Case study : Hodonin (Czech Republic)

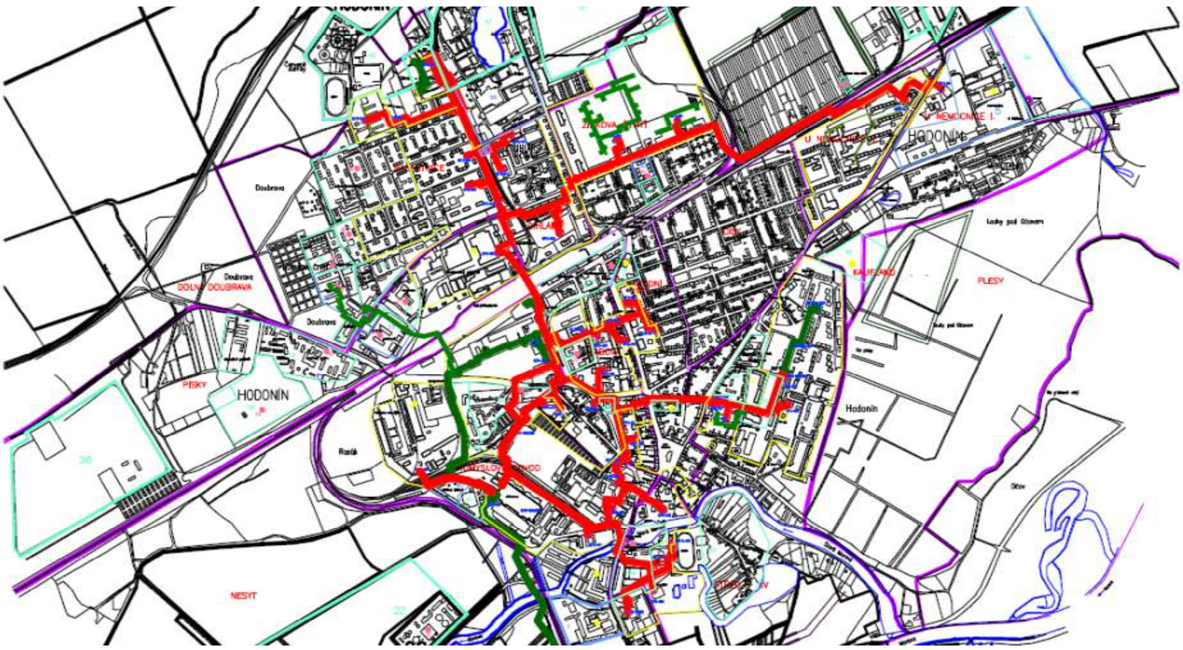
Name of the project:	Possibilities of utilization of alternative heat sources in Hodonín Power Plant DH system
Location:	50.566240, 16.055673
Name and type of owner:	Tha main business activity of ČEZ Teplárenská, a.s. is the production, procurement, distribution and selling of heat. The company currently provides heat supplies to approx. 144 000 households and additional 7 685 consumnption points which include hospitals, schools, administrations, business areas and industrial objects in the Czech Republic. All of that is managed from 39 locations in 7 Czech regions and 9 operational units.
Owner contact person:	Ing. Alexej Hrebiček, +420 475 256 621, alexej.hrebicek@cez.cz

