Large district heating network development based on Waste Heat Recovery

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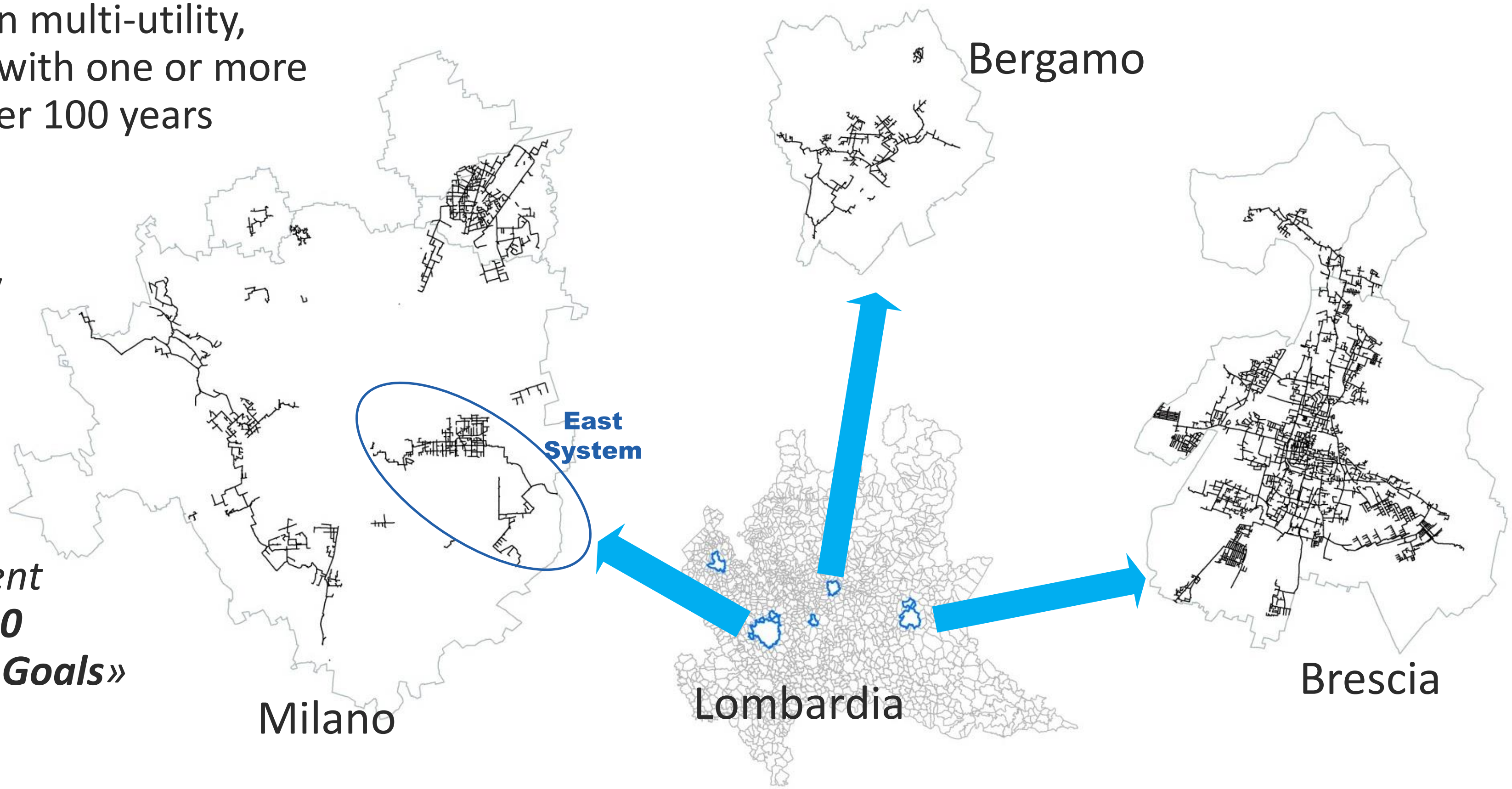
#SESAAU2021

