SDHplus
Solar District Heating in Europe

WP3 – Case study for changeover to SDH

500.000 sqm of collector area for 20 % solar fraction in large city network of Graz

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1. INTRODUCTION

1.1. INITIAL SITUATION

The district heating network of Graz delivers 1,050 GWh of heat per year to around 54,000 households. 80% of energy supplies are based on three major fossil generation plants operated by Verbund/ATP in Werndorf Mellach. Due to major price declines within the power trading sector, the operator Verbund can no longer operate the oil and gas generation plants from an economic point of view. Additionally, the coal-fired power plant has reached its life of installation. Therefore, Verbund announced the generation plant´s final close-down by 2020 in a press release on May 14, 2014.

The city of Graz is currently looking for new options to secure the district heating´s energy supply from 2020 onwards. Objectives are to guarantee affordable, long term and independent energy supply solutions based at least partly on renewable energies. Still, current plans for future energy generation and delivery mainly focus on fossil based energy supply.

With over 15.000 sqm of solar district heating, Graz is already now a pioneer for solar thermal in large city district heating.

1.2. DESCRIPTION CITY OF GRAZ

Graz is Austria's second largest city. As of 1.1.2012 the number of inhabitants is 266.965 (main residence), corresponding to a population density of 2,058 ih/km². Together with surrounding communities, the number of inhabitants in the Graz region amounts to 405,000.

Long-term trends show a continuous growth of population in the city of Graz and communities in the urban hinterland: current predictions foresee an increase in population to approximately 490,000 by 2050 (districts of Graz and Graz surroundings).

The forecast of dynamic population and economic growth represents a special challenge for the development of the City of Graz.

Any expansion of the existing settlement area (building land) will only be pursued to a limited extent in line with the goals of reducing building and infrastructure land use and this area can only have a nominal role in providing land for future residential and industrial plot requirements.

1.3. ENERGY DEMAND AND SUPPLY OF GRAZ

The energy used for heating and hot water in the residential and service buildings of Graz was about 2,100 GWh in 2009 (this figure represents a portion of the total energy requirement for Graz). The main energy carriers for this are district heating (33 %), oil (25 %), electrical energy (some 20 %) and gas (some 15 %). Renewable energy carriers (biomass and other alternative energy carriers) have a share of slightly below 5 %. The remaining 2 % are covered by coal.

2. DISTRICT HEATING (DH) NETWORK

The development of the DH network in Graz started in the year 1963 with the initial operation of the district heating power station (steam generator with connected turbines). In the year 1998 the utility (Stadtwerke Graz) in Graz sold appr. 680 GWh/a.

Through a steady extension of the grid the utility (Energie Graz GmbH, former Stadtwerke Graz) could further raise the heat supply by district heating.

Red areas in Figure 1 show the stage of extension (by now) of the district heating grid in Graz. Deep red areas mark the current DH net while slight red areas show planned extensions until 2020. Yellow areas show the gas supply network of the city of Graz.

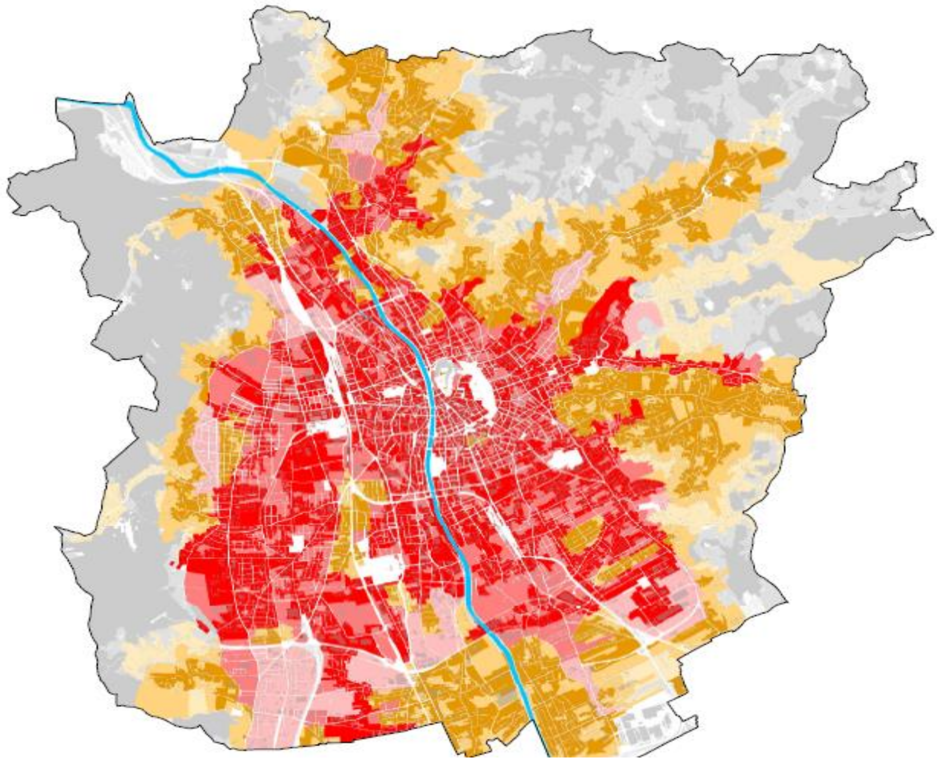

Figure 1: District heating network of Graz (in red, source: Holding Graz)

2.1. HEAT SOURCES

The total heat delivery of the district heating grid of Graz is about 1.050 GWh/year . Approximately 77% of the capacity is delivered by a CHP (CCGT MELLACH) with a capacity of 246 MW, 15 km outside of Graz, and is transported via a main pipe into the city. Another significant heat resource is waste heat from the steel plantcalled “Marienhütte” (MH) and another CHP (“CMST”) near a big automotive component supplier. The solar thermal fraction is about 0.5%, and was extended in 2014 by another 1,4 MW.

