# Solar district heating is able of taking the full summer load in cities!

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**Abstract**

Solar District Heating has been used in combination with biomass to cover the summer heat demand, in new quarters to support heating and hot water with long term storage and in cities to replace a small portion of summer load coming from fossil fuels. This presentation will demonstrate that even in big cities- like Graz- the summer load can be completely switched from fossil fuels to waste heat and solar heat.

This can be achieved by decentral use of area for placing the panels, integrating the existing volume of district heating and existing tanks as a storage to balance solar gains and demand.

Moreover, through placing storage tanks at relevant customers the peak load management in winter can be supported with the same tank that is helping solar in summer to balance the energy flow. So additional customers can be supplied with the same distribution pipes used more efficiently.

Technical and economical feasibility is proven; reduction of burning gas is a goal in most political programs. Still there is significant hesitation in district heating companies.

## 1. Introduction

The original intention in solar district heating in Austria was to support biomass district heating in summer operation. As biomass boilers even in low load operation need maintenance, have wear and tear and usually have relatively low efficiency in summer, the operators were looking for alternative solutions. The first solar supported district heating systems had storage tanks to allow a 24 hour solar supply and solar panels mounted on the roof of the heating plant.

These installations are typically sized between 200 kW and 1 $MW_{th}$ (300 m²-1400 m²), and more than 50 of them are operating today all over Austria but as well in Germany, Denmark and Sweden.

In cities solar district heating was used but actually covering only a tiny potion of the total heat demand, so the installation on the UPC arena (former Arnold Schwarzenegger Stadium) with 1 MW nominal power delivers less than 0.1 % of the cities annual heat demand. However, compared to the summer load peak power was it taking care of 5 % and solar produced app. 1 % of the monthly summer heat needs.

By expanding the solar projects with a plant close to the heating plant with a nominal power of currently 3.5 MW (finally 5 MW) and one in the north if Graz (Waterworks, 2.7 MW) the annual contribution is multiplied by 7 but still marginal for the city's energy balance.

In a close cooperation with the utility Energie Graz a plan for expanding the solar plants was developed, a joint venture was formed to realize this potential. Finally, after a short time political influence stopped the collaboration.