Context of the study

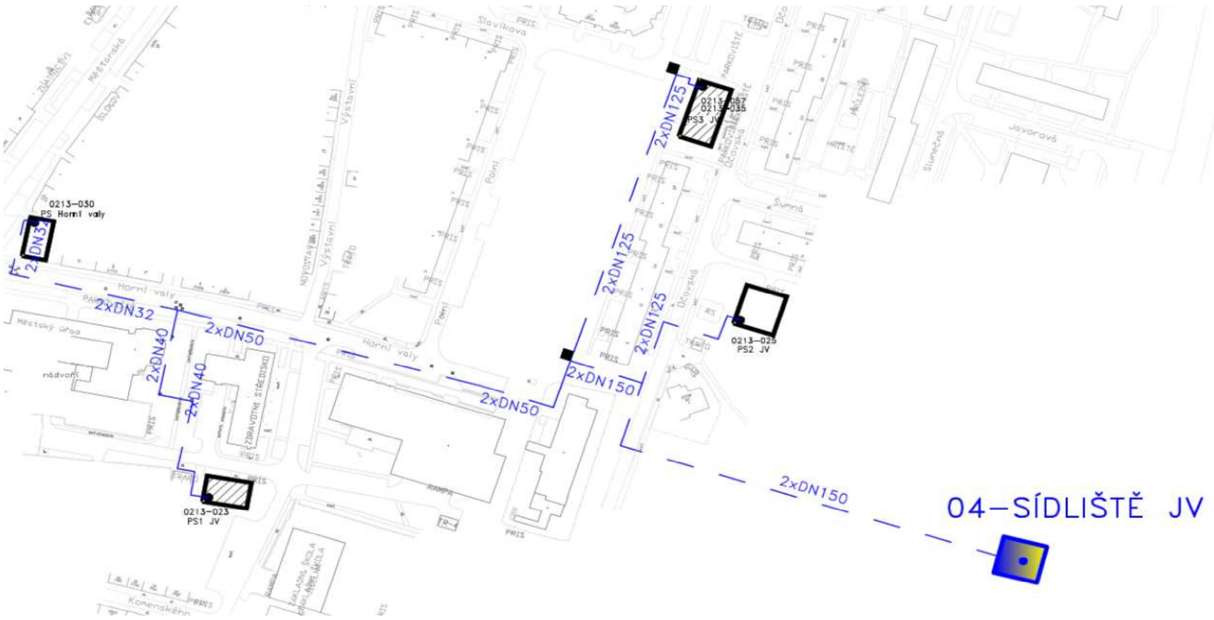
Evaluation of possibilities to implement solar heat system into DH system Hodonín for the South-East estate was carried out as a part of a study aiming to evaluate the technical and economic impacts of the scenario to decentralize heat supplies in cities of Hodonín and Holíč. The evaluation of alternative heat sources for the locality included gas boilers, solar systems, as well as air-to-water heat pumps.

Current state

The city of Hodonín is located at the altitude of 167 metres, the outdoor design temperature according to Czech standards is -12 °C, avarage outdoor temperature during heating season is 4.2 °C, the heating season lasts 215 days. The heat supplies are provided with heat system devided by the type of heat-carrying medium. The primary branches are steam feeders TN 0213, TN 0215, and hot water pipe Sever 02221 for Hodonín, and hot water feeder 0220 for Holíč. The company also operates several hot water systems which are connected to heat transfer stations PS EHO2, PS1 JV, PS3-II JV, PS ISŠ, PS Malá Kasárna, PS1 VK, PS2 VK and PS HZS. The level of transfer is primary and secondary in Hodonín, and primary for the locality of Holíč. Total length of the steam pipeline DH network is 14.45 km. Characteristics of the steam at the source output are: pressure 0.9 - 1.8 MPa, temperature 210 - 270 °C. The steam pipeline supplies primary customers and transfer stations with subsequent secondary distribution system. Total length of the hot water pipeline is 22.2 km, temperature gradient is 150/70 or 130/60 °C accordingly. The hot water pipeline supplies primary customers and transfer stations with subsequent secondary distribution system. Total length of the hot water pipeline is 10.45 km. The system is depicted in the following scheme.



For evaluation of possibilities to implement alternative energy sources, the locality "South-East estate" has been chosen. It is an area in Southeastern part of Hodonín where primary-level as well as secondary-level transfer occurs. The area is currently connected with steam feeder Hodonín. Average heat supply to the customers is 77 165 GJ.