In 2011 a new gas fired CHP plant started operation in Mellach. In 2014, this plant was put out of operation due to low electricity prices.

For Graz, three different plants are generating energy for heating as well as to meet power demands. The plants rely on two different primary energy sources (natural gas, coal).

The three main plants in and around Graz, providing energy for the district heating grid are:

- The district heating power station Mellach (using coal) with a maximum thermal output of 230 MW.

• The district heating power station Graz (based on natural gas) with a maximum thermal output of 250 MW.

• The district heating power station CMST in Thondorf with a maximum thermal output of 30 MW.

Figure 2 shows the load profile of the different plants for generating heat for the district heating network, without consideration of the waste heat from the steel mill “Marienhütte” and the solar thermal plants “Stadion Liebenau” and “Waterworks Andritz”.

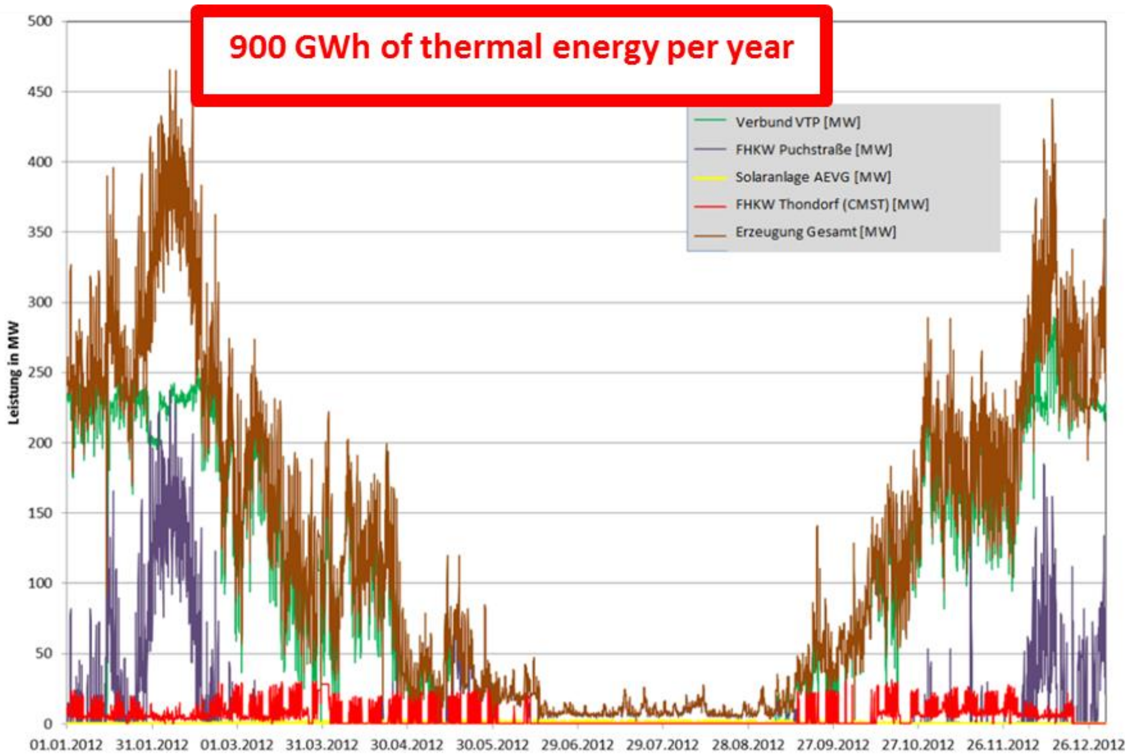

Figure 2: Load profile of heat sources of the district heating grid in Graz, 2012 without generation from Marienhütte, solar thermal plant Liebenau and solar thermal plan waterworks Andritz); source: Steirische Gas-Wärme