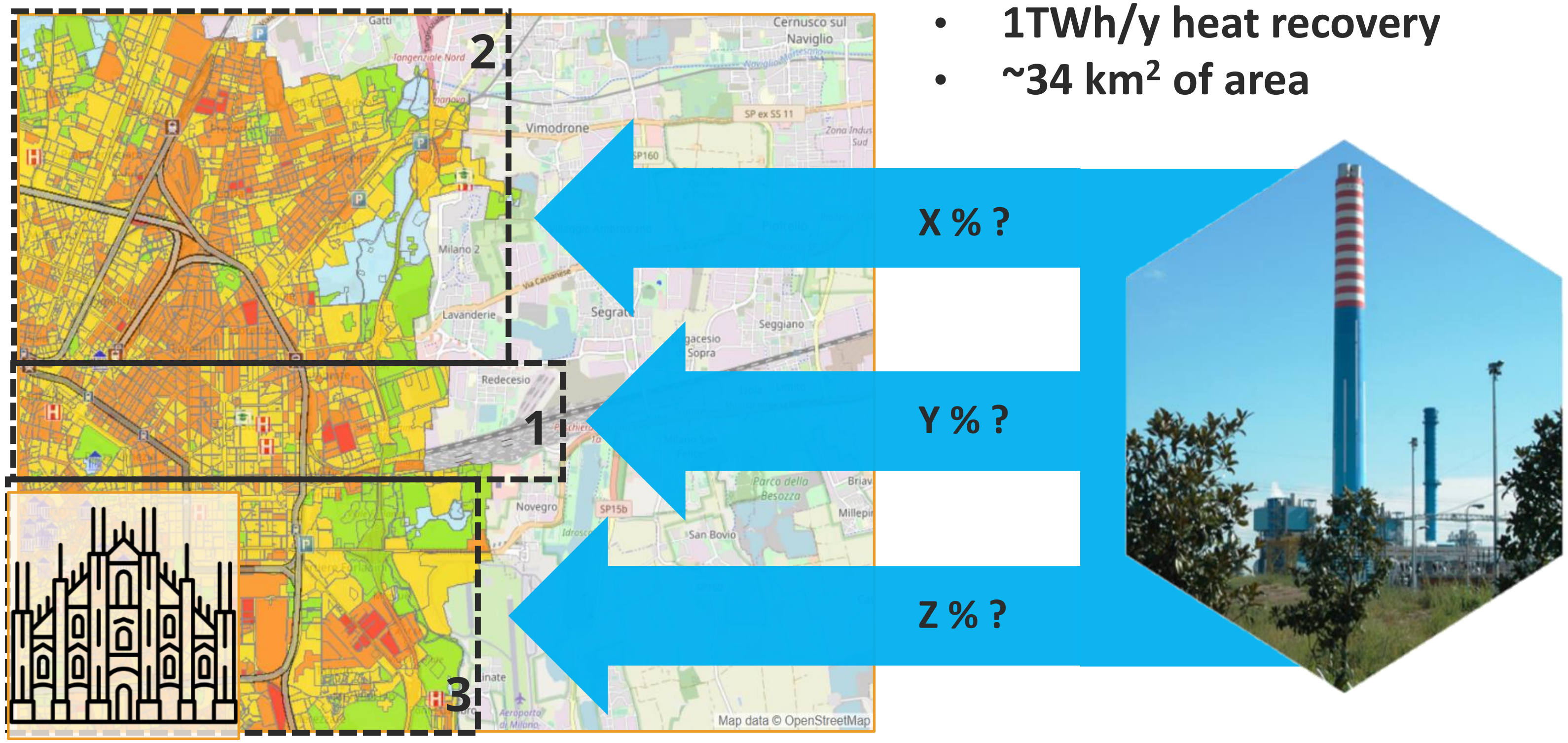
A2A Calore e Servizi

- **A2A Calore e Servizi** is part of A2A, a “Life Company”. A2A is the biggest Italian multi-utility, serving over 2.3 million customers with one or more services, 12,000 employees and over 100 years of history
- We manage District Heating & Cooling networks and other Energy efficiency services in the cities of Milan, Brescia and Bergamo
- National leader in DHC industry
- *«By 2030, we want to make a solid contribution to the attainment of **11 of the 17 United Nations 2030 Agenda Sustainable Development Goals**» including #07 Affordable and clean energy and #13 climate action*



