Increasing Investments in District Energy Systems in Cities – a SE4All Energy Efficiency Accelerator – City of Belgrade

Final results of the interconnection study
Founded in 2007

Spinoff of the Operations Research (OR) team of the University of Bologna

We develop solutions and services based on analytics & optimization

Young and highly skilled team: everyone holds a STEM Master Degree or PhD

We are Data scientists, Business consultants, Operations Research specialists, SW application dev. professionals

We work for medium and large enterprises in several industries: Energy, Waste, Logistics, Retail, etc.

We participate in the scientific community and active in fostering “OR in Practice”

2 main Offices

Consultancy services and Commercial HQ in Bologna

SW Factory in Cesena
Proposition in DH

**GENERATION**
- DSS for Energy production optimisation
  - H/P/C demand forecast
  - Operational scheduling of production assets to optimise operating margin
  - Budgeting and what-if yearly analyses
  - System integration for automatized process

**DISTRIBUTION**
- DSS for network development optimisation
  - Investment (NPV) optimisation analysis
  - Technical and economic decision drivers integration
  - Advanced built-in thermal-hydraulic model for feasibility check

**DEMAND**
- Advanced analytical methodologies
  - Heat consumption patterns and profiling
  - Identification and qualification of user clusters
How to plan District Heating (Cooling) Network Development roadmaps that maximise the Return on Invested Capital (i.e. Net Present Value), amongst countless possible options?

**THE BUSINESS OBJECTIVE**

**CHALLENGES FOR DECISION MAKING**

- **Geographic** dimension of the business issue (overcome Excel)
- Economic value assignments on costs and revenues sides
- Several possible potential scenarios (what-if)
- Thermal-hydraulic feasibility analysis of proposed solutions
DHN: the solution

Existing & potential pipings

Existing & potential users

Existing & potential plants

Import + Puntual editing/drawing

Tariffs & Capex/Opex

Technical constraints

Financial parameters

Advanced Scenario Mgmt
The tool allows for a smooth transition of the feasibility and commercial analysis from Marketing & Sales to Engineering department.
The key challenge: identify the optimal new network configuration

Analyze the technical and economic impacts of:

- Different interconnection scenarios
- Different piping sizing
- Integration of “carbon-friendly” energy sources

Goal: striking a balance between complex conflicting options

- Technical and operational drivers
- Resource allocation
- Reference load to dimension
- One vs multi-connections
- Renovation vs New Piping
- Peak vs Low Load
Project approach

Preliminary Activities
- Data collection and integrity checks

Calibration
- Calibration and validation of Optit’s hydraulic model

Scenarios Analyses
- Technical/economic analyses of identified investment scenarios

Delivery
- Shared assessment + Full report & Cartographic representation of the results

**Reliable characterization of the current DH system**

Benchmark 3 major sub-grids:
- **Optit’s model vs SCADA vs TERMIS**
  - Deviation < 0.3 bar for supply/return pressures & ΔP at the plant and the network’s critical points

**Pre-feasibility studies of investment scenarios**

- Produced, analyzed and discussed several (100+) potential new network configurations
  - Technical and economic insights on future infrastructure investment and its impact on operations
Subject of the analyses

Focus on:
- Novi Beograd (NB)
- Konjarnik (KO)
- Dunav (DU)
- Zemun (ZE)

NEW CONFIGURATIONS

- Perspective users to be connected (88 MWth)
- New (greener) sources: Thermal Plant (600 MWth) + WTE (56 MWth)
- Planned construction of new piping and refurbishing of existing piping

TWO SEPARATE HYDRAULIC SYSTEMS

- Temperature-based regulation (always nominal flows) in Zemun-NB
- Flow-based regulation (demand-dependent flows) in Konjarnik-NB-Dunav
New Zemun-NB system

**Work Conditions**

- The connection must allow Zemun’s current plant shut-down
- NB backbones have tight constraints (supply and Δp at the plant)
- The new network configuration must follow the current hydraulic regime and temperature-based regulation
- Can leverage upon presence of closed pipes linking NB main backbones

**Investigation Lines**

- Hydraulic balance of new network configurations
- Impact of opening different sets of closed pipes
- Impact of the new backbone construction
- Characterization of the pumping stations
New Zemun-NB system

**NEW NETWORK CONFIGURATION**

**Δp distribution**
- 1.0-1.5 bar
- 1.5-2.0 bar
- 2.0-3.0 bar
- > 3.0 bar

**New opened pipes**
- M1
- M2
- M3
- M4
- M5

**Current Status**

**Perspective Scenario**

**Improved system resiliency**
The hydraulic balance complies with the technical constraints provided and adheres to the current conditions.

