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#SESAAU2021

An open spatial optimisation model to asses economically sustainable national district heating potential

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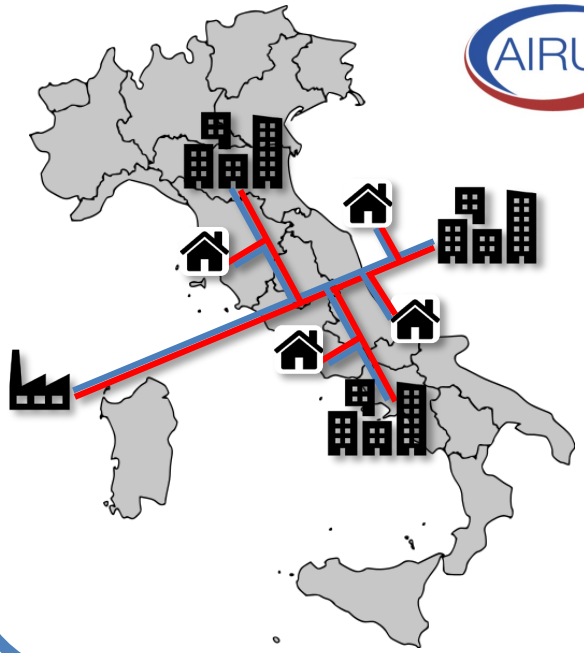
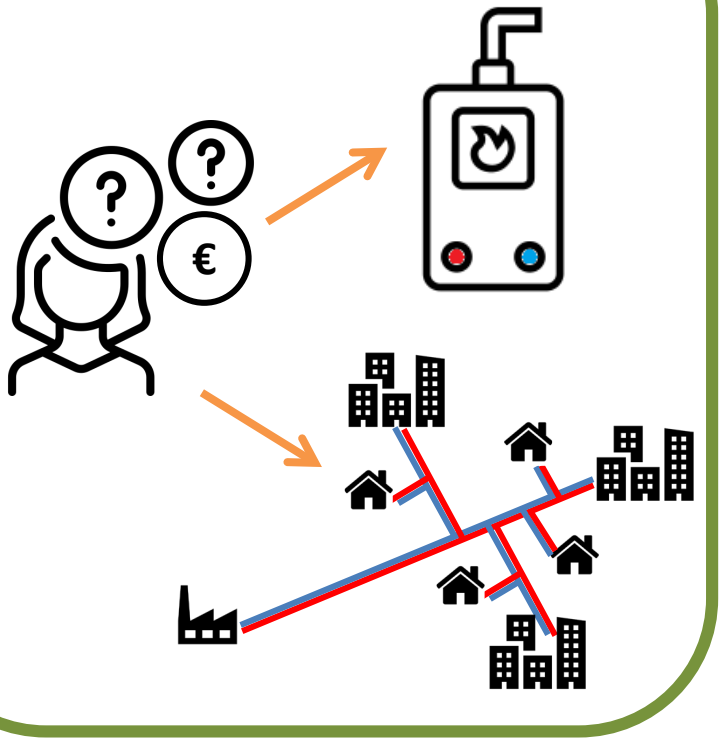
Scope

Potential diffusion of DH



Economic sustainability of heat



Politecnico di Milano e Torino., *Valutazione del potenziale di diffusione del teleriscaldamento efficiente sul territorio nazionale*, 2020
https://www.camera.it/application/xmanager/projects/leg18/attachments/upload_file_doc_acquisiti/pdfs/000/004/811/Memoria_AIRU_Report_finale_.pdf

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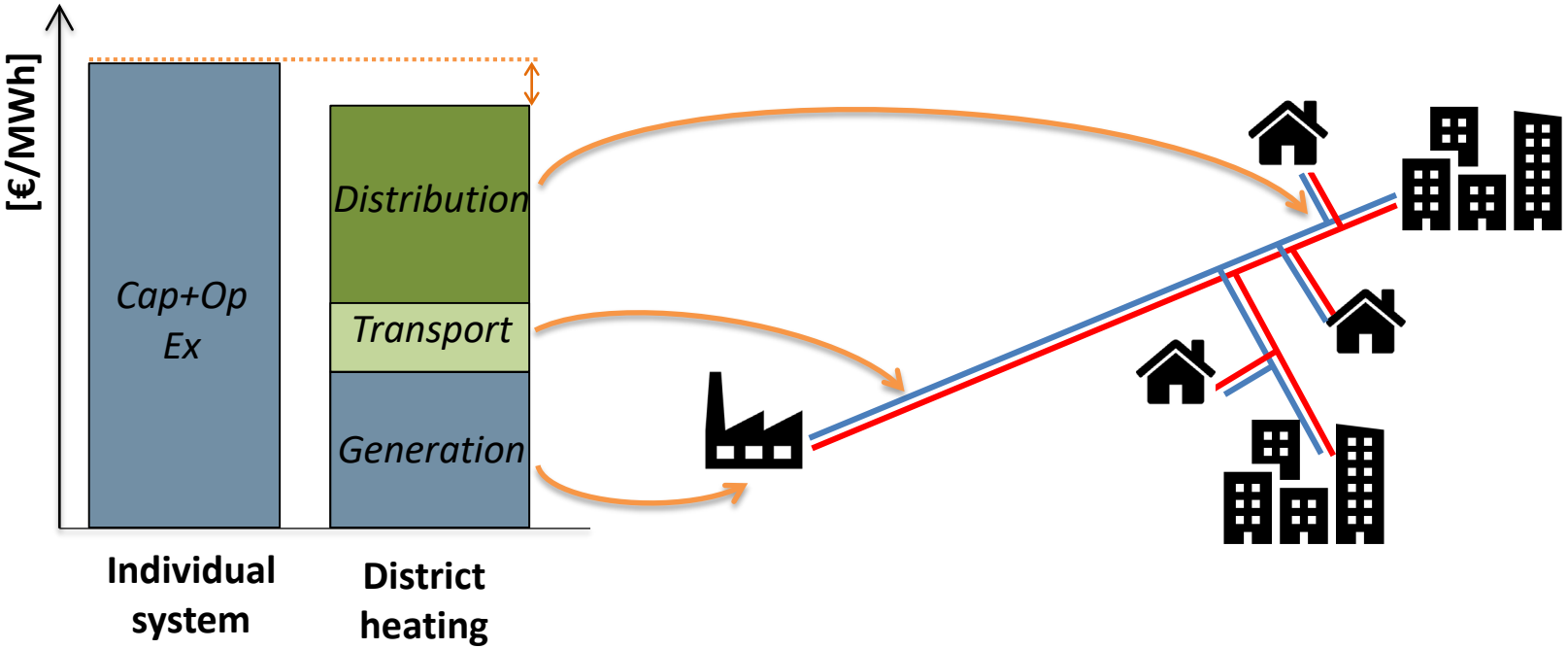
Economic sustainability



