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Impact of heating planning on the economic viability of district heating in Brasov-Romania

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4th International Conference on Smart Energy Systems and 4th Generation District Heating 2018
#SES4DH2018

4DH
4th Generation District Heating Technologies and Systems

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DH in Brasov

- Primary purpose:
  - To supply steam to the industry consumers,
  - To supply hot water to the residential consumers.

- Inefficiency in Brasov DH system:
  - Shutdown of industrial consumers in 1990 -> Oversized pipelines for remaining consumers
  - Lack of coherent policy in reviving the DH system
  - Loss of further consumers.

- In the recent years, the Local Counsel has established new actions toward increase of DH efficiency.

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progRESsHEAT project in Brasov

- ProgRESsHEAT project (H2020): aimed to support the market uptake of existing and emerging renewable technologies.

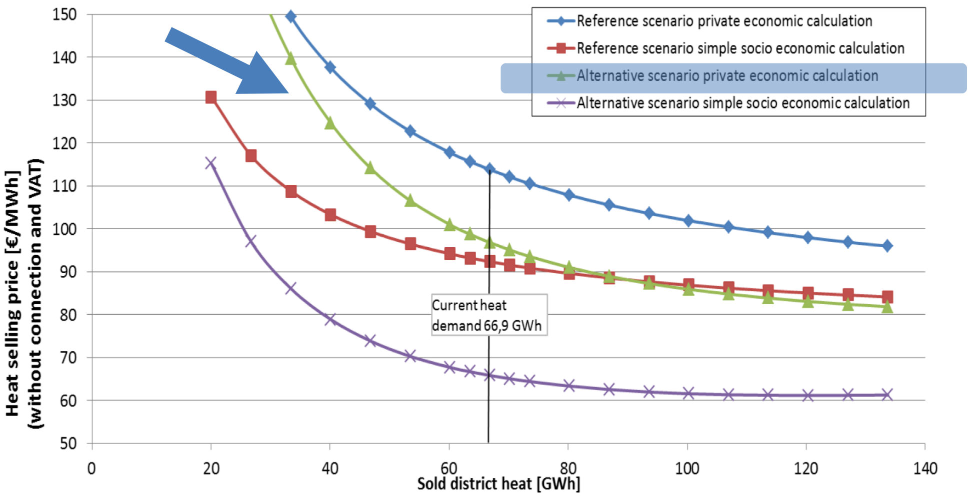
- Results among all, include policy recommendations for Brasov's DH system:
  - provision of long-term loans for investments into the network infrastructure
  - implementation of heating and cooling planning to define zones that are preferable for DH

- DH areas were defined by areas around the existing distribution network

- Two scenarios were developed to study the least cost combination of heat savings, district heat and individual supply.
  - Simple socioeconomic perspective
  - Private economic perspective

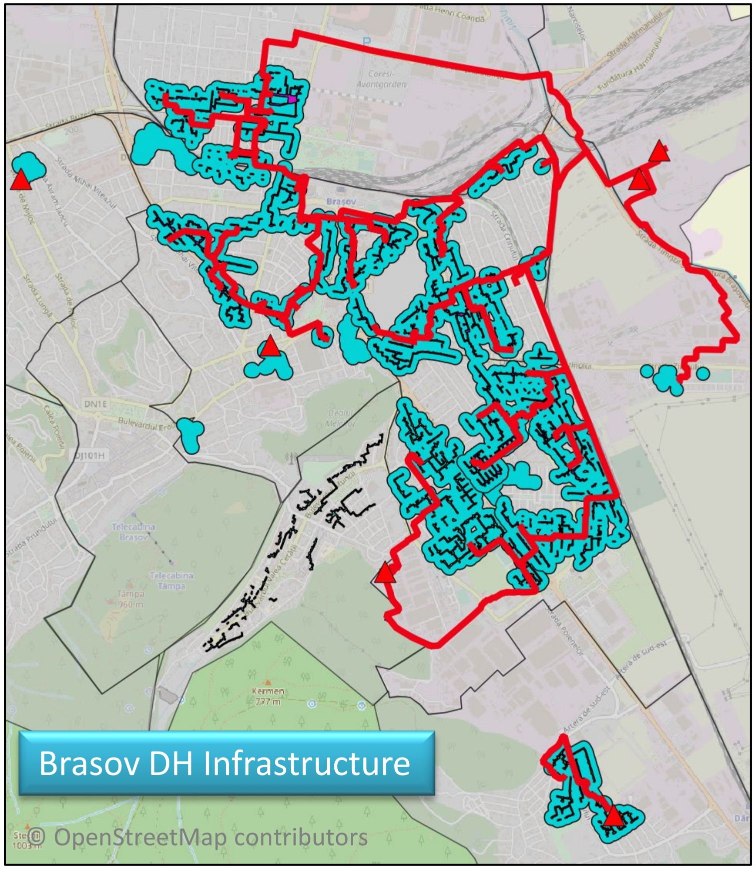
Alternative Scenario
Private economic calculation

