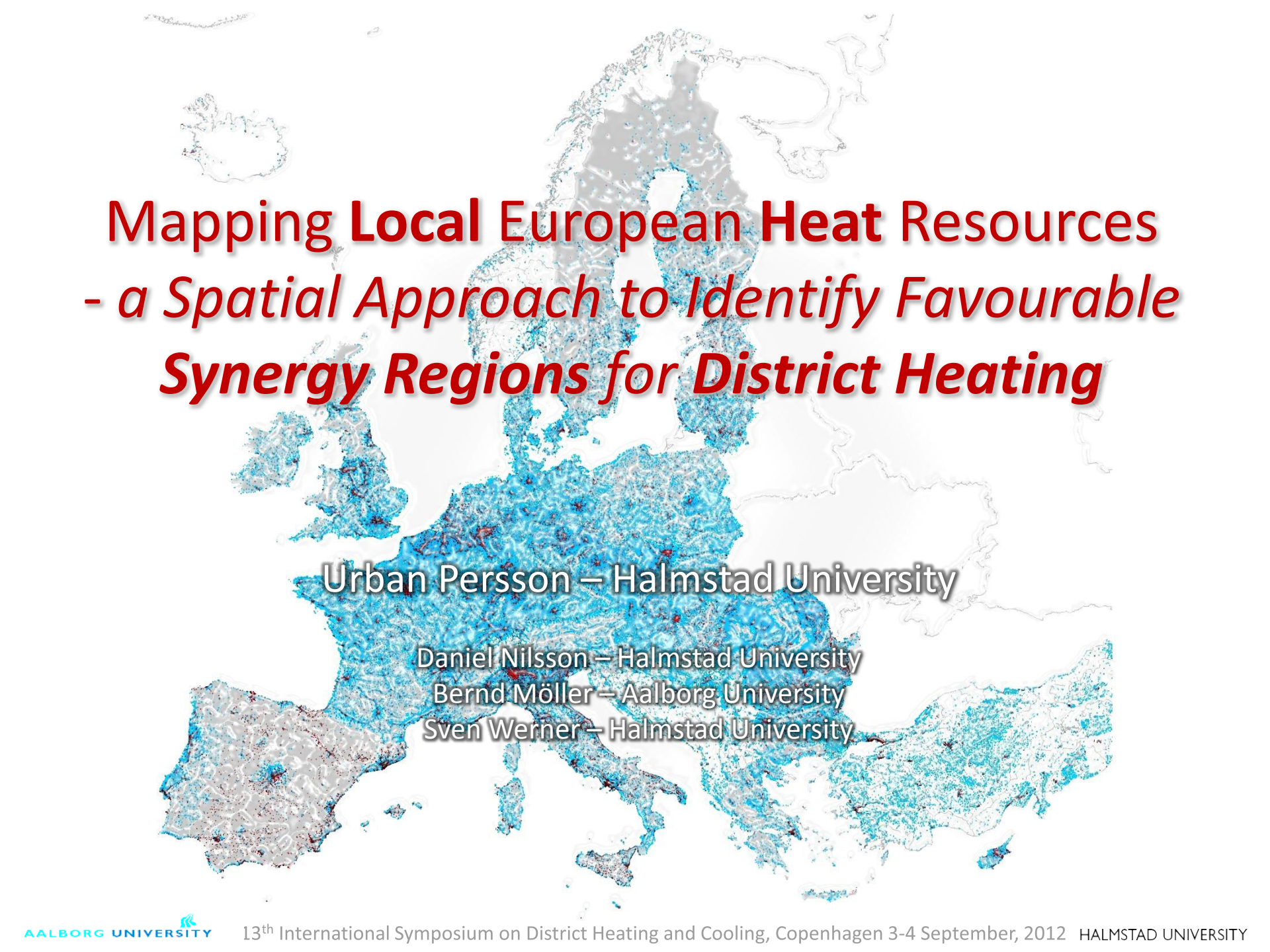
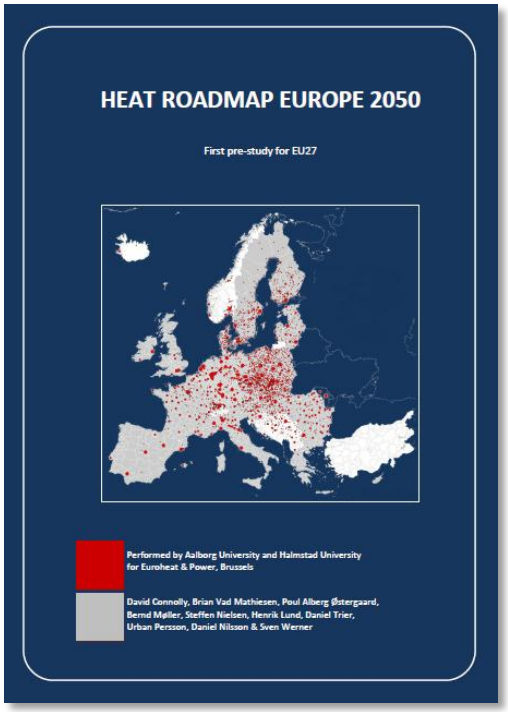


Mapping **Local** European **Heat** Resources
- a Spatial Approach to Identify Favourable ***Synergy Regions*** *for* ***District Heating***

Urban Persson – Halmstad University

Daniel Nilsson – Halmstad University
Bernd Möller – Aalborg University
Sven Werner – Halmstad University

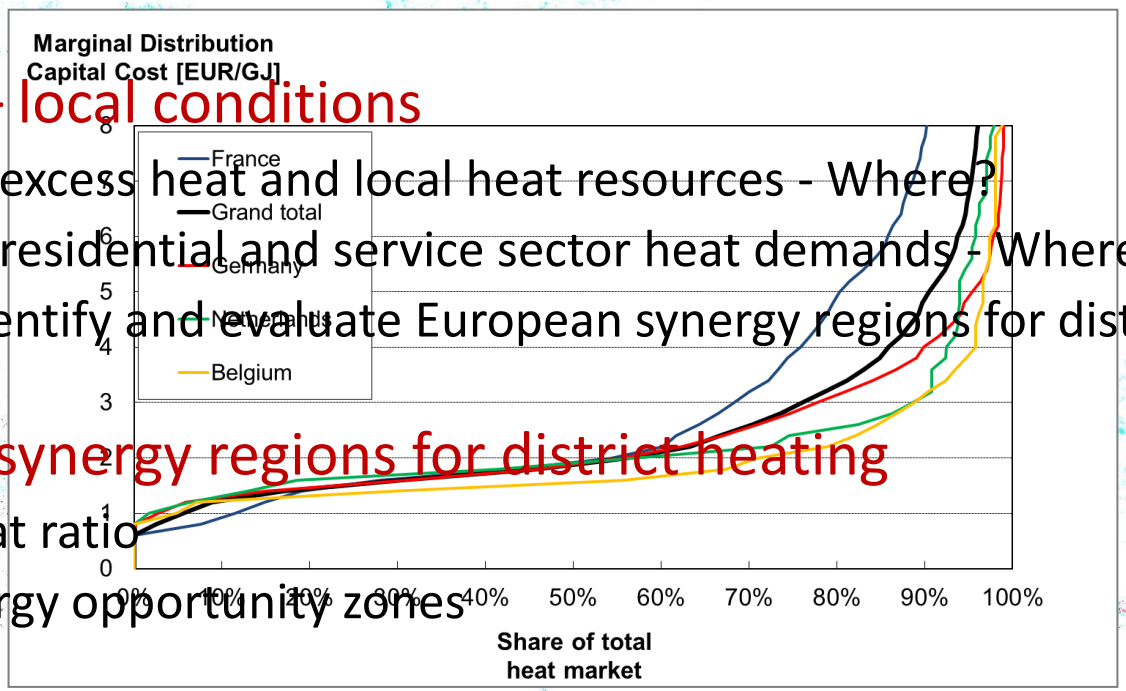
Background



- Heat Roadmap Europe 2050 project
  - First pre-study: January to April 2012
  - Report published June 4th, 2012 (www.euroheat.org)
  - Cooperation: Aalborg and Halmstad Universities
  - Methodological approach:
    - Traditional energy system modelling:
      - Scenario forecasts
    - **Mapping of local conditions:**
      - **Geographic information system (GIS) analysis**
- Initiative by Euroheat & Power, Brussels
  - Alternative projections of the future European heat market
  - Strategic aim to the Intelligent Energy Europe program
  - Full study planned for 2014-2017
- The Halmstad University District Heating and Cooling Database (HUDHC)
  - Created in June 2010: two major updates (June 2011 and May 2012)

