SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

2019 HIGHLIGHTS

Task 55 – Towards the Integration of Large SHC Systems in DHC Networks

THE ISSUE

In recent years, megawatt-scale solar thermal district heating (SDH) systems have gained increasing attention globally. Several ambitious projects were successfully implemented in countries such as Austria, Germany, Italy, France, Spain, and Norway. Large-scale SDH systems and their large-sized seasonal storages have become attractive options for cost effective and low carbon heat supply. In the next step, large systems will become even bigger and likely grow from MEGA to almost GIGA-sized installations. These systems will be able to meet the increasing energy demand of city districts and of whole cities. Compared to conventional heat generation systems, the effective operation of a SDH network and its seasonal storage can guarantee a primary energy consumption reduction of >70% in thermal needs. However, the actual integration of large solar thermal systems into existing and new networks faces several challenges. Expertise on the integration of large solar thermal systems into district networks is limited. Therefore, SHC Task 55 collects and disseminates technical and economic solutions to leverage large-scale solar thermal district heating and cooling systems worldwide.

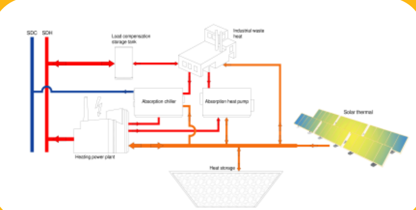
OUR WORK

SHC Task 55 aims to provide a platform for practitioners and scientists to present the benefits and challenges of SDH and SDC systems. It collects research results on options and measures to realize sophisticated SDH and SDC systems by focusing on characteristics of solar thermal systems, technical and economic specifications of district heating networks that are relevant for the integration of solar thermal systems and hybrid technologies, analyses of system components and their integration, modular designs of large SDH/SDC systems, and economic requirements of large SDH/SDC systems in different market regions. Finally, SHC Task 55 collaborates with the IEA Technology Collaboration Programme on District Heating and Cooling including Combined Heat and Power (IEA DHC).

Participating Countries

Austria
Canada
China
Denmark
Finland
France
Germany
Spain
Sweden
United Kingdom

Task Period 2016 – 2020
Task Leader Sabine Putz, SOLID, Austria
Email s.putz@solid.at
Website http:task55.iea-shc.org

