SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

International Energy Agency

Solar Heating and Cooling Programme
Strategic Plan 2014-2018

Edited by
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STRATEGIC PLAN FOR THE IEA SOLAR HEATING & COOLING PROGRAMME 2014 - 2018

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1. Introduction

The Implementing Agreement on Solar Heating and Cooling was established in 1977 with the objective of co-operative research, development, demonstration and exchange of information regarding solar heating and cooling systems. The Agreement is responsive to the energy policies and programs of the participating countries, and as they continue to change, so will the Agreement.

Solar technology is relevant to the work of many of the IEA Implementing Agreements, particularly the building related Agreements in the Working Parties on Renewable Energy and End Use Energy. Cooperation with these Agreements will continue to be important to achieve system and building integration and to generate energy savings.

Over the last 10 years, the Agreement has co-operated with solar thermal trade associations in Australia, Europe, and North America and the European Technology Platform on Renewable Heating and Cooling (ETP RHC), in particular, with its Solar Thermal Panel (ESTTP).

The purpose of the Strategic Plan is to provide direction and focus for the activities of the Solar Heating and Cooling Implementing Agreement over the next five-year term. It was developed through an interactive process with the Executive Committee and represents the Committee's views.

This Strategic Plan is based on the research priorities of the member countries and it is also supports the results and recommendations of the IEA Technology Roadmap - Solar Heating and Cooling, which was published in July 2012. The Strategic Research Priorities of the Solar Thermal Panel of the European Technology Platform on Renewable Heating and Cooling also provided guidance for the Plan.

What do we mean by Solar Heating and Cooling?
Solar energy technologies and architectural designs that include active **solar thermal heating** and **cooling**, **photovoltaics for heating** and **cooling**, **passive solar** and **daylighting** are essential components of a sustainable energy future. These technologies and design techniques can be applied to providing comfort, light and sanitary hot water in the built environment and heating, cooling and drying in industrial and agricultural processes. Also essential to the development of markets are improved **solar resource data,** worldwide harmonization of **test standards** and **certification programs** and the regular publication of **worldwide market data** on solar thermal heating and cooling.

Therefore in this Strategic Plan, the term solar heating and cooling refers to all of these aspects, including photovoltaic/thermal technologies.

2. Current Status of Solar Heating and Cooling

It is very likely that in the near future, fossil fuels will become too expensive to be used for hot water preparation, for heating and cooling of buildings or for industrial processes due to limited availability and the financial impact of carbon constraints. The necessity to reduce 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. Solar oriented architecture, city and regional planning as well as the large-scale deployment of renewable energies - especially of solar thermal systems - is an essential pre-requisite to a sustainable supply of heating and cooling.

Solar technologies can supply energy for all building applications - heating, cooling, hot water, light and electricity - without the harmful effects of greenhouse gas emissions created by conventional energy sources. The independent *Global Climate Decision Makers Survey* presented at the United Nations Climate Change Conference in Bali 2007, showed that among 20 carbon reduction technology options, "solar thermal and passive solar are considered to be the technologies with the highest carbon reduction potential without undesired side effects over the next 25 years".

Solar technologies are appropriate for all building types - single-family homes, multi-family residences, office and industrial buildings, schools, hospitals, and other public buildings - and applicable anywhere in the world. Active solar technologies can also be used for agricultural and industrial process heat applications as well as for refrigeration, water treatment and seawater desalination.

The unique benefits of solar thermal energy

Within the renewable heating and cooling portfolio, solar thermal applications have specific benefits:

- Solar thermal always leads to a direct reduction in primary energy consumption.
- Solar thermal can be combined with a large range of back-up heat sources.
- Solar thermal does not rely on limited hydrocarbon resources, which are also needed for other energy and non-energy purposes.
- Solar thermal generally supplies energy at or near the site where it is used therefore it reduces the substantial investments to increase power generation and electricity and gas transmission capacities.
- Solar thermal can be applied everywhere.
- Solar thermal prices are highly predictable, since the largest cost occurs at the point of installation, and therefore does not depend on future oil, gas, biomass, or electricity prices. The running costs are negligible.
- The environmental impact of solar thermal systems over their life cycle is extremely low.
- Heat can be easily stored for the short term; therefore solar thermal does not require expensive peak power back up from the grid.

2.1 Implementation of active solar thermal systems

By the end of 2012, an installed capacity of 268 GW_{th} corresponding to a total of 383 million square meters of collector area was in operation. Compared with other forms of renewable energy, solar heating's contribution in meeting global energy demand is, besides the traditional renewable energies like biomass and hydropower, second only to wind power. This fact, however, is still underestimated in energy policies.

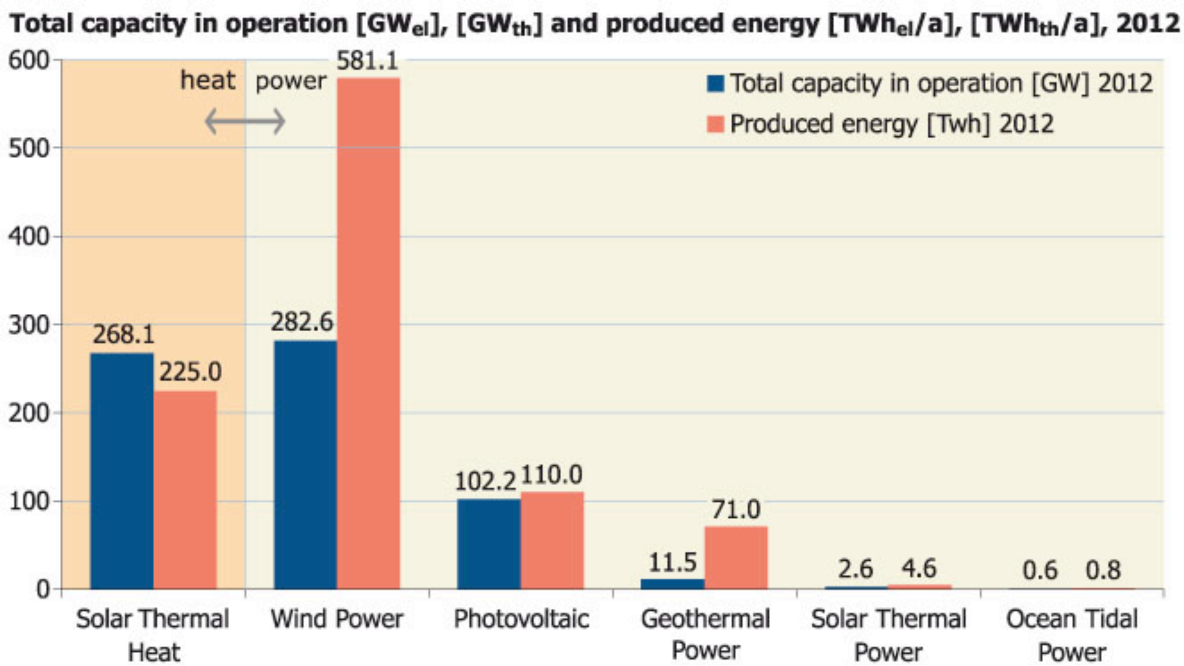


Figure 1: Total capacity in operation [GW_{el}], [GW_{th}] 2012 and annual energy generated [TWh_{el}], [TWh_{th}]. Source: IEA SHC 2013).

