Integrated energy concept at "Röhrer Höhe", featuring heat pump and solar thermal system
City of Stuttgart, Germany

Summary

The new retirement home in the south western edge of Stuttgart was built in a location were only electricity could be used for heating. Thus the initial energy concept which proposed a standard electrical heating system was altered to a ground coupled heat pump with a 161 m² solar thermal system to supply the energy for hot water in summer. In addition the building envelope was improved compared to national standards. The solar system was funded by the Deutsche Bundesstiftung Umwelt and the heating system was funded by the state of Baden-Württemberg. The additional costs for the building envelope were paid for by the city of Stuttgart.

End-user area
- [x] New buildings
- [ ] Refurbishment of buildings
- [ ] Transport and mobility
- [ ] Financial instruments
- [ ] Industry
- [ ] Legal initiatives (regulations, directives, etc)
- [ ] Planning issues
- [ ] Sustainable communities
- [ ] User behaviour
- [ ] Education
- [ ] Other

Target Audience
- [x] Citizens
- [ ] Households
- [x] Property owners
- [ ] Schools and universities
- [ ] Decision makers
- [x] Local and regional authorities
- [ ] Transport companies
- [ ] Utilities
- [ ] ESCOs
- [x] Architects and engineers
- [ ] Financial institutions
- [ ] Other

Technical
- [x] Energy efficiency
- [x] Heating
- [ ] Cooling
- [ ] Appliances
- [ ] Lighting
- [ ] CHP
- [ ] District Heating
- [x] Solar energy
- [ ] Biomass
- [ ] Wind
- [x] Geothermal
- [ ] Hydro power
- [ ] Other

Context

The energy supply concept for the new retirement home 'Haus Rohrer Höhe' with 76 flats presented us with a major challenge: According to the local development plan dating back to the 1970s, the use of emitting fuels is not allowed. The only conceivable heating system was thus based on electricity.

This is why we developed an energy scheme that combines improved cladding with a solar thermal system and a ground-coupled heat pump. This combination results in an energy consumption for heating and hot water of 60 kWh/m²a.

Objectives

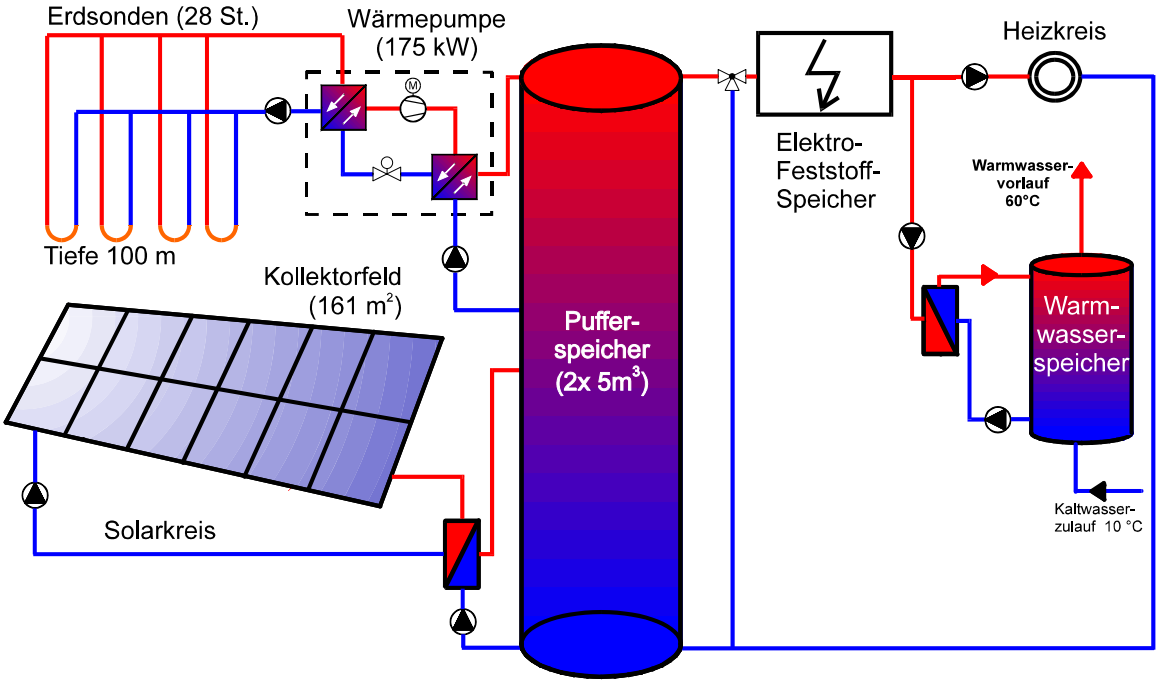
The objective of all activities of the municipal energy management in Stuttgart is to reduce the energy consumption of public buildings and thus reducing energy costs, emissions of pollutants and greenhouse gas emissions. In this project we achieve this target by a variety of measures adapted to the local boundary conditions. The ground coupled heat pump was our first geothermal project and allowed us to study that technology.