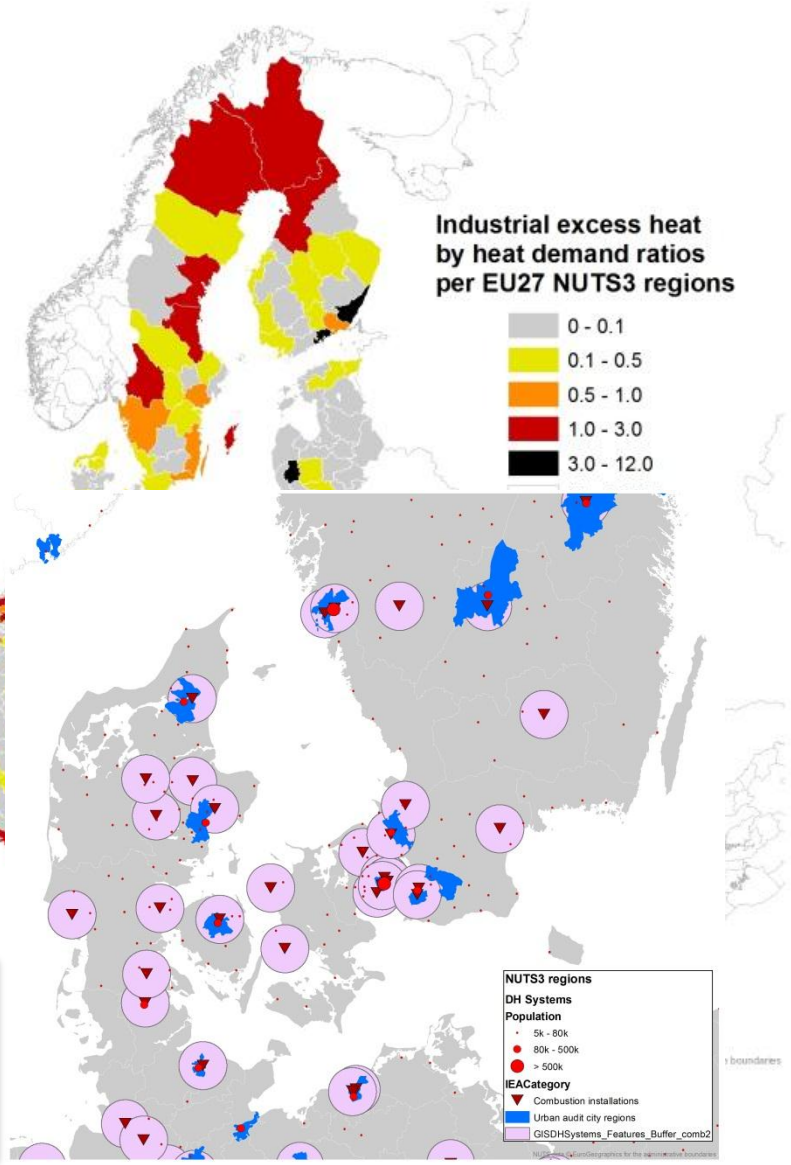
Research questions

- General conditions
  - Presence of excess heat (TPG & Energy intensive industry)
  - Presence of local heat resources (biomass, solar, geothermal)
  - District heating systems – excess heat recovery and local heat resource utilisation, general system efficiency, fuel substitution
  - NUTS3 regions – Local resolution!
  - DH expansion possibilities in European urban areas
- Key issues – local conditions
  - European excess heat and local heat resources - Where?
  - European residential and service sector heat demands - Where?
  - How to identify and evaluate European synergy regions for district heating?
- Favourable synergy regions for district heating
  - Excess heat ratio
  - Heat synergy opportunity zones



Data and methodology

- Synergy regions for district heating
  - The excess heat ratio concept
    - NUTS3 region characterization
    - Quota of excess heat and heat demands
  - Heat synergy opportunity zones
    - Site characterization
      - Excess heat activities
      - District heating systems
    - HUDHC database – European DH cities
    - Existing DH systems as starting point
    - Feasible transmission distance determined by heat demand magnitude



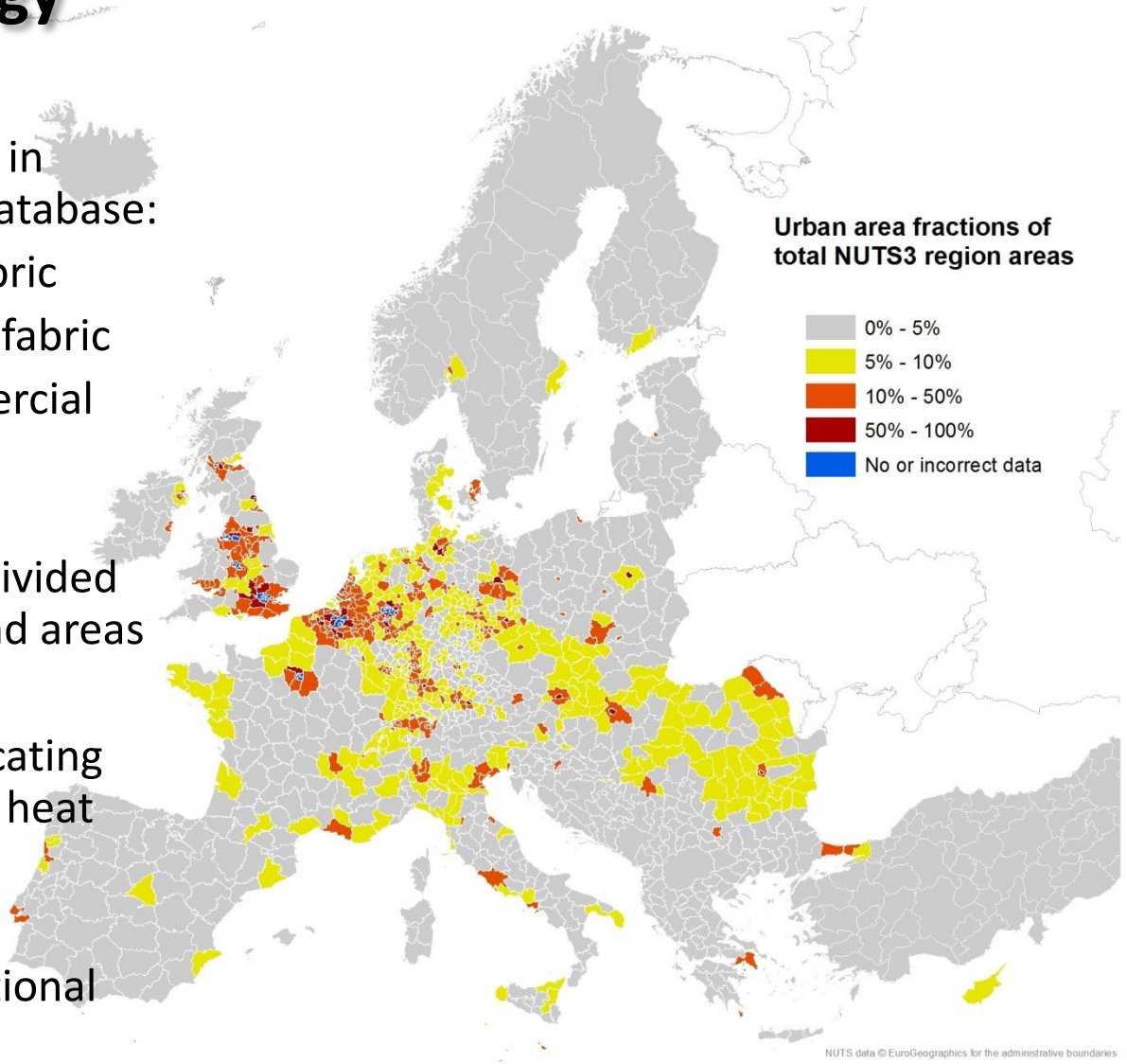
$$f(x) = \begin{cases} \frac{x}{3.6} * 100 & x \leq 1.08\ PJ \\ 30 & x > 1.08\ PJ \end{cases} \quad \text{[km]}$$

Data and methodology

- Five main data categories & data sources
  - Spread of urban fabric
    - EEA Corine land cover 2000 database
    - Eurostat
  - Heat demands for SH & DHW in residential and service sectors
    - International Energy Agency (IEA)
    - Eurostat
  - Excess heat activities
    - EEA European Pollutant Release and Transfer Register (E-PRTR)
    - Confederation of European Waste-to-Energy Plants (CEWEP)
    - International Solid Waste Association (ISWA)
  - Local heat resources
    - Eurostat
    - WP4 Ecoheatcool
    - European Commission
    - European Geothermal Energy Council (EGEC)
  - European district heating systems
    - The Halmstad University District Heating and Cooling Database (HUDHC)