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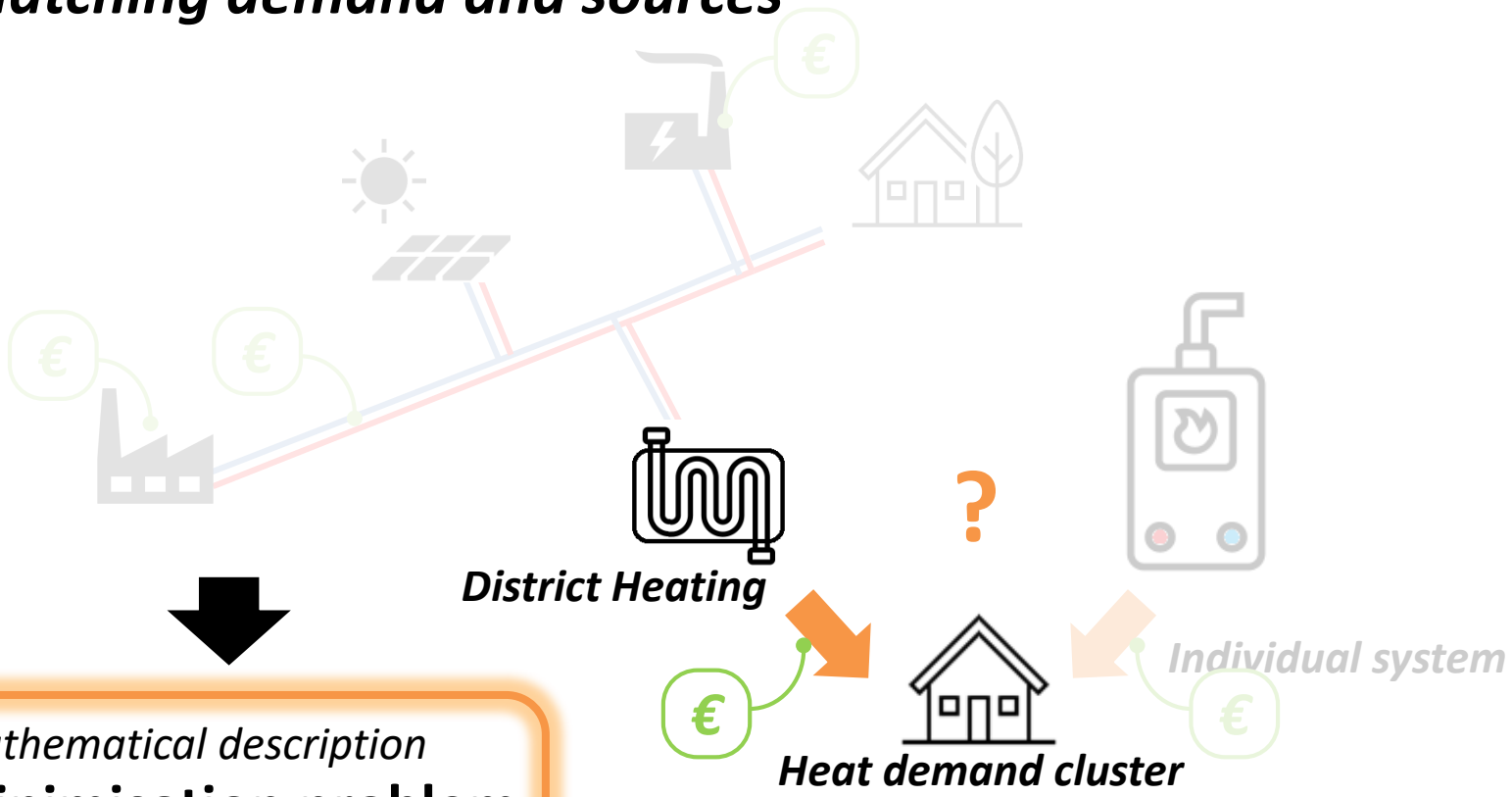
Matching demand and sources



Mathematical description

Minimisation problem

delivered heat cost

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Minimisation of costs

oemof ['ø:mɔf]
open energy modeling framework

- It is a "***modular open source framework to model energy supply systems***"
- Based on the ***graph theory***, it solves a ***linear programming problem*** – in this case

Objective Function, Total costs of delivered heat

Decision Variables, heat flows DH or individual

Parameters, costs efficiencies

→ **Min:** $\sum_d$ (*energy* ***flow***$_d$ * *energy* ***cost***$_d$)