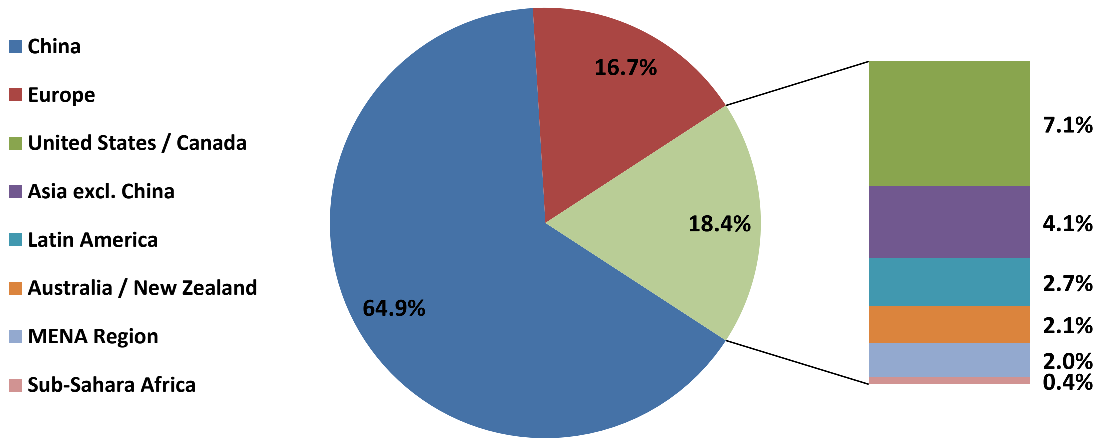
2.1.1 Status of Industry and Market

By the end of 2011, an installed capacity of 234.6 GW_{th} corresponding to a total of 335.1 million square meters[1] of collector area was in operation worldwide.

The vast majority of the total capacity in operation was installed in China (152.2 GW_{th}) and Europe (39.3 GW_{th}), which together accounted for 81.6% of the total installed. The remaining installed capacity was shared between the United States and Canada (16.7 GW_{th}), Asia excluding China (9.6 GW_{th}), Latin America (6.3 GW_{th}), Australia and New Zealand (4.9 GW_{th}), the MENA[2] countries Israel, Jordan, Lebanon, Morocco and Tunisia (4.7 GW_{th}) as well as between some Sub-Sahara African countries (0.9 GW_{th}), namely Mozambique, Namibia, South Africa and Zimbabwe.

1 To compare the installed capacity of solar thermal collectors with other energy sources, solar thermal experts agreed upon a methodology to convert installed collector area into solar thermal capacity at a joint meeting of the IEA SHC Programme and major solar thermal trade associations held September 2004 in Gleisdorf, Austria. The represented associations from Austria, Canada, Germany, the Netherlands, Sweden and United States as well as the European Solar Thermal Industry Federation (ESTIF) and the IEA SHC Programme agreed to use a factor of 0.7 kW_{th}/m^2 to derive the nominal capacity from the area of installed collectors.

2 Middle East and North Africa



Asia excluding China:	India, Japan, Korea South, Taiwan, Thailand
Latin America:	Brazil, Chile, Mexico, Uruguay
Europe:	EU 27, Albania, Macedonia, Norway, Switzerland, Turkey
MENA Region:	Israel, Jordan, Lebanon, Morocco, Tunisia
Sub-Sahara Africa:	Mozambique, Namibia, South Africa, Zimbabwe

Figure 2: Share of the total installed capacity in operation (glazed and unglazed water and air collectors) by economic regions.

In terms of capacity in operation normalized to population, the leading countries in hot water collector capacity in 2011 per 1,000 inhabitants were Cyprus (542 kW_{th}/1,000 inhabitants); Austria (406 kW_{th}/1,000 inhabitants); Israel (400 kW_{th}/1,000 inhabitants); Barbados (322 kW_{th}/1,000 inhabitants), Greece (268 kW_{th}/1,000 inhabitants), Australia (212 kW_{th}/1,000 inhabitants), Germany (131 kW_{th}/1,000 inhabitants), Turkey (129 kW_{th}/1,000 inhabitants), China (114 kW_{th}/1,000 inhabitants) and Jordan (114 kW_{th}/1,000 inhabitants).

Newly installed capacity worldwide in 2011

In the year 2011, a total capacity of 48.1 GW_{th}, corresponding to 68.7 million square meters of solar collectors, was installed worldwide. This means an increase in new collector installations of 14.3% compared to the year 2010.

The main markets were in China (40.32 GW_{th}) and Europe (3.93 GW_{th}), which together accounted for 92.1% of the overall new collector installations in 2011.

The breakdown of the newly installed capacity in 2011 by collector type is 14.7% glazed flat-plate collectors, 81.9% evacuated tube collectors, 3.2% unglazed water collectors and 0.2% glazed and unglazed air collectors.

