Impact of grid infrastructure on the economic viability of District heating in Brasov-Romania

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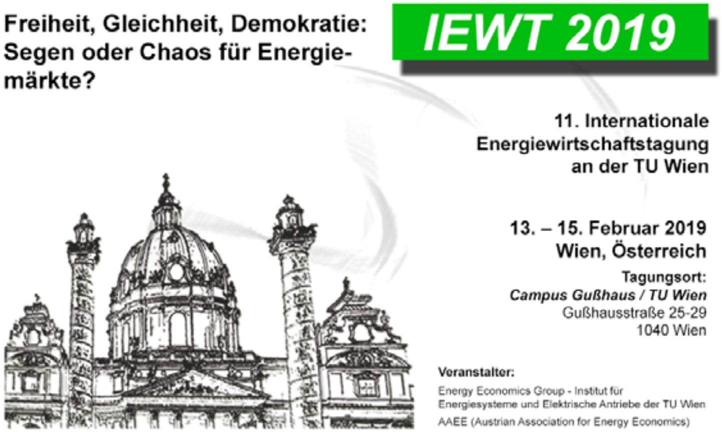
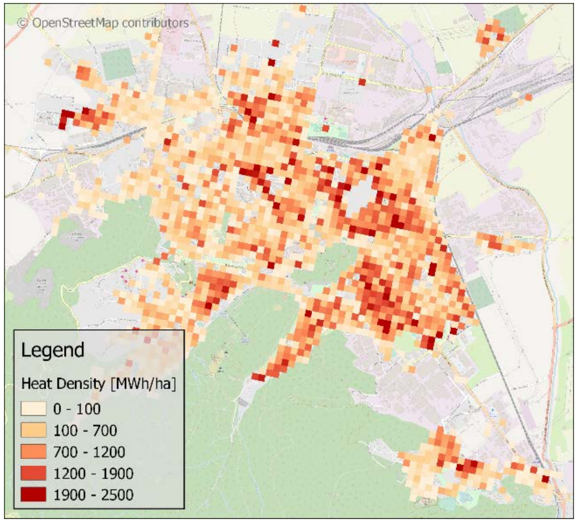


Motivation

- Research questions:
  - How to determine **economic** district heating (DH) areas?
  - How the available capital for investment on grid affect the DH areas & potentials?
- Approach
  - Calculation of DH distribution grid cost based on the heat densities,
  - Defining district heating areas with consideration of investment restrictions,
  - Model for identification of economic DH areas.
- Application for the case study of Brasov – Romania
  - Sensitivity analyses on investment restriction.
- Conclusion and next steps

Approach

DH Distribution Costs



- Input GIS layers from ProgRESsHEAT* project:
  - Heat demand density map (HDM) – 1ha resolution
  - Plot ratio map – 1ha resolution

- For each pixel of HDM in each year within the investment period, the followings should be calculated:
  - Annual heat demand (D_t) based on the expected accumulated energy saving (S),
  - Annual heat supply via DH system (Q_t) depending on the market shares (MS_0 & MS_m),
  - Annualized specific investment cost per unit of delivered heat: according to Persson & Werner** (audit were performed in 83 cities in DE, NL, FR, BE on over 1700 networks.

