Industrial waste heat recovery: potential and economic feasibility for district heating in Italy

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Ricerca di sistema elettrico nazionale
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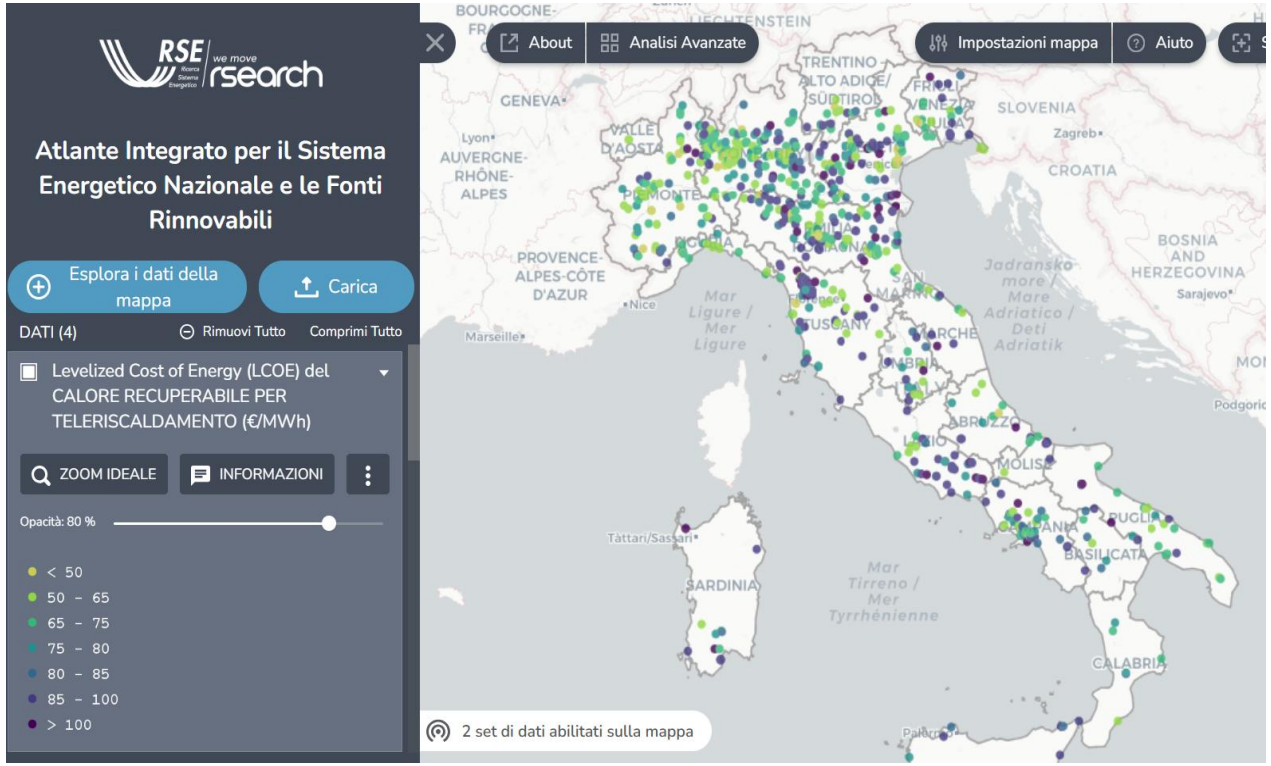
Presentation content

Web tool for the promotion of Industrial Waste Heat recovery in DH

Presentation of the tool main features:

- heat demand mapping
- industrial waste heat sources mapping
- Optimization
- Project evaluation



Four Pillars for Industrial Decarbonisation

Energy efficiency	• Energy Management • Improved Process Efficiency • **Waste heat recovery**

Industrial Electrification	• Electrification of Heating Process • Electrification of Hydrogen Production • Development of Electrified Process

Low carbon Fuel	• Development of Carbon free Alternative Fuel • Utilization of Carbon free Alternative Fuel • Development of Biofuel Infrastructure

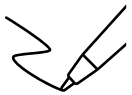
Carbon Capture, Utilisation and storage	• Carbon Capture, Utilization and Storage • Chemical Utilization