Data and methodology

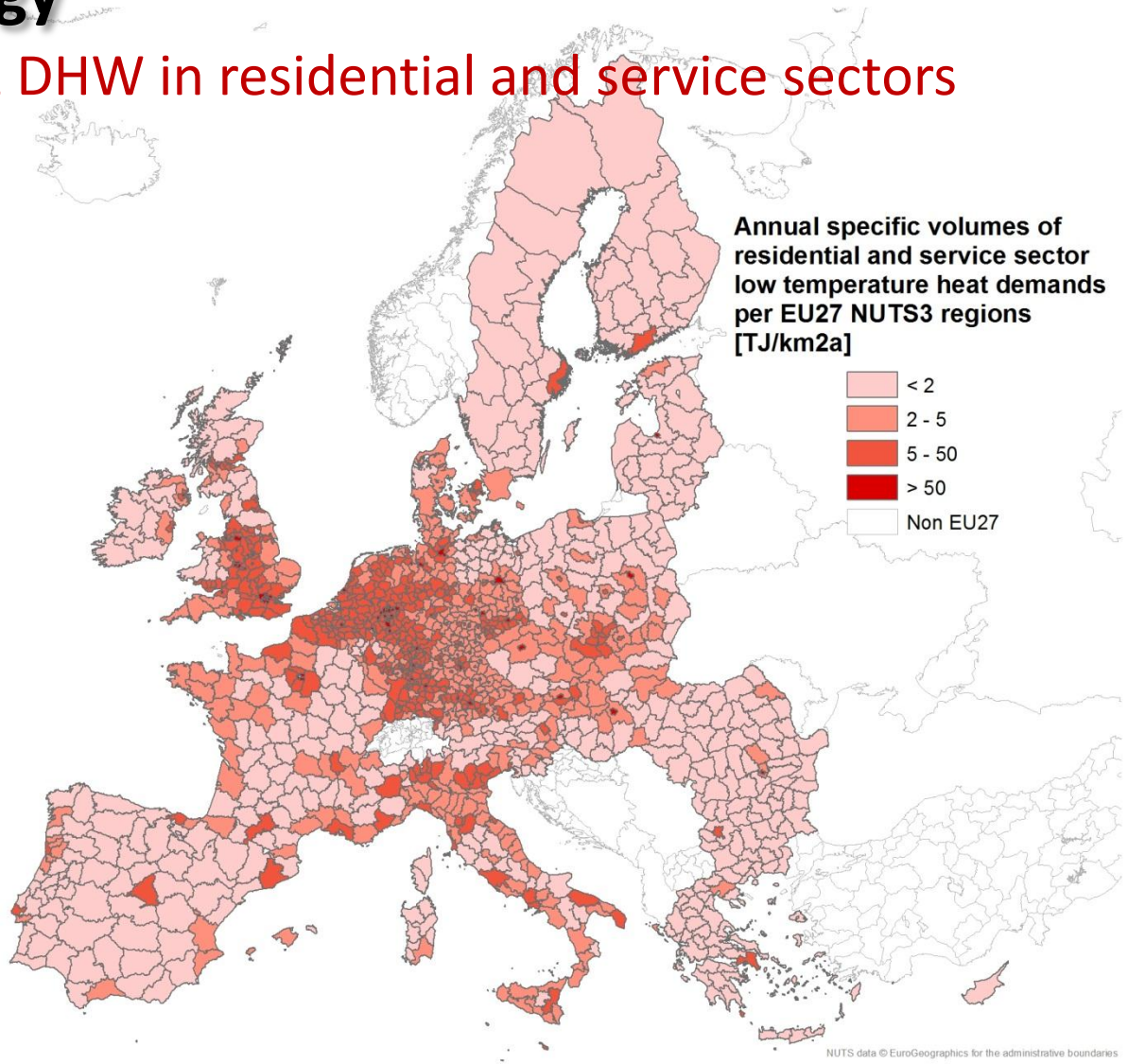
- Spread of urban fabric
  - Division of artificial areas in Corine land cover 2000 database:
    - Continuous urban fabric
    - Discontinuous urban fabric
    - Industrial and commercial areas
  - Total urban fabric areas divided by total NUTS3 region land areas
  - Urban area fraction: Indicating high population and high heat density regions
  - High resolution and additional data categories



Data and methodology

- Heat demands for SH & DHW in residential and service sectors

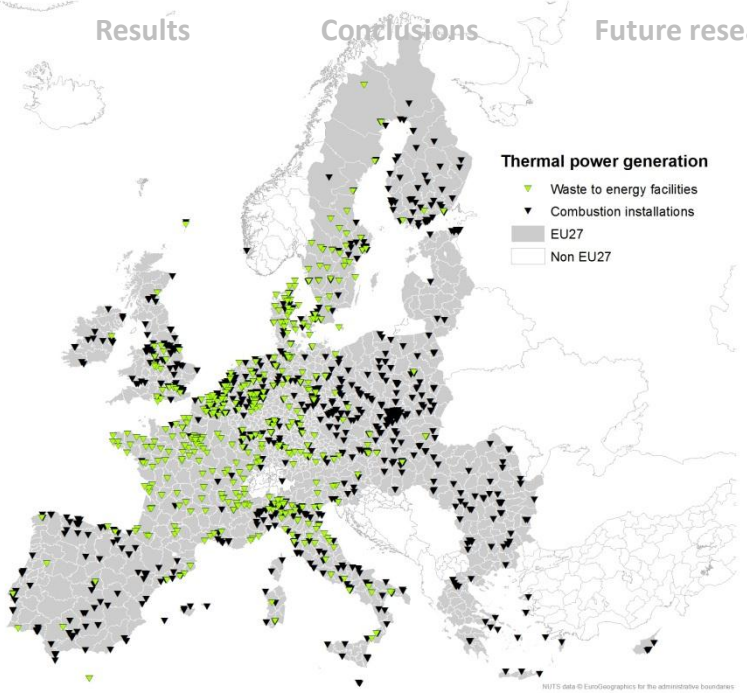
	$Q_{Res\&serv}$ [EJ/a]	P_{tot} [kn]	$q_{Res\&serv}$ [GJ/na]
Austria	0.247	8355	30
Belgium	0.343	10753	32
Bulgaria	0.064	7607	8
Cyprus	0.010	797	13
Czech Republic	0.236	10468	23
Denmark	0.183	5511	33
Estonia	0.039	1340	29
Finland	0.196	5326	37
France	1.702	64350	26
Germany	2.733	82002	33
Greece	0.162	11260	14
Hungary	0.220	10031	22
Ireland	0.119	4450	27
Italy	1.099	60045	18
Latvia	0.060	2261	26
Lithuania	0.057	3350	17
Luxembourg	0.019	494	39
Malta	0.002	414	4
Netherlands	0.503	16486	31
Poland	0.709	38136	19
Portugal	0.105	10627	10
Romania	0.293	21499	14
Slovakia	0.109	5412	20
Slovenia	0.039	2032	19
Spain	0.520	45828	11
Sweden	0.258	9256	28
United Kingdom	1.473	61595	24
EU27	**11.50**	**499687**	**23**

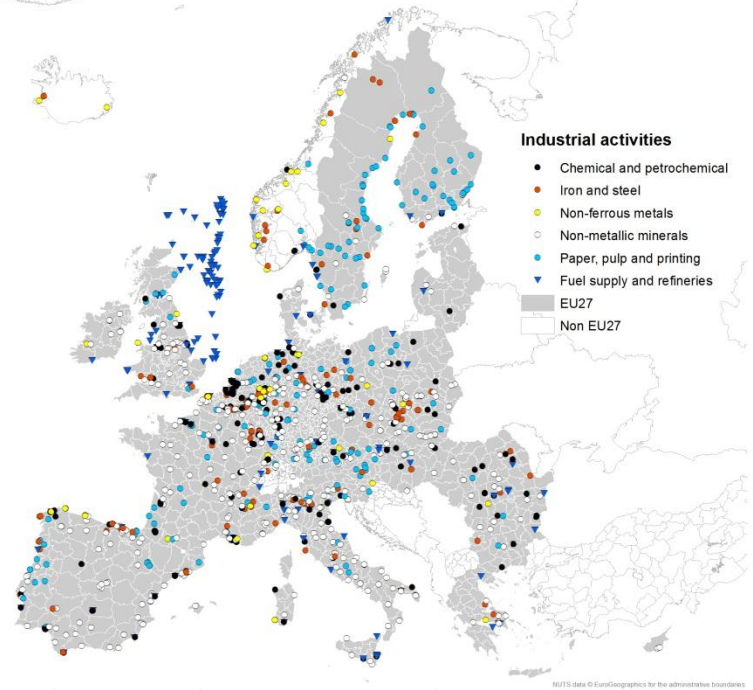


Estimated low temperature heat demands in residential and service sectors in EU27 Member States, 2008.