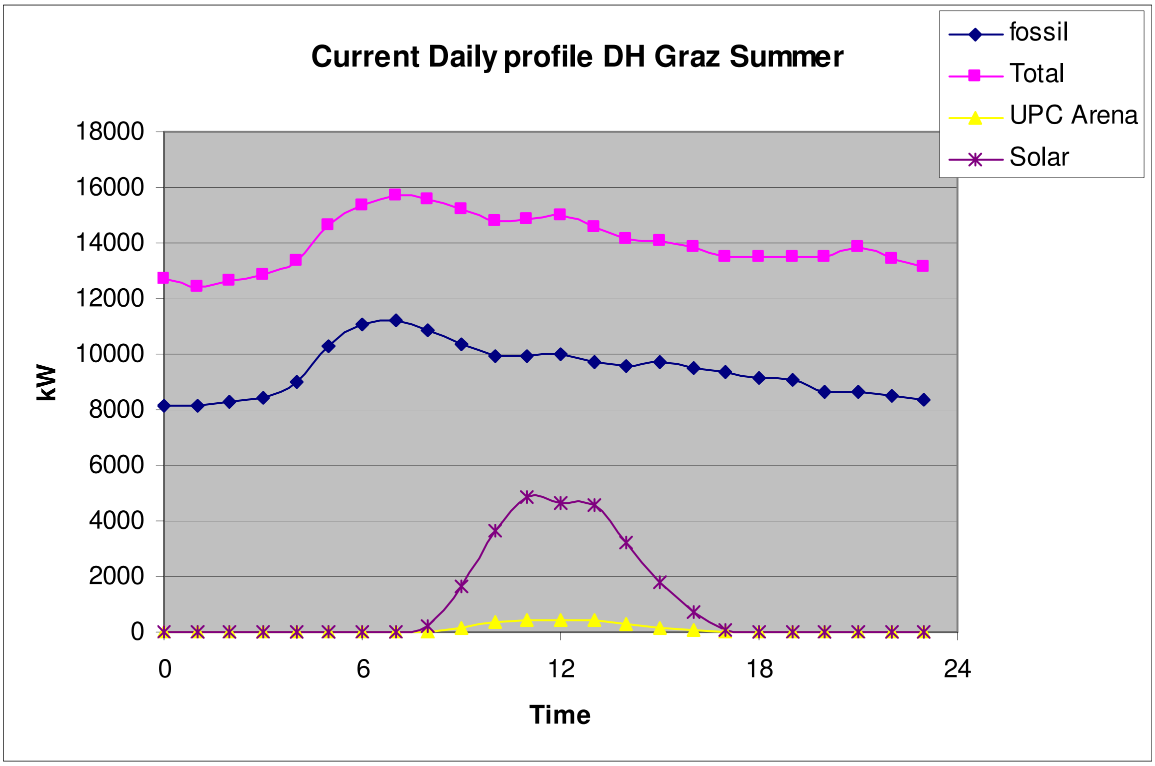
## 2. District Heating Graz

District Heating in Graz is run by Energie Graz, a company partly city owned and partly owned by the Styrian utility. Energie Graz is getting heat out of the following sources:

- Coal fired cogeneration in Mellach, 20 km south of Graz, 230 MW, operational only in winter time
- Oil fired cogeneration plant in Werndorf, next to Mellach, 230 MW, operational only in Winter time
- Gas fired heating plant in Graz, 250 MW, used to cover peaks in winter and supply in the shoulder seasons. Several smaller gas boilers assist for summer operation
- Gas fired cogeneration plant 30 MW in the south of Graz, providing process heat to automotive industry,
- Industrial waste heat Marienhütte (steel company) with 5 to 7 MW peak power
- Solar plants UPC Areana (1 MW), Puchstraße (3.5 MW) and Andritz (2,7 MW)

Winter peak load in the past was 382 MW, typical summer load is app. 15 MW. As the district heating net was started in 1960, many substations and customers systems are designed for relatively high temperatures, return temperature is between 50° and 60° while supply is between 75° (summer) and 120° (winter).

The volume of the district heating net is app. 15.000 m³ and has 270 km network.




Pic. 1: Current summer supply of district heating in Graz

## 3. Solar concept and energy balance

To provide the summer load of average 15 MW over 24 hours, a total energy supply of 360 MWh is needed. As industrial waste heat is covering roughly 40-50%, solar can produce 180 to 200 MWh per day. Based on an good summer performance of 2,2 kWh/m², this allows installation of 56 MW (80.000 m²) without interfering with waste heat.

### 3.1 Place for solar panels

80.000 m² seems to be a lot of space needed to put panels on, and we checked if this area is available. Today's already existing plants have a total area of 10.500m² feeding into district heating and additional 4.000m² supplying energy to subnets of the district heating.

Immediately after launching the concept internally, further roofs and ground areas suited for 15.000m² were offered, so this would already qualify for more than 35% of the needed surface (see pic. 2).

Today still new possible areas are frequently offered to us. Seeing the roof cadastre that has been elaborated by the city of Graz, it is quite easy to find the suited space. The individual analyses is rather challenging taking in account different static consideration and construction, future plans on individual buildings, and developing the suited commercial structure.

### 3.2 Load Management

As only 1/3 of the produced solar energy is used during daytime, 120 MWh need to be stored either in customers tanks or in the district heating net. Using 7.500 m³ supply pipes and overheating them during daytime by 14 K will allow to store that much heat in the pipes. In addition, there is a 2.000m³ tank already available at the heating plant, so including this tank will lower the overheating to ca. 10 K.

This will lead to changes in the mass flow in the district heating as well as slightly increased net losses. Through the reduced mass flow less electricity for the pumps will be necessary.