The Project

Web tool for the promotion of Industrial Waste Heat recovery in DH

Collaboration RSE and PoliMI

- Matching between heat demand and industrial waste heat sources



- Potential recovery projects

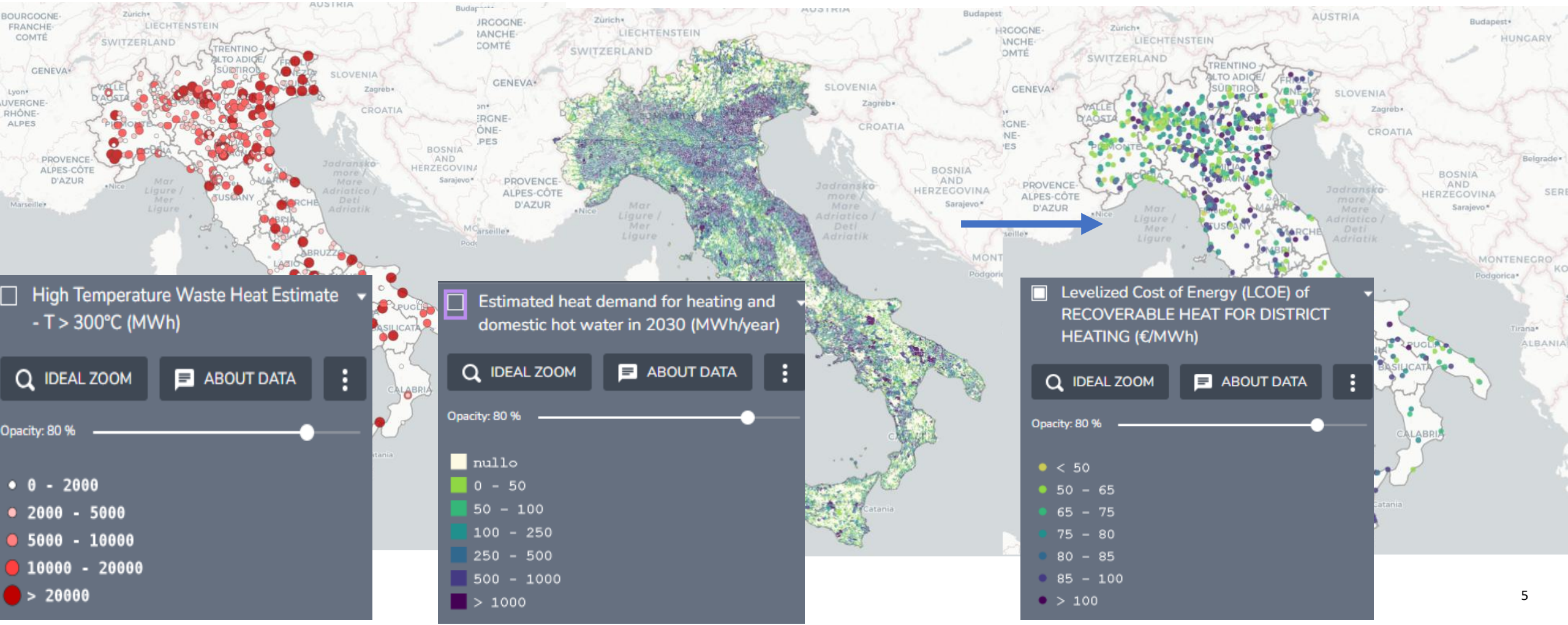
- User customized analysis – embedded optimization algorithm

