2050

Heat Roadmap Europe

A low-carbon heating and cooling strategy

Development of Peta4 District heating beyond urban centres

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 695989.

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Motivation

- Heating and Cooling Strategy of the European Commission: important to quantify heating and cooling strategies across Europe
- To provide the basis for supply strategies, which aim at local resource utilization as well as energy efficiency.

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Research Objectives

- To identify, by means of continuous spatial modelling, the distribution of heat demands
- To prepare a quantitative decision basis for future heat supply in European countries
- To facilitate the search for the boundaries of district heat supply between urban and rural areas

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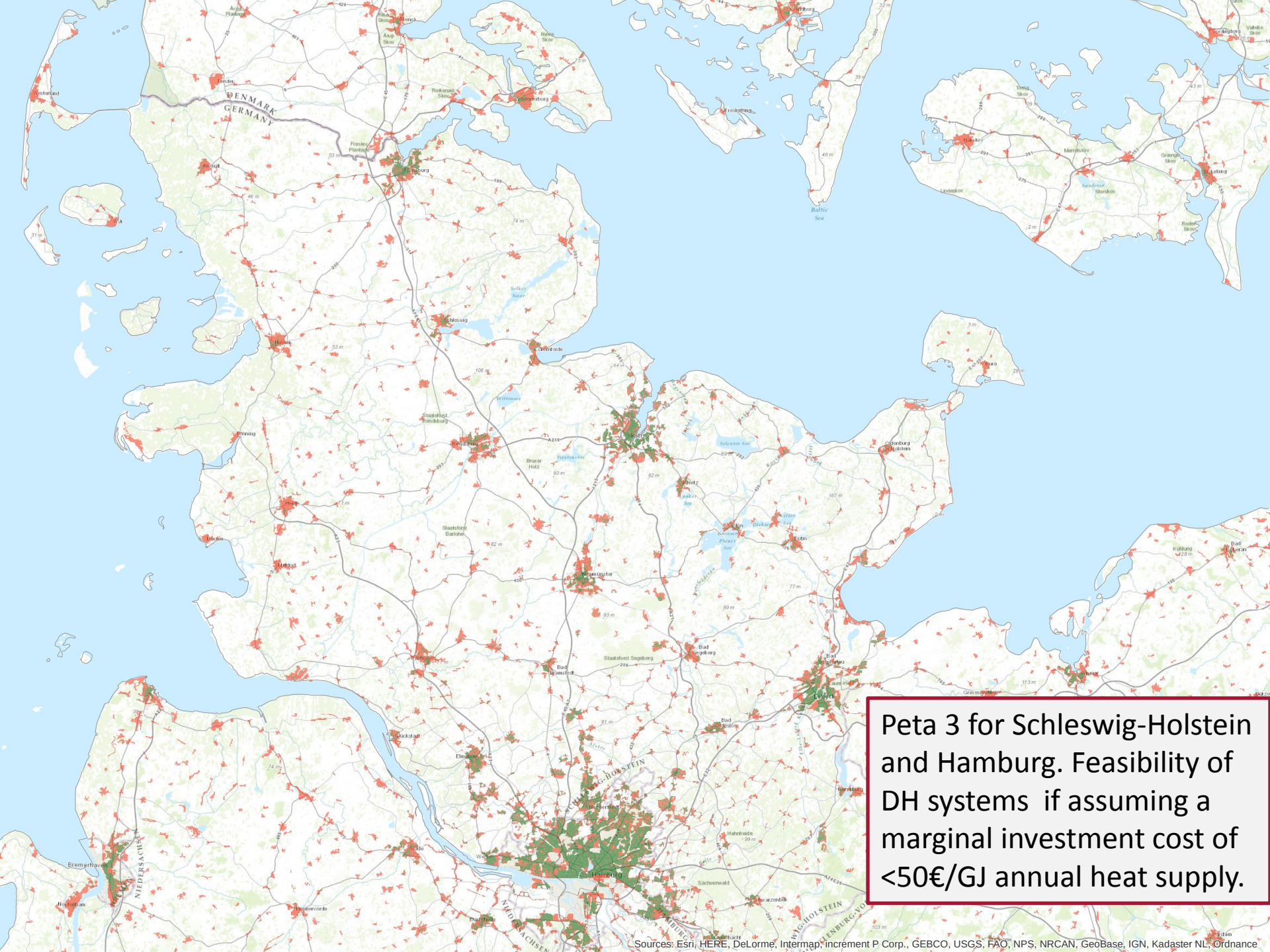
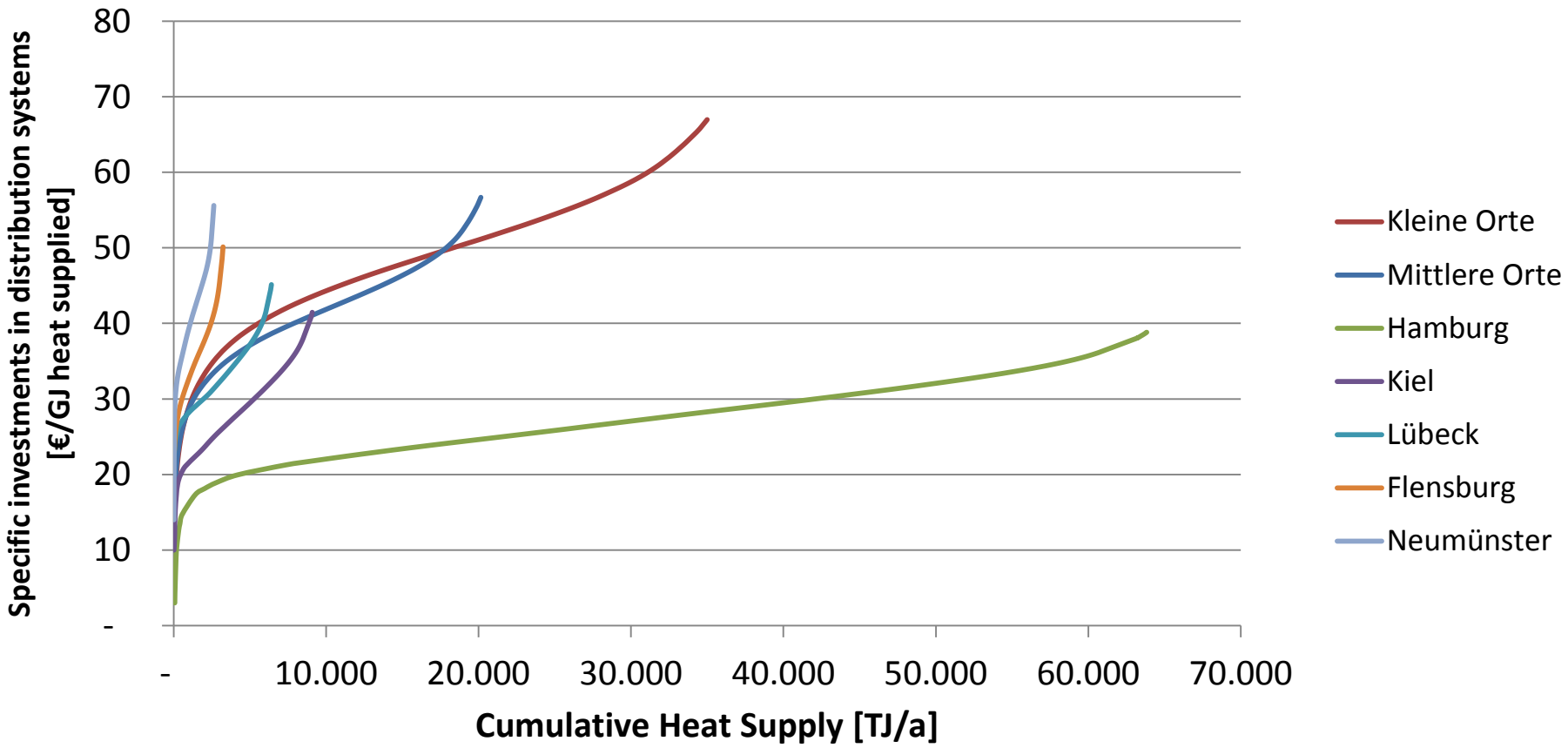