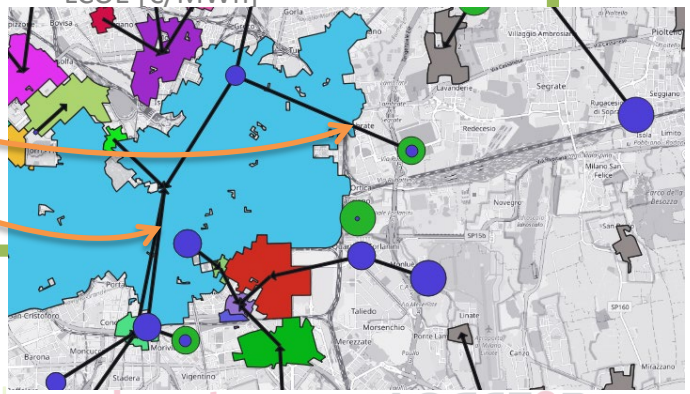
d= demand cluster

delivered heat [MWh/y]

LCOE [€/MWh]

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

Energy balancies, limited resources



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

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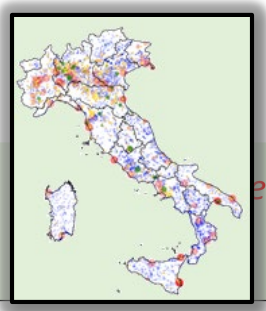


eat sources

Waste heat recovery (High temperature)

Source

Waste heat recovery via heat pump (Low temperature)

Source

Replicated for every industrial site

bus

Replicated for every connection

Transport network

Transformer

Heat for network

Replicated for every demand cluster

Heat for USER

Gas CHP

Source

Solar thermal

Source

Deep geothermal

Source

Shallow geothermal

Source

Biomass CHP

transformer

bus

DH network

Transformer

Individual system

Source

bus

Heat demand

Sink

Replicated for every NUTS3 region

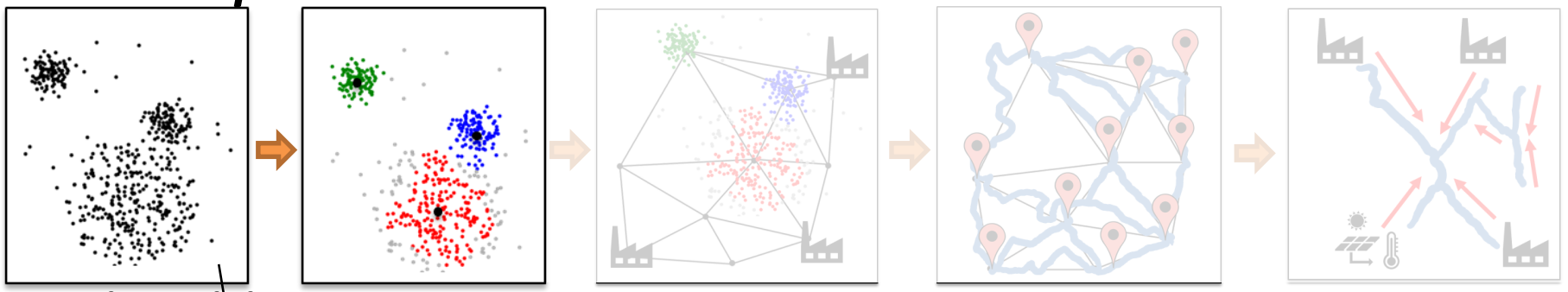
Natural resources

Regional available biomass

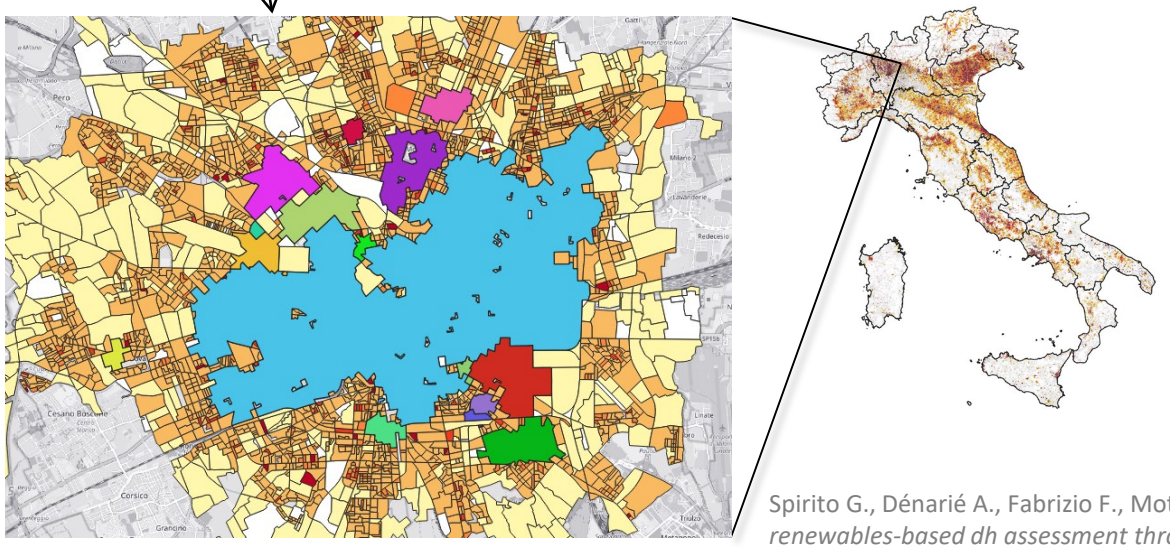
Source

266 000 variables
73 000 transformers
87 000 sources
6 500 sinks
18 000 buses

Work steps



Heat demand clustering



- DB scan algorithm
- **Energy intensity** and **proximity** criteria
- Reduction of computational effort
- 400 000 census areas → **6 500 clusters**