The Atlas

Industrial waste heat sources

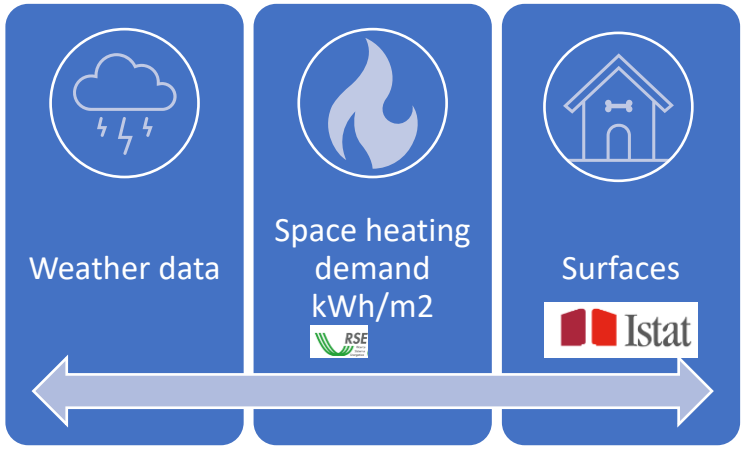
Heat Demand

Potential WH recovery in DH

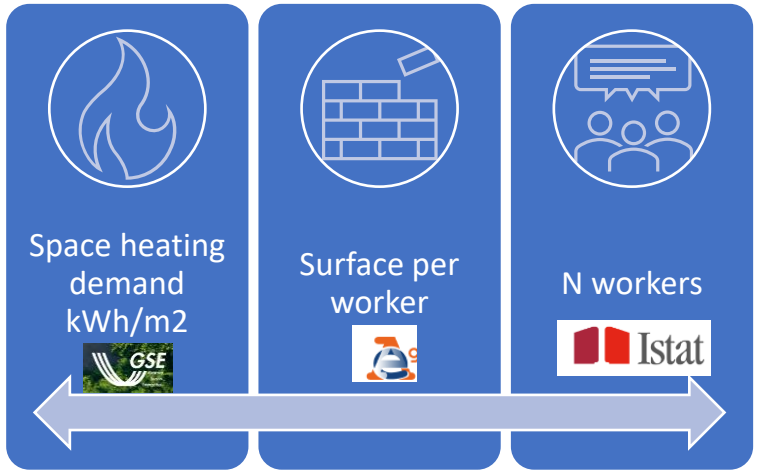


Heat demand map - methods

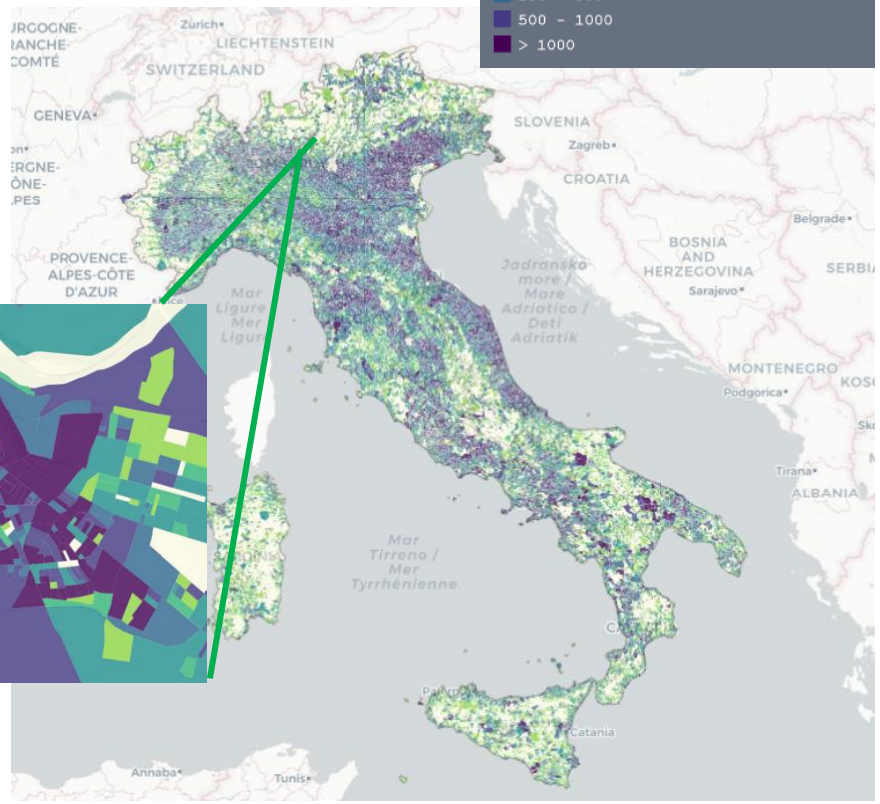
Residential



Terziary



Census area
Building type (single/multi-family)
Construction year



Census area
Tertiary sector

REFURBISHMENT SCENARIO NECP 2030

1%/year residential
2,5%/year tertiary

Industrial waste heat map - method

CO2 emission → Primary energy → Weaste Heat

ETS Register

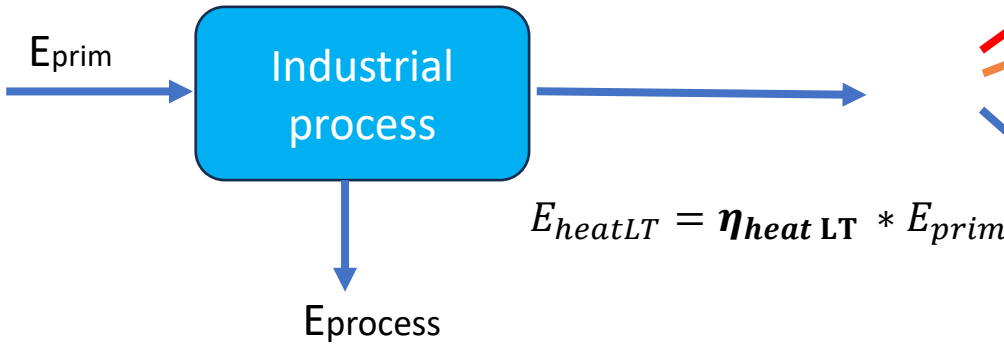
fCO2 emission factors

$E_{heat} = \eta^{*}_{heat} * E_{prim}$

$E_{heatHT} = \eta_{heat\,HT} * E_{prim}$

$E_{heatMT} = \eta_{heat\,MT} * E_{prim}$

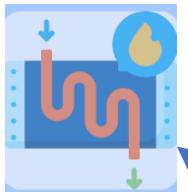
$E_{heatLT} = \eta_{heat\,LT} * E_{prim}$



