HEATflex

Smart Energy Systems ERA-Net

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HEATflex Toolbox

Thermal-hydraulic analysis and components

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This project has been funded by partners of the ERA-Net SES 2018 joint call RegSys (www.eranet-smartenergysystems.eu) – a network of 30 national and regional RTD funding agencies of 23 European countries. As such, this project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 775970. On Danish side HEATflex is partly funded by the Innovation Fund Denmark (IFD) under file No 9045-00003B. On the Austrian side HEATflex is funded by the Austrian Climate and Energy Fund.

1. Hydraulic calculation tools

Hydraulic calculations are necessary to determine the dimensions of the different pipes in the district heating system. For this, various simulation programmes can be used, such as e.g. Termis. Termis is used for pipe design, hydraulics and thermal analyzes, operational planning and analysis of alternative scenarios. Termis helps determine the maximum production volume, optimal pipe size, as well as requirements for the pump for the given configuration.

For existing piping systems, Termis can be used for capacity and operational planning analyzes, such as minimizing operating costs and training costs.

An example of a grid design, using Termis software, is shown in the following figure.

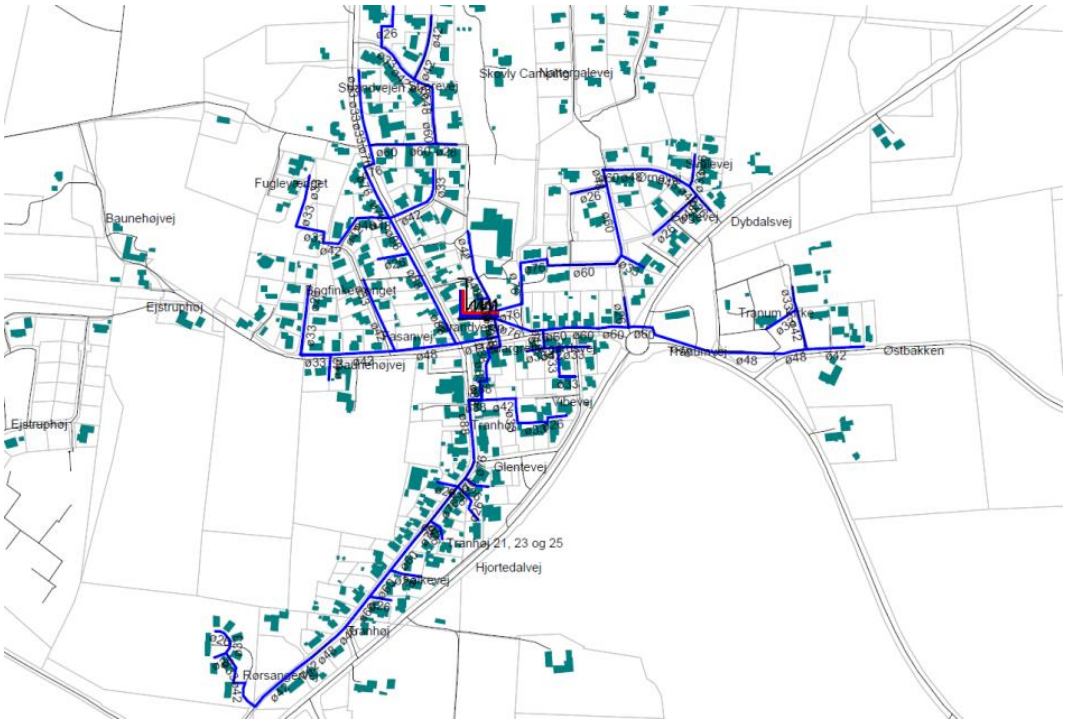

Figure 1: Example of a district heating grid simulated in Termis (Source: PlanEnergi)

Usually, the following inputs are needed to run hydraulic simulation tools:

- Background maps; roads, buildings, elevation curves, etc.
- Pipe catalogue; available dimensions, heat loss, etc.
- Consumer information; demand, difference temperature
- Boundary conditions; designing temperature, pressure gradient, flow velocity, etc.