The Opportunity

- Within the **NextGenerationEU plan**, the opportunity has materialised to study the recovery of **waste heat** from the Cassano's thermal-electric plant
- A preliminary design of a **backbone** to reach the East Milan area has been done, together with a **storage** system to increase peak capacity, with 3 feeding nodes
- This may expand the **East Milan** system (area 1), bringing DH to a vast, highly populated area



- **1TWh/y heat recovery**
- **~34 km^2 of area**

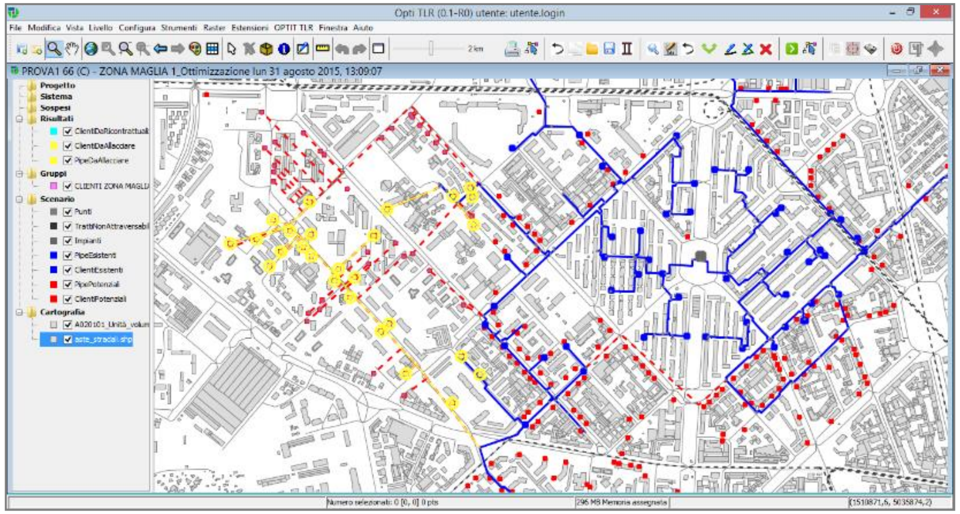
The Goal

- How to optimize the allocation of the available heat on the expansion areas (1, 2 e 3 in figure)?
- Which potential users should be connected first to increase sustainability?
- What is the optimal piping layout?

Optimize the DH network design and investment budget, taking into account **technical and economical constrains**

Accredited Spin-off of the Alma Mater Università di Bologna (Operations Research and Management Science), based in Bologna and Cesena (Italy). We design, develop and provide state-of-art Solutions and Services in Advanced Analytics and Optimization

Long-lasting experience in DHC modelling and Optimisation DSS. Significant role in key DHC communities (DHC+, Celsius Cities, UNEP's District Energy in Cities Initiative, several EU Horizon 2020 projects, Italian and EU commercial projects …)



Network Development Optimisation and Simulation

Energy Production Optimisation of Smart Energy Systems

Tool for Optimal Development of DH Networks

BUSINESS OBJECTIVES

Support **development of District Heating/Cooling networks**, achieving **maximum ROI/NPV** while respecting all thermo-hydraulic, economic and urbanistic constraints.

