Decision Support System in District Heating: Analysing, Connecting, Developing and Optimising, a joint effort!

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Matteo Pozzi, Optit Srl
From OPERATIONS RESEARCH To OPTIMISED OPERATING NETWORKS
Summary

From Academy to Business Solution ... (Optit srl)
- Research to business
- DH/C network development optimisation

... through full industrialisation ... (A2A)
- Complex business investment decisions ...
- ... managed to optimality

... ready to scale up for the Int’l Markets (Optit srl)
- High impacts on strategic and commercial development
- Partnering to scale up
Optit: spin-off from Bologna University

Optit srl is a spinoff of the Operations Research team of the University of Bologna with the mission to develop innovative Decision Support Systems based on state-of-the-art Operations Research.

**WHAT WE DO**

- IT solutions development & deployment
- Operations Research and Mathematical Modelling
- Business analysis & management consulting

**MAIN BUSINESS AREAS**

- WASTE
- ENERGY
- LOGISTICS & TRANSPORTS
- RESOURCE MANAGEMENT
- CUSTOM OPTIMISATION MODEL
A first exploratory project is funded in 2008-2010 to the University of Bologna to explore innovative algorithms to optimise development of DH networks.

The idea: given an existing DH and multiple potential customers across a given area:

- Where should new pipes be built ... 
- Which potential new customers should be acquired first ... 
- ... in order to achieve max Net Present Value?
Optit invests on the potential for industrial application of academic POC

Agreement with UNIBO: algorithm is acquired vs. royalty over future revenues (which would fund further research)

Full SW application is developed, including:

- Integration of model in open source GIS
- Model enhanced to manage real life instances (various hundred of points)
- First deploy to leading Italian Utility
Network setup and configuration

- Import of existing network and customers (*)
- Import of potential customers
- Editing of each element of the DH system

(*) Multiple networks can be managed as separate instances
Management of scenario parameters

- Configuration of heating plants
- Selection of prospects
- Set up of revenues and costs
- Set up of optimization parameter: technical, economic, and constraint
Optimisation of DH network

**Optimal Solution**
- Customers to be connected
- Pressures at pipes
- Backbone and service pipes to be built with min. diameter;
- investment value: costs, revenues, cash flows, NPV
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A2A is the main player in the DH sector in Italy (30% market share)

<table>
<thead>
<tr>
<th>OPERATING DATA(^{(1)})</th>
<th>2016</th>
<th>2017</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat volumes sales</td>
<td>GWh/t</td>
<td>2.412</td>
<td>2.959</td>
</tr>
</tbody>
</table>

\(^{(1)}\) Net of distribution losses; 2016 including 5 month LGH consolidation; 2017 onward FY LGH consolidation

<table>
<thead>
<tr>
<th>ASSET PORTFOLIO*</th>
<th>2016</th>
<th>2017</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal capacity - property plants</td>
<td>MWt</td>
<td>1.797</td>
<td>1.811</td>
</tr>
<tr>
<td>District heating networks</td>
<td>Km</td>
<td>1.175</td>
<td>1.190</td>
</tr>
</tbody>
</table>

* 2016 including 5 month LGH consolidation; 2017 onward FY LGH consolidation

<table>
<thead>
<tr>
<th>Network extension (pair of pipes)</th>
<th>Customers</th>
<th>Heated volumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>(km)</td>
<td>(n.)</td>
<td>(Mm³)</td>
</tr>
<tr>
<td>Bergamo</td>
<td>71</td>
<td>585</td>
</tr>
<tr>
<td>Brescia area</td>
<td>669</td>
<td>20.392</td>
</tr>
<tr>
<td>Milan area</td>
<td>299</td>
<td>3.181</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1.039</strong></td>
<td><strong>24.158</strong></td>
</tr>
</tbody>
</table>

A2A also own and manage two small DC systems, one in Milan and one in Brescia (50 GWh/y, total networks extension 13 km)
Main DH systems

- **A2A: DH networks**

  - **Milan area**
  - **Bergamo**
  - **Brescia area**
  - **Lombardia**

  **Operating pressure**
  - up to 14 bar

  **Operating temperature**
  - winter: 90°C ÷ 120°C supply, 60°C return
  - summer: 80°C ÷ 90°C supply, 60°C return
The business problem (1)

Potential customers
- $P \leq 0.2$ MW
- $0.2 < P \leq 0.5$ MW
- $0.5 < P \leq 1$ MW
- $1 < P \leq 5$ MW
- $P > 5$ MW

Development areas
- New pipeline

Interconnection
4 km

Width < 1 km

Heat demand potential > 100 MW (130 GWh)
The business problem (2)

Summarising

- Huge heat demand potential
- Limiting conditions both for the production side and for transport capacity of the system
- Need to analyse and compare a lot of small areas to decide on DH development plan