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

$$0 \leq S \leq 1 \quad ; \quad t \in \{0,1,2,\ldots,m\}$$

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

$$L = 1/w = 1/\left(61.8 \cdot e^{-0.15}\right) \quad \text{[m]}$$

$$d_a = 0.0486 \cdot \ln\left(Q_t / L\right) + 0.0007 \quad \text{[m]}$$

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

$$Inv = \propto * \frac{C_1 + C_2 * d_a}{Q/L}$$

* www.progressheat.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

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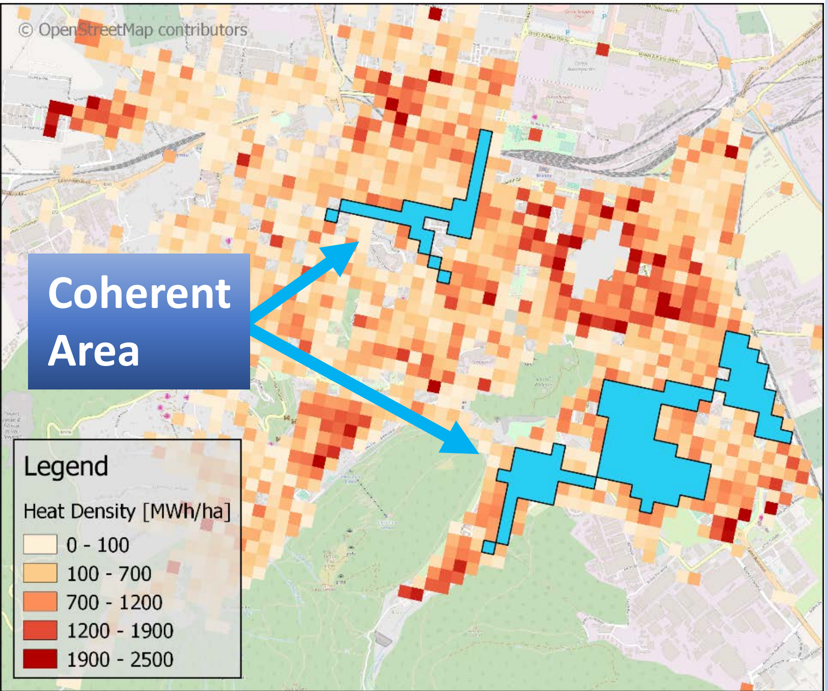
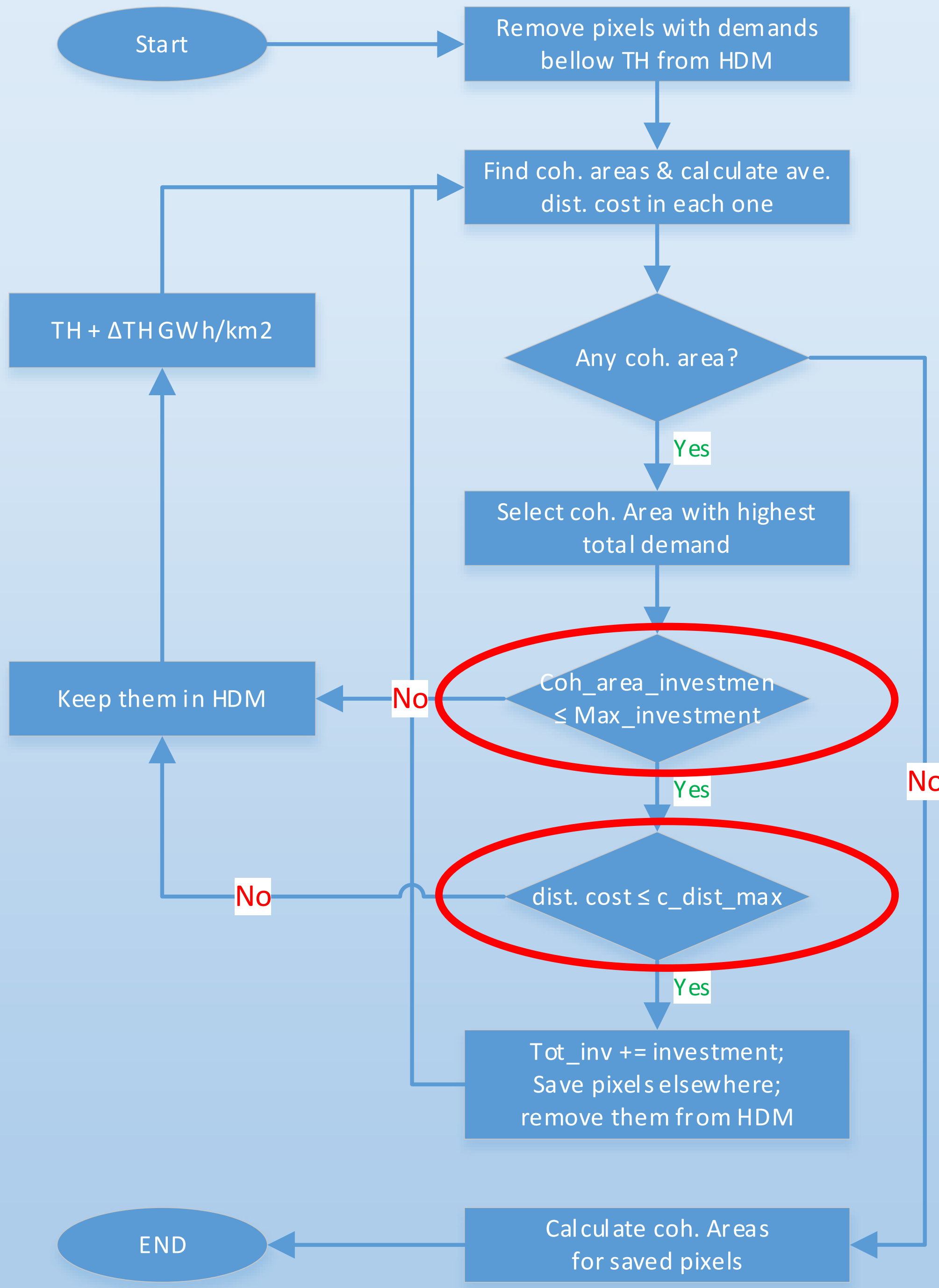
DH coherent areas

- Iterative process for determination of coherent areas.
- Restrictions:
  - Available Capital
  - Specific DH distribution cost ceiling.
- Preference is given to areas with higher heat demand rather than lower specific distribution grid costs.





Model for determination of economic DH areas

- The model maximizes the profit from heat sales via DH and at the same time, determines the economic coherent areas, the configuration of

- Model parameters are:
  - Center-to-center distance of the coherent areas,
  - Available heat sources, their location and cost functions (fix and operational costs),
  - Share of heat demand that should be supplied by DH in each coherent area,
  - Range of available pipeline dimensions in the market and their specific costs.

