Utilization of geothermal heat from thermal water in Straubing, Germany

Werner Jähn

Stadtwerke Straubing, Sedanstraße 10, D - 94315 Straubing, Germany

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Abstract In the city of Straubing geothermal heat will be obtained out of the Southern Germany **Malm** stone karst (about **800m).** Warm water **(36°C) from** one thermal well with a high capacity **(50** *Us* **= 180 m³/h)** is available. The thermal water will be cooled down **(13°C)** and reinjected by a pressure system to the same aquifer where it has been extracted from. The geothermal heat will be used for heating the thermal spa, the new city hall and the future big library as well as other public buildings. Moreover the geothermal heat will be integrated to the existing close-range heating-network. In addition, part of the thermal water is used for bathing. This facility can be used economically due to this double usage.

1. THE CITY OF STRAUBING

1.2 Location

Straubing has **43.000** inhabitants and is located in Bavaria along the Danube between Regensburg and Passau (Figure 1).

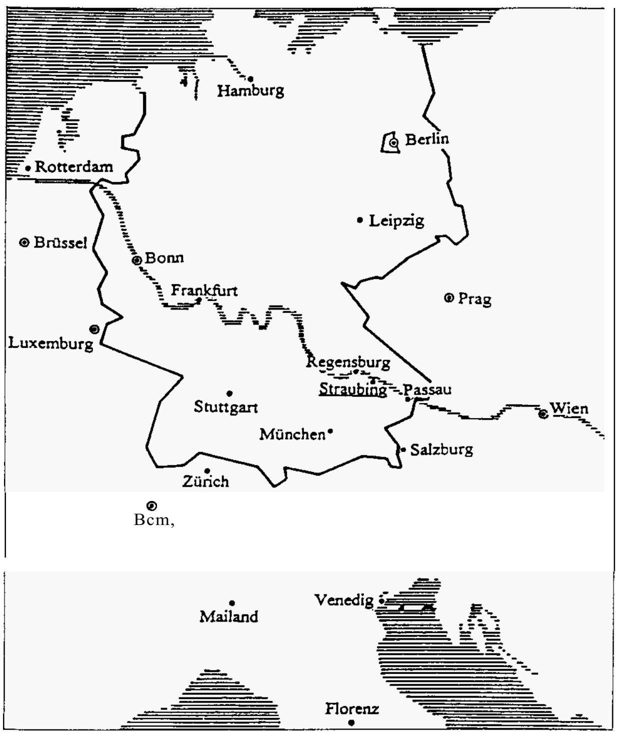

Figure 1: Location of the City of Straubing in Bavaria

Straubing is located in the middle of a fertile agricultural area. The first documented mention of the city was in the year 898 AD and its history was shaped by the rich farmers who lived there.

Over the past decades industrialization has increased. Staubing has expanded into a large city and has been classified as a major center by the district planners.

As far as geology is concerned, Straubing is located on the eastern border of the southern *German* molasse basin. The proximity to the Danube rim fault (Donaurandbruch) offers favorable conditions for tapping thermal water from the Malm aquifer (ca. 800 - 1000 m deep), which consists of karstic lime and dolomite layers. This thermal water is known to have therapeutic qualities and is ca. 35" - 50°C, depending on the depth. (Figure 2)

