Case study : Radvanice (Czech Republic)

Name of the project:	Study of scenarios of heat supply to the town of Radvanice
Adress of the project:	50.566240, 16.055673
Name and type of the owner:	ČEZ Teplárenská, a.s. - ČEZ Teplárenská supplies heat to approx. 7,500 points of delivery, and besides 140,000 households the heat is delivered to hospitals, administrations, schools and factories. The total annual supply adds up to 9,000 TJ. ČEZ Teplárenská delivers heat to 39 locations of the Ústí nad Labem, Karlovy Vary, Central Bohemia, Pardbuice, Hradec Králové, Moravia-Silesia regions, as well as the South Moravia region where it also exports heat abroad from the Hodonín Power Station to the Slovakian town of Holíč.
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Context of the study

Evaluation of the possibility to implement solar system to the district heating of Radvanice was part of complex analysis aimed comparison of different heat sources. The study technically and economically evaluates defined scenarios of optimalization of the current state and decentralization of heat supply.

Current state

The heat for heating and hot water is provided by long-distance supply from the brown-coal Porici Power Station (EPO). The primary medium is steam of 1,1 Mpa pressure and 250°C temperature. The network consists of the primary steam line Krkonoše from which the branch line Radvanice is diverted outside the premises of EPO. The steam line Radvanice, total of 11km, leads through villages of Lhota and Bezděkov, and continues mainly through forest terrain to the shut-off valve of the Radvanice branch. The steam line itself then continues to the Kateřina mines. Due to the closure of the mines in this locality, this part of the steam line is no longer in operation. The steam line is led on surface level for its entire length, mainly on 1m-high steel consoles fixed in concrete bases with standard compensators. In some places there are steel bridges (crossing of paths, forestry etc.). Besides the primary steam supply to the town of Radvanice there are branches (mainly owned by ČEZ Teplárenská) in Lhota and Bezděkov to supply properties in these villages without condensate return. These supplies are intended solely for heating and hot water supply for residential buildings and recreational objects.

The dimensions of the steam line Radvanice corresponds with the capacity of the supply for coal mines in Radvanice. Due to the termination of mining in this locality the capacity of the steam line is excessive. That leads to higher relative heat losses of the system, particularly in Summer.


The steam line Radvanice terminates at two exchange stations. Heat is being tranformed into hot water there, and subsequently distributed. The exhange stations are following:

VS91 tranforms steam into water of 105/70°C PN 16 which is being distributed via underground pre-insulated pipeline into objects where the heat is measured together for heating and hot water. From this exchange station another branch leads to 3 objects (primary school, canteen and cultural centre) with parameters of 90/70 PN 6 as a secondary supply without hot water.

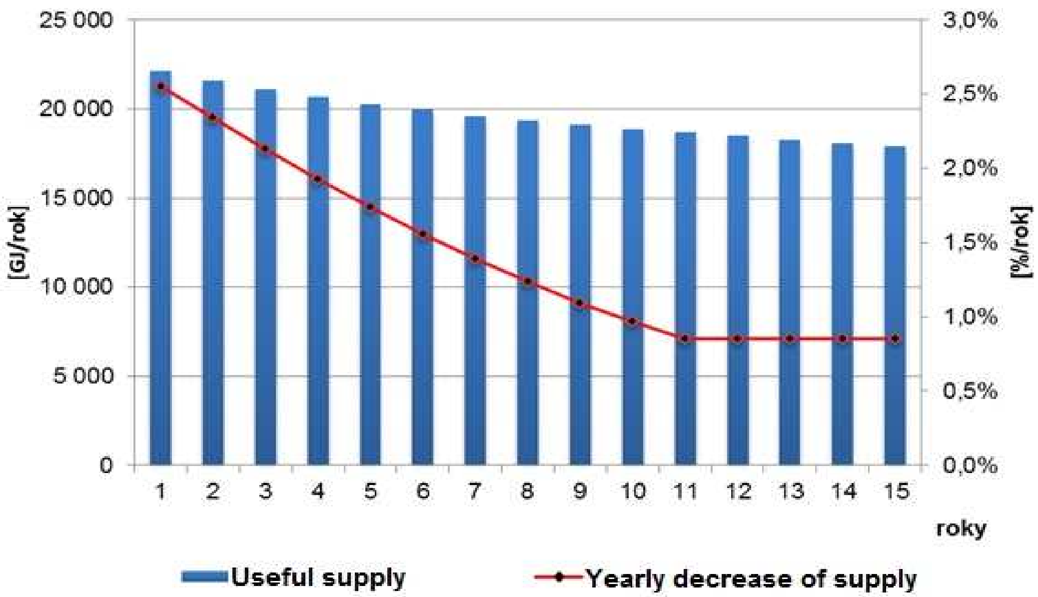

VS92 is classic secondary exchange station supplying heating 90/70 PN 6 and hot water with central domestic hot water preparation in the heat exchange station (55°C) via 4-pipe pre-insulated pipeline into residential buildings.