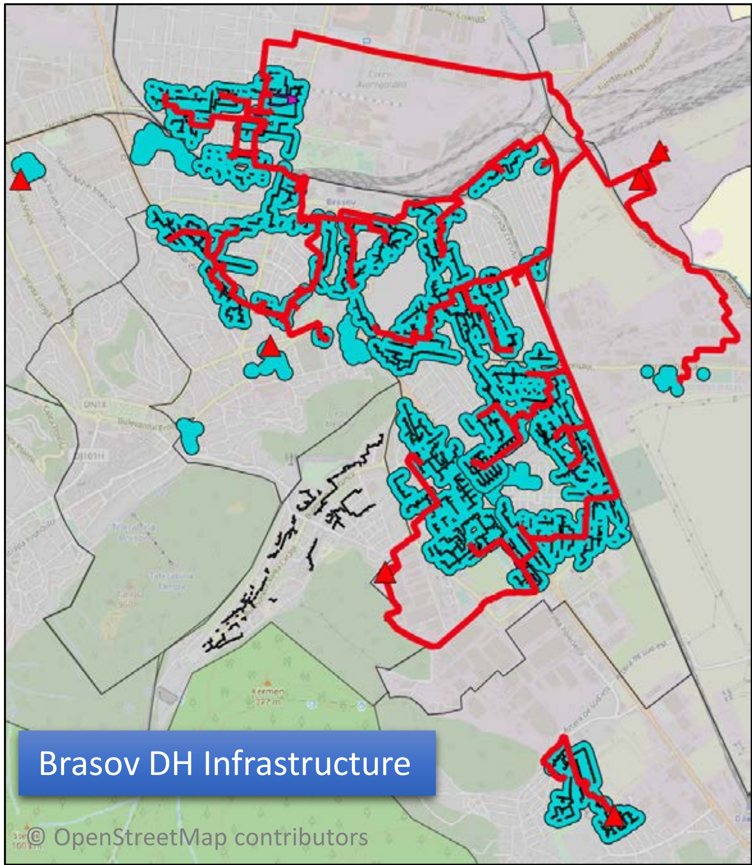
- Main variables are:
  - Binary variable for coherent areas (economic or not economic),
  - Binary variable for the heat sources (supplies or does not supply),
  - Binary variable for transportation lines between regions and also heat sources,
  - Max heat that flows through the pipelines.

$$\max HeatSaleRevenue - GenerationCosts - Dist.GridCost - Trans.GridCost$$

Application for the case study of Brasov (based on ProgRESsHEAT project)

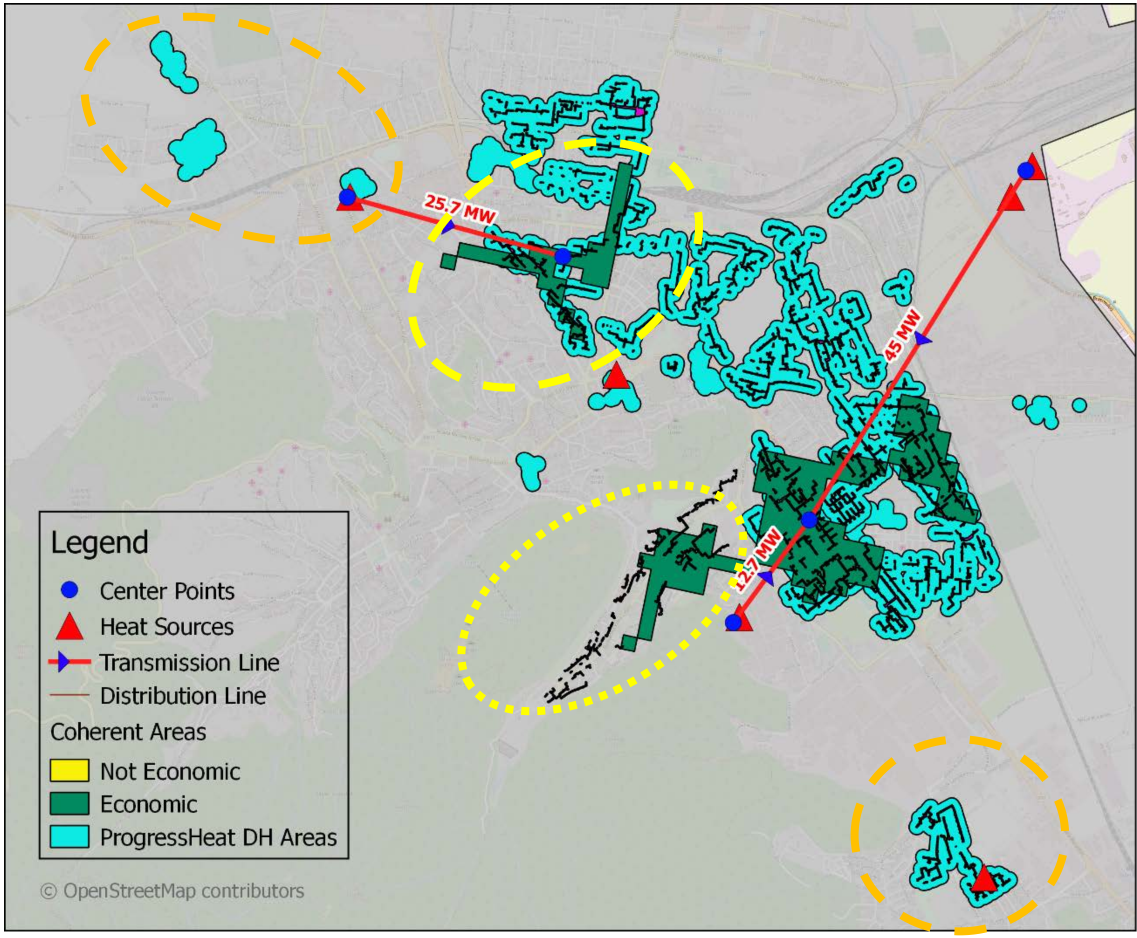
- Investment in grid (for the 50% of the grid that has not been renovated so far).
  - Transport and distribution grid investments: ~28 M. Euros
  - No consideration of VAT nor cost of connection to the buildings.

Parameter	Value
Period	2014 – 2030
Depreciation time of the grid	25 Years
DH market share 2014	16%
DH market share 2030	62%
Expected accumulative energy savings	17,50%
Interest rate	6%
Specific distribution grid cost ceiling	27 €/MWh
Heat sale price (excl. VAT)	89,5 €/MWh
Peak load factor	5,68e-4
Heat losses in grid	20%
Available capital for investment in grid	???