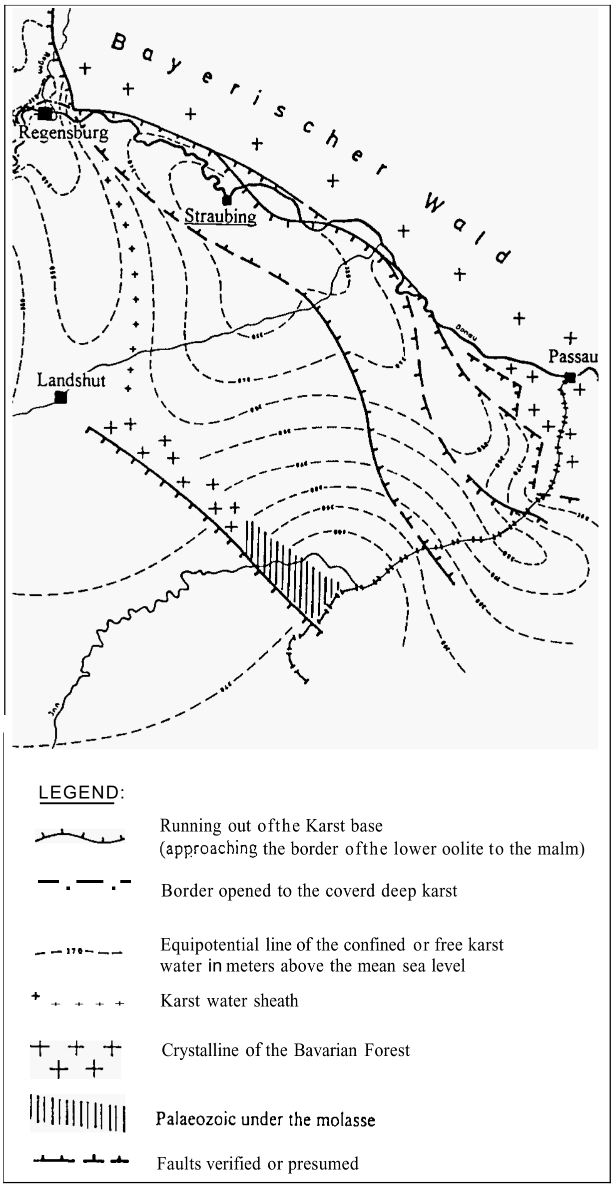

Figure 2: Equipotential lines of the confined or free karst water

1.2 Straubing is Environmentally Aware

The citizens of Straubing have always been progressive and aware of the environment. Already in **1901** there was a power heat association between the municipal power works and the municipal slaughter house nearby. The waste heat that arose from the production of electricity was pumped into the slaughter house for their use.

Starting in **1926** there were two hydroelectric power plants that provided electrical power without damaging the environment. Since the **1970s** many heat pumps have been in operation and at the beginning of the **1980s**, several block heat power plants were constructed in order to produce energy in a more rational way with less damage to the environment. By means of heat pumps in the waterworks, warmth is extracted from the drinking water and used for heating purposes.
The citizens in Straubing have been making use of solar energy by means of collectors and photovoltaic for many years.

Now, since **1990** geothermal energy has been **gaining** significance in Straubing.

2. UTILIZATION OF GEOTHERMAL HEAT

2.1 Foundation

In the year **1910** in the process of digging for brown coal in Straubing, workers hit hot water at a depth of 800 m and were disappointed. The water gushed up as high as the houses in a stream as thick as a man's arm. The drill hole was quickly closed up again. Luckily all of the records from this time were saved and can be referred to today. Thus it was confirmed that also in Straubing there was a sufficient reservoir of warm to hot thermal water in the **Malm** stone karst of the southern German molasse basin. In addition it was proven in analysis that not only thermal water was to be found in this area, but also mineral water, which is being used in the same quality in therapeutic baths for balneological purposes in Bad Birnbach, for example, and in other spas. In Straubmg experts were called in to consider whether this thermal and mineral water might be used in combination for bathing and heating. Calculations were made and show that a facility of this kind would be economical to operate in the long run.

2.2 Search for Geothermal Heat

The city of Straubing instructed the Municipal Works in **1989** to start up deep drilling to tap the thermal and mineral water in sufficient amounts so that a geothermal heat project could be started. This deep drilling at a cost of USD **1.55** million **was** generously supported by the European Community (40%) and the State of Bavaria **(10%). As** had been hoped, warm water (38°C) in sufficient amounts **(215** m^3/h) was tapped **in** the **Malm** stone karst (ca. 800 m deep).

Scientific investigations have shown that the water is of therapeutic **quality.** It is classified as „sodium chloride hydrogen carbonate thermal water containing fluoride". The authorities responsible have approved **the** extractions of **18** m^3/h for bath water and **162** m^3/h for heating purposes. After use the bath water is allowed to flow into the drainage ditch which leads to the Danube. The water used for heating purposes, which need only be cooled down, must be reinjected into the same aquifer (Malm) for hydrogeological reasons. This **will** guarantee that the resources are conserved. Under these conditions the Municipal Works Straubing could begin working on a comprehensive plan.

To launch a geothermal heat project such as this, it is necessary to have a financially solvent company, good engineers and concerned politicions and, above all, a „generous source of financial support".

