

2022 HIGHLIGHTS

Task 62 – Solar Energy in Industrial Water & Wastewater Management

THE ISSUE

The change to a sustainable, resource- and energy-efficient industry represents a significant challenge for the coming years. The efficient supply of energy, the best possible integration of renewable energy sources and the recovery of resources in the sense of a circular economy must go hand in hand. The use of solar process heat represents a large, but so far largely unused, potential in industry. Innovative and concrete solutions are needed for the long-term and successful introduction of solar thermal energy. The integration of solar process heat to supply technologies for wastewater treatment represents a new field of application with excellent technical and economic potential for solar thermal energy. The efficient interaction, the nexus between solar energy, water and industry opens up new and innovative approaches.

OUR WORK

SHC Task 62 is developing and providing the most suitable and accurate information on the technical and economical possibilities for effectively applying solar thermal energy and solar radiation to disinfect, decontaminate and separate industrial process water and wastewater. This Task is supporting specifically the solar energy industry, the water technology sector and the producing industry in identifying new technologies, innovative fields of application and business opportunities.

The main objective of Task 62 is to improve the conditions and increase the applications of solar-driven separation and water purification technologies in industrial applications in order to push the solar water treatment market and to solve water problems at locations with abundant solar energy resources. Innovative results are expected in the field of collector technology and the identification of new applications, such as for municipal and industrial wastewater treatment plants.

Participating Countries

Australia

Austria

Denmark

Germany

Italy

Netherlands

Portugal

Spain

Sweden

United Kingdom

Task Period

2018 – 2022

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KEY RESULTS IN 2022

Integration Concepts for Solar Water Treatment

As a result of the IEA SHC Task 62, integration concepts are available to create a framework for the optimized combination of wastewater treatment technologies with energy supply. Consideration is given to solar thermal technologies, other renewable energy technologies (e.g., heat pumps), and surplus heat (waste heat) from industrial processes or their hybrid combination (PVT collectors).

The system integration concepts graphically illustrate how energy sources, such as solar thermal, can be integrated in combination with wastewater treatment processes, such as thermal separation processes (an example technology is Membrane Distillation (MD)), to meet the energy demand in a renewable way. The integration concepts are modular and include 3 modules: base modules, auxiliary modules (add-on modules), and integration modules. Each concept has at least one base module for renewable thermal energy supply (energy collection unit), such as solar thermal or heat pumps. There is also the possibility to integrate waste heat. In addition to the basic modules, there are many add-on modules (e.g., charging, storage, discharge, integration). Additional modules allow the integration of renewable process heat modules for heat supply on the process or system level and allow for the adaptation of the concept to the respective requirements. Figure 1 shows an example of the heat supply for MD at the process level. The MD process module changes depending on the requirements, such as batch or continuous operation, as well as realized internal heat recovery and can be replaced by other water treatment processes.

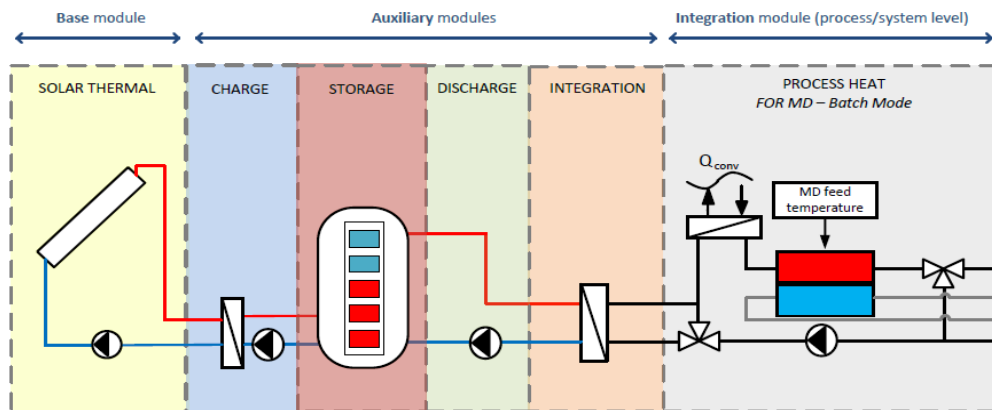


Figure 1. Integration concept for solar thermal energy in combination with thermal treatment technologies (e.g., Membrane Distillation, MD).