THE SOLUTION

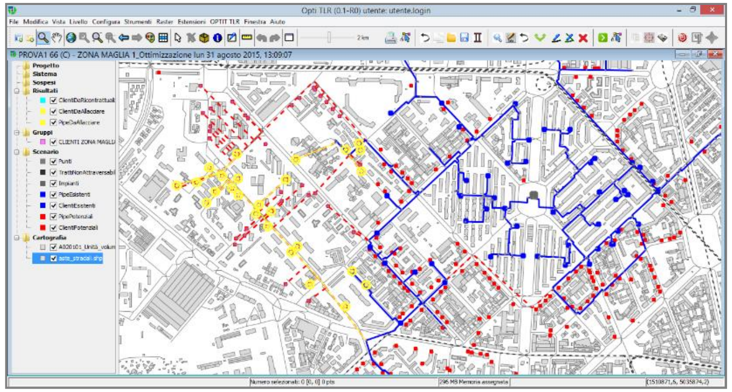
Decision support system based on open-source **GIS** technology, to support generation of multiple optimal development scenarios with advanced modelling tools **integrating all decision drivers** (technical & economical)*

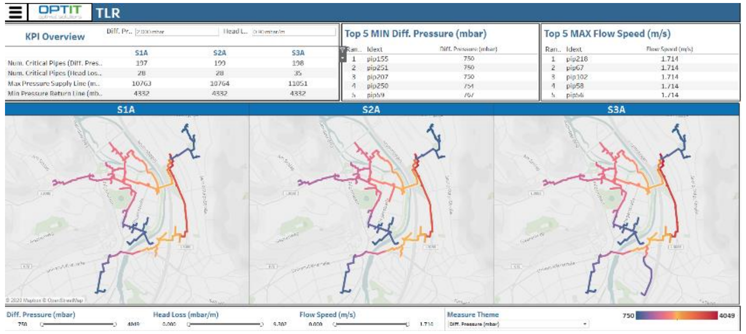
KEY FEATURES

- Large set of **decision parameters** to reproduce decision making process of large leading utilities
- Industry standard **thermal-hydraulic modelling**
- Quick generation of highly complex **development scenarios**

APPLICATIONS

- Support **strategic investments** (new networks or network expansion)
- Support **commercial development** (set of next best potential customers)
- Simulation to support advanced **what-if analysis**





Parametri input

Parametro	Valore
GRUPPO DI RIFERIMENTO	Potenza (KW) >= 50.0 Distanza (m) <= ...
Costo fisso contratto nuovo allaccio (€)	0
Costo fisso contratto ricontrattualizzazion...	100
Pressione min cliente (bar)	0,4
Fattore contemporaneità	0,6
Tasso di interesse VAN	0,065
Max clienti allacciabili	50
Max clienti ricontrattualizzabili	100

INDICE	VALORE
VAN	€ 399.739
TIR	12,1%
BPT	14

ANNO	RICAVO	COSTO	AMMORTAMENTO	IMPONIBILE	TASSE	FLUSSO_NETTO	COEFF	VALORE ATTUALIZZATO	VALORE__ATT_CUMULATO
0	€ 221.612	€ 1.093.214	€ 23.296	€ 65.348	€ 20.519	-€ 892.122	1,000	-€ 892.122	-€ 892.122
1	€ 354.579	€ 357.999	€ 28.656	€ 113.175	€ 35.537	-€ 38.957	0,926	-€ 36.071	-€ 928.193
2	€ 443.223	€ 362.768	€ 32.229	€ 145.060	€ 45.549	€ 34.906	0,857	€ 29.926	-€ 898.267
3	€ 487.546	€ 340.945	€ 34.016	€ 161.002	€ 50.555	€ 96.046	0,794	€ 76.245	-€ 822.022
4	€ 531.868	€ 367.538	€ 35.802	€ 176.945	€ 55.561	€ 108.769	0,735	€ 79.949	-€ 742.074
5	€ 576.190	€ 394.131	€ 37.589	€ 192.887	€ 60.567	€ 121.492	0,681	€ 82.686	-€ 659.388

* The tool is the evolution of a system presented at 4DH conference in 2016, used in other projects at EU level including

The business challenge

The Challenge

- **«Blank Canvas» network development** strategy over a very **vast area** (~34 km^2 in urban area)
- Huge **dimension** of problem: more than 20,000 arc roads and 8-10,000 potential customers
- Large uncertainty on **several technical and economic decision variables**
- **Challenging delivery timeline** to support engagement with local institutions

The project's requirements:

- **Pragmatic approach to the Feasibility Study** to focus on key economic and technical issues
- **Focus on the project's goals** leveraging on the tool's functionalities (hydraulic model, economic optimisation)
- **Flexible management of several** scenarios
- Allow good **User Experience** to share results and analysis