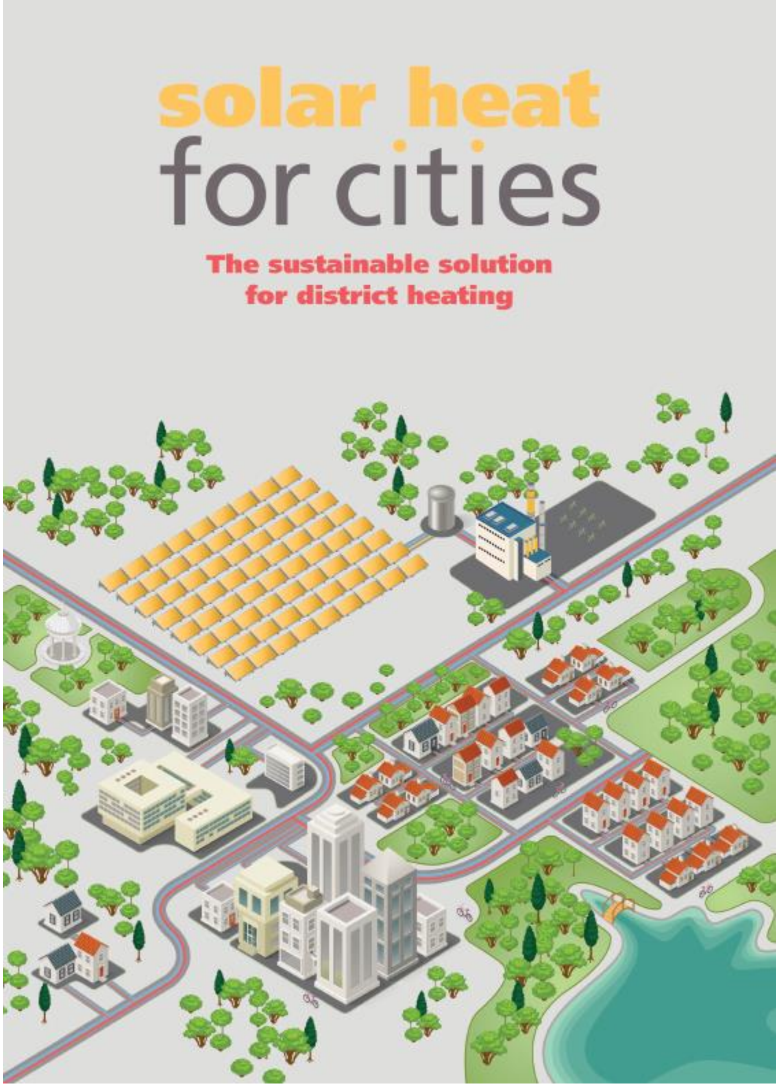


KEY RESULTS IN 2019

Brochure "Solar heat for cities - The sustainable solution for district heating"

The investor brochure was elaborated within IEA SHC Task 55 by Bärbel Epp from Solrico and published in November 2019.
The brochure contains very useful info charts and general information about large scale SDH as well as several case studies of SDH installations in Denmark, China, Serbia, Austria, France, Latvia and Germany.
Download: http://task55.iea-shc.org/publications

SDH markets are growing in Denmark, Germany, China and new markets are starting like in France, Italy, Poland, Spain etc. To increase the market share of SDH in new and existing markets, communication efforts are necessary. Therefore, one important activity in Subtask D was the preparation of an investor brochure with 20 pages in English language.
The target of this brochure is to raise awareness and interest about this technology and facilitate the entry of investors into SDH by answering their key questions. Successful case studies and testimonials that prove the key advantages of using SDH are a core part of the brochure. In order to meet the needs of the stakeholders, the seven sponsors as well as other experts work together in a task force to set up the content. The whole group of experts within Task 55 was involved in reviewing the drafts to ensure high quality content.



Evolution of the Austrian district heating and the role of solar thermal: Scenarios for 2030

District heating (DH) generation accounts for 26% of the residential heat demand in Austria. Almost 60% of DH is generated by CHP plants which are using biomass and combustible waste as fuel. However, the share of heat pumps and solar thermal in DH generation in Austria is expected to increase in the near future. In this study, AIT evaluated the share of Solar thermal in DH generation in Austria in 2030. The study bases on an open-source modelling tool called Balmorel which is a partial equilibrium optimization model with calculating the optimal dispatch and investment on different generation technologies in electricity and DH system. The figure below shows a comparison between the optimal DH generation technologies in 2030 (model results) with the current DH generation portfolio in 2018. The results show that the share of solar thermal in DH generation increases from almost zero in 2018 up to 1.05 TWh in 2030 (which is 3.8% of total DH generation in that year). Sensitivity analysis proved that the investment cost of solar thermal technology and fossil fuel prices are determining factors on the future evolution of solar thermal. A 20% increase in biomass and natural gas prices will result in higher capacity of solar thermal and a growth up to 1.3 TWh generation from this generation technology in 2030.