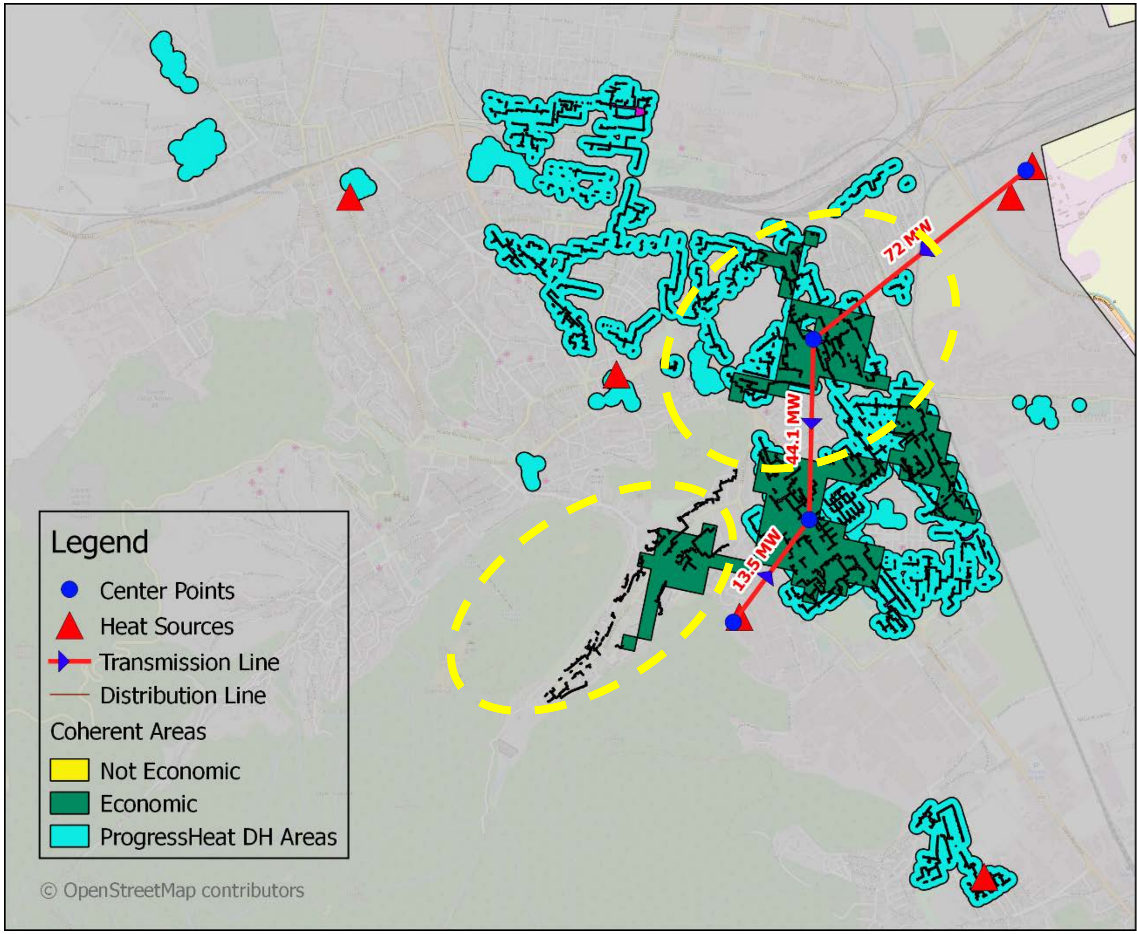
Results: 80% of ProgRESsHEAT investment level

- Investment restriction:
  - 22,6 M€
- DH Potential:
  - 122,2 GWh
- Specific distribution and transportation costs:
  - 16,6 EUR/MWh