- Private economic calculation:
  - Investment in generation facilities
  - Investment in grids (For 50% of the grid that is not renovated so far.)
  - VAT and cost for connection of customers are NOT considered.



Sensitivity of heat selling prices to sold district heat

Reference:
http://www.progressheat.eu/IMG/pdf/d2-2_brasov_v5_upload_2017-12.pdf



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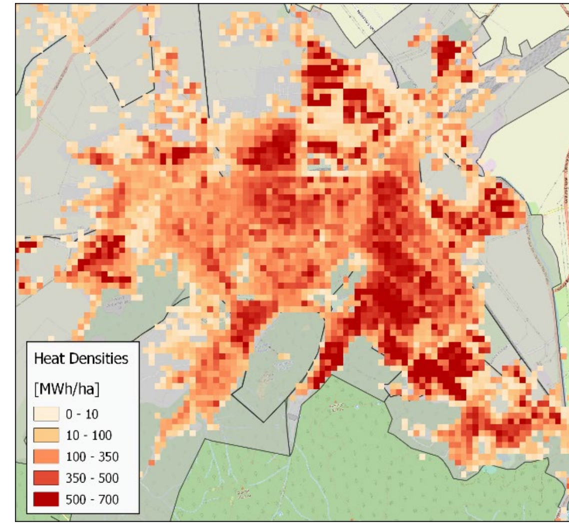
DH area definition using GIS layers



- Input GIS Layers from Hotmaps* project (H2020 project):
  - **European heat demand density map - 1ha resolution**
  - **European plot ratio map - 1ha resolution**

- For each pixel of HDM in each year within the investment horizon (m years) is calculated:
  - Annual heat demand (D_t) based on expected accumulated energy saving,
  - Annual Supplied heat by DH system (Q_t) based on market share (MS_0 & MS_m),
  - Distribution grid investment cost as proposed by Persson & Werner** (from Swedish experience).

$$D_t = D_0 \cdot \sqrt[m]{(1-S)^t}$$

$$0 \le S \le 1 \quad ; \quad t \in \{0,1,2,\dots,m\}$$

$$Q_t = D_t \cdot \left[MS_0 + t \cdot \frac{MS_m - MS_0}{m} \right]$$

$$L = 1/w = 1/\left(61.8 \cdot e^{-0.15}\right)$$

$$d_a = 0.0486 \cdot \ln\left(Q_t / L\right) + 0.0007$$

$$Inv_T = \frac{C_{1,T} + C_{2,T} \cdot d_a}{\left(\sum_{t=0}^{m} \frac{Q_{T+t}}{(1+r)^t} + \sum_{t=m+1}^{n} \frac{Q_{T+m}}{(1+r)^t} \right) / L}$$