Peta 3 for Schleswig-Holstein and Hamburg. Feasibility of DH systems if assuming a marginal investment cost of <50€/GJ annual heat supply.
Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance

Cost-Supply studies in Peta 3



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From Peta 1 to Peta 4

- Heat Roadmap Europe, pre-study 1 (2012)
  - Heat demand by NUTS3, no detailed mapping
- Heat Roadmap Europe, pre-study 2 (2013)
  - Heat demand mapped at 1km resolution
  - Heat supply mapped on NUTS3 level
- Stratego WP2 (2015)
  - Heating and cooling demands mapped at 100m
  - Infrastructure costs, renewable energy, web mapping
- Heat Roadmap Europe (2016)
  - Improved mapping demands beyond urban areas
  - Allocation of supply to demands

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Development of Peta 4, the Pan-European Thermal Atlas

- Distribution of heating and cooling demands to a 100m grid:
  - A model of a representative distribution rather than an accounting model of real demands
  - Distribution based on specific demands and sectorial plot ratios (single/multi residential, service)

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From Peta3 to Peta4: methods

- Incorporation of the new ESM data (European Settlement Map, part of the EC GHSL)
- Basis for distribution of heat demand
- Extensive regression analysis of available urban geodata to find distribution formulas for building areas
- Derived plot ratios for service sector and residential, single and multi-family buildings

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How can buildings be distributed by area and type?

- There are no registers of all European buildings, and few on the national scale
- Existing typologies are difficult to apply for continuous mapping
- Therefore Peta applies a combined Top-Down / Bottom-Up approach:
  - National statistics are broken down to NUTS3 level
  - A heating index is calculated for each NUTS3 area, weighted by population and local heating habits
  - Population distributed to a 1km^2 grid and plot density maps form the basis of a local heat density model

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Plot ratios by geostatistics

- Ordinary Least Square multi-linear regression techniques were used to model plot ratios
- They were based on several explanatory variables:
  - Population
  - Degree of soil sealing
  - European Settlement Map, % built-up
  - Derivatives of these: neighbourhood statistics
  - Land use type

