Heat Roadmap Europe: Towards a sustainable, resilient and competitive heating sector by 2050 – Data and country profiles

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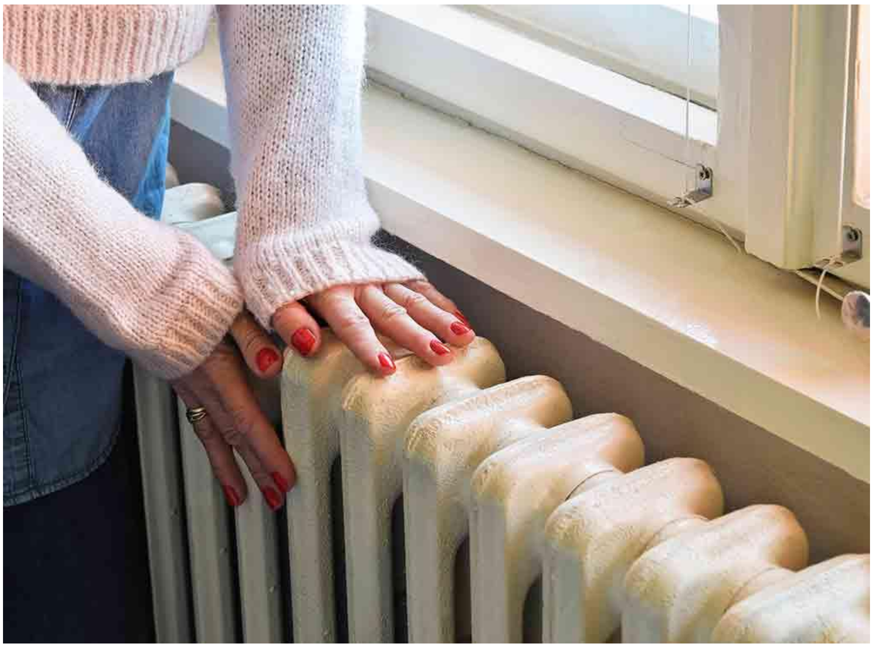

Heat Roadmap Europe

Towards a sustainable, resilient and competitive heating sector by 2050 – Data and country profiles

This report is a supplementary report to the Heat Roadmap Europe – Main report. This report shows how ambitious heat savings, large-scale district heating expansion to a 55% market share, and smart electrification can reduce EU primary energy use, eliminate reliance on fossil fuels, and enhance competitiveness. More than 3 PWh of waste and renewable heat potentials have been identified, of which at least 650 TWh are assessed as usable. By integrating renewable and waste heat into adaptive, low-temperature networks, supported by large-scale heat pumps and thermal storage, Europe can achieve a sustainable and resilient heating sector by 2050. Smart electrification and district heating go hand in hand. The report focuses on the EU level but also provides exploitable country-level results.

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This report builds primarily on analyses conducted within the EU-funded project sEEnergies (Grant Agreement No 846463). It was prepared with support from Euroheat & Power and carried out in 2024–2025. The report forms part of the Heat Roadmap Europe project series and is the fifth in the series (heatroadmap.eu). It consists of a main report and a supplementary report, which complements the main report by providing additional EU-level and country level data on primary waste heat potentials, as well as downloadable maps in PNG format.

Contents

1 Introduction

This report is part of the Heat Roadmap Europe series' fifth study. This supplementary report complements the main report by providing additional EU-level and country-level evidence on primary waste-heat potentials and district heating. It combines spatial mapping across different district-heating deployment levels, including city-focused results and detailed maps showing where recoverable waste heat can be integrated into adaptive, low-temperature district-heating networks. By linking these mapped potentials to pathways for district-heating expansion, supported by large-scale heat pumps and thermal storage - the aim is to strengthen the empirical basis for planning, investment, and implementation at EU, national, and city scales.

The supplementary report presents waste-heat shares and potentials under different district-heating market-share assumptions at both EU level and for individual countries. When linking waste and renewable heat potentials to an EU-level district-heating share, the results reflect a top-down spatial modelling approach in which lower-cost and larger opportunities are prioritized first. This is necessary because there are no consistent EU-wide data describing the locations or extents of existing district-heating networks. As a result, country-level results, where district heating may rely on waste heat, geothermal energy, or solar thermal, and where cost structures vary are not directly comparable with EU-level optimization. For example, an EU-wide district-heating share of 33% may correspond to only 5% district-heating penetration in a given country if lower-cost expansion options exist elsewhere.

To strengthen this analysis, the report incorporates extensive technical data on future heat sources and district-heating potentials. It includes technical district-heating potentials (TWh) at a 55% EU27 market share across a broad range of waste-heat and renewable-heat categories; projected waste-to-energy and waste-treatment potentials for 2020–2050; total waste volumes (million tonnes); expected heat production (TWh/y); and available data centre waste heat under multiple scenarios. The assessment also examines global and European nuclear capacities and estimates of nuclear waste-heat availability in 2023 and 2050. Industrial waste-heat potentials at 25°C, 55°C, and 95°C are quantified for each EU27 + UK country, with further detail for selected Member States.

Additional modelling covers national-level district-heating network costs, the identification of the most suitable cities for district-heating expansion based on cost and heat-source availability, and country-level overviews of district-heating shares and mapped waste-heat sources. The spatial modelling methodology includes heat-demand estimation using building-stock and population data, district-heating potential derived from heat-demand and floor-area grids, the mapping of future heat sources, and the calculation of full and technical potentials (TWh/y). A scenario-based prioritization allocates heat sources sequentially to baseload demand, with solar thermal evaluated separately before integration. Finally, the report provides key modelling inputs, costs, capacities, and scenario-specific assumptions used to link these spatial and technical findings to broader energy-system analyses.

2 Waste heat potential and data for EU

2.1 Technical potentials of district heating at 55% EU27 market share in TWh.

Table 1: Technical potentials of district heating at 55% EU27 market share in TWh, divided on each EU27 country and the 10 sources of heat.

	WTE [TWh]	Industry H [TWh]	Industry M [TWh]	WWT [TWh]	Supermarkets/ Food retail [TWh]	Industry L [TWh]	Metro stations [TWh]	Solar thermal [TWh]	Geothermal [TWh, 40MW]	Geothermal [TWh, 70MW]
Austria	2,61	2,68	4,42	3,29	0,82	7,90	0,22	2,70	9,74	8,95
Belgium	1,85	2,63	5,94	2,80	0,79	11,38	0,23	4,28	5,58	4,80
Bulgaria	1,97	0,53	0,54	0,37	0,12	0,90	0,13	1,38	2,83	1,80
Czechia	2,25	1,33	2,45	2,61	0,43	3,65	0,19	2,31	1,55	1,55
Germany	34,40	16,02	26,87	29,44	7,88	50,53	1,33	32,51	70,29	61,43
Denmark	2,09	0,87	2,67	2,63	0,64	3,74	0,04	2,47	7,92	6,99
Estonia	0,80	-	0,12	0,10	0,03	0,18	-	0,35	-	-
Greece	1,83	2,26	2,41	2,27	0,05	2,84	0,23	1,62	-	-
Spain	11,68	6,04	12,24	12,77	1,74	19,33	2,14	14,54	12,86	11,63
Finland	3,77	0,88	1,66	1,41	0,19	3,86	0,05	2,17	-	-
France	21,80	5,65	14,80	16,60	2,13	24,57	2,19	17,42	49,46	42,38
Croatia	0,49	0,18	0,43	0,37	0,14	0,60	-	0,63	1,41	1,41
Hungary	1,80	0,33	0,84	2,91	0,66	1,65	0,21	2,28	5,67	4,02
Ireland	2,05	-	4,00	1,53	0,15	5,49	-	1,24	5,43	5,43
Italy	8,85	4,79	7,51	10,73	0,78	12,78	1,17	15,93	32,95	28,37
Lithuania	0,41	0,11	0,18	0,48	0,34	0,37	-	0,76	-	-
Luxembourg	0,21	0,62	0,57	0,25	0,05	0,80	-	0,45	-	-
Latvia	0,36	0,11	0,21	0,17	0,09	0,29	-	0,62	-	-
Malta	0,08	-	0,01	-	0,00	0,02	-	0,48	-	-
Netherlands	8,68	3,06	6,66	6,26	0,22	13,88	0,11	6,37	25,99	17,64
Poland	4,32	1,06	3,65	5,97	1,50	6,28	0,10	5,85	10,57	8,69
Portugal	0,88	0,28	0,37	0,96	0,14	0,63	0,28	0,55	1,35	1,35
Romania	2,90	0,69	0,62	2,55	0,44	1,11	0,20	1,55	3,47	2,34
Sweden	4,70	1,72	3,53	3,26	0,34	7,53	0,18	3,32	-	-
Slovenia	0,28	0,29	0,99	0,37	0,23	1,35	-	0,75	1,80	1,27
Slovakia	1,10	0,48	1,25	0,83	0,29	2,00	-	1,02	1,33	0,88
EU27	122,18	52,65	104,97	110,94	20,18	183,65	8,99	123,58	250,19	210,93

2.2 Waste to Energy potentials

Table 2, Expected Waste to Energy potentials and waste treatment in the EU27 + UK countries for 2020-2050 in mio. tonnes.

	Total waste generation		Total waste treatment (mio. tons)			
	Total waste (mio. tons)	Waste (t/capita)	Disposal - landfill and other	Recovery – recycling & backfilling	Recovery - energy recovery	Disposal - Incineration
Austria	68,9	7,7	29,6	33,3	2,8	0,9
Belgium	68,1	5,9	3,5	46,6	4,0	0,6
Bulgaria	116,4	16,8	100,8	8,5	0,7	0,1
Croatia	6,0	1,5	1,4	2,5	0,2	0,0
Cyprus	2,2	2,5	0,6	0,5	0,2	0,0
Czechia	38,5	3,6	3,9	30,0	1,4	0,1
Denmark	20,1	3,5	1,3	12,5	3,5	0,0
Estonia	16,2	12,2	6,0	9,0	0,3	0,0
Finland	116,1	21,0	94,7	11,7	6,2	0,1
France	310,4	4,6	77,4	188,4	22,5	4,2
Germany	401,2	4,8	67,4	267,4	45,1	2,0
Greece	28,4	2,7	14,1	7,1	0,4	0,0
Hungary	17,2	1,8	4,2	15,0	1,3	0,1
Ireland	16,2	3,2	4,1	8,8	1,2	0,0
Italy	174,9	2,9	15,6	122,7	8,1	0,7
Latvia	2,9	1,5	0,5	1,4	0,2	0,0
Lithuania	6,7	2,4	2,0	1,8	0,5	0,0
Luxembourg	9,2	14,6	2,2	7,2	0,3	0,0
Malta	3,5	6,8	0,3	3,0	0,0	0,0
Netherlands	125,1	7,2	51,2	60,2	9,4	1,2
Poland	170,2	4,5	34,8	97,9	3,7	0,3
Portugal	16,6	1,6	3,8	5,9	1,2	0,0
Romania	141,4	7,3	127,5	8,4	2,0	0,1
Slovakia	12,8	2,3	3,0	6,7	0,6	0,0
Slovenia	7,5	3,6	0,4	6,6	0,2	0,0
Spain	105,6	2,2	31,1	51,7	3,4	0,1
Sweden	151,8	14,7	114,3	21,1	8,9	0,1
EU27	2.154,0	4,8	796,0	1.036,1	128,9	9,8
UK	282,4	4,2	76,5	122,5	8,5	7,3

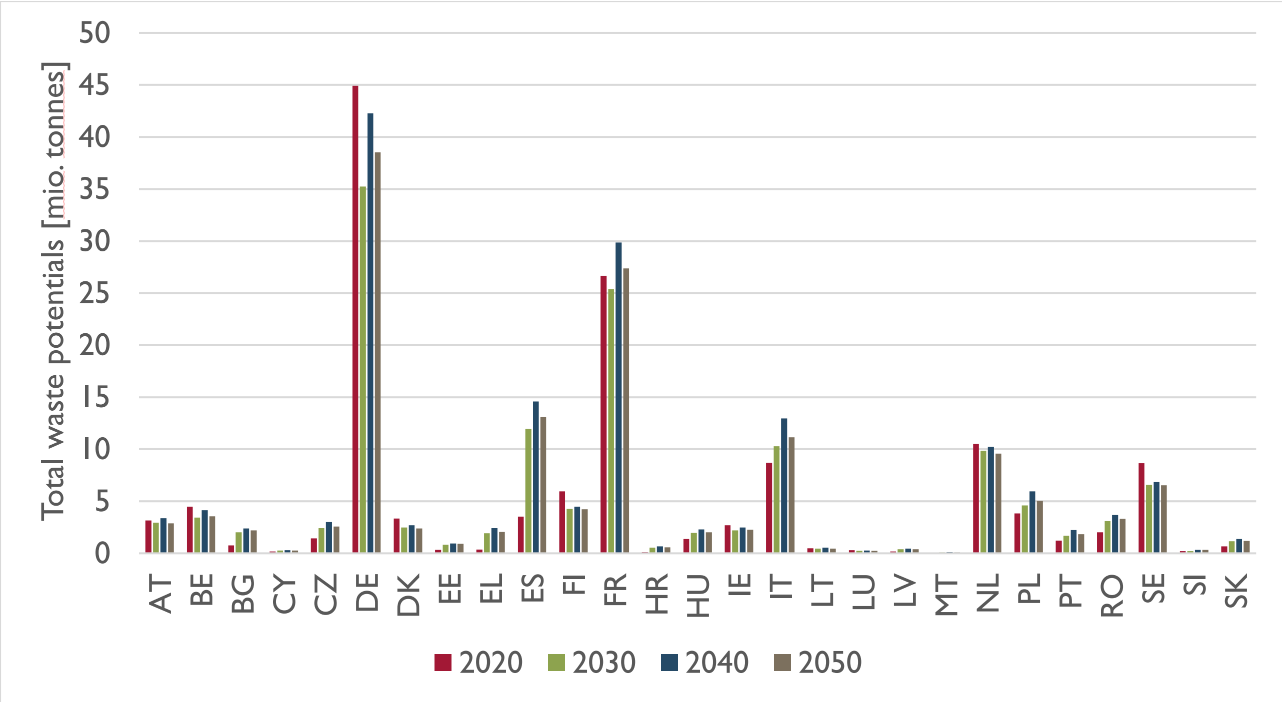


Figure 1: The total waste potential projected from 2020-2050 for each EU27 country.

Table 3, The total expected heat production from waste-to-energy from 2020-2050, according to (CEWEP, 2023).

	Heat production (TWh) WtE				
Year	2020	2030	2035	2040	2050
European Union - 27 countries (from 2020 CEWEP)	90,09	135,97	124,28	127,55	115,93
European Union - 28 countries (incl. UK) (HRE5)	2020	2030	2035	2040	2050
Austria	2,13	2,73	2,70	3,13	2,64
Belgium	3,01	3,19	2,99	3,84	3,28
Bulgaria	0,51	1,89	1,81	2,20	2,02
Cyprus	0,13	0,25	0,23	0,29	0,26
Czech Republic	0,96	2,24	2,07	2,77	2,37
Germany	30,16	32,75	33,56	39,09	35,37
Denmark	2,25	2,32	2,21	2,50	2,18
Estonia	0,22	0,76	0,75	0,87	0,84
Greece	0,25	1,80	1,64	2,25	1,88
Spain	2,38	11,10	10,44	13,50	12,01
Finland	3,99	3,96	3,87	4,13	3,89
France	17,91	23,59	22,48	27,62	25,12
Croatia	0,09	0,50	0,46	0,62	0,52
Hungary	0,92	1,81	1,70	2,11	1,85
Ireland	1,82	2,06	1,96	2,29	2,07
Italy	5,83	9,56	8,79	12,00	10,24
Lithuania	0,32	0,42	0,39	0,50	0,42
Luxembourg	0,20	0,23	0,22	0,25	0,21
Latvia	0,13	0,37	0,35	0,43	0,37
Malta	0,01	0,09	0,08	0,104	0,08
Netherlands	7,04	9,15	8,90	9,47	8,80
Poland	2,57	4,28	3,91	5,51	4,63
Portugal	0,82	1,58	1,42	2,06	1,69
Romania	1,36	2,89	2,74	3,39	3,05
Sweden	5,81	6,11	5,98	6,34	6,01
Slovenia	0,15	0,20	0,20	0,29	0,29
Slovakia	0,44	1,08	1,01	1,28	1,11
United Kingdom	10,89	15,11	14,63	17,73	15,87
EU27	91,39	126,88	122,82	148,83	133,20
EU27 + UK	102,28	142,00	137,45	166,56	149,06

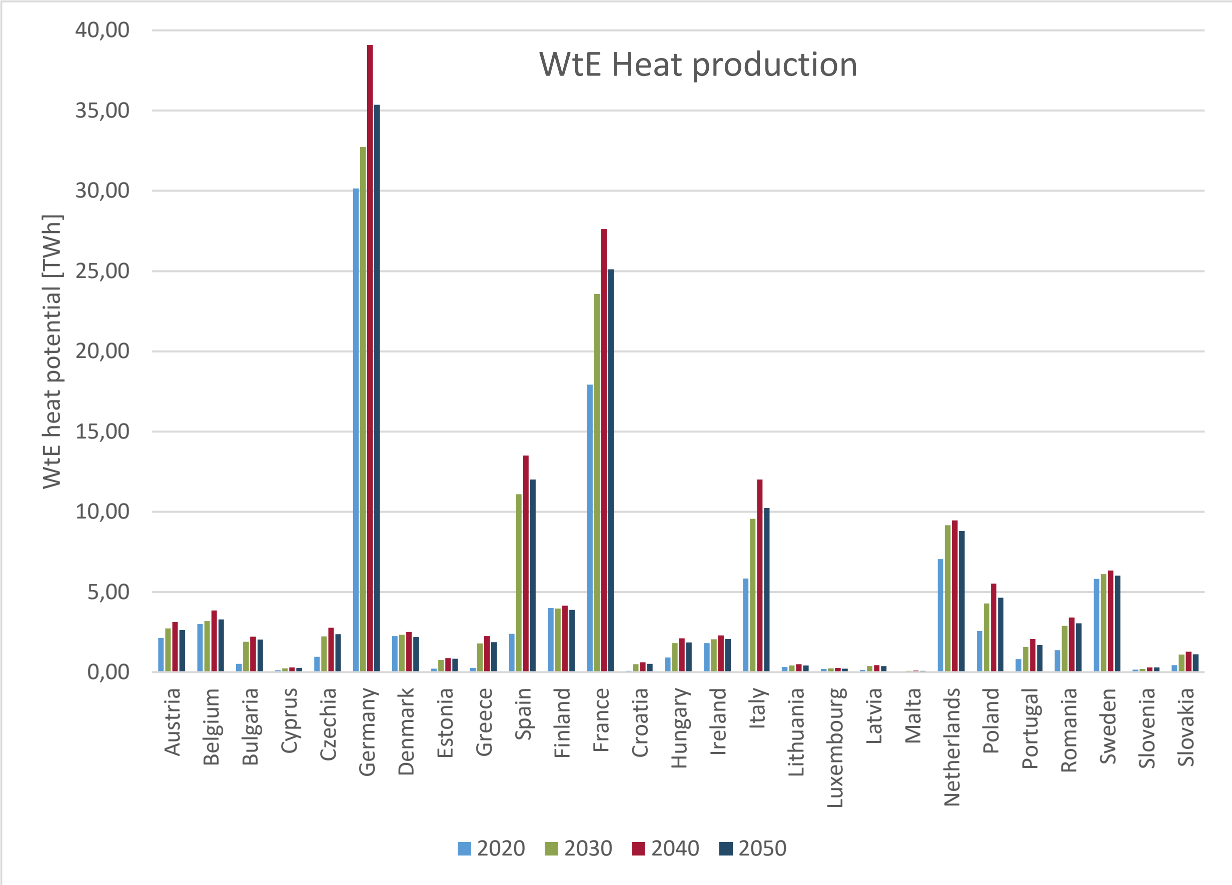


Figure 2: The total waste to energy for heating potential projected from 2020-2050 for each EU27 country.

2.3 Waste heat from data centres

Table 4, Available waste heat from data centres for the EU27 + UK countries in TWh/year in the base scenario

Base scenario	**Total available waste heat (=El. consumption) [TWh/year]**				**Available waste heat from IT equipment [TWh/year]**				**Additional available waste heat [TWh/year]**			
Year	**2024**	**2030**	**2040**	**2050**	**2024**	**2030**	**2040**	**2050**	**2024**	**2030**	**2040**	**2050**
Austria	0,9	1,2	1,8	2,5	0,8	0,9	1,5	2,2	0,4	0,3	0,3	0,3
Belgium	1,6	2,1	3,3	4,6	1,7	2,0	3,1	4,4	0,3	0,1	0,2	0,2
Bulgaria	0,2	0,2	0,4	0,5	0,1	0,1	0,3	0,4	0,1	0,1	0,1	0,1
Cyprus	0,1	0,1	0,1	0,2	0,1	0,0	0,1	0,1	0,1	0,0	0,0	0,0
Czechia	0,8	1,0	1,6	2,2	0,5	0,6	1,1	1,6	0,5	0,4	0,5	0,6
Germany	17,1	22,9	35,3	49,3	12,6	18,6	31,8	46,9	4,9	4,4	3,5	2,4
Denmark	3,6	4,8	7,4	10,3	1,4	4,5	7,0	9,8	0,3	0,3	0,4	0,5
Estonia	0,2	0,2	0,4	0,5	0,1	0,2	0,3	0,4	0,1	0,1	0,1	0,1
Greece	0,4	0,6	0,9	1,2	0,5	0,4	0,7	1,0	0,3	0,2	0,2	0,2
Spain	3,8	5,1	7,9	11,1	2,1	3,5	6,0	8,8	1,4	1,7	2,0	2,3
Finland	1,2	1,6	2,4	3,4	1,1	1,5	2,3	3,2	0,2	0,1	0,1	0,2
France	13,1	17,6	27,0	37,7	7,5	12,7	21,8	32,2	4,1	4,8	5,2	5,6
Croatia	0,2	0,2	0,4	0,5	0,1	0,1	0,3	0,4	0,1	0,1	0,1	0,1
Hungary	0,2	0,2	0,4	0,5	0,1	0,2	0,3	0,4	0,1	0,1	0,1	0,1
Ireland	6,5	8,7	13,5	18,8	4,7	8,3	12,8	17,9	0,8	0,4	0,6	0,9
Italy	5,5	7,4	11,3	15,8	2,9	5,7	9,7	14,3	1,3	1,7	1,6	1,5
Lithuania	0,1	0,1	0,1	0,2	0,1	0,1	0,1	0,2	0,0	0,0	0,0	0,0
Luxembourg	0,3	0,4	0,5	0,8	0,3	0,3	0,4	0,6	0,2	0,1	0,1	0,1
Latvia	0,1	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,0
Malta	0,1	0,1	0,1	0,2	0,1	0,0	0,1	0,1	0,1	0,0	0,0	0,0
Netherlands	5,9	7,9	12,2	17,0	4,1	6,4	10,9	16,1	1,6	1,5	1,2	0,8
Poland	2,7	3,7	5,6	7,9	1,6	2,7	4,6	6,7	0,9	1,0	1,1	1,2
Portugal	0,2	0,3	0,5	0,7	0,3	0,2	0,4	0,6	0,2	0,1	0,1	0,1
Romania	0,2	0,2	0,4	0,5	0,1	0,2	0,3	0,4	0,1	0,1	0,1	0,1
Sweden	4,5	6,1	9,3	13,0	3,0	5,8	8,9	12,4	0,5	0,3	0,4	0,6
Slovenia	0,2	0,2	0,4	0,5	0,1	0,2	0,3	0,4	0,0	0,1	0,1	0,1
Slovakia	0,1	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0
EU27	**69,5**	**93,1**	**143,3**	**200,2**	**46,3**	**75,3**	**125,1**	**181,9**	**18,8**	**17,9**	**18,2**	**18,2**
United Kingdom	11,7	13,7	18,5	24,0	7,5	9,3	14,0	19,1	3,5	4,4	4,6	4,9
EU27 + UK	**81,2**	**106,8**	**161,8**	**224,2**	**53,8**	**84,6**	**139,1**	**201,1**	**22,3**	**22,3**	**22,8**	**23,1**

Table 5, Available waste heat from data centers for the EU27 + UK countries in TWh/year in the high scenario.