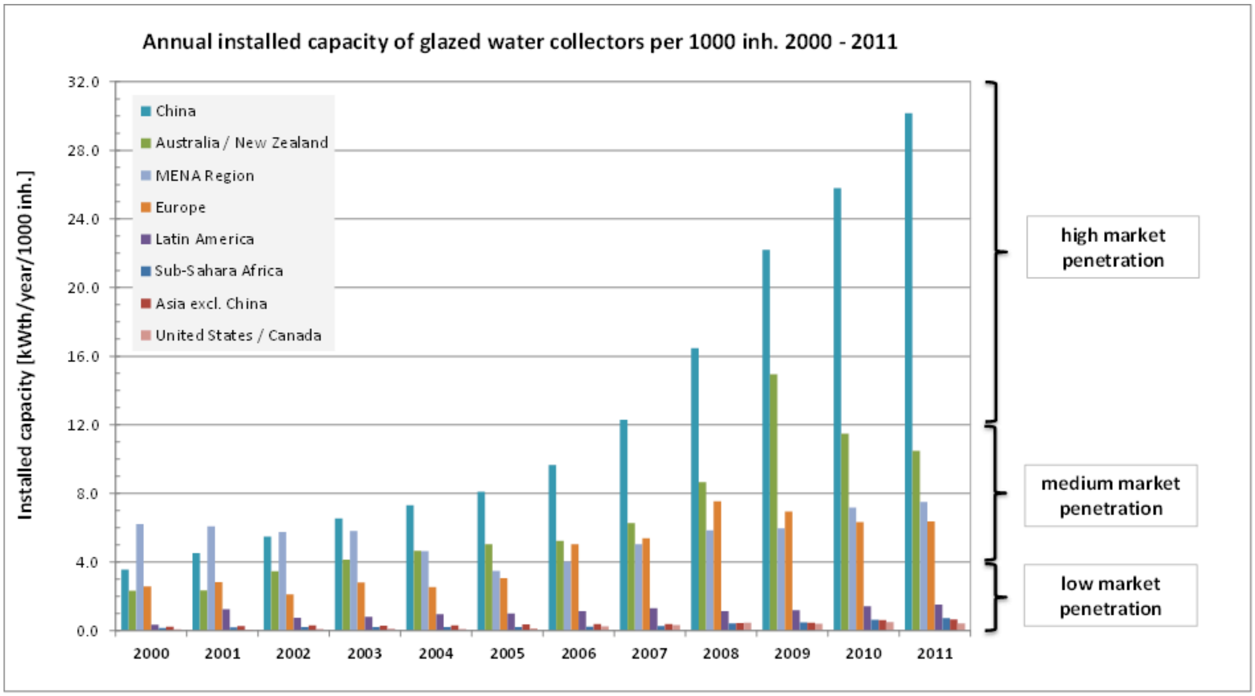
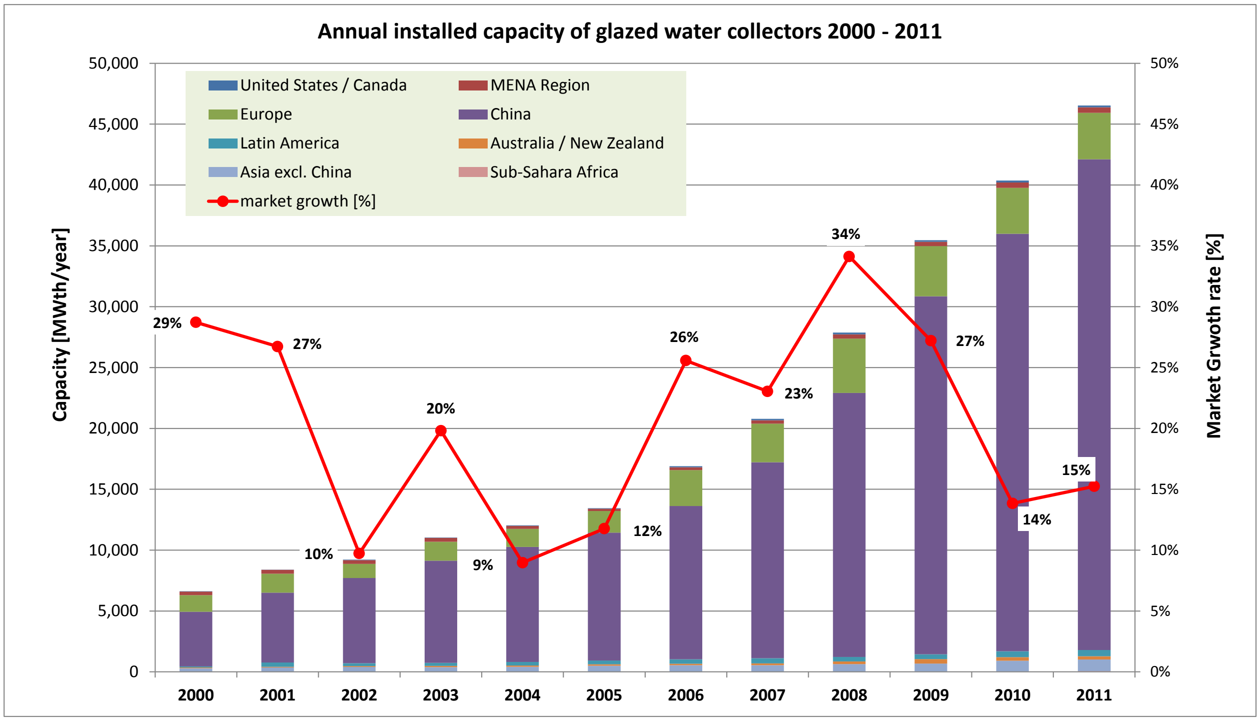


Figure 3: Annual installed capacity of flat plate and evacuated tube collectors in kW_{th} per 1,000 inhabitants from 2000 to 2011.

Market development of glazed water collectors between 2000 and 2011

The worldwide market development of glazed water collectors is characterized by a steady growth over the past 11 years. Between 2000 and 2011 the average growth rate worldwide was around 20%.

Between 2000 and 2011 the annual installed glazed water collector area worldwide increased 7-fold, and compared to the year 2010 the worldwide market grew by 15.4%. The growth rate remained at a stable level compared to the period 2009/2010 after a downfall in the two preceding years.



Sub-Sahara Africa:	Mozambique, Namibia*, South Africa, Zimbabwe
Asia excluding China:	India, Japan, Korea South, Taiwan, Thailand**
Latin America:	(Barbados**), Brazil, Chile, Mexico, Uruguay**
Europe:	EU 27, Albania, Macedonia**, Norway, Switzerland, Turkey
MENA Region:	Israel, Jordan, Lebanon, Morocco*, Tunisia
	* 2011 estimated / ** 2010 and 2011 estimated

Figure 4: Annual installed capacity of flat plate and evacuated tube collectors from 2000 to 2011.

2.1.2 Distribution by system type and application

The thermal utilization of the energy from the sun varies greatly in different regions on Earth. It can be roughly distinguished by the type of solar thermal collector used, the system operation (pumped solar thermal system or thermosiphon systems), and the main application of the heat energy gained from the sun (hot water preparation, space heating, industrial processes, cooling).

In China, vacuum tube collectors play an important role and since China is by far the largest market with high growth rates, the worldwide figures tend towards a higher share of this type of solar thermal collector as well. Unglazed water collectors account for 9% of the cumulated water collectors installed worldwide.

Worldwide more than three quarters of all solar thermal systems installed are operated by means of the thermosiphon[3] principle and the rest are pumped solar heating systems. Similar to the distribution by type of solar thermal collector, the Chinese market influences the overall figures most and in 2011 89% of the newly installed systems were estimated to be thermosiphon systems while pumped system accounted for only 11%.

3 Thermosiphon systems work passively (without pumping) by positioning the store above the collectors and allowing natural circulation (hot water rising) to drive the flow from collector to store.

The estimated number of solar thermal systems in operation exceeded 67 million by the end of 2011. Of these, an estimated 85%were used for domestic hot water preparation in single-family houses and 10% were attached to larger domestic hot water consumers such as multifamily houses, hotels, hospitals, schools, etc. Around 4% of the worldwide installed capacity supplied heat for both domestic hot water and space heating (solar combi-systems). The remaining systems amounted for round 1% or almost 3 million square meters of solar thermal collectors and delivered heat to district heating networks, industrial processes or thermally driven solar cooling applications

Worldwide large-scale solar thermal applications

Megawatt-scale solar supported district heating systems and solar heating and cooling applications in the commercial and industrial sector have gained increasing interest all over the world in recent years and several ambitious projects have been successfully implemented in the past.

In July 2011, the world's largest solar thermal system connected to a district heating system was commissioned in Riyadh, Saudi Arabia. The solar thermal plant, with a total capacity of 25 MW_{th} (36.305 m^2), is connected to a heating network for the supply of space heating and domestic hot water of a university campus[4]. Another successful solar supported heating network was implemented in Alberta, Canada. The Drake Landing community uses a 1.6 MW_{th} (2.293 m^2) centralized solar thermal plant connected to a seasonal storage to supply more than 90% of the energy needed for space heating 52 detached energy efficient homes[5].