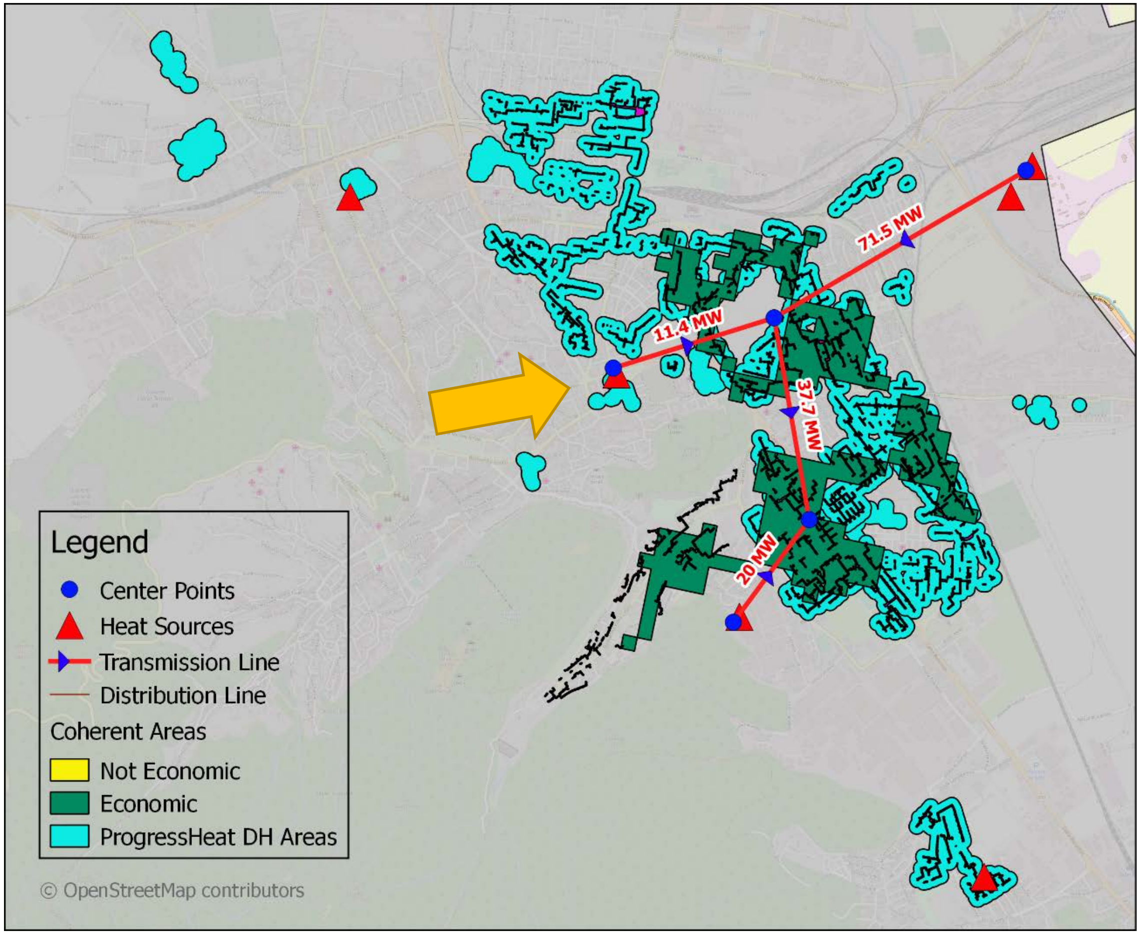
Results: 90% of ProgRESsHEAT investment level

- Investment restriction:
  - 25,4 M€
- DH Potential:
  - 125,3 GWh
- Specific distribution and transportation costs:
  - 17.19 EUR/MWh



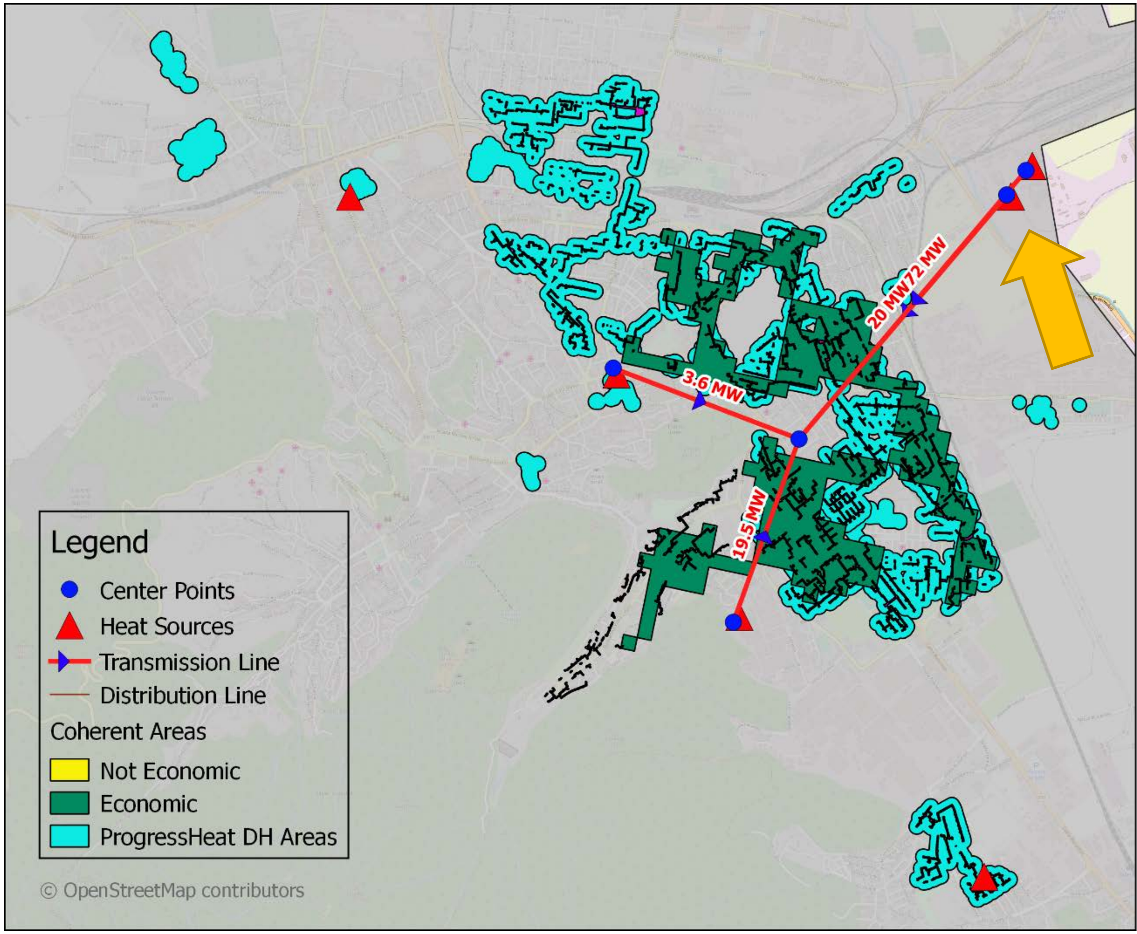
Results : 100% of ProgRESsHEAT investment level