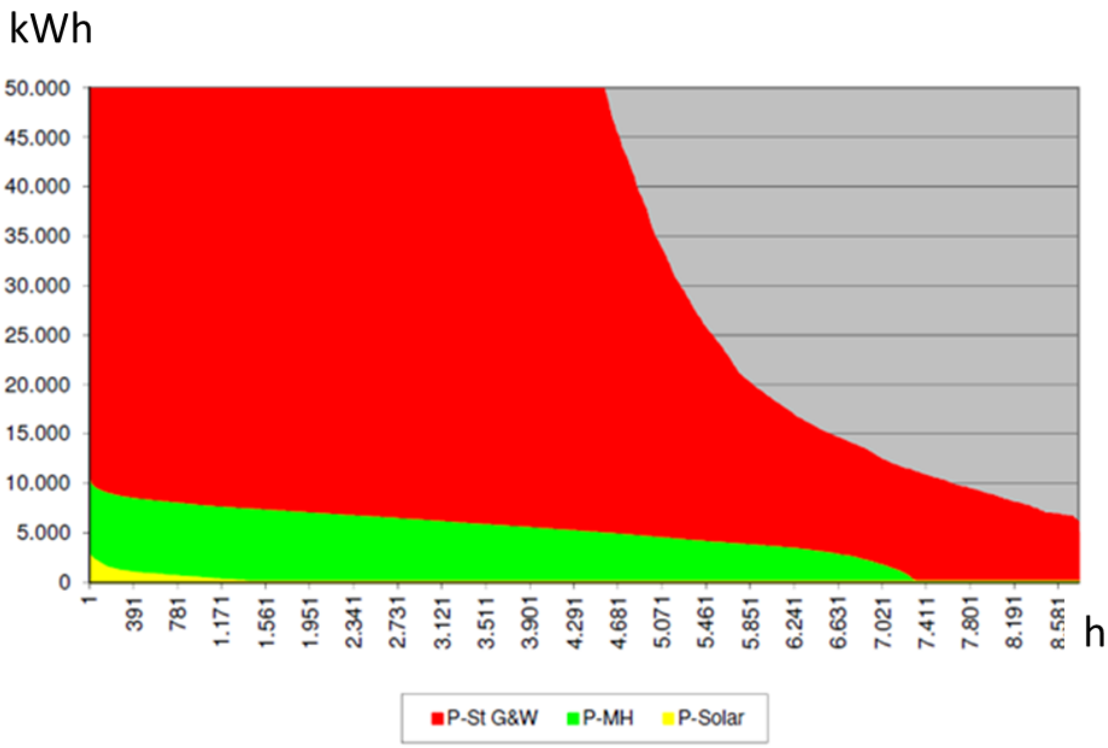

Figure 3: Heat generation in 2009 consisted of gas and coal (red), waste heat from "Marienhütte" (green) and solar thermal energy; source: Energie Graz

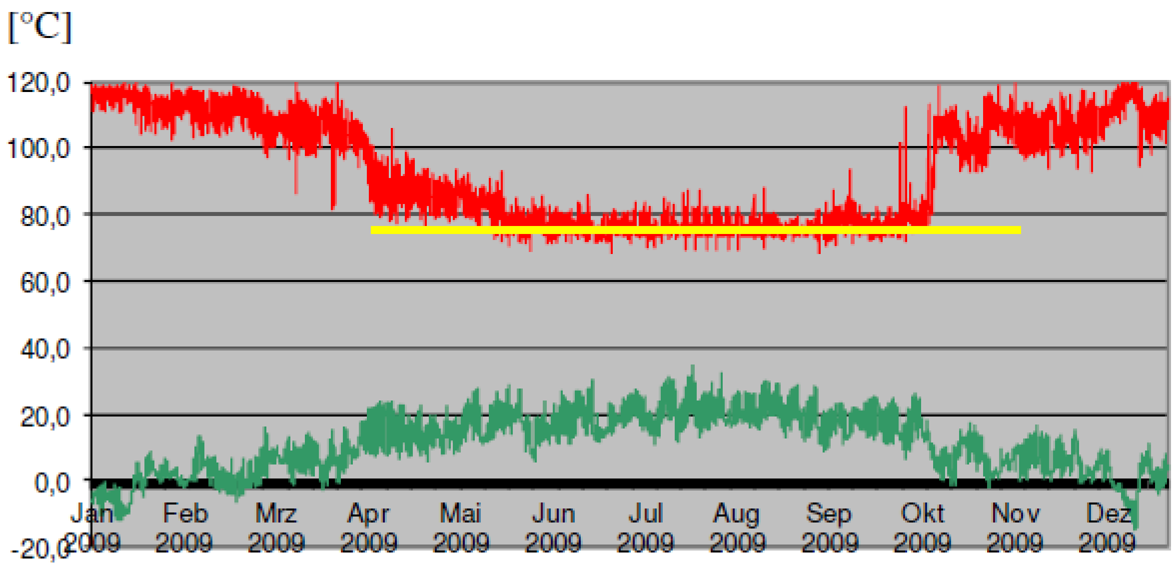

Figure 4: Temperature curve of flow temperature (red) according to ambient temperature at the district heating plant Puchstraße in 2009; source Energie Graz

2.1.1.1. *Solar district heating in Graz*

Currently three big solar thermal installations feed into the DH net of Graz, solar yield approx. 4,290 MWh/a, which were erected in 2002, 2008 and 2009 (see Figure 5).

WW Andritz	Fernheizwerk/AEVG	Stadion Liebenau
		
2009	2008	2002
3.855 m²	7.200 m²	1.407 m²
2.000 kW	3.600 kW	750 kW
1.600 MWh/a	3.000 MWh/a	590 MWh/a

Figure 5: large scale solar thermal installations feed the DH net of Graz

2.1.2. **Heat distribution to the customer**

Water is the basic heat transfer medium and carries energy in the insulated pipe network of Graz to the final customers. The district heating system is conducted below streets or in energy tunnels, consisting of feed and return lines. Water arrives at the single customer´s final station with a temperature of 120°C. For water to reach this temperature without evaporation, it must be under pressure. Supply temperatures at the CHP plant are around 120°C in winter and around 75°C in summer. In Graz, district heating systems are operating all-season. At customer level, the heat network is connected to the central heating of the dwellings by heat exchangers. The water used in the district heating system is not mixed with the water of the central heating system of the dwelling and flows back to the CHP plant with around 50°C.