The load in Zemun is taken on by the expanded capacity in NB, allowing the current local boiler house to be dismissed.

The interconnection investment itself (without the costs of integrating TENT A) has an immediate payback time (< 2 months).
## Initial Work Conditions

- The multi-network connection will **maximize the supply of new sources** (especially at lower loads)
- Significant **altitude differences** pose technical challenges to pressure management
- Presence of **closed pipes** linking the separated networks may be an opportunity

### Potential new backbones (green lines)

### Potential refurbishment of existing backbones (purple lines)

### Planned new pumping station(s)

### Connection of new users (63 MW\textsubscript{th})

### Existing Boiler stations (15 MW\textsubscript{th}) to be shut down
New NB-DU-KO system

INVESTIGATION LINES

- Hydraulic balance of the new aggregated network
  - Minimize operating pressures
- Planned new piping vs refurbishment of existing assets
  - Trade-off between costs/technical Benefit
- How to operate in low-load conditions
  - Is it feasible to rely on new sources only?
- Impact of opening closed-down pipes
  - Does it improve the hydraulic balance?
- Design of the new pumping station(s)
  - What is the required minimum Δp?
New NB-DU-KO system

SUMMARY OF RESULTS WORK CONDITIONS

The “outer ring” has been proved not to provide significant benefit

Planning guidelines have been confirmed and refined, integrating additional spot actions
**NEW NETWORK CONFIGURATION (100% FLOW)**

**Scenario 1: NB-DU-KO Connection (100% Flow)**

- Shift in critical areas
- $\Delta p$ distribution

**Scenario 2: NB-DU Connection (100% Flow)**

- Shift in critical areas

**Current Status**
In low load scenarios the heat coming from TENT-A serves an even larger portion of Dunav’s system, allowing a decrease in $\Delta p$ at the plant, without reaching critical conditions at the peripheral sections of the network.
CONCLUSIONS

The interconnection plan is feasible and may be achieved in different manners (S1 & S2), allowing for operational flexibility in case of boundary conditions variations.

Refurbishment of long segments of existing pipeline is necessary in order to comply with the technical constraints and avoid bottlenecks (yet, the outer ring has been seen to be superfluous).

In low-load conditions the new sources may be saturated within the technical constraints and many areas in Dunav and Konjarnik may be then served by TENT-A, decreasing the Δp required at the former plants.

The interconnection investment itself (without the costs of integrating TENT-A) has an payback time of less than 3 years.
Conclusions

✓ The current networks have been configured into Optit’s tool, with a successful validation against both SCADA data and TERMIS simulations.

✓ Lots of (+100) potential investment scenarios have been considered and analyzed, determining the best trade-off between investment costs and technical benefits.

Interconnection scenarios are feasible and show increased operating flexibility in different load conditions, that can be exploited in light of future further network expansion.

✓ The finalized scenarios have been provided through cartographic data, KPI assessment and investment cash flow analysis.
Initiate the DH **upgrading process** for 8 systems up to the investment stage (Generation, Distribution, Use)

Produce **Best Practices and Tools** Handbooks

Develop regional / national action plans for DHN **retrofitting**

Replicate the proposed solutions across Europe

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 785014. The sole responsibility for the content of this report lies with the authors. It does not necessarily reflect the opinion of the European Union nor of the Executive Agency for Small and Medium-sized Enterprises (EASME). Neither the EASME nor the European Commission are responsible for any use that may be made of the information contained therein.
Thank you for your attention!