Data and methodology

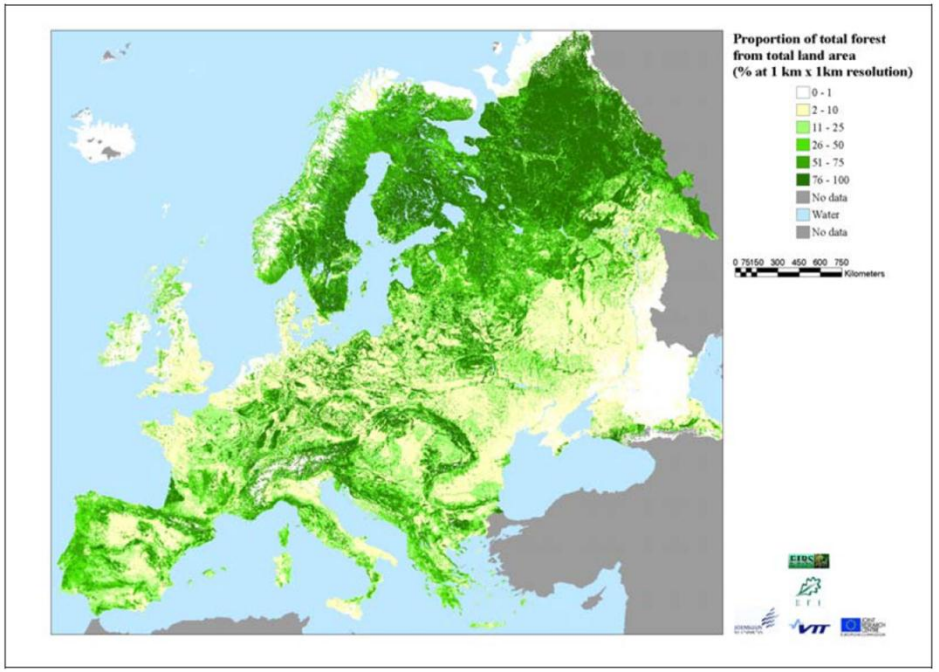
- Excess heat activities
  - Thermal power generation (≈ 15 EJ/a)
    - 961 TPG plants > 50 MW
    - 410 Waste-to-Energy facilities
  - Industrial activities (? EJ/a)
    - 231 Chem. & petrochemical plants
    - 140 Iron & steel works
    - 30 Non-ferrous metal works
    - 421 Non-metallic mineral facilities
    - 172 Paper & pulp plants
    - 191 fuel supply & refineries
  - 2556 European excess heat activities, given performed interpretations of data
  - Wide geographical distribution of activities

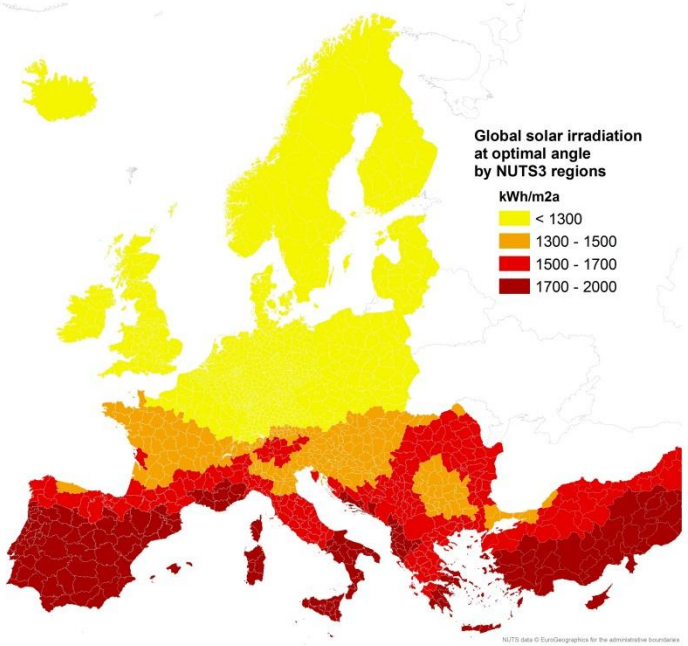




Data and methodology

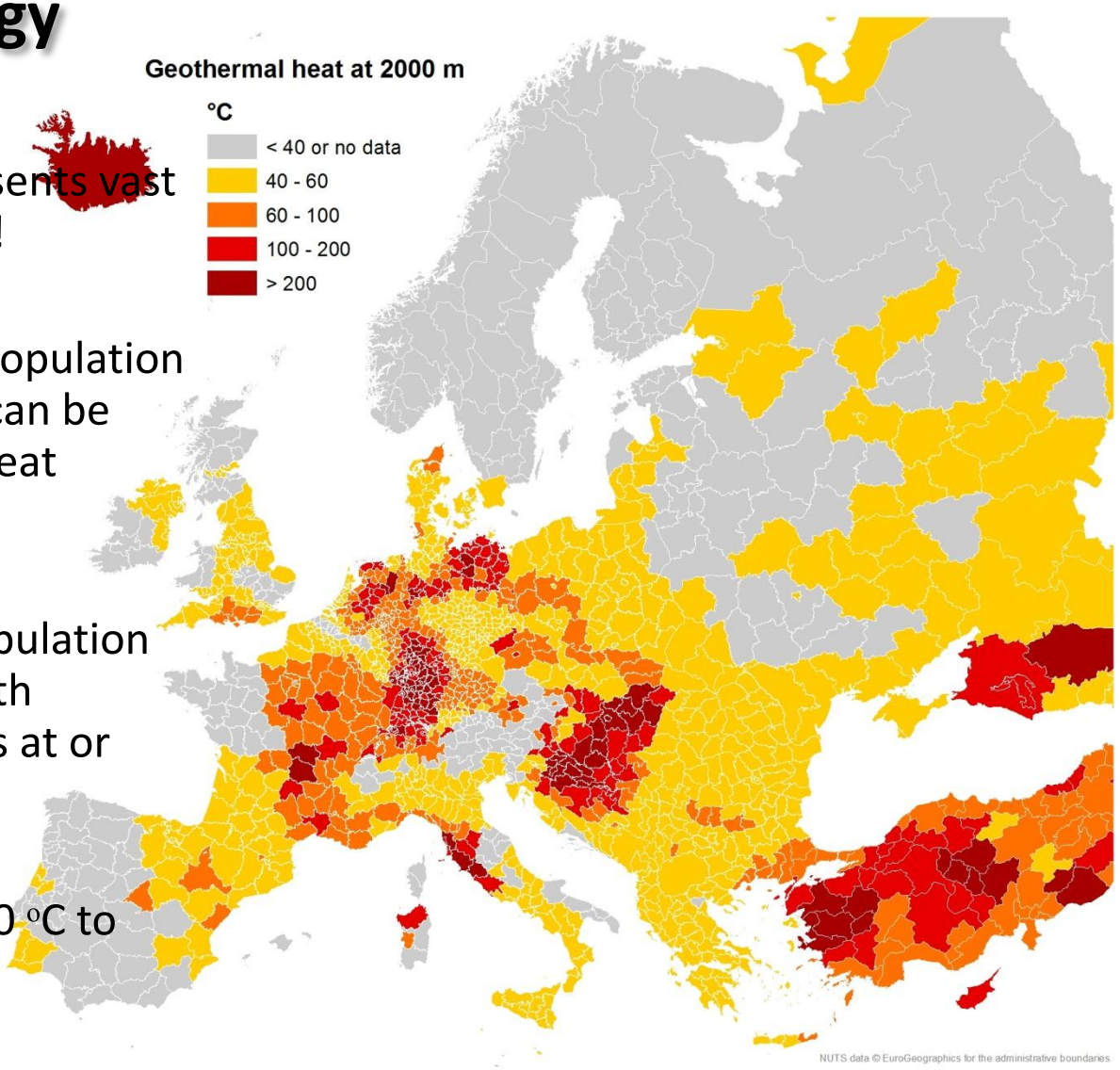
- Local heat resources
  - Availability and magnitude of renewable heat streams heterogeneously spread:
    - Biomass (forestry propagation)
    - Solar (geographic location)
    - Geothermal (earth crust composition)
  - Biomass – 241 PJ supply to EU27 district heating systems in 2009
  - Global solar irradiation - twice as intense in Southern compared to Northern Europe
  - Solar heat – 0.108 PJ supply to Danish district heating systems in 2009