- Investment restriction:
  - 28,2 M€
- DH Potential:
  - 150,7 GWh
- Specific distribution and transportation costs:
  - 17.65 EUR/MWh



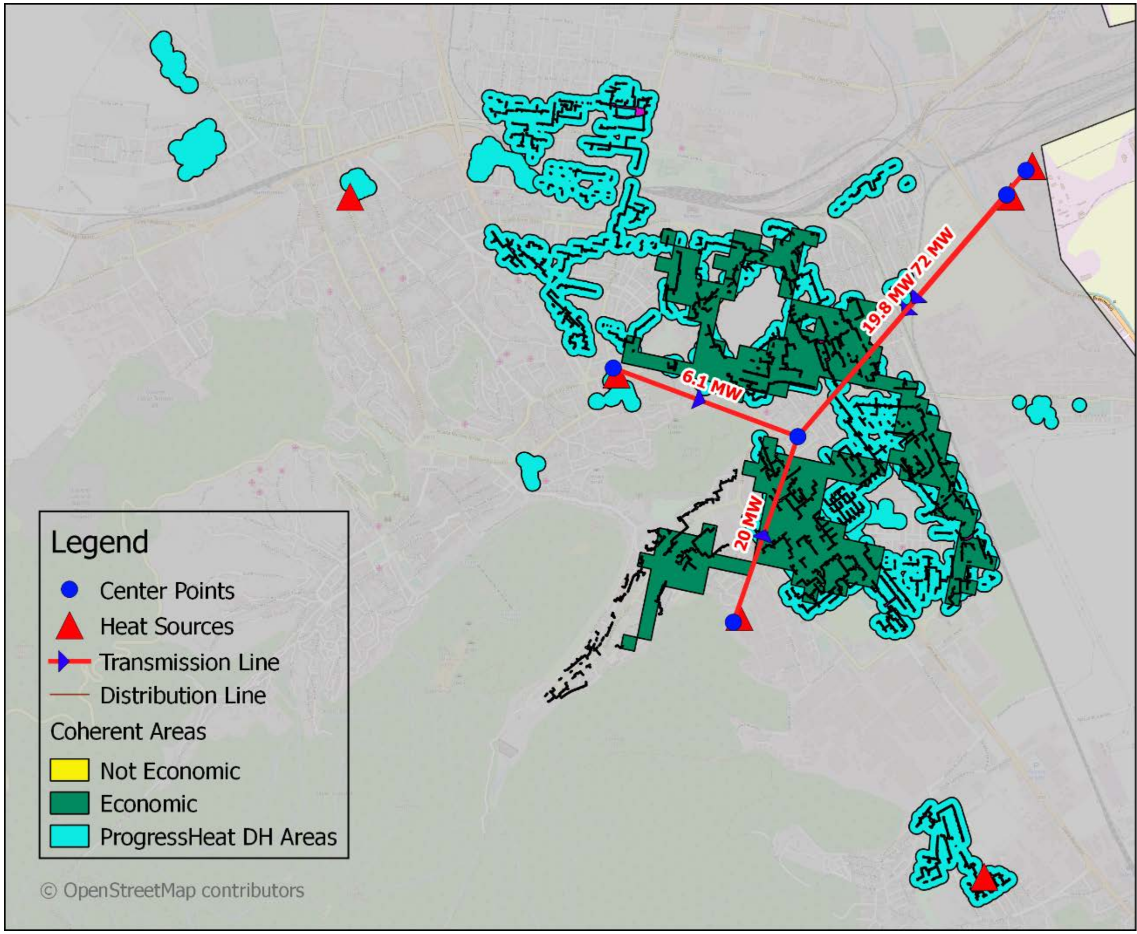
Results: 110% of ProgRESsHEAT investment level

- Investment restriction:
  - 31 M€
- DH Potential:
  - 168,7 GWh
- Specific distribution and transportation costs:
  - 17.64 EUR/MWh



