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Smart heat supply in Austria within the PITAGORAS project

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Abstract

The European funded cooperative research and demonstration project PITAGORAS is focused on efficient integration of city districts with industrial parks through smart thermal grids. The overall objective of the project is to demonstrate a highly replicable, cost-effective and greatly energy efficient large-scale energy generation system for sustainable urban planning of low energy city districts. As part of the project two demonstration plants namely in Brescia, Italy and Kremsmünster, Austria are being designed and will be built and tested during the project. The demonstration plant in Austria focuses on installing a large-scale solar thermal system of 10,000 m²; including seasonal storages with a total capacity of 60,000 m³ in order to supply the local district with heat and to reduce the gas consumption of a large combined heat and power (CHP) plant nearby. Additionally, to the demonstration plant in Austria the collector efficiency of several different collector types of different collector manufacturers is being tested under real outside conditions, which may give valuable insights on these collectors in order to choose the most efficient collector for the demonstration plant and ultimately on the future development of solar collectors.

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Keywords: District heating; large-scale solar thermal system, seasonal storage.

1. Introduction

Within the European Union cities are responsible for approximately 70% of the overall primary energy consumption. This share is expected to further increase up to 75% in 2030. Given the EU's ambitious 2020/30 reduction targets this issue represents an immense challenge for decarbonizing the EU energy system. More precisely, the development of low energy solutions for thermal energy supply to cities is one of the main needs nowadays. However, the recovery of waste heat of industries in and near cities offers a huge potential. It is evident, that industries throw away a large amount of energy.

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The European funded cooperative research and demonstration project PITAGORAS focuses on efficient integration of city districts with industrial parks through smart thermal grids. Technologies and concepts for low and medium temperature waste heat recovery, including the consideration of integrating renewable energy sources (RES) such as solar thermal energy for sustainable urban planning of low energy city districts are main concepts in this project. The project already started in November 2013 and will be finished in October 2017. As part of the project two demonstration plants namely in Brescia, Italy and Kremsmünster, Austria are being designed and will be built and tested during the project. In Brescia waste heat will recovered from an electric arc furnace and from a steel factory, which will be fed into the city's district heating (DH) network. The demonstration plant in Austria focuses on installing a large-scale solar thermal system including seasonal storages in order to supply the local district with heat and to reduce the gas consumption of a large CHP plant nearby. Additionally, to the demonstration plant in Austria the collector efficiency of several different collector types of different collector manufacturers is being tested under real outside conditions, which may give valuable insights on these collectors in order to choose the most efficient collector for the demonstration plant and ultimately on the future development of solar collectors.

Nomenclature

PITAGORAS Sustainable urban **P**lanning with **I**nnovative and low energy **T**hermal **A**nd power **G**eneration fr**O**m **R**esidual **A**nd renewable **S**ources

2. Pilot demonstration plant in Kremsmünster, Austria

2.1. Concept of the pilot demonstration plant

Kremsmünster is located in the northern part of Austria in the federal state Upper Austria approximately 30 km southwest from its capital Linz. The DH net in Kremsmünster is 30 years old and covers 65% of the overall heat demand of the municipality, which is approximately 20 GWh per year. Almost 75% of the energy demand for DH in Kremsmünster is supplied by a gas-fired CHP plant. Additionally, a gas boiler supplies 17.5% for the DH demand, mainly for peak load management in the winter season. The remaining 7.5% are supplied by a biomass heating plant and by waste heat from a glass manufacturer.

The gas boiler and the CHP plant are owned by the Austrian company Rohöl-Aufsuchungs AG (RAG). The CHP operates with three 800 MW gas turbines. The thermal capacity of the CHP plant amounts 6 MW. The vast majority of the produced electricity of the CHP plant is used for their own electricity demand, which estimates approximately 14.3 GWh/y. As already mentioned above, the produced heat of the CHP is mainly fed into the local DH network and to other heat consumers. The left side of Figure 1 gives an overview of the location of RAGs gas boiler, CHP plant and their oil storage tanks.

RAGs core business includes among the other things, the exploration, development and storage of oil and gas. Through the use of company-owned storage facilities, RAG does not only ensure the supply of petroleum products within Austria, but also plays an important role for the security of supply in Central Europe. Other activities include storing oil, trading and transporting gas, as well as realizing projects in the renewable energy sector.