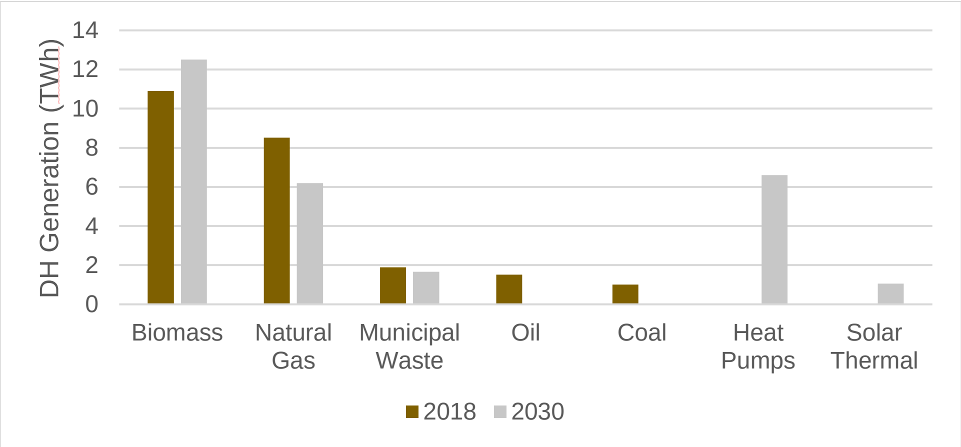


Figure: District heating generation in Austria (2018 vs 2030)

Urban-DH-extended: Large-scale solar thermal and storage applications for district heating in an Austrian context

Within the Austrian research project Urban-DH-extended, whose aim is to increase the flexibility of existing district heating networks and share of renewables in district heating systems, AEE INTEC analyzed three different district heating systems (Klagenfurt, Mürzzuschlag and Wien). Different extensions for the current energy systems were proposed, e.g. solar thermal installations combined with long-term energy storages with/without heat pumps, increase of operation hours of combined heat and power plants through addition of large thermal energy storage tanks. Furthermore, scenarios different energy policy settings were analyzed in the different scenarios. Some results are summarized in following figures.

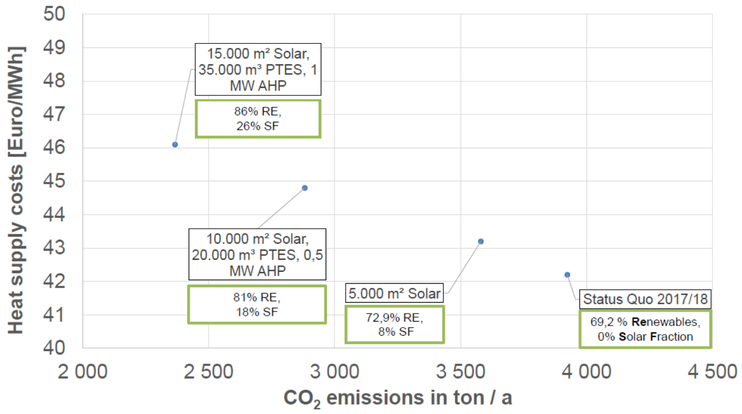


Figure: CO_2 emissions and heat supply costs for different system concepts (DH network Mürzzuschlag)