Spirito G., Dénarié A., Fabrizio F., Motta M., Macchi S., Persson U., *Potential diffusion of renewables-based dh assessment through clustering and mapping: A case study in Milano*, Energies 2021, 14, 627. https://doi.org/10.3390/en14092627

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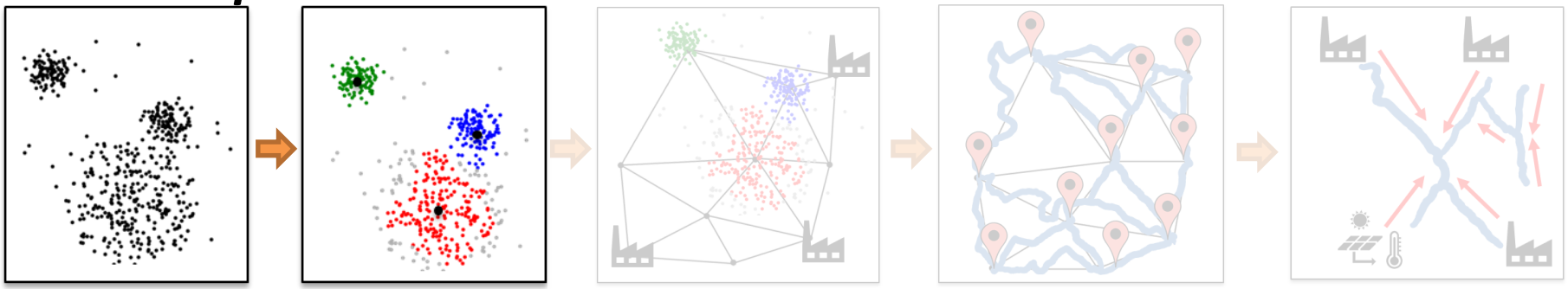
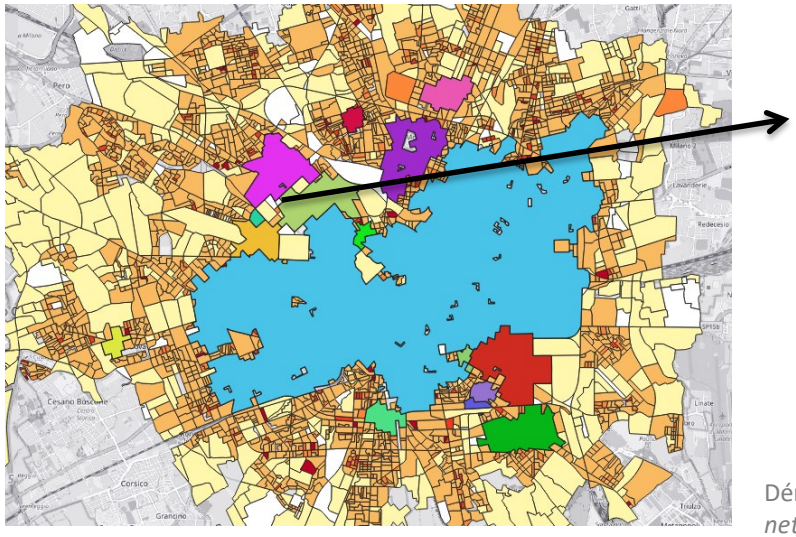
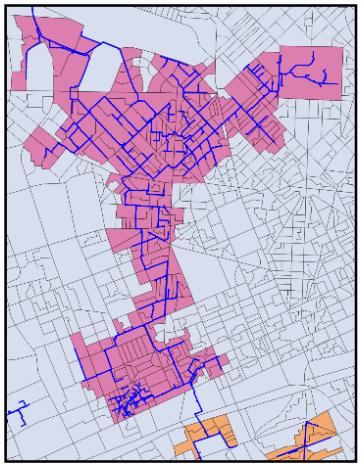
Work steps

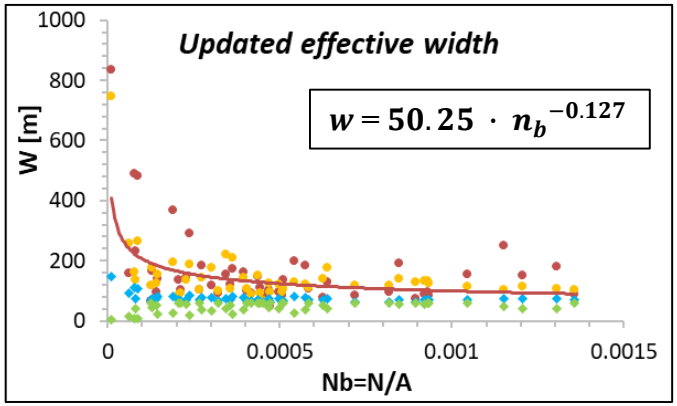


Heat demand clustering



Distribution costs





Dénarié A., Macchi S., Fabrizio F., Spirito G., Motta M., Persson U., *A validated method to assess the network length and the heat distribution costs of potential district heating systems in Italy*, Int. J. of Sustainable Energy Planning and Management, 31, 59–78. https://doi.org/10.5278/ijsepm.6322