Heat consumption

Location of consumtion	Type of consuption	Number of consumtion points	Useful supply [GJ/year]
Lhota a Bezděkov	single family houses	62	2 309
Radvanice	singlefamily houses	29	1 925
Radvanice	multi family houses housing units	23	3 825
Radvanice	public buildings	11	2 356
Radvanice	industry	1	567
Radvanice	public buildings	4	1 555
Radvanice	public buildings	1*	28
Radvanice	multi family houses	9	9 046
Radvanice	multi family houses	9*	3 429
Celkem		**139**	**25 038**

Perspective of supplies

Analysis of perspective of supplies was carried out in two levels. Firstly the level of insulation and replacement of the original windows and doors in objects - points of delivery connected to district heating - was evaluated, and the pontential of energetic savings was estimated. Secondly, objects (in particular residential houses) which are situated in proximity to the district heating network and are either not connected, or have connection however are not being supplied by district heating, were identified. As far as the heat-technical characteristics of particular objects are concerned, it is safe to say that objects are mostly insulated, or had at least the windows replaced for modern plastic double glazed ones. The total potential of savings is based on expert estimation at cca 27% of the total heat consumption for heating. The following graph presents consecutive reduction of heat supply driven by improving of heat-technical characteristics of objects' coats.



From the perspective of disconnecting end users from the DH system, the Radvanice locality is very specific. It is given by the history of the town linked with mining, its placement in remote and environmentally problematic part of the Trutnov region, absence of industrial areas, and also the fact that the town is currently not connected to gas network. Areal application of alternative sources is therefore very limited. At present state of heat supply via the steam line Radvanice there is no threat of disconnecting of larger number of customers.

Evaluated scenarios

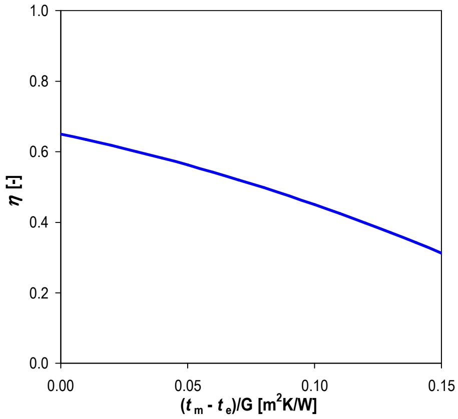
Variant	Description of variant
0a	Present state of the art
0b	Steam line in operation for the winter period. Central electrical DHW preparation in summer (usage of already installed equipment).
0c	Steam line in operation for the winter period. Local electrical DHW preparation in summer.
1a	Biomass boiler
1b	Biomass boiler in operation in winter period. Central electrical DHW preparation in summer (usage of already installed equipment).
1c	Biomass boiler in operation in winter period. Local electrical DHW preparation in summer.
2	Biomass boiler. Bivalent heat pump for DHW preparation and preheating.
3a	Biomass boiler. SDH with 5 % solar fraction
3ax	Biomass boiler. SDH with 5 % solar fraction (roof instalation)
3b	Biomass boiler. SDH with 15 % solar fraction
3c	Biomass boiler. SDH with 25 % solar fraction
4	Biomass boiler with steam turbine fro steam reduction (300 kW)
5a	Natural gas boiler
5b	Natural gas CHP

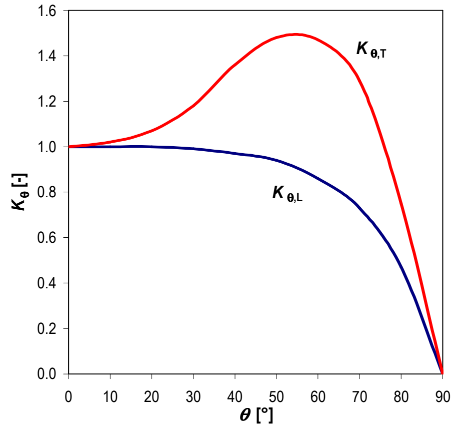
Scenarios involving solar heating systems

The subject of the scenarios was evaluation of techincal possibilities of implementation of solar system to the district heating system in Radvanice using simulation analyses in the TRNSYS software. Solar system was evaluated in scenarios with 5, 15 and 25% of total heat consumption, and consequently 5% with placement on the roofs of residential buildings (see picture below). For these scenarios the parameters of the solar system were proposed (solar collectors, area, volume of storage tank). Biomass boiler is considered as the primary (peak) source of heat.