At a maximum load of 423 MW 7,000 tons of water per hour are circulating within the system. District heating pipes in Graz have 25 mm - 600 mm diameter. Within these diameters, different types of main transport, side and house service connection network pipes are installed.

2.1.3. **Key Data**

The following data give a summarized overview about the district heating grid in Graz:

- Pipe length: 633km
- Water content: 15619m³
- Heat capacity: 900 GWh/year
- 568 MW connected power

2.2. AVAILABLE WASTE HEAT

2.2.1. Waste heat Recovery Marienhütte

The company Marienhütte Stahl- und Walzwerk GmbH is Austria´s single bar-shaped concrete steel producer. It runs a conventional 40 tons electric arc furnace, in which 400,000 tones crude steel based on scrap metal are melted per year.

Figure 6 shows the evolution of the waste heat usage of the company from the year 1993 to 2011. In the year 2001 the supply to the district heating system could have been extended through the integration of a cooling circle, and has been further extended in the year 2003 through a second cooling circle. In 2010 a buffer storage was built which further increased the heat supply. In 2011 the heat supply could be extended to 60 GWh per year through the redesign of a heat exchanger.

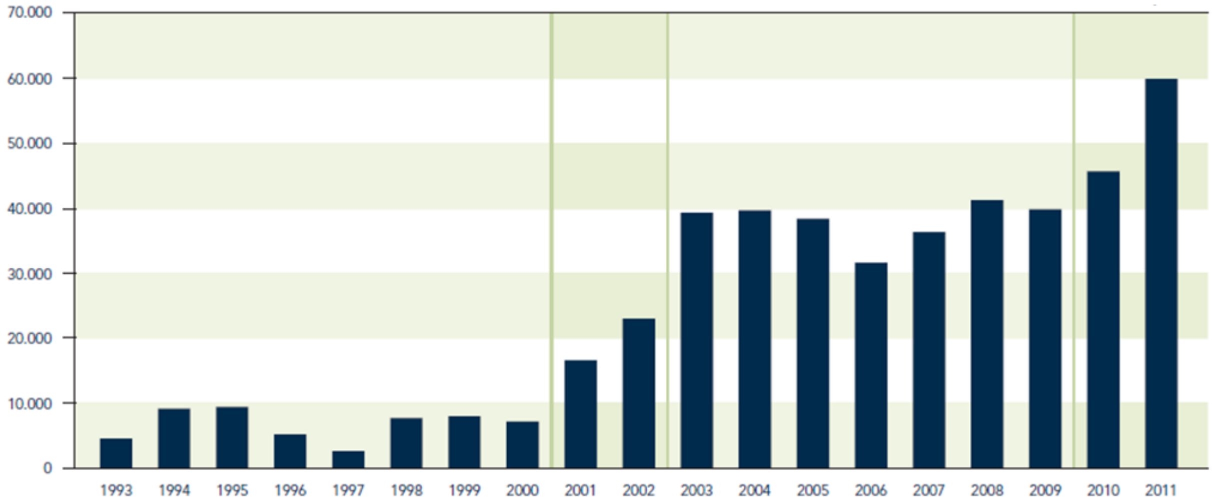

Figure 6: Waste heat recovery in MWh "Marienhütte" 1993 – 2011; source: Energie Graz

3. PLANT AND STORAGE CONCEPT DESCRIPTION

Several solar, biomass and construction companies built a consortium and have elaborated an alternative solution for the city of Graz´s district heating network energy demand: a large solar-biomass combination plant. The plant will cover at least 20% of Graz´s district heating demand based on renewable energy sources. The concept illustrates how 500,000 m² of solar thermal collectors could deliver 206,000 MWh of heat. Two thirds of the collector area could be mounted along the existing district heating pipeline Mellach-Graz, approx. 15 km long, and one third could be installed on areas within the city of Graz. Solar collector areas will be built on non-agricultural areas along the existing district heating pipeline. Collectors within the city of Graz will be mounted on large industry, on shopping malls and on infrastructure roof tops.

The solar district heating network will be supported by a 40 MW biomass plant for temperature rise in winter, and by three large scale seasonal storages which store heat surplus generated in summer times. The storages and the Mellach network combined will be able to cover peak capacities of up to 200 MW.