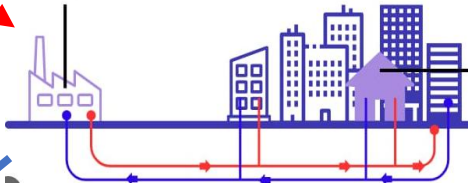
High Temperature

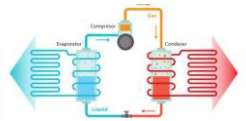
Medium Temperature

Low Temperature



Heat Exchanger





HX + Heat Pump

High Temperature> 300°C

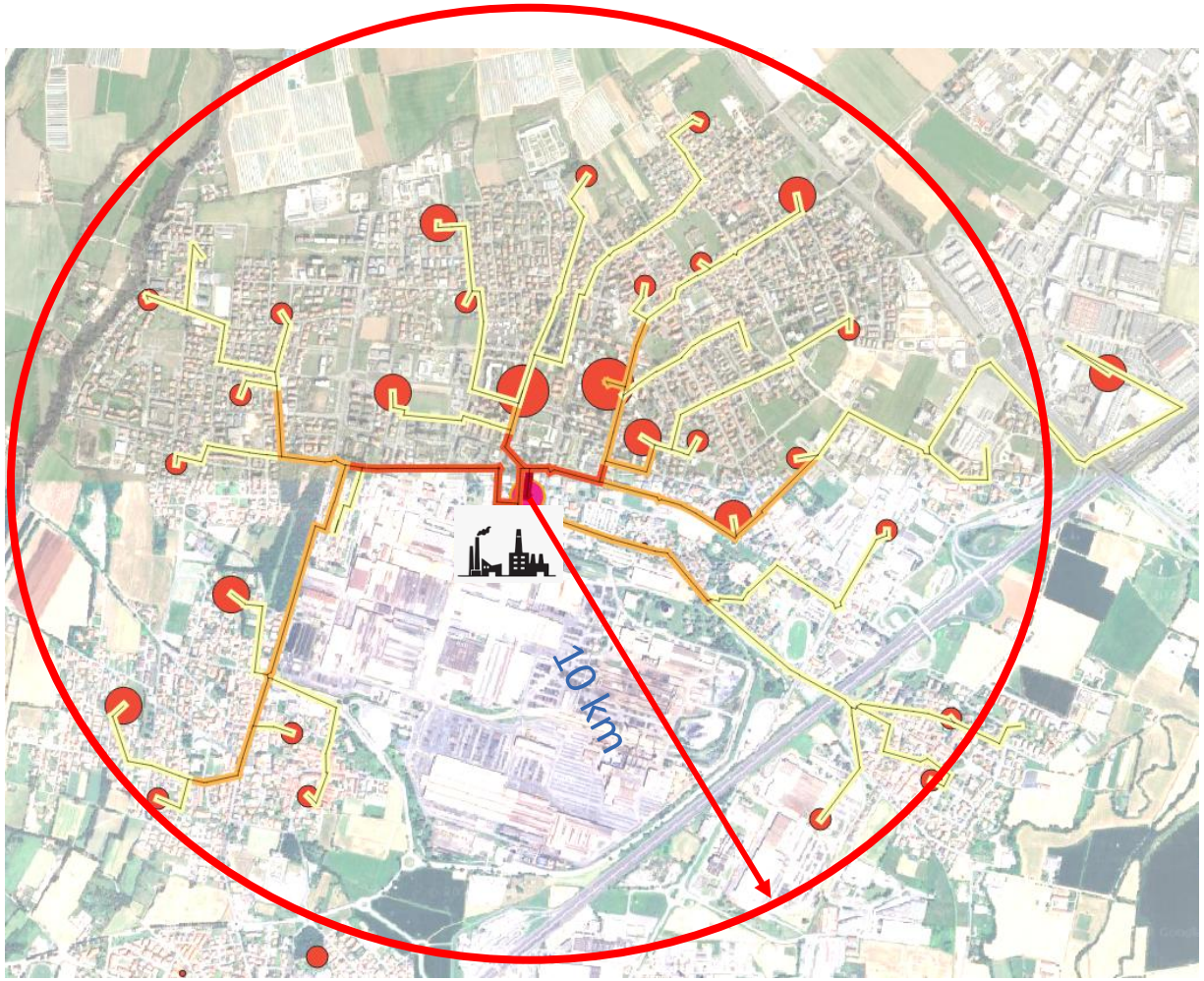
100 °C <Medium Temperature < 300°C

Low Temperature< 100 °C

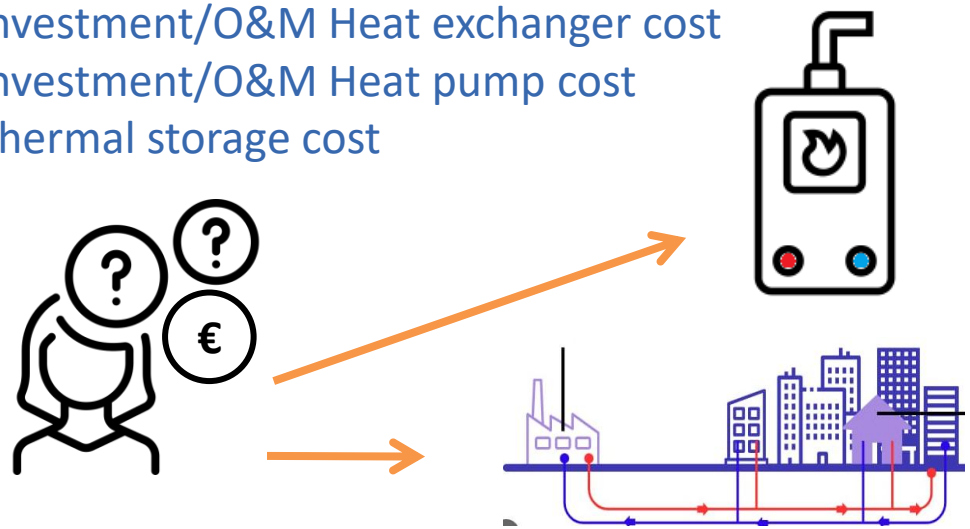
* G. Bianchi, G.P. Panayiotou, L. Aresti, S.A. Kalogirou, G.A. Florides, K. Tsamos, S.A. Tassou, P. Christodoulides, *Estimating the waste heat recovery in the European Union Industry*, Energy, Ecol. Environ. 4 (2019) 211–221. https://doi.org/10.1007/s40974-019-00132-7.

Recovering Industrial waste heat in DH

Simulation of local project of WH recovery in DH



- **Matching** waste heat recovery with local heat demand through DH
- Use an **optimization** algorithm that **minimizes** the **cost** of **heat** delivery
- Considered Costs:
  - Transmission network cost
  - Distribution network cost
  - Waste heat cost
  - Investment/O&M Heat exchanger cost
  - Investment/O&M Heat pump cost
  - Thermal storage cost

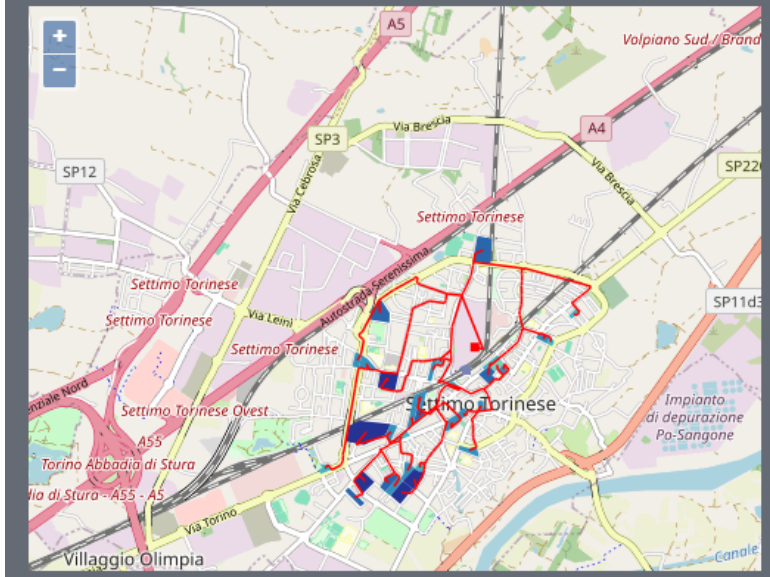


Potential WH recovery in DH –LCoE [€/MWh]

Integrated Atlas for the National Energy System and Renewable Sources

HEAT POINT ID No. 1213

Recovery energy [MWh] 31060.49125 of a plant located in the municipality of Settimo Torinese, province of Torino



Considered radius [m]	10000	Thermal losses [%]	5%
Transport network length [m]	2588.19	Energy available from HT source [MWh]	11406.69
Distribution network length [m]	3913.80	Energy supplied to the TLR_ HT [MWh]	11406.69
Transport network cost [Keur]	3381.44	Energy available from LT source [MWh]	21255.51
Distribution network cost [Keur]	2825.58	Energy supplied to the TLR_ LT [MWh]	21255.51
HT Investment Cost [Keur]	118.69	Energy served by DH [MWh]	31060.49
Investment Cost LT [Keur]	2505.27	Energy supplied by individual solar - boiler [MWh]	610467.74
LCOE [€/MWh]	61.94		