In Singapore, a large-scale solar thermal heating and cooling installation with a total capacity of 2.73 MW_{th} (3,900 m^2) started operation in 2011 as well. The roof mounted solar thermal plant is connected to a 1.76 MW_{th} absorption chiller and supplies hot water and cooling to around 2,500 students, who live and study at a newly created 76,000 m^2 campus[6].

In June 2013, the world´s largest collector field will be completed in Chile. The installation will cover a total of 39,300 m^2 with an annual output of 50 GWh. The solar thermal system is designed to cover more than 80% of the heat used to refine copper at the world´s largest copper mine[7]. Another large-scale process heat application, and the largest solar thermal system in the United States, was dedicated in April 2012 in North Carolina. The 5.5 MW_{th} (7,800 m^2) solar thermal system equipped with flat plate collectors supplies hot water to a turkey processing plant, lessening the use of propane gas[8].

The largest solar process heat applications installed in China are connected to dyeing and weaving mill factories. A system with a thermal peak capacity of 9.1 MW_{th} (13,000 m^2) was constructed in the province of Zhejiang and two other projects of 10.5 MW_{th} (15,000 m^2) have been commissioned in the neighboring province of Jiangsu.

2.1.3 Impact on Energy Supply

The annual collector yield of all water-based solar thermal systems in operation by the end of 2011 was 195.5 TWh (or 704.0 PJ). This corresponds to an energy savings equivalent to 20.9 million tons of oil and 64.1 million tons of CO_2.

4 http://solarthermalworld.org/content/saudi-arabia-worlds-biggest-solar-thermal-plant-operation
5 http://www.dlsc.ca/
6 http://www.solid.at/index.php?option=com_content&task=view&id=53&Itemid=73&lang=en
7 http://www.sunmark.com/
8 http://solarthermalworld.org/content/usa-contractor-runs-7804-m2-collector-system-prestage-foods-factory

2.2 Solar architecture, daylight and urban planning

2.2.1 Architecturally integrated solar systems

Energy use in buildings worldwide accounts for over 40% of primary energy use and 24% of greenhouse gas emissions[9], and as solar energy can be sourced close to the end-use and used directly as free daylight, passive solar heat or as heat, cooling and/or electricity from active systems, there are great advantages to develop envelope-integrated solar systems that avoid long transmission and/or conversion losses.

Solar energy systems are not used widely in mainstream building practice. Short term financial criteria have dominated decision making. However, as costs of renewable-based energy systems decline and the price of oil and gas continue to increase, financial considerations increasingly encourage the deployment of renewable technology.

As renewable technologies find favor financially, other factors also need consideration. For instance, a general lack of awareness and knowledge of the different technologies amongst building professionals, a general reluctance to use "new" technologies and limitations stemming from architectural and aesthetic considerations in the integration of solar systems. Due to the large size of solar systems in relation to the scale of the building envelope, the quality of their integration has a major impact on the final architectural quality of the building. It has been observed that a poor architectural integration into the building envelope hinders the acceptance and spread of solar technologies.

Although good examples of solar components and architecturally appealing solar buildings exist, there is still need for further development in terms of products, design tools, and skills. More products are needed with improved flexibility in sizes, surface textures and colours and jointing Due to the growing interest of architects to use solar, manufacturers are becoming increasingly aware of the need for new products specifically adapted to architectural integration, or at least for an increased flexibility in their existing products, leading to novel development activities in the solar thermal integration.

Architecturally inspiring solar buildings provide good examples of buildings with well-integrated solar systems and convince architects and clients to invest. However, architecturally inspiring examples of energy-efficient building renovation with solar are few and need to be supported further.

2.2.2 Daylight

Lighting accounts for approximately 19%, that is 2900 TWh[10], of global electricity consumption.
Research and developments in the field of energy efficient lighting techniques encompasses daylighting, electric lighting and lighting controls combined with activities employing and bringing these techniques to the market can contribute significantly to reduce worldwide electricity consumptions and $C0_2$ emissions. One recent study indicated[11] that investments in energy - efficient lighting is one of the most cost-effective ways to reduce CO_2 emissions.

The façade market has grown significantly worldwide in the last decades. Innovations took place in the field of glazing, sun shading, as well as lighting controls.

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9 IEA (2008) *Promoting Energy Efficiency Investments – case studies in the residential sector* ISBN 978-92-64-04214-8.
10 IEA (2006). *Light's Labour's Lost, Policies for Energy-efficient Lighting*, IEA , 2006
11 P.-A. Enkvist, T. Nauclér, J. Rosander(2007)., *A cost curve for greenhouse gas reduction: A global study of size and cost of measures to reduce greenhouse gas emissions yields important insights for businesses and policy makers*, McKinsey Quarterly

Numerous and diverse advanced fenestration systems promising good sun protection and good daylight supply have recently entered the market. However, none have had significant market impact, mainly due to current high costs. Mainstream manufacturers are building new plants to introduce advanced components such as electro-chromic glazing on larger scales.

Another trend is the integration of active solar gain systems (photovoltaic and /or thermal collectors) directly into the façade. These approaches have to be matched closely with the needs for a sufficient daylight supply in the indoor spaces adjacent to the façade. Façade controls can be closely integrated into the building systems to find a good compromise between solar protection and daylight supply. More advanced solutions allow shading controls according to sun and shading patterns on the façade.

Promising developments include integrating sun shading, glare protection and light redirecting functionality into the glazing layer. Nanostructured mirror systems and micro optical light guiding components are approaching test stage. The future will most probably bring hybrid lighting systems like OLED based glazing systems or compound LED roof light components, allowing daylight to penetrate and add electric lighting in times of insufficient natural illumination.

Techniques specifically for retrofitting facades are being developed, benefiting from high levels of prefabrication to achieve minimal disturbance of occupants during retrofit.

A high level of innovation is expected in smart windows. Lighting controls schemes based on auto adaptive, approaches (integrating user acceptance and energy efficiency) or CCD camera driven façade controls will add to this. Some of these products currently under development will soon be market ready.

For designers and practitioners significant progress has been made recently in providing rating methods for the impact of daylight use for instance in the scope of regulations. This allows better analysis of natural lighting conditions, and thereby optimized designs. Consequently, early initiatives are underway to recognize daylight as quantifiable regenerative energy source.

2.2.3 Solar energy in the urban environment

Public policy and regulation are encouraging zero-energy buildings, communities and whole cities. Increased use of solar energy is a significant part of realising zero energy communities. The interaction between buildings and neighbourhoods needs to be considered, to maximise passive solar gains and daylight thereby, reducing energy use in buildings and improving the inhabitants' comfort and lighting. Also, active solar energy systems integrated in the urban fabric will supply renewable energy as heat, electricity and cooling, helping cities reach sustainable solutions. This, together with the integration of other renewable energy sources, provides challenges for control systems development.

National and regional policy formation and strategies striving to minimize environmental impact will set the context in which urban planners develop plans for urban areas, and developers working with architects and builders create buildings and spaces that meet the needs of residents. When new areas are planned, buildings should be oriented appropriately and be solar ready even if not all buildings will integrate solar systems initially.