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More information may be needed, depending on the programme, the specific project details, and project circumstances.

When designing a grid, the dimensions will normally be designed for the winter load, but it is important to check the dimensions for the summer load since there might be weak spots in the grid with very low pressure and flow. In general, the grid should be designed with the smallest dimensions possible in order to minimize the losses. However, potential future extensions of the grid may be considered as well.

It is possible to operate the district heating network with lower temperature levels during the summer period and hence, increasing the efficiency of the district heating network. In some cases, it might be feasible to close down operation for a short period, to avoid high heat losses. However, this depends always on the overall situation. For instance, it is not possible to close down the grid operation if the agreement with the consumers is guaranteed heat supply, which also provides the heat for domestic hot water provision.

See and learn more about Termis at https://www.se.com/dk/da/product-range-download/61613-termis-engineering/#/documents-tab

Danfoss also developed a similar simulation tool for district heating systems, calles Energis. It works similar to Termis and more information about this software can be found at https://assets.danfoss.com/documents/152406/AI336334653291de-010102.pdf

2. OPTIT thermal-hydraulic optimisation[1]

It is important to provide companies in the DH sector with decision-making models able to guide them towards the best choices, be it in the areas of energy generation, distribution, or consumption. Optit provides concrete solutions capable of the highest levels of efficiency all along the energy supply chain:

- Optimised planning for developing networks for district heating/cooling, with the aim of maximising the Return on Investment.
- Advanced thermohydraulic simulations of district heating networks.
- Optimisation of the operational management of complex energy systems (co-/tri-generation, integration of renewable sources, heat pumps, heat storage)

[1] https://www.optit.net/en/solutions/energy/

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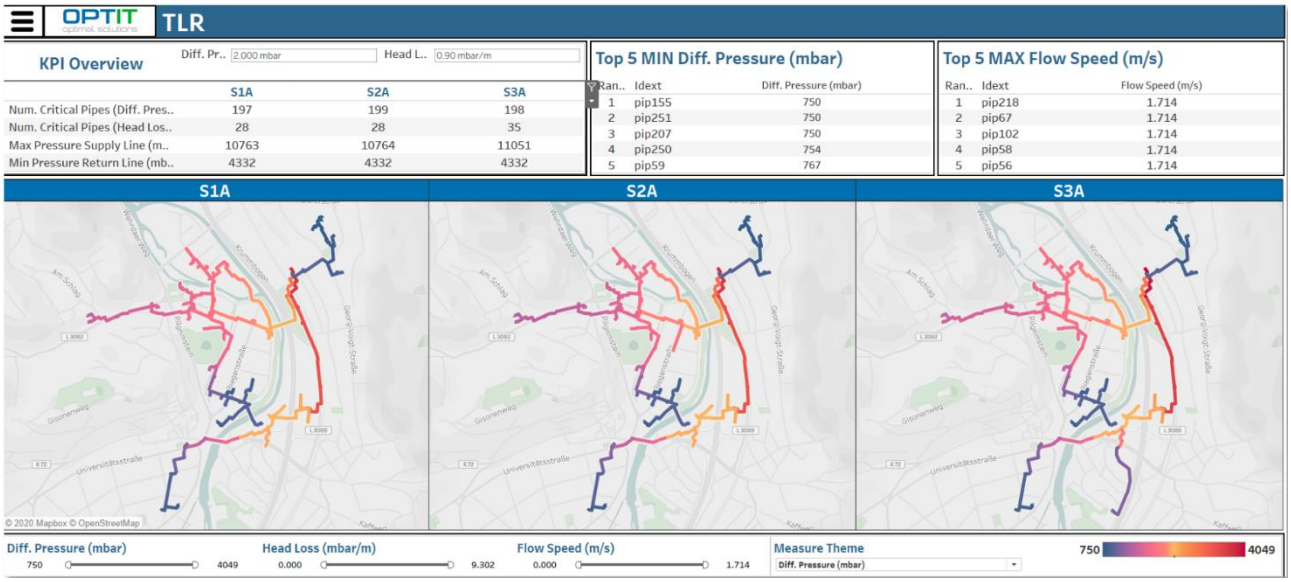