Data and methodology

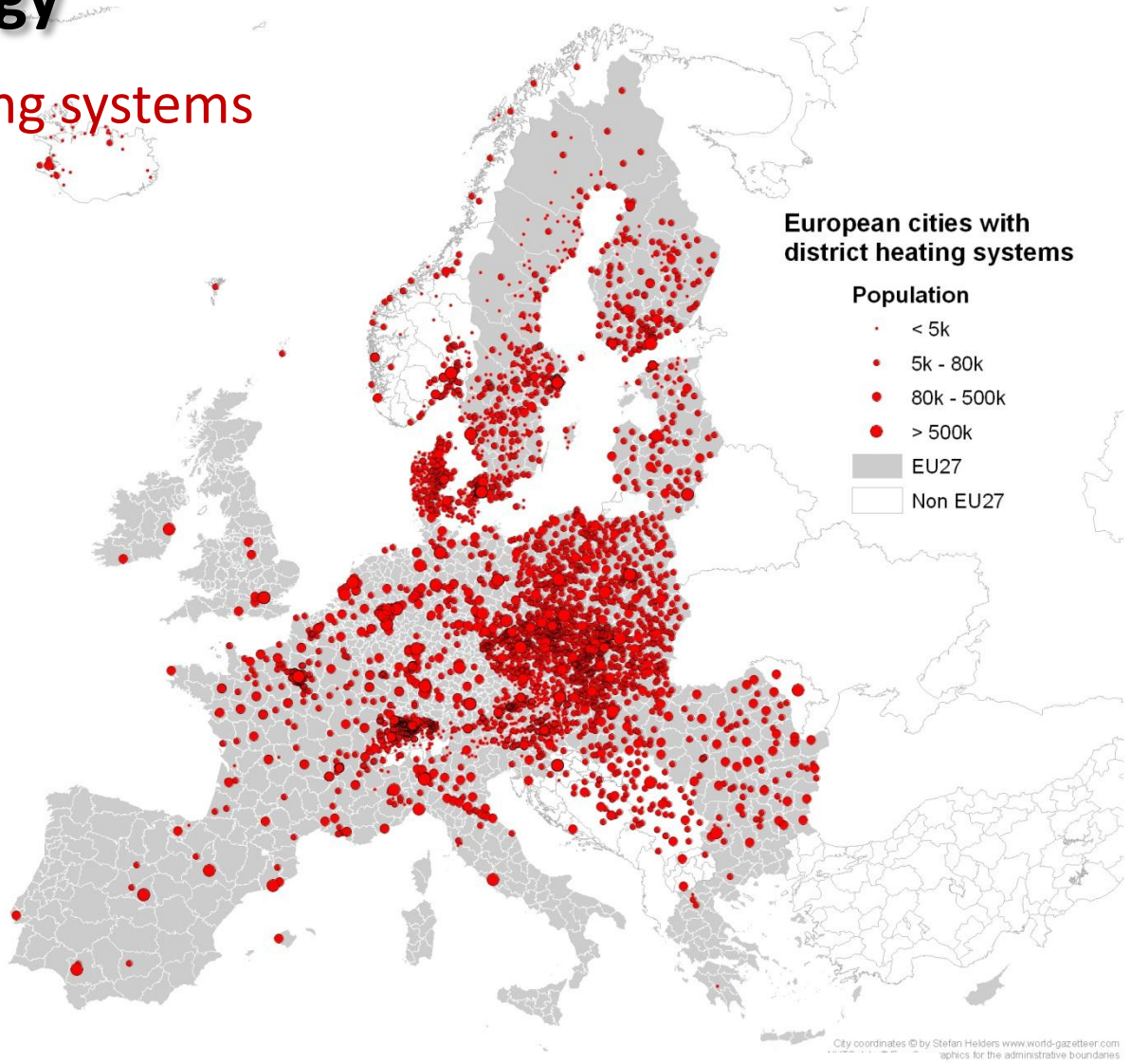
- Local heat resources
  - Geothermal assets represents vast heat resources in Europe!
  - ¼ of the total European population lives in urban areas that can be reached by geothermal heat through DH distribution
  - 4 % of the total EU27 population lives in NUTS3 regions with geothermal temperatures at or above 200 °C
  - 8 % in NUTS3 regions: 100 °C to 200 °C
  - 19 % in NUTS3 regions: 60 °C to 100 °C



Data and methodology

- European district heating systems

	Europe	EU27	EU27 population concerned	
			[Mn]	[%]
Systems	4174	3549	60	12
- in cities over 5000 residents	2778	2430		
Cities concerned	3731	3233	141	28
- cities over 5000 residents	2432	2173		
NUTS3 regions - concerned	660	600	287	57
NUTS3 regions - all	1461	1303	500	100

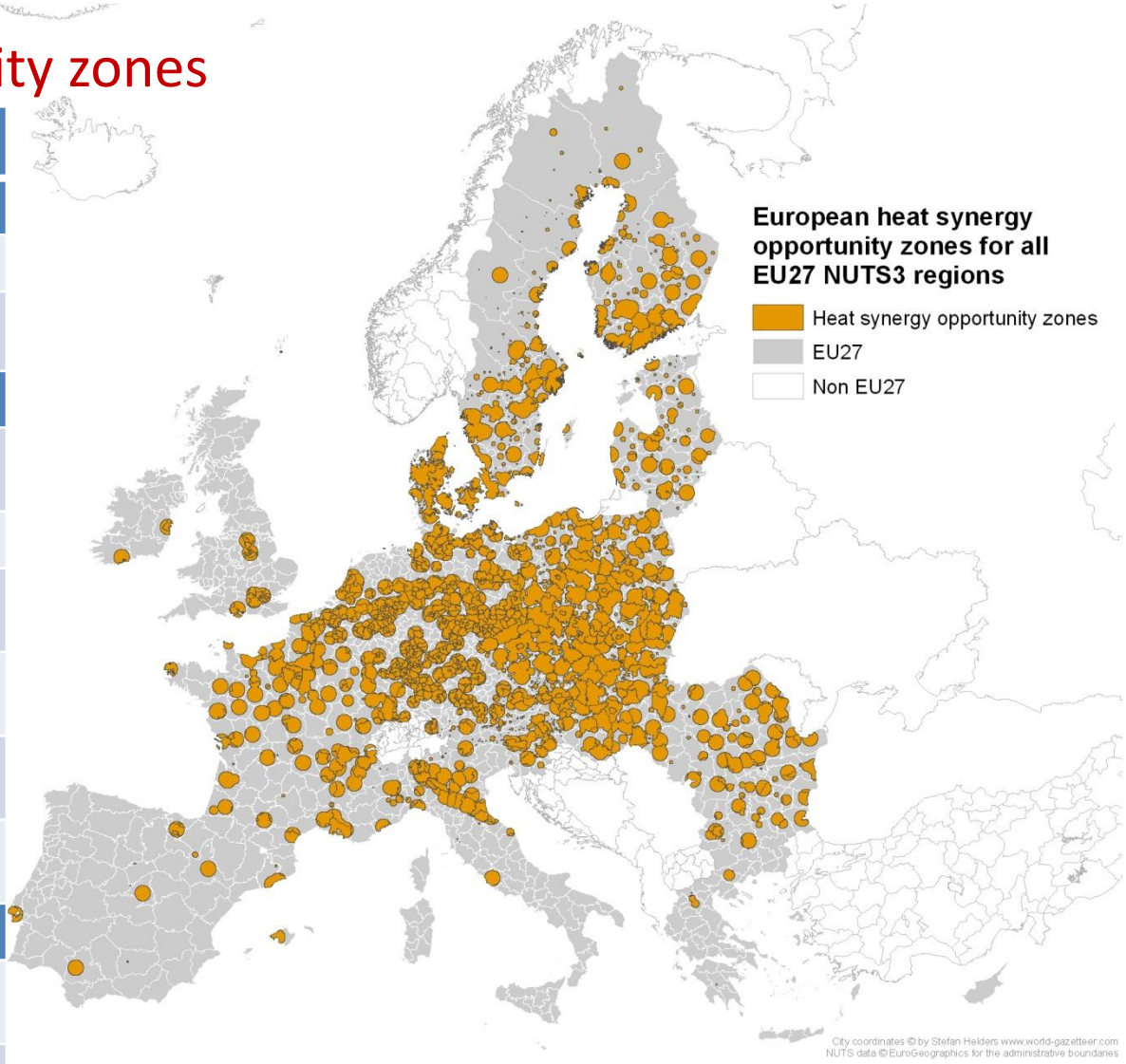


District heating systems in Europe according to the current content of the HUDHC database (June 2012)

Results

- Heat synergy opportunity zones

	Total	HSOZ	[%]
European NUTS3 regions and land areas			
NUTS3 regions	1303	979	75
Land area (km²)	4267644	1283185	30
Energy intensive industrial activities			
Chem. & petrochemical	231	151	65
Iron & steel	140	101	72
Non-ferrous metals	30	17	57
Non-metallic minerals	421	204	48
Paper, pulp & printing	172	110	64
Fuel supply & refineries	191	63	33
Thermal power generation activities			
Comb. installations	961	595	62
Waste-to-Energy	410	280	68
Grand Total	**2556**	**1521**	**60**



General properties of assessed EU27 heat synergy opportunity zones (HSOZ) at max 30 km.