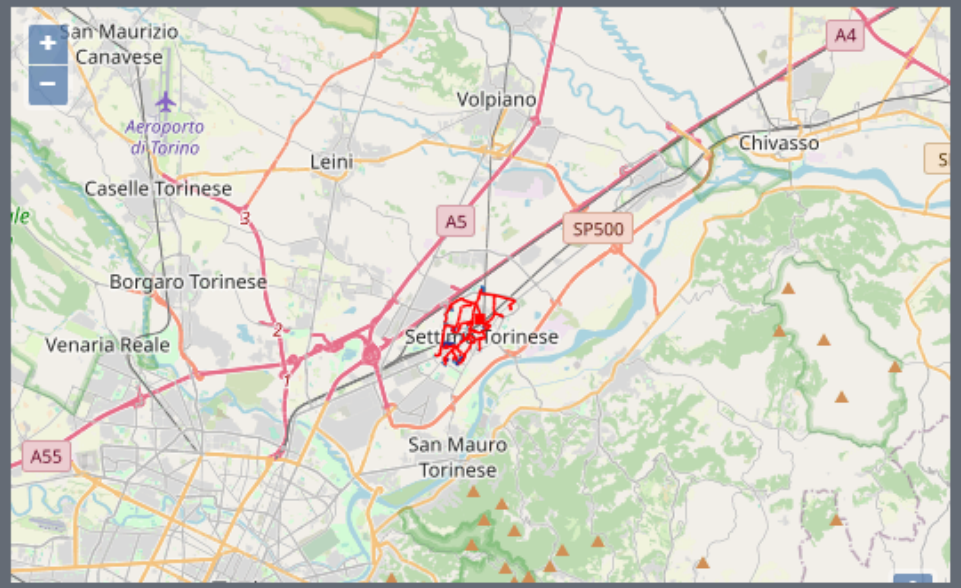
- 0
- 0 - 100
- 100 - 200
- 200 - 500
- 500 - 1000
- 1000 - 1500
- > 1500

CLOSE

User-defined parameter settings

HEAT POINT ID no. 1213

Recovery energy [MWh] 45.141837 of a plant located in the municipality of Settimo Torinese, province of Torino

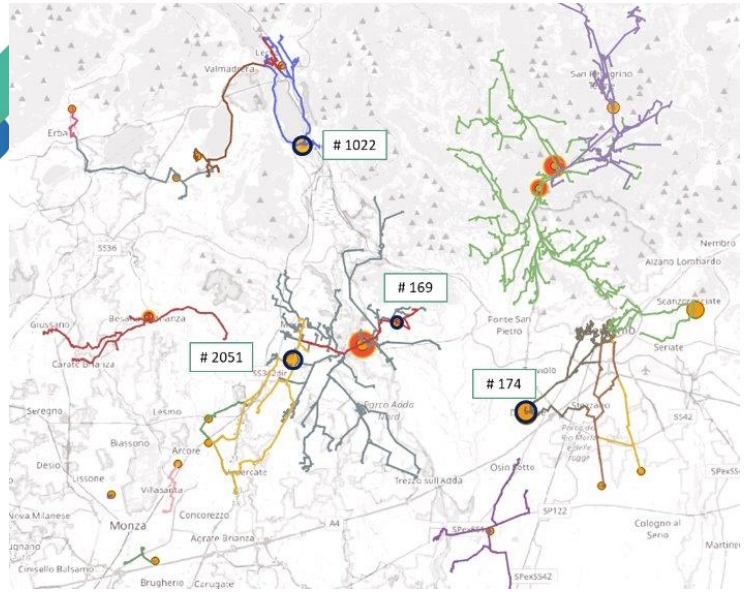


Name:		Surname:		Mail:	

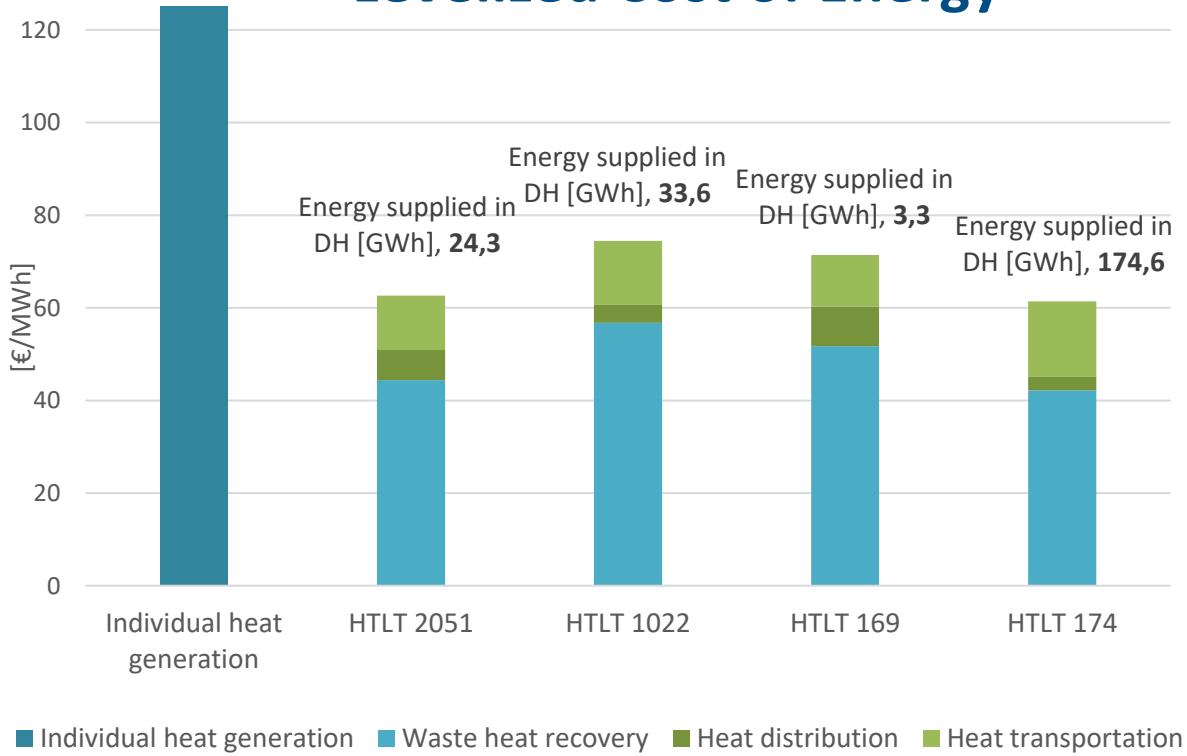
Considered radius (m)		Waste heat cost HT (€/MWh)	23,0714022
Heat recovered by type of source HT (MWh)	11406,69	Cost of waste heat LT (€/MWh)	34,14
Heat recovered by type of source LT (MWh)	21255,51	Cost of gas (€/MWh)	53
Equivalent hours of operation (h)	3500	Electricity cost (€/MWh)	109
Discount rate for actualization (%)	6		