As a result

- Market survey for DSS tool (network development optimisation)
- Development of an existing tool based on A2A requirements
Further improving the DSS

- Optit and A2A have been collaborating for more than 2 years, leading to multiple improvements:
  - Management of larger instances more effectively;
  - Math model’s refined to match commercial simulation SW
  - Improvement of several functionalities, including capability to draw potential backbones directly from the user interface (whose diameter is chosen to optimality)
- Further investments ongoing to manage revamping of mature systems
Case studies (1)

**Gestione simulazioni**

**Visualizzazione risultati**

**Versione confronto:** 1 - Martinetti (VIRTUALE)

### Parametri input

<table>
<thead>
<tr>
<th>Parametro</th>
<th>Arzaga Est _Optimizzazione 08/05/2017,...</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRUPPO DI RIFERIMENTO</td>
<td></td>
</tr>
<tr>
<td>Costo fisso contratto nuovo allacciamento (€)</td>
<td></td>
</tr>
<tr>
<td>Costo variabile nuovo allacciamento (€/kW)</td>
<td></td>
</tr>
<tr>
<td>Quota contributo di default per SST client...</td>
<td></td>
</tr>
<tr>
<td>Quota contributo di default per rete (%)</td>
<td></td>
</tr>
<tr>
<td>DeltaP minimo al cliente (bar)</td>
<td></td>
</tr>
</tbody>
</table>

### Parametri output

<table>
<thead>
<tr>
<th>Parametro</th>
<th>Arzaga Est _Optimizzazione 08/05/2017,...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Num tot potenziali gruppo di riferimento</td>
<td>22</td>
</tr>
<tr>
<td>Potenza tot potenziali gruppo di riferimento</td>
<td></td>
</tr>
<tr>
<td>VAN complessivo (€)</td>
<td>3.538.890</td>
</tr>
<tr>
<td>Num clienti da allacciare</td>
<td>21</td>
</tr>
<tr>
<td>Potenza totale nuovi clienti (kW)</td>
<td>16.180,5</td>
</tr>
<tr>
<td>Ricavo nuovi allacciamenti (valore attuale)</td>
<td>7.792.120</td>
</tr>
</tbody>
</table>

[Image of a map with marked areas and a software interface with data from a simulation]
Scenario comparison

<table>
<thead>
<tr>
<th>Area Name</th>
<th>network extension [m]</th>
<th>Heat volume [MWh/y]</th>
<th>Investment [€]</th>
<th>NPV [€]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arzaga East</td>
<td>1.400</td>
<td>20.800</td>
<td>1.600.000</td>
<td>3.500.000</td>
</tr>
<tr>
<td>Arzaga East (without hospital)</td>
<td>1.200</td>
<td>8.900</td>
<td>1.100.000</td>
<td>1.100.000</td>
</tr>
<tr>
<td>Arzaga West</td>
<td>1.100</td>
<td>6.100</td>
<td>1.000.000</td>
<td>955.000</td>
</tr>
<tr>
<td>Gulli East</td>
<td>950</td>
<td>6.630</td>
<td>830.000</td>
<td>800.000</td>
</tr>
<tr>
<td>Crimea East</td>
<td>800</td>
<td>6.100</td>
<td>710.000</td>
<td>790.000</td>
</tr>
<tr>
<td>Martinetti</td>
<td>820</td>
<td>5.395</td>
<td>710.000</td>
<td>630.000</td>
</tr>
<tr>
<td>Crimea West</td>
<td>540</td>
<td>3.500</td>
<td>470.000</td>
<td>410.000</td>
</tr>
<tr>
<td>Gulli West</td>
<td>520</td>
<td>2.800</td>
<td>430.000</td>
<td>270.000</td>
</tr>
</tbody>
</table>

Operating network
From analysis to construction site

Via Martinetti - Milan
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Effective support to decision making...

- New networks feasibility and high level design
- Expansions of existing networks (backbones)
- What if scenario analysis (infrastructure)
- New customer acquisition campaigns
- Optimisation of customer portfolio
- What if scenario analysis (tariffs and costs)
- Maximisation of Net Present Value, provides optimal balance between CAPEX, OPEX and Turnover
- Solutions incorporate both commercial and tactical rationales, leading to more effective internal processes (often used by sales dep’t)
Optit and A2A’s have partnered up to support DH/C development design and optimisation analysis:

- Solution maps the real Investment Decision Making process
- (open source) GIS tool allows effective user experience
- State-of-the-art mathematical model integrates thermal-hydraulic and economic decision drivers (at once)
- Long lasting asset design and construction experience guarantees business driven approach, covering the full value chain (from heat generation to end user delivery)
- Strong technical engineering expertise to ensure smooth evolution towards final design and execution
Questions or comments?

Thank you for your attention

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