Objectives:

- **Support a complex decision making process** involving multiple stakeholders
- **Provide reliable KPIs and visualisation means** to evaluate the most promising target scenarios
- Assess **impacts and interdependencies** of key decision variables

The methodology

	Problem Setup	Network Design	What-if Analysis
AIM	Handle problem dimension Bundle available geographic and economic data	Saturation of available power over most promising prospects Optimisation of CAPEX while respecting hydraulic constraints	Fine tuning of scenarios Achieve reliable and robust budgeting requirements for investment
PHASE	Scenario configuration starting from roads map	Feasible optimal configuration of network	Solution refinement and resiliency assessment
OUTPUT	Data upload and integration Key simplifying assumptions to de-couple 3 zones	2-step network design approach (see following slide) Baseline scenarios ready for sensitivity analysis	Identification of most promising target scenario Basis for larger engagement of decision stakeholders

The 2-step Network Design approach

1 Network Layout

Objective function:
Topology optimization
(*minimization of network length considering piping flow*)

2 CAPEX Optimization

Objective function:
Diameters optimization
(*target power saturation respecting hydraulic constraints*)

Layout Model → **Techno-economic Model**

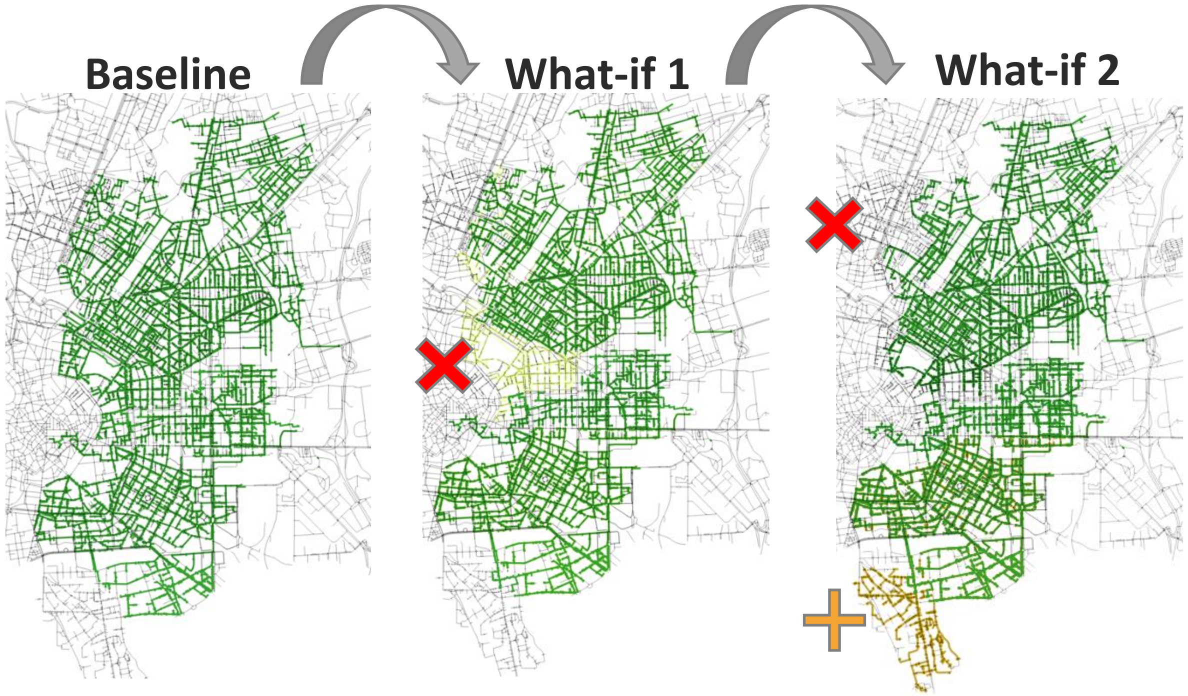
Output:
Backbones graph

Output:
Optimally sized network

What-if & Sensitivity analysis

Main decision drivers explored

- **Capacity Allocation to different zones** linked to given constraints, leading to different expansion patterns
- **User Acquisition variability** ranging from 100% to 70% of the total users
- **Piping Costs** variation evaluation, associated to expected infrastructural issues
- Different **Peak Power** availability