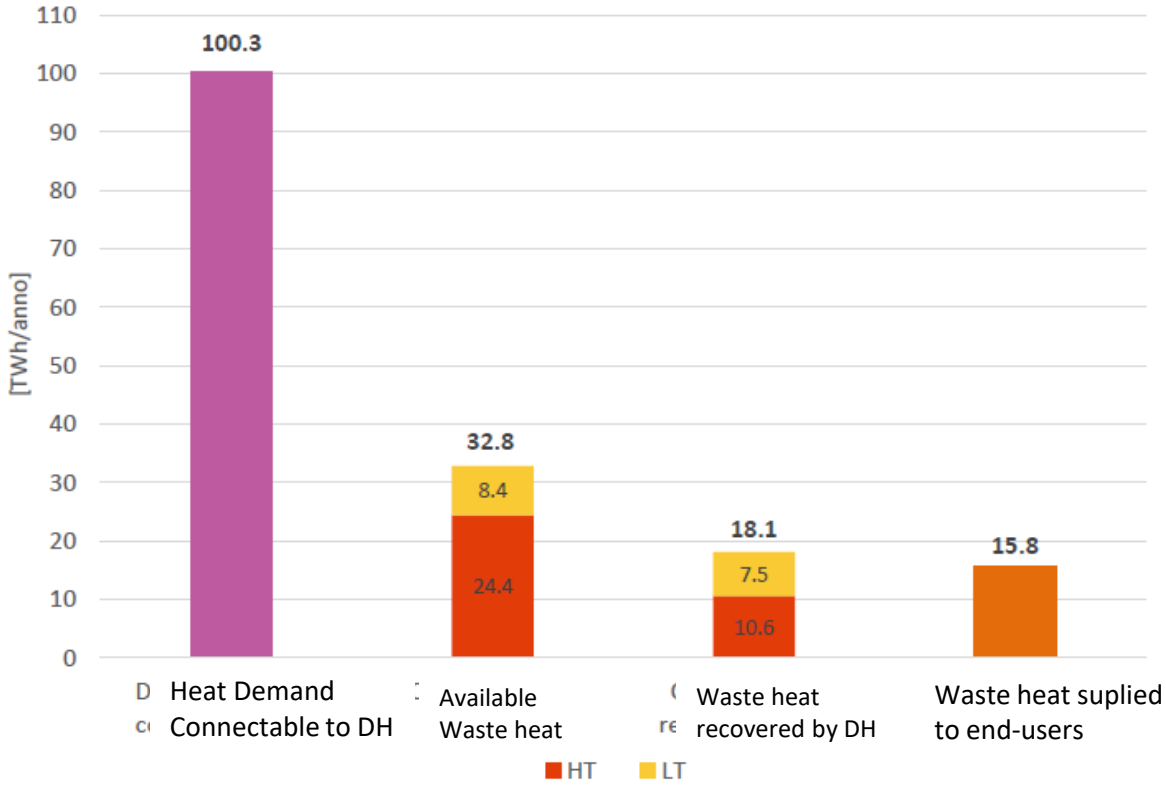
atlanteintegrato.rse-web.it

Recovering Industrial waste heat in DH - results

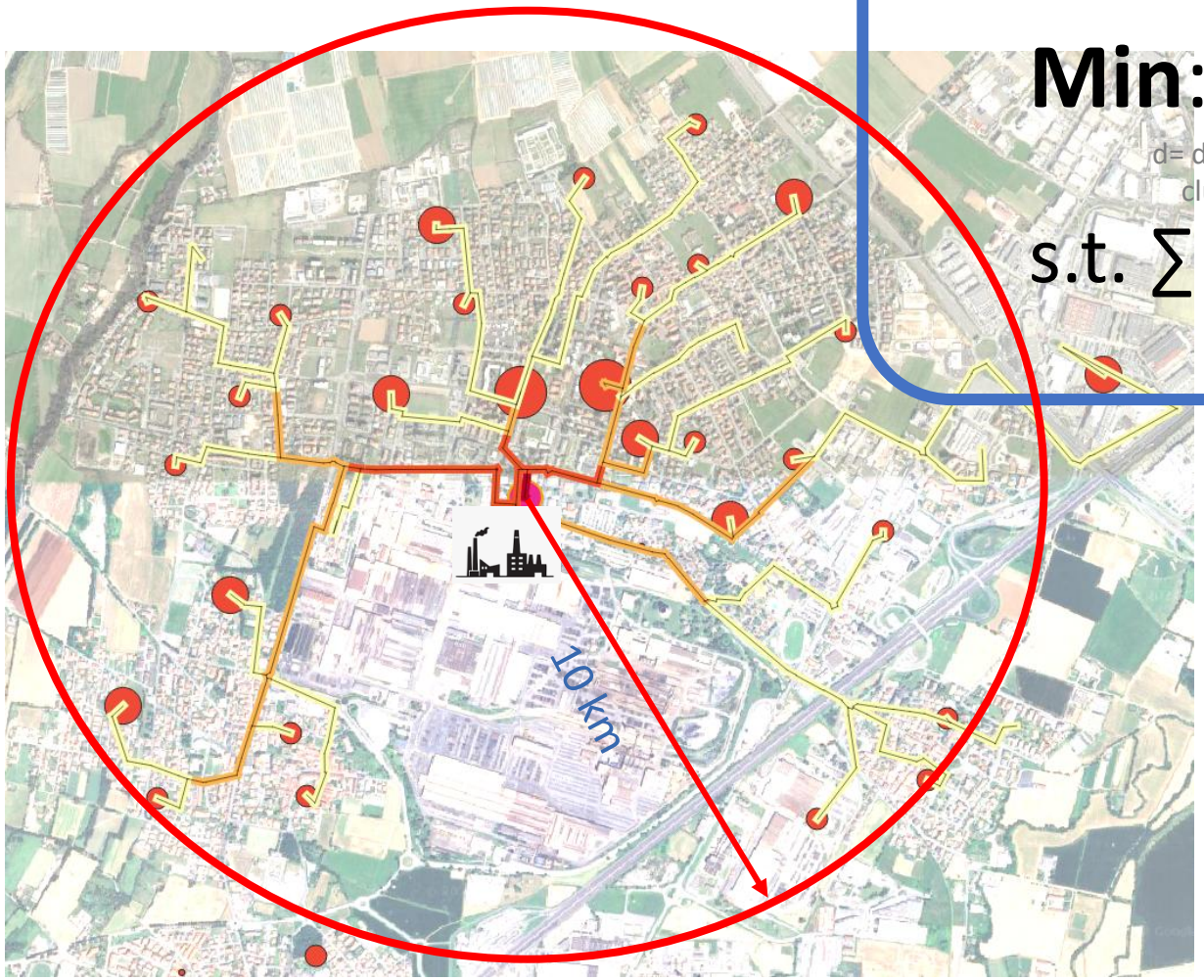


Levelized Cost of Energy





Optimization algorithm