Process

Technical description of the project
The energy supply concept comprises three main components:

- solar thermal collectors with 161 m² collector area
- electrical heat pump 175 kW_{th} with 28 ducts 100m depth each
- three electric solid-capacity boilers

The south oriented solar collectors are used for domestic hot water heating during the summer. In winter time the return flow of the heating system is preheated by the collectors. A new technique called "Solar-Roof" was used. This is large-scale prefabricated solar panels that could cover a whole roof from ridge to gutter. Heat source for the heat pump are 28 ducts that have been drilled besides the building with a distance of 6 m in between the ducts.



A highly motivated engineering company together with the energy management convinced the decision makers to invest in this rather new technology based on a ground coupled heat pump with a solar system. The drilling diameter of the ducts had to be enlarged because of mineral water sources in the surrounding. No further problems with the ducts occurred during the construction work.

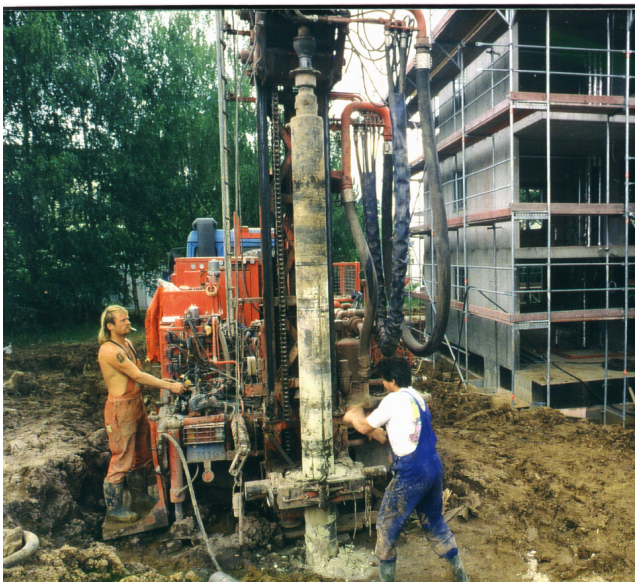


Figure: drilling of the ducts

The design of the conventional heating system in the building and design of the innovative components (solar, heat pump, ducts) has been realised by two different consulting companies. This led to several problems:

- The DDC-control of heat pump and electric boilers did not work properly
- The return temperatures form the (conventional) heating system was too high
- problems with the (conventional) domestic hot water preparation
- electric boilers are very badly adjustable to the demand
- the operation of the system requires educated staff

Financial resources and partners

Solar system	70.700 €
Heat pump with installation	69.100 €
duct with piping	150.600 €
Electric boiler with installation	68.800 €
Sum	**359.200 €**
	4.700 €/flat

All cost are excluding VAT

The solar system was funded by Bundesstiftung Umwelt (new technology of the collector modules) and the heat pump and ducts were funded by Wirtschaftsministerium Baden-Württemberg.

Results

After some work, the system is now running in a satisfying manner. The solar system operates very well, but the heat pump systems performance is a little bit worse than expected because of the reasons mentioned above.
The heat pump produces approximately 500.000 kWh of heat per year and consumes 165.000 kWh of electricity. This gives the system an efficiency of 3.0 which is acceptable with the boundary conditions mentioned.

The costs of solar collectors were 46.100 € and the costs for piping and controlling the solar system were 24.000 €. The heat pump caused an investment of 68.500 € which includes the installation and control system. The cost for drilling the ducts was 149.000 € (or 53 € per m of duct). All these costs are excluding VAT. The solar collectors produces between 55.000 and 60.000 kWh/a, a gain of 340 kWh/m² per year. This is an average value for the local conditions.

Figure: Building just finished

Lessons learned and repeatability

In general heat pump systems are an excellent technology to heat buildings. They perform best, when a warm heat source is available and when the required temperature level is as low as possible. The length of the ducts can be reduced if underground water improves the heat exchange. A geological survey prior to the project is essential. This system is in general restricted to new buildings. Our project was a successful one with the given boundary conditions. For a follow up project, there are a few recommendations valid for all sites. The geothermal system would perform better if there were a cooling load in summer. If there is a big hot water demand, this load determines the required temperature level for the heat pump. We recommend a second stage heat pump combined with a solar system. Solid capacity boilers can be adjusted very badly to a changing load. This leads to problems when switching from charging the hot water boiler to heating the hot water circulation. The heating system based only on floor heating is not accepted by all residents. We would therefor recommend an additionally installation of small radiators. In a follow-up project a combination between a geothermal system and an air-to-water heat exchanger for summer use will be investigated.

Contact for more information:

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