Results

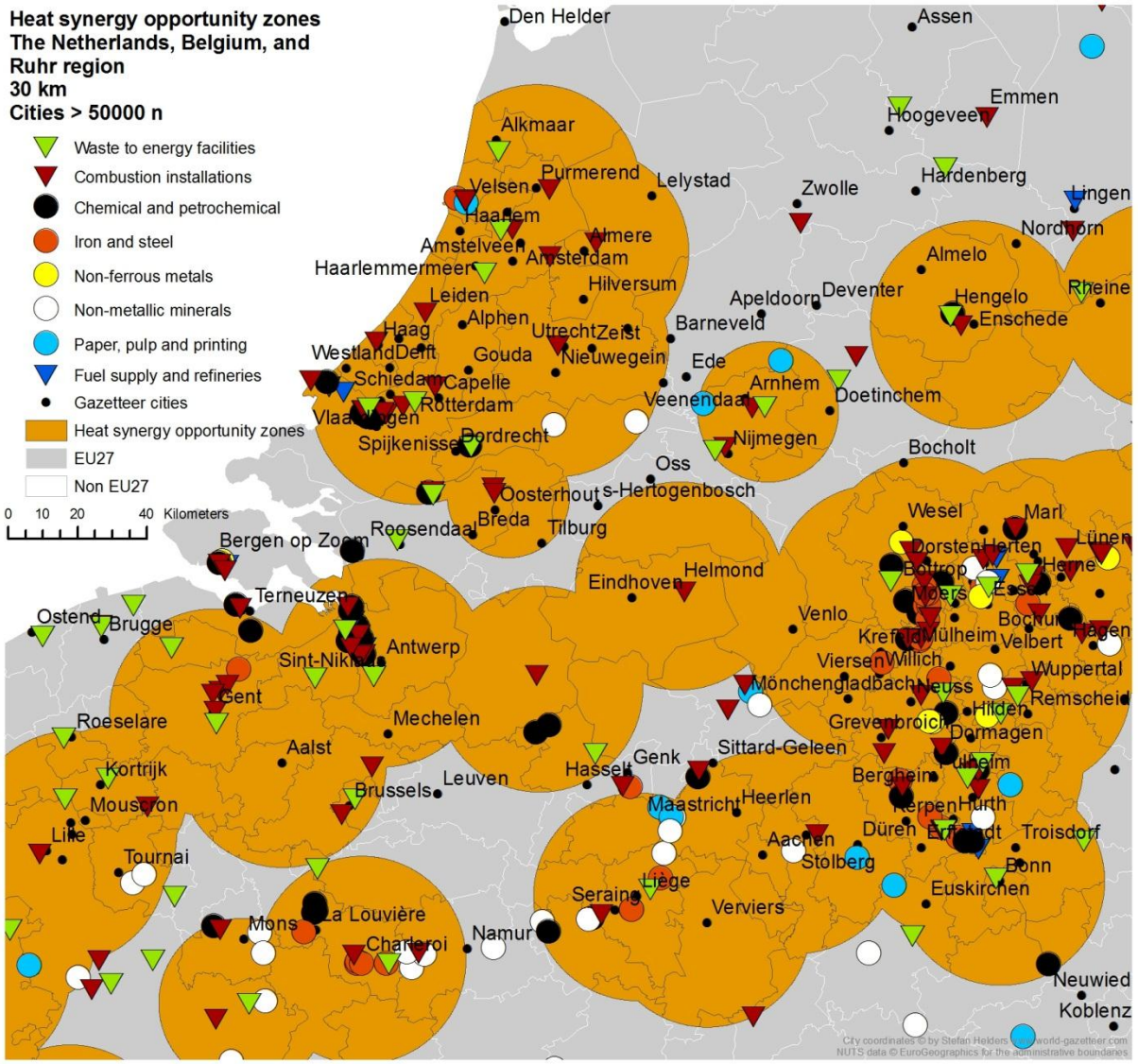
- Heat synergy opportunity zones
  - Close-up:

The Netherlands, Belgium, and Ruhr region

With excess heat activities…

High correspondence with study results (60%)

Synergy regions for district heating



Results

- Heat synergy opportunity zones
  - Close-up:

  Denmark,

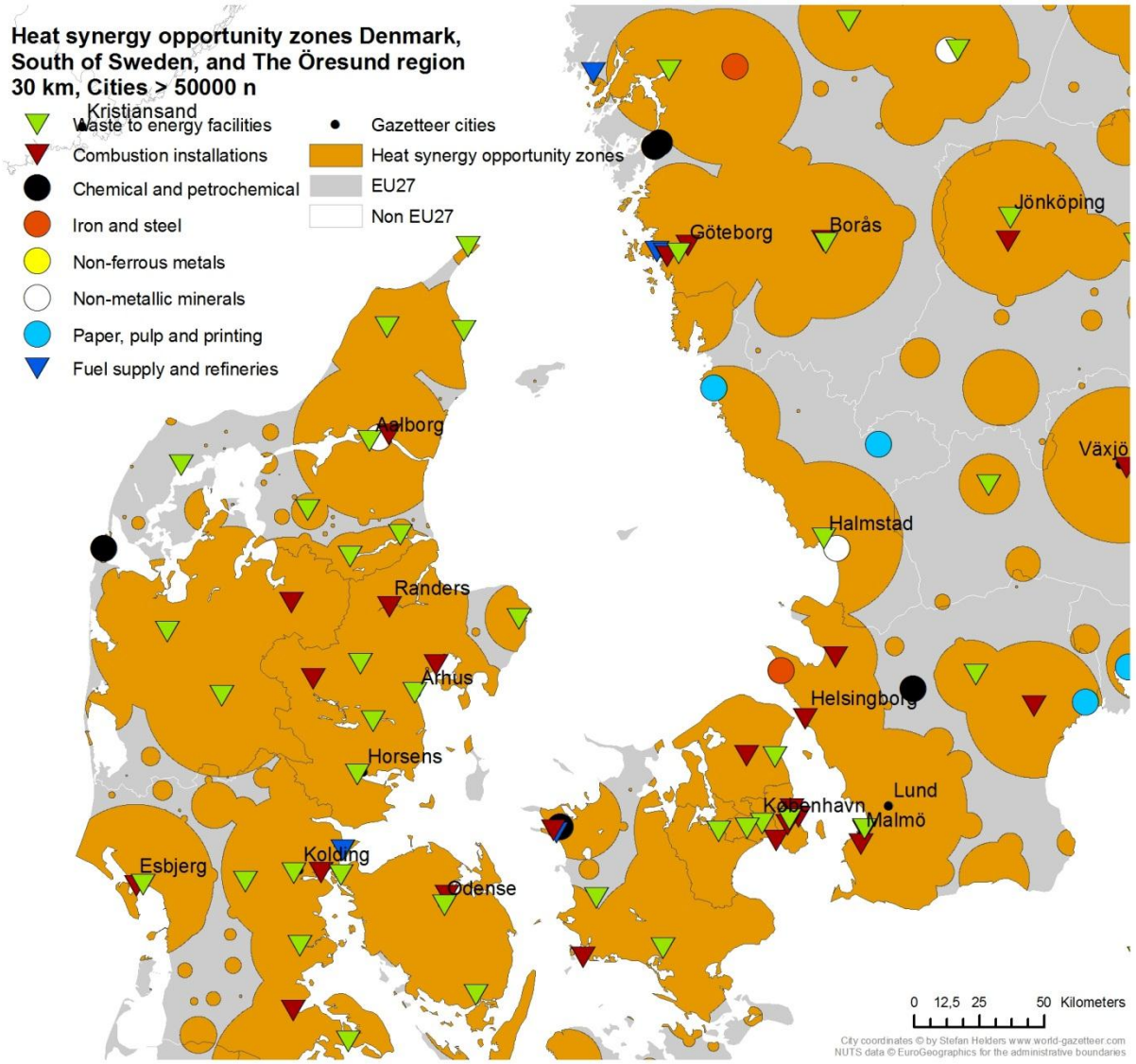
  South of Sweden,

  and the Öresund region

  With excess heat activities…

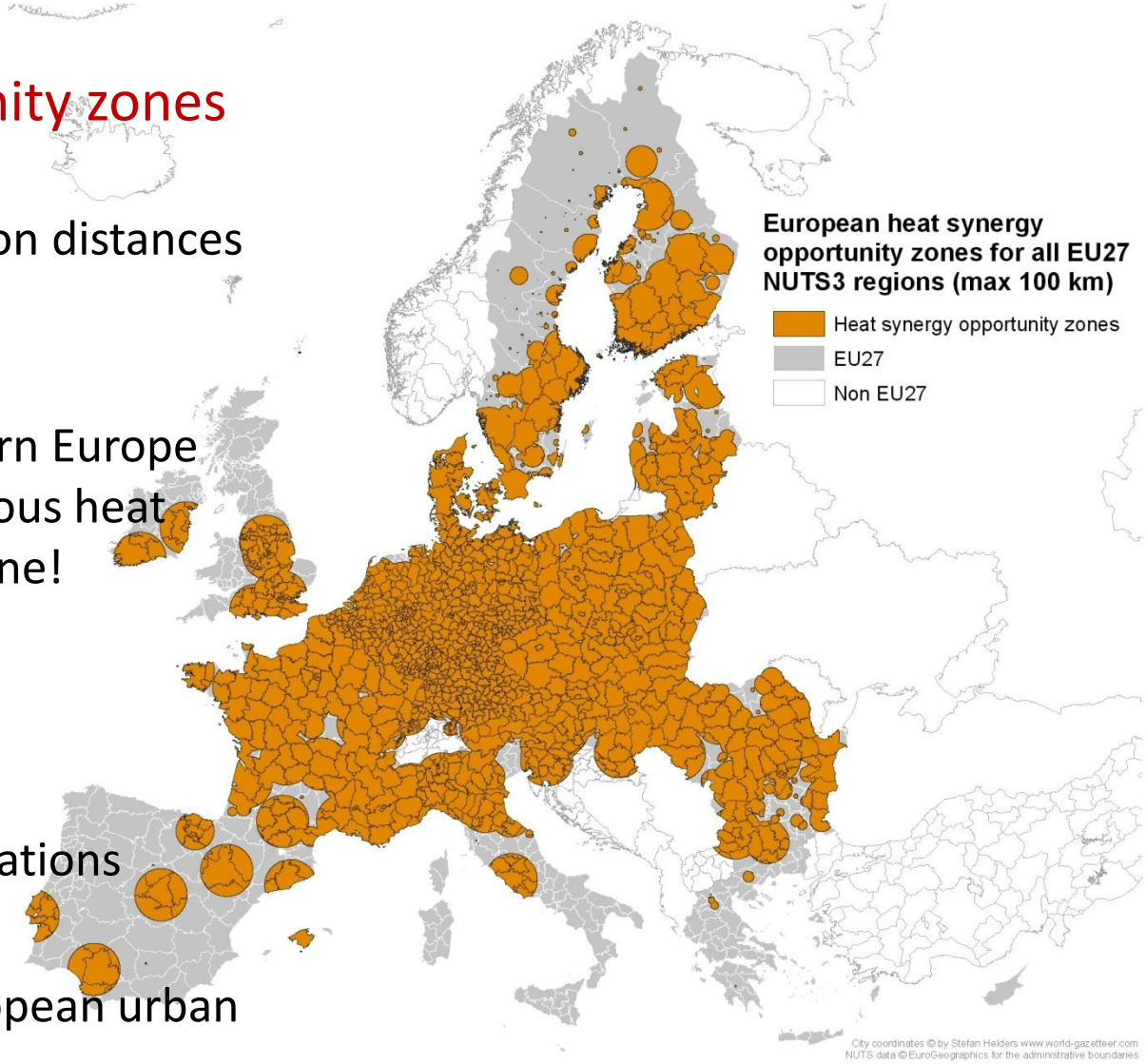
  High correspondence with study results (60%)

  Very large geographical coverage in Denmark



Results

- Heat synergy opportunity zones
  - If extending transmission distances to 100 km…
  - All of central and eastern Europe constitute one continuous heat synergy opportunity zone!
  - Feasibility issues?
  - Heat demand concentrations
  - Future increase of European urban populations



Conclusions

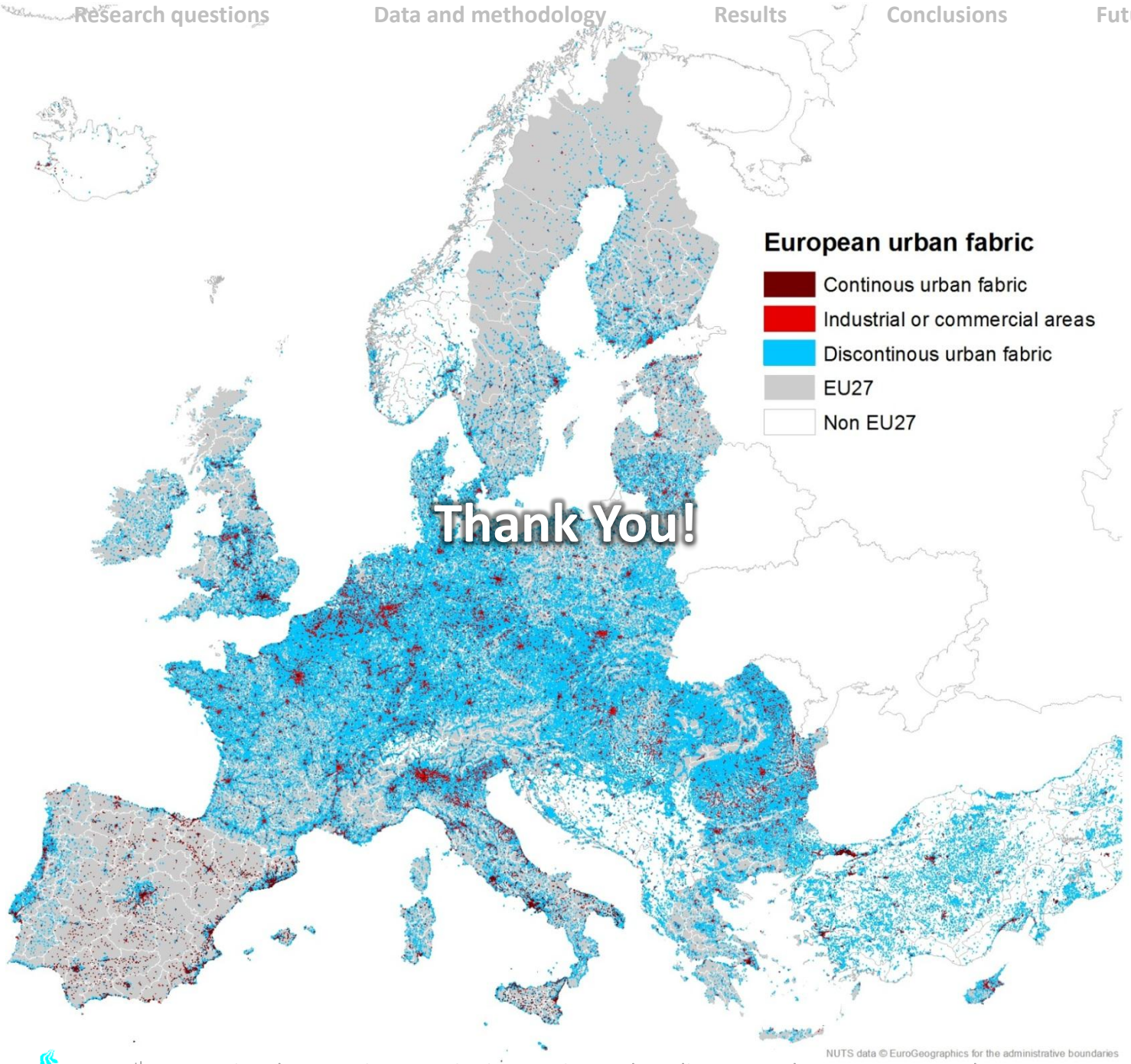
- Including local conditions in energy modelling produce alternative forecast
  - Increased recognition of district heating systems as energy efficiency infrastructures
- Dynamic range of possible future heat supply for modern district heating
  - Local heat resource utilisation by district heat distribution
- Geographic Information System (GIS) software – useful tool!
  - Convenient association of other data to any spatially defined location
  - High capacity processing of spatial information
  - Highly communicative map outputs
  - GIS based analysis – supporting real life heat synergy collaborations in Europe
- Heat synergy opportunity zones – 30 km
  - 60% of EU27 excess heat activities in heat synergy opportunity zones
  - 30% of EU27 land area within heat synergy opportunity zones
  - 23 GJ/na (average EU27) ➔ 30 km ➔ ≈ 50000 residents
- DH a key piece in the puzzle of organising efficient energy supply structures

Future research

- The excess heat ratio concept
  - Excess heat volumes – compatibility of data, recovery factors
  - Concept definition – include coefficients (population density, availability of heat source, distances etc.)