2.3 Comprehensive Plan

From the location of the production well, the thermal water is to be conducted through future building areas past various heat consumers - such as bathing facilities and sanatoria - by means of a single-pipe system. The thermal water should also be conducted along agricultural operations and finally to a fish farm.

For technical reasons the reinjection drilling must be located an adequate distance from the production **drilling** so that the thermal water itself does not cool down (doublet method of construction).

Taking this aspect into consideration, the location of the reinjection **drilling** was chosen to be near the Danube, about 2 km distant from the production drilling. (Figure 3)

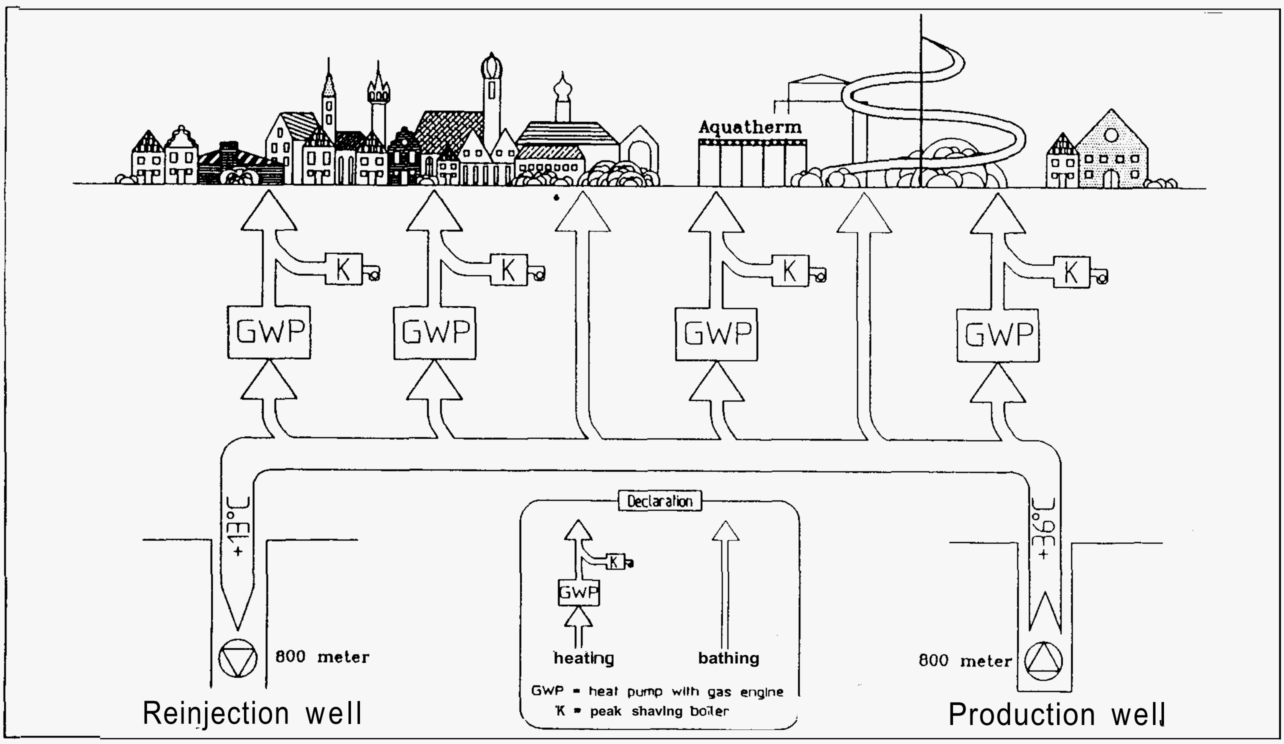

Figure 3: The Straubing Geothermal Project.- Thermal and mineral water for bathing and heating

One factor that determined the location was the proximity of the historical drilling of 1910 mentioned above, which was just across the Danube. Thus an adequate karstification of the Malm could be expected here, which would lead to a good production or reinjection of the water.

On its way from the production well to the reinjection well, a part of the thermal water flow will be cooled down in each of the central stations of the heat consumers by means of heat pumps. The water that has been cooled down in this way is then returned to the main pipe. The resulting mixed temperature, which is obviously less than the required 36°C, is conveyed to the next heat consumer. This process is repeated until all predetermined heat consumers are provided with geothermal heat. In this way the thermal water is cooled down to ca. 13°C and returned to the reinjection well.