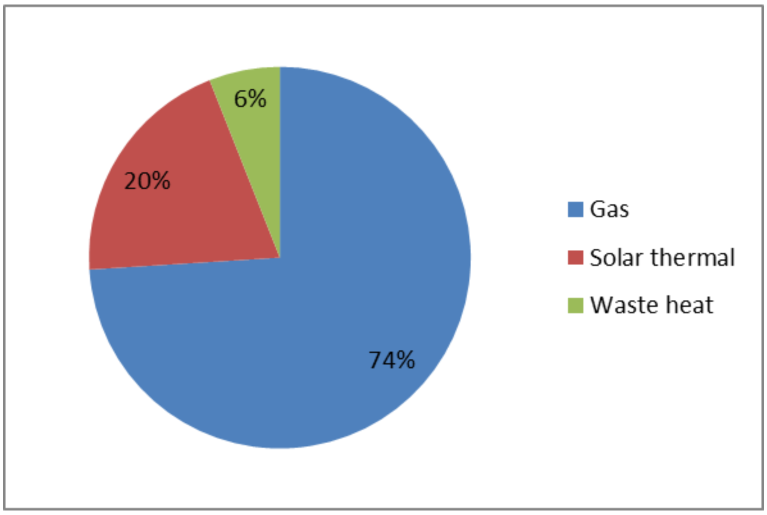

Figure 7: distribution of future energy supply for Graz district heating

3.1. ENERGY FLOWS

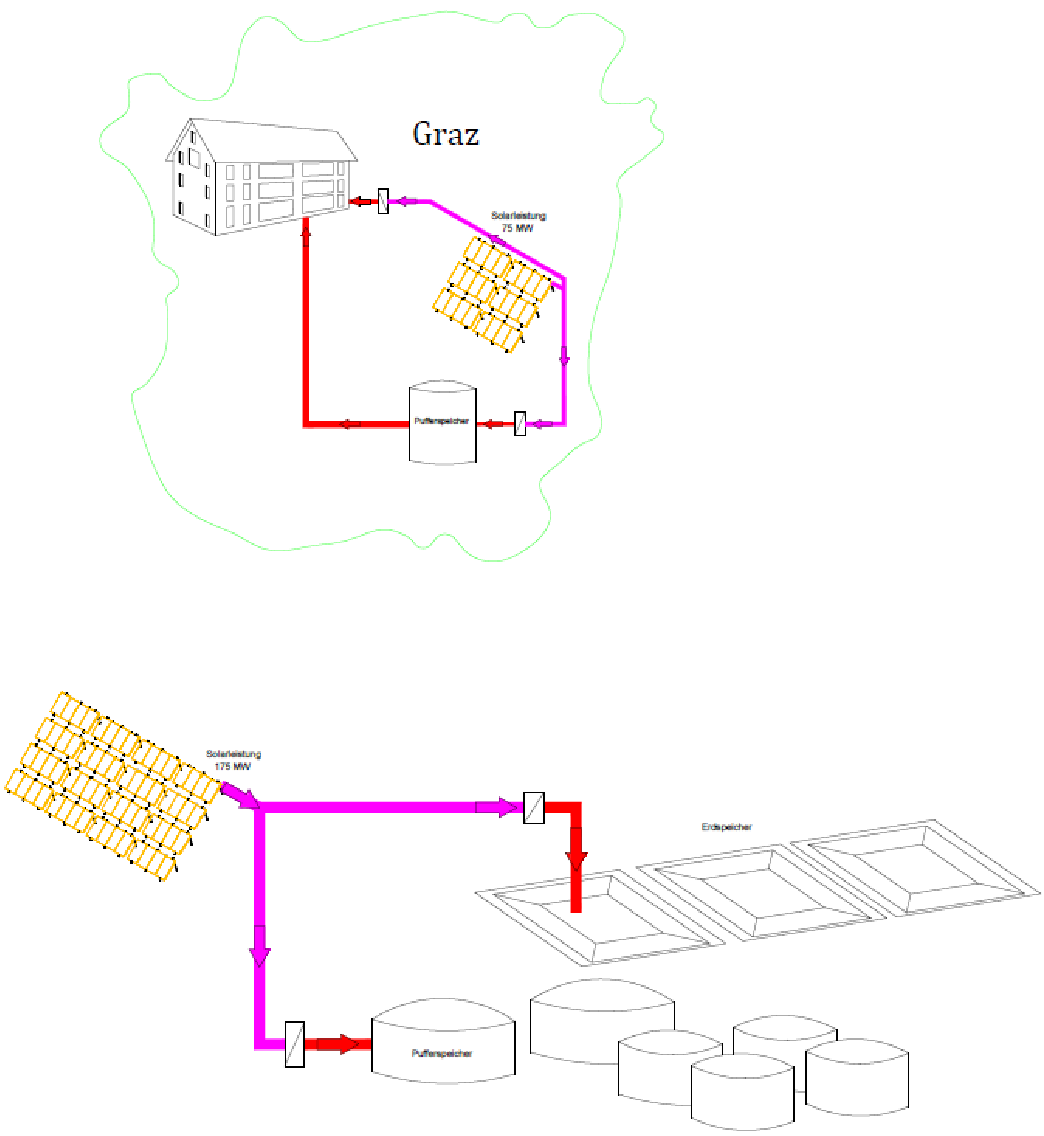

Figure 8: schematic energy flow in summer months

In summer months the heat pipeline between Graz and Mellach in the south is switched off due to the low heat demand in the city. In these months the city is supplied by the solar collectors of 150.000 sqm which are installed in the city area, in combination with a large buffer storage. The large collector arrays of 350.000 sqm in summer months only charge the large seasonal storages which are located in the south of Graz.