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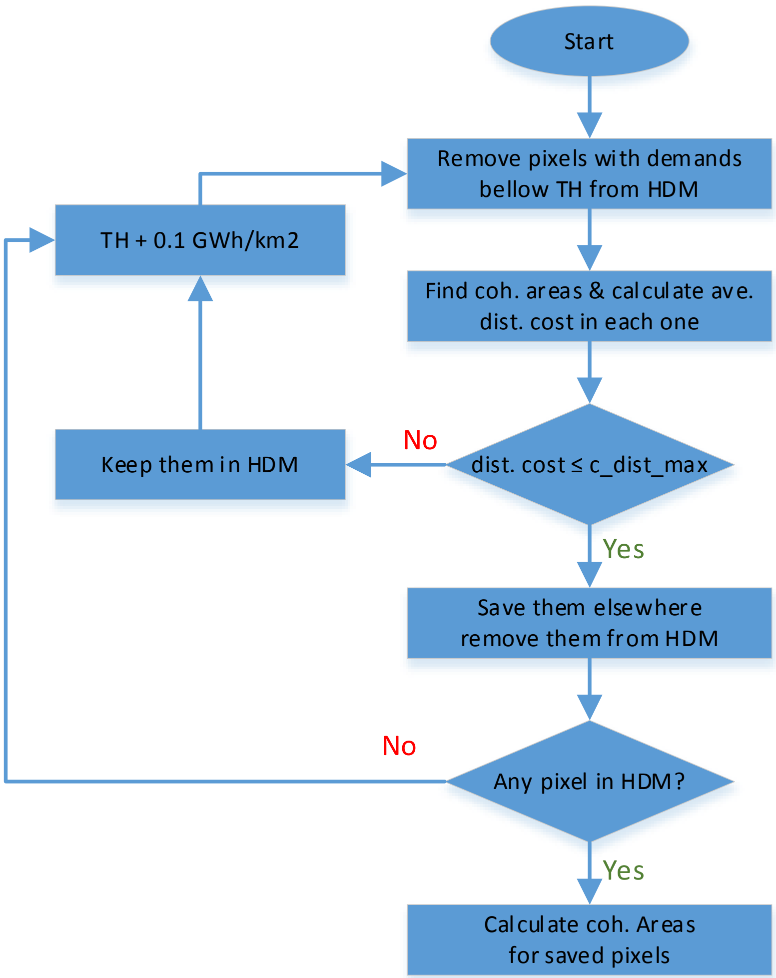
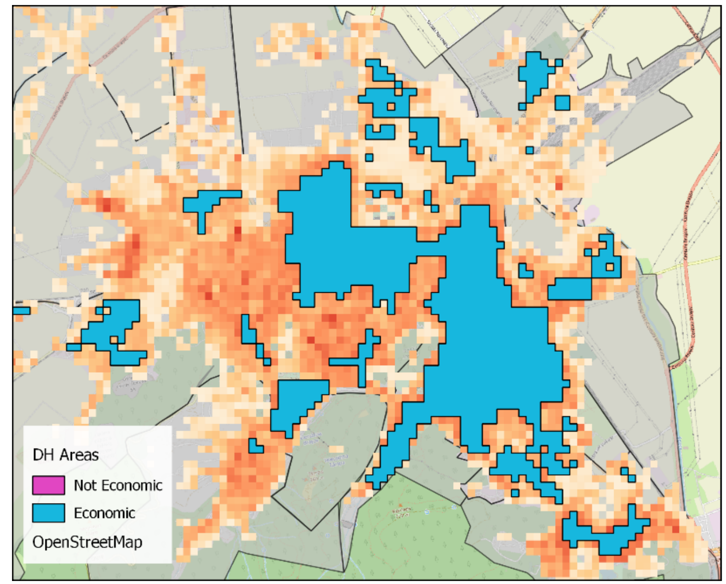
* www.hotmaps-project.eu
** Persson U, Werner S. Heat distribution and the future competitiveness of
district heating. Applied Energy 2011;88:568–76.
doi:10.1016/j.apenergy.2010.09.020.

Coherent areas





- Outputs of this step are:
  - Coherent areas
  - DH potential in coherent areas
  - Distribution grid cost in coherent areas

Grid model

- The aim of grid model is to **supply as much coherent areas as possible** with existing heating sources and at the same time **maintain the whole system economic**.

