become available.

In order to achieve this goal, R&D in the field of storage technology has to have a high priority. Fundamental research is required to bring about a fundamental and innovative breakthrough with regard to reaching the target of time-indifferent, compact storages. New approaches, like thermo-chemical (TC) storage concepts, need to be explored. Separate paths of development are required in order to achieve an evolution in new generations of storage concepts. Each step in the evolution from water storage, to PCM (phase change materials) storage, to TC storage will bring us closer to compactness and time independence.

4.2.1 New materials and concepts

The development and use of new materials offers great innovation potential in storage technology. Sorptive and thermo-chemical processes achieve significantly higher storage densities than the water storage tanks used today. New materials have already proven to have better properties than the previously used silica gel and zeolite types. Alongside further research into new materials, reduction of the production costs also plays a significant role.

Especially in short-term storage, latent heat storage tanks using a solid-liquid phase change will offer a balance between load and source or sink, in summer and winter. Latent heat storage systems can be integrated into the building or technical systems in a variety of different ways, for example through integration into the building materials and components or by introduction into the heat transfer fluid. Both variations require R&D work at all levels, from material research, through component development, to system integration and actual operation.

Another important aspect is the further development of insulation of storage systems using new materials like vacuum insulation, super insulation and the use of natural materials with the aim to reduce heat losses, insulation layer thickness and recyclability.

4.2.2 Integration into the building

With the introduction of seasonal storage systems, the demands for storage space will greatly increase. Beside the aim to increase storage density, this demand could be met by integrating the storages into the traditional construction elements of the building. Elements such as floors, ceilings, walls and plastering will absorb and store extra heat and then return this to the building, either directly or in a controlled manner, as required. This direction is already indicated by the use of internal plastering containing PCM at a number of demonstration sites.

By integration of the storage functionality into the wall, a complete decentralised solar thermal unit with solar collector in the facades, storage in the wall, and layers which control the heat fluid are possible.

4.3 Heat transfer and equipment

In the future, a large proportion of solar thermal collectors will remain separate from the storage medium and will still require a heat transfer circulation loop. The development of new types of heat transfer media, e.g. ionic fluids, and collector loop materials, e.g. metallised plastic pipes, could improve system output and reduce costs.

New pumps especially developed for the solar heat circuit are already reducing the electricity demand by more than 80%. These pumps, together with additional functionality such as measurement of the pressure within the loop, will become standard within the next years. In addition thermally driven pumps will be developed.

Expansion tanks and vessels, overpressure valves, heat exchangers and other system components will be further integrated and developed, e.g. to resist high temperatures.

4.4 Controllers and monitoring systems

By 2030, there will be only one controller for the solar thermal system, the backup heating and the cooling system with an integrated monitoring functionality. This device will allow an immediate overview of the system functions and will report faults at an early stage. The controller will be self-optimising and will minimise error situations. Improved control strategies will be possible by using weather forecasts to increase the system output.

Development of so-called “power/energy matchers” or “energy hubs” will increase the overall system efficiency, e.g. by matching the timing of the load to the timing of the availability of the energy supply. In district heating systems, peak loads in the net will be avoided by allowing power companies to adjust certain load pattern and energy production parameters.

4.5 Solar district heating systems with and without very large seasonal storages

4.5.1 Solar district heating

In dense building areas or in applications with a mismatch between load and available collector mounting possibilities, district heating systems will be necessary in order to cover a large share of the heat requirements by means of solar thermal energy. These systems will be in use in all sizes, for settlements with a small numbers of buildings as well as for large residential settlements or industry and commercial areas.

Solar block and district heating systems benefit in general from economy-of-scale effects, as the systems and the contracts are large. The competitiveness of solar block and district heating systems will benefit from the further development of large module collectors.

Combined solar thermal energy systems and wood fuel boilers will be the most feasible type of block and district heating systems in 2030. District heating and cooling as well as centralised systems should be predominant in new infrastructure design concepts for the city of tomorrow.