The integration of solar energy strategies (active and passive) in existing urban areas is equally important. The goal to integrate solar systems in already built areas is challenging and there is a need to develop methods and tools to support the use of solar energy in existing urban environments. Strategies for both new developments and existing areas are therefore important.

As well as addressing technical issues energy-economic models are needed which include renewable energies including solar thermal. This will reduce future lost opportunities, which may occur during the transition of urban energy structures if renewable energy supply options are not considered and inappropriate decisions are taken with long-term adverse impact.

Buildings and urban planning have a long time horizon; solar energy planning will increase the future potential to use solar energy. If solar access is not taken into account it will remain a barrier for centuries. Research and development into solar ready planning is therefore important and urgent.

3. Vision

More than 47%[12] of the final energy demand in the world is used for heating and cooling requirements in buildings and in industry. On the basis of a strong reduction of energy demand through combined energy efficiency measures, solar architecture and solar oriented urban planning, solar energy will be the most important energy source for heating and cooling in new buildings and in the existing building stock by 2050. Already state-of-the-art buildings exist today, that are fully heated by solar thermal energy. The vision – and the opportunity – is to include architectural design as a driving force for the use of solar energy.

Mature solar thermal technologies are commercially available, but further developments are still needed to provide new components, systems and applications, reduce the cost of systems and increase market deployment. Turning solar thermal into a major energy resource for heating and cooling by 2050 is an ambitious, but a realistic goal. It is achievable – provided that the right mix of research & development, industrial growth, consistent market deployment measures and adequate political framework conditions are applied. The IEA SHC program has a major role in reaching this ambition.

Based on the assumptions above the long term vision for solar thermal energy in this Agreement for the period 2014-2018 is:

By 2050 a worldwide capacity of 5kW$_{th}$ per capita of solar thermal energy systems installed and significant reductions in energy consumption achieved by using passive solar and daylighting: thus solar thermal energy meeting 50% of low temperature[13] heating and cooling demand.

12 Cogeneration and Renewables – Solutions for a low carbon Energy Future, IEA 2011
13 Low temperature heat up to 250°C

4. Mission

The mission for the Agreement for the period 2014-2018 is:

To enhance collective knowledge and application of solar heating and cooling through international collaboration in order to fulfill the vision

The Solar Heating and Cooling Agreement's mission assumes a systematic approach to the application of solar technologies and designs to whole buildings, and industrial and agricultural process heat. Based on this mission, the Agreement will carry out and co-ordinate international R&D work and will continue to cooperate with other IEA Implementing Agreements as well as the solar industry to expand the solar market. Through international collaborative activities, the Agreement will support market expansion by providing access to reliable information on solar system performance, design guidelines and tools, data and market approaches, and by developing and integrating advanced solar energy technologies and design strategies for the built environment and for industrial and agricultural process heat applications.

The Agreement's target audience is the design community, solar manufacturers, and the energy supply and service industries that serve the end-users as well as architects, cities, housing companies and building owners. Therefore, the Agreement must strengthen its links to these intermediary businesses.

5. Key Technologies and Applications

As already mentioned in the Introduction, this Strategic Plan's key technologies and applications are based on the research priorities of the member countries and it is also based on the results and recommendations of the IEA Technology Roadmap - Solar Heating and Cooling. Furthermore, the Strategic Research Priorities of the Solar Thermal Panel of the European Technology Platform on Renewable Heating and Cooling also provided guidance for the Plan.

In the near future, the most important solar heating and cooling applications in the member countries of the Solar Heating and Cooling Implementing Agreement are expected to be:

- Solar water heating
- Solar space heating by district heating and combi systems (domestic hot water and space heating) with a high solar fraction
- Solar heat for industrial processes and agriculture
- Solar cooling, air conditioning and refrigeration
- Solar water treatment

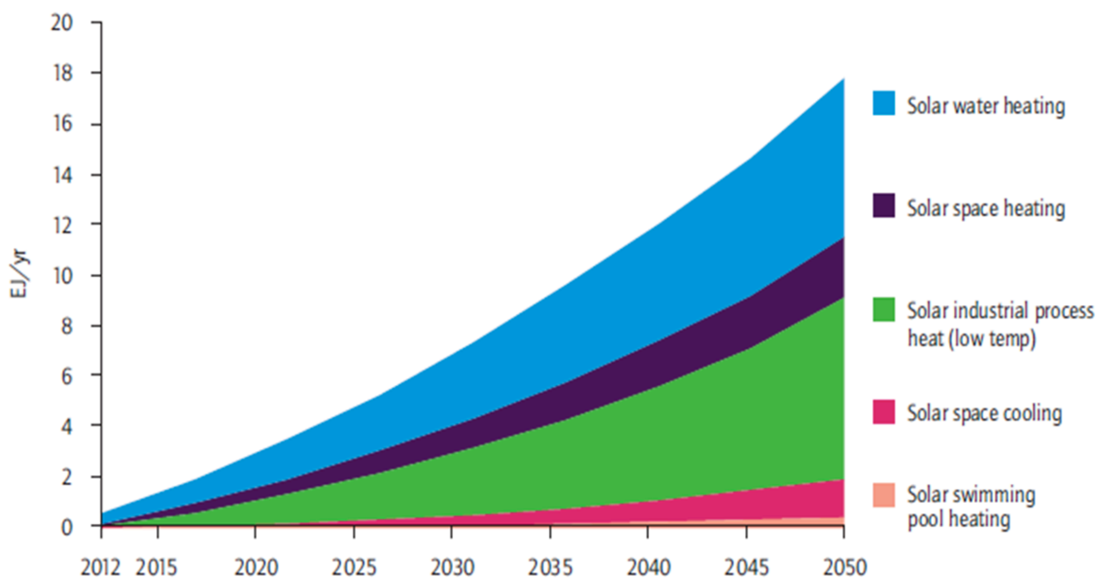

Figure 4: The most important solar heating and cooling applications according to the IEA Roadmap for solar heating and cooling (Source: IEA Technology Roadmap, Solar Heating and Cooling, Paris 2012).

Most of the applications mentioned above are related to the building sector. To realize this huge potential for solar heating and cooling, it is essential to integrate solar technologies into the built environment in an appropriate way. The most important activities of the SHC Implementing Agreement in the building and urban planning sector are therefore seen in:

- Passive and active solar building designs
- Solar based renovation of the existing building stock
- City and regional planning based on solar design requirements
- Solar district heating and cooling
- Daylighting

The goals set in the Vision can be reached if the competitiveness of solar thermal systems are significantly increased through cost reduction and improved performance and reliability based on an overall integrated system approach. To achieve this further R&D is needed in the following four sectors.