- The model **parameters** are:
  - Center-to-center Euclidean distances between coherent areas,
  - Available heat sources and their cost functions (fix and operating costs),
  - Supplied heat by DH system in each coherent area,
  - Available range of pipeline capacities and their specific costs

- The main model **variables** are:
  - Binary variable for the coherent area,
  - Binary variable for the heat sources,
  - Binary variable for the pipelines,
  - Heat capacities that flow through pipelines.

- **Objective function** (revenue oriented prize-collecting problem)
  - Maximize difference between heat sale revenue and transmission line costs

$$\max \quad heat\_sale\_price * \sum_i Q_{\max,i} * q_i - \sum_i \sum_j TLC_{ij} * l_{ij} * y_{ij} \qquad \forall (i,j) \in A$$

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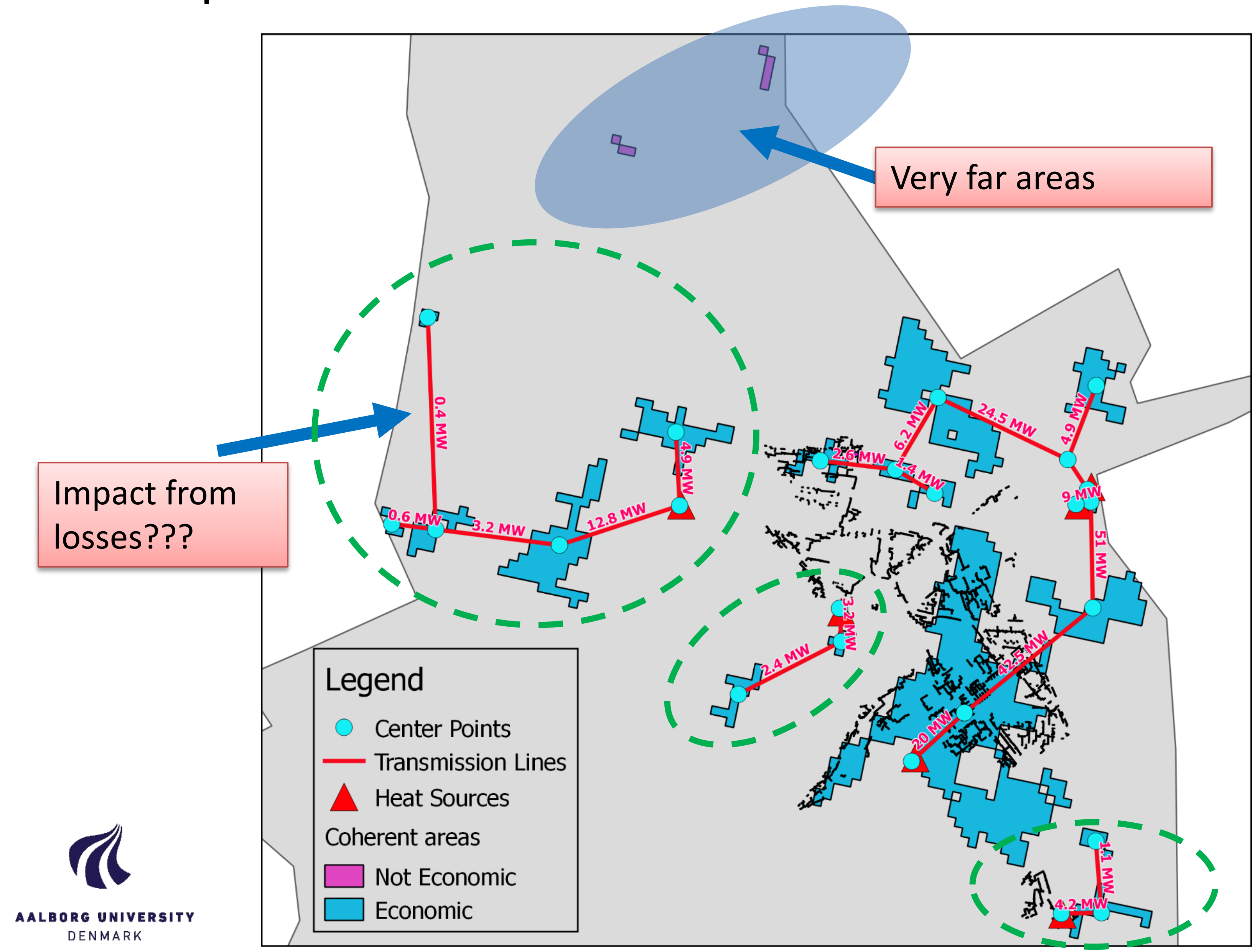
Scenario parameters