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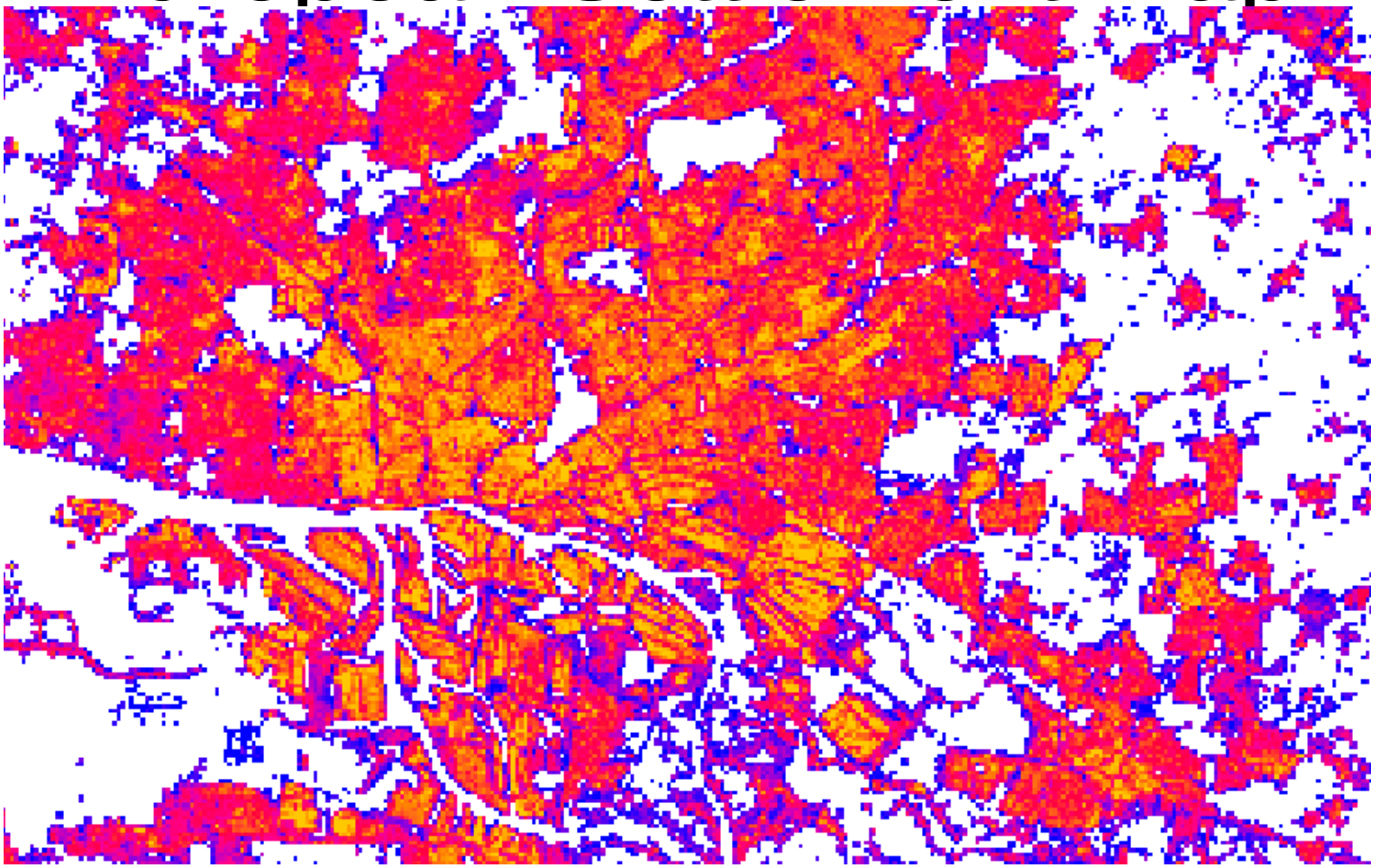
European Settlement Map



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ESM (2016) for Hamburg

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Plot ratios for res. and serv. sectors

- Plot ratio: m^2 building area per ha land area
- Use Danish building register aggregated to 100m grid as training set of known variables
- Prepare hypotheses, test with single regressions
- Derive multi-linear regression function
- Like in HRE3, but now we add geographically weighted regression analysis to check local validity

For each cell, plot ratios for residential (single/multi-family) and service sectors were calculated.

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Coefficients to model service building plot ratio

a	b * Pop1000	b * Pop100	c * Soilseal>87 %	d * FocalMean300m of Soilseal>87%	e * Builtup where Soilseal>87 %	f * FocalMean300m of Builtup where Soilseal>87%	g * Sum of osm roads length	R sqaured
-11283	0.53		121	24.5				0.13
-12535		22	127	47				0.10
-1166	0.5				68	9.8		0.161
-1637		22			63	46		0.131
-8903	0.51		83	3.8 *	66			0.164
-9927		22	86	22	72			0.137
-8906	0.5		83	4.9 *	67	– 2.9 *		0.164
-9865		22	85	14	65	23		0.138
-9052	0.5		84	3.9 *	67	2.6 *	0.67 **	0.16
-10136		22	87	12	65	23	1.34	0.138
-9285	0.5		88		67		0.76	0.164
-9190	0.52		88		67			0.164
					h * Builtup	i * FocalMean300m of Builtup	g * Sum of osm roads length	
+148		18.9			38	2.3		0.15

Low confidence levels

- All of our regression analyses show low (R^2 <0.2) correlation coefficients
- Normally this is considered to be a problem
- However, R^2 in aggregated 1km grids becomes higher than 0.6
- This means that our model is good at absolute densities in supply areas, but poor at knowing exactly where the heat demand is located.