Results: 120% of ProgRESsHEAT investment level

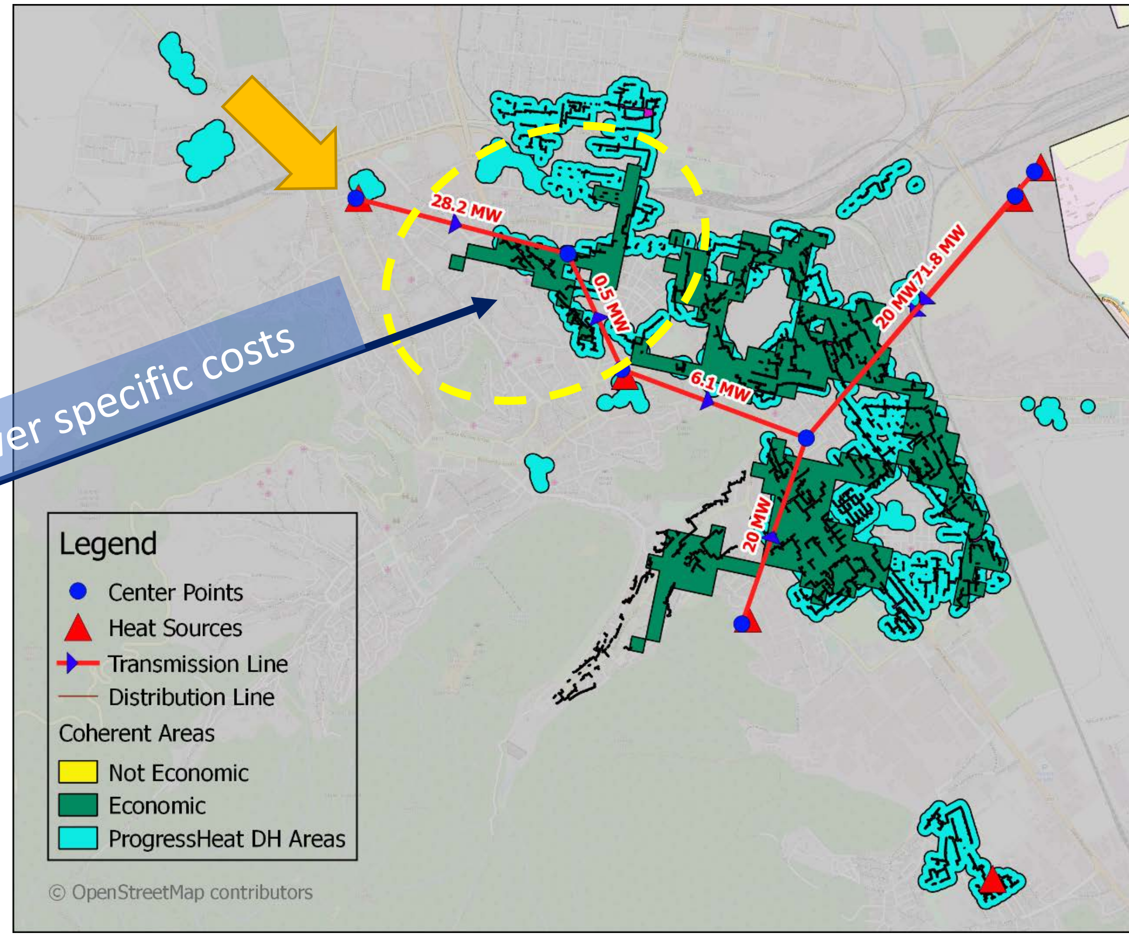
- Investment restriction:
  - 33,8 M€
- DH Potential:
  - 172,73 GWh
- Specific distribution and transportation costs:
  - 17,7 EUR/MWh



Results: 130% of ProgRESsHEAT investment level

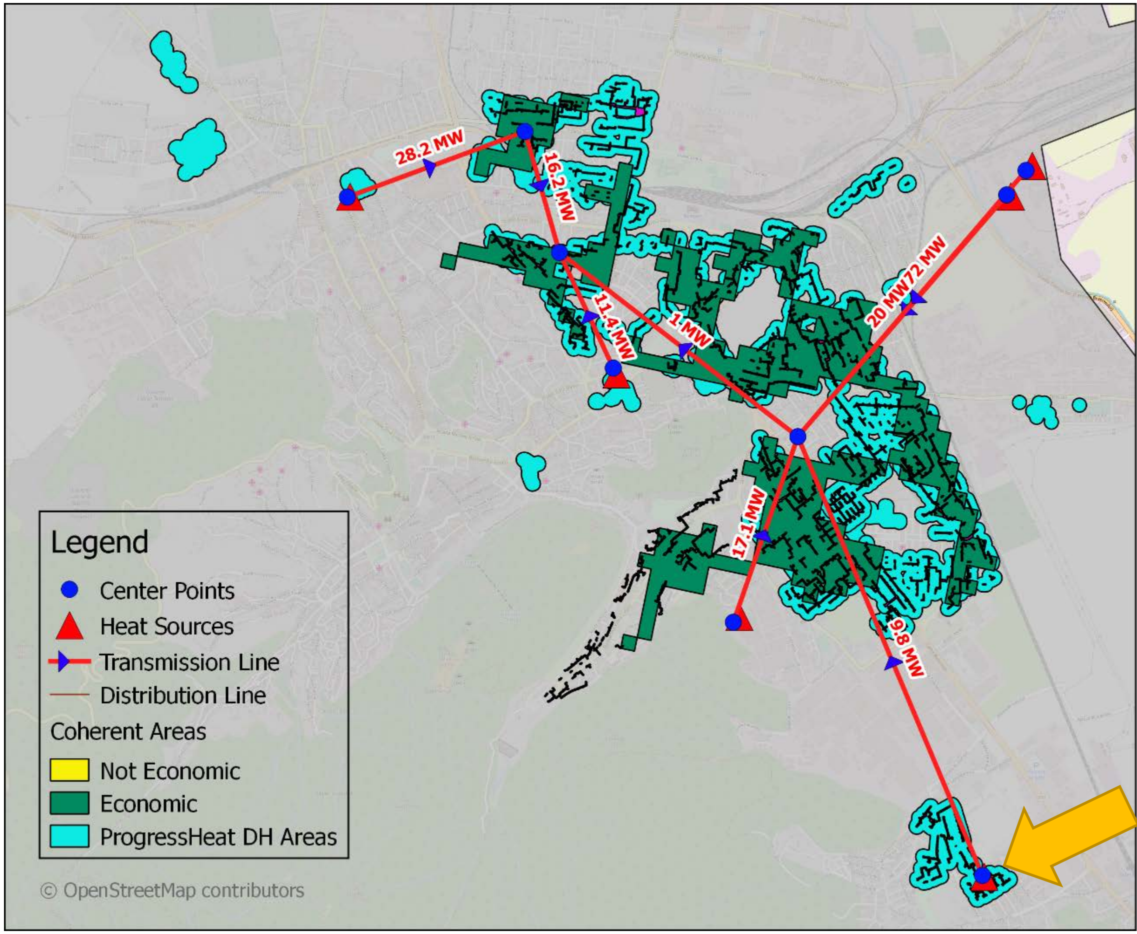
- Investment restriction:
  - 36,7 M€
- DH Potential:
  - 214,64 GWh
- Specific distribution and transportation costs:
  - 16.85 EUR/MWh