4.5.2 Very large seasonal storages

Very large seasonal storages within district heating systems are necessary in order to cover a large share of the heat demand by means of solar thermal and will be common in 2030. They benefit from the reduced surface area to volume ratio and therefore lower specific heat losses in comparison with small seasonal storages in detached houses. The first demonstration plants of large seasonal storages with a volume of some 10,000 m³ are installed in Central and Northern Europe as pit storages, ground storages and aquifer storages. Further development is necessary to reduce costs and increase the efficiency.

4.6 Thermally driven cooling systems

Thermally driven cooling systems can use any type of heat source that provides adequate temperatures. They are especially suitable for use with solar thermal energy because of the correlation between the level of solar irradiation and the cooling services required. Currently, the air-conditioning world market is dominated by decentralised room air-conditioners, e.g. split and multi-split systems. Moreover, these systems are habitually less efficient than larger centralised technologies; they cause a tremendous impact on the electricity requirements in terms of energy and power. This underlines the need for the development of small-scale solar thermal driven cooling machines in the range of 2-5 kW units.

Solar cooling and air-conditioning is still in the early stages of development and therefore offers extensive potential for innovation. Thus, there is a requirement of extensive research into improving storage materials and heat transfer media and also the further development of systems, to turn them into highly compact, efficient units. One major field of research activities has to be the development of small-scale systems that can cover simultaneously heating and cooling, so-called “solar-combi-plus systems”. The aim is to achieve commercial compact products that can be offered to consumers as alternatives to the small-scale conventional chillers. Furthermore, significant development work is required in their integration into general building technology.

In the short term, the main tasks for research and development are: state-of-the-art system technology and design, operation and system monitoring as well as the development of "best practice" guidelines and general standardisation. In the medium term, compact combined systems for heating, cooling and process water heating (solar-combi-plus) in residential and small office buildings must be developed and the know-how must be transferred to the planners and installation engineers. These systems have to be in the form of packages involving a minimum of construction effort in the building in order to achieve maximum reliability comfort. In the long term, units must be developed that are significantly more compact, especially in the areas of lower power systems and for decentralised use in single rooms or integration into a facade. Facade-integrated modules will provide heating, ventilation, cooling and dehumidification as required.

R&D effort is needed for systems with sorption processes on the low driving temperatures market, between 85 and 110°C. Further development is necessary to lower driving temperatures without efficiency losses in order to raise the heat production efficiency of solar thermal collectors, especially flat-plate collectors. In existing buildings and distribution systems, cooling systems with high driving temperatures are usually necessary since the installed systems require low inlet temperatures. Therefore it becomes necessary to use highly efficient solar collectors.

For multi-stage processes with maximum efficiency, solar collectors for high temperatures between 140 and 180°C have to be developed. Promising possibilities are also offered by systems that operate as single-stage systems under low levels of solar irradiation and then switch to a two-stage system when the solar irradiation is higher, or when a backup heat source such as a biomass burner is used.

The success of solar thermal assisted cooling systems depends on the availability of highly efficient systems which are able to replace the electrically driven split systems currently being used. Significant R&D work is required in order to substantially improve efficiency in the heat and mass transfer of the reactor, as well as in the internal interconnection for maximisation of heat recovery.

4.7 Solar sea water desalination and water treatment

New processes are under development to design small, decentralised, solar thermal driven sea water desalination and water treatment systems which are especially tuned to match the special conditions for solar energy applications. New processes are necessary because the well-known processes such as MED (Multi Effect Distillation) and MSF (Multi Stage Flash) which are used in large-scale sea water desalination systems are not suitable for small solar thermal systems. The first approaches are membrane distillation, humidification-dehumidification stills and multi-stage solar stills.

4.8 Auxiliary systems

The remaining heat requirements of buildings which are 50% to 100% solar heated will be covered in a CO_2-neutral manner by the use of biomass or geothermal energy, in single buildings as well as in block and district heating systems. In these systems, the integration of the auxiliary heat source has to be optimised in order to guarantee optimised efficiency of the entire system.