New, Innovative Concepts for Solar Collectors

Conventional solar energy technologies are characterized by the separation of the solar energy generation and the industrial process. Integration takes place, for example, via heat exchangers (e.g., integrated into baths) or a system for energy supply. Concepts for solar reactors represent a process intensification approach, where the integration part is omitted, and the energy generation and processes are combined into one component. The process, therefore, takes place directly in the energy supply unit (e.g., solar collector).

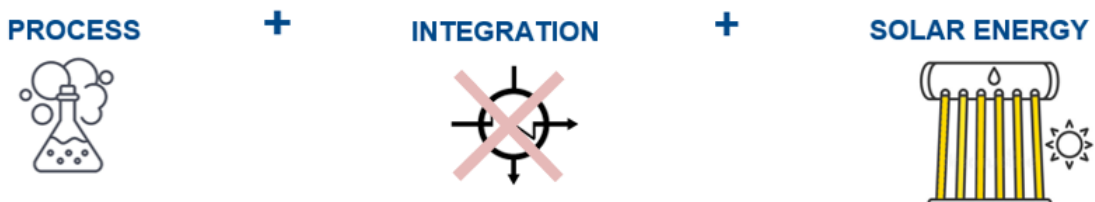


Figure 2. Approach of solar reactors.

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Solar Energy in Industrial Water & Wastewater Management

Within the work of the IEA SHC Task 62, new solar reactors for thermal and photon water treatment were collected. For example, the concept of AEE INTEC for a Solar reactor can be mentioned. The design of the solar reactor includes a targeted process intensification approach in which a photo-electrochemical cell (PEC) is integrated into a concentrating solar collector tube with optimized rheology. To concentrate the solar irradiation, the solar collector tube is surrounded by a concave trough mirror. The photo-electrochemical process is used to split water into its components by directly using sunlight to produce alternative fuels such as hydrogen. To increase the process efficiency, wastewater is used in test series since pollutants and waste substances contained in wastewater (e.g., microplastics, pesticides, trace substances) serve as an additional "source" of hydrogen (sacrificial substances). The advantage – at the same time the fuel is produced, there is a significant elimination of pollutants, and thus purification of the wastewater takes place. The reactor is set up in the laboratory of AEE INTEC in Gleisdorf (Austria) and is tested there under natural irradiation conditions.

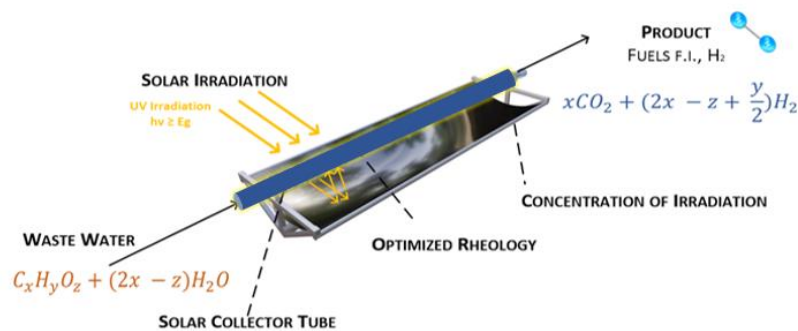


Figure 3. Concept of a solar reactor created by AEE INTEC (Austria, Gleisdorf).

Technology Position Paper

A Technology Position Paper will be published and posted on the Task webpage in early 2023. This paper includes the current status of solar water treatment and the potential and actions to be taken for increased market penetration.

SHC
SOLAR HEATING AND COLLECTING TASK 62

Technology Position Paper

Solar energy for industrial water and waste water management

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of soluble substances in combination with their renewable energy supply need to be developed.