Figure 2: OPTIT scenarios for a DH grid[1]

The possibilities of OPTIT are high, especially following options are covered:

- Most valuable customers to be connected
- Backbone and service pipes to be extended with optimal diameter;
- Hydraulic feasibility of perspective scenarios
- Optimization of Heat Generation for future development
- Possibility to evaluate alternative scenarios with technical or economic variations
- Technical simulations of future network configurations
- Evaluation of Policy & Tariff Frameworks
- Detailed Hydraulic Model to analyse critical areas
- Investment value: costs, revenues, cash flows, NPV

Best practice example – Analysis Belgrade network

In the Belgrade DH grid analysis were done with OPTIT to evaluate the interconnection opportunities. Following boundary conditions were asked to analyse:

- Connection of a new 10 MW_{th} user, close to the end of the grid
- New DN350 backbone pipe
- Location of new pumping stations
- New renewable energy source connection
- “Outer ring” was calculated not to be necessary

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- Shut down of existing boiler stations

3. Bypass at DH grids[2]

Insufficient flow rates at the end of district heating pipes often lead to the district heating supply pipe cooling down. Bypasses help to avoid this, but this often leads to further problems in the district heating network, such as high return temperatures. The company Frese is a Danish component manufacturer, specialised in pressure independent control valves, with build-in max. flow limiters. Frese have recently developed IoT based valves who can address these problems.

The "Frese BYPASS" provides deep insight into a district heating grid, allowing to optimise energy efficiency by lowering temperature and reducing pressure. This bypass allows to monitor, operate and control the bypasses remotely and ensuring significant savings on energy. These intelligent components increase the value for service providers and customers.

It's possible to reduce heat loss in the grid and ensure that the customers always have access to hot water. The new data also allows you to optimise pump operation, avoiding unnecessarily high pressure. Frese BYPASS is designed with easy operation in mind. It can be retrofitted into existing installations, and because it is wireless and battery operated there is no need for complex or expensive external connections, wi-fi or sim cards. The solution uses the LPWAN network Sigfox, which has its own infrastructure already in place.

Frese has also developed a "flow guard" to wireless limit the flow at consumers (district heating substations). The valve measures the temperature and the pressure of the flow in the return pipe. Excessively high return temperatures or short circuits at customers can thus easily be recognized. Historical measurement data can be used to optimise the grid pump. The pressure in the return pipe is usually too high and provides information about the pump control. A characteristic curve for regulating the main pump in the grid can be implemented and thereby energy can be saved. The FLOWGUARD valve can also be used for basic peak-shaving, which in turn saves consumption costs.

The Frese IoT valves are monitored and operated via the webbased Frese FLOWCLOUD®. With the dashboard you have one central access point to all your Frese IoT units with access to historic graphs of pressure, temperature etc. The FLOWCLOUD® enables the integration of third-party systems via API. For example, the desired temperature can be set wirelessly. The differential pressure can also be measured with the valve closed and alarms can be set to a desired level. Most valve data are requested every 6 hours, although shorter intervals are also possible. This affects the life of the battery.