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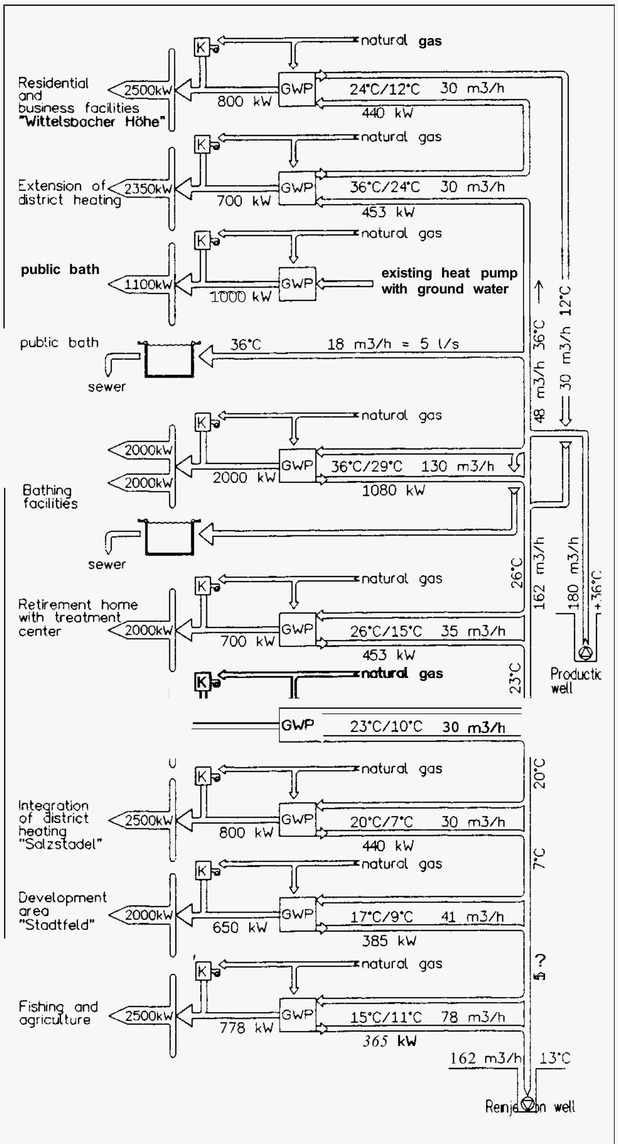

Figure **4**: Details of The Geothermal Project in Straubing

Evaluations of the economic efficiency were conducted and the conclusion was that the project would have a chance if there were sufficient heat extraction, additional use as bath water and, of course, generous financial support. Also taken into consideration at that time (1990) were the rising costs of energy. In addition to that there was fear of a European-wide CO_2 tax. ***An*** application was made and the result was a 50% subsidy (40% EC and 10% State of Bavaria) for reinjection drilling and the connecting conduit with an estimated volume of ca. USD 2.9 million.

2.4 Reinjection Drilling

In 1992 reinjection drilling (drilling site 2) was completed. At a depth of ca. 840 m warm water was found with the same quality as drilling site 1. Unfortunately, it was not as high-yielding. Only ca. 40 l/s (144 m^3/h) could be produced. Nevertheless, the temperature at 38°C was 2°C warmer that at drilling site one.

A peculiarity was discovered at drilling site two. Under economical conditions though it was possible to produce 40 l/s, only 5 l/s could be reinjected. Expensive methods were used to improve the reinjection. Underground implosions and subsequent pressure acidification, as well as an expensive fracturing attempt, were supposed to widen the crevices. Unfortunately these attempts were unsuccessful.

New ideas about the use of geothermal heat had to be taken into consideration. A suggestion was made to reverse the system and to have a second pipe for the bath water.

2.5 Trial Phase

So that the geothermal heat project in Straubing can finally stand on its own two economic feet, the heat supply from within the earth is supposed to be examined. Again it was possible to receive 50% subsidies from the EC and the State of Bavaria for the total costs of USD 1.86 million.

By feeding thermal water from drilling site 1 into the nearby in- and outdoor swimming pool Aquatherm, 72,752 m^3 of *gas* can be saved annually. A positive by-product is also the fact that 44,150 m^3 of bath water does not run through the drinking water network annually.