	Baseline -	What-if 1 South+	What-if 2 South++
NPV (€)	€€€	6,5%	11,7%
IRR (%)	%%	1,4 p.p.	2,9 p.p.
TOTAL COST (€)	€€€	-2,4%	-5,4%
BACKBONES COST (€)	€€€	0,5%	-1,2%
CONNECTIONS COST (€)	€€€	-2,2%	2,3%
EXTRA COSTS (€)	€€€	-17,4%	-38,0%
SST COSTS (€)	€€€	-1,9%	-0,5%
TOTAL LENGTH (km)	286,2	-0,4%	-1,0%
BACKBONES LENGTH (km)	235,5	0,0%	-2,0%
CONNECTIONS LENGTH (km)	50,7	-2,1%	3,1%
€/m COST (TOT)	€€€	-2,1%	-4,6%
€/m COST (pipes only)	€€€	-2,9%	-5,4%
€/m COST (backbones only)	€€€	0,1%	-2,8%
CONSUMERS DENSITY (MWh/km)	XXX	0,2%	1,7%
CONSUMERS DENSITY (€/MWh)	€€€	-2,7%	-5,1%

INSTALLED PIPE DN (km)	Baseline -	What-if 1 South+	What-if 2 South++
Distribution Network (DN < 300)	261,1	0,2%	-1,2%
Transmission Network (DN ≥ 300)	25,1	2,2%	0,0%