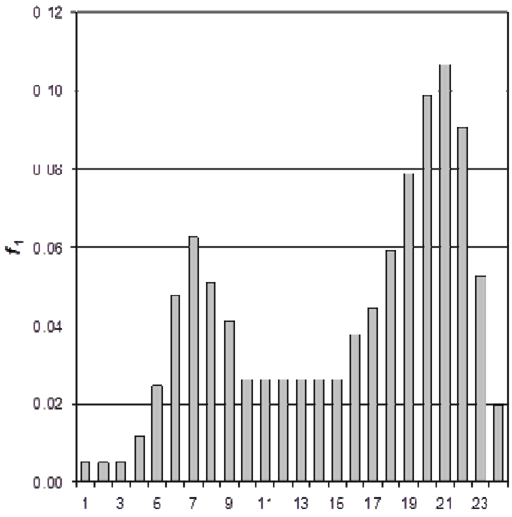
Within this study, a new central heat source is forseen on the land close to Legionářů and Jižní streets. Considering the current steam system, the new design envisages realization of new primary steam and hot water distribution pipelines terminated in the existing transfer stations, including recosntruction of the steam/water transfer stations into exchange stations. The system's dimensions were designed according to expected parameters of the heat-carrier fluid and the amount of heat energy. The pipes are envisaged as preinsulated placed in impassable underground ducts.

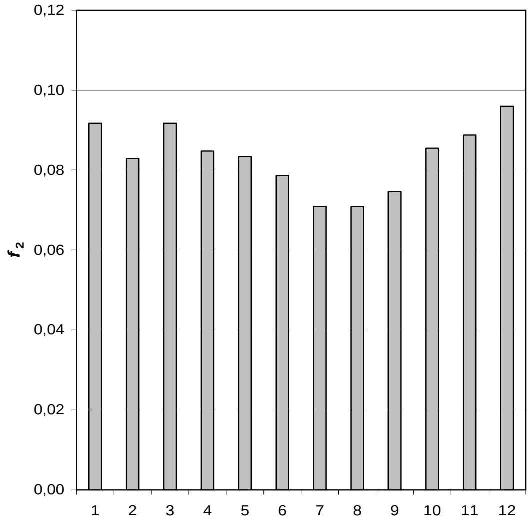
Heat consumption

The annual average heat consumption of the DH which should be to some extent covered by solar distrcit heating system is approx. 77 000 GJ. The heat consumption splits into:
heating - 66 % (approx. 51 300 GJ/year)
hot water preparation - 33 % (approx. 26 000 GJ/year)

Supply point	Name of the supply point	Heat supply [GJ]	Heating [GJ]	Heat for hot water [GJ]
26	PS Horní Valy	1 190	1 190	0
27	PS JV1	4 591	4 259	332
28	PS JV2	38 262	24 746	13 516
29	PS JV3	20 412	13 399	7 013
29	SNP3 MSB	12 710	7 718	4 992
Total		**77 165**	**51 312**	**25 853**

The hot water consumption during the day and over the year is depicted in the following graphs. The heating period is considered to last between 1st September and 31st May, and the specific heat loss of connected buildings was set in such way that the condition for predefined consumption of heat for heating is met for the respective climatic year.





Scenarios involving solar heating systems

The objective of these variants was to evaluate technical possibilities of implementation of solar systems into DH system of South-East estate in Hodonín with the use of simulation analyses in TRNSYS software. The solar system was evaluated in scenarios with fraction of 5, 25 and 50% of total heat consumption. For these scenarios, parameters of the solar system were proposed (solar collectors' area, volume of storage tank). Natural gas boiler is envisaged as the peak (main) source of heat.

Input parameters

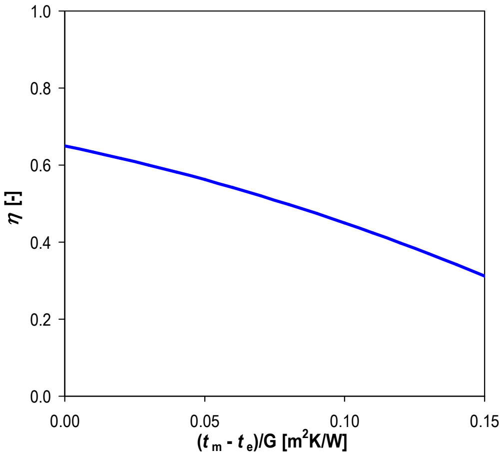
With regards to operational temperatres of DH distribution system over the year, solar tube vacuum collectors were selected for the simulation analysis with the following parameters:

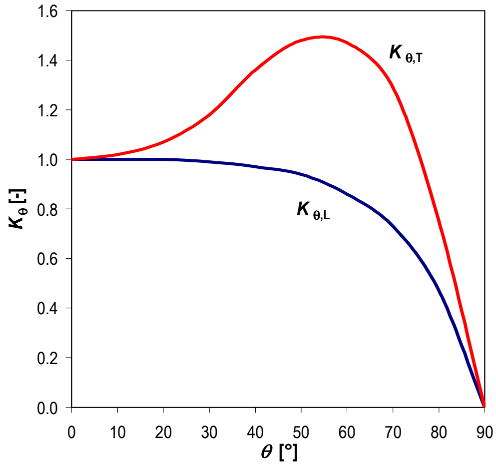
Optical efficiency: 0,65

Heat transfer coefficient: 1,5 W/(m^2.K)

Quadratic heat transfer coefficient: 0.005 W/(m^2.K^2)

Area of the collectors was calculated based on the analysis of required solar fraction of 5%, 25% and 50%. Within the analysis, the solar collectors are uniformely oriented towards the South with the tilt of 45°. Installation of the collectors shall be on terrain/roof with average annual reflectance of 20%. The low-flow regime of approx. 20 l/(h.m^2) was chosen for the solar collectors due to minimization of the pipes' dimensions. The carrier fluid of the collector circuit is propylenglycol-based antifreeze mixture (50/50 diluted with water). For each scenario, based on required area of solar collectors, the flow rate of carrier fluid, the internal diameter of pipes, and the pipe length of the collector circuit were determined. There is enough space in the area for placement of collectors on the terrain; the possibility of the terrain's utilization is subject to negotiation, the same applies to the utilization of roofs (buying / renting). When comparing the placement of collector array (roofs vs. ground), it is usually necessary to use ground for larger collector areas due to space requirements. Placement on the ground also comes with lower costs. When evaluating the central connection of solar system(s), the heat loss is substantially higher for roof placement due to longer distribution of the heat carrier fluid.





Volume of the storage tank for accumulating heat gains from solar collectors is the result of analysis for achieving required solar fraction of 5%, 25% and 50%. The accumulation substance is water. The storage tank is envisaged as cylindrical with the ratio of hight/radius of approx. 1. The storage tank shall be on surface. Heat insulation of the storage tank shall be 30 cm on its entire surface with heat conductivity of 0,06 W/(m.K). It is assumed that stratification of water will be ideally controlled by interal stratification elements. Maximum temperature in the tank shall be 90°C.

The simulation software TRNSYS uses databases of hour-based climate data processed into so called typical meteorological years (TMY). For the Czech Republic there are only 5 official databases from 5 localities: Praha, Kuchařovice, Churáňov, Hradec Králové and Ostrava. The requirement of the client was to perform the analysis for the conditions of Hodonín (South Moravia) which are not available in the TMY format. The closest locality of Kuchařovice was therefore chosen for the purposes of the simulations.

Definition of output parameters

To clearly interpret the results, basic parameters observed in the analysis are defined below.

Area of solar collectors Ak [m^2] is the area of the aperture, i.e. area of the orifice (glazing) through which the solar radiation enters the collector.