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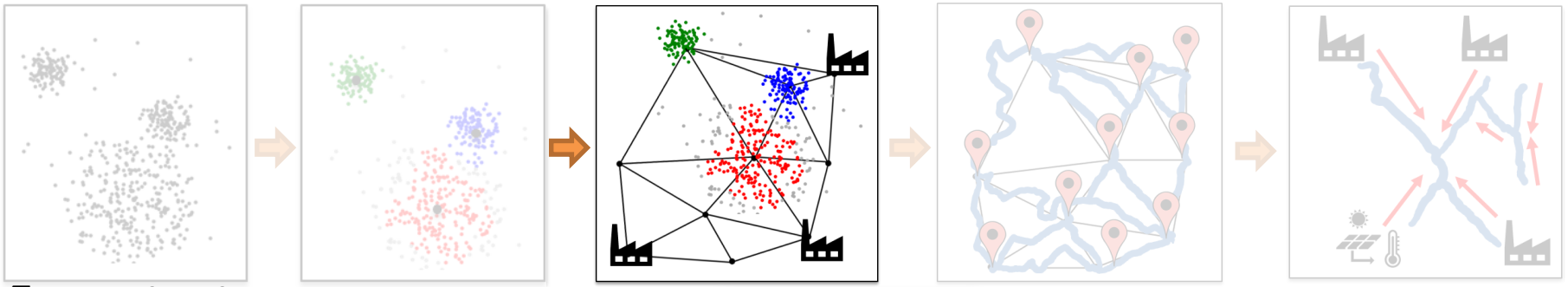
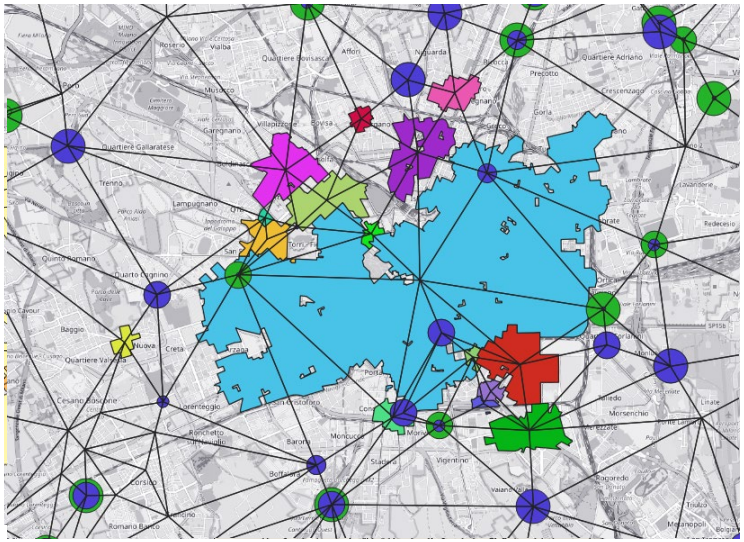
Work steps



Transport costs



- Delaunay **triangulation**
- **Graph** demand sources
- **Transport** costs
- Potential **flows**

Dénarié A., Fabrizio F., Spirito G., Macchi S., Cirillo V. F., Motta M., Persson U., *Assessment of waste and renewable heat recovery in DH through GIS mapping: The national potential in Italy*, Smart Energy, Volume 1, 2021, 100008, https://doi.org/10.1016/j.segy.2021.100008

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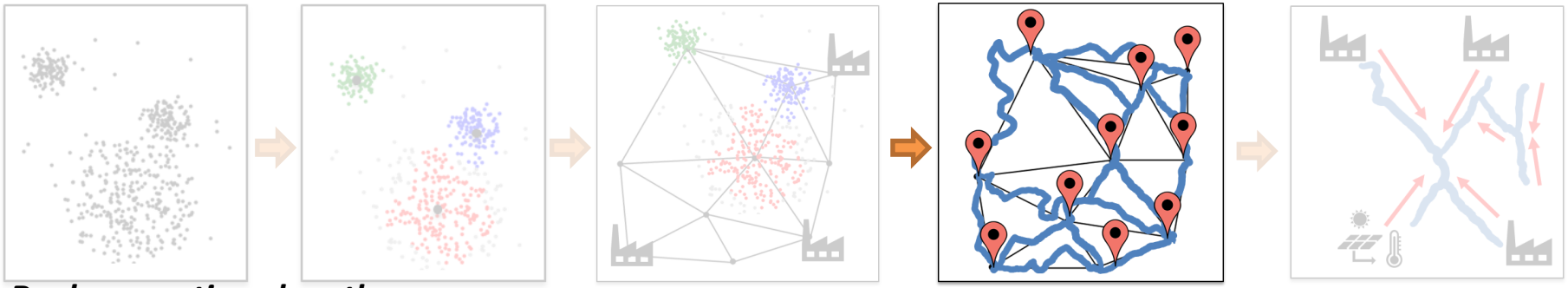
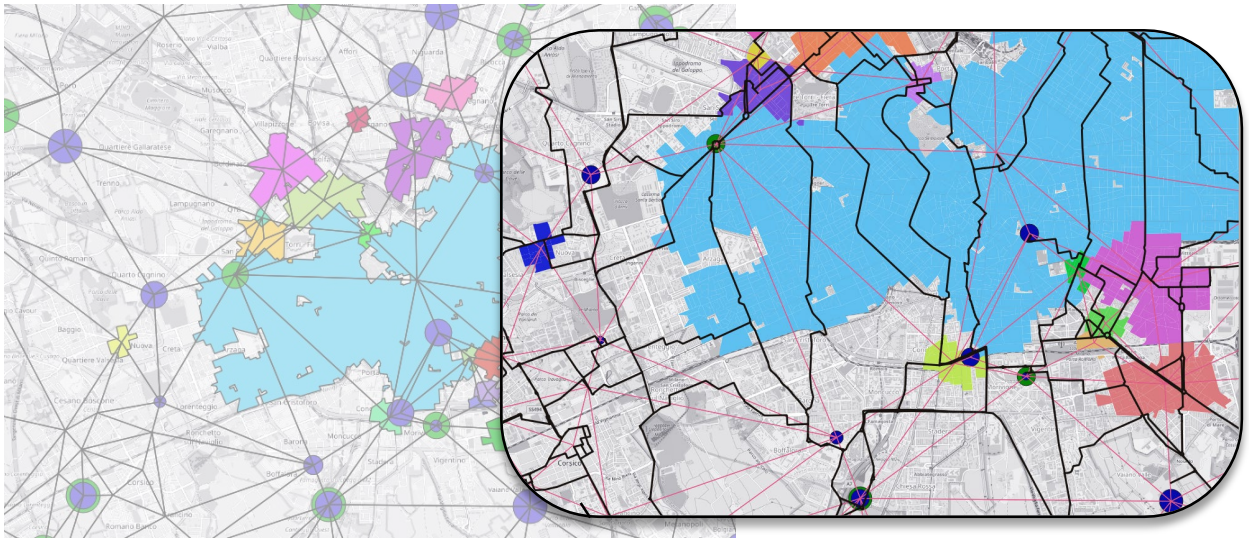