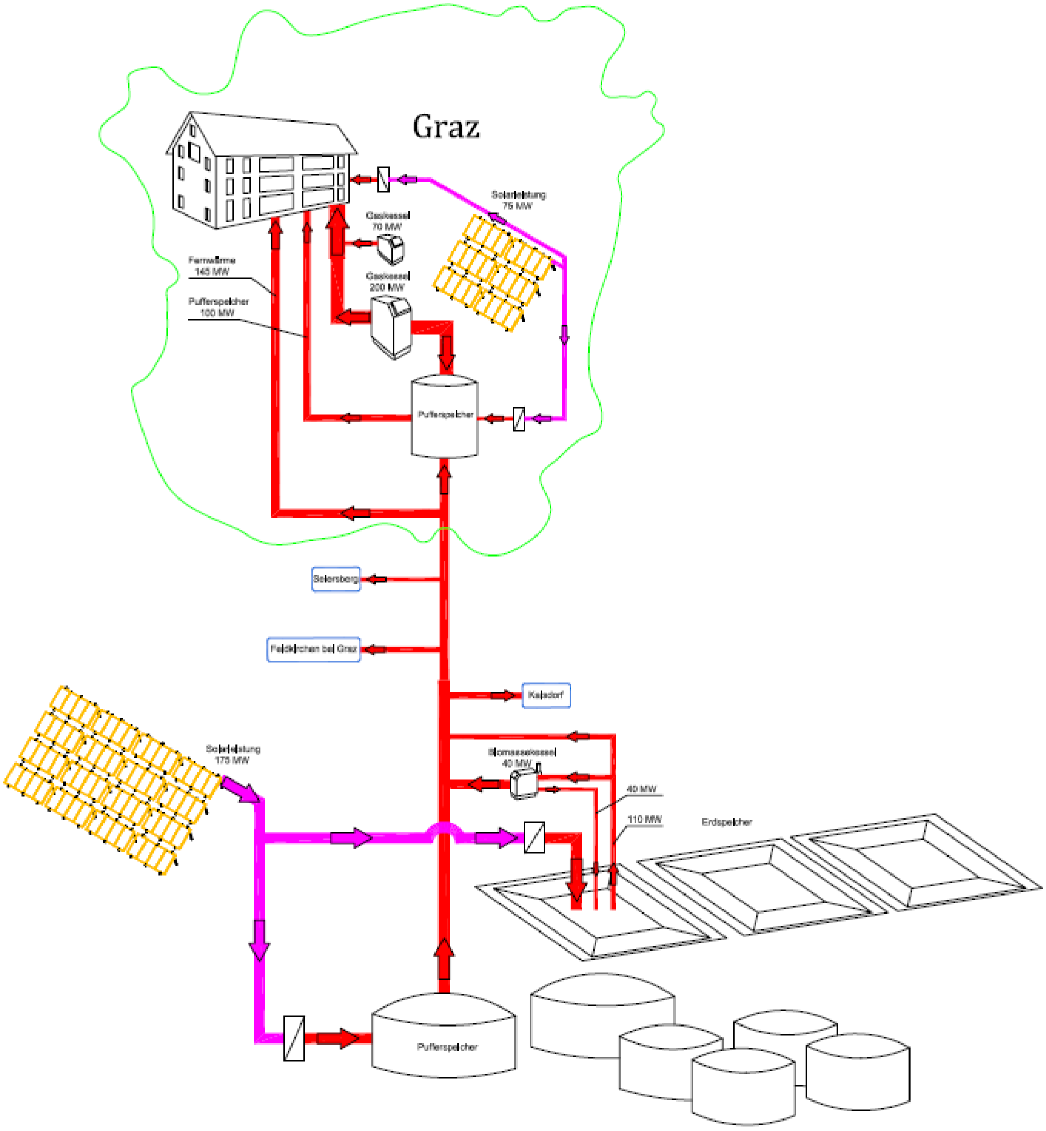

Figure 9: Schematic energy flow in winter months and heating period

In winter months the heat comes from all collector arrays and seasonal storages, boosted by a biomass boiler and a gas boiler. The biomass boiler of 40 MW heat capacity is installed in Mellach and boosts the temperature from the seasonal storages. The hotter parts of the seasonal storages are directly fed in. This heat goes via the large heat transport line of ca. 15 km to Graz and also supplies villages along the pipeline. In Graz the heat is partly supplied directly to customers and partly feeds a large buffer storage. This buffer storage is supported by the main gas boiler of 200 MW capacity in order to reach high flow temperatures beyond 100 C on cold winter days. The gas boiler also feeds directly into the grid, as well as a peak power gas boiler of 70 MW.

In addition, the buffer storage in the center of Graz can reduce the peaks of the gas boiler in the winter time. This is illustrated in figure 10 below, where one week in winter is illustrated.