The 100% solar heated buildings and processes will cover the heat demand in years when average weather conditions prevail. In order to provide heating under occasional extreme weather conditions, small backup heat sources will be installed. The brief usage periods of these devices allow a low-cost design to be used. The renewable backup systems could be pellet burners or biogas boilers. It is also conceivable that, by 2030, small chemical or hydrogen-based storage systems will be available, which can be loaded in summer and then used as a backup system to cover peak loads.

4.9 Regulations and other framework conditions

In order to support the further development and market deployment of solar thermal energy, it is necessary to provide, in addition to the technology itself, the appropriate framework conditions. Among these are methods of testing and assessing the thermal performance, durability and reliability of systems and components, as well as tools and education packages for installation engineers, planners and architects, awareness campaigns and improvements to subsidy schemes and solar thermal ordinances. Additional effort is needed to develop contracting and financing instruments.

5 Perspective and support requirements

5.1 Cost reduction perspective

In previous years, the price of solar thermal systems for single family houses, which have a market share of more than 80% in Europe, decreased continually. In all European markets the trend has been equal, although the system costs vary a lot according the typical size, type and quality.

The learning curve of the costs for a typical DHW system in Central Europe as shown in figure 6 indicates the past cost development as a function of time and increasing installed capacity. The estimates as to further cost development are based on the typical learning curve theories, depending on the expected growth of installed capacity.

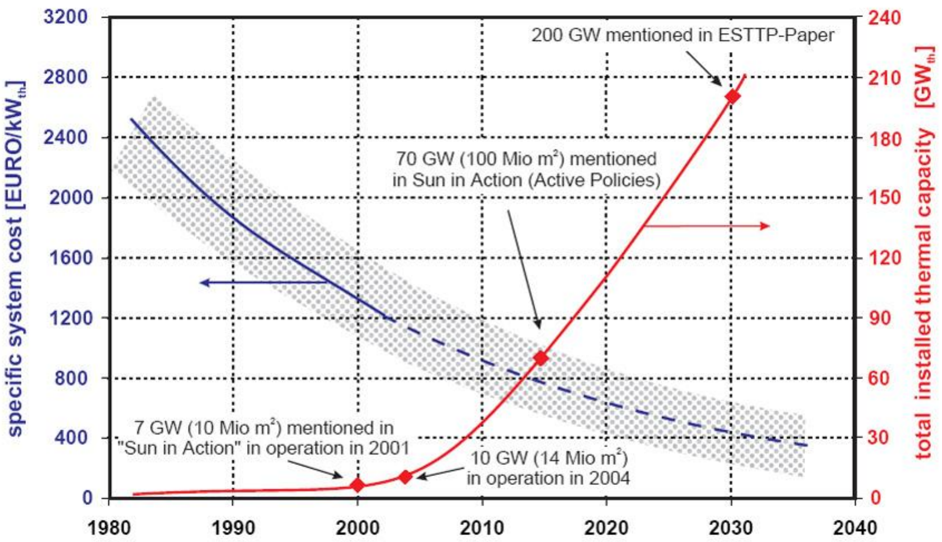

Fig. 2: Development of specific costs and installed capacity for small solar thermal systems with forced circulation in Central Europe

Within 20 years, costs will be reduced by more than 50%. In Southern Europe, solar thermal energy is much cheaper due to higher solar radiation and lower costs for solar thermal systems. Therefore, in a lot of Southern European regions, solar heat is already cost-competitive with heat produced by fossil fuels. Further cost reductions will depend on the development of the market and of the technology. Therefore market entrance policy and R&D activities have to be continued or strengthened.

5.2 Economy of the solar thermal sector

By 2030, solar thermal technology will have developed into a large economic sector, both worldwide and in Europe. There will be a strong solar thermal industry with significant exports. More than 200,000 jobs will be created in the European Union based on a annual production and installation of solar thermal systems with a power of more than 20 GW_{th}. Many of these jobs will also be linked to the installation and building sector. These jobs will therefore be spread geographically and between SMEs and large companies.