Real connections length



- Routing techniques
- Streets path for connections hypothesis

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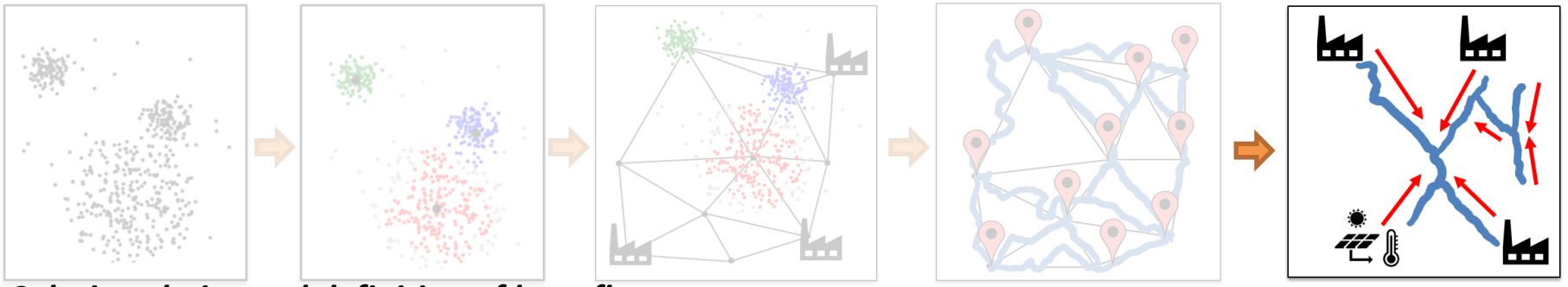
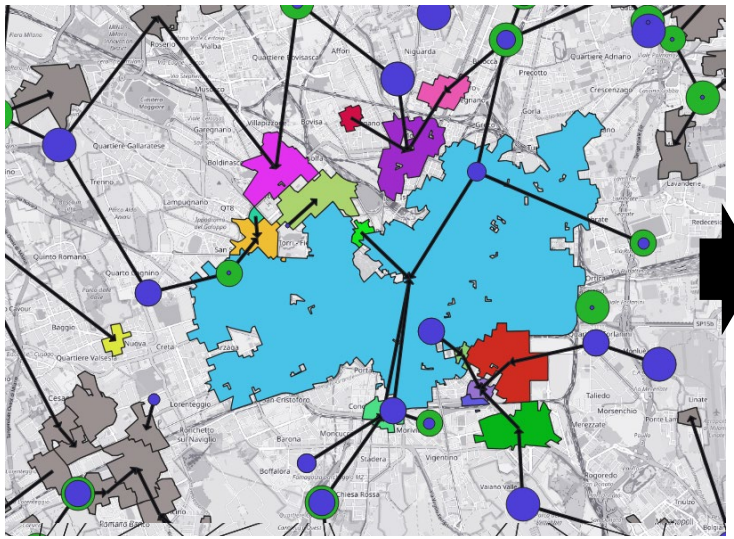


Solution choice and definition of heat fluxes



DH potential

- Definition of DH vs individual system
- Minimisation of costs
- 260 000 variables