[2] https://www.frese.eu/Campaigns/Frese-Bypass/en-GB

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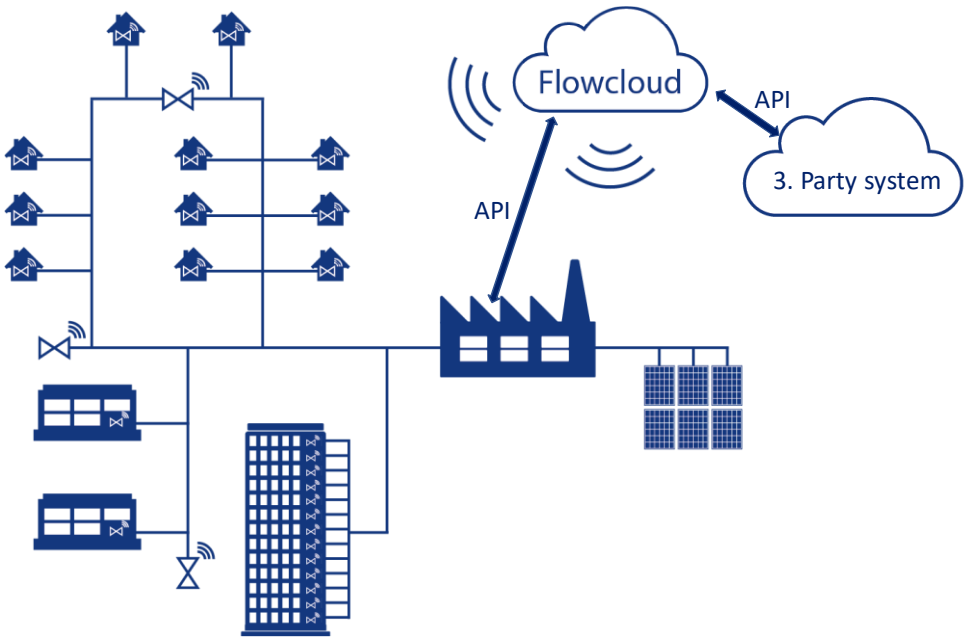

Figure 3: Bypass valves with wireless communication; FLOWCLOUD® connection to 3rd party systems; source: Frese

A best practice example shows the effect at Viborg district heating. “In a specific area of our network we could actually reduce the pressure much more than we had expected. We had set the pressure according to a regular pressure calculation, but data showed that we did not need that level at all. We could reduce the pressure by 0.4 bar in that area”, explains Tom Diget, Distribution Manager at Viborg district heating company. The bypass valves distributed in the network showed that the main pump can be operated with a smaller differential pressure and only the booster pump located in the grid should be operated with a slightly higher pressure. This modest change in the district heating network reduced the energy consumption 27,400 kWh.

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Figure 4: Frese BYPASS installed at Viborg district heating[2]

By placing Frese BYPASS strategically, the return temperature can be raised slightly at the critical points, while the inflow temperature can be lowered throughout the entire network, says Tom Diget: "That's where the money starts rolling in. Each time we lower the inflow temperature by 1 degree, we save DKK 250,000 (~33,600 Euro) in reduced heat loss. That's the real money, and that's what we should be able to do with this solution."

By monitoring the forward- and return pressure throughout the network it was discovered that over time there was an overall increase in network pressure. A small investigation was preformed, and it was soon discovered that a full in-line filter with a malfunctioning alarm was the cause of the pressure increase.

Martin Overbjerg from Frese mention that it is important to get the information and possibility to control at the far end of the DH grid and not only at the main heating plant. Many DH utilities are interested in the IoT valves and are currently testing them in their own network. The common thing is that they all want to have more information and control with the far ends of their networks. Martin's last statement was "I believe that

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in the future DH utilities will not be selling heat, but a room comfort temperature". This might give more flexibility for the DH grid, e.g. for peak load shaving.

4. Optimisations solutions[3]

Various solutions for optimisation of district heating grids exist. Here is mentioned the iGRID solution from Grundfos, that makes it possible to optimize the operation of the DH network by e.g. dividing the network into smaller zones. Within the individual zones, iGRID ensures optimal operation by means of standardized mixing loops in wells, cabinets or on bottom frames as well as control via real-time data from well measuring points and bypass cabinets.

What is done is that this solution helps reduce temperatures for decentralised city zones by mixing return water into the supply line of any branch in your grid, ensuring great benefits:

- R
  Lower temperatures in the grid mean reduced heat loss through the pipes – which results in savings and increased capacity.

- IMPROVED SYSTEM CONTROL
  Decentralised and distributed mixing loops ensure that pressure is only added when needed, which ultimately enables lower system pressure from the district heating plant and reduces leakages in the system.

Moreover, by lowering the return temperatures, the effectiveness of the heat (or cooling) production is increased. Real-time monitoring of temperature and pressure from critical parts of the system provides an overview and benchmarks for potential optimisation areas.

[3] https://product-selection.grundfos.com/dk/products/igrid?tab=documentation

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