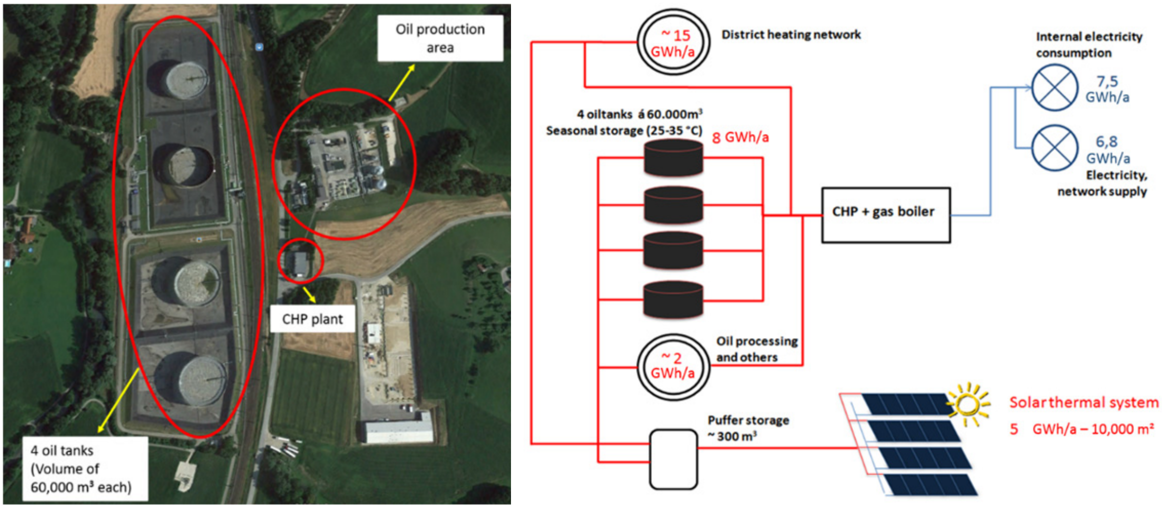

Fig. 1. RAGs CHP plant and oil storage tanks, description of the demonstration plant.

The demonstration plant in Kremsmünster focuses on installing a large-scale solar thermal system of 10,000 m² including a seasonal storage next to RAGs CHP plant. The thermal capacity of the solar thermal system will have a capacity of approximately 5 MW, which enables gas savings of roughly 1 Mio m³ year. The seasonal storage system will enable an energy efficient operation of the different heat suppliers and heat consumers. In an earlier stage of the project, it was planned to rebuild one of the 4 tanks, fill it with water and to use it as seasonal storage tank. However, according to RAG they are obliged to use the fourth tank as a security storage due to new regulations. Therefore, it was necessary to think about other possibilities to store the energy produced by the solar thermal plant for at least several months. Currently, the oil tanks are kept at a temperature level of approximately 25°C throughout the year. The stored oil requires a minimum temperature of 20°C and can be heated up to a maximum of approximately 30°C. The new concept foresees to feed in one part of the generated solar energy into the tanks and to increase the temperature of the oil to a maximum of 30°C during the summer in order to reduce the demand of gas for heating in the winter months (right side of Figure 1). With this concept, the oil tanks are used as seasonal low-temperature storage. Moreover, the oil production station should be supplied by solar heat. In the oil production station, the oil-water mixture, which is extracted from the ground, has to be heated up to approximately 60°C in order to separate the water from the oil and ultimately is not entering in suspension. In addition to the above mentioned heat sinks solar energy will also be used in the summer months to feed the local DH network of Kremsmünster.

As a next step a calculation of the energy yield was performed by S.O.L.I.D. based on a variety of parameters (i.e. irradiation data for Kremsmünster, angle of the collectors, azimuth angle, collector mean temperature, distance between collector rows, estimated losses in the solar circuit and in the distribution system). Furthermore, SOLITES did a preliminary dynamic simulation, which is illustrated in Figure 2. However, it has to be noted that this is a simulation of the first concept, which is still subject to some uncertainties (e.g. temperatures of the process side, pipe lengths, final selection of the collector type) and will be repeated after a full-detailed integration concept in the next steps of the project.

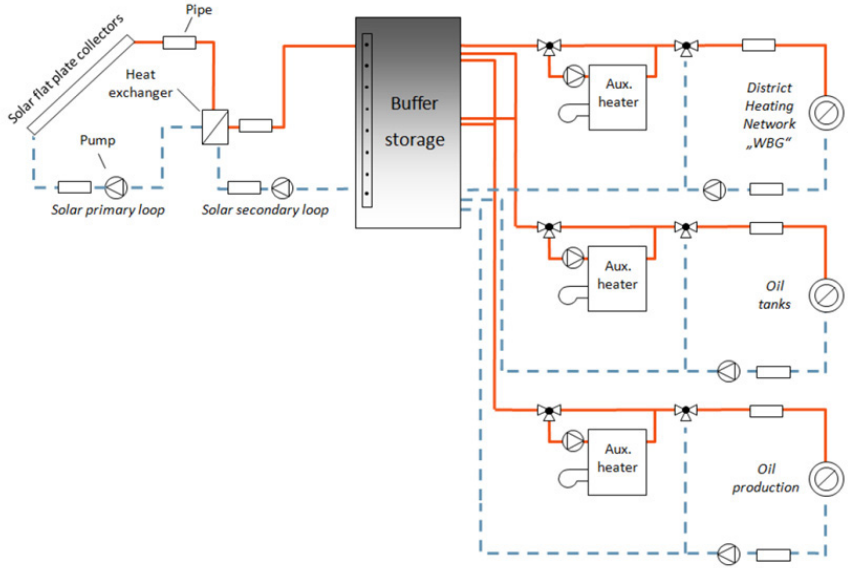

Fig. 2. Hydraulic scheme of the demonstration plant (Source: SOLITES).