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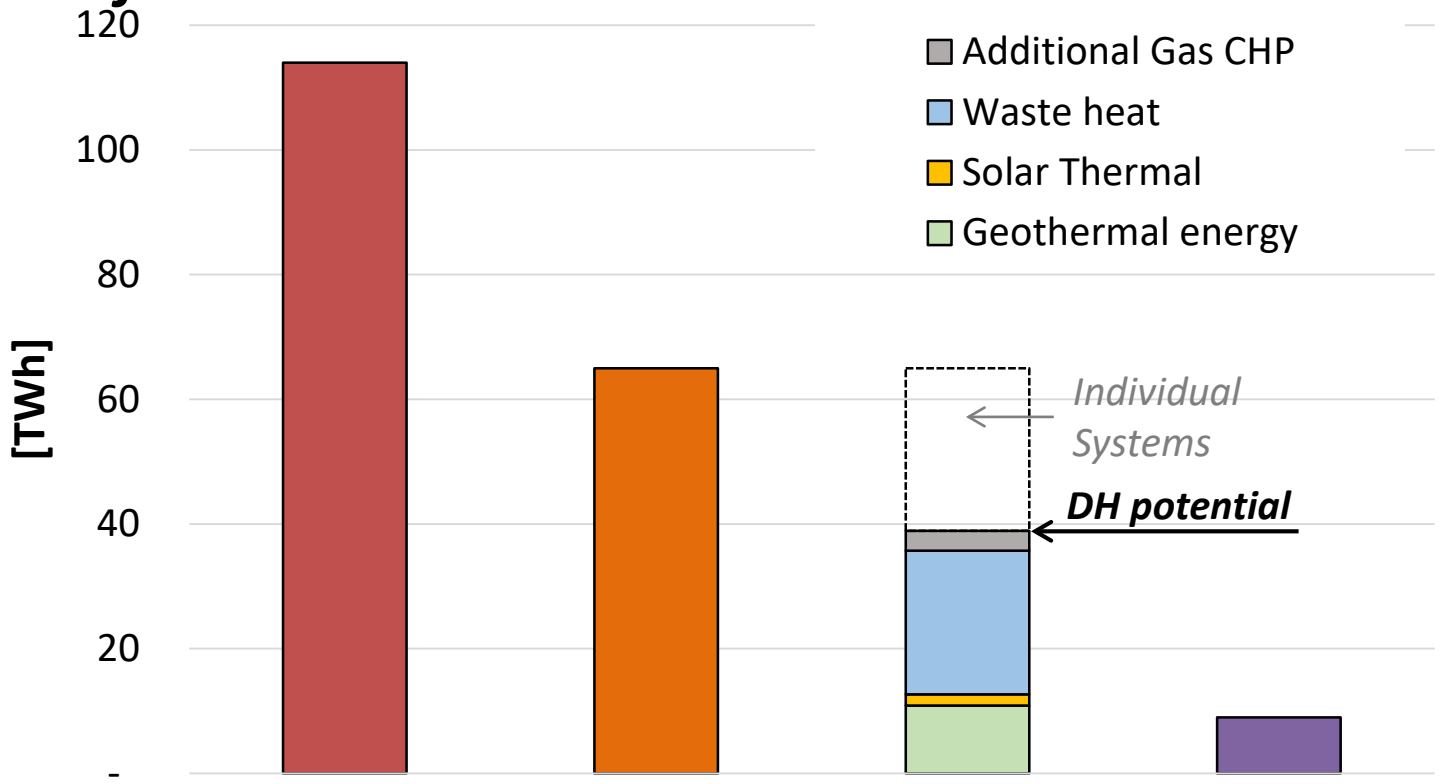
Potential for DH results



Total civil heat demand 329 TWh

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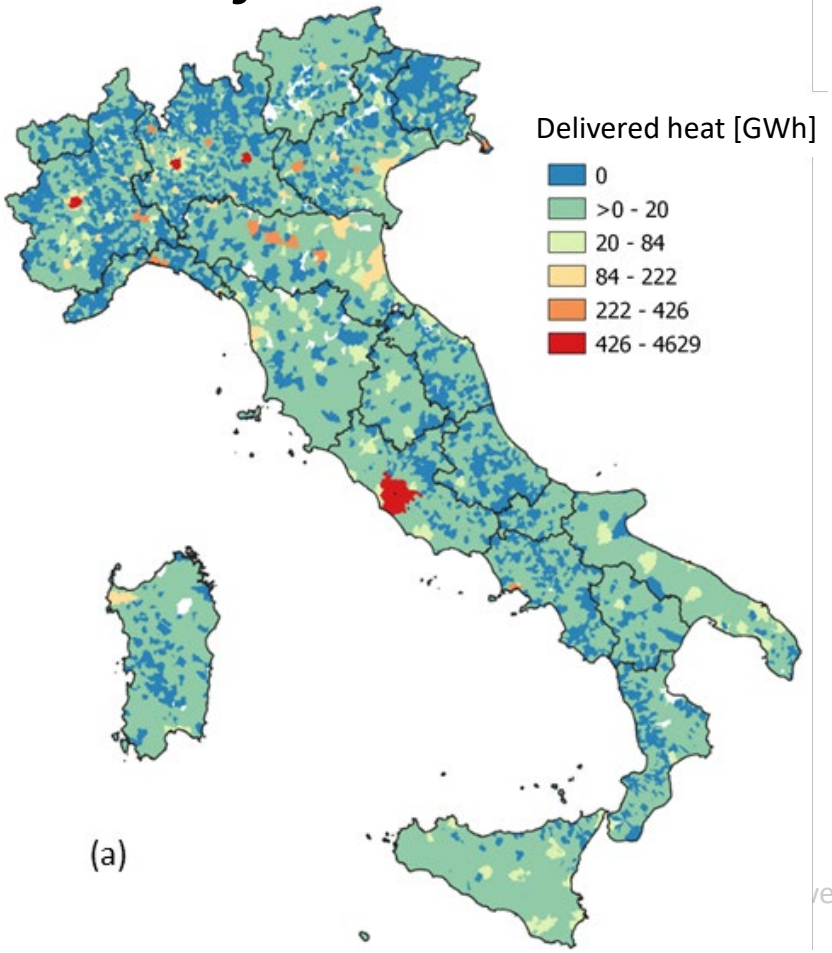
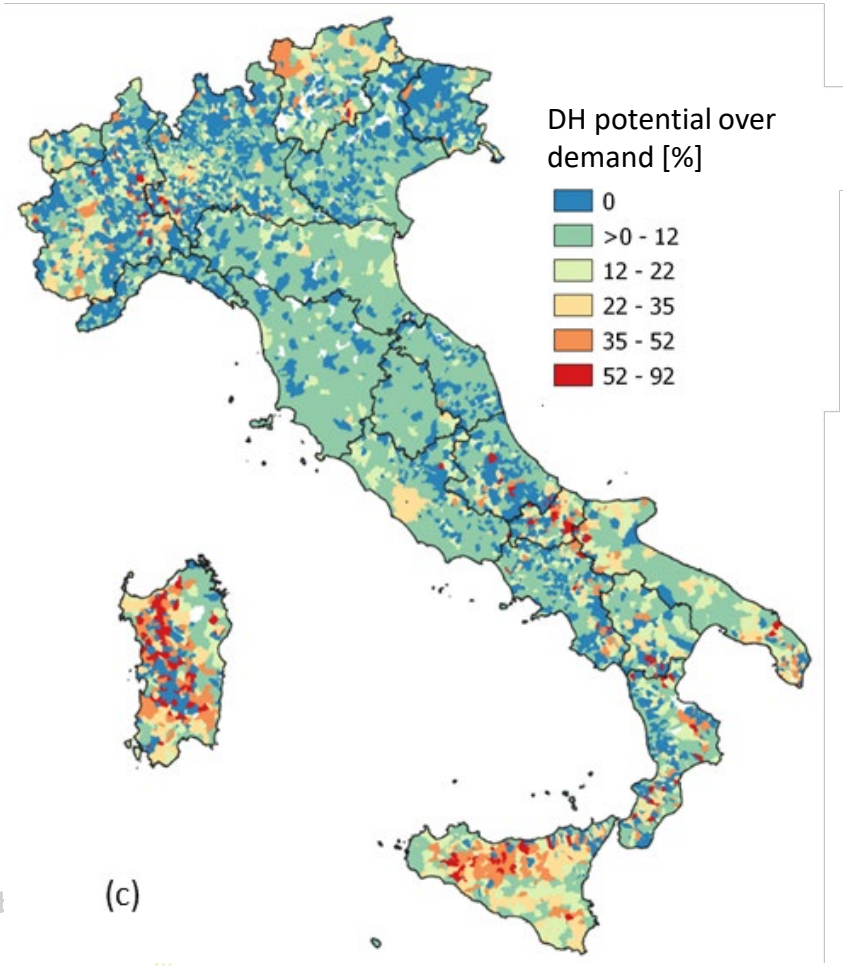
Potential for DH results