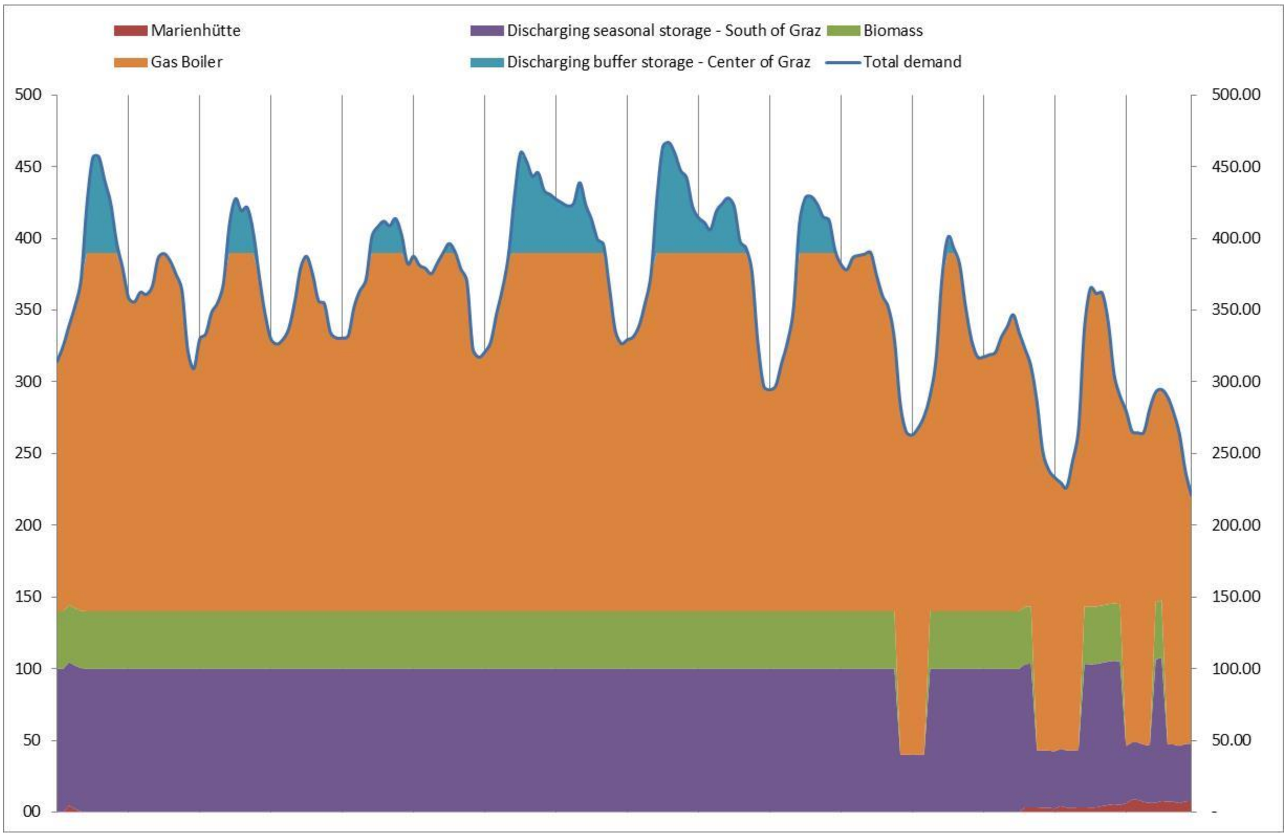

Figure 10: Peak time in winter for one week

3.2. ENERGY GAINS OF THE SYSTEM CONCEPT

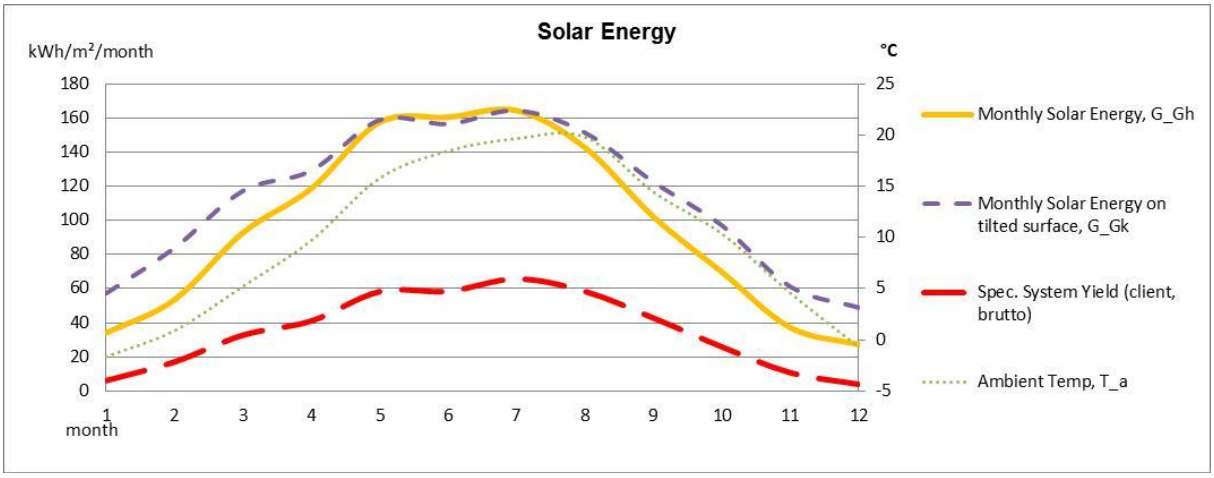

Figure 11: Solar radiation on 30° tilted solar panels (red line) over a period of one year for Graz, Austria

The solar radiation data has been collected from Meteonorm. These data have been the basis for calculating the specific system yield in a calculation tool, developed by SOLID.