$$\textbf{Min}: \Sigma_d \left(\textit{energy } \textbf{\textit{flow}}_d * \textit{energy } \textbf{\textit{cost}}_d \right)$$

d= demand cluster

energy flow$_d$: delivered heat [MWh/y]

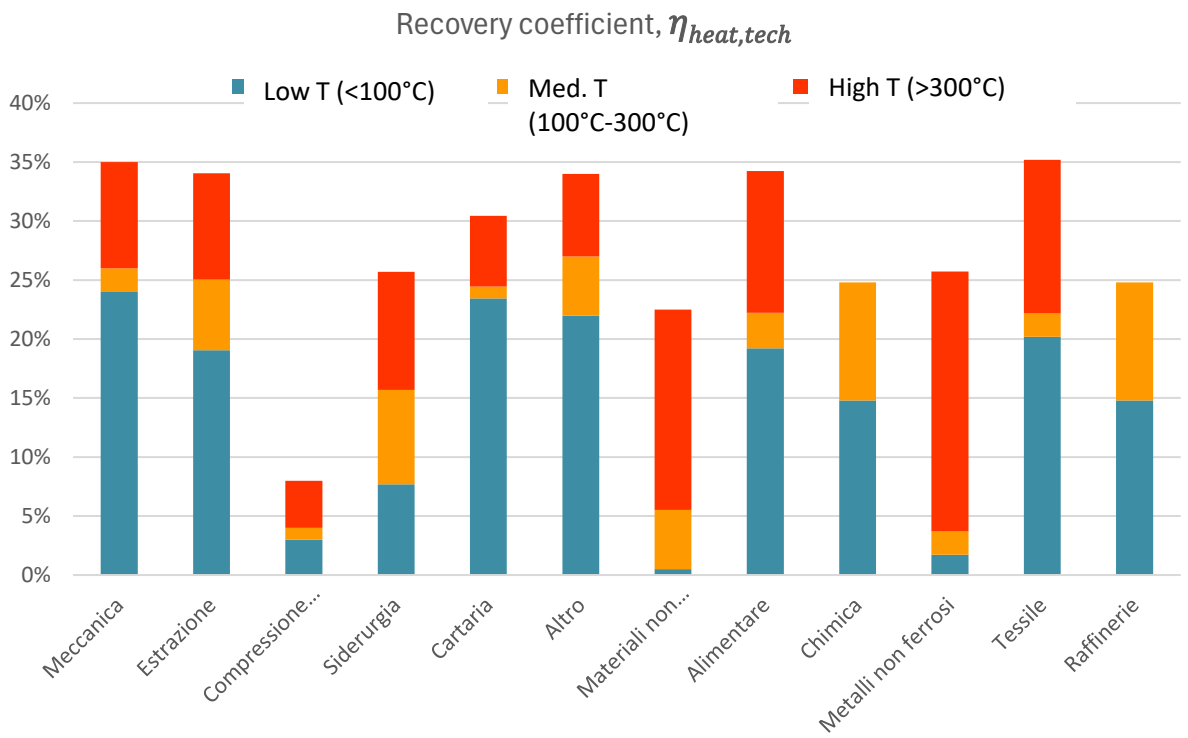
energy cost$_d$: LCOE [€/MWh]