5.1 Components

- **Advanced flat-plate and evacuated tube collectors** with improved efficiency and overheat protection based on developments such as new coatings and high vacuum or noble gas insulation. These collectors will increase the energy gained under winter conditions, while maintaining high levels of durability and increasing the cost efficiency of the manufacturing and installation process.
- **Development of medium and high temperature collectors.** The use of solar thermal energy in the medium (100 – 250°C) and high (250 – 400°C) temperature range requires the availability of cost effective and highly efficient collectors.
- **Compact, long-term thermal storage technologies** for buildings and industrial applications that significantly reduce the space required for heat storage devices. This will lead to cheaper and more practical seasonal heat storage, allowing large amounts of heat accumulated during the summer to be used for heating during the winter.
- Advanced and cost effective **large-scale sensible heat storages** like pit storages, borehole storages and aquifer storages for applications in district heating and industry.
- Improved **components for solar thermally driven cooling systems.** In particular advanced sorption materials and heat exchangers must be developed to improve the performance of thermally driven cooling machines. In addition, new, highly flexible cooling cycles (high temperature lift; double, triple stage and new open sorption, including hybrid sorption-compression, advanced ejector cycles) have to be developed to allow solar operation under variable temperature and power conditions, as well as cooled open solid sorption cycles with a high dehumidification potential for warm and humid climates.
- Improved and high efficient **heat rejection units** for solar air-conditioning, cooling and refrigeration systems will also improve efficiency and increase the potential for application of passive cooling concepts.
- Multifunctional **dynamic solar façade systems** including daylighting and PVT systems.
- Architectural designed components and elements for building integration.

5.2 Systems

- Low cost/high performance and easy to install **solar water heating systems** for climates with high solar radiation. These systems might be based on new materials like polymers.
- Compact **hybrid solar heating systems** that provide a 100% heat solution for houses. These systems should combine solar thermal components and storages, which have to be the main heat supplier (>50%), with gas, heat pumps, renewable electricity or biomass as back-up source.
- **"Solar Active Houses"** that cover between 50 – 100% of the annual heating and cooling demand.
- **Long life, low operation and maintenance systems for residential buildings** that will provide confidence in long term performance of solar systems and decrease the life cycle costs, by developing and promulgating technical processes covering design, commissioning and monitoring to ensure the long term quality of the systems.

- **Solar heating and cooling based on photovoltaic systems** with particular focus on system control, energy storage and smart grid interaction.
- **Integrated solutions for heating and cooling of buildings** that use solar thermal or photovoltaic or hybrid solar energy conversion techniques. Concepts will focus on solutions, not technologies and appropriate design, installation and operation processes will be developed.
- Cost competitive **solar air-conditioning, cooling and refrigeration systems** including industrial solar refrigeration systems.
- Advanced solutions for the integration of **large-solar thermal systems into smart thermal/electrical grids**. R&D is needed on system technology to develop advanced district heating systems, which are able to deal with a combination of centralized and decentralized hybrid heat sources like solar thermal, heat pumps, biomass CHP plants and waste heat. The integration of the thermal energy storage must be optimized in addition. Smart metering and load management systems are needed to combine solar district heating systems with the electrical grid. Such smart thermal-electrical grids will meet the load balancing needs of combined heat and power production in an open market for electricity.
- Turnkey **solar thermal process heat systems.** R&D is needed to classify and optimize relevant industrial processes to make them more suitable for solar thermal systems, e.g. through conversion from steam-based to hot water-based supply systems and adaptation of machinery and heat exchangers for solar input. In addition, novel integration schemes of solar generated steam by medium-temperature collectors are needed for industrial steam networks.
- **Solar water treatment systems** to produce drinking water or to clean wastewater.
- **Intelligent metering and control systems** of the overall energy flows in buildings to contribute to a reduction in energy consumption and the optimisation of solar energy usage.

5.3 Integration into the overall energy system

The Agreement will focus on energy efficiency measures combined with the integration of solar technologies in buildings, in industrial processes and in regional and urban infrastructures. Specific areas of work include:

- **Solar design and demonstration for new and existing buildings and urban districts** (solar heating, daylighting, solar cooling and passive solar).
- Solar **design guidelines for industrial applications** as well as classification of suitable industrial processes and adoption of industrial processes to the requirements of solar heat supply.
- Design guidelines for the integration of large-scale **solar thermal systems into smart thermal/electric grids.**
- **New business models** addressing the financial, operational and legal issues of medium to large-scale solar heating and cooling systems in the residential and industrial sector as well as concerning district heating.
- **New policy, incentive and program models** that support the development of a sustainable market for local, low emission heating and cooling technology.

5.4 Design and planning tools

- Solar resource assessment and data applications, including forecasting.
- Rating and certification procedures.

- Simulation models and programs.
- Computer aided architectural design and other tools to handle solar energy issues at early building design stage.
- Test methods for new applications and components.
- Training materials.
- Assessment methods and tools for urban planning with solar energy.

5.5 Accompanying Measures

- Training.
- Capacity building.

6. Objectives and Strategies

To fulfill its mission, the SHC Executive Committee has agreed upon the following strategies to meet the objectives stated above.

SHC OBJECTIVE 1

To be the primary source of high quality technical information and analysis on solar heating and cooling and daylighting technologies, designs and applications.

Strategies

- Continue and improve the work of the Solar Heating and Cooling **Information Center.**
- Assure that technical **information** and **analysis** developed in this Agreement is available and disseminated to the target audiences in useful formats.
- Working through relevant international standards organizations, support the development and harmonization of **standards** necessary for the widespread use of solar designs and technologies in the building, agricultural and industrial sectors.
- Provide high quality ancillary data, such as solar resource data, and analytical tools that support R&D, effective deployment, and market growth for solar technologies and applications.

SHC OBJECTIVE 2

To contribute to a significant increase in the performance of solar heating and cooling technologies and designs.

Strategies

- Increase **user acceptance** of solar designs and technologies.
- Continue to develop **cost-effective** designs and technologies in collaboration with appropriate intermediary industries.
- Identify and prioritize **R&D needs** for solar heating and cooling that will lead to expanded markets.

SHC OBJECTIVE 3

Contribute to cost reduction of solar thermal components and systems in order to increase their market competitiveness.

Strategies

- Work with industry and Standards organizations to reduce **the overhead costs of compliance** and rating of solar systems.
- Work with research organizations and industry to identify and implement ways to **improve cost effectiveness** of solar collectors and systems by for example, the use of new materials, plug and function systems, improved production processes and time-efficient installation techniques.

SHC OBJECTIVE 4

To enhance cooperation with industry, international organizations and local, regional and national governments on increasing the market share of solar heating and cooling technologies and designs.

Strategies

- Work with appropriate **intermediary industries** and end users to accelerate the market penetration of solar designs and technologies.

- Work with international organizations like UNIDO, UNEP, IRENA, governments and municipalities to promote and expand **favorable policies** to increase the market share.

- Work towards or support the greater use of solar designs and technologies in **developing countries**.

- Work to address issues regarding building design, aesthetics and architectural value and long-term urban energy strategies.

SHC OBJECTIVE 5

To increase the awareness and understanding on the potential and value of solar heating and cooling systems by providing information to decision makers and the public.

Strategies

- **Communicate** the value of solar heating and cooling designs and technologies in publications, conferences, workshops and seminars to the public and relevant stakeholders.
- Provide **analysis** that links solar heating and cooling designs and technologies to energy security concerns, environmental and economic goals.
- **Quantify and publicize** the environmental, economic and climate change benefits of solar heating and cooling and supporting policy measures, solar designs and technologies in meeting environmental targets and addressing policies and energy supply security.
- **Review** our products in relation to our objectives – Annual Reports, Solar Update Newsletters, National Programme Review Reports, "*Solar Heating Worldwide: Markets and Contributions to the Energy Supply report.*"
- **Present** the SHC Solar Award annually/bi-annually.
- **Maintain** the SHC web site.