SOLID expect that this system will deliver approx. 412 kWh/m², that means in total 206 GWh with 500,000 sqm. The collector field in the south of Graz will deliver approx. 173 GWh, the collectors in the city of Graz will deliver approx. 33 GWh.

In figure X below you can see the distribution of all energy sources which are used including the total amount of energy which is discharged from the storages.

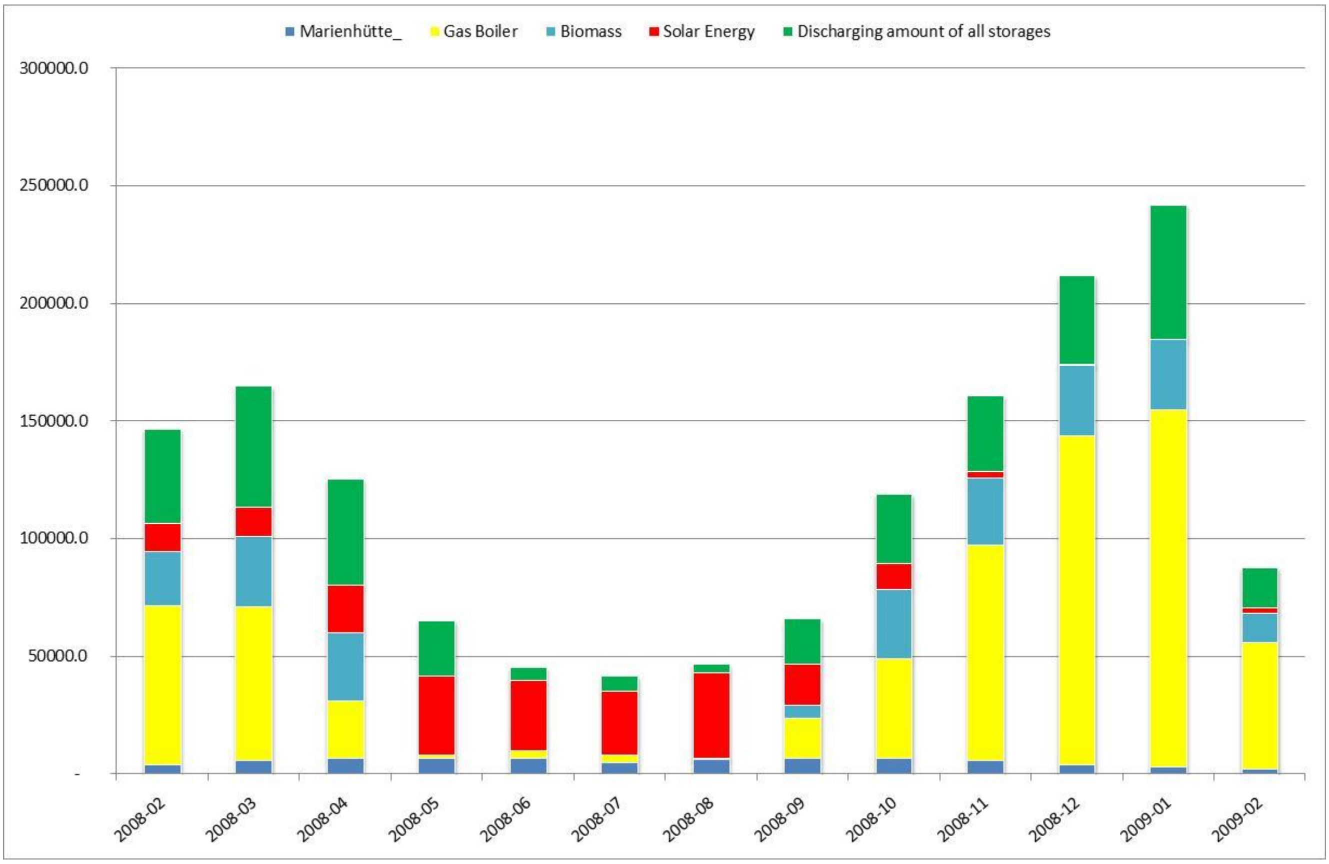

Figure 12: Distribution of energy sources over the whole year

<u>Summary:</u>

▪ Location:	Graz
▪ Inclination collectors:	30°
▪ Collector area:	500,000 m²
▪ Specific solar yield:	412 kWh/m²
▪ Total solar yield:	206 GWh/year

3.3. ECONOMICS

The total investment to realize the whole project would be 180 M Euro within a five year period. Access to non-agricultural and roof top areas within the city of Graz are currently under negotiations.

The price per MWh generated heat within the system are 41 Euro, which is far less than current prices based on natural gas.

Price per kilowatt is 12 Euro, where heat will be delivered at point of demand.

Especially domestic companies will benefit from value-adding processes, which consist of approx. 45% of collectors and mounting facilities, 35% of pipe work or and storage construction, 10% of biomass plants and 10% of project management and engineering processes.

3.4. FURTHER EFFICIENCY MEASURES

Parallel measures taken by the network provider will ensure a reduction of the district network´s temperatures over the next 15 years.