- Use the inputs and outputs of the alternative scenario from ProgRESsHEAT project in the developed method.

Time horizon	2014 - 2030
Grid depreciation time	25 years
DH connection rate 2014	16%
DH connection rate 2030	62%
Accumulated energy savings	17.50%
Interest rate	6%
Specific energetic distribution grid costs	27 €/MWh
Heat Sale price (without VAT)	89.5 €/MWh

Outputs from GIS-based method



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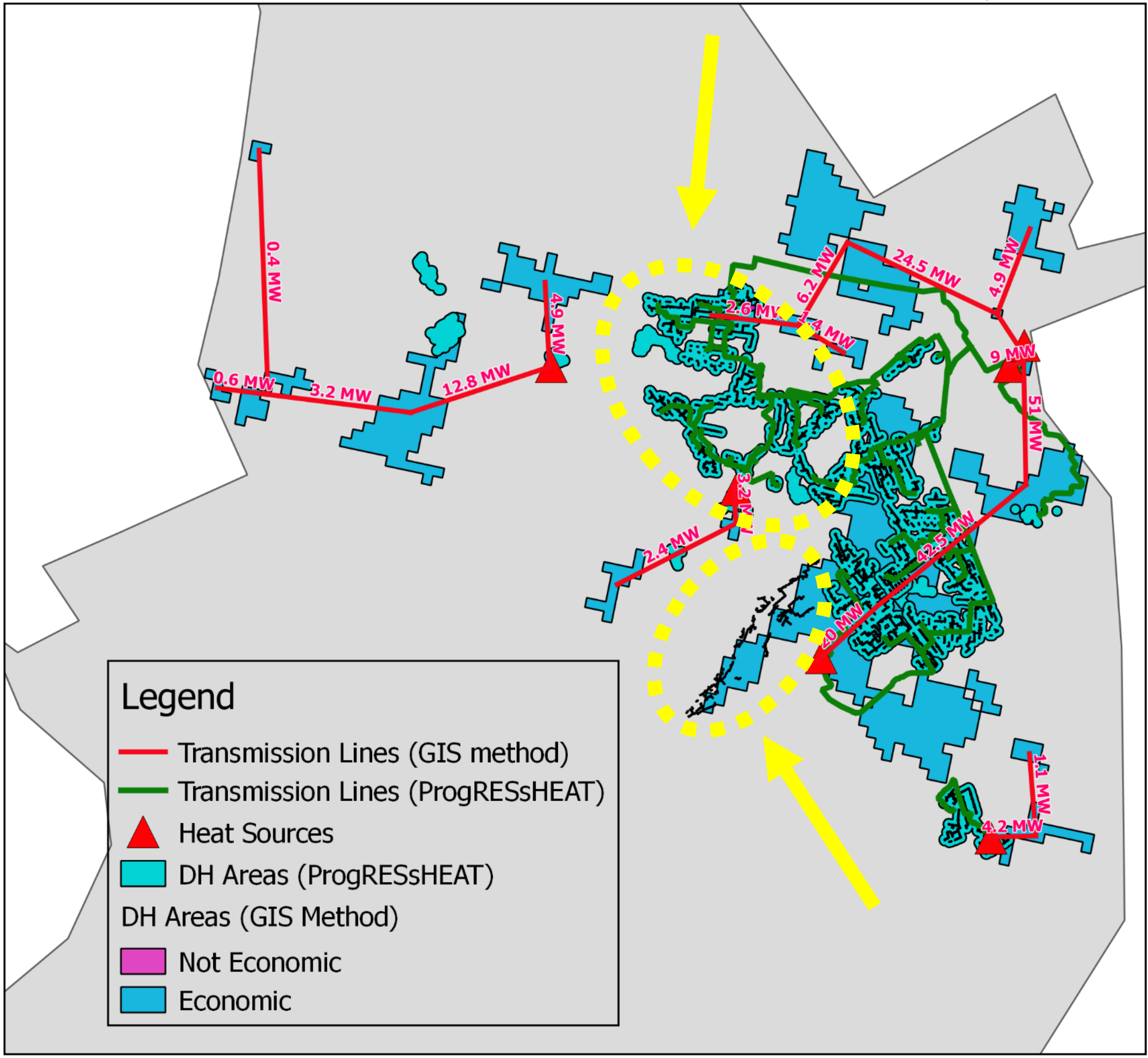
Comparison (I)