7. Action Plan

Annual Action Plans are developed and agreed by the ExCo each year to ensure that actions necessary to deliver this Strategic Plan are completed within the appropriate timeframe.

The annual Action Plan for 2014 is attached as Appendix 1.

8. Programme Management

8.1 Organization

The Executive Committee is the management body of the IEA Solar Heating and Cooling Agreement. It is composed of one representative from each Contracting Party and Sponsor to the Implementing Agreement. Each Contracting Party and Sponsor (with some limitations) has one vote. The Executive Committee elects a Chairman and up to two Vice-Chairman who serve a two-year term. The Chairman may serve for a maximum of two consecutive terms.

The management of the individual projects is the responsibility of Operating Agents who are selected by the Executive Committee.

8.2 Sponsors

To increase collaboration with industry associations, the Agreement adopted the new IEA member category of "Sponsors." Based on the IEA's definition, the following guiding principles were adopted by the Executive Committee:

- Sponsors must be approved by the CERT.
- Admission shall be limited to major international industry associations and international non-profit organizations that are in-line with the SHC Agreement's objectives.
- A single company shall not be accepted as a Sponsor.
- The number of Sponsors in the Implementing Agreement shall not be greater than half of the number of Contracting Parties.
- Sponsors shall have no greater rights or benefits than Contracting Parties.
- Sponsors are to have voting rights in the Executive Committee except on issues of unanimity.
- Sponsors are to pay half the amount that Contracting Parties pay annually to the Common Fund.
- Sponsors may not be designated as Chair or Vice-Chair of the IA.
- Sponsors must participate in at least 1 Task. The participant may be from the Sponsor organization or a member organization of the Sponsor organization.
- Sponsors may propose and initiate new Tasks.
- Sponsors may serve on a Task Publication Review Committee. All Task Publication Review Committees shall have at least 1 Contracting Party.
- Sponsors are to follow the same procedure, as stated in the SHC Policy & Procedures Handbook, to withdraw from the Agreement as Contracting Parties.

8.3 Committees

To manage specific Agreement activities, the Executive Committee has created the following Committees:

- **Information Center Steering Committee** to help guide the activities of the Information Center and support the work of the Information Center Manager. The committee consists of the Executive Committee Chairman and Vice-Chair(s), Operating Agent Chair, 1 Executive Committee member, Webmaster and SHC Secretariat.

- **Solar Award Committee** to manage the selection and recognition of the SHC Solar Award recipient. The Committee consists of the ExCo Chair, Information Center Chair, 2 Executive Committee members and the Operating Agent Chair.

- **SHC Conference Committee** to organize the Agreement's *International Conference on Solar Heating and Cooling for Buildings and Industry*. The Committee consists of Executive Committee members, Operating Agents, Conference Organizer and others as needed.

- **Trade Association Committee** to work with the major solar heating and cooling trade associations to maximize the synergy between their interests and the SHC Agreement's activities. The Group consists of 4-5 Executive Committee members.

- **Website Committee** to work with the webmaster on improving the SHC website. The committee consists of Executive Committee members, Operating Agents, Information Manager and SHC Secretariat.

8.4 Information Dissemination

Recognizing the absence of or limited information and statistical data disseminated on solar heating and cooling, daylighting and integrated building technology and design, the Agreement will continue to strengthen its dissemination activities through its Information Center and its own platforms (SHC Solar Award, website, newsletter, annual report, Task reports, conference presentations, journal articles) and other channels, such as the IEA (OPEN Bulletin, Secretariat), conferences/events, trade journals, etc.

9. Performance Review

This Strategic Plan is a guiding reference document and not a set course of action. The objective of an annual review is to assess if the current strategy should be altered to account for changes in the Agreement or in the field of solar heating and cooling.

9.1 Annual Review

The Strategic Plan will be reviewed every year to assess its relevance and progress being made to achieve the Strategic Objectives and annual Action Plan. The Chair and Vice-Chairs will review progress and present their findings to the Executive Committee, who will approve of their report and recommend corrective actions, if required.

9.2 National Programme Review

Executive Committee members will submit an online national report annually. Every 2-3 years the Executive Committee will conduct a national program review session. At this time, Executive Committee members are to prepare an oral and written paper on the current status of solar in their country.

9.3 Task Evaluations

Mid-term and **final evaluations** of Tasks and Working Groups will be conducted to assess the quality of the technical work, management, products and results. The Agreement's Policies and Procedures Handbook contains a description of the evaluation process. The Operating Agent or Working Group Leader will carry out these evaluations**.** The Executive Committee votes on its approval or request modifications. In general, the evaluations will be qualitative rather than in-depth, quantitative analysis. Criteria to be applied are:

Final Evaluations
Regarding quality:

- Objectives achieved
- Management quality and effectiveness
- Technology outcomes
- Information plan outcomes
- Relevance of results
- Fulfillment of industrial needs
- Adequacy of allocated resources

Regarding impacts:

- Adequacy of SHC and national technology transfer efforts
- Did the activity make a difference? If so, why? If not, why not?
- Economic value to national participants and industries
- Information/technology transfer from the activity
- Application of the Task results
- Educational benefits

10. Collaboration

10.1 Within the IEA

In order to conduct efficient R&D and eliminate duplication of work, it is important to identify common R&D topics, and if appropriate, coordinate activities with the other IEA building-related Implementing Agreements in the buildings co-ordination group. Other important collaborative activities are the exchange of information, hosting of joint meetings, and development of joint projects in areas of common interest.

It also is important to continue to enhance the dissemination of information through collaborative activities with IEA Headquarters, the statistics department and the Renewable Energy Working Party.

10.2 With other IEA Agreements

Collaborating with other Implementing Agreements is important to combine effort and to avoid duplication of work. The SHC Agreement currently has collaborative Tasks with the following IEA Agreements: Energy in Buildings and Communities (EBC), Energy Conservation through Energy Storage (ECES), Photovoltaic Power Systems (PVPS), District Heating and Cooling (DHC), Heat Pump Programme (HPP), and SolarPACES. The SHC Agreement will continue to develop its current relationships and foster new ones with the Building-Related Implementing Agreements. The SHC Agreement will also actively collaborate with the IEA's Building Coordination Group and contribute to the Future Buildings Forum[14].

To facilitate collaborative activities with other Implementing Agreements, the SHC Executive Committee approved a policy on collaborative Tasks with other IEA Agreements. This policy recognizes that although, from a management point of view, it is better to formally manage a Task in only one Executive Committee at a time, there are Tasks that lend themselves to collaboration. To facilitate this process, the Executive Committees of SHC and EBC, have agreed upon four levels of collaboration.

Minimal

ExCo A is responsible for the management of the Task.

ExCo B does not help to define the work. The Task is fully defined and managed by ExCo A with appropriate input from ExCo B.

Experts selected by ExCo B participate in the Task with the same rights and responsibilities as experts from ExCo A (i.e., attend Task meetings, provide requested input on time, etc.).

Moderate

ExCo A is responsible for the management of the Task.