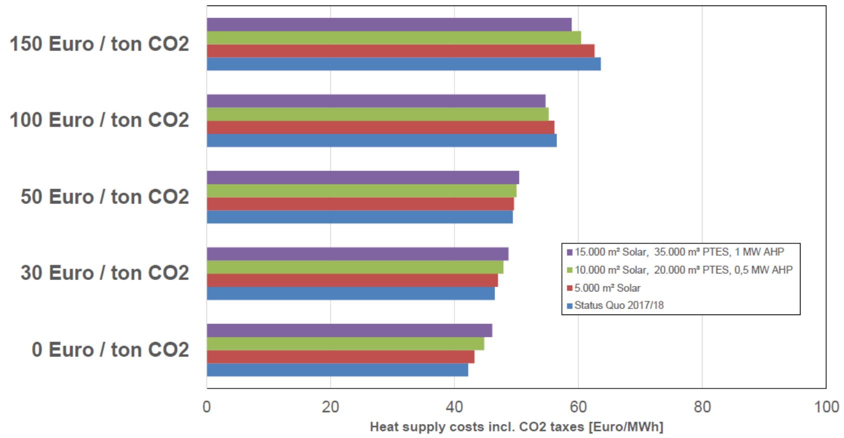
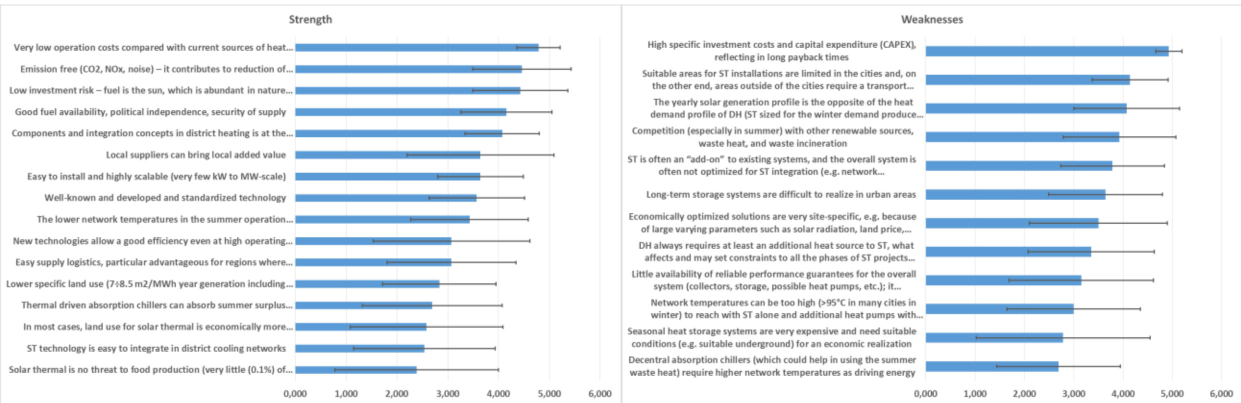
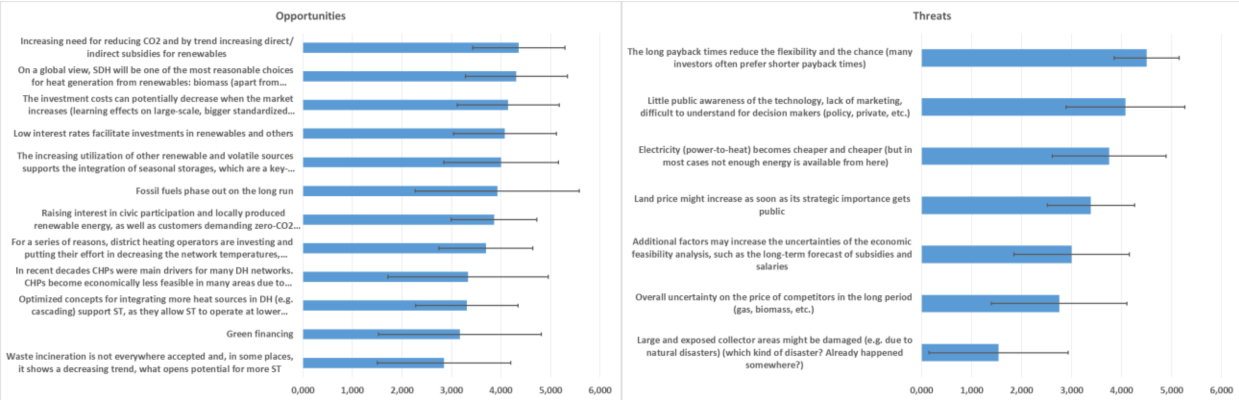


Figure: Implications of CO_2 taxes on heat supply costs of competing technologies (DH network Mürzzuschlag)

SWOT Analysis of the integration of large-scale ST systems in DHC

Within the IEA SHC Task 55 Expert Meeting in Härnösand (Sweden, October 2019), the participants provided a rating of all the points of a proposed SWOT analysis (0: not relevant to 5: very relevant). The rating allows to rank the points in order of relevance. The results are represented below.