Input parameters

Simulation analysis in TRNSYS was based on boundary conditions determined by the client, or adjusted by the processor based on common designing of supplying district heating into buildings. 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 in the conditions of the closest locality - Hradec Králové (East Bohemia). In addition, due to the specific conditions of the locality, the amount of solar radiation was reduced by 15% against the TMY. The annual avarage temperature is 8.3 °C. The total annual solar radioation on horizontal surface is 1078 kWh/m2.year (916 kWh/m2.year after correction); on south-faced surface tilted by 45° it adds up to 1228 kWh/m2.year (1043 kWh/m2.year after correction). The area of solar collectors are the result of analysis for achieving the required solar coverage of 5%, 15% and 25%. Within the analysis the solar collectors are uniformly tilted by 45° and south-faced. Installation of collectors is assumed on terrain of average annual reflectance of 20%. The low-flow regime of cca 20 l/(h.m2) was chosen for the solar collectors due to minimization of the pipes dimensions. The carrier fluid of the collector circuit is popylenglycol-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 was determined.





Volume of the storage tank for accumulating heat gains from solar collectors is the result of analysis for achieving required solar coverage of 5%, 15% and 25%. The accumulation substance is water. The storage tank is considered 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 cunductivity of 0,03 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.

Definition of input parameters

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

Area of solar collectors Ak [m2] is the area of the aperture, i.e. the area of the orifice (glazing) through which the solar radiation enters the collector.

Volume of water heat accumulation tank Vw [m3] is the volume of water inside the tank (concrete basin, underground reservoir).

Utilized solar gains Qss,u [GJ] are the 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/(m2.year)] are utilized gains from the solar system relative to installed area of aperture Ak of solar collectors. The savings from one m2 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 coverage f [%] (solar share) is the proportion between the gain from the solar system (utilized gain) and the total heat demand.

Overall results

solar fraction [%]	5	10	25
collector area [m^2]	753	2 545	5 800
storage volume [m^3]	38	510	1 450
specific solar gains [kWh/m^2.rok]	528	493	390

Economic parameters of scenarios with solar system

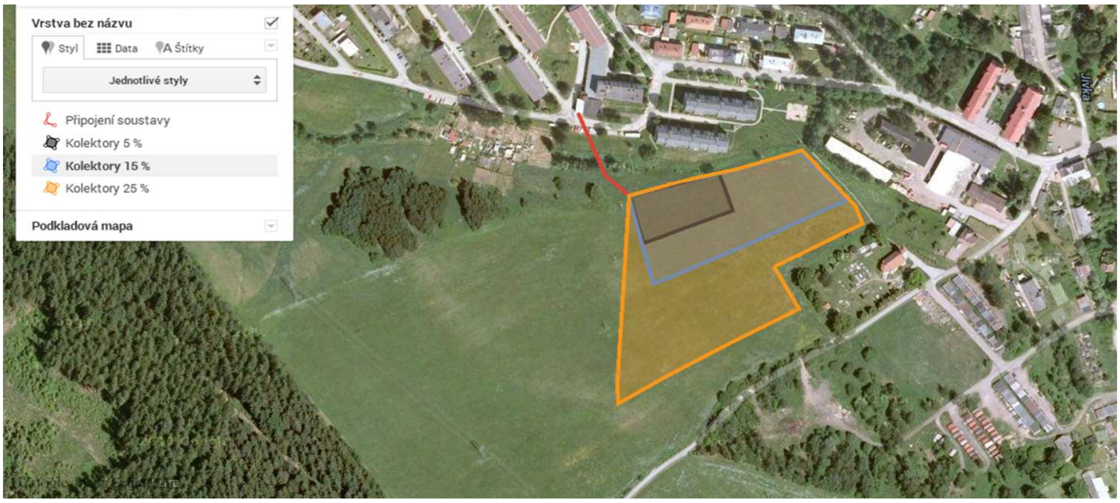
In the study the economic parameters were evaluated in detail based on the requirements of the investor. To compare the scenarios involving solar system here are presented the final heat prices without profit and VAT in comparison with the current heat prices in the region.

Variant	primary distribution heat price	secondary distribution heat price	heat price for DHW preapration in heat exchanger	total
	[CZK/GJ]	[CZK/GJ]	[CZK/GJ]	[CZK/GJ]
STAV	379	481	456	-
1a	434	538	453	486
3a	460	570	479	514
3ax	473	585	491	528
3b	520	643	538	580
3c	554	685	572	618

SDH plant opportunities & threats, benefits & limits

Based on the outputs of the economic analysis, the application of alternative sources of energy is realistic for low shares of the total heat supply. Potential implementation of solar system is supported by minimum costs of fuel consisting only from the costs of electric energy to operate the circulation pumps and the regulation. This fact ensures stability of the heat costs for the entire operation period of the system when the production cost is mainly derived from the investment costs for the realization of the project. There may be a problem with securing areas for installation of solar collectors which might be complicated either in the case of installation on the roofs (renting of areas), or in the case of installation on the ground (permission process, resistence of the public). Based on the facts stated above, it is clear that implementation of solar system increases the final heat costs in the system compared to the stand-alone biomass boiler.

Photographies



Authors

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