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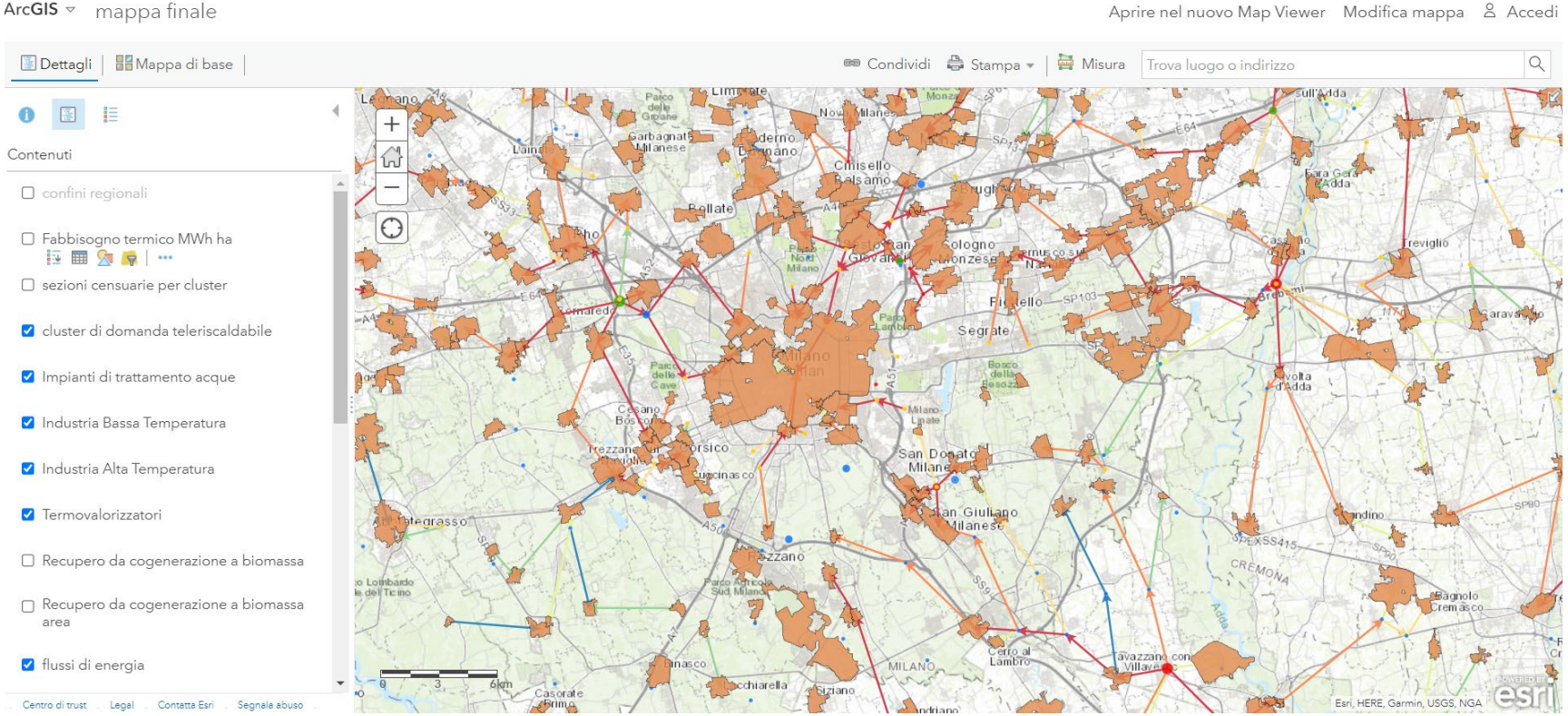
Potential for DH results



https://zenodo.org/record/4284531

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Discussion

- Criteria – minimisation of costs - other criteria are possible
- Point of view - the system, the user, the utilities
- Update with additional sources and criteria
- Limitation of heat demand (cluster)

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Conclusions

- **Open** methodology
- Detailed **spatial** dimension - Map
- Demand and source **matching** (economic – current conditions)
- **Potential** diffusion of technology (over x4)

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Thank you for your attention

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