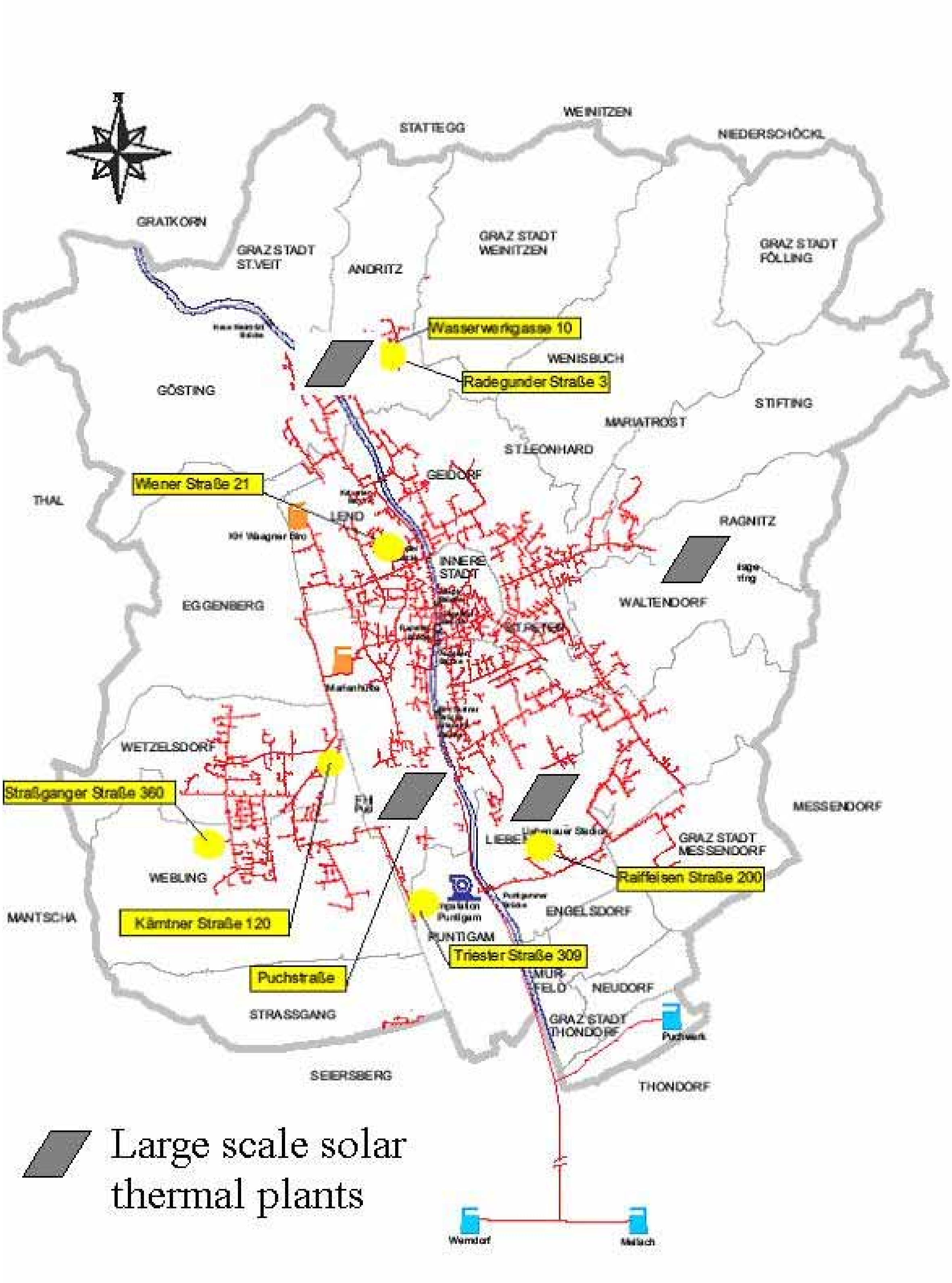
## 4 Commercial models

Currently there are two models under discussion. While the first plants were build under the framework of a feed in contract, today a model similar to electricity with supplying green energy to customers is developed. Alternatively, the utility could invest on itself.

Feed-in tariffs on heating are subject of negotiation between the solar operator and the district heating company. As the district heating company has a rather strong position- take the offer or leave it-, the overall rates for solar heat (including energy price and energy related taxes) of todays plants are 20-25% lower than the price paid for "conventional" heat. Nevertheless it was possible with funding to develop economic feasible concepts where the investment will pay for itself after 15-20 years.

Today more and more customers wish to get $CO_2$ free heat and ask for direct purchasing of solar heat. The commercial model actually has been developed with electricity and gas separating the energy costs into a energy price and a fee for using the distribution net. This model is encouraging investments, and allows the customer to select according to his wishes.