Task work is jointly defined, that is, ExCo B provides input to the Task Concept Paper and the Task Definition Phase (preparation of the Annex, Work Plan and Information Plan). Once the work is defined, ExCo A manages the Task.

If the two ExCos agree to collaborate at this level, it is assumed that they will make

14 This strategic plan is in agreement with the priorities set by the IEA EBC Future Buildings Forum 2013

every effort to resolve any differences. Such resolution implies that ExCo A is willing to make changes in the Annex and Task Work Plan proposed by ExCo B. However, as Executive Committees are independent and sovereign bodies, it is understood that such decisions remain the sole responsibility of ExCo A. If at any point in the process ExCo A feels that it cannot agree with ExCo B's recommendations, the collaboration should revert back to the "Minimal" level.

High

ExCo A is responsible for the management of the Task.

Task work is jointly defined and ExCo A and ExCo B are to agree on any proposed revisions to the Task Work Plan once the Task is underway.

Joint

Task work is jointly managed be ExCo A and ExCo B acting in unanimity and described by an Annex in both Implementing Agreements.

There may be one OA representing both ExCos or co-OAs, one from each ExCo. The OA's obligations should be clearly outlined and agreed upon during the Task Definition Phase.

Both ExCos must agree to participate in the management of the collaborative work to be done and oversee its progress.

To ensure accountability, in the case of Minimal, Moderate and High levels of collaboration ExCo B members must send a National Participation Letter for their experts. This Letter should be sent to the Task OA with copies to ExCo A Chairman and ExCo A Secretariat.

In the case of a joint collaboration National Participation Letters should be sent to the Task OA with a copy to the ExCo A and ExCo B Secretariats.

In the case of Minimal, Moderate and High levels of collaboration if ExCo B desires greater involvement in the Task then a greater degree of collaboration should be proposed by ExCo B to ExCo A.

Besides these formal levels of participation, tasks can exchange information with other tasks and inform other tasks about their results, by their own initiative or on request of the ExCos.

Determining the degree of coordination

Potential joint activities should be identified at an early stage of their development. To facilitate identification of suitable future collaborative work this information should already be given in the first draft of work proposal, thus be included in the Project Concept template. The ExCos then perform the following steps:

1. ExCo A identifies potential collaborative work in an early stage.
2. ExCo A proposes level of collaboration and leading ExCo to ExCo B and lists their arguments.
3. ExCo B discusses proposed collaboration. If ExCo B doesn't agree with the proposed it makes a counterproposal to ExCo A and lists their arguments.
4. If a counterproposal has been made the ExCo chairs decide on this acting in unanimity.

10.3 With Industry

The Agreement will continue to foster its relationships with the solar thermal industry and trade associations. A Memorandum of Agreement has been signed with associations from around the world. It is expected that joint meetings will continue to be held every 1-2 years.

It is strongly recommended that industry workshops organized by Tasks continue to be held, as this is critical for collaboration and the dissemination of Task results.

10.4 With Other Institutes

To strengthen dissemination activities and increase the number of individuals using Task results, the Agreement will build upon and expand its existing relationships with institutes outside of the IEA. These institutes include, but are not limited to:

- European Union
- European Technology Platform on Renewable Heating and Cooling and its Solar Thermal Panel
- International Solar Energy Society (ISES)
- International standard organizations, (e.g., ISO, CEN, ASHRAE)
- World Bank

<u>Appendix 1</u>

SHC PROGRAMME – ACTION PLAN 2014

ACTION		COMMENT
To be the primary source of high quality technical information and analysis on solar heating and cooling technologies, designs and applications.		
1	Start of new IA term	March 1, 2014
2	Produce 2013 Annual Report	Publish by April 2014
3	Produce Solar Heat Worldwide report	Publish by June 2014
4	Countries post their Country Status Reports on SHC web site	2nd quarter
5	Produce Position Paper: Solar and Heat Pumps	May 2014
6	Produce Position Paper: Polymeric Materials for Solar Thermal Applications	October 2014
7	Produce Position Paper: Solar Renovation of Non-residential Buildings	October 2014
8	Review Strategic Plan	October 2014
9	Announce new Task publications on web site	To be done once reports are approved by the ExCo
To contribute to a significant increase in the performance of solar heating and cooling technologies and designs.		
1	Start Task on New Generation Solar Cooling & Heating Systems	February 2014
	Conduct Mid-term Evaluation for Task 43, Rating and Certification	May 2014
	Conduct Mid-term Evaluation for Task 46, Solar Resource Assessment and Forecasting	May 2014
2	Conduct Mid-term Evaluation for Task 49, Solar Heat Integration in Industrial Processes	May 2014
3	Conduct Mid-term Evaluation for Task 50, Advanced Lighting Solutions for Retrofitting Buildings	May 2014
	Present Final Management Report and Technical Presentation for Task 40, Net Zero Energy Solar Buildings, and dissemination of results	May 2014
4	Present Final Management Report and Technical Presentation for Task 44, Solar and Heat Pump Systems	May 2014
6	Present Final Management Report and Technical Presentation for Task 39, Polymeric Materials for Solar Thermal Applications	October 2014
7	Present Final Management Report and Technical Presentation for Task 47, Solar Renovation of Non-residential Buildings	October 2014

To enhance cooperation with industry and government on increasing the market share of solar heating and cooling technologies and designs.		
1	Continue to collaborate with trade associations	Hold SHC/Trade Association Meeting
2	Collaborate with the ESTIF and ISES	Continue collaboration in areas of conferences, publications, websites
3	Collaborate with other IEA and IA's	Participate in Building Coordination Group meetings Attend one REWP meeting per year (Spring meetings deal specifically with IAs)
To increase the awareness and understanding on the potential and value of solar heating and cooling systems by providing information to decision makers and the public.		
1	Hold 3rd International Conference on Solar Heating and Cooling in China	October 2014
2	Present SHC Solar Award at 3rd SHC Conference in China	October 2014
3	Disseminate Press Releases on SHC activities and results	To be done as needed
4	Task 44 handbook 2nd in SHC book series published by Wiley-VCH	1st quarter
5	Commercial publication of Task 40 book	2nd quarter

Appendix 2

A description of all Tasks and a list of their publications are provided on the SHC web site, www.iea-shc.org.

Current Tasks of the IEA Solar Heating and Cooling Programme

Task 39 - Polymeric Materials for Solar Thermal Applications

Task 40 - Net Zero Energy Solar Buildings

Task 42 - Compact Thermal Energy Storage

Task 43 - Solar Rating & Certification Procedures

Task 44 - Solar and Heat Pump Systems

Task 45 - Large Scale Solar Heating and Cooling Systems

Task 46 - Solar Resource Assessment and Forecasting

Task 47 - Solar Renovation of Non-Residential Buildings

Task 48 - Quality Assurance and Support Measures for Solar Cooling Systems

Task 49 - Solar Heat Integration in Industrial Processes

Task 50 – Advanced Lighting Solutions for Retrofitting Buildings

Task 51 – Solar Energy in Urban Planning

Task 52 – Solar Thermal & Energy Economics in Urban Environments

Task Under Development

Task 53 –New Generation Solar Heating and Cooling Systems