- Continuation of the Heat Roadmap Europe project
  - Second pre-study discussed for autumn 2012
  - Consolidation of data and methods
  - Future heat demands
  - Identification of European excess heat ”hot spots”

- Continuous updating of HUDHC
  - Q and L data for existing entries
  - Data on new district heating and cooling systems
  - DHC data – Share it with us!

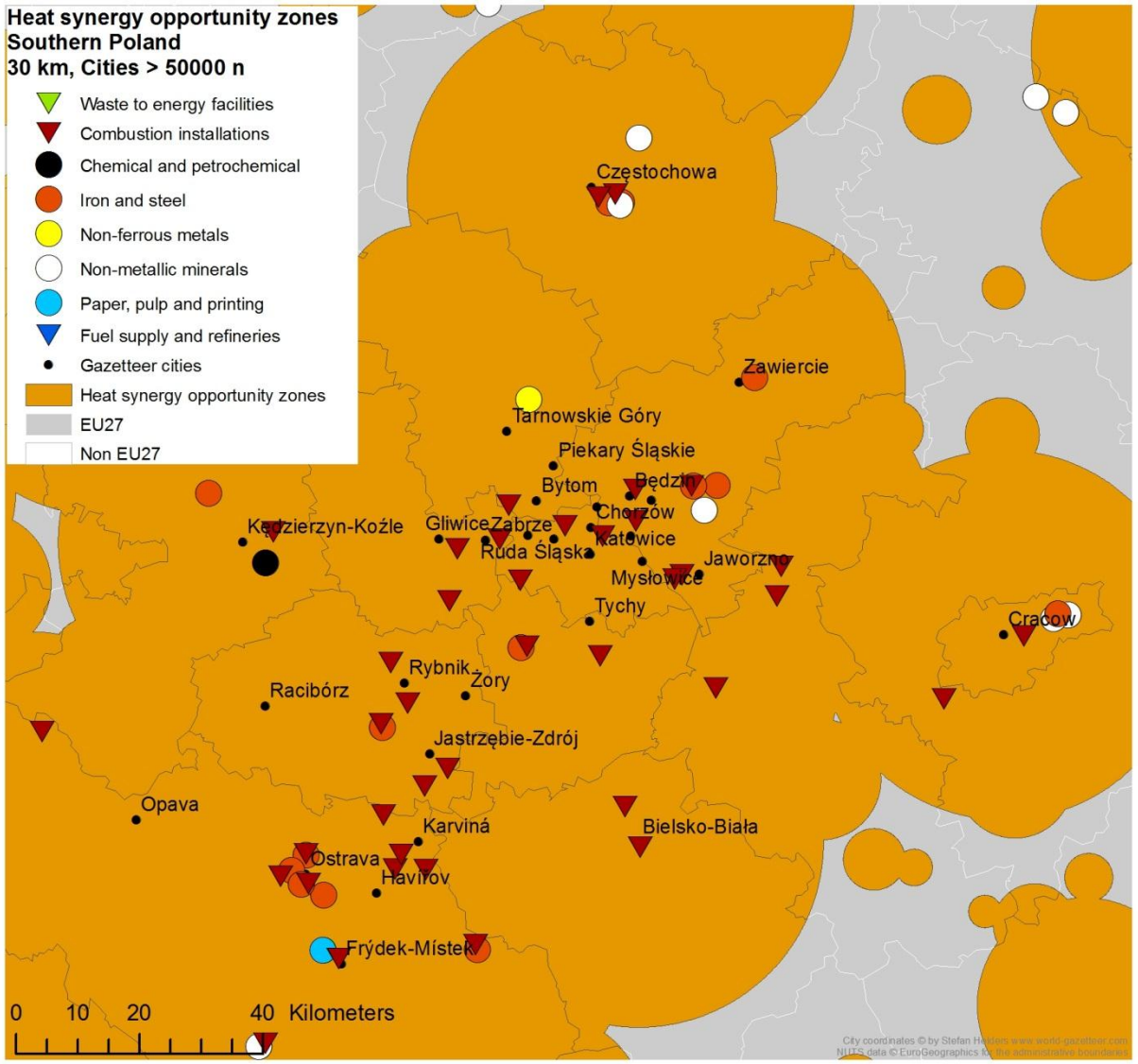

European urban fabric
Continous urban fabric
Industrial or commercial areas
Discontinous urban fabric
EU27
Non EU27
Thank You!
NUTS data © EuroGeographics for the administrative boundaries

Results

- Heat synergy opportunity zones
  - Close-up:

  Southern Poland

  With excess heat activities…

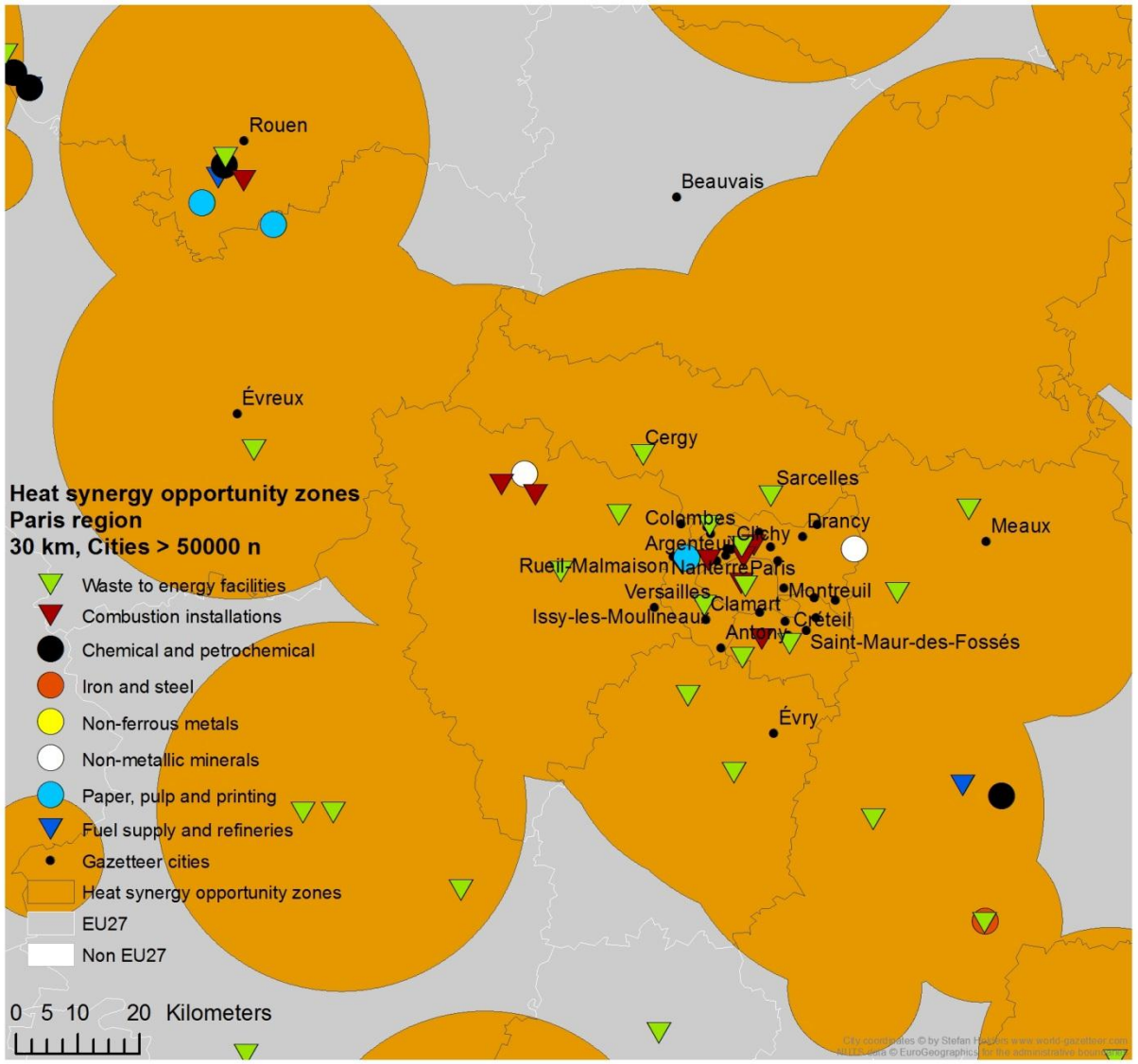


Results

- Heat synergy opportunity zones
  - Close-up:

  Paris region

  With excess heat activities…



Results

- Heat synergy opportunity zones
  - Close-up:

  London region

  With excess heat activities…