Both models with an equivalent compensation to fossil energy costs allow implementation of significant solar plants with todays funding of app. 30- 40% investment costs.




Pic. 2: The map shows existing sites (squares) and potential sites (Circuit) for solar plants in Graz

Investment by the utility would be easy but there own economic evaluation usually is not designed favorable for high upfront costs with low maintenance later on. So their tools end up in showing losses; we have seen this with several utilities.

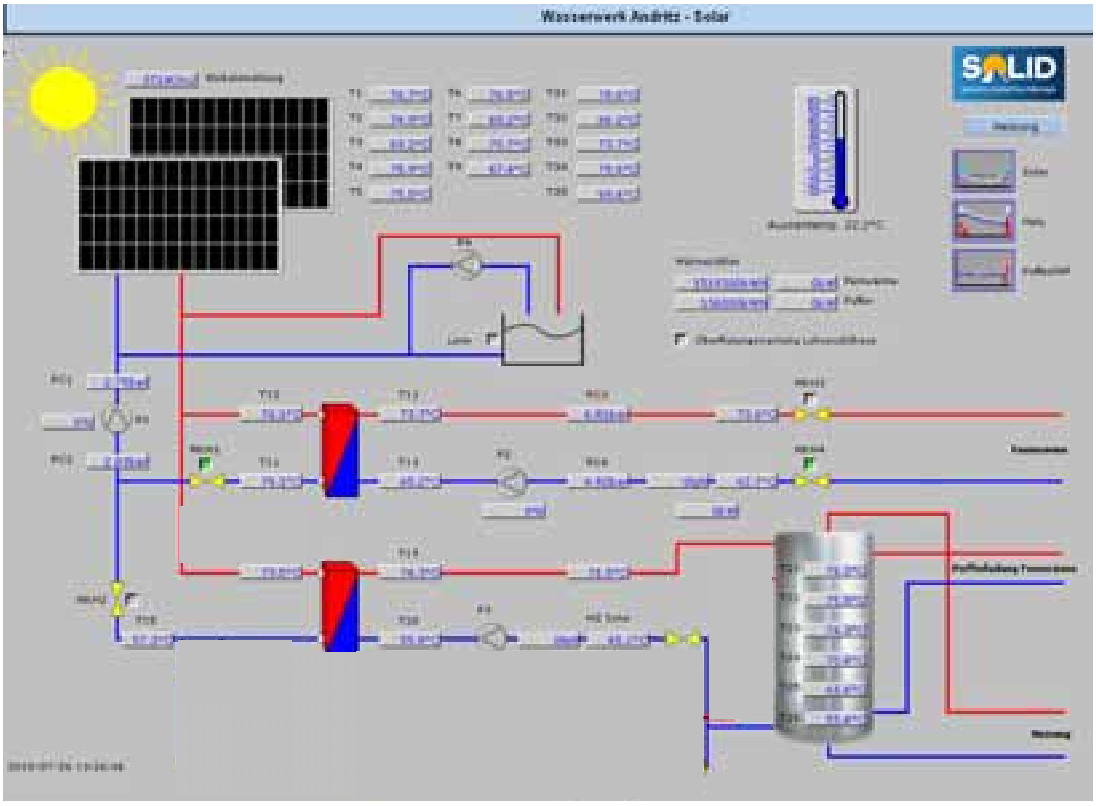
### 4.1 How to get the roofs?

Building owners offering there roofs want to get a good reputation on the one hand but financial benefits as well. The proven model gives a certain amount of solar energy on discounted rates from the solar operator to the building owner. Alternatively, some owners charge a rent for the roof or the ground.

Combing heat supply to the building with a storage tank will create additional benefit by reducing the winter peak heating load.

Solar collectors need to be developed special both for providing temperatures of 80 to 100°C and to be suited for large scale installations. The results of the last years have proven satisfying performance with a flat plate collector with double glazing.

The hydraulic system usually includes a preferred supply to the local loads having lower return/supply temperatures than the district heating. This includes the storage tank. Only when the local energy demand is satisfied, the surplus is sent to the district heating ("Fernwärme", shown in picture 3).




Pic. 3: hydraulic scheme of solar plant Wasserwerk Andritz