- Investment costs in
  - GIS-based method
  - ProgRESsHEAT
- Data consistency



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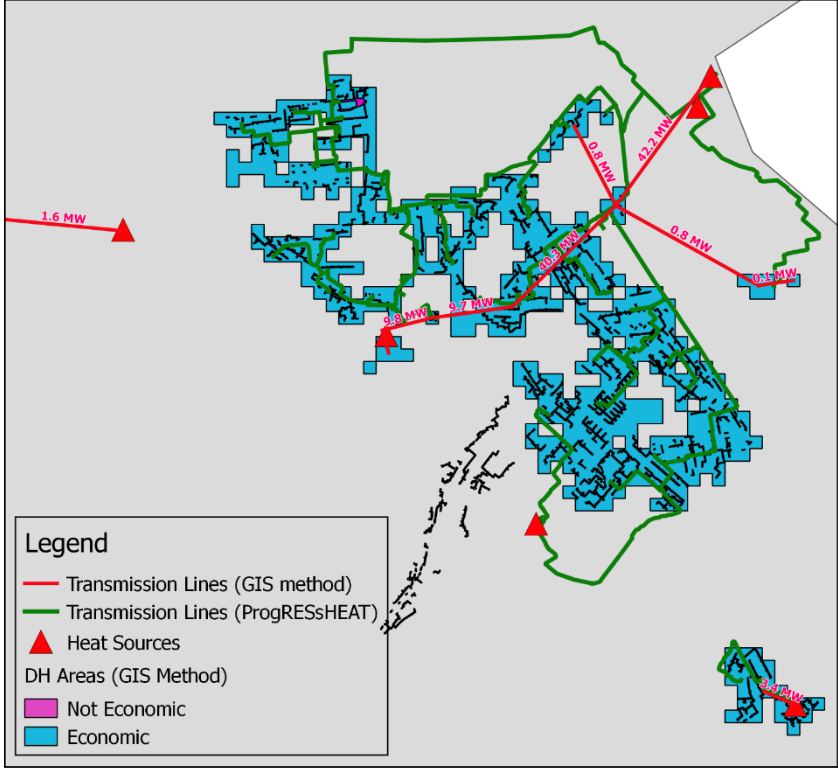
Comparison (II)



Parameter	ProgRESsHEAT	GIS-Based method	Comment
DH FED (2014)	66.86 GWh	37 GWh	
Distribution grid trench length	108 km	140 km	ProgRESsHEAT does not include house connections
Transmission grid trench length	46 km	16 km	
Gird’s energetic specific cost	27 €/MWh	23.9 €/MWh	Simple transmission line model

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Conclusions

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- In areas with existing infrastructure, considering available resources and budgets, a compromise may provide a better results compared to the optimal solution!
- For a better comparison of two methods, a consistence dataset is required.
- For the future works:
  - impact from heat losses in the grid,
  - street routes rather than Euclidean distances for the transmission lines,
  - Adapt the generic DH distribution grid cost to the case study conditions.