Lower specific costs



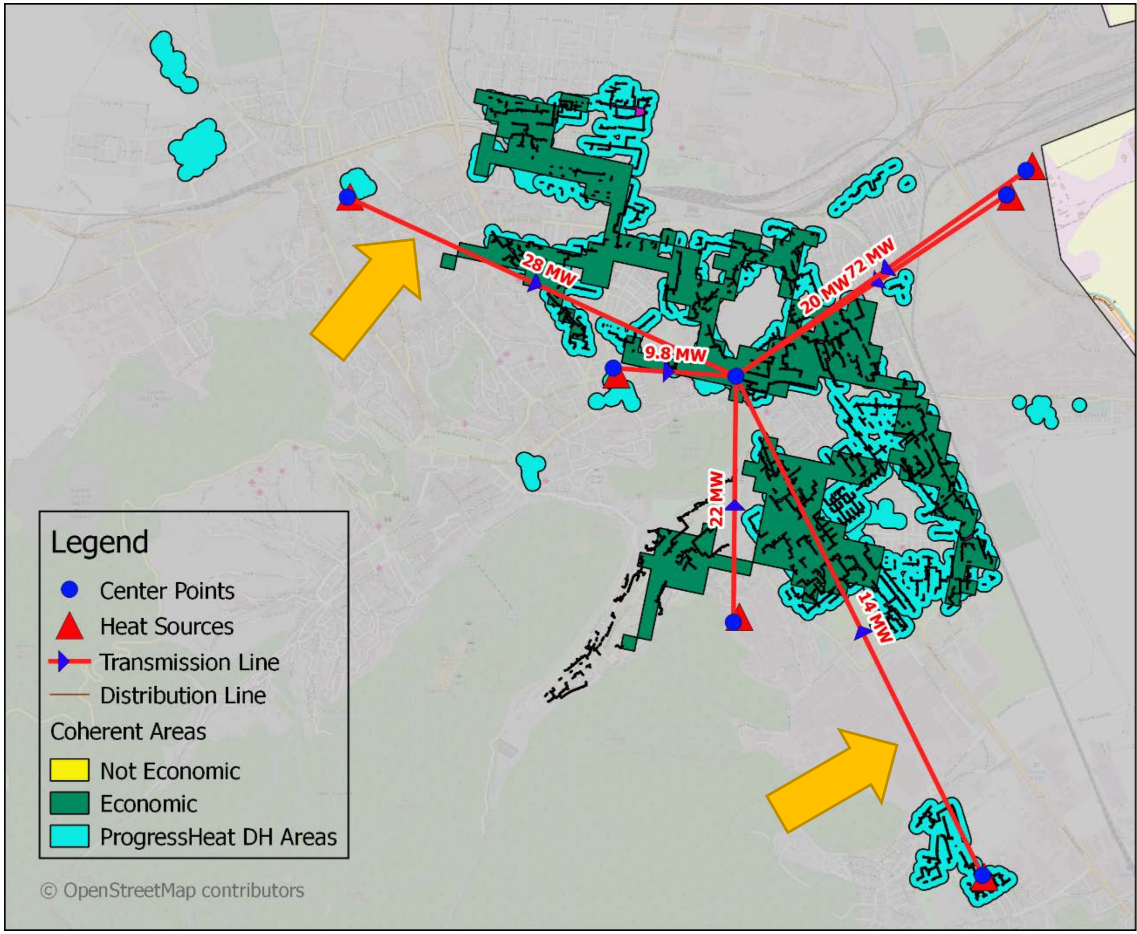
Results: 140% of ProgRESsHEAT investment level

- Investment restriction:
  - 39,5 M€
- DH Potential:
  - 232,2 GWh
- Specific distribution and transportation costs:
  - 17,74 EUR/MWh



Results: 150% of ProgRESsHEAT investment level

- Investment restriction:
  - 42,3 M€
- DH Potential:
  - 242,9 GWh
- Specific distribution and transportation costs:
  - 18,4 EUR/MWh



Conclusion

- A method for the determination of economic DH areas were introduced.
- The results of the model were compared with the result of ProgRESsHEAT project.
- Giving privilege to areas with higher heat demand rather than areas with lower grid costs, can reduce the investment risks from loss of costumers. Therefore, results of the provided method are relatively more reliable.
- There are still some additional steps that should be done:
  - Test the model for other regions (St. Polten),
  - Better modeling the transportation lines,
  - Consideration of additional parameters (e.g. pumping effort)

Thank you for your attention!

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Orig. Photo: Patrick Stargardt

DH Distribution Costs

- Annualized specific investment cost per unit of delivered heat
  - $C_{1,T}$, $C_{2,T}$ Construction costs constant [€/m] and Construction costs coefficient [€/m²]
  - L Total trench length [m]
  - w Effective width of distribution pipeline [m]
  - da Pipe Diameter [m]

Type equation here.

- Assumptions:
  - Continuous improvement of buildings
  - Simultaneous construction of pipelines

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

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

$$Inv = \propto * \frac{C_1 + C_2 * d_a}{Q/L}$$

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