Supplying Aquatherm with warm water has also taken the burden off of the heat pump equipment at the pool facilities. Heating is done here with thermal heat that is close to the temperature of the earth's surface, that is, with water from a depth of 15 - 20 m at a temperature of 11°C. When the water has cooled down to 5°C it pours into a nearby stream.

Releasing capacities in this facility has enabled a retirement home and a nearby school to be included in the existing heating network. In this way Straubing has already put the thermal heat closer to the earth's surface as well as the heat from the Malm karst to good, sensible use.

3. ECONOMICAL USE OF THE TOTAL PROJECT

The costs for the total project as described above were originally, i.e., during the 1990 planning phase, estimated at USD 12.4 million. Since completion of all of the equipment, an annual saving of 2000 t of fossil fuels can be reported. Thus the expenditures are justifiable. The geothermic cost price were determined to be ca. **27.9 USD/MWh,** taking the supply of bath water into consideration. If the additional costs for hooking up buildings, transfer stations, charges for administration and marketing and only a negligible fee for risks and profits are added up, the lowest sales price turned out to be 46.4 USD/MWh. These calculations are only valid if the heat consumers do actually take advantage of this form of heating.

In the meantime newer estimates show that the investment amount will be closer to ca. USD 19 million. The geothermic cost prices are currently figured to be 47 **USD/MWh.** Here, too, the final expenses for heating and thermal water were predicted. Including the usual additional costs and charges, the fmal sale price for heat would be **65.6 USD/MWh,** which is unacceptable. The price for heat in Straubing at the moment is 52.6 USD/MWh.

It is most diffucult to reach a suitable balance between the costs and the income when a geothermal project is involved. Initially there are high investment costs. Afterwards you can hook up the heat consumers step-by-step.

Even if there are a sufficient number of potential consumers, negotiations over the concrete hook-up fail again and again because of the price, which is clearly above the price of gas and oil. At the moment we are obliged to turn to municipal and local establishments that are willing to pay a higher heating bill than would ordinarily be necessary with gas heat, for example. They do so just for the sake of the project itself and the environment.

For a start, the municipal hall in Straubing should be mentioned, which will be dedicated the end of 1995. It has a connecting service of 1000 kW and will consume ca. 2400 MWh per year.

In order to achieve some economic use under these circumstances, it is necessary to work with an approach that is less than fully integrated. This means that large heat consumers will have to be supplied by portable, gas-fired equipment. *Only* after a sufficient number of heat consumers are available can the hurdle of large investments be taken for geothermal heat.

4. CURRENT SITUATION

Evaluations of the economic efficiency came to the conclusions that installing two pipes, one for thermal water for heating purposes and the other for thermal water for bathing use, would jeopardize the entire project.
A single-pipe system must be retained. The use of cascading remains the foundation of the entire geothermal project. The flow direction from drilling site one to drilling site two must also be retained, otherwise by the time it reached Aquatherm the water would have cooled down. This means that further studies and intensified measures must be undertaken so that drilling site two is suitable as the reinjection well in the future.

While these studies are going on, the thermal water from drilling site two should be used to heat the municipal hall nearby. In this way heat from drilling site 2 can be used m a trial phase also, just as it has been done with drilling site 1.

The expensive connecting conduit cannot and should not be built until there are enough interested customers along the pipeline route.

The large-scale use of g e o t h d heat with heat pumps, supported by block heat power plants and gas boilers should take place in heating centers. These will be built as they are required. One facility will be started in 1995 at a cost of ca. USD 1.2 million.

5. CLOSING REMARKS

Whenever you are speaking to experts about geothermal heat, everyone always agrees that this heating method will *gain* in significance more and more in the future. We had assumed that the investments costs would remain stable and that the energy prices would be steadily increasing, but just the opposite has occurred. These projects are becoming more and more expensive to launch and the energy prices of the competition - I am thinkmg of gas and oil prices here - are decreasing slightly, as the past years have proven. This situation has put geothermal heat in a precarious position. The *only* way to get it out of this position is for increasing support from public *funding* to be made available.

I hope that we can all further the use of geothermal heat - for the sake of the environment.

W. Jähn
Managing Director

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