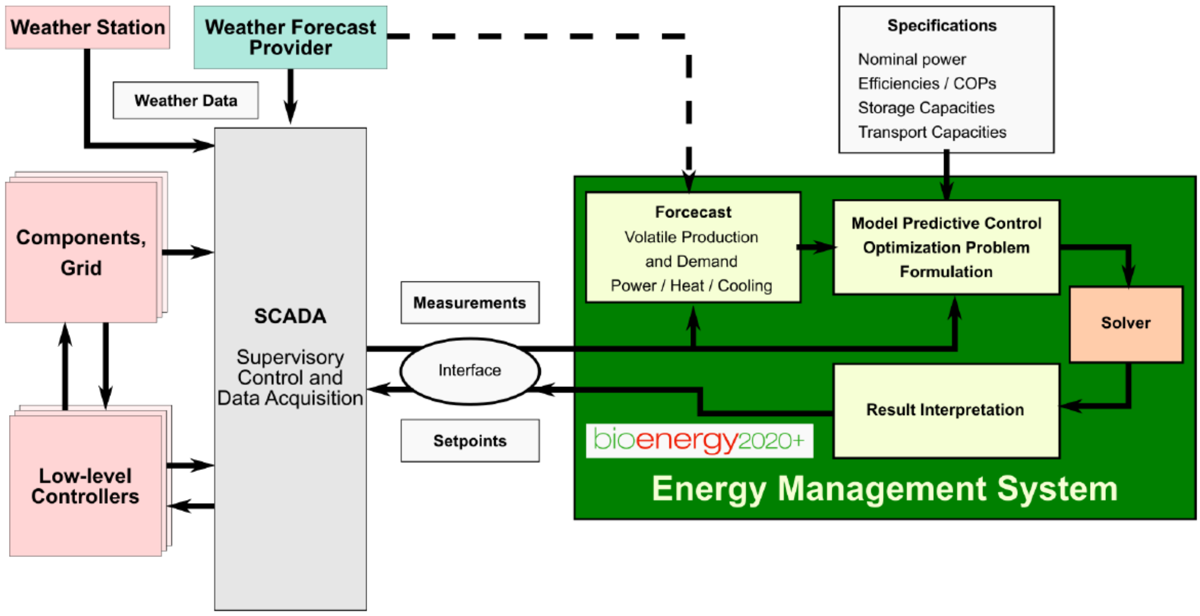




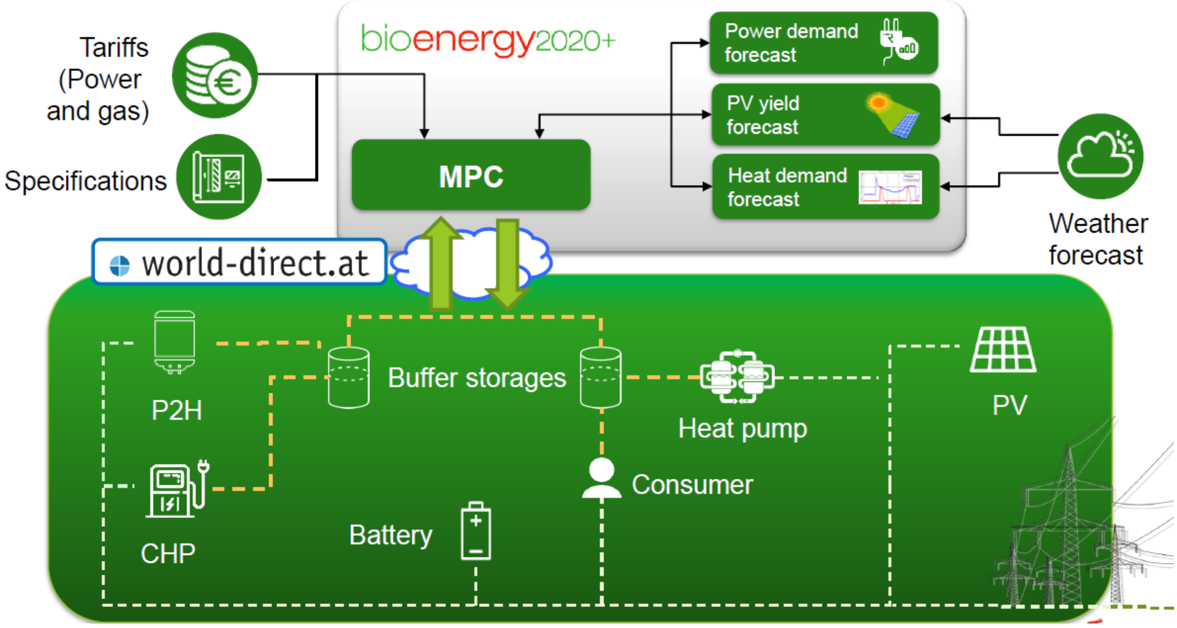
Modular Energy Management System (EMS) for the operation of cross-sectoral energy systems

