Technology Fact Sheet – District heating

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Introduction

District heating typically means supply of heat generated in a centralized source (heat only or CHP plant), to residential and other building types in the city. While the first historic systems used steam as the heat carrier and served mainly for distributing heat within industrial plants, modern district heating systems use hot water and the heat is transferred to buildings by substations via heat exchangers.

Supply of heat in industrial plants and business parks follows the same trends: Steam for technological purposes has been mostly eliminated and heat is used practically only for space heating and domestic hot water preparation. The historic advantages of using a larger centralized heat generation source fired by solid fuels are less important when currently high quality fuels (like natural gas) are used; in some cases this may lead to decentralization of the supply, with local small boilers. Nevertheless preserving a centralized (district) heating system still offers better conditions for utilization of combined heat and power which has much better energy efficiency compared to separate production of heat-only and electricity supplied over the grid (originating mostly from condensing, that is power-only plants).

Step by step to implement a feasibility study

1. Analysing Status Quo

The analysis should answer the following questions

- What is the current heat supply system of the business park? (centralized/decentralized)
- If centralized, what is the condition of the distribution pipes and substations? (matching the current heat demand, heat and water losses, state of repair)
- If decentralized, would a new centralized system bring energy and financial savings?

The basic data necessary for the analysis are the following:

- Energy consumption in the last 3 years by individual energy types (electricity, purchased heat, fuel consumption by fuel types, water) and by calendar months. Availability of daily or hourly values of consumption would be helpful for assessing actual peak demands.
- Energy consumption of individual buildings as metered or calculation of building energy performance and typical profiles of energy demands for technological processes

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- Lay-out of energy sources and consumption points/buildings in the business park with indication of connection points of energy supply.

2. Technical Assessment

A preliminary design of a new district heating system (or check-up of the existing one) should be performed in the following steps.

- Marking the main heat consumption points in the business park layout with peak load (design) values (in kW)
- Marking possible routes of heat supply lines from the source(s) to the consumption points with respect to available space for placing the hot water pipes inside or outside the buildings, above or below ground, depending on actual conditions in the business park. Several options should be prepared.
- Designing the pipe diameter (DN) in each section of the route (between the branching points). The calculation requires assuming the following parameters:
  - nominal temperature difference (supply return temperatures; typically 90/70 °C)
  - water velocity (typically 1 m/s)
- Calculating the pressure losses in the whole network. The calculation will determine the most distant point from the hydraulic perspective. The pressure diagram of this loop has to be checked for sufficient overpressure (against atmosphere) in all points
- Selection of the circulation pump(s) and calculation of annual pumping energy. The pump(s) should be equipped with variable speed control and auto-adaptive functions (speed control to constant or variable differential pressure or following the signal from the higher level control system).
- Calculating the heat losses of the whole network. The insulation should be designed so as to meet the minimum requirements on specific heat losses (W/(m.K)) according to relevant legislation.

Heat source – its capacity will be designed (if new) or checked (if existing) based on the above heat load balances (sum of demands in consumption points and losses in the network). Actual total peak of demand is usually less than the simple sum of peaks in all points but the source has to be designed with some redundancy in capacity.
Besides the obvious solutions (such as natural gas boilers), other options should be also considered (biomass boilers, CHP).

Network piping –standard technology of piping for hot water heat distribution is

- inside the buildings: steel pipes with added mineral wool insulation and aluminium sheet coating
- outside the buildings and overground: steel pipes with mineral wool insulation and steel sheet coating

- underground: buried <u>preinsulated steel pipes</u> with polyurethane (PU) foam insulation and plastic outer cover pipe; or
  for small pipes (about <DN 100) <u>preinsulated plastic pipes</u> with PU foam or closed-cell-polyethylene foam insulation, also with plastic cover pipe. The advantages of plastic pre-insulated pipes are higher flexibility in placing the route (can be bended), faster installation of long route sections (pipes are supplied in a wind-up of up to 100 m length) and no need for static stress calculation as with steel pipes. Plastic pipes however can be used only for temperatures up to 90 °C.