High growth - high PUE	**Total available waste heat (=El. consumption) [TWh/year]**				**Available waste heat from IT equipment [TWh/year]**				**Additional available waste heat [TWh/year]**			
Year	**2024**	**2030**	**2040**	**2050**	**2024**	**2030**	**2040**	**2050**	**2024**	**2030**	**2040**	**2050**
Austria	1,3	1,3	2,4	3,8	0,8	1,0	2,0	3,3	0,4	0,3	0,3	0,6
Belgium	2,1	2,4	4,4	7,1	1,7	2,1	3,8	6,0	0,3	0,4	0,6	1,0
Bulgaria	0,3	0,3	0,5	0,8	0,1	0,2	0,4	0,7	0,1	0,1	0,1	0,1
Cyprus	0,1	0,1	0,2	0,3	0,1	0,1	0,1	0,2	0,1	0,0	0,0	0,0
Czechia	1,1	1,2	2,1	3,4	0,5	0,7	1,6	2,9	0,5	0,5	0,6	0,5
Germany	18,7	26,0	47,2	75,4	12,6	20,8	40,4	64,5	4,9	5,1	6,9	11,0
Denmark	1,9	5,4	9,9	15,8	1,4	4,7	8,5	13,5	0,3	0,8	1,4	2,3
Estonia	0,3	0,3	0,5	0,8	0,1	0,2	0,4	0,7	0,1	0,1	0,1	0,1
Greece	0,8	0,6	1,1	1,8	0,5	0,4	0,9	1,6	0,3	0,2	0,2	0,3
Spain	3,7	5,8	10,6	16,9	2,1	3,9	8,5	14,4	1,4	1,9	2,1	2,5
Finland	1,3	1,8	3,2	5,1	1,1	1,5	2,7	4,4	0,2	0,3	0,5	0,7
France	12,4	19,9	36,1	57,7	7,5	14,3	30,9	49,3	4,1	5,6	5,3	8,4
Croatia	0,3	0,3	0,5	0,8	0,1	0,2	0,4	0,7	0,1	0,1	0,1	0,1
Hungary	0,3	0,3	0,5	0,8	0,1	0,2	0,4	0,7	0,1	0,1	0,1	0,1
Ireland	5,9	9,9	18,0	28,7	4,7	8,5	15,4	24,6	0,8	1,4	2,6	4,2
Italy	4,5	8,3	15,2	24,2	2,9	6,4	13,0	20,7	1,3	2,0	2,2	3,5
Lithuania	0,1	0,1	0,2	0,3	0,1	0,1	0,1	0,2	0,0	0,0	0,0	0,0
Luxembourg	0,5	0,4	0,7	1,2	0,3	0,3	0,6	1,0	0,2	0,1	0,1	0,2
Latvia	0,1	0,1	0,2	0,3	0,1	0,1	0,1	0,2	0,0	0,0	0,0	0,0
Malta	0,1	0,1	0,2	0,3	0,1	0,1	0,1	0,2	0,1	0,0	0,0	0,0
Netherlands	6,1	8,9	16,3	26,0	4,1	7,2	13,9	22,2	1,6	1,8	2,4	3,8
Poland	2,7	4,2	7,6	12,1	1,6	3,0	6,5	10,3	0,9	1,2	1,1	1,8
Portugal	0,5	0,4	0,7	1,0	0,3	0,3	0,6	0,9	0,2	0,1	0,1	0,2
Romania	0,3	0,3	0,5	0,8	0,1	0,2	0,4	0,7	0,1	0,1	0,1	0,1
Sweden	3,7	6,9	12,5	19,9	3,0	5,9	10,7	17,0	0,5	1,0	1,8	2,9
Slovenia	0,1	0,3	0,5	0,8	0,1	0,2	0,4	0,7	0,0	0,1	0,1	0,1
Slovakia	0,3	0,1	0,2	0,3	0,1	0,1	0,1	0,2	0,1	0,0	0,0	0,0
EU27	**69,5**	**105,5**	**191,7**	**306,1**	**46,3**	**82,2**	**162,9**	**261,6**	**18,8**	**23,2**	**28,8**	**44,5**
United Kingdom	11,7	14,9	23,2	34,2	8,1	9,9	18,6	29,2	2,9	4,9	4,6	5,0
EU27 + UK	**81,2**	**120,3**	**214,9**	**340,3**	**54,4**	**92,2**	**181,5**	**290,9**	**21,7**	**28,2**	**33,5**	**49,4**

Table 6, Available waste heat from data centers for the EU27 + UK countries in TWh/year in the low scenario.

Low growth – low PUE	Total available waste heat (=El. consumption) [TWh/year]				Available waste heat from IT equipment [TWh/year]				Additional available waste heat [TWh/year]			
Year	**2024**	**2030**	**2040**	**2050**	**2024**	**2030**	**2040**	**2050**	**2024**	**2030**	**2040**	**2050**
Austria	1,3	1,0	1,3	1,7	0,8	0,8	1,2	1,6	0,4	0,2	0,2	0,2
Belgium	2,1	1,8	2,5	3,2	1,7	1,7	2,3	3,1	0,3	0,1	0,1	0,2
Bulgaria	0,3	0,2	0,3	0,4	0,1	0,1	0,2	0,3	0,1	0,1	0,1	0,1
Cyprus	0,1	0,1	0,1	0,1	0,1	0,0	0,1	0,1	0,1	0,0	0,0	0,0
Czechia	1,1	0,9	1,2	1,5	0,5	0,6	0,9	1,2	0,5	0,3	0,3	0,3
Germany	18,7	19,3	26,2	34,4	12,6	16,7	24,7	32,8	4,9	2,7	1,5	1,6
Denmark	1,9	4,0	5,5	7,2	1,4	3,9	5,2	6,9	0,3	0,2	0,3	0,3
Estonia	0,3	0,2	0,3	0,4	0,1	0,2	0,2	0,3	0,1	0,0	0,0	0,0
Greece	0,8	0,5	0,6	0,8	0,5	0,3	0,5	0,7	0,3	0,1	0,1	0,1
Spain	3,7	4,3	5,9	7,7	2,1	3,1	4,6	6,2	1,4	1,2	1,2	1,5
Finland	1,3	1,3	1,8	2,3	1,1	1,3	1,7	2,2	0,2	0,1	0,1	0,1
France	12,4	14,8	20,0	26,3	7,5	11,4	17,0	22,8	4,1	3,4	3,1	3,5
Croatia	0,3	0,2	0,3	0,4	0,1	0,1	0,2	0,3	0,1	0,1	0,1	0,1
Hungary	0,3	0,2	0,3	0,4	0,1	0,2	0,2	0,3	0,1	0,0	0,0	0,0
Ireland	5,9	7,4	10,0	13,1	4,7	7,0	9,5	12,5	0,8	0,4	0,5	0,6
Italy	4,5	6,2	8,4	11,1	2,9	5,1	7,6	10,2	1,3	1,1	0,9	0,9
Lithuania	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,0
Luxembourg	0,5	0,3	0,4	0,5	0,3	0,2	0,4	0,5	0,2	0,1	0,0	0,0
Latvia	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,0
Malta	0,1	0,1	0,1	0,1	0,1	0,0	0,1	0,1	0,1	0,0	0,0	0,0
Netherlands	6,1	6,6	9,0	11,9	4,1	5,7	8,5	11,3	1,6	0,9	0,5	0,6
Poland	2,7	3,1	4,2	5,5	1,6	2,4	3,5	4,8	0,9	0,7	0,6	0,7
Portugal	0,5	0,3	0,4	0,5	0,3	0,2	0,3	0,4	0,2	0,1	0,1	0,1
Romania	0,3	0,2	0,3	0,4	0,1	0,2	0,2	0,3	0,1	0,0	0,0	0,0
Sweden	3,7	5,1	6,9	9,1	3,0	4,9	6,6	8,7	0,5	0,2	0,3	0,4
Slovenia	0,1	0,2	0,3	0,4	0,1	0,2	0,2	0,3	0,0	0,0	0,0	0,0
Slovakia	0,3	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,0	0,0	0,0
EU27	**69,5**	**78,4**	**106,4**	**139,8**	**46,3**	**66,5**	**96,3**	**128,1**	**18,8**	**11,9**	**10,0**	**11,7**
United Kingdom	11,7	12,3	15,0	18,2	6,7	9,4	12,5	15,5	4,3	2,9	2,5	2,7
EU27 + UK	**81,2**	**90,7**	**121,3**	**158,0**	**53,0**	**75,8**	**108,8**	**143,7**	**23,1**	**14,9**	**12,5**	**14,3**

2.4 Nuclear assessment

The next table tries to summarize key data about the nuclear energy infrastructure for different countries. In the table you can see the total number of nuclear plants of each country with a distinction on how many they are operational. As well as the ones under construction and the proposed to be built in the future because the horizon for the project is 2050. In that sense the age or lifetime expectancy is also taken into consideration to estimate if the plant will be operating still in 2050. The column labelled as EU27 filters out whether a country is part of the European Union or not, in order to use the data for these countries which is particularly relevant for the analysis of the EU27 case study. In conclusion, this table offers valuable insights into global nuclear energy strategies and future capacity changes, enabling to assess energy supply and to picture how nuclear fits within the broader energy mix. It is also important to mention that the distribution profile for the nuclear energy to know its hourly behaviour in time the historic distribution was taken from Energy Charts. As it can be expected, for the countries that have no nuclear energy in their energy mix the distribution file is a constat of zero.

Table 7: The countries globally with nuclear based power plants and their capacities.

Country	Plants	Proposed	Operational	Under construction	2023 Net capacity	Age of operation 2023	2030 Net capacity	Age of operation 2030	2040 Net capacity	Age of operation 2040	2050 Net capacity	Age of operation 2050
Argentina	7	2	3	1	1641	50,5	1666	30,5	1326	40,5	718	50,5
Armenia	2	1	1	0	416	70,0	416	50,0	0	0,0	0	0,0
Bangladesh	4	2	0	2	0	24,5	2160	4,5	2160	14,5	2160	24,5
Bulgaria	4	1	2	0	2006	59,5	2006	39,5	2006	49,5	1003	59,5
China	86	0	54	28	52981	32,4	70233	13,0	73686	22,4	73686	32,4
Czech Republic	6	0	6	0	3934	58,5	3934	38,5	3934	48,5	2056	58,5
Egypt	4	0	0	4	0	19,7	2200	0,0	3300	9,7	3300	19,7
Finland	5	0	4	0	4394	61,6	4394	41,6	2997	51,6	1600	0,0
France	57	0	56	1	61370	63,6	63000	43,6	54880	53,6	14170	0,0
India	27	0	18	8	5660	40,9	12201	20,9	12201	30,9	11809	40,9
Hungary	4	0	4	0	1916	65,0	1916	45,0	1916	55,0	0	0,0
India	27	0	18	8	5660	40,9	12201	20,9	12201	30,9	11809	40,9
Iran	2	0	1	1	915	30,0	1889	10,0	1889	20,0	1889	30,0
Japan	12	0	10	2	9486	55,7	12139	35,7	11359	45,7	8007	55,7
Mexico	2	0	2	0	1552	57,5	1552	37,5	1552	47,5	775	57,5
Pakistan	6	0	6	0	3262	35,5	3262	15,5	3262	25,5	3262	35,5
Romania	2	0	2	0	1300	48,5	1300	28,5	1300	38,5	1300	48,5
Slovenia	1	0	1	0	688	67,0	688	47,0	688	57,0	0	0,0
Russia	42	0	37	5	27727	53,8	30427	33,8	27337	43,8	14705	53,8
Slovakia	8	0	6	1	2800	60,3	2800	40,3	2800	50,3	936	0,0
South Africa	2	0	2	0	1854	65,5	1854	45,5	1854	55,5	0	0,0

South Korea	28	0	25	3	24489	47,1	28509	27,1	28509	37,1	21930	47,1
Spain	7	0	7	0	7123	64,6	7123	44,6	7123	54,6	0	0,0
Sweden	6	0	6	0	6937	67,5	6937	47,5	5897	57,5	0	0,0
Switzerland	4	0	4	0	2973	74,0	2608	54,0	1233	0,0	0	0,0
UAE	4	0	1	1	1337	26,8	5321	6,8	5321	16,8	5321	26,8
The Netherlands	1	0	1	0	482	77,0	482	57,0	0	0,0	0	0,0
United Kingdom	11	0	9	2	5883	53,4	9143	33,4	9143	43,4	4458	53,4
Türkiye	4	0	0	4	0	21,8	4456	1,8	4456	11,8	4456	21,8
UAE	4	0	1	1	1337	26,8	5321	6,8	5321	16,8	5321	26,8
Ukraine	17	0	15	2	13107	60,9	13107	40,9	13107	50,9	2850	0,0
Belarus	2	0	1	0	1110	27,5	2220	7,5	2220	17,5	2220	27,5
USA	94	0	92	1	94718	68,1	94294	48,1	58542	58,1	5750	0,0
Belgium	5	0	5	0	3928	71,0	3928	51,0	2076	0,0	0	0,0
Brazil	5	2	2	1	1884	46,7	3224	26,7	3224	36,7	2615	46,7
Canada	23	4	19	0	13624	66,5	13624	46,5	9504	56,5	2634	0,0

Table 8, Nuclear capacities and estimated nuclear waste heat in 2023 and 2050.

Nuclear capacity and waste heat	Nuclear Capacity (MW)	Total heat loss (TWh)	Nuclear Capacity (MW)	Total heat loss (TWh)
Year	2023	2023	2050	2050
Austria	0	0	0	0,0
Belgium	3928	22,9	0	0,0
Bulgaria	2006	11,7	1003	5,9
Cyprus	0	0,0	0	0,0
Czechia	3934	23,0	2056	12,0
Germany	0	0,0	0	0,0
Denmark	0	0,0	0	0,0
Estonia	0	0,0	0	0,0
Greece	0	0,0	0	0,0
Spain	7123	41,6	0	0,0
Finland	4394	25,7	1600	9,3
France	61370	358,4	14170	82,8
Croatia	0	0,0	0	0,0
Hungary	1916	11,2	0	0,0
Ireland	0	0,0	0	0,0
Italy	0	0,0	0	0,0
Lithuania	0	0,0	0	0,0
Luxembourg	0	0,0	0	0,0
Latvia	0	0,0	0	0,0
Malta	0	0,0	0	0,0
Netherlands	482	2,8	0	0,0
Poland	0	0,0	0	0,0
Portugal	0	0,0	0	0,0
Romania	1300	7,6	1300	7,6
Sweden	6937	40,5	0	0,0
Slovenia	688	4,0	0	0,0
Slovakia	2800	16,4	936	5,5
EU27	96878	565,8	21065	123,0

2.5 Industry waste heat aggregated

This section presents the aggregated industrial waste heat at 25°C, 55°C, and 95°C for each EU27 + UK country, based on the studied scenarios and summed across all source subcategories. Low temperature waste heat (25°C) consists of waste heat from industry, metros, supermarkets and baseload. Medium temperature waste heat (55°C) originates from industry, wastewater treatment and baseload. High temperature waste heat (95°C) consists of waste heat from industry, waste-to-energy and baseload. The relation between the base year of 2015 and 2050 is calculated, to show the expected development of available waste heat.

Table 9: This section presents the aggregated industrial waste heat at 25°C, 55°C, and 95°C for each EU27 + UK country, based on the studied scenarios and summed across all source subcategories.

Waste heat available UNIT: TJ	Temp	Base year	Frozen efficiency		BAT (No extra recycling)		BAT (high recycling)	BAT (high recycling)	2015/2050
Country temp	°C	2015	2030	2050	2030	2050	2030	2050	Relation %
Austria	25	47.083	52.852	59.410	48.147	51.006	46.447	45.800	97%
Austria	55	29.486	33.295	37.186	28.990	28.760	27.729	24.769	84%
Austria	95	25.144	28.404	31.697	24.191	23.460	23.141	19.997	80%
Belgium	25	63.188	69.050	74.947	62.453	63.163	60.846	58.016	92%
Belgium	55	37.803	41.388	44.757	35.294	33.448	34.172	29.758	79%
Belgium	95	32.018	35.053	37.877	29.081	26.807	28.131	23.540	74%
Bulgaria	25	16.258	19.064	19.744	16.831	15.169	16.838	15.315	94%
Bulgaria	55	10.692	12.607	13.029	10.632	9.003	10.638	9.142	86%
Bulgaria	95	9.458	11.148	11.515	9.227	7.592	9.231	7.728	82%
Croatia	25	9.494	12.843	13.398	11.673	11.064	11.655	11.042	116%
Croatia	55	6.791	9.476	9.894	8.447	7.818	8.428	7.796	115%
Croatia	95	5.910	8.338	8.706	7.352	6.714	7.333	6.692	113%
Cyprus	25	1.838	1.968	2.012	1.761	1.631	1.761	1.631	89%
Cyprus	55	1.421	1.522	1.556	1.334	1.213	1.334	1.213	85%
Cyprus	95	1.233	1.320	1.349	1.140	1.020	1.140	1.020	83%
Czechia	25	30.668	36.901	41.638	33.694	34.826	33.054	32.658	106%

Czechia	55	21.927	26.470	29.813	23.567	23.708	23.028	21.923	100%
Czechia	95	18.688	22.556	25.401	19.741	19.479	19.317	18.005	96%
Denmark	25	15.875	19.304	23.132	17.560	19.358	17.569	19.379	122%
Denmark	55	11.955	14.457	17.318	12.897	13.816	12.903	13.832	116%
Denmark	95	10.620	12.803	15.334	11.291	11.936	11.297	11.952	113%
Estonia	25	4.480	5.257	5.690	4.741	4.668	4.741	4.668	104%
Estonia	55	3.098	3.652	3.954	3.197	3.084	3.197	3.084	100%
Estonia	95	2.648	3.125	3.383	2.688	2.550	2.688	2.550	96%
Finland	25	43.612	47.489	50.848	44.970	45.885	44.313	43.861	101%
Finland	55	20.946	23.066	24.788	20.840	20.347	20.354	18.896	90%
Finland	95	17.289	19.072	20.505	16.896	16.168	16.500	14.940	86%
France	25	155.922	181.998	206.783	167.367	177.365	164.757	168.246	108%
France	55	100.890	119.290	135.579	106.014	108.105	104.050	101.264	100%
France	95	85.964	101.806	115.747	88.899	89.073	87.304	83.236	97%
Germany	25	295.565	340.298	360.738	314.528	311.405	308.482	292.423	99%
Germany	55	175.683	203.916	215.486	180.906	169.168	176.190	155.109	88%
Germany	95	148.319	172.191	181.823	149.768	136.649	145.989	125.036	84%
Greece	25	65.835	75.982	77.794	68.341	62.939	67.732	60.831	92%
Greece	55	55.637	64.202	65.770	57.198	52.126	56.620	50.013	90%
Greece	95	52.159	60.146	61.614	53.269	48.217	52.708	46.167	89%
Hungary	25	18.990	21.193	21.539	19.492	18.192	19.202	17.354	91%
Hungary	55	11.207	12.479	12.657	10.942	9.490	10.726	8.869	79%
Hungary	95	9.583	10.672	10.819	9.172	7.723	8.991	7.193	75%
Ireland	25	32.665	41.899	46.105	34.568	30.429	34.577	31.277	96%
Ireland	55	25.787	33.076	36.401	26.359	22.041	26.366	22.816	88%
Ireland	95	24.359	31.223	34.362	24.609	20.222	24.616	20.986	86%
Italy	25	172.786	191.979	204.577	172.323	163.313	170.116	156.533	91%
Italy	55	112.393	125.072	132.931	107.147	95.713	105.774	90.902	81%

Italy	95	98.427	109.440	116.245	91.895	79.804	90.769	75.666	77%
Latvia	25	5.091	6.283	5.902	5.587	4.720	5.591	4.734	93%
Latvia	55	3.905	4.820	4.528	4.192	3.460	4.195	3.471	89%
Latvia	95	3.412	4.211	3.956	3.606	2.927	3.608	2.938	86%
Lithuania	25	4.793	5.302	5.542	4.755	4.559	4.755	4.559	95%
Lithuania	55	2.625	2.942	3.074	2.486	2.239	2.486	2.239	85%
Lithuania	95	2.171	2.439	2.547	2.001	1.746	2.001	1.746	80%
Luxembourg	25	8.248	5.788	5.884	4.950	4.124	4.827	3.781	46%
Luxembourg	55	6.165	4.396	4.472	3.610	2.758	3.547	2.628	43%
Luxembourg	95	5.669	4.032	4.100	3.256	2.406	3.200	2.297	41%
Malta	25	170	206	181	184	147	184	147	86%
Malta	55	131	159	140	140	109	140	109	83%
Malta	95	114	138	121	119	92	119	92	81%
Netherlands	25	69.374	75.388	79.516	68.730	67.557	67.529	64.231	93%
Netherlands	55	39.155	42.659	44.919	36.713	33.513	35.718	30.741	79%
Netherlands	95	32.860	35.803	37.690	29.992	26.538	29.176	24.209	74%
Poland	25	88.295	107.613	111.725	98.104	92.420	97.316	89.783	102%
Poland	55	55.142	67.451	70.053	59.070	52.732	58.456	50.951	92%
Poland	95	47.258	57.837	60.066	49.713	43.253	49.228	41.804	88%
Portugal	25	31.799	35.865	35.722	33.062	30.286	33.101	30.506	96%
Portugal	55	19.879	22.636	22.774	20.142	17.949	20.188	18.169	91%
Portugal	95	16.927	19.273	19.394	16.872	14.749	16.916	14.960	88%
Romania	25	31.004	32.844	33.992	29.844	28.126	29.418	26.625	86%
Romania	55	19.651	20.625	21.270	17.967	16.023	17.618	14.856	76%
Romania	95	16.538	17.333	17.861	14.751	12.759	14.464	11.762	71%
Slovakia	25	17.870	20.965	22.520	18.971	19.414	18.000	16.182	91%
Slovakia	55	12.717	15.028	16.082	13.133	12.690	12.392	10.130	80%
Slovakia	95	10.838	12.808	13.704	10.946	10.375	10.334	8.141	75%

Slovenia	25	7.051	8.881	9.612	8.157	8.015	8.265	8.051	114%
Slovenia	55	5.370	6.850	7.390	6.190	5.893	6.269	5.915	110%
Slovenia	95	4.891	6.248	6.734	5.605	5.270	5.679	5.291	108%
Spain	25	142.112	161.655	169.374	148.552	142.293	147.165	138.376	97%
Spain	55	95.146	108.673	114.041	96.802	89.787	95.840	86.870	91%
Spain	95	82.613	94.308	98.956	82.782	75.398	81.980	72.876	88%
Sweden	25	44.227	46.839	51.389	44.835	47.084	44.371	45.542	103%
Sweden	55	23.437	24.407	26.505	22.643	22.426	22.255	21.249	91%
Sweden	95	19.809	20.553	22.290	18.828	18.290	18.520	17.323	87%
United Kingdom	25	106.526	125.734	132.696	112.938	106.641	111.166	101.914	96%
United Kingdom	55	76.246	90.313	95.371	78.680	71.699	77.320	68.073	89%
United Kingdom	95	65.421	77.558	81.932	66.272	59.018	65.168	55.948	86%
EU27	25	1.424.294	1.625.706	1.739.714	1.484.180	1.459.161	1.462.613	1.391.551	98%
EU27	55	909.040	1.044.616	1.116.367	916.852	857.419	900.614	806.717	89%
EU27	95	784.920	902.280	963.796	777.689	711.214	764.382	668.147	85%
EU27 + UK	25	1.530.820	1.751.440	1.872.411	1.597.118	1.565.802	1.573.779	1.493.465	98%
EU27 + UK	55	985.285	1.134.929	1.211.737	995.533	929.118	977.934	874.790	89%
EU27 + UK	95	850.341	979.839	1.045.728	843.961	770.232	829.550	724.095	85%

2.6 Industry waste heat – sub-sectors 25˚C

This section presents industrial waste heat at 25°C divided into sources for each the selected countries of France, Germany Hungary, Poland and Spain, based on the studied scenarios.

Table 10: The industrial waste heat at 25°C divided into sources for each the selected countries of France, Germany Hungary, Poland and Spain, based on the studied scenarios.

25°C:	Waste heat available UNIT: TJ		Base year	Frozen efficiency		BAT (No extra recycling)		BAT (high re-cycling)	BAT (high recycling)	2015/2050
Country	**Industrial sub-sector**	**Product**	**2015**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**Relation %**
France	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
France	Chemicals	Ethylene	15.243	15.155	14.109	14.824	13.370	14.824	13.370	88%
France	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
France	Chemicals	Ammonia	1.095	1.126	1.006	1.025	850	1.025	850	78%
France	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
France	Chemicals	Rest of chemicals	4.553	4.220	3.949	4.108	3.715	4.108	3.715	82%
France	Iron and steel	BF/BOF steel	1.801	1.909	1.966	1.347	1.966	1.123	1.070	59%
France	Iron and steel	Pig iron	5.631	6.687	7.026	6.658	5.620	5.307	2.533	45%
France	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
France	Iron and steel	EAF steel	829	879	905	614	0	772	0	0%
France	Iron and steel	Coke oven	5.318	6.316	6.636	5.353	6.636	4.266	3.451	65%
France	Foundries	Ferrous metals casting	3.243	3.438	3.541	3.438	3.541	3.438	3.541	109%
France	Iron and steel	Rest of iron and steel	7.975	9.259	8.873	8.384	7.428	8.366	6.873	86%
France	Non-ferrous metals	Aluminium primary	457	499	519	499	519	436	357	78%
France	Non-ferrous metals	Aluminium secondary	474	515	525	416	326	437	378	80%
France	Foundries	Nonferrous metals casting	776	840	840	804	628	804	628	81%
France	Non-ferrous metals	Rest of non-ferrous metals	4.519	4.894	4.917	4.538	3.845	4.517	3.756	83%
France	Non-metallic minerals	Cement	12.253	15.310	15.692	13.696	12.722	13.696	12.722	104%
France	Non-metallic minerals	Flat glass	0	0	0	0	0	0	0	N/A

France	Non-metallic minerals	Container glass	0	0	0	0	0	0	0	N/A
France	Non-metallic minerals	Rest of non-metallic minerals	25.633	31.547	32.197	28.221	26.102	28.221	26.102	102%
France	Paper and pulp	Tissue paper	487	552	610	518	610	518	610	125%
France	Paper and pulp	Graphic paper	1.431	1.705	1.883	1.600	1.821	1.600	1.821	127%
France	Paper and pulp	Board and packag. Paper	1.817	2.062	2.368	1.936	2.180	1.936	2.180	120%
France	Paper and pulp	Chemical pulp	2.387	2.710	3.329	2.710	3.329	2.710	3.329	139%
France	Paper and pulp	Mechanical pulp	0	0	0	0	0	0	0	N/A
France	Paper and pulp	Recovered fibre pulp	197	230	277	224	251	224	251	128%
France	Paper and pulp	Rest of paper and pulp	2.215	2.550	2.953	2.454	2.857	2.454	2.857	129%
France	Others	Others	57.590	69.595	92.662	64.000	79.051	63.975	77.852	135%
Germany	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Ethylene	32.467	35.339	35.985	34.309	33.812	34.309	33.812	104%
Germany	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Ammonia	2.631	2.763	2.790	2.515	2.407	2.515	2.407	91%
Germany	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Rest of chemicals	34.944	38.762	39.637	37.464	37.023	37.464	37.023	106%
Germany	Iron and steel	BF/BOF steel	5.508	5.839	6.014	4.121	6.014	3.436	3.272	59%
Germany	Iron and steel	Pig iron	15.526	19.172	20.346	19.088	17.955	15.214	8.676	56%
Germany	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Germany	Iron and steel	EAF steel	2.028	2.150	2.215	1.503	0	1.889	0	0%
Germany	Iron and steel	Coke oven	8.433	10.413	10.940	8.825	10.940	7.034	5.689	67%
Germany	Foundries	Ferrous metals casting	10.059	11.420	11.763	11.420	11.763	11.420	11.763	117%
Germany	Iron and steel	Rest of iron and steel	12.742	14.810	13.827	13.590	11.768	13.565	11.050	87%
Germany	Non-ferrous metals	Aluminium primary	588	643	669	643	669	561	459	78%
Germany	Non-ferrous metals	Aluminium secondary	2.370	2.577	2.623	2.079	1.629	2.186	1.888	80%
Germany	Foundries	Nonferrous metals casting	2.657	2.874	2.874	2.753	2.149	2.753	2.149	81%
Germany	Non-ferrous metals	Rest of non-ferrous metals	12.009	13.011	13.091	11.691	9.440	11.648	9.392	78%
Germany	Non-metallic minerals	Cement	24.474	30.871	31.643	27.617	25.653	27.617	25.653	105%

Germany	Non-metallic minerals	Flat glass	5.633	6.724	7.141	6.004	5.340	6.004	5.340	95%
Germany	Non-metallic minerals	Container glass	3.452	3.722	3.326	3.132	2.204	3.132	2.204	64%
Germany	Non-metallic minerals	Rest of non-metallic minerals	33.032	38.706	39.297	34.429	30.979	34.429	30.979	94%
Germany	Paper and pulp	Tissue paper	854	989	1.113	926	1.113	926	1.113	130%
Germany	Paper and pulp	Graphic paper	5.252	5.962	6.518	5.594	6.407	5.594	6.407	122%
Germany	Paper and pulp	Board and packag. Paper	4.638	5.266	6.045	4.944	5.391	4.944	5.391	116%
Germany	Paper and pulp	Chemical pulp	2.348	2.665	3.274	2.665	3.274	2.665	3.274	139%
Germany	Paper and pulp	Mechanical pulp	152	179	216	176	213	176	213	140%
Germany	Paper and pulp	Recovered fibre pulp	1	1	1	1	1	1	1	97%
Germany	Paper and pulp	Rest of paper and pulp	2.302	2.618	2.971	2.487	2.838	2.487	2.838	123%
Germany	Others	Others	71.464	82.824	96.421	76.552	82.425	76.513	81.430	114%
Hungary	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Ethylene	3.801	4.196	4.291	4.107	4.116	4.107	4.116	108%
Hungary	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Ammonia	347	365	368	339	328	339	328	94%
Hungary	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Rest of chemicals	1.080	1.218	1.269	1.187	1.210	1.187	1.210	112%
Hungary	Iron and steel	BF/BOF steel	276	293	302	207	302	172	164	59%
Hungary	Iron and steel	Pig iron	695	617	635	614	453	490	185	27%
Hungary	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Hungary	Iron and steel	EAF steel	27	29	29	20	0	25	0	0%
Hungary	Iron and steel	Coke oven	935	830	855	703	855	561	445	48%
Hungary	Foundries	Ferrous metals casting	225	238	245	238	245	238	245	109%
Hungary	Iron and steel	Rest of iron and steel	578	564	512	501	418	502	379	66%
Hungary	Non-ferrous metals	Aluminium primary	0	0	0	0	0	0	0	N/A
Hungary	Non-ferrous metals	Aluminium secondary	209	227	231	183	143	193	166	80%
Hungary	Foundries	Nonferrous metals casting	245	264	264	253	198	253	198	81%
Hungary	Non-ferrous metals	Rest of non-ferrous metals	2.152	2.332	2.346	2.071	1.615	2.067	1.633	76%

Hungary	Non-metallic minerals	Cement	1.374	1.636	1.677	1.463	1.359	1.463	1.359	99%
Hungary	Non-metallic minerals	Flat glass	510	569	592	508	440	508	440	86%
Hungary	Non-metallic minerals	Container glass	109	112	100	94	66	94	66	61%
Hungary	Non-metallic minerals	Rest of non-metallic minerals	2.651	3.178	3.237	2.834	2.549	2.834	2.549	96%
Hungary	Paper and pulp	Tissue paper	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Graphic paper	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Board and packag. Paper	329	338	344	317	344	317	344	105%
Hungary	Paper and pulp	Chemical pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Mechanical pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Recovered fibre pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Rest of paper and pulp	13	13	14	13	14	13	14	105%
Hungary	Others	Others	3.433	4.175	4.227	3.840	3.537	3.841	3.512	102%
Poland	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Ethylene	3.173	3.748	3.798	3.639	3.486	3.639	3.486	110%
Poland	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Ammonia	2.315	2.431	2.455	2.213	2.118	2.213	2.118	91%
Poland	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Rest of chemicals	8.061	8.742	8.797	8.280	7.882	8.280	7.882	98%
Poland	Iron and steel	BF/BOF steel	975	1.034	1.065	730	1.065	608	579	59%
Poland	Iron and steel	Pig iron	2.688	2.691	2.771	2.679	2.480	2.135	1.209	45%
Poland	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Poland	Iron and steel	EAF steel	623	660	680	462	0	580	0	0%
Poland	Iron and steel	Coke oven	1.252	1.253	1.291	1.062	1.291	847	671	54%
Poland	Foundries	Ferrous metals casting	1.731	1.835	1.890	1.835	1.890	1.835	1.890	109%
Poland	Iron and steel	Rest of iron and steel	1.212	1.208	1.073	1.094	870	1.088	804	66%
Poland	Non-ferrous metals	Aluminium primary	0	0	0	0	0	0	0	N/A
Poland	Non-ferrous metals	Aluminium secondary	209	227	231	183	143	193	166	80%

Poland	Foundries	Nonferrous metals casting	768	831	831	796	621	796	621	81%
Poland	Non-ferrous metals	Rest of non-ferrous metals	3.560	3.853	3.862	3.566	2.781	3.561	2.792	78%
Poland	Non-metallic minerals	Cement	11.943	14.212	14.568	12.714	11.810	12.714	11.810	99%
Poland	Non-metallic minerals	Flat glass	2.625	2.925	3.046	2.612	2.262	2.612	2.262	86%
Poland	Non-metallic minerals	Container glass	1.737	1.783	1.593	1.500	1.056	1.500	1.056	61%
Poland	Non-metallic minerals	Rest of non-metallic minerals	13.865	17.170	17.395	15.269	13.701	15.269	13.701	99%
Poland	Paper and pulp	Tissue paper	266	287	293	269	293	269	293	110%
Poland	Paper and pulp	Graphic paper	530	574	585	538	553	538	553	104%
Poland	Paper and pulp	Board and packag. Paper	1.216	1.315	1.341	1.235	1.278	1.235	1.278	105%
Poland	Paper and pulp	Chemical pulp	1.275	1.352	1.392	1.352	1.392	1.352	1.392	109%
Poland	Paper and pulp	Mechanical pulp	11	12	12	11	12	11	12	107%
Poland	Paper and pulp	Recovered fibre pulp	0	0	0	0	0	0	0	N/A
Poland	Paper and pulp	Rest of paper and pulp	1.524	1.638	1.675	1.576	1.631	1.576	1.631	107%
Poland	Others	Others	26.733	37.833	41.081	34.490	33.804	34.466	33.575	126%
Spain	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Ethylene	7.713	8.406	8.589	8.161	8.044	8.161	8.044	104%
Spain	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Ammonia	421	442	446	402	385	402	385	91%
Spain	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Rest of chemicals	9.825	10.713	10.961	10.368	10.227	10.368	10.227	104%
Spain	Iron and steel	BF/BOF steel	862	913	941	671	941	560	512	59%
Spain	Iron and steel	Pig iron	2.482	2.434	2.311	2.426	1.406	1.934	481	19%
Spain	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Spain	Iron and steel	EAF steel	1.630	1.728	1.780	1.312	132	1.648	1.165	71%
Spain	Iron and steel	Coke oven	5.304	5.202	4.939	4.568	4.939	3.641	2.569	48%
Spain	Foundries	Ferrous metals casting	2.602	2.482	2.301	2.482	2.301	2.482	2.301	88%
Spain	Iron and steel	Rest of iron and steel	5.013	4.526	3.578	4.065	2.834	4.040	2.615	52%

Spain	Non-ferrous metals	Aluminium primary	381	412	412	412	412	363	297	78%
Spain	Non-ferrous metals	Aluminium secondary	209	227	231	183	143	193	166	80%
Spain	Foundries	Nonferrous metals casting	318	344	344	329	257	329	257	81%
Spain	Non-ferrous metals	Rest of non-ferrous metals	11.176	12.104	12.165	11.386	10.015	11.329	9.746	87%
Spain	Non-metallic minerals	Cement	11.781	14.721	15.089	13.169	12.232	13.169	12.232	104%
Spain	Non-metallic minerals	Flat glass	0	0	0	0	0	0	0	N/A
Spain	Non-metallic minerals	Container glass	0	0	0	0	0	0	0	N/A
Spain	Non-metallic minerals	Rest of non-metallic minerals	26.777	33.068	33.731	29.581	27.346	29.581	27.346	102%
Spain	Paper and pulp	Tissue paper	434	455	362	427	362	427	362	83%
Spain	Paper and pulp	Graphic paper	845	887	704	832	653	832	653	77%
Spain	Paper and pulp	Board and packag. Paper	1.508	1.503	1.122	1.412	1.025	1.412	1.025	68%
Spain	Paper and pulp	Chemical pulp	2.228	2.223	1.766	2.223	1.766	2.223	1.766	79%
Spain	Paper and pulp	Mechanical pulp	14	15	12	15	12	15	12	81%
Spain	Paper and pulp	Recovered fibre pulp	193	198	166	193	144	193	144	75%
Spain	Paper and pulp	Rest of paper and pulp	776	786	614	759	588	759	588	76%
Spain	Others	Others	49.620	57.867	66.811	53.176	56.129	53.106	55.483	112%

2.7 Industry waste heat – sub-sectors 55˚C

This section presents industrial waste heat at 55°C divided into sources for each the selected countries of France, Germany Hungary, Poland and Spain, based on the studied scenarios and summed across all source subcategories.

Table 11: The industrial waste heat at 55°C divided into sources for each the selected countries of France, Germany Hungary, Poland and Spain, based on the studied scenarios.

55°C:	Waste heat available UNIT: TJ		Base year	Frozen efficiency		BAT (No extra recycling)		BAT (high recycling)	BAT (high recycling)	2015/2050
Country	**Industrial sub-sector**	**Product**	**2015**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**Relation %**
France	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
France	Chemicals	Ethylene	4.266	4.242	3.949	3.989	3.555	3.989	3.555	83%
France	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
France	Chemicals	Ammonia	355	365	327	288	206	288	206	58%
France	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
France	Chemicals	Rest of chemicals	1.288	1.194	1.117	1.108	983	1.108	983	76%
France	Iron and steel	BF/BOF steel	1.757	1.862	1.918	1.307	807	1.089	117	7%
France	Iron and steel	Pig iron	4.606	5.470	5.747	5.441	5.690	4.337	2.944	64%
France	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
France	Iron and steel	EAF steel	805	853	879	590	141	741	570	71%
France	Iron and steel	Coke oven	3.674	4.363	4.585	3.400	3.236	2.710	1.310	36%
France	Foundries	Ferrous metals casting	2.924	3.100	3.193	3.100	3.193	3.100	3.193	109%
France	Iron and steel	Rest of iron and steel	6.527	7.577	7.261	6.700	5.813	6.692	5.317	81%
France	Non-ferrous metals	Aluminium primary	440	481	501	481	501	420	344	78%
France	Non-ferrous metals	Aluminium secondary	377	409	417	318	234	334	274	73%
France	Foundries	Nonferrous metals casting	609	659	659	627	464	627	464	76%
France	Non-ferrous metals	Rest of non-ferrous metals	3.775	4.089	4.108	3.762	3.125	3.741	3.027	80%
France	Non-metallic minerals	Cement	9.472	11.836	12.132	10.378	9.458	10.378	9.458	100%

France	Non-metallic minerals	Flat glass	0	0	0	0	0	0	0	N/A
France	Non-metallic minerals	Container glass	0	0	0	0	0	0	0	N/A
France	Non-metallic minerals	Rest of non-metallic minerals	19.817	24.389	24.892	21.386	19.407	21.386	19.407	98%
France	Paper and pulp	Tissue paper	149	169	187	146	145	146	145	97%
France	Paper and pulp	Graphic paper	438	522	577	451	450	451	450	103%
France	Paper and pulp	Board and packag. Paper	556	632	725	546	572	546	572	103%
France	Paper and pulp	Chemical pulp	968	1.099	1.349	1.099	1.349	1.099	1.349	139%
France	Paper and pulp	Mechanical pulp	0	0	0	0	0	0	0	N/A
France	Paper and pulp	Recovered fibre pulp	60	71	85	66	68	66	68	113%
France	Paper and pulp	Rest of paper and pulp	762	877	1.015	812	898	812	898	118%
France	Others	Others	37.264	45.032	59.958	40.020	47.807	39.991	46.612	125%
Germany	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Ethylene	9.087	9.891	10.072	9.104	8.848	9.104	8.848	97%
Germany	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Ammonia	854	896	905	706	610	706	610	71%
Germany	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Rest of chemicals	9.897	10.978	11.226	9.984	9.672	9.984	9.672	98%
Germany	Iron and steel	BF/BOF steel	5.374	5.697	5.867	3.997	2.468	3.332	357	7%
Germany	Iron and steel	Pig iron	12.700	15.682	16.642	15.600	16.478	12.434	8.525	67%
Germany	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Germany	Iron and steel	EAF steel	1.969	2.088	2.150	1.443	346	1.813	1.395	71%
Germany	Iron and steel	Coke oven	5.826	7.194	7.558	5.606	5.335	4.468	2.159	37%
Germany	Foundries	Ferrous metals casting	9.070	10.297	10.606	10.297	10.606	10.297	10.606	117%
Germany	Iron and steel	Rest of iron and steel	10.714	12.452	11.626	11.232	9.565	11.218	8.916	83%
Germany	Non-ferrous metals	Aluminium primary	567	620	645	620	645	541	443	78%
Germany	Non-ferrous metals	Aluminium secondary	1.883	2.046	2.084	1.590	1.170	1.672	1.370	73%
Germany	Foundries	Nonferrous metals casting	2.085	2.255	2.255	2.144	1.589	2.144	1.589	76%

Germany	Non-ferrous metals	Rest of non-ferrous metals	9.698	10.508	10.572	9.296	7.223	9.252	7.154	74%
Germany	Non-metallic minerals	Cement	18.921	23.866	24.463	20.928	19.073	20.928	19.073	101%
Germany	Non-metallic minerals	Flat glass	3.534	4.218	4.480	3.576	2.874	3.576	2.874	81%
Germany	Non-metallic minerals	Container glass	1.960	2.113	1.888	1.623	958	1.623	958	49%
Germany	Non-metallic minerals	Rest of non-metallic minerals	24.031	28.158	28.588	24.362	21.238	24.362	21.238	88%
Germany	Paper and pulp	Tissue paper	262	303	341	261	267	261	267	102%
Germany	Paper and pulp	Graphic paper	1.609	1.827	1.997	1.577	1.553	1.577	1.553	97%
Germany	Paper and pulp	Board and packag. Paper	1.421	1.613	1.852	1.393	1.461	1.393	1.461	103%
Germany	Paper and pulp	Chemical pulp	952	1.081	1.327	1.081	1.327	1.081	1.327	139%
Germany	Paper and pulp	Mechanical pulp	46	55	66	53	64	53	64	138%
Germany	Paper and pulp	Recovered fibre pulp	0	0	0	0	0	0	0	84%
Germany	Paper and pulp	Rest of paper and pulp	746	848	962	759	805	759	805	108%
Germany	Others	Others	42.478	49.230	57.312	43.675	44.993	43.612	43.845	103%
Hungary	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Ethylene	1.064	1.174	1.201	1.106	1.095	1.106	1.095	103%
Hungary	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Ammonia	113	118	119	98	88	98	88	78%
Hungary	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Rest of chemicals	306	345	360	322	322	322	322	105%
Hungary	Iron and steel	BF/BOF steel	269	286	294	200	124	167	18	7%
Hungary	Iron and steel	Pig iron	569	505	520	502	514	400	266	47%
Hungary	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Hungary	Iron and steel	EAF steel	26	28	29	19	5	24	19	71%
Hungary	Iron and steel	Coke oven	646	573	591	447	413	356	166	26%
Hungary	Foundries	Ferrous metals casting	203	215	221	215	221	215	221	109%
Hungary	Iron and steel	Rest of iron and steel	459	448	406	386	314	386	278	61%

Hungary	Non-ferrous metals	Aluminium primary	0	0	0	0	0	0	0	N/A
Hungary	Non-ferrous metals	Aluminium secondary	166	180	184	140	103	147	121	73%
Hungary	Foundries	Nonferrous metals casting	192	208	208	197	146	197	146	76%
Hungary	Non-ferrous metals	Rest of non-ferrous metals	1.698	1.840	1.851	1.601	1.180	1.597	1.197	70%
Hungary	Non-metallic minerals	Cement	1.063	1.265	1.296	1.109	1.011	1.109	1.011	95%
Hungary	Non-metallic minerals	Flat glass	320	357	371	302	236	302	236	74%
Hungary	Non-metallic minerals	Container glass	62	64	57	49	29	49	29	47%
Hungary	Non-metallic minerals	Rest of non-metallic minerals	1.921	2.303	2.346	1.996	1.734	1.996	1.734	90%
Hungary	Paper and pulp	Tissue paper	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Graphic paper	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Board and packag. Paper	101	103	105	89	80	89	80	80%
Hungary	Paper and pulp	Chemical pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Mechanical pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Recovered fibre pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Rest of paper and pulp	4	4	4	4	3	4	3	80%
Hungary	Others	Others	2.026	2.464	2.494	2.160	1.870	2.161	1.839	91%
Poland	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Ethylene	888	1.049	1.063	966	933	966	933	105%
Poland	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Ammonia	751	789	797	621	536	621	536	71%
Poland	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Rest of chemicals	2.408	2.611	2.627	2.254	2.077	2.254	2.077	86%
Poland	Iron and steel	BF/BOF steel	951	1.009	1.039	708	437	590	63	7%
Poland	Iron and steel	Pig iron	2.199	2.201	2.267	2.189	2.244	1.745	1.161	53%
Poland	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Poland	Iron and steel	EAF steel	605	641	661	443	106	557	429	71%

Poland	Iron and steel	Coke oven	865	866	892	675	624	538	251	29%
Poland	Foundries	Ferrous metals casting	1.561	1.655	1.704	1.655	1.704	1.655	1.704	109%
Poland	Iron and steel	Rest of iron and steel	1.031	1.027	912	914	711	909	653	63%
Poland	Non-ferrous metals	Aluminium primary	0	0	0	0	0	0	0	N/A
Poland	Non-ferrous metals	Aluminium secondary	166	180	184	140	103	147	121	73%
Poland	Foundries	Nonferrous metals casting	603	652	652	620	459	620	459	76%
Poland	Non-ferrous metals	Rest of non-ferrous metals	2.801	3.031	3.039	2.768	2.046	2.763	2.057	73%
Poland	Non-metallic minerals	Cement	9.233	10.988	11.262	9.635	8.781	9.635	8.781	95%
Poland	Non-metallic minerals	Flat glass	1.647	1.835	1.911	1.556	1.212	1.556	1.212	74%
Poland	Non-metallic minerals	Container glass	986	1.012	904	777	459	777	459	47%
Poland	Non-metallic minerals	Rest of non-metallic minerals	10.090	12.495	12.659	10.809	9.398	10.809	9.398	93%
Poland	Paper and pulp	Tissue paper	81	88	90	76	68	76	68	84%
Poland	Paper and pulp	Graphic paper	163	176	179	152	137	152	137	84%
Poland	Paper and pulp	Board and packag. Paper	373	403	411	348	313	348	313	84%
Poland	Paper and pulp	Chemical pulp	517	548	564	548	564	548	564	109%
Poland	Paper and pulp	Mechanical pulp	3	4	4	3	4	3	4	105%
Poland	Paper and pulp	Recovered fibre pulp	0	0	0	0	0	0	0	N/A
Poland	Paper and pulp	Rest of paper and pulp	525	564	577	522	503	522	503	96%
Poland	Others	Others	16.696	23.628	25.656	20.692	19.312	20.666	19.069	114%
Spain	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Ethylene	2.159	2.353	2.404	2.166	2.113	2.166	2.113	98%
Spain	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Ammonia	137	143	145	113	98	113	98	71%
Spain	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Rest of chemicals	2.773	3.023	3.093	2.759	2.682	2.759	2.682	97%
Spain	Iron and steel	BF/BOF steel	841	891	918	652	439	543	100	12%

Spain	Iron and steel	Pig iron	2.030	1.991	1.890	1.983	1.875	1.581	971	48%
Spain	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Spain	Iron and steel	EAF steel	1.583	1.678	1.728	1.263	568	1.587	1.486	94%
Spain	Iron and steel	Coke oven	3.665	3.594	3.413	2.960	2.524	2.359	1.067	29%
Spain	Foundries	Ferrous metals casting	2.346	2.238	2.074	2.238	2.074	2.238	2.074	88%
Spain	Iron and steel	Rest of iron and steel	4.073	3.677	2.907	3.219	2.169	3.202	2.002	49%
Spain	Non-ferrous metals	Aluminium primary	367	397	397	397	397	350	287	78%
Spain	Non-ferrous metals	Aluminium secondary	166	180	184	140	103	147	121	73%
Spain	Foundries	Nonferrous metals casting	249	270	270	256	190	256	190	76%
Spain	Non-ferrous metals	Rest of non-ferrous metals	9.637	10.438	10.490	9.779	8.515	9.721	8.228	85%
Spain	Non-metallic minerals	Cement	9.108	11.381	11.665	9.979	9.095	9.979	9.095	100%
Spain	Non-metallic minerals	Flat glass	0	0	0	0	0	0	0	N/A
Spain	Non-metallic minerals	Container glass	0	0	0	0	0	0	0	N/A
Spain	Non-metallic minerals	Rest of non-metallic minerals	20.701	25.564	26.077	22.417	20.331	22.417	20.331	98%
Spain	Paper and pulp	Tissue paper	133	140	111	120	77	120	77	58%
Spain	Paper and pulp	Graphic paper	259	272	216	235	150	235	150	58%
Spain	Paper and pulp	Board and packag. Paper	462	461	344	398	232	398	232	50%
Spain	Paper and pulp	Chemical pulp	903	901	716	901	716	901	716	79%
Spain	Paper and pulp	Mechanical pulp	4	5	4	4	3	4	3	79%
Spain	Paper and pulp	Recovered fibre pulp	59	61	51	57	37	57	37	62%
Spain	Paper and pulp	Rest of paper and pulp	270	274	214	256	180	256	180	67%
Spain	Others	Others	33.222	38.743	44.731	34.511	35.218	34.449	34.632	104%

2.8 Industry waste heat – sub-sectors 95˚C

This section presents industrial waste heat at 95°C divided into sources for each the selected countries of France, Germany Hungary, Poland and Spain, based on the studied scenarios and summed across all source subcategories.

Table 12: The industrial waste heat at 95°C divided into sources for each the selected countries of France, Germany Hungary, Poland and Spain, based on the studied scenarios.

95°C:	Waste heat available UNIT: TJ		Base year	Frozen efficiency		BAT (No extra recycling)		BAT (high re-cycling)	BAT (high re-cycling)	2015/2050
Country	**Industrial sub-sector**	**Product**	**2015**	**2030**	**2050**	**2030**	**2050**	**2030**	**2050**	**Relation %**
France	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
France	Chemicals	Ethylene	2.673	2.657	2.474	2.415	2.098	2.415	2.098	78%
France	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
France	Chemicals	Ammonia	248	255	228	181	112	181	112	45%
France	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
France	Chemicals	Rest of chemicals	814	754	706	672	577	672	577	71%
France	Iron and steel	BF/BOF steel	1.698	1.800	1.854	1.252	758	1.044	95	6%
France	Iron and steel	Pig iron	3.470	4.121	4.330	4.093	4.274	3.262	2.207	64%
France	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
France	Iron and steel	EAF steel	773	819	844	557	110	700	515	67%
France	Iron and steel	Coke oven	3.371	4.003	4.206	3.040	2.858	2.423	1.113	33%
France	Foundries	Ferrous metals casting	2.782	2.949	3.038	2.949	3.038	2.949	3.038	109%
France	Iron and steel	Rest of iron and steel	5.734	6.656	6.379	5.781	4.933	5.779	4.479	78%
France	Non-ferrous metals	Aluminium primary	418	457	475	457	475	399	326	78%
France	Non-ferrous metals	Aluminium secondary	362	394	401	304	221	319	259	71%
France	Foundries	Nonferrous metals casting	585	633	633	601	441	601	441	75%
France	Non-ferrous metals	Rest of non-ferrous metals	3.614	3.914	3.933	3.592	2.962	3.571	2.867	79%
France	Non-metallic minerals	Cement	8.216	10.266	10.523	8.866	7.958	8.866	7.958	97%

France	Non-metallic minerals	Flat glass	0	0	0	0	0	0	0	N/A
France	Non-metallic minerals	Container glass	0	0	0	0	0	0	0	N/A
France	Non-metallic minerals	Rest of non-metallic minerals	17.189	21.155	21.591	18.269	16.327	18.269	16.327	95%
France	Paper and pulp	Tissue paper	110	125	138	103	99	103	99	90%
France	Paper and pulp	Graphic paper	323	385	425	318	305	318	305	94%
France	Paper and pulp	Board and packag. Paper	410	466	534	384	390	384	390	95%
France	Paper and pulp	Chemical pulp	791	898	1.103	898	1.103	898	1.103	139%
France	Paper and pulp	Mechanical pulp	0	0	0	0	0	0	0	N/A
France	Paper and pulp	Recovered fibre pulp	45	52	63	48	47	48	47	105%
France	Paper and pulp	Rest of paper and pulp	589	677	785	616	674	616	674	114%
France	Others	Others	31.751	38.369	51.087	33.505	39.314	33.488	38.206	120%
Germany	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Ethylene	5.692	6.196	6.309	5.444	5.140	5.444	5.140	90%
Germany	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Ammonia	596	625	632	443	349	443	349	59%
Germany	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Germany	Chemicals	Rest of chemicals	6.260	6.944	7.101	5.993	5.616	5.993	5.616	90%
Germany	Iron and steel	BF/BOF steel	5.193	5.505	5.670	3.829	2.318	3.193	290	6%
Germany	Iron and steel	Pig iron	9.567	11.814	12.537	11.733	12.376	9.352	6.392	67%
Germany	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Germany	Iron and steel	EAF steel	1.890	2.004	2.064	1.363	269	1.712	1.259	67%
Germany	Iron and steel	Coke oven	5.345	6.600	6.934	5.013	4.712	3.995	1.835	34%
Germany	Foundries	Ferrous metals casting	8.630	9.797	10.091	9.797	10.091	9.797	10.091	117%
Germany	Iron and steel	Rest of iron and steel	9.391	10.915	10.191	9.697	8.133	9.694	7.550	80%
Germany	Non-ferrous metals	Aluminium primary	538	588	612	588	612	514	420	78%
Germany	Non-ferrous metals	Aluminium secondary	1.812	1.969	2.005	1.519	1.104	1.597	1.295	71%
Germany	Foundries	Nonferrous metals casting	2.002	2.166	2.166	2.056	1.508	2.056	1.508	75%
Germany	Non-ferrous metals	Rest of non-ferrous metals	9.308	10.084	10.146	8.888	6.840	8.845	6.774	73%

Germany	Non-metallic minerals	Cement	16.412	20.702	21.219	17.878	16.046	17.878	16.046	98%
Germany	Non-metallic minerals	Flat glass	3.229	3.855	4.093	3.224	2.516	3.224	2.516	78%
Germany	Non-metallic minerals	Container glass	1.743	1.879	1.679	1.404	777	1.404	777	45%
Germany	Non-metallic minerals	Rest of non-metallic minerals	21.048	24.663	25.040	20.996	17.940	20.996	17.940	85%
Germany	Paper and pulp	Tissue paper	193	223	252	184	181	184	181	94%
Germany	Paper and pulp	Graphic paper	1.186	1.346	1.472	1.110	1.052	1.110	1.052	89%
Germany	Paper and pulp	Board and packag. Paper	1.047	1.189	1.365	981	995	981	995	95%
Germany	Paper and pulp	Chemical pulp	778	883	1.084	883	1.084	883	1.084	139%
Germany	Paper and pulp	Mechanical pulp	34	40	49	38	47	38	47	136%
Germany	Paper and pulp	Recovered fibre pulp	0	0	0	0	0	0	0	77%
Germany	Paper and pulp	Rest of paper and pulp	563	640	726	556	578	556	578	103%
Germany	Others	Others	35.862	41.562	48.386	36.150	36.364	36.100	35.299	98%
Hungary	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Ethylene	666	736	752	671	651	671	651	98%
Hungary	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Ammonia	79	83	83	63	53	63	53	68%
Hungary	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Hungary	Chemicals	Rest of chemicals	194	219	228	196	192	196	192	99%
Hungary	Iron and steel	BF/BOF steel	260	276	284	192	116	160	15	6%
Hungary	Iron and steel	Pig iron	428	380	392	378	386	301	200	47%
Hungary	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Hungary	Iron and steel	EAF steel	25	27	27	18	4	23	17	67%
Hungary	Iron and steel	Coke oven	593	526	542	400	365	318	141	24%
Hungary	Foundries	Ferrous metals casting	193	204	211	204	211	204	211	109%
Hungary	Iron and steel	Rest of iron and steel	402	392	356	331	264	331	231	57%
Hungary	Non-ferrous metals	Aluminium primary	0	0	0	0	0	0	0	N/A
Hungary	Non-ferrous metals	Aluminium secondary	160	173	177	134	97	141	114	71%

Hungary	Foundries	Nonferrous metals casting	184	199	199	189	139	189	139	75%
Hungary	Non-ferrous metals	Rest of non-ferrous metals	1.633	1.769	1.779	1.532	1.117	1.529	1.134	69%
Hungary	Non-metallic minerals	Cement	922	1.097	1.124	947	850	947	850	92%
Hungary	Non-metallic minerals	Flat glass	293	326	339	273	206	273	206	70%
Hungary	Non-metallic minerals	Container glass	55	57	51	42	23	42	23	42%
Hungary	Non-metallic minerals	Rest of non-metallic minerals	1.688	2.023	2.061	1.726	1.469	1.726	1.469	87%
Hungary	Paper and pulp	Tissue paper	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Graphic paper	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Board and packag. Paper	74	76	78	63	54	63	54	73%
Hungary	Paper and pulp	Chemical pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Mechanical pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Recovered fibre pulp	0	0	0	0	0	0	0	N/A
Hungary	Paper and pulp	Rest of paper and pulp	3	3	3	3	2	3	2	73%
Hungary	Others	Others	1.732	2.107	2.133	1.811	1.523	1.811	1.492	86%
Poland	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Ethylene	556	657	666	577	542	577	542	97%
Poland	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Ammonia	524	550	556	390	307	390	307	59%
Poland	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Poland	Chemicals	Rest of chemicals	1.587	1.721	1.732	1.378	1.203	1.378	1.203	76%
Poland	Iron and steel	BF/BOF steel	919	975	1.004	678	410	565	51	6%
Poland	Iron and steel	Pig iron	1.657	1.658	1.708	1.647	1.685	1.312	870	53%
Poland	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Poland	Iron and steel	EAF steel	581	615	634	419	83	526	387	67%
Poland	Iron and steel	Coke oven	794	794	818	603	551	481	212	27%
Poland	Foundries	Ferrous metals casting	1.485	1.574	1.622	1.574	1.622	1.574	1.622	109%
Poland	Iron and steel	Rest of iron and steel	906	903	802	791	603	787	553	61%

Poland	Non-ferrous metals	Aluminium primary	0	0	0	0	0	0	0	N/A
Poland	Non-ferrous metals	Aluminium secondary	160	173	177	134	97	141	114	71%
Poland	Foundries	Nonferrous metals casting	579	626	626	594	436	594	436	75%
Poland	Non-ferrous metals	Rest of non-ferrous metals	2.690	2.912	2.919	2.652	1.939	2.648	1.950	72%
Poland	Non-metallic minerals	Cement	8.009	9.531	9.769	8.230	7.387	8.230	7.387	92%
Poland	Non-metallic minerals	Flat glass	1.505	1.677	1.746	1.402	1.060	1.402	1.060	70%
Poland	Non-metallic minerals	Container glass	877	900	804	673	372	673	372	42%
Poland	Non-metallic minerals	Rest of non-metallic minerals	8.836	10.942	11.085	9.313	7.935	9.313	7.935	90%
Poland	Paper and pulp	Tissue paper	60	65	66	53	46	53	46	76%
Poland	Paper and pulp	Graphic paper	120	130	132	107	92	107	92	77%
Poland	Paper and pulp	Board and packag. Paper	275	297	303	245	211	245	211	77%
Poland	Paper and pulp	Chemical pulp	422	448	461	448	461	448	461	109%
Poland	Paper and pulp	Mechanical pulp	2	3	3	3	3	3	3	104%
Poland	Paper and pulp	Recovered fibre pulp	0	0	0	0	0	0	0	N/A
Poland	Paper and pulp	Rest of paper and pulp	406	437	447	397	376	397	376	92%
Poland	Others	Others	14.308	20.249	21.988	17.405	15.833	17.384	15.616	109%
Spain	Chemicals	Carbon black	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Ethylene	1.352	1.474	1.506	1.295	1.228	1.295	1.228	91%
Spain	Chemicals	Methanol	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Ammonia	95	100	101	71	56	71	56	59%
Spain	Chemicals	Soda ash	0	0	0	0	0	0	0	N/A
Spain	Chemicals	Rest of chemicals	1.749	1.907	1.951	1.655	1.558	1.655	1.558	89%
Spain	Iron and steel	BF/BOF steel	812	861	887	625	415	521	89	11%
Spain	Iron and steel	Pig iron	1.529	1.500	1.424	1.492	1.409	1.189	728	48%
Spain	Iron and steel	Rolled steel	0	0	0	0	0	0	0	N/A
Spain	Iron and steel	EAF steel	1.519	1.610	1.659	1.198	504	1.505	1.375	90%
Spain	Iron and steel	Coke oven	3.362	3.298	3.131	2.663	2.243	2.123	920	27%

Spain	Foundries	Ferrous metals casting	2.232	2.129	1.974	2.129	1.974	2.129	1.974	88%
Spain	Iron and steel	Rest of iron and steel	3.680	3.323	2.627	2.866	1.894	2.854	1.746	47%
Spain	Non-ferrous metals	Aluminium primary	348	377	377	377	377	332	272	78%
Spain	Non-ferrous metals	Aluminium secondary	160	173	177	134	97	141	114	71%
Spain	Foundries	Nonferrous metals casting	239	259	259	246	180	246	180	75%
Spain	Non-ferrous metals	Rest of non-ferrous metals	9.208	9.973	10.023	9.322	8.074	9.266	7.793	85%
Spain	Non-metallic minerals	Cement	7.900	9.872	10.118	8.525	7.652	8.525	7.652	97%
Spain	Non-metallic minerals	Flat glass	0	0	0	0	0	0	0	N/A
Spain	Non-metallic minerals	Container glass	0	0	0	0	0	0	0	N/A
Spain	Non-metallic minerals	Rest of non-metallic minerals	17.956	22.175	22.620	19.149	17.105	19.149	17.105	95%
Spain	Paper and pulp	Tissue paper	98	103	82	85	49	85	49	50%
Spain	Paper and pulp	Graphic paper	191	200	159	165	97	165	97	51%
Spain	Paper and pulp	Board and packag. Paper	340	339	253	280	148	280	148	43%
Spain	Paper and pulp	Chemical pulp	738	736	585	736	585	736	585	79%
Spain	Paper and pulp	Mechanical pulp	3	3	3	3	3	3	3	78%
Spain	Paper and pulp	Recovered fibre pulp	44	45	38	42	24	42	24	55%
Spain	Paper and pulp	Rest of paper and pulp	210	213	166	196	134	196	134	64%
Spain	Others	Others	28.845	33.639	38.839	29.528	29.593	29.473	29.046	101%

3 District heating networks

3.1 Summary statistics of grid cost in the modeled national district heating systems (3GDH).

Table 13: Summary statistics of grid cost in the modeled national district heating systems for the EU27 + UK countries (3GDH). Costs in M€.

Country	Count of district heating areas	Grid cost [M€]						Grid cost per system	Grid cost per unit of heat demand (EUR/MWh)
		Min.	Max.	Standard Deviation	Sum	Mean	Median		
Austria	1046	0,27	4.7901	179,0	29.672	28,37	4,51	28,37	739
Belgium	1318	0,37	5.891	261,0	53.027	40,23	4,78	40,23	818
Bulgaria	591	0,28	2.248	106,7	13.773	23,30	3,77	23,30	764
Czechia	1446	0,27	2.954	92,9	27.675	19,14	3,83	19,14	750
Germany	13435	0,27	15.641	228,0	392.673	29,23	5,86	29,23	760
Denmark	1280	0,28	5.045	157,2	30.879	24,12	4,34	24,12	711
Estonia	237	0,27	941	64,9	2.841	11,99	2,02	11,99	402
Greece	221	0,56	7.217	499,6	15.403	69,69	4,37	69,69	1.077
Spain	3528	0,27	9.738	274,1	139.037	39,41	6,98	39,41	807
Finland	1362	0,28	2.212	69,8	12.769	9,38	1,54	9,38	328
France	4463	0,27	25.158	429,7	219.816	49,25	5,08	49,25	966
Croatia	346	0,59	1.769	102,9	6.429	18,58	2,88	18,58	767
Hungary	893	0,28	4.178	160,8	27.648	30,96	5,52	30,96	878
Ireland	236	0,96	6.031	401,3	13.607	57,66	4,60	57,66	914
Italy	9853	0,27	8.174	119,8	164.212	16,67	3,92	16,67	698
Lithuania	356	0,28	1.021	88,0	8.354	23,47	3,57	23,47	622
Luxembourg	283	0,40	1.103	78,1	4.249	15,01	3,22	15,01	520
Latvia	365	0,28	1.065	66,9	4.703	12,88	1,87	12,88	372
Malta	14	1,58	460	116,5	573	40,95	5,64	40,95	321
Netherlands	1050	0,77	12.325	493,3	92.096	87,71	9,34	87,71	1.085
Poland	2878	0,27	2.504	87,4	62.224	21,62	3,28	21,62	648
Portugal	271	0,74	2.587	172,2	6.958	25,68	2,99	25,68	1.305
Romania	315	0,80	3.685	233,6	19.606	62,24	8,64	62,24	1.060

Sweden	1056	0,27	4.410	189,7	43.775	41,45	6,06	41,45	815
Slovenia	454	0,28	1.084	58,3	5.750	12,67	2,83	12,67	544
Slovakia	414	0,53	1.354	90,0	13.160	31,79	4,77	31,79	969
United Kingdom	4101	0,27	31.656	612,3	271.107	66,11	4,92	66,11	927

3.2 Summary statistics of specific cost in the modeled national district Heating systems.

Table 14: Summary statistics of specific cost in the modeled national district heating systems for each EU27 + UK country. Costs in EUR/MWh.

Country	Count of district Heating areas	Specific cost [EUR/MWh]					
		Min.	Max.	Range	Standard Deviation	Mean	Median
Austria	1046	3,39	50,00	46,61	10,01	42,98	46,90
Belgium	1318	6,62	50,00	43,38	10,55	43,30	47,13
Bulgaria	591	7,35	50,00	42,65	10,88	37,53	39,46
Czechia	1446	8,06	50,00	41,94	7,44	37,05	38,42
Germany	13435	4,13	50,00	45,87	7,10	42,83	46,16
Denmark	1280	7,24	49,99	42,75	8,83	39,61	40,98
Estonia	237	4,88	49,85	44,97	9,37	25,15	24,89
Greece	221	15,98	50,00	34,02	6,77	43,81	47,00
Spain	3528	3,52	50,00	46,48	7,63	42,54	46,28
Finland	1362	2,48	47,58	45,10	9,15	19,66	19,64
France	4463	4,53	50,00	45,47	7,96	45,18	48,03
Croatia	346	14,59	49,95	35,36	8,88	35,31	34,25
Hungary	893	9,12	50,00	40,88	11,31	41,73	45,61
Ireland	236	14,68	49,99	35,31	4,77	44,03	46,75
Italy	9853	3,38	50,00	46,62	8,59	35,89	37,22
Lithuania	356	4,35	49,95	45,60	8,77	33,15	33,13
Luxembourg	283	11,68	43,44	31,76	9,50	29,97	30,47
Latvia	365	3,15	47,85	44,70	8,55	23,39	24,11
Malta	14	15,73	49,86	34,13	6,62	41,27	48,67
Netherlands	1050	19,23	50,00	30,77	9,22	46,24	48,27
Poland	2878	4,49	50,00	45,51	4,51	34,02	34,57
Portugal	271	20,70	49,99	29,29	7,31	46,16	47,74
Romania	315	21,82	49,99	28,17	6,10	44,79	47,49
Sweden	1056	3,33	50,00	46,67	9,51	40,54	45,22
Slovenia	454	7,18	48,93	41,75	7,08	31,27	32,06
Slovakia	414	9,38	49,99	40,61	10,30	41,98	45,75
United Kingdom	4101	2,15	50,00	47,85	5,31	43,04	46,52

3.3 List of calculated future heat demands in all the modelled national district heating systems.

Table 15: Future heat demands in all the modelled national district heating systems.

Country	Count of district heating areas	Heat demand [GWh] - until 63,74% of the EU27 heat market				
		Largest system	Standard deviation amongst systems	Total district heating demand	Average size of the modelled systems	Median size of the modelled system
Austria	1.046	12.074	402	40.157	38,4	3,89
Belgium	1.318	11.518	452	64.799	49,2	3,96
Bulgaria	591	3.698	174	18.033	30,5	3,54
Czechia	1.446	5.390	165	36.882	25,5	3,64
Germany	13.435	24.560	401	516.790	38,5	4,61
Denmark	1.280	11.651	344	43.405	33,9	3,71
Estonia	237	3.347	224	7.067	29,8	2,91
Greece	221	6.958	486	14.298	64,7	4,39
Spain	3.528	21.010	498	172.279	48,8	5,47
Finland	1.362	7.754	245	38.880	28,6	3,16
France	4.463	44.389	702	227.531	51,0	3,89
Croatia	346	2.687	154	8.387	24,2	3,09
Hungary	893	6.339	234	31.475	35,2	4,74
Ireland	236	6.799	451	14.887	63,1	4,77
Italy	9.853	18.749	261	235.301	23,9	3,71
Lithuania	356	2.453	183	13.428	37,7	3,64
Luxembourg	283	2.702	190	8.173	28,9	3,72
Latvia	365	4.377	254	12.655	34,7	2,76
Malta	14	1.610	411	1.787	127,7	6,50
Netherlands	1.050	13.081	510	84.895	80,9	6,99
Poland	2.878	5.641	179	96.039	33,4	3,42
Portugal	271	1.974	131	5.331	19,7	2,43
Romania	315	4.552	275	18.503	58,7	6,56
Sweden	1.056	7.501	312	53.704	50,9	5,34
Slovenia	454	2.670	140	10.566	23,3	3,15
Slovakia	414	1.556	104	13.586	32,8	4,42
United Kingdom	4.101	45.071	819	292.582	71,3	4,11

3.4 EU27 District Heating levels in relation to national District Heating shares.

Table 16: EU27 District Heating levels in relation to national District Heating shares in percentage.

Country / EU27 district Heating Share [%]	5	10	15	20	25	30	35	40	45	50	55	60	65
Austria	-	18,77	18,77	26,64	33,97	35,21	39,49	40,74	43,98	48,66	53,70	58,54	70,30
Belgium	-	23,15	23,15	30,02	35,19	38,34	45,48	48,95	54,40	58,41	62,48	66,63	78,73
Bulgaria	-	-	-	11,69	15,79	20,71	27,37	30,73	36,89	44,88	48,96	52,79	64,18
Cyprus	-	-	-	-	-	-	-	-	-	-	-	-	-
Czechia	-	-	8,30	11,05	15,00	16,17	23,09	27,68	33,88	40,11	46,88	52,12	63,93
Germany	7,16	12,40	20,78	25,99	31,84	36,43	41,69	47,31	53,21	59,03	64,70	70,77	85,00
Denmark	-	18,32	18,32	22,60	26,75	32,15	37,35	43,39	47,86	53,45	58,03	63,77	76,83
Estonia	-	-	23,76	23,76	29,20	32,48	32,48	32,48	40,17	42,20	44,52	47,59	56,49
Greece	-	-	-	24,46	31,38	31,38	31,38	32,85	38,51	42,89	46,27	48,50	56,60
Spain	8,57	15,79	19,05	23,10	31,52	36,25	42,12	46,79	51,01	55,81	61,40	66,96	79,09
Finland	-	11,06	18,01	23,78	27,09	32,68	37,61	40,74	43,80	46,79	49,79	52,96	62,44
France	10,66	10,66	13,73	16,41	22,62	28,40	32,59	37,74	41,74	45,07	48,39	52,09	61,54
Croatia	-	-	-	9,52	9,52	11,89	13,98	16,07	19,09	20,91	23,79	27,42	33,45
Hungary	-	-	11,21	11,21	14,43	22,60	27,54	32,68	36,94	41,61	46,79	51,84	62,67
Ireland	-	-	-	23,38	23,38	23,38	29,52	32,82	36,43	42,24	46,82	49,34	57,64
Italy	5,26	12,61	14,45	17,32	21,66	26,59	30,20	35,28	40,52	46,20	52,88	60,27	74,39
Lithuania	-	-	-	14,45	18,59	23,83	28,09	30,37	35,48	37,85	42,08	44,24	52,65
Luxembourg	-	-	-	42,74	42,74	48,45	52,77	52,77	62,34	66,07	69,23	76,04	92,08
Latvia	-	19,86	19,86	28,11	31,14	36,52	40,23	43,79	47,07	49,55	52,11	55,18	64,65
Malta	-	-	-	-	-	41,37	41,37	41,37	41,37	41,37	44,17	44,96	51,72
Netherlands	-	-	18,14	18,14	23,70	29,87	39,61	47,90	54,25	60,71	66,46	70,01	80,75
Poland	-	-	3,17	13,05	15,72	22,58	27,04	33,14	37,60	43,02	47,64	51,05	60,85
Portugal	-	-	-	-	-	9,26	13,05	13,05	14,15	17,36	19,09	21,71	28,15
Romania	-	-	-	9,01	9,01	9,01	14,54	20,15	25,50	29,82	32,89	35,22	41,22

Sweden	-	-	16,00	19,59	22,64	31,79	38,62	44,17	49,14	55,14	60,29	65,53	76,92
Slovenia	-	-	-	12,68	17,71	22,07	23,93	26,41	32,37	37,21	41,76	45,97	56,51
Slovakia	-	-	-	-	-	9,14	10,94	19,62	29,33	36,01	43,55	48,49	58,21
United Kingdom	-	-	11,77	19,16	23,98	29,29	34,52	39,80	44,99	49,93	54,92	60,00	65,00

3.5 EU27 District Heating levels in relation to national grid costs in M€.

Table 17: EU27 District Heating levels in relation to national grid costs in M€.

Country / EU27 district Heating Share [%]	Austria	Belgium	Bulgaria	Cyprus	Czechia	Germany	Denmark	Estonia	Greece	Spain
5%	-	-	-	-	-	28.299	-	-	-	9.738
10%	4.791	11.020	-	-	-	46.823	5.045	-	-	18.755
15%	4.791	11.020	-	-	2.954	76.193	5.045	941	-	22.874
20%	7.750	16.406	2.248	-	3.859	96.441	6.578	941	7.217	32.284
25%	10.970	20.429	2.995	-	5.409	121.536	8.221	1.222	8.916	46.245
30%	11.562	22.951	3.901	-	5.819	142.290	10.490	1.399	8.916	54.624
35%	13.943	28.597	5.164	-	8.820	167.195	12.756	1.399	8.916	66.447
40%	14.596	31.683	5.874	-	10.748	196.555	15.669	1.399	9.336	76.792
45%	16.552	36.645	7.402	-	13.702	229.444	17.913	1.911	11.271	86.371
50%	19.474	40.375	9.649	-	16.955	264.711	20.973	2.067	12.789	97.721
55%	22.798	44.534	10.989	-	20.847	303.347	23.731	2.267	14.053	112.337
60%	26.513	49.134	12.270	-	24.239	351.155	27.577	2.553	14.820	128.749
65%	30.569	55.343	13.906	-	27.707	396.538	31.362	3.079	15.715	145.460

Table 18: EU27 District Heating levels in relation to national grid costs in M€.

Country / EU27 district Heating Share [%]	Finland	France	Croatia	Hungary	Ireland	Italy	Lithuania	Luxembourg	Latvia	Malta
5%	-	25.158	-	-	-	8.174	-	-	-	-
10%	2.212	25.158	-	-	-	19.416	-	-	1.065	-
15%	3.549	35.119	-	4.178	-	22.288	-	-	1.065	-
20%	4.645	45.129	1.769	4.178	6.031	28.343	1.865	1.733	1.617	-
25%	5.249	69.120	1.769	5.720	6.031	36.305	2.481	1.733	1.867	-
30%	6.476	92.026	2.255	8.943	6.031	46.251	3.376	1.988	2.290	460
35%	7.550	109.597	2.648	10.948	7.688	54.158	4.113	2.214	2.632	460
40%	8.238	132.805	3.090	13.206	8.595	66.089	4.521	2.214	2.970	460
45%	8.950	151.925	3.722	15.360	9.482	79.180	5.572	2.764	3.299	460
50%	9.734	168.396	4.143	18.195	11.111	94.990	6.089	3.010	3.603	460
55%	10.598	185.719	4.877	21.450	12.245	115.676	7.089	3.205	3.917	491
60%	11.662	205.839	5.787	24.941	13.038	141.356	7.643	3.741	4.323	529
65%	13.379	230.889	6.688	28.197	14.267	160.793	8.902	4.186	5.153	476

Table 19: EU27 District Heating levels in relation to national grid costs in M€.

Country / EU27 district Heating Share [%]	**Netherlands**	**Poland**	**Portugal**	**Romania**	**Sweden**	**Slovenia**	**Slovakia**	**EU27**	**United Kingdom**
5%	-	-	-	-	-	-	-	71.369	-
10%	-	-	-	-	-	-	-	134.285	-
15%	20.605	2.504	-	-	7.461	-	-	220.586	31.656
20%	20.605	10.850	-	3.685	9.027	1.084	-	314.286	56.144
25%	27.217	13.448	-	3.685	10.516	1.521	-	412.605	71.640
30%	34.411	19.992	2.587	3.685	15.494	1.933	2.019	512.171	88.159
35%	47.127	24.295	3.675	6.372	19.424	2.130	2.383	620.649	104.666
40%	57.863	30.976	3.675	9.458	23.212	2.374	4.334	736.735	121.612
45%	66.483	36.584	3.991	12.666	26.703	3.085	6.663	858.099	140.505
50%	75.344	43.832	4.904	15.172	31.479	3.696	8.407	987.283	158.162
55%	83.910	50.738	5.3821	17.128	36.099	4.308	10.609	1.128.346	176.837
60%	89.429	56.482	6.103	18.690	41.070	4.969	12.146	1.284.760	196.685
65%	98.160	65.557	5.662	21.151	46.424	5.817	13.516	1.468.214	217.774

3.6 Assessment of district heating at EU27 level in relation to heat demand coverage, specific and total grid cost in district heating areas.

Table 20: Assessment of district heating at EU27 level in relation to heat demand coverage, specific and total grid cost in district heating areas.

Country / EU27 district heating share [%]	Heat demand [TWh]		Specific Cost [EUR/MWh]	Grid cost 3GDH [M€]		Grid cost 4GDH [M€]	
	sum	mean	mean	sum	mean	sum	mean
0-5 (4,75)	133,1	26,63	18,71	71.369	14.274	73.089	14.618
5-10 (9,63)	137,0	10,54	15,63	62.916	4.840	64.432	4.956
10-15 (14,77)	144,3	5,34	19,51	86.301	3.196	88.381	3.273
15-20 (19,93)	145,0	2,68	21,02	93.700	1.735	95.958	1.777
20-25 (24,97)	141,5	1,51	23,06	98.319	1.046	100.689	1.071
25-30 (29,99)	140,6	0,81	23,66	99.565	576	101.965	589
30-35 (34,99)	140,4	0,47	25,58	108.478	363	111.093	372
35-40 (39,99)	140,5	0,28	27,31	116.086	234	118.883	239
40-45 (44,99)	140,4	0,16	28,84	121.364	137	124.289	141
45-50 (49,99)	140,3	0,09	31,12	129.185	82	132.298	84
50-55 (54,99)	140,4	0,04	33,92	141.063	44	144.463	45
55-60 (59,99)	140,3	0,02	37,34	156.413	18	160.183	19
60-65 (63,73)	104,9	0,01	41,97	126.149	4	129.190	4

3.7 Assessment of district heating at EU27 level in relation to population coverage, population density and size of the district heating areas.

Table 21: Assessment of district heating at EU27 level in relation to population coverage, population density and size of the district heating areas. (ReUseHeat, 2022)

EU27 District heating share [%]	Number of district heating systems	Number of unique countries	Population [persons]		Population density [persons/km2]	Area [km2]	
			Sum	Mean	Mean	Sum	Mean
0-5 (4,75)	5	4	21.241.954	4.248.391	6.854	3.431	686,2
5-10 (9,63)	13	8	17.628.748	1.356.058	6.288	3.106	239,0
10-15 (14,77)	27	11	18.053.952	668.665	4.991	4.371	161,9
15-20 (19,93)	54	20	19.489.797	360.922	4.671	4.663	86,4
20-25 (24,97)	94	19	17.655.457	187.824	4.092	5.366	57,1
25-30 (29,99)	173	23	15.903.903	91.930	3.819	5.185	30,0
30-35 (34,99)	299	23	15.428.402	51.600	3.295	5.827	19,5
35-40 (39,99)	497	22	14.319.660	28.812	3.056	6.382	12,8
40-45 (44,99)	884	25	13.573.469	15.355	2.589	6.707	7,6
45-50 (49,99)	1581	25	13.074.334	8.270	2.239	7.244	4,6
50-55 (54,99)	3216	26	12.447.827	3.871	1.677	8.158	2,5
55-60 (59,99)	8635	26	10.423.229	1.207	1.012	9.494	1,1
60-65 (63,73)	32233	26	4.572.429	142	535	7.917	0,3

3.8 Industry share of total demand

The table shows the share of the industrial demand over the total demand per country. This was used to determine the district heating distribution files.

Table 22: The table shows the share of the industrial demand over the total demand per country. This was used to determine the district heating distribution files.

Country	The total district heating demand	Country	The total district heating demand	Country	The total district heating demand
Austria	2,75%	Germany	2,82%	Poland	3,14%
Belgium	1,61%	Greece	1,03%	Portugal	1,91%
Bulgaria	5,68%	Hungary	4,28%	Romania	5,79%
Croatia	1,83%	Ireland	3,27%	Slovakia	1,60%
Cyprus	0,00%	Italy	3,24%	Slovenia	2,57%
Czechia	8,58%	Latvia	0,15%	Spain	0,92%
Denmark	0,64%	Lithuania	2,06%	Sweden	2,40%
Estonia	2,79%	Luxembourg	0,17%	United Kingdom	0,48%
Finland	5,16%	Malta	0,00%	EU27	2,62%
France	0,73%	Netherlands	4,97%	EU27 + UK	2,35%

4 City level results

Identification of optimal cities for district heating development

This appendix identifies the most suitable cities for the development of (district heating systems by integrating high shares of waste heat from various investigated sources. The analysis focuses on the largest urban areas with significant contributions from high-temperature industrial waste heat, medium- and low-temperature waste heat, and geothermal and solar potential. While the district heating model delineates suitable district heating areas within cities based on heat density, this section consolidates these distinct areas into a unified framework at the city level. By aggregating the heat demand and waste heat potential of individual district heating areas to city-level combined zones, the analysis reduces the number of data entries, thereby enhancing the clarity and efficiency of the assessment at both the EU and national scales.

The analysis further emphasizes larger urban centers, focusing on cities with populations exceeding 45,000 inhabitants, where the implementation of district heating systems is more feasible and economically viable. Figure 3-6 illustrate the cities with the highest shares of heat demand covered by waste heat from various sources - namely, high-temperature industrial processes, medium- and low-temperature activities, and geothermal energy - relative to city size.

In these visualizations, the size of each bubble reflects the proportion of heat demand covered by the corresponding waste heat source, with larger bubbles representing coverage levels exceeding 75% of the heat demand. The bubble colors denote the population size of the respective cities, providing an additional layer of insight. For clarity, the maps highlight the names of the largest cities exhibiting the highest heat demand shares covered from waste heat sources.

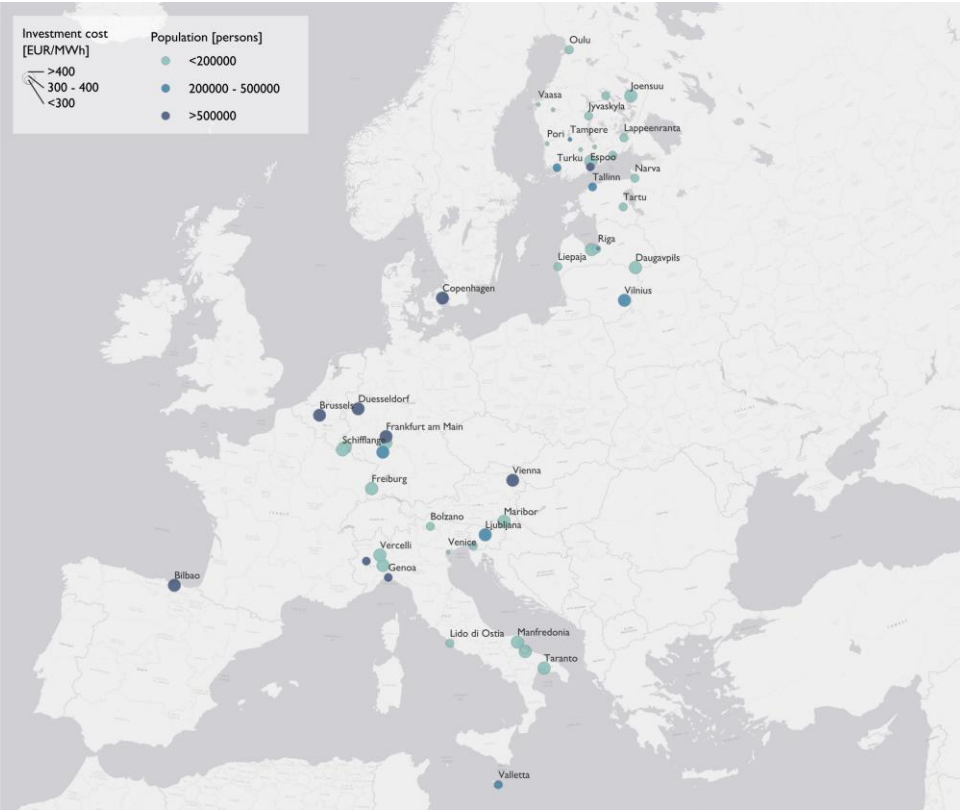


Figure 3 The 50 most suitable cities for the development of district heating based on investment costs.

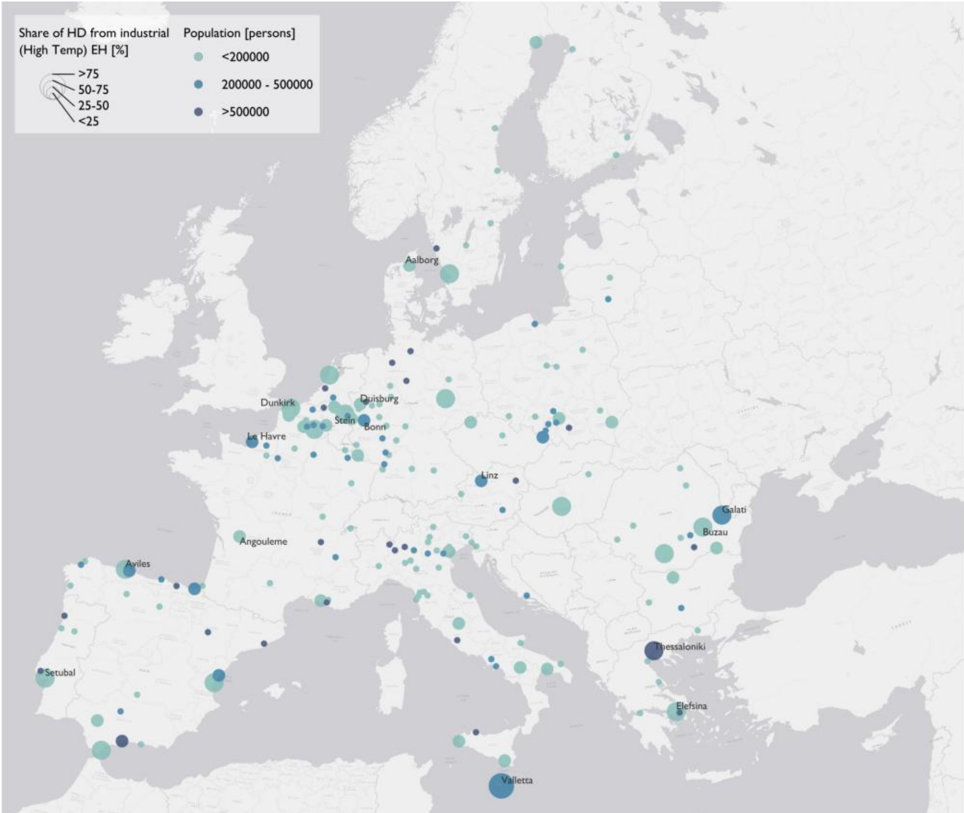


Figure 4 Mapped share of heat demand covered from high temperature industrial waste heat in comparison to the city's population.

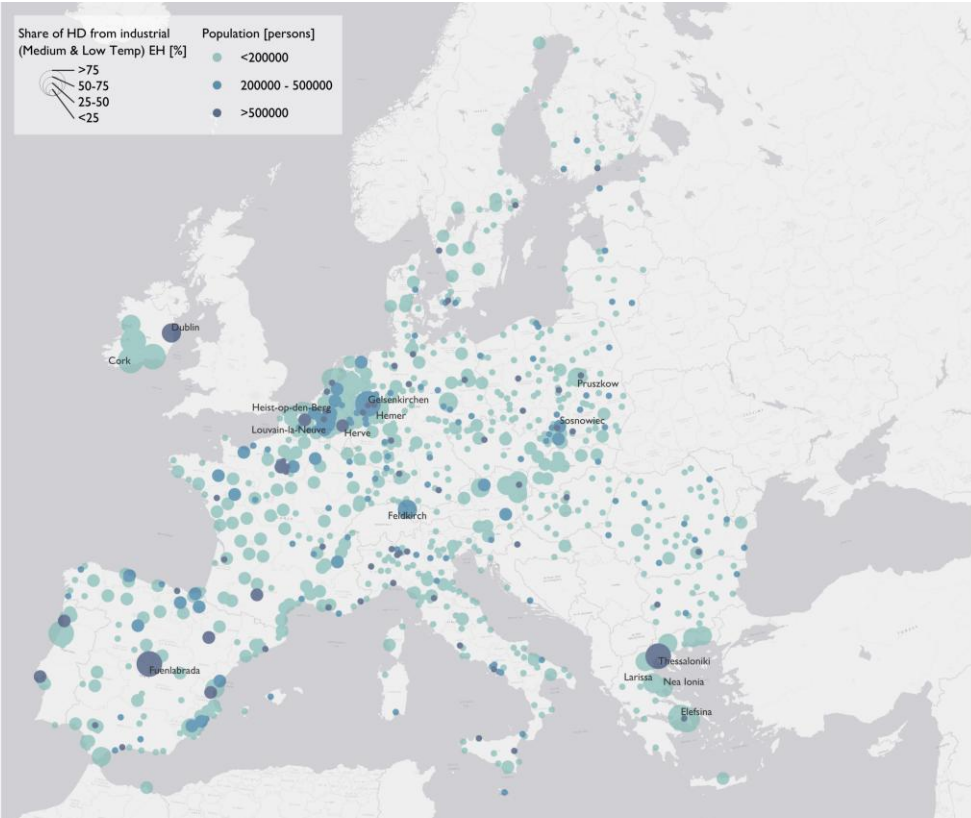


Figure 5 Mapped share of heat demand covered from medium and low temperature industrial waste heat in comparison to the city's population.

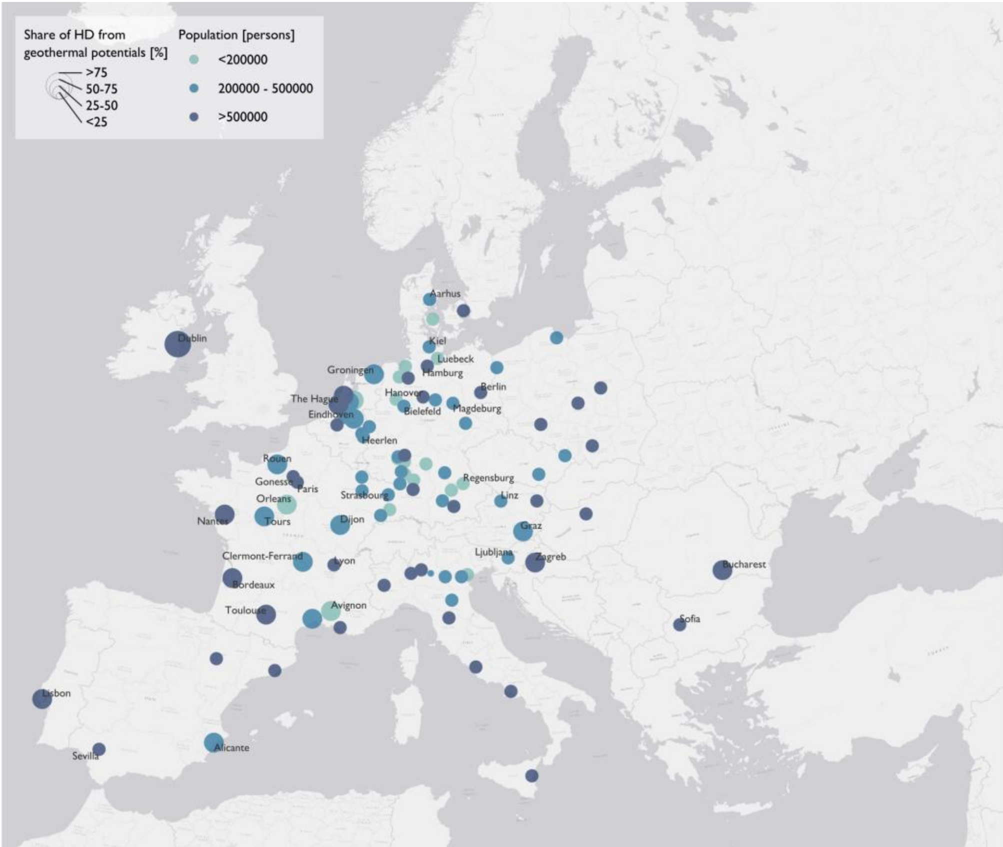


Figure 6 Mapped share of heat demand covered from geothermal potential in comparison to the city's population.

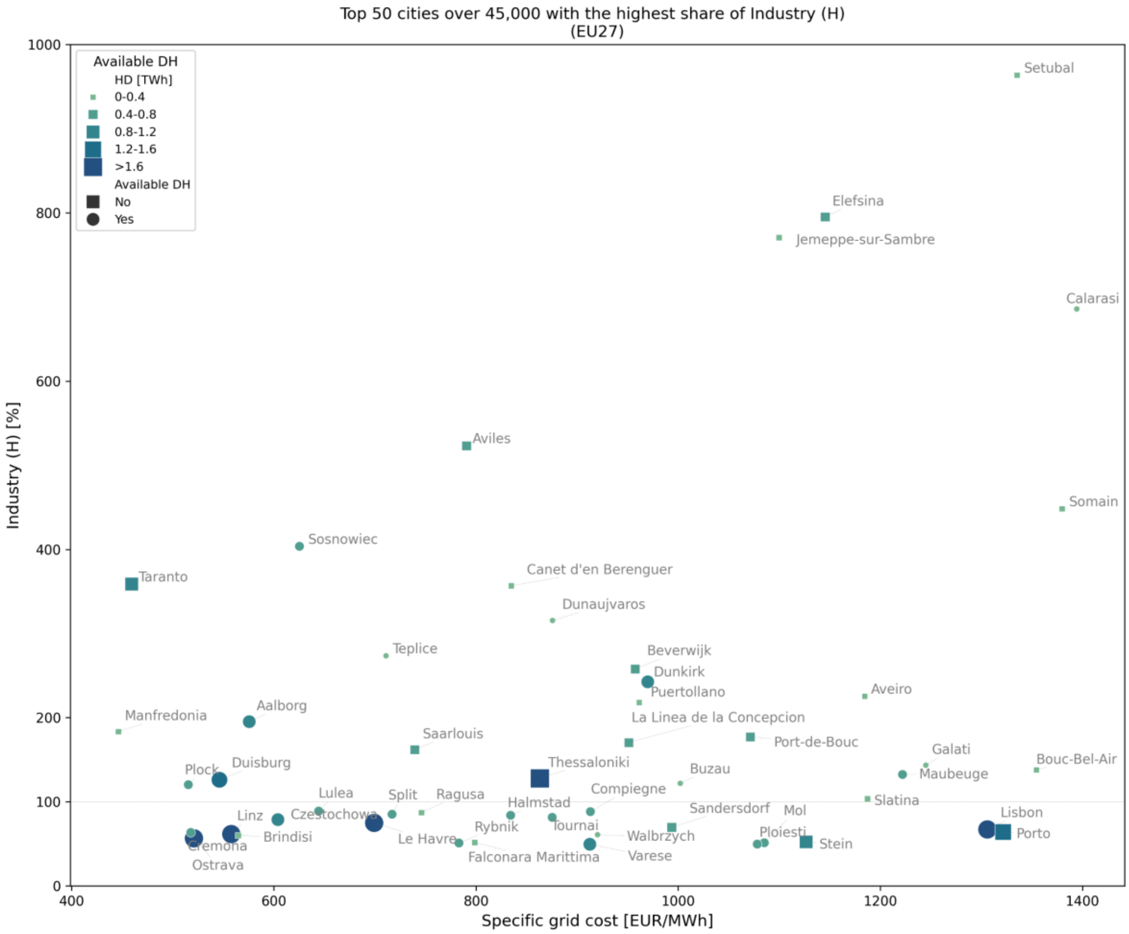


Figure 7 Scatterplot of the share of heat demand covered from high temperature industrial waste heat in comparison to the investment cost.

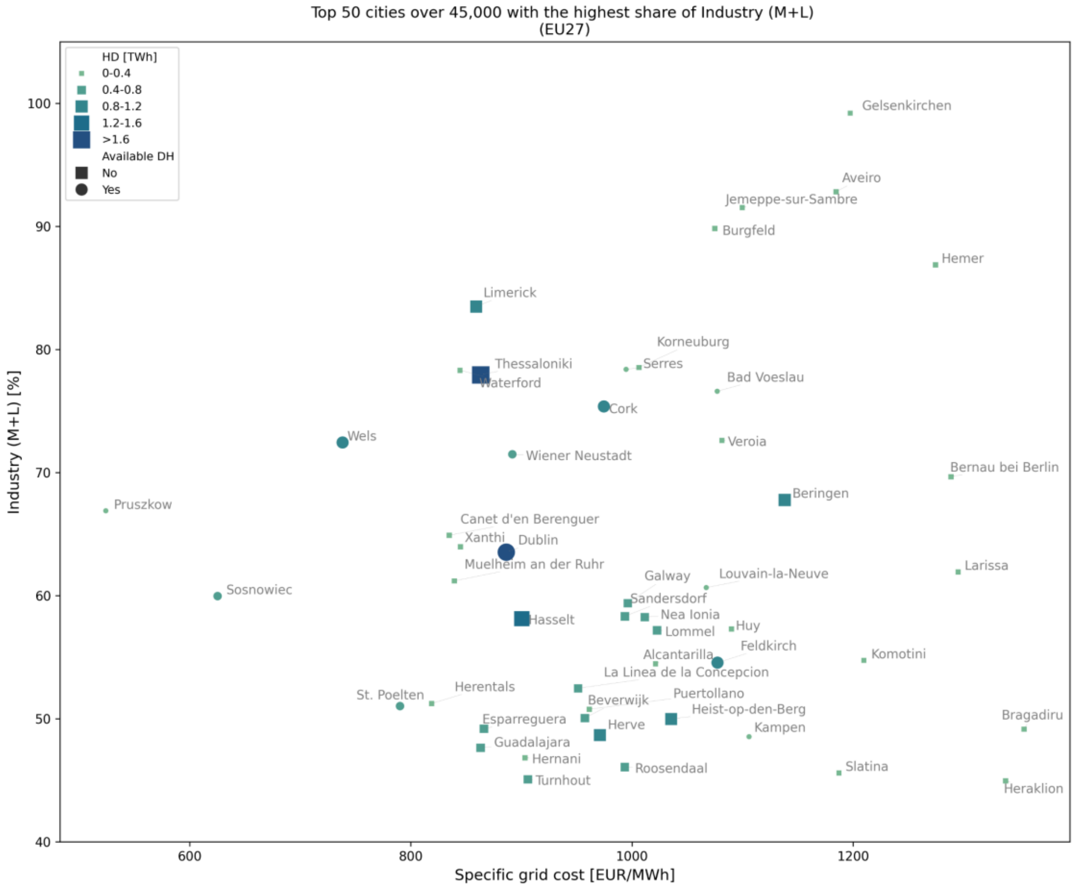


Figure 8 Scatterplot of the share of heat demand covered from medium and low temperature industrial surplus heat in comparison to the investment cost.

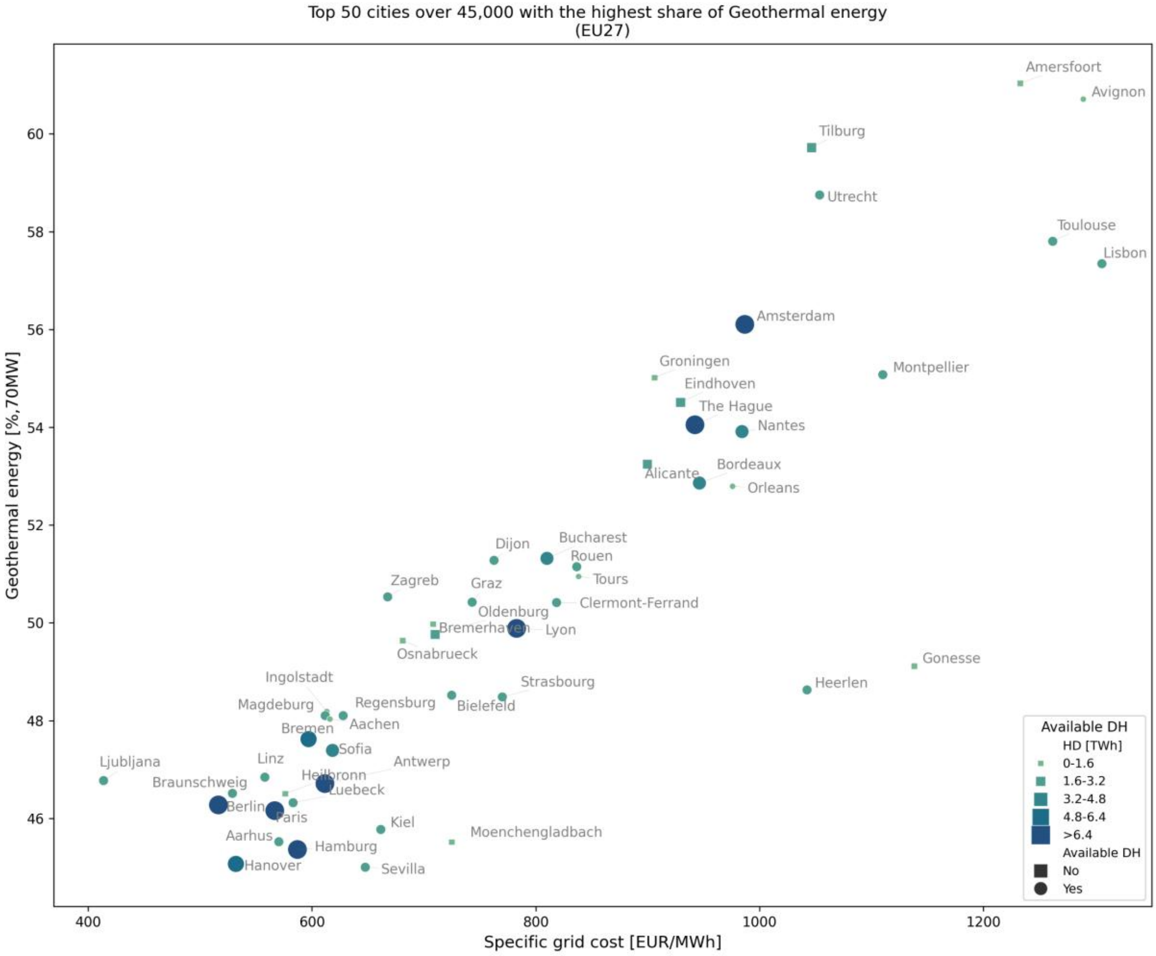


Figure 9 Scatterplot of the share of heat demand covered from geothermal potential in comparison to the investment cost.

Table 23 The 50 cities in EU27 with the highest shares of heat demand in district heating covered by high temperature industrial waste heat.

City	Country	Heat demand [TWh]	Investment cost [EUR/MWh]	Waste heat from Industry (H) [TWh]	Share of heat demand by high temp industrial waste heat	Available district heating	Available geothermal
Valletta	ML	1,70	310,2	2,07	122%	No	No
Elefsina	Greece	0,46	1.145,4	0,32	70%	No	No
Thessaloniki	Greece	1,97	863,1	1,22	62%	No	No
Setubal	Portugal	0,11	1.335,2	0,07	60%	No	No
Slatina	Romania	0,12	1.187,1	0,07	59%	No	No
Galati	Romania	0,34	1.245,0	0,20	59%	Yes	No
La Linea de la Concepcion	Spain	0,49	951,1	0,27	56%	No	No
Maubeuge	France	0,44	1.222,0	0,24	55%	Yes	No
Buzau	Romania	0,31	1.002,1	0,17	55%	Yes	No
Canet d'en Berenguer	Spain	0,25	834,7	0,13	54%	No	No
Dunaujvaros	Hungary	0,24	875,7	0,13	54%	Yes	No
Beverwijk	Netherlands	0,72	957,4	0,39	54%	No	Yes
Dunkirk	France	1,10	969,9	0,59	53%	Yes	No
Stein	France	0,87	1.126,3	0,46	53%	No	Yes
Sandersdorf	Germany	0,46	993,5	0,24	52%	No	No
Aviles	Spain	0,62	790,7	0,32	52%	No	No
Halmstad	Sweden	0,61	834,3	0,32	51%	Yes	No
Le Havre	Netherlands	1,98	699,3	0,98	50%	Yes	No
Ragusa	Italy	0,23	746,0	0,11	50%	No	No
Angouleme	France	0,57	1.384,7	0,27	48%	Yes	No
Bonn	Germany	2,91	654,5	1,38	47%	Yes	No
Calarasi	Romania	0,07	1.394,3	0,03	47%	Yes	No
Linz	Austria	2,81	557,9	1,32	47%	Yes	Yes
Alcala de Guadaira	Spain	0,34	729,5	0,16	46%	No	No
Saarlouis	Germany	0,80	739,3	0,37	46%	No	No
Duisburg	Germany	1,60	546,2	0,73	46%	Yes	No
Aalborg	Denmark	1,18	575,7	0,54	46%	Yes	Yes
Taranto	Italy	0,85	459,1	0,37	44%	No	No
Marsala	Italy	0,16	860,2	0,07	44%	No	No
Lulea	Finland	0,55	644,3	0,24	43%	Yes	No
Port-de-Bouc	France	0,58	1.071,4	0,25	43%	No	No

Ostrava	Czechia	1,84	521,0	0,80	43%	Yes	Yes
Pleven	Bulgaria	0,35	711,2	0,15	42%	Yes	No
Jaroslaw	Poland	0,13	885,8	0,05	42%	Yes	No
Teplice	Czechia	0,38	711,0	0,16	42%	Yes	No
Longuenesse	France	0,29	1.105,1	0,12	40%	No	No
Zawiercie	Poland	0,15	777,0	0,06	40%	Yes	No
Mestre	Italy	1,54	548,1	0,61	40%	No	Yes
Mol	NO	0,55	1.085,2	0,21	39%	Yes	No
Maastricht	Netherlands	0,59	1.087,4	0,22	38%	No	Yes
Somain	France	0,11	1.379,8	0,04	35%	No	No
Gijon	Spain	1,32	513,0	0,42	32%	No	No
Jemeppe-sur-Sambre	Belgium	0,06	1.099,7	0,02	29%	No	No
Eschweiler	Germany	0,56	926,1	0,16	28%	No	No
San Sebastian	Spain	1,07	705,4	0,30	28%	No	No
Castello de la Plana	Spain	1,15	747,3	0,32	28%	No	Yes
Malaga	Spain	1,63	666,3	0,45	28%	No	No
Potenza	Italy	0,19	685,9	0,05	27%	No	No
Terni	Italy	0,39	768,4	0,10	26%	No	No
Asti	Italy	0,36	524,5	0,09	25%	No	No

Table 24 The 50 cities in EU27 with the highest shares of heat demand in district heating covered by medium and low temperature industrial waste heat.

City	Country	Heat demand 2050 [GWh]	Investment cost [EUR/MWh]	Industry (M+L) [GWh]	Share of heat demand by M+L temp sources	Available district heating	Available geothermal
Paiania	Greece	13,33	1.123,25	20,75	155,71	No	No
Elefsina	Greece	462,78	1.145,41	712,96	154,06	No	No
Fuenlabrada	Spain	4,34	1.322,99	5,68	130,69	No	No
Gelsenkirchen	Germany	1,65	1.197,21	1,57	95,10	No	No
Burgfeld	Germany	7,79	1.074,90	6,99	89,73	No	No
Limerick	Ireland	801,93	859,05	669,61	83,50	No	No
Aveiro	Portugal	58,10	1.184,49	48,39	83,28	No	No
Hemer	Germany	12,63	1.274,47	10,47	82,90	No	No
Waterford	Ireland	345,53	844,38	270,65	78,33	No	No
Thessaloniki	Greece	1.973,67	863,10	1.536,59	77,85	No	No
Cork	Ireland	1.009,84	974,63	761,19	75,38	Yes	No
Serres	Greece	198,59	994,73	144,25	72,64	Yes	No
Veroia	Greece	107,24	1.081,23	77,89	72,63	No	No
Wels	Austria	802,04	738,38	581,07	72,45	Yes	Yes
Korneuburg	Austria	240,23	1.006,27	169,48	70,55	No	No
Bad Voeslau	Austria	240,60	1.077,13	166,06	69,02	Yes	No
Wiener Neustadt	Austria	595,86	891,90	396,21	66,49	Yes	No
Pruszkow	Poland	28,49	524,29	18,94	66,49	Yes	No
Jemeppe-sur-Sambre	Belgium	57,05	1.099,68	37,16	65,13	No	No
Canet d'en Berenguer	Spain	247,57	834,74	160,71	64,91	No	No
Beringen	Belgium	841,94	1.138,05	536,92	63,77	No	No
Dublin	Ireland	6.807,45	886,41	4.325,16	63,54	Yes	Yes
Muelheim an der Ruhr	Germany	1,91	839,38	1,17	61,21	No	No
Galway	Ireland	619,53	996,12	367,98	59,40	No	No
Sandersdorf	Germany	461,10	993,53	268,96	58,33	No	No
Nea Ionia	Greece	415,95	1.011,46	242,36	58,27	No	No
Hasselt	Belgium	1.406,73	900,32	817,41	58,11	No	Yes
Larissa	Greece	330,36	1.294,81	187,47	56,75	No	No
Lommel	Belgium	716,00	1.022,58	398,67	55,68	No	Yes
Komotini	Greece	126,35	1.209,54	69,19	54,76	No	No
Feldkirch	Austria	1.011,61	1.077,38	551,94	54,56	Yes	Yes
Alcantarilla	Spain	305,46	1.021,23	166,40	54,47	No	No
Louvain-la-Neuve	Belgium	380,85	1.067,20	205,23	53,89	Yes	No
Xanthi	Greece	189,24	844,75	100,37	53,04	No	No
La Linea de la Concepcion	Spain	487,02	951,12	255,58	52,48	No	No
St. Poelten	Austria	461,20	790,30	235,36	51,03	Yes	No

Herentals	Belgium	337,29	818,82	171,33	50,80	No	No
Beverwijk	Netherlands	724,66	957,41	362,84	50,07	No	Yes
Heist-op-den-Berg	Belgium	949,55	1.035,32	474,72	49,99	No	No
Esparreguera	Spain	483,99	866,05	238,12	49,20	No	No
Bragadiru	Romania	30,41	1.354,48	14,95	49,16	No	No
Sosnowiec	Poland	510,56	625,36	249,75	48,92	Yes	No
Herve	Belgium	813,22	970,93	395,94	48,69	No	No
Kampen	Netherlands	269,30	1.105,92	130,73	48,55	Yes	No
Huy	Belgium	182,69	1.089,84	87,76	48,04	No	No
Guadalajara	Spain	461,95	863,10	220,12	47,65	No	No
Hernani	Spain	188,28	903,16	88,20	46,84	No	No
Slatina	Romania	117,23	1.187,08	53,46	45,61	No	No
Bernau bei Berlin	Germany	7,03	1.288,32	3,18	45,18	No	No
Heraklion	Greece	373,19	1.337,76	167,83	44,97	No	No

Table 25 The 50 cities in EU27 with the highest shares of heat demand in district heating covered by geothermal potentials.

City	Country	Heat demand [GWh]	Investment cost [EUR/MWh]	Geothermal energy [%,70MW]
Dublin	Ireland	6.807,45	886,41	79,71
Amersfoort	Netherlands	1.029,71	1.232,91	61,04
Avignon	France	1.035,05	1.289,30	60,71
Tilburg	Netherlands	2.173,45	1.046,34	59,72
Utrecht	Netherlands	1.998,70	1.053,68	58,75
Toulouse	France	3.135,95	1.261,94	57,80
Lisbon	Portugal	2.360,87	1.305,89	57,34
Amsterdam	Netherlands	8.418,84	986,80	56,10
Montpellier	France	1.772,87	1.110,12	55,07
Groningen	Netherlands	1.117,25	906,08	55,02
Eindhoven	Netherlands	2.420,54	929,27	54,51
The Hague	Netherlands	13.080,87	942,24	54,05
Nantes	France	3.429,26	984,29	53,91
Alicante	Spain	2.047,35	899,59	53,25
Bordeaux	France	3.385,76	946,26	52,86
Orleans	France	1.213,40	975,82	52,79
Bucharest	Romania	4.554,78	810,01	51,32
Dijon	France	1.905,91	762,70	51,28
Rouen	France	2.573,33	836,61	51,15
Tours	France	1.263,93	838,25	50,95
Zagreb	Croatia	2.793,52	667,66	50,53
Graz	Austria	2.450,45	743,12	50,42
Clermont-Ferrand	France	1.819,31	818,58	50,42
Bremerhaven	Germany	1.258,33	708,25	49,98
Lyon	France	7.580,60	782,86	49,89
Oldenburg	Germany	1.637,76	709,93	49,77

Osnabrueck	Germany	1.465,01	681,04	49,64
Gonesse	France	1.394,27	1.138,22	49,12
Heerlen	Netherlands	1.666,20	1.042,40	48,63
Bielefeld	Germany	1.976,66	724,86	48,52
Strasbourg	France	2.298,22	770,10	48,48
Ingolstadt	Germany	1.470,62	613,34	48,18
Magdeburg	Germany	2.456,72	611,84	48,10
Regensburg	Germany	1.661,92	627,88	48,10
Aachen	Germany	1.504,17	616,02	48,03
Bremen	Germany	5.167,26	596,93	47,62
Sofia	Bulgaria	3.787,69	618,34	47,39
Linz	Austria	2.807,55	557,90	46,84
Ljubljana	Slovenia	2.717,45	413,77	46,77
Antwerp	Belgium	10.278,37	611,56	46,71
Braunschweig	Germany	2.196,11	528,93	46,51
Heilbronn	Germany	1.438,39	576,07	46,51
Luebeck	Germany	2.050,41	583,14	46,32
Berlin	Germany	24.588,46	516,38	46,28
Paris	France	44.389,24	566,76	46,16
Kiel	Germany	1.825,52	661,51	45,77
Aarhus	Denmark	2.781,33	570,41	45,52
Moenchengladbach	Germany	1.589,32	724,81	45,52
Hamburg	Germany	16.005,95	587,00	45,36
Hanover	Germany	6.169,32	532,00	45,07

5 National-level waste heat and renewable heat potentials

This section contains an overview for each country studied in the Heat Roadmap Europe main report. The overview consists of table showing the district heating shares and the related sources of waste heat. It is important to understand that these shares differ from the shares presented in the EU27 market share assessment. Further the potential for each waste heat source, is visualized on maps. When applicable, the following sources of waste heat are geolocated:

1. Geothermal energy (Baseload of district heating area, capacity >40MW).
2. Geothermal energy (Baseload of district heating area, capacity >70MW).
3. Baseload high temperature waste heat
4. Baseload low temperature waste heat
5. Baseload medium temperature waste heat
6. High temperature from industry
7. High temperature from waste-to-energy
8. Low temperature from industry
9. Low temperature from metros
10. Low temperature from supermarkets
11. Medium temperature from industry
12. Medium temperature from wastewater treatment

In this appendix, some graphs from the different countries, as the ones shown in the main report for the EU27 will be presented. They represent a comparison of the different scenarios in two aspects: the biomass consumption and the general cost of all the system. Several modifications could be done with the cost as a sensitivity analysis was done, however the basic cost was chosen so no scenario has any advantage over the others, more than the natural advantage of the system itself. For all the countries and graphs there are two sections in each scenario: the three first columns of the graph, represents the 3rd generation district heating grid, and the 3 last columns with a transparency, show the results of the 4th generation.

5.1 Austria

Table 26: District heating shares specific to Austria and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Austria	5	18,77	12,07	1,05	0,84	0,76	1,19	1,31	0,12	0	0	0	0	0
	10	18,77	12,07	1,05	0,84	0,76	1,19	1,31	0,12	0	0	0	0	0
	15	18,77	12,07	1,05	0,84	0,76	1,19	1,31	0,12	0	0	0	0	0
	20	23,06	14,84	1,32	1,89	0,76	1,19	1,31	0,12	0	0	0	0	0
	25	26,64	17,13	1,52	1,89	1,01	1,65	1,34	0,17	0,02	0	0	0,12	0,12
	30	30,45	19,58	1,75	1,91	1,21	2,02	1,58	0,24	0,02	0	0	0,22	0,22
	35	35,21	22,65	2,12	1,91	1,65	2,46	1,77	0,3	0,02	0	0,01	0,22	0,22
	40	40,29	25,91	2,45	1,92	2,18	2,85	2,18	0,41	0,02	0	0,01	0,22	0,22
	45	45,14	29,04	2,58	2,14	2,8	3,24	2,51	0,48	0,02	0	0,01	0,22	0,22
	50	50,07	32,21	2,6	2,24	3,4	3,68	2,8	0,59	0,02	0,04	0,05	0,22	0,22
	55	55,02	35,39	2,62	2,39	4,03	4,01	3,07	0,74	0,02	0,09	0,1	0,22	0,22
	60	60	38,6	2,63	2,47	4,5	4,13	3,33	0,9	0,02	0,24	0,24	0,22	0,22
	65	62,43	40,16	2,64	2,48	4,62	4,13	3,46	0,96	0,02	0,34	0,35	0,22	0,22

Figure 10: Geothermal energy for Austria (Baseload of district heating area, capacity >40MW).

Figure 11: Geothermal energy for Austria (Baseload of district heating area, capacity >70MW).

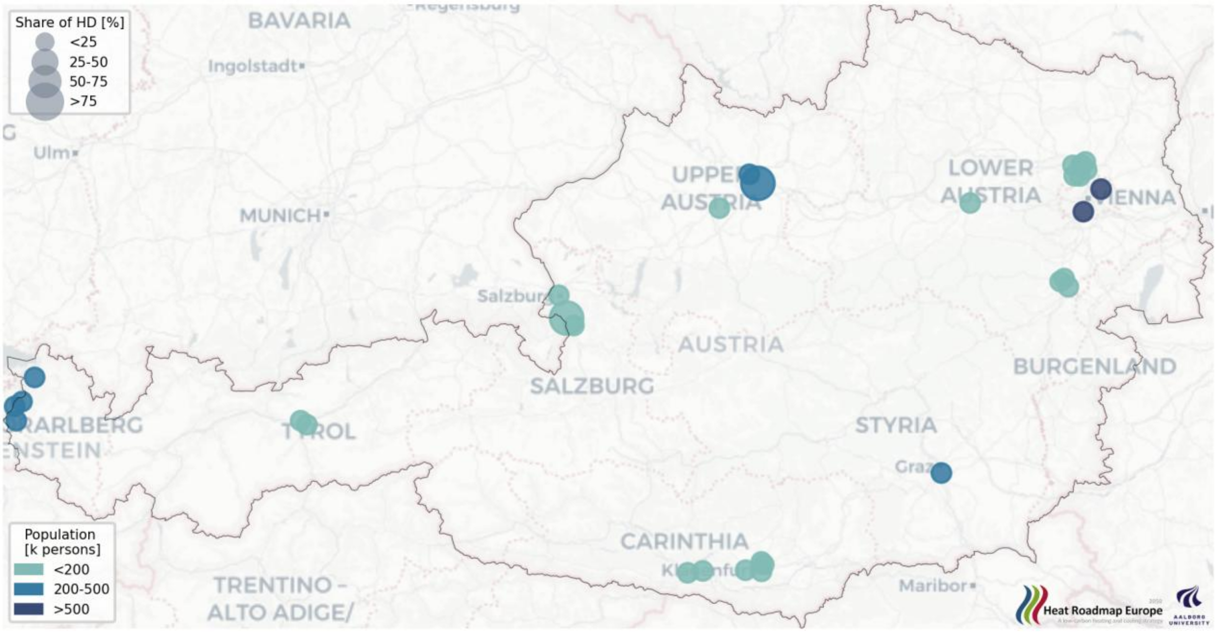


Figure 12: Baseload high temperature waste heat for Austria.

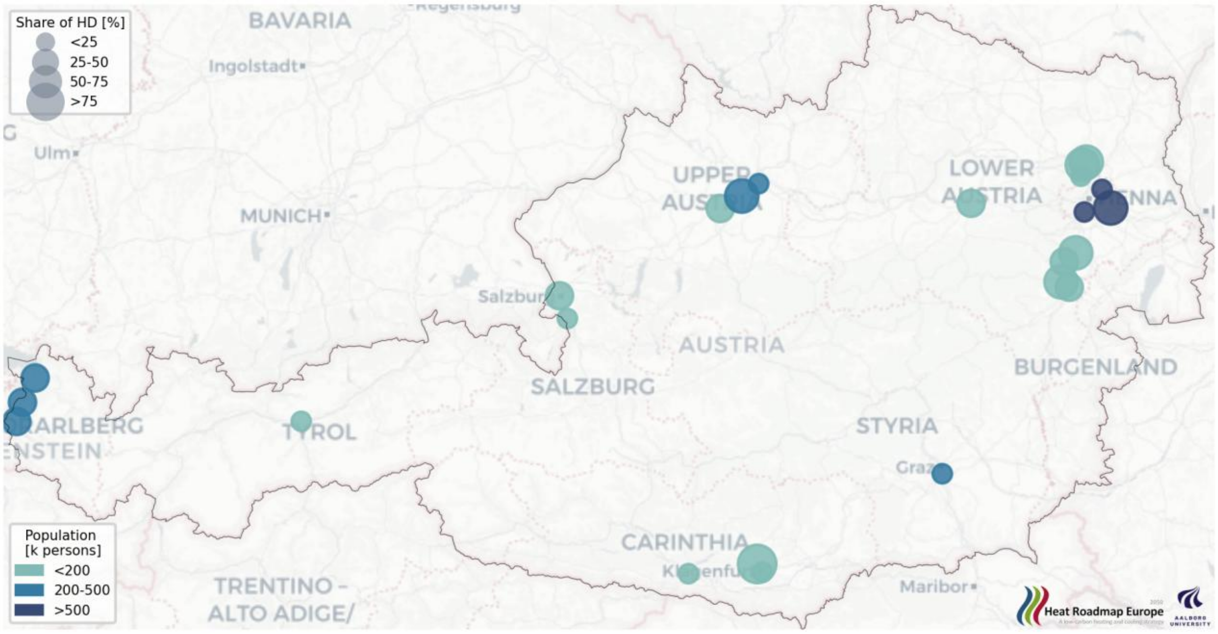


Figure 13: Baseload low temperature waste heat for Austria.

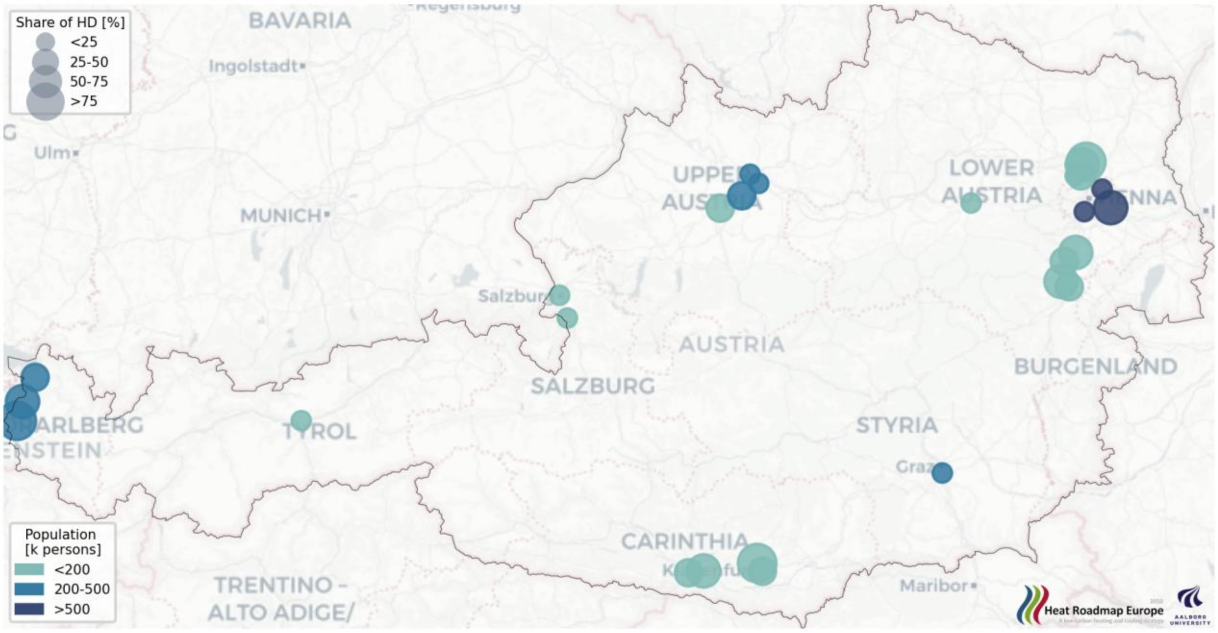


Figure 14: Baseload medium temperature waste heat for Austria.

Figure 15: High temperature from industry for Austria.

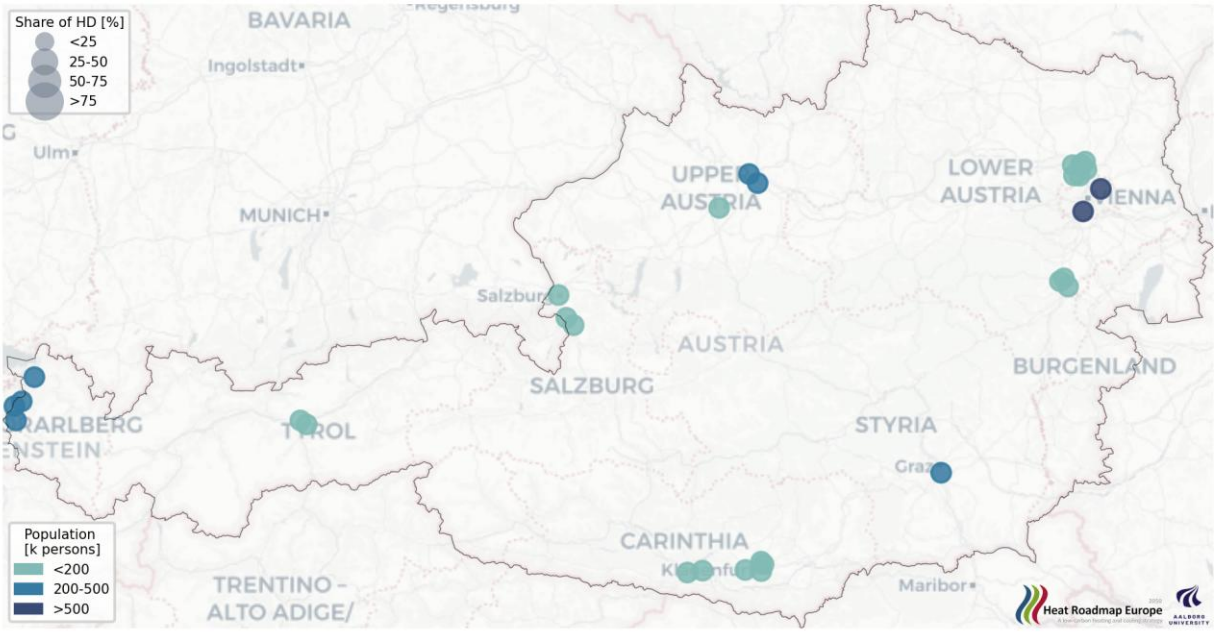


Figure 16: High temperature from waste-to-energy for Austria.

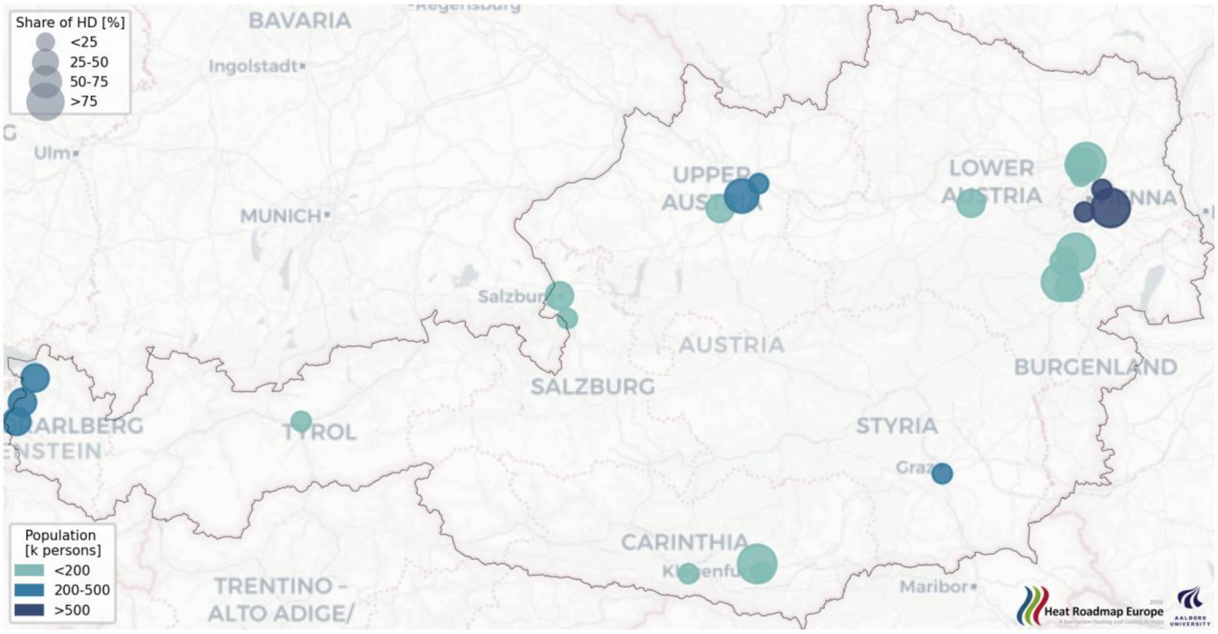


Figure 17: Low temperature from industry for Austria.

Figure 18: Low temperature from metros for Austria.

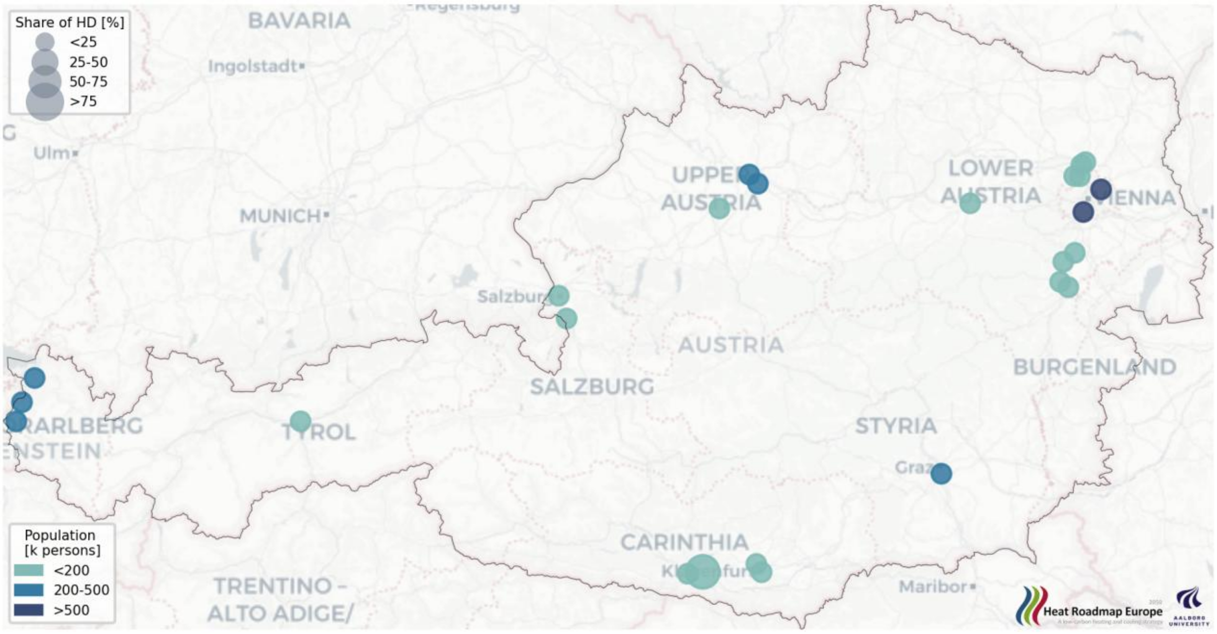


Figure 19: Low temperature from supermarkets for Austria.

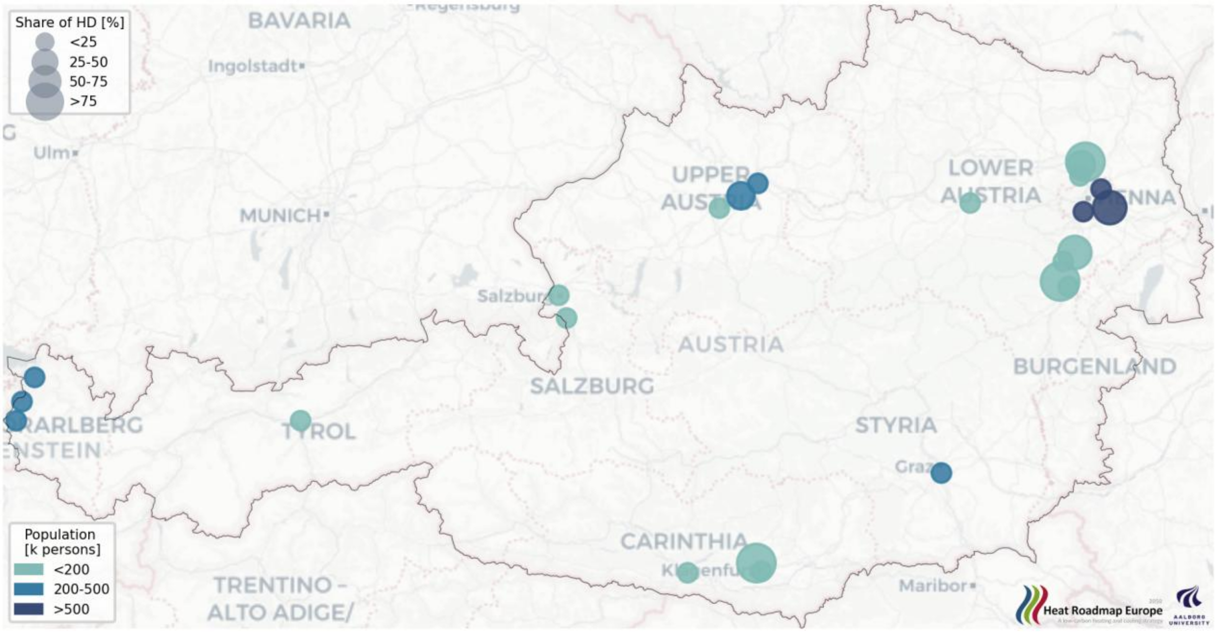


Figure 20: Medium temperature from industry for Austria.

Figure 21: Medium temperature from wastewater treatment for Austria.

5.2 Belgium

Table 27: District heating shares specific to Belgium and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Belgium	5	12,43	11,52	0,37	0	0,59	1,16	0,74	0,09	0,23	0	0	0	0
	10	12,43	11,52	0,37	0	0,59	1,16	0,74	0,09	0,23	0	0	0	0
	15	23,15	21,46	0,69	1,64	1,21	2,37	1,09	0,17	0,23	0	0	0,57	0,57
	20	23,15	21,46	0,69	1,64	1,21	2,37	1,09	0,17	0,23	0	0	0,57	0,57
	25	26,55	24,61	0,82	1,66	1,56	3,05	1,27	0,23	0,23	0	0	0,57	0,57
	30	30,02	27,82	0,92	1,66	2	3,9	1,4	0,27	0,23	0	0	0,57	0,57
	35	35,19	32,62	1,09	1,92	2,5	4,85	1,61	0,34	0,23	0	0	0,57	0,57
	40	40,51	37,55	1,25	2,05	3,06	5,69	1,97	0,39	0,23	0	0,04	0,57	0,57
	45	45,48	42,15	1,4	2,16	3,65	6,74	2,2	0,45	0,23	0	0,08	0,57	0,57
	50	50,06	46,39	1,53	2,54	4,15	7,53	2,31	0,51	0,23	0,02	0,13	0,57	0,57
	55	55,04	51,01	1,64	2,54	4,83	8,64	2,5	0,61	0,23	0,09	0,19	0,57	0,57
	60	60,04	55,64	1,81	2,57	5,49	9,37	2,71	0,71	0,23	0,19	0,3	0,57	0,57
	65	65	60,24	1,89	2,64	6,07	9,84	2,84	0,83	0,23	0,37	0,48	0,57	0,57

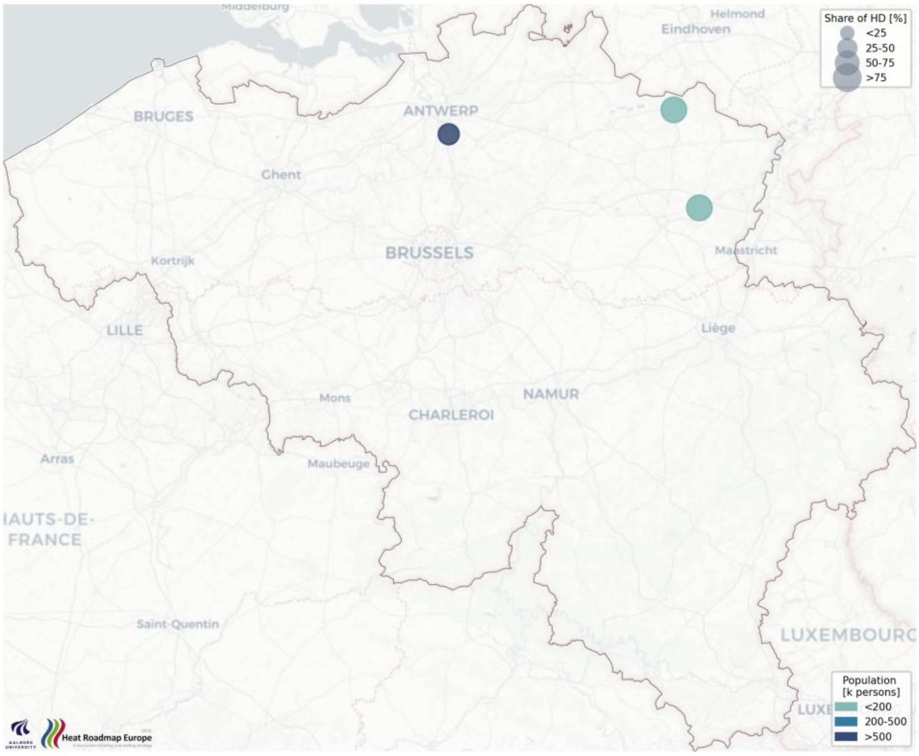


Figure 22: Geothermal energy for Belgium (Baseload of district heating area, capacity >40MW).

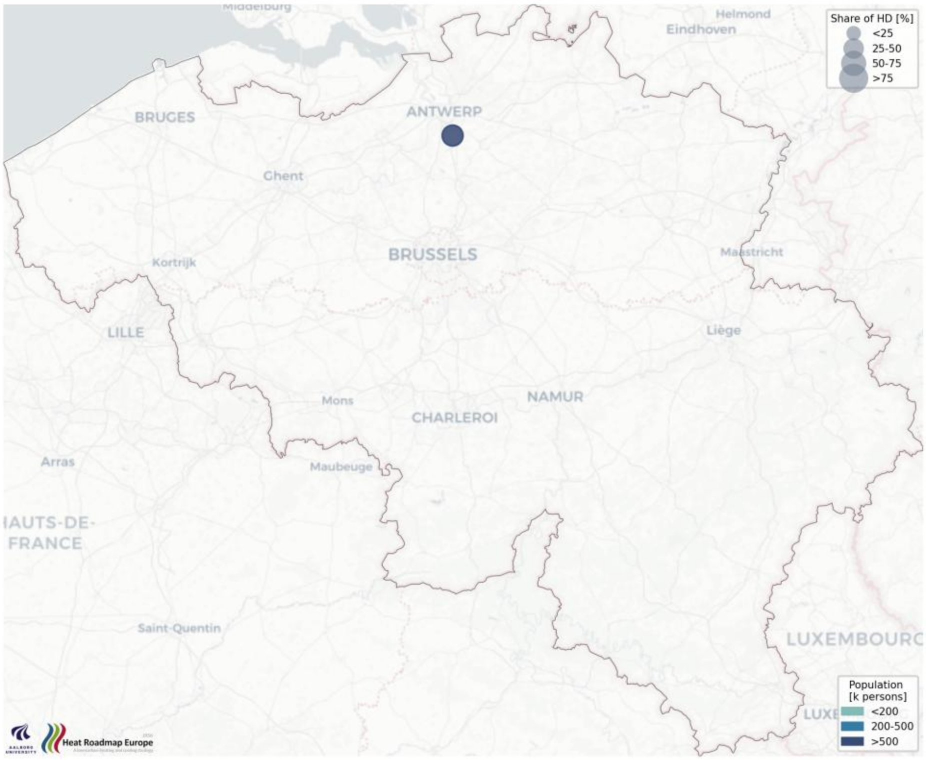


Figure 23: Geothermal energy for Belgium (Baseload of district heating area, capacity >70MW).

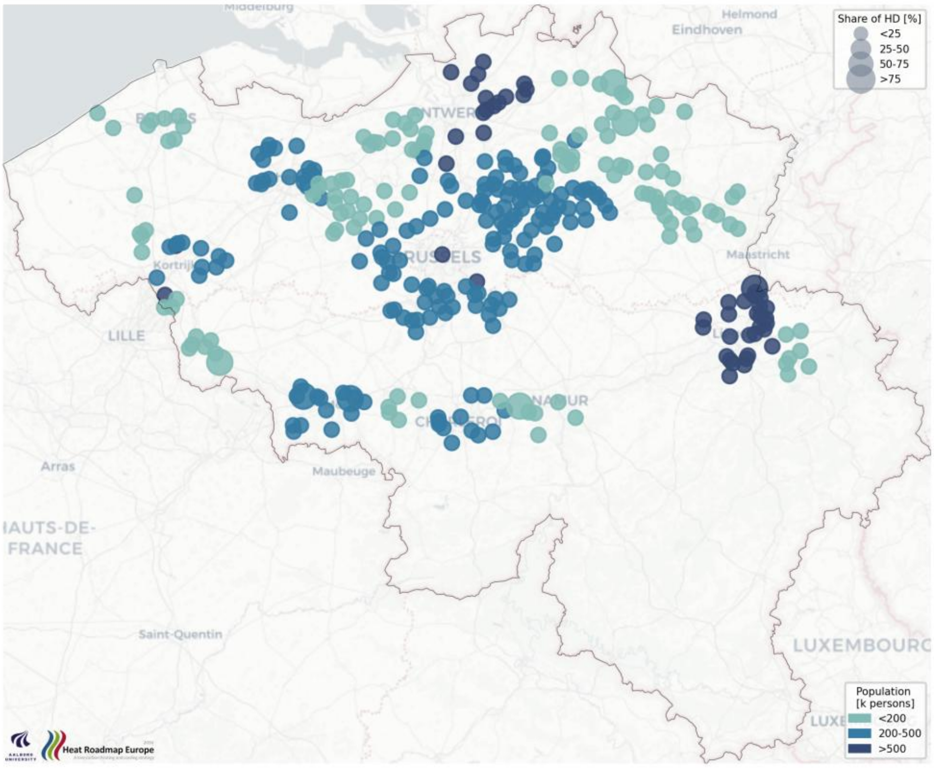


Figure 24: Baseload high temperature waste heat for Belgium.

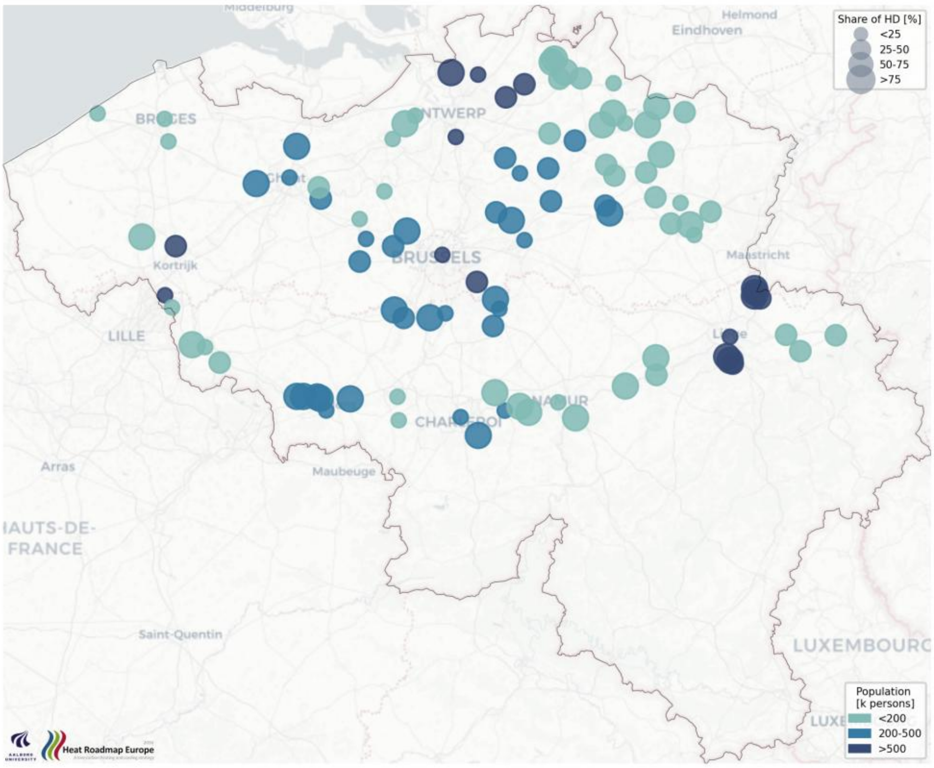


Figure 25: Baseload low temperature waste heat for Belgium.

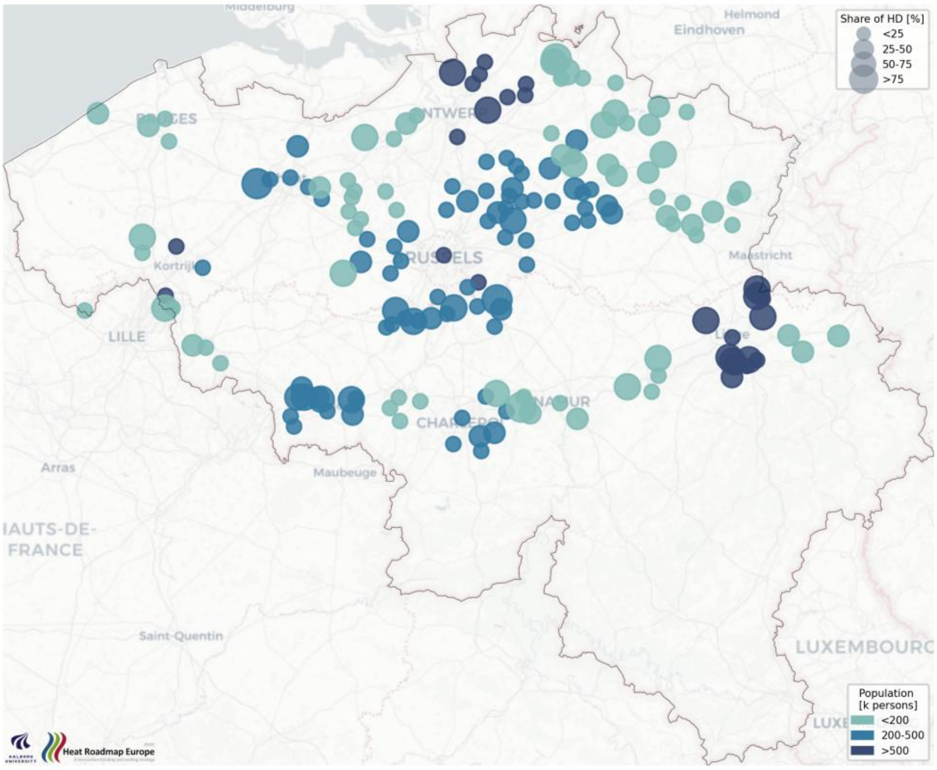


Figure 26: Baseload medium temperature waste heat for Belgium.

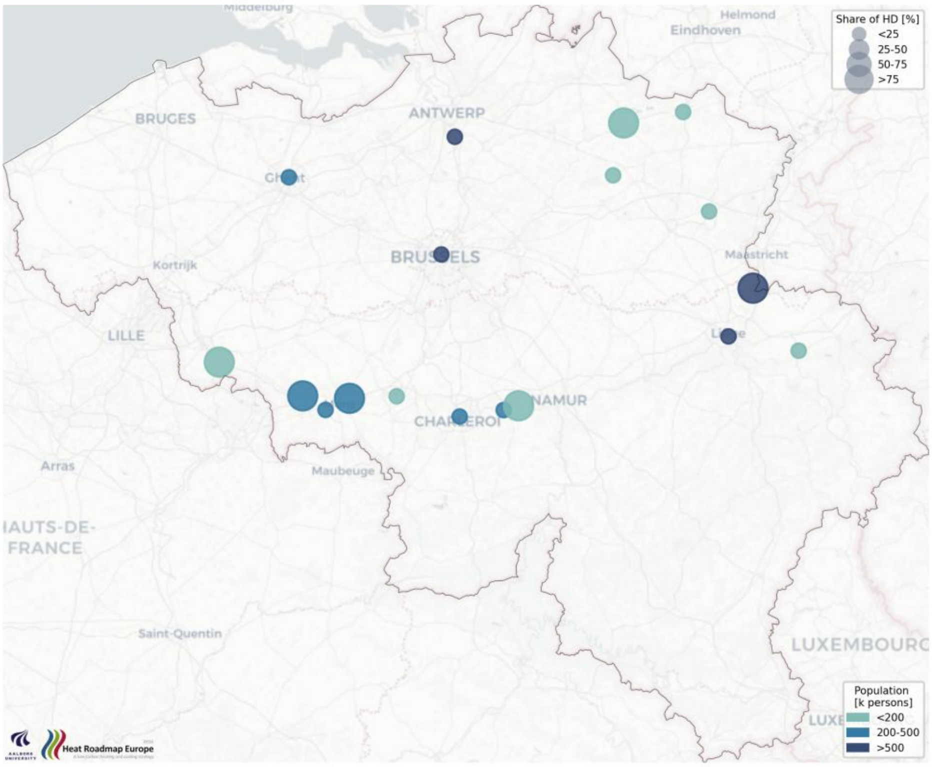


Figure 27: High temperature from industry for Belgium.

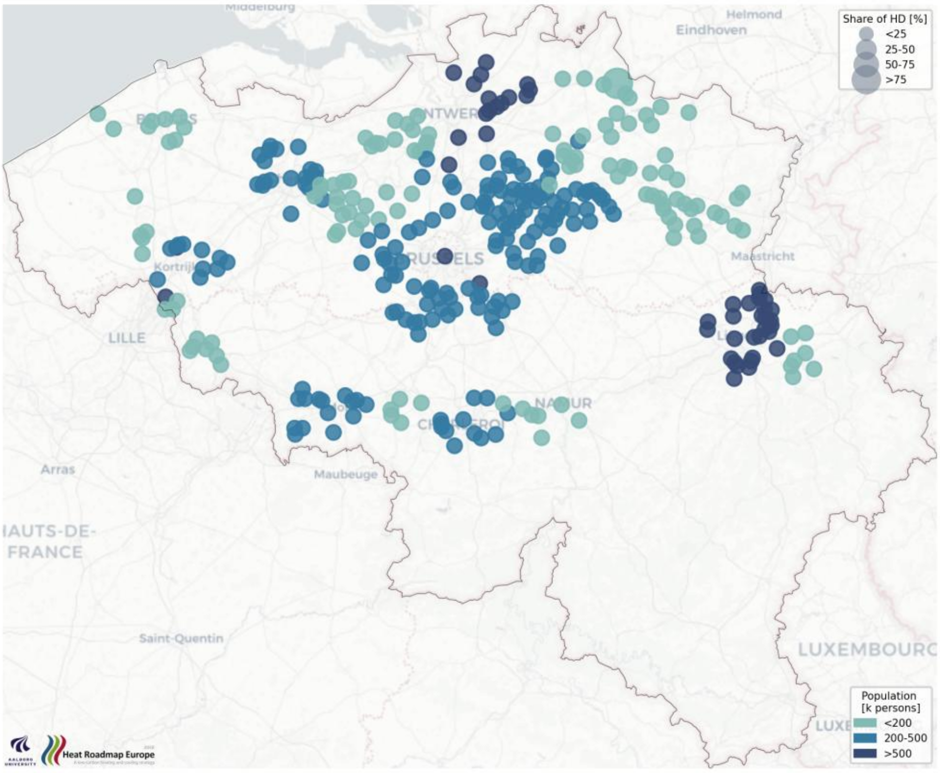


Figure 28: High temperature from waste-to-energy for Belgium.

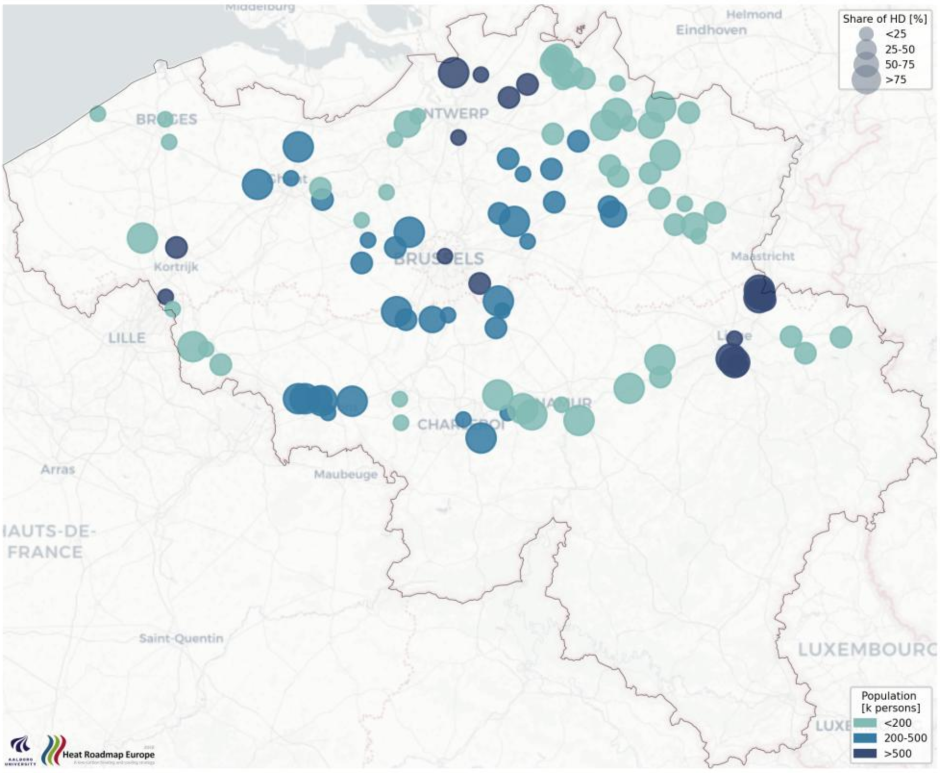


Figure 29: Low temperature from industry for Belgium.

Figure 30: Low temperature from metros for Belgium.

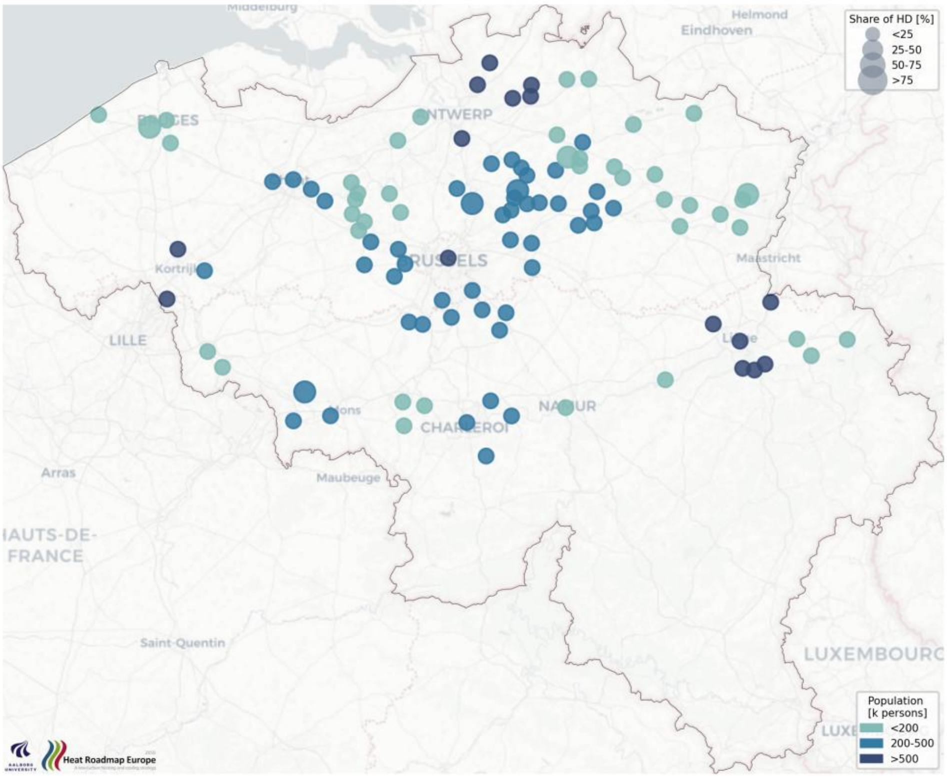


Figure 31: Low temperature from supermarkets for Belgium.