A Modular Energy Management System (EMS) developed by Bioenergy 2020+ was implemented in two sites. The EMS calculates a strategy of operation by solving an optimization problem with following characteristics (scheme below):

- Modular composition of configurations
- Implementation of MILP (mixed integer linear programs) for on/off decisions
- Adaptive self-learning forecast for volatile production and demand (multi-linear regression for continuous, discrete Markov chain for switching processes)
- Time-variable energy prices and availabilities

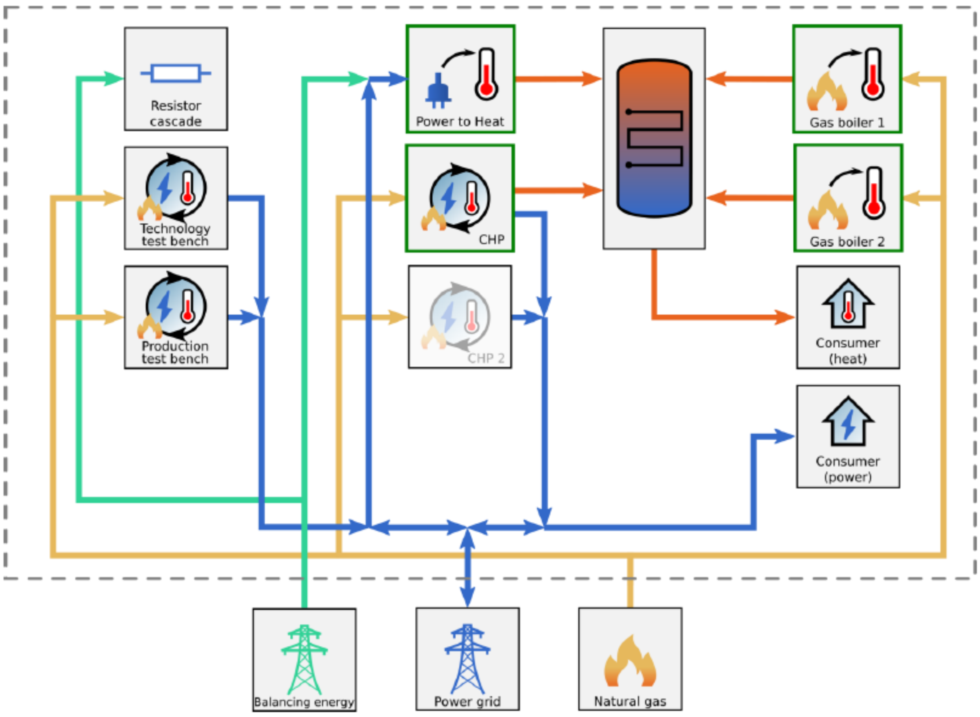


Implementation in a building complex in Innsbruck (scheme below).