Figure 3 displays the energy balance of one year of operation of the entire system with the integration of all four oil tanks for seasonal storing the solar thermal energy, which was simulated by TRNSYS. With an oil tank temperature between 20 – 30°C the solar net energy gain is 449 kWh/m² per year. Including heat losses, the overall heat production of the system equals to 4,210 MWh. 52% of the overall produced heat is used to heat up the oil tanks. 651 MWh, which equals to 33% are used for the oil production station and roughly 1% are directly fed into the DH network.

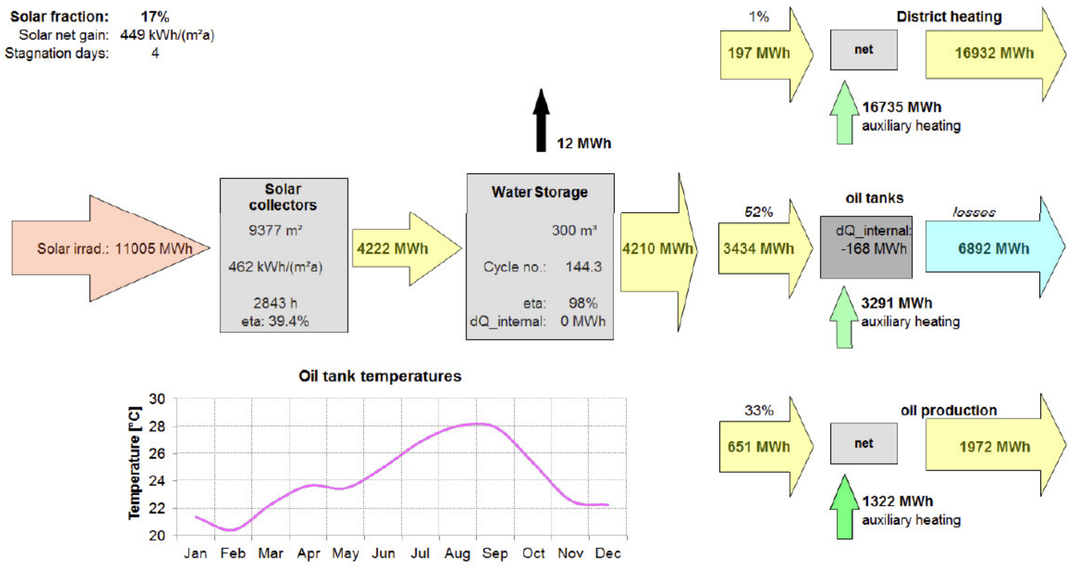

Fig. 3. Simulation output (Source: SOLITES).

2.2. Collector efficiency tests

Additionally, in order to achieve a higher solar net gain, it is also important to use the most efficient high temperature solar collectors. A test field in the city of Graz with a collector field of 2,480 m² gives valuable insights regarding the energy efficiency of different collectors under real outside conditions. Six different collector types from four different collector manufacturers are being tested under the same conditions. The tests are running since summer 2014. Based on these tests and on the generated data, the best suited collector will then be chosen for the demonstration plant Kremsmünster in order to further improve the efficiency of the system. However, since these tests are part of another research project, which is still running, communicating specific data to the general public will be provided at a later stage of the project.

2.3. Impact of the demonstration plant

Although the PITAGORAS project is still running until October 2017, first estimations of the impact of the demonstration plant in Kremsmünster are highly promising. Energy savings of fossil fuels are estimated to be approximately 5 GWh per year. On an environmental point of view, this means a reduction of CO_2 emissions of roughly 1,500 tons per year. Furthermore, due to the solar thermal system the CHP plant will be used more efficiently, which leads to economic savings. Regarding the DH net in Kremsmünster, the peak loads will be covered and the share of renewable energy sources (RES) within the net is increasing to approximately 25%. However, specific results and representative data will be presented at a later stage of the project.

Nevertheless, it already can be said, that the demonstration plant in Kremsmünster is a high replicable system with a certain multiplication factor for other cities and municipalities, which goes in line with one of the main objectives of the PITAGORAS project.

2.4. Next steps in Kremsmünster within the PITAGORAS project

Currently there are final negotiations about the heat delivery contract before starting the construction of the demonstration plant in Kremsmünster. Simultaneously the detailed planning is going on until the end of 2015. The construction and implementation of the solar thermal system will be completed until October 2016. Furthermore, the monitoring and the optimization of the system will take place in 2017.