Heat demand forecasting and operational optimization of a real-life, large district heating network

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Transition Technologies - Key figures

One of the leading Engineering and IT firms in Advanced Technologies

Complementary services between IT, Engineering and Outsourcing

3 continents, 7 countries, 19 offices

72 m EUR Revenue 2018

1600 Employees worldwide

Including greatest companies in:

- EDF
- E.on
- Vattenfall
- Trianel Energie
- Statoil
- astora
- uniper
- SSE
- Siemens
- Airbus
- Volkswagen
- BMW
- Thales
- EADS Astrium
- Audi
- HP
- IBM
- Siemens
- Caterpillar
- Rexroth Bosch Group
- Pearson
- Ministry of Finance
- Ministry of Digital Affairs
Sources of operating costs and methods for their reduction

- Decreasing the efficiency of the CHP
- Pumping cost
- Heat loss
- Leaks
Sources of operating costs and methods for their reduction

- Decreasing the efficiency of the CHP
- Differential pressure control using pressure measurement in a critical node
- Pumping cost
- Heat loss
- Leaks
Sources of operating costs and methods for their reduction

- Decreasing the efficiency of the CHP
- Replacement of pipelines
- Heat loss
- Pumping cost
- Leaks
Sources of operating costs and methods for their reduction

- Decreasing the efficiency of the CHP
- Modernization of DH substations controllers and heat exchangers (lowering $T_2$)
- Heat loss
- Pumping cost
- Leaks
Sources of operating costs and methods for their reduction

Decreasing the efficiency of the CHP

- Heat loss
- Pumping cost
- Leaks
Typical scope of „Smart district heating” projects

- Chambers monitoring system
- Integration with partners
- Modernization of pumping stations control system
- Demand Site Management
- Remote control of valves
- Improving DH substations meters
Typical scope of "Smart district heating" projects

- Enterprise service bus
- Modernization of pumping stations control system
- Demand Site Management
- Remote control of valves
- Improving DH substations meters
- Dashboards for dispatcher
- DH network simulator
- Chambers monitoring system
- Integration with partners
Typical scope of “Smart district heating” projects

- Forecasting and optimization
- DH network simulator
- Integration with partners
- Demand Site Management
- Enterprise service bus
- Pumping stations control system
- Remote control of valves
- Improving DH substations meters
- Dashboards for dispatcher
- Chambers monitoring system

- Typical scope of „Smart district heating” projects
Typical scope of „Smart district heating” projects

Example: **Smart District Heating** project carried out by Veolia Energia Warszawa S.A.

The task of **Transition Technologies** in that project:
To create an optimal strategy for controlling the network, using measurements data.

Goals:
- Lowering operating cost
- Reduction of CO₂ emissions by **14 500 ton** per year.
\[ K = K_{\text{heat}} + K_{\text{EP}} + K_{\text{pen}} \]

where:
- \( K_{\text{heat}} \) the purchase cost of heat from the CHPs,
- \( K_{\text{EP}} \) the purchase cost of electricity for pumping stations,
- \( K_{\text{pen}} \) cost of penalties (e.g. for exceeding the maximum flow in the CHP).

To build the optimizer we need to know:
- **Clear goal**
- Set of decision variables
- Proper heat demand forecast
- Network model (that represents physical phenomena)
- Constraints
Definition of optimization task

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- Clear goal
- **Set of decision variables**
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- State of the peak load heating plants (running or not)
- Supply temperature in the heating plants
- Supply pressure in the heating plants
- Pressure head in pumping stations
Definition of optimization task

To build the optimizer we need to know:

- Clear goal
- Set of decision variables
- **Proper heat demand forecast**
- Network model (that represents physical phenomena)
- Constraints

- Insensitive to data gaps
- Forecast horizon corresponding to the optimization horizon
Definition of optimization task

To build the optimizer we need to know:

- Clear goal
- Set of decision variables
- Proper heat demand forecast
- **Network model (that represents physical phenomena)**
- Constraints

- Fast calculations (rather without iterative calculations)
- Taking into account the influence of sources, valves, pumping stations
- Usefulness in the optimization process (e.g. continuous second derivatives)
Definition of optimization task

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- Clear goal
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- **Constraints**

- Ensuring the safe operation of the system
- Contract restrictions with a heat supplier
- Contract restrictions with customers
- **Existing practices**
Heat demand forecasting

Deep Artificial Neural Network

**Inputs**

**Weather data:**
- Avg. wind direction [deg]
- Avg. radiation [Wh/m2]
- Avg. temperature [°C]
- Avg. wind [m/s]
- Avg. humidity [%]
- Avg. Cloudiness. [8 degrees scale]

**The weather data transformations:**
- Avg. temperature$^2$
- Avg. temperature$^3$
- $\sqrt{\text{Avg. temperature}}$
- Avg. wind
- Avg. wind$^2$
- Avg. wind$^*$ Avg. temperature
- Wind direction share on axis North/South/West/East
- Wind chill

**Variables connected with time:**
- Hour
- Week day
- Day working/weekend
- Holidays
- Christmas

**Variables:**
- Heat demand historical measurements

For the entire network

- Heat demand forecast
- Heat demand - measurement
- Ambient temperautre forecast

**Forecast is calculated for:**

- For the entire network
- For $X \cdot 10^1$ zones
- For $X \cdot 10^3$ substations
Models were created based on:
- Historical data,
- Data obtained from identification experiments on the simulator.

About 2000 dynamic models in total.

Model inputs:
- Season and set of working sources
- Forecasted heat demand
- Valves opening
- Supply temperature and pressure in the plants
- Pressure head in pumping stations
- Work plan for plants and pumping stations (charts, tables)
- Control scenarios in a number of variants (aggressive and conservative ones)
- Interactive user interface
- Dashboards for analysts and dispatcher
- Integration with external systems (also with simulators)
- Alarms
Thank you

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