2.1 Status Quo on water treatment technologies

Water treatment technologies are already available on the market for different application targets. For desalination/recovery of water, technologies include examples like multi-stage flash distillation (MSF), multi-effect distillation (MED), humidification-dehumidification (HDC), separation and filtration processes based on membranes include:

- pressure driven processes like reverse osmosis (RO) and Ultra-Filtration (UF, MF, MUF)
- membrane driven processes like electrodialysis (ED)
- concentration driven processes like diffusion dialysis (DD), permeation and
- thermally driven processes like membrane distillation (MD)

Regarding desalination and distribution systems, advanced oxidation processes (AOPs) for degrading contaminants in the waste water are available. Examples are photo-oxidation or Fenton-Fenton processes.

2.2 Energy demand for water and waste water treatment - forecast

The forecast for energy demand of water treatment by 2040 shows that the energy use for the water sector will increase tremendously in comparison to 2020 and will be ~1,470 TWh.

Electricity consumption in the water sector for years 2020-2040

Forecast for electricity consumption in the water sector (TWh/year)

By comparing this to the world's final energy demand forecast in industry for 2040, the water sectors take up around 1% of the total demand. The major parts of the energy demand for water treatment will be needed for waste water treatment (22%).

Forecasted Energy Demand 2020-2040

3 Potential

Forecasted electricity demand for waste water treatment and desalination electricity will be the predominant energy source, which even more affects the already advancing decarbonation of the energy system and the strain on the electrical energy power supply. If only 10% of the electricity demand forecasted by 2040 will be covered by solar-based technologies, solar thermal and solar photovoltaic, a considerable reduction of around 68 TWh can already be realized. By substituting the average CO₂ emissions of 273 g/kWh based on the electricity mix for the European Union in 2021, a total reduction of 18.7 Mt of CO₂ can be achieved.

3.1 Potential technologies for solar supply

Solar energy is currently used in the industrial sector mainly to supply production processes with solar process heat. The thermal utilization of solar energy can be done with active or passive systems. For industrial processes, mainly active systems are used. The basic principle of active solar thermal heat utilization is the conversion of shortwave solar radiation into heat (photo-thermic conversion) by absorbing the solar radiation with a suitable collector. State of the Art of collector types can be classified according to the heat transfer medium (liquid or air) or how they absorb radiation (concentrating or non-concentrating). Concentrating systems use beam radiation with one or heliostats tracking. Standard collectors are non-concentrating flat plate collectors with liquid as heat transfer medium, using an absorber with an anti-reflexive cover. They are typically used for temperatures levels until 100 °C or slightly above. Concentrated tube collectors achieve higher temperatures than flat plate collectors and are also common in the industry.

Options: Technologies actively being realized by solar thermal energy or solar photovoltaic (AEE INTEC)

Applications for solar supply offer therefore a high potential for different technologies, in terms of solar thermal supply, membrane or separation.

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Technologies offer great potential for industrial integration. Solar photovoltaic could be used mainly for ACPs.

3.2 Potential applications in industry

Several specific industry sectors have a high demand for integrating waste water treatment technologies at different application areas. Some general application areas are:

Applications in different industrial sectors for solar water treatment (AEE INTEC)

4 Actions Needed

Demarcation and upgrading of solar driven water treatment. Using separation technologies such as membrane distillation in combination with solar process heat represents an innovative step in industry. The technical and economic potential assessment for the use of solar-driven water treatment sets the course for further research and development projects in the most important industrial sectors and municipal wastewater treatment, but also for change in rural areas in e.g. Africa for application like drinking water production. With an increase of the identified potentials, and the still necessary research and development needs, follow-up projects for the demarcation of solar supply and separation technologies for waste water are needed to increase the awareness and experiences.

New materials and coatings. Especially in terms of membrane technologies, their long-term stability and efficiency for various industrial applications needs further improvement. Especially for MD, there are only isolated developments and a high need for research in this field, among others also to minimize fouling in organically fouled water streams and increase their selectivity, durability and mechanical stability.

Development of innovative collector concepts. Solar reactor concepts, where solar supply and processes are merged in one collector need to be developed.