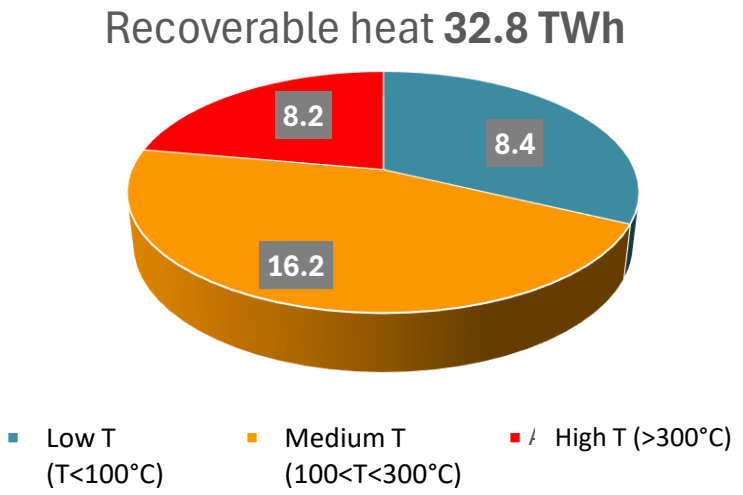
$$\text{s.t.} \sum \text{flow}_{in} = \sum \text{flow}_{out}$$

Package - oemof.solph – linear optimisation library for energy systems
https://oemof.org/libraries/#solph

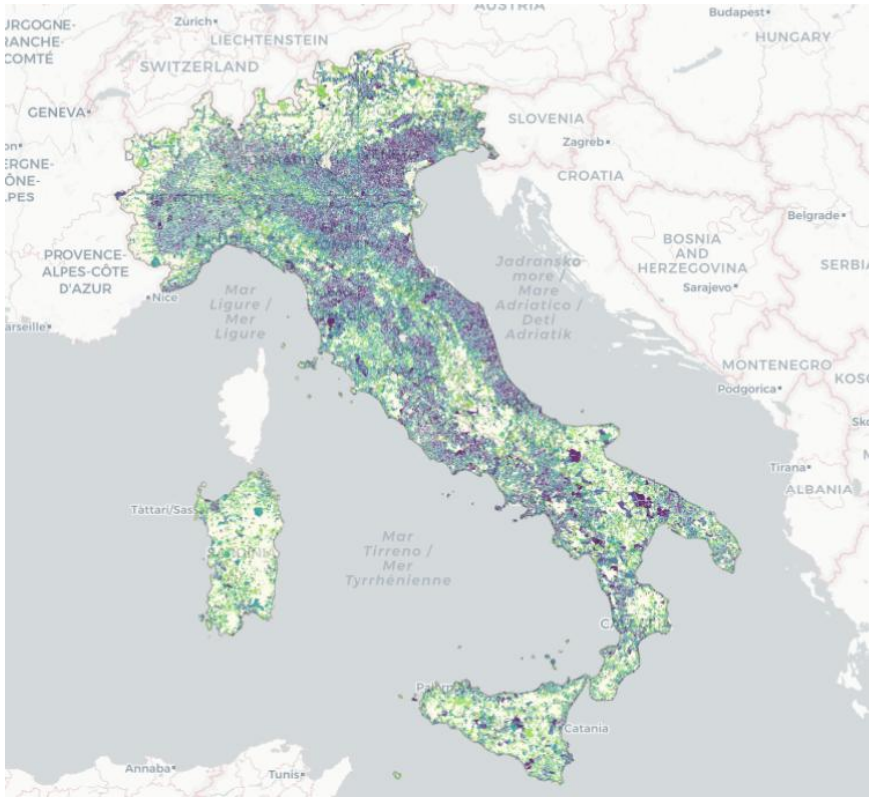
- Output:
  - Transmission network length and cost
  - Distribution network length and cost
  - Investment HT /LT cost
  - LCOE [€/MWh]
  - Energy supplied by DH

Industrial waste heat map- results

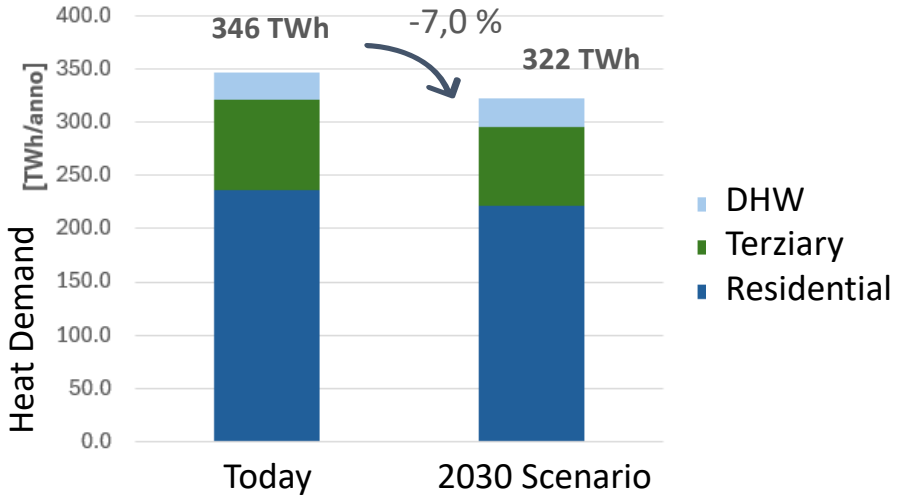




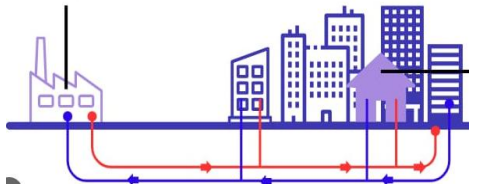
Heat demand map



Heat Demand for civil users



100 TWh
Connectable to DH



Industrial waste heat map

High temperature

Medium temperature

Low temperature