Current annual turnover in the EU market (2005) is over 1 billion euros and sharply rising. Although no actual employment statistics are available, it is estimated that the current solar thermal industry (complete supply chain) employs over 25,000 persons (full-time equivalents).

5.3 Support requirements

In order to facilitate development, a consistent and stable support environment is required in the rather volatile energy market. Support involves general support for R&D work, implementation support for systems which pass the demonstration stage, and demonstration support for projects aiming to demonstrate and learn about the innovations.

5.3.1 Subsidies for market deployment

Technological development needs market development. Therefore, market deployment measures are necessary, as long as solar thermal energy is more expensive than heat from fossil fuels. Currently, most of the subsidy schemes provide grants like in Germany or Austria, or tax reduction for the installation of a solar thermal system like in France. In Spain, solar thermal systems have to be installed due to a solar ordinance.

The most important aspect of a successful subsidy scheme is that it works continuously over a longer period. If there are grants, the budget has to grow every year in order to cover the expected growth of the market and therefore the growing numbers of applications. The alternative is to provide a tax reduction for solar thermal systems which is not limited.

5.3.2 Budget for research and demonstration programs

In order to create an innovative atmosphere in the solar thermal branch, there is a need to have sufficient R&D activities in public institutions as well as in industry, and therefore a sufficient budget for R&D. Up to now, the public R&D budget is too low to trigger a dynamic technological development. In order to achieve the goals set out in this vision document, a strong increase of R&D activities in the solar thermal sector in all European countries is required. Therefore the budget for R&D and demonstration programmes on the national and the EU level has to be increased significantly to a figure of approximately 80 Mio Euro annually.

5.3.3 Additional measures to create a solar thermal market

To accelerate the introduction of products to the market and to produce a further rapid spread of solar thermal energy usage, support of the following measures is also necessary:

- Implementation of awareness, marketing, image-building and informational campaigns
- Training of installation engineers
- Development of processes for the comprehensive evaluation of solar thermal systems
- Introduction of mechanisms for controlling/monitoring the functions of solar thermal systems
- Further development of European and international standards and guidelines for solar thermal systems and components

6 Summary

At the beginning of 2005, approximately 10 GW_{th} of solar thermal capacity were in operation in Europe. In the Solar Thermal Vision 2030, it is believed that with the right mix of R&D, industrial deployment and consistent market implementation, the total installed capacity could well increase to at least 200 GW_{th} by 2030. This goal is ambitious but well achievable given the right mix of support measures and increased R&D. By 2030, solar thermal technologies will cover up to 50% of all applications which require temperatures of up to 250°C.

Solar thermal has a huge potential for innovation that should now be fully exploited. This covers the areas of efficiency increase, as well as cost reduction of solar collectors and other components used in solar thermal energy production. In particular, system technology and heat storage systems are key elements which must be developed further.

This vision of solar heating and cooling in 2030 refers to both decentralised and centralised systems as appropriate for domestic and commercial buildings, both newly built and existing building stock, cooling applications, process heat, block & district heating, and desalination. Technical developments and requirements are addressed, such as:

- Solar absorption surfaces
- Heat storage (as one of the key research topics for the coming decades)
- Heat transfer
- Cooling technologies
- Large-scale solar energy systems (district, process heat/cooling, desalination)
- Advanced control strategies

The learning curve for solar thermal systems indicates the past cost development as a function of time and increasing installed capacity. Further reductions are based on the typical learning curve theories which see a further reduction as the market development progresses and the technology matures.

In order to facilitate development, a consistent and stable support environment is required in the rather volatile energy market. Support involves general support for R&D work, implementation support for systems which pass the demonstration stage, and demonstration support for projects aiming to demonstrate and learn about the innovations.

The European Solar Thermal Technology Platform will further follow, monitor and identify the areas in which strengthened R&D efforts will have the highest positive impact on the uptake of solar thermal energy. One of the goals of the ESTTP is to develop and implement a strategic research agenda for the solar thermal sector, which will help the industry, the research community and public funding bodies to focus on high-impact topics. This will reinforce the European solar thermal sector's leading technological position.