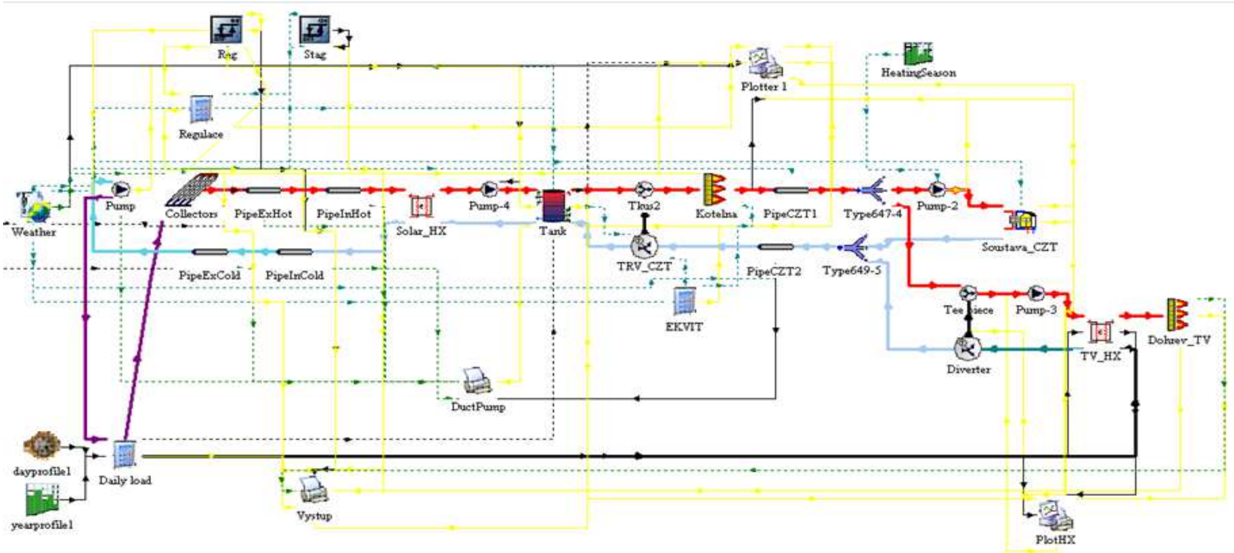
Volume of water heat accumulation tank Vw [m^3] is the volume of water inside the tank (concrete basin, underground reservoir).

Utilized solar gains Qss,u [GJ] are gains transfered from the solar system to the heat delivery. The border is usually the output from the accumulation tank or the subsequent exchanger.

Relative solar gains qss,u [kWh/(m^2.year)] are utilized gains from the solar system relative to installed area of aperture Ak of solar collectors. The savings from one m^2 of installed area of solar collectors, which is a certain economic criterion, can be derived from this parameter. They are also a measure of efficiency of the solar system (when divided by the solar energy absorbed by the collectors).

Solar fraction f [%] (solar share) is the proportion between the gain from the solar system (utilized gain) and the total heat demand.

Simulation model in the TRNSYS software



Overall results

solar fraction [%]	5	25	50
collector area [m^2]	1 950	13 800	32 500
storage volume [m^3]	80	39 000	160 000
specific solar gains [kWh/m^2.year]	553	388	329

Economic parameters of scenarios with solar system

The main objective of the study was to design and technically evaluate the possibilities of decentralization of DH system in Hodonín. Subsequently, the goal was to calculate the limit heat prices for each of the localities. This price was then compared to the current price separately for primary and secondary transfer. Considering the required boundary conditions, only the price of the variant with 5% solar fraction dropped below the current heat price from the primary network.

SDH plant opportunities & threats, benefits & limits

Based on the outputs of the economic analysis, utilization of alternative sources of energy is feasible for low shares on the total heat supply. The limit heat prices of both sources (solar system, heat pump) are almost identical. Potential implementation of the solar system is supported by low costs of fuel consisting only of the costs of electric energy required to operate circulation pumps and regulation. This fact secures stability of the heat costs for the entire operation period of the system, thus the production cost is mainly derived from the investment costs of the project's realization. Heat pumps are more compact solution which does not require procurement of areas for installation of solar collectors which may be complicated both for their placement on the roofs and on the ground (rental of space). Utilization of alternative heat sources was therefore recommended only for low shares on the total heat supply - variants with 5% solar fraction.

Authors

This factsheet was prepared by David Borovský and Matěj Malý (AF-CITYPLAN s.r.o.)

Intelligent Energy Europe Programme
of the European Union