Implementation in a factory for CHP units (scheme below) with following special challenges:

- Participation in the balancing energy market
- Limited control possibilities (only influence on set-points of gas boilers to control TES temperature and of power-to-heat and CHP production to control power import/export)



Main results:

- Forecast for PV yield, heat and power demand have good accuracy in the first implementation
- Good performances of EMS including heat requires good low-level control concepts (appropriate concepts for HVAC control, SCADA, PLC, communication)
- Low-level controllers operating at high efficiency are necessary when handling electrical power

- Obtaining recent (= low latency) and frequent (= high frequency) and consistent (= no outages) data is a challenge when not directly connected to a SCADA system
- Constantly changing circumstances are a challenge for real implementation (need for continuously new information on system configuration, when changing during EMS development, and on low-level controllers and plant capabilities)
- Challenges linked to TESs:
  - Determining a meaningful single value for the state of charge of thermal storages is hard
  - Changing temperatures lead to changing parameters (storage capacities, transport capacities, COP, heat losses, etc.)

Integrating heat pumps into SDH systems

Large-scale thermal energy storage (TES) will be required regardless of the future composition of the energy system. In solar district heating systems (SDH), the solar contribution can be significantly increased with large-scale TES. A heat pump (HP) can be integrated into the SDH system to further reduce or even replace the fossil backup (BU). The electricity consumed by the HP has to be considered in relation to the reduction or replacement of fossil energy. The time of electricity consumption and the composition of the electricity mix must be considered.
Results show that heat pumps can be integrated in SDH systems with the aim of achieving higher share of REs and thus reducing/replacing the use of fossil fuels.
The mismatch between (electricity) demand and RE availability should be considered, e.g. by means of time dependent primary energy conversion factors. Integration of a HP in a SDH can have environmental benefits, but careful planning is required and time of electricity use hast to be considered. With constant PE factor the benefit of using a HP is overrated. However, first of all, a significant reduction of the energy demand of the building stock is a prerequisite for a sustainable energy system.

KEY EVENTS IN 2019

Solar Academy TASK 55 Webinar

The International Solar Energy Society was very happy to host the IEA SHC Solar Academy's 2019 series.
This first webinar in 2019 on 21th of March shared the latest results of IEA SHC Task 55 on Large Scale SHC Systems Integration into District Heating and Cooling Networks.
Solar District Heating (SDH) is in the early market development stage. Large solar thermal plants feeding into district heating networks represent only about 1% of the installed capacity of solar thermal systems, despite the fact that competitive prices lower than 40 €/MWh can be reached. In the long run, solar district heating could represent 4-15% of the total technical potential of solar thermal energy.

The aim of this IEA SHC work is to develop technical and economic requirements for the commercial market introduction of solar district heating and cooling (DHC) for a broad range of countries. The activities aim to improve technological know-how, market know-how and understanding of the boundary conditions as well as to provide expert know-how for project initiation and implementation and for training. A key element will be the direct cooperation of SDH experts with associations and companies in the district heating sector as a means to bridge the gap between these sectors.
TASK 55 Speakers were:

Jianhua Fan
Speech: In the webinar presentation talked about solar heating plants and system integration of different renewables for example, solar heat, heat pump and biomass etc. Several application examples were introduced.

Lucio Mesquita
Speech: The Drake Landing Solar Community is a Canadian solar district heating system with seasonal thermal storage, which supply heat to 52 homes in Okotoks, Alberta. This demonstration project, designed to achieve over 90% solar fraction, was commissioned in the summer of 2007 and it is currently in its 12th year of operation. This presentation described the system design and its measured performance throughout the years.

Jan-Erik Nielsen
Speech: Seasonal storage of solar district heating.
Jan Erik Nielsen presented experiences from Danish large scale seasonal storages – including measured performance. It was shown that it is possible to obtain very low store heat losses.

Karin Rühling
Speech: She presented the method and some simulation results concerning de-centralized feed in of solar thermal heat and heat from block heat and power plants into existing district heating systems.

Sabine Putz
Speech: In the role of the Operating Agent of Task 55 Sabine Putz presented the Task structure, the scope and the main objectives of Task 55

ISES sent a report on the statistics and feedback from the webinar participants. In total, 1268 people clicked on the webinar registration link. Of these people, 586 (46%) registered. 267 people attended the live webinar (46% of registered).
ISES told the OA, that it was one of the highest webinar participations ever. A detailed report from ISES is available.