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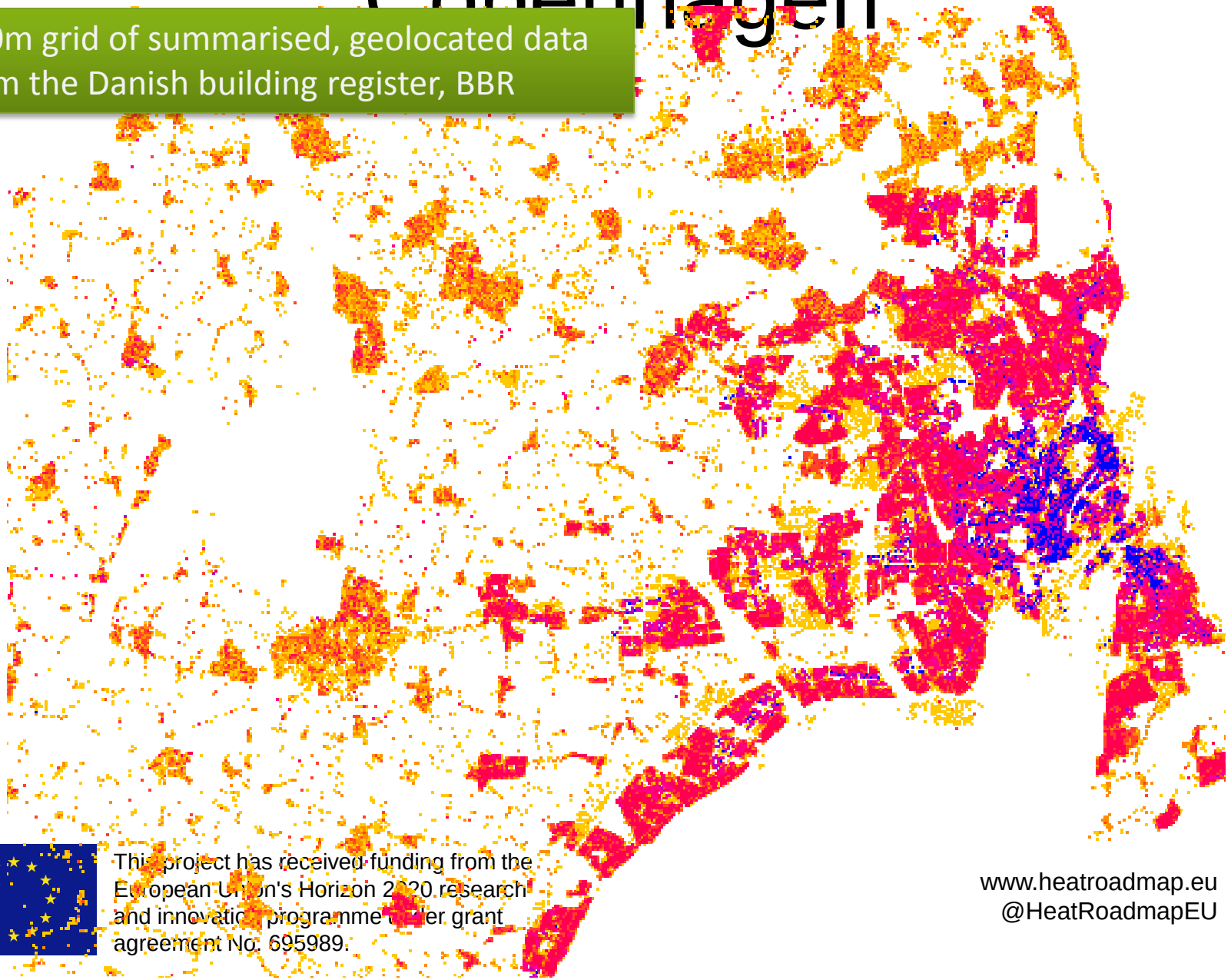
Observed plot ratio, Copenhagen