Advanced analysis tools & deliverables

- BI support
- Scenario shapefiles
- Cash flow sheets

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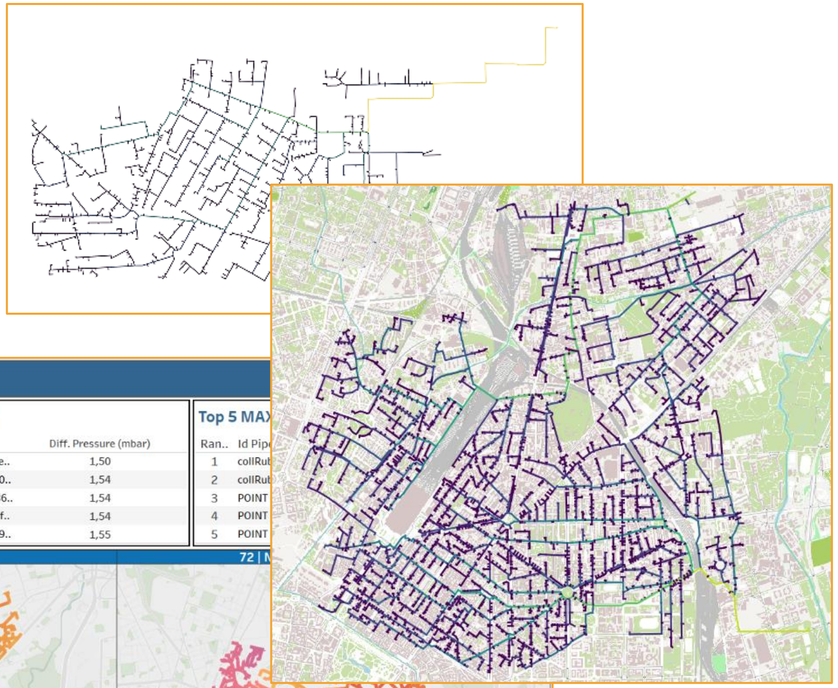
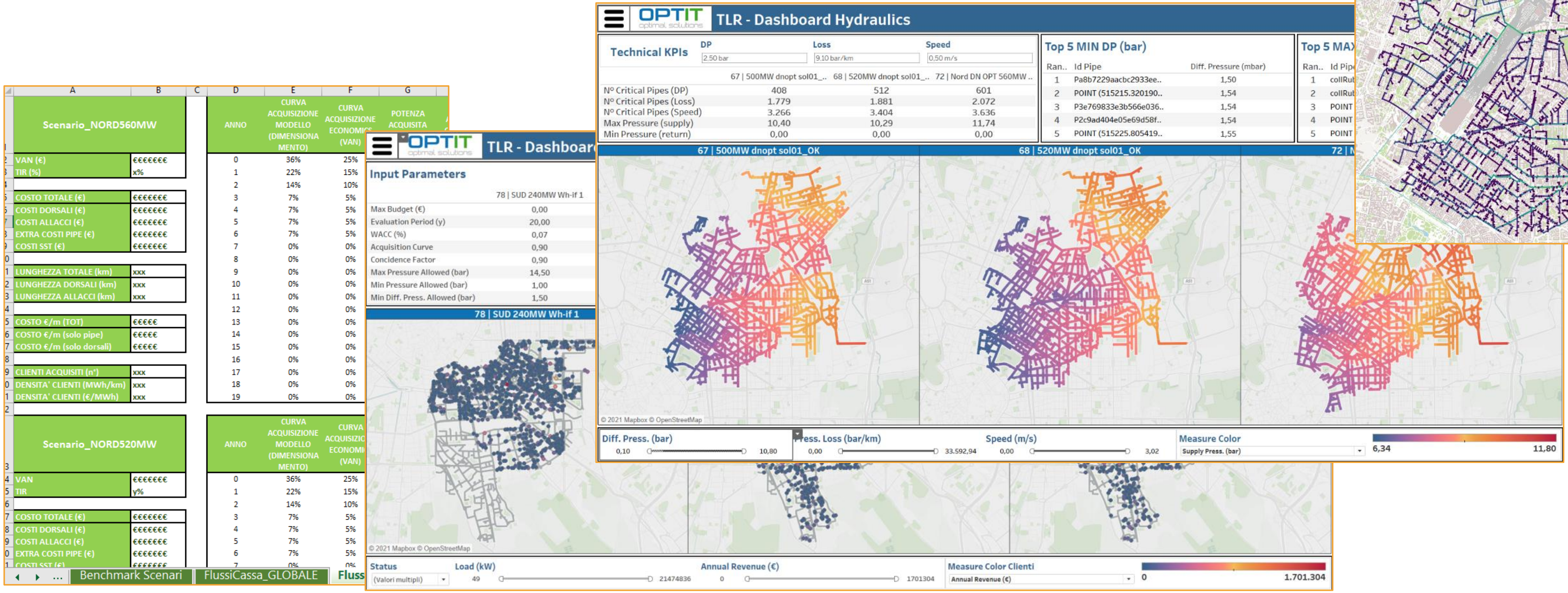
- High impact analysis
- Usability
- Stakeholder engagement





Conclusions

- **Proven approach for very large DH Networks design**
  - ❑ Starting from the project scope definition, **a step-by-step approach based on Optit's advanced Decision Support System enabled the joint team qualify the most significant scenarios**, out of a virtually limitless number of possible expansion patterns, within challenging time constraints
- **Backbone Topology and Optimal Sizing Definition**
  - ❑ **The optimal network topology was designed for each target area**, taking into account specific technical and economic constraints
  - ❑ **CAPEX and NPV Optimization for each scenario was achieved**, yielding the perspective network outlook for each scenario, while ensuring thermal-hydraulic feasibility
  - ❑ **The most promising scenario of network configuration was eventually identified**, with corresponding technical and economic KPIs (expected investment costs)
- **Comprehensive Deliverables**
  - ❑ **Cash-flow sheets, target KPIs and cartographic representation** of each scenario was provided, leading to further deep-dive analysis and supporting decision making process across various stakeholders
- **Future Steps**
  - ❑ Consolidate the technical and economic conditions, in a dynamic multi-stakeholder context
  - ❑ Refine the NPV assessment, taking into account further operational and economic conditions
  - ❑ Locally adjust the network topology in order to assess more detailed geographic constraints

Thank you for your attention

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