UK Workshop “Solar Heat Networks: Policy, Planning, Design and Performance - GBP 320 million for low-carbon heat networks


Picture: Christian Holter, SOLID (left) and Jan-Erik Nielsen. PlanEnergi (right)

Heat networks have been proven as a reliable, cost-effective and low carbon means of providing heat, yet in the UK just 2 % of buildings are heated in this way. This number is supposed to increase by the Heat Networks Investment Project (HNIP) launched in October 2018. Over the next three years, the Department of Business, Energy and Industrial Strategy (BEIS) is investing British Pounds (***GBP)*** 320 million of capital funding into low-carbon heat networks. To foster the knowledge among planners, engineers, administrators and utilities on how to integrate solar energy into these networks, BEIS in cooperation with the IEA Solar Heating and Cooling (IEA SHC) Programme organised a 1-day workshop titles *Solar Heat Networks: Policy, Planning, Design & Performance* at the beginning of March in London.
Photos: BEIS

As the workshop topic was triggered from Task 55, the organisers invited two experienced SDH experts from the IEA SHC research platform IEA SHC TASK 55 on "Integration large SHC Systems into DHC Networks": Jan Erik Nielsen (on the right) from the Danish engineering office PlanEnergi and Christian Holter, CEO of the solar thermal system turnkey supplier S.O.L.I.D. in Austria. In several presentations they shared their knowledge about integration of solar and seasonal storages into heat networks, and about system performance and heat supply contracts.

Picture: Richard Hall, IEA SHC Alternate Vice Chair and co-organiser of the workshop

Richard Hall, IEA SHC Alternate Vice Chair, outlined that renewable heat is not on track: "However, solar heat networks are now becoming possible in the UK due to the HNIP, which aims to increase the number of heat networks being built".

The HNIP scheme supports the development or construction of new heat networks as well as the extension or refurbishment of existing once as long as they meet the European Commission definition of 'efficient district heating and cooling' which means the network has to fulfil one of the four criteria:

- 50 % renewable energy share
- 50 % waste heat share
- 75 % cogeneration heat
- 50 % of renewable and waste heat as a combination

Furthermore, the heat network operator must reach heat prices that are "no more than the counterfactual". Public, private and third sector representatives are eligible to provide individual projects in England and Wales (see attached subsidy scheme brochure). All project developments stages are supported:

- Heat mapping and master planning
- Feasibility study
- Detailed project development
- Commercialisation and construction

HNIP awards grants up to 50 % of the capital expenditure up to a maximum of GBP 5 million and hands out loans between GBP 25,000 and 25 million. Founding rounds are planned on a quarterly basis. The first round closed on 5 April. The two-stage application process involves a pre-application to ensure that projects applying for funding meet the HNIP eligibility criteria and is followed by a full application to the scheme. Submissions for HNIP funding can be made at any time, so the programme administrators encourage applicants to get in contact as early as possible.

SHC TASK 55 Keynote Speech at SWC/SHC 2019

420 attendees from 50 countries participated in the joint SHC and SWC (International Energy Agencies Solar Heating and Cooling Program together with the Solar World Conference) conference in Santiago de Chile from 04 – 07 November 2019. High-ranking officials attended the research conferences on solar technology, the SHC and SWC became the country's largest events on climate change in Chile this year after the cancellation of the UN Climate conference COP25, which had been scheduled to take place in Santiago in December 2019. The conference experts in solar energy did come to Chile to debate a wide variety of topics, ranging from solar cooling and heating, the integration into buildings and districts and process heat to education and training.

Sabine Putz had a keynote speech about “Large Scale Solar District Heating” and has presented a poster about IEA SHC TASK 55. Sabine Putz also has been interviewed by Bärbel Epp (SOLRICO) about solar heat in cities and the role model of large scale district heating in Denmark. The interview can be found here:

https://www.youtube.com/watch?v=e4bjYf1BNUU&list=PLJnsUy6hAZRqUVHU5ka0ubP_hc2rRCnlQ&index=7