Heat substations can be in principle designed as

- <u>pressure dependent</u> ("mixing") where the hot water from the primary distribution enters directly through a 3-way-control valve the secondary system in the building. A secondary circulation pump supplies hot water to the radiators and its supply temperature is adjusted in each loop separately by mixing the colder return water.
- <u>pressure independent</u> where primary and secondary circuits are divided by a heat exchange surface (typically a plate heat exchanger (HE)). The HE represents an additional cost, but the static pressure on both sides can be designed independently and operational problems on the secondary side (such as water losses) are not directly influencing the primary distribution.

<u>Domestic hot water</u> (DHW) is typically prepared at the heat substation in a special circuit (a separate heat exchanger where cold drinking water is heated up by primary or sometimes also secondary water). Depending on the character of DHW consumption, a large, small or no DHW tank is used.

Steam should be used only where the technological demand requires so. Modern technologies often switch to alternative energy carriers which are more energy efficient, even if the primary energy source is more expensive (such as electricity). Where steam has to stay, it is often better to install a small local steam generator (boiler) rather than transport steam to a longer distance. Steam distribution systems are still justified in large plants with many steam consumption points, e.g. in chemical and especially petrochemical industry.

In some older district heating systems steam distribution network still survives for historic reasons but they are gradually replaced by hot water. Steam systems have typically high losses (heat transfer losses due to higher temperatures and more importantly, heat and medium losses due to high leakage rate both on the steam and condensate side, especially due to mal-functioning steam traps).

3. Further assumptions

Besides technical information needed for the design of the district heating system, a number of economic and financial parameters have to be assumed for the economic evaluation and selecting the best option of the design and its comparison with competitive options of heating.

Most important are energy prices (electricity, heat, fuels) and project financing options or in other words cost of money depending on investor's approach (equity, bank loan, subsidy).

Optimization calculations of the district heating design options can be based on annual costs assuming constant energy prices. However comparing district heating with other heating options using different energy types has to be based on price development forecast over the next 10 -15 years.

4. Economic calculation

District heating projects are typically evaluated based on least costs principle. Supply of heat is a service with parameters well defined on the customer side which are the same in all evaluated options. Revenues are typically cost based (with some reasonable profit margin), or their level is set based on past operation history, and are thus not relevant for the project optimization.

Total annual costs for heat supply to the end-user points (or specific costs per unit of supplied heat) are often used as a simple evaluation criterion.

Least cost analysis has to consider the entire life time of the project. Total costs are composed of the fix and variable part (the latter depending on actual amount of heat supply in a given year).

Fix costs components are the following:

- annual equivalent of capital costs: can be calculated as depreciation costs of investment (following internal investor's bookkeeping rules rather than tax depreciation) or as annuity of capital costs with respective financial costs (e.g. annuity with 8% interest rate over 20 years corresponds to about 1/10 of capital costs)
- maintenance and repair costs: costs of wear and tear parts and replacement of components with lifetime shorter than that of the project, including associated services
- personnel costs: i.e. staff costs with all mandatory payments
- other fix costs: such as insurance

Variable costs are typically

- energy costs, i.e. costs for heat (if purchased from external supplier), fuels, electricity. Different heating solutions will have different fuel costs at the generation side and different heat losses and pumping energy in the network.
- other material costs such as for water and other consumables, waste disposal and mandatory fees.

As mentioned above, the best option is that with the least total or specific heat supply costs.

Another evaluation approach is determining the operational costs savings against the current situation and calculating the investment costs payback time of internal rate of return considering the operational costs savings as partial revenue. However these indicators serve only for checking whether the project is competitive with other investor's ventures and are not suitable for optimization (low cost and technically limited solutions might have nice paybacks and high IRR but very low impact on reducing the heat supply costs).

5. Recommendation

Evaluation of several heat supply options will identify the best solution from the economic point of view. The next step should be a feasibility study analysing the selected project in more detail from the technical as well as economic and financial point of view. This can result in a recommendation for the project to be implemented. The final decision has to be taken by the investor after evaluating all advantages and risks of the project.