100m grid of summarised, geolocated data from the Danish building register, BBR



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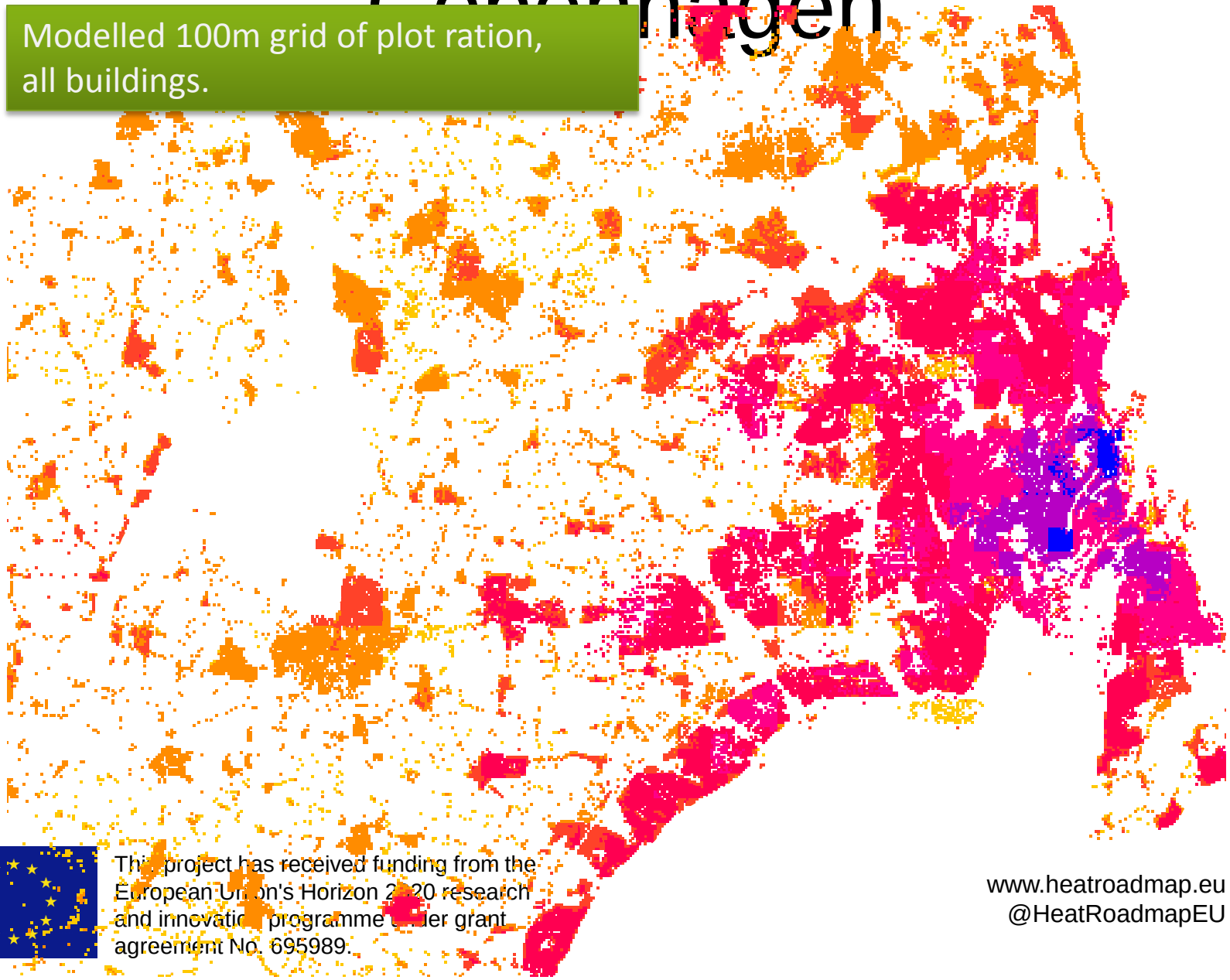
Modelled plot ratio, Copenhagen

Modelled 100m grid of plot ration, all buildings.



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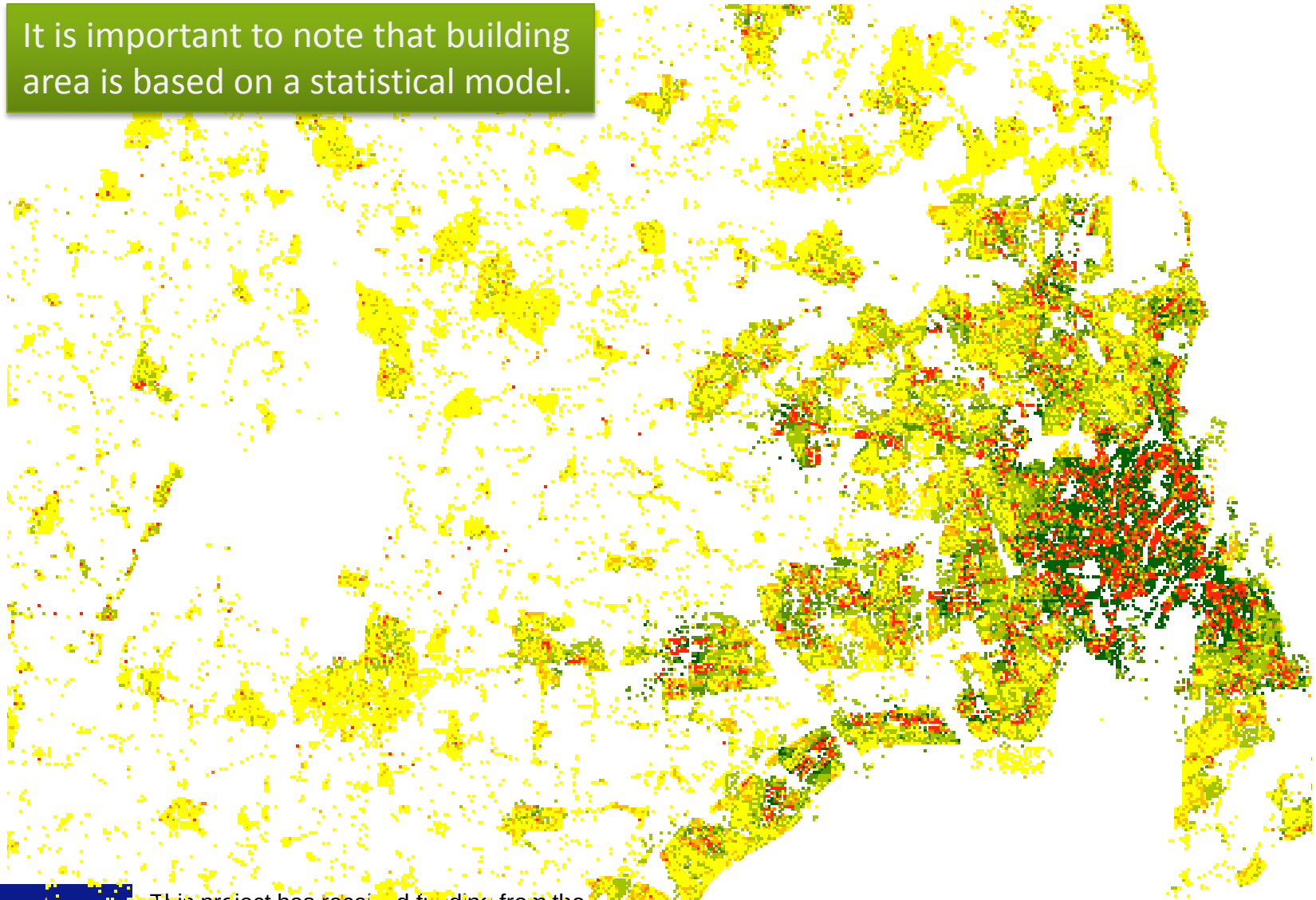
Residuals of plot ratio

It is important to note that building area is based on a statistical model.



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Classification of heat demand

Heat demand density [TJ/km2]	Classification of supply strategy depending on heat demand density
< 20	Rural areas outside reach for DH
20 – 50	Recommendation for DH in new buildings
50 – 120	Recommendation for low temp DH in existing buildings
120 - 300	Guide for conventional DH in existing buildings
> 300	Obvious DH potential

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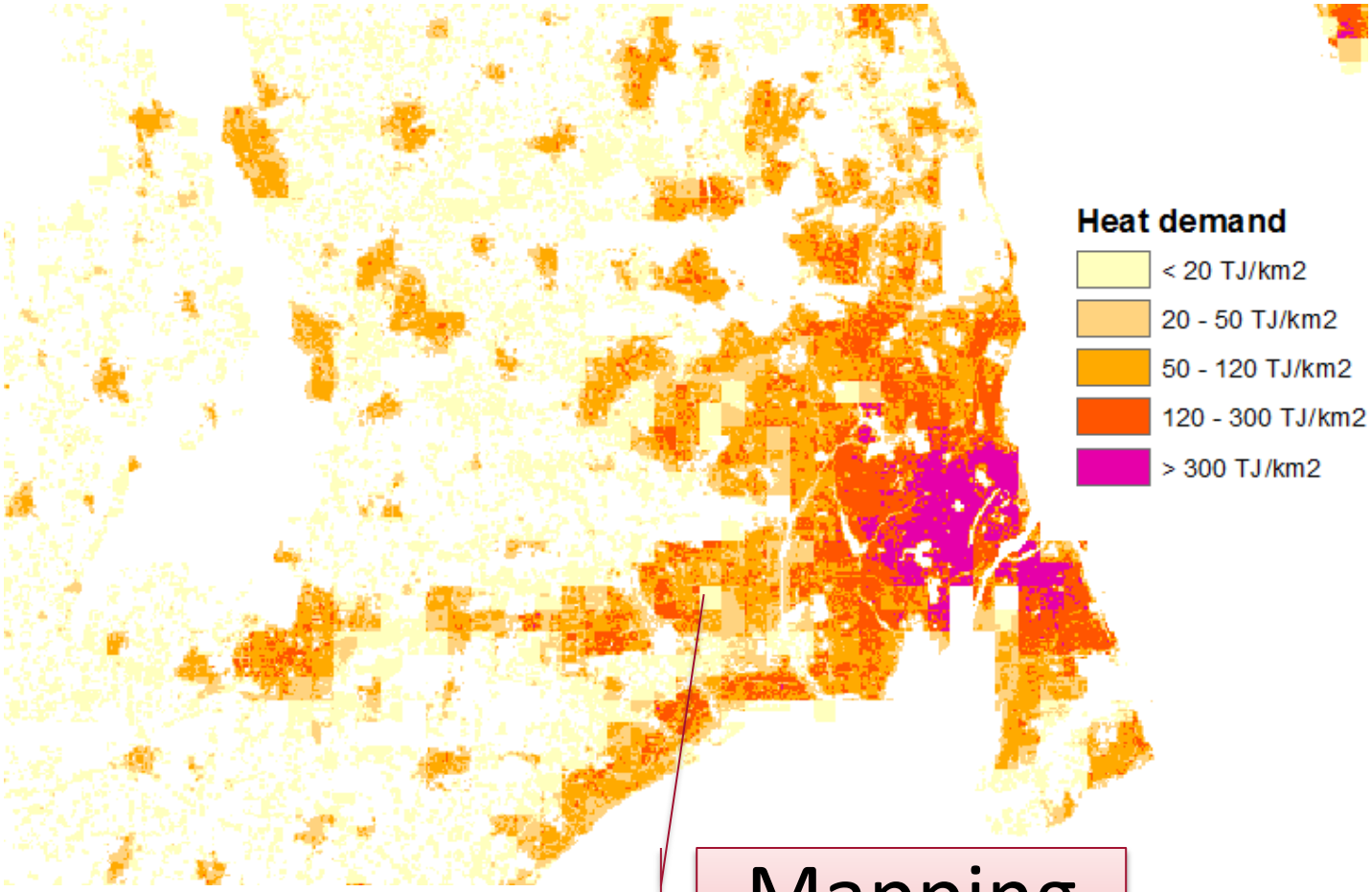
Heat demand supply areas



Mapping artefacts!

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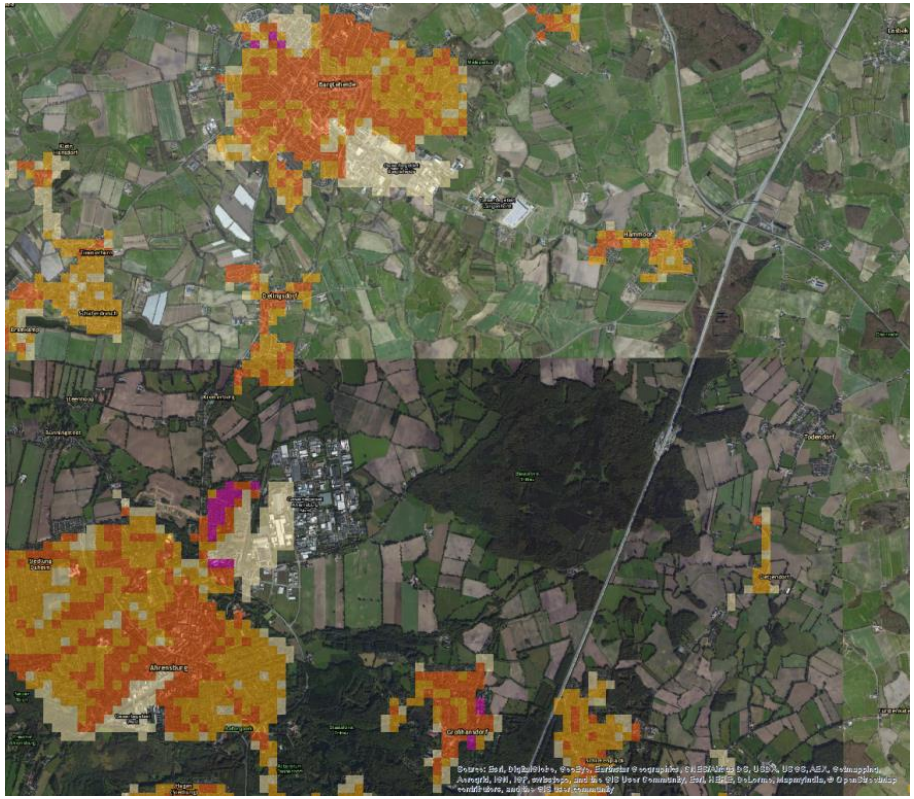
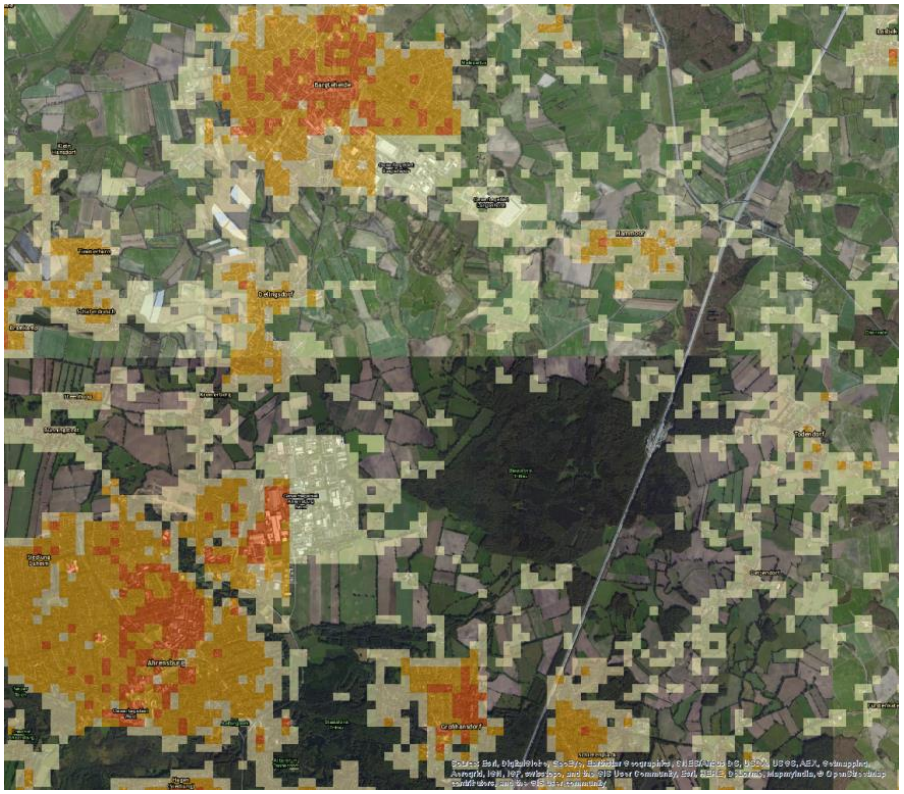
Comparison between Peta 3 and 4

Peta 3



Peta 4 alpha



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Next steps

- Spatial model of (continuous) heat demand classification: URBAN – LARS – RURAL areas
- Develop method for future specific heat demand (Results from climate models)
- Develop model for the future development of urban areas

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LARS: Local Assignment of Restricted Supply Areas

- LARS areas are located between urban and rural areas, where it is difficult to say if DH is feasible or not.
- LARS areas are a product of regulation rather than physical constraints
- However if all economic parameters are the same, LARS areas can be modelled as a function of heat demand density
- The extent of the LARS area needs to be flexible

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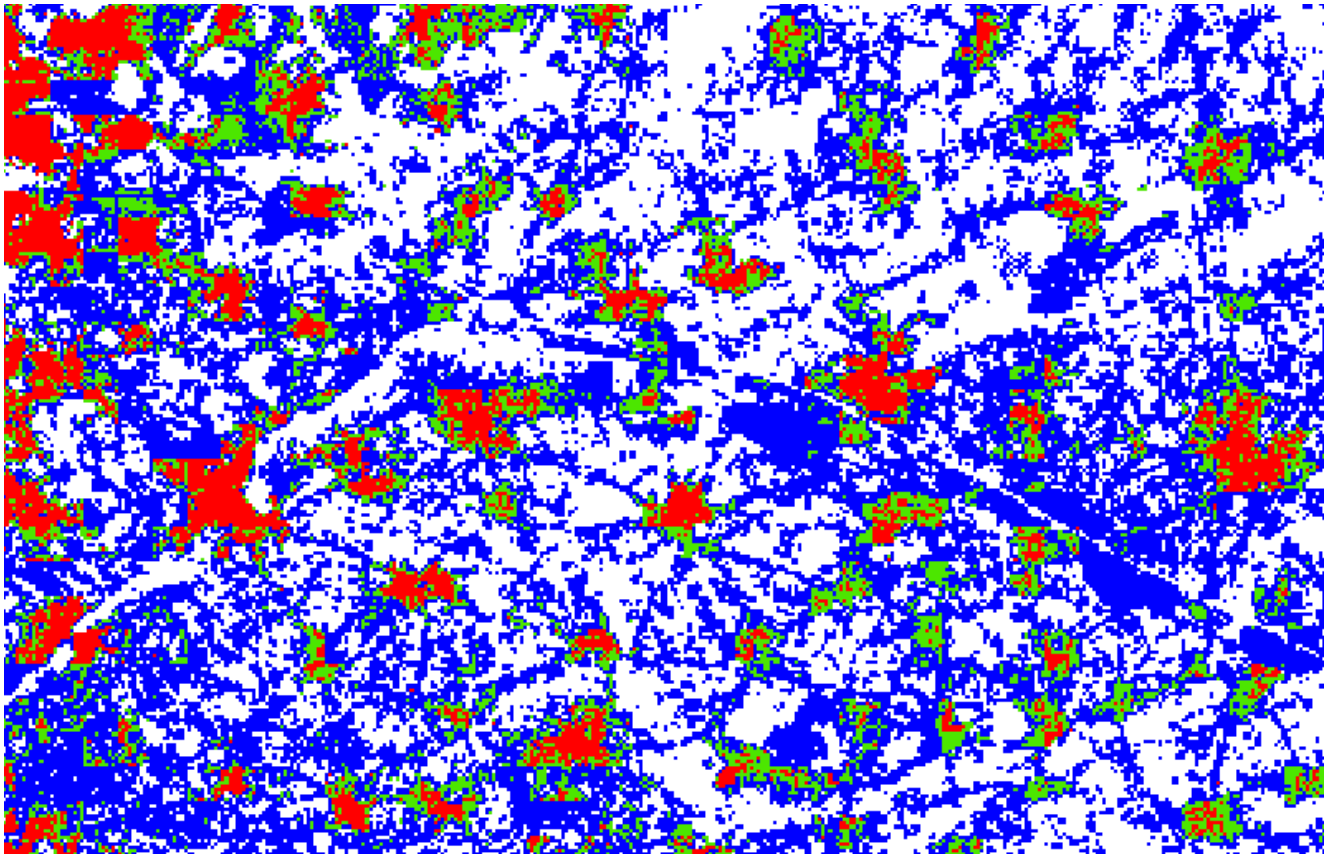
LARS areas mapped in Belgium



Red: > 60 TJ/km2; blue: < 30 TJ/km2; Green: possible “LARS” area

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What else is going on?

- Removal of artefacts by inclusion of land use data
- New building areas (1990, 2000, 2006) located
- Heat demand adjusted to altitude
- Future heat demand adjusted to local climate change scenarios (IPPC RCP 4.5 and RCP 8.5)
- Excess heat supply calculations improved
- Mapping of local heat pump technology and COP
- Choice of web-based mapping platform

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- Results so far:
  - Draft maps of heat demand in 14 MS
  - Draft maps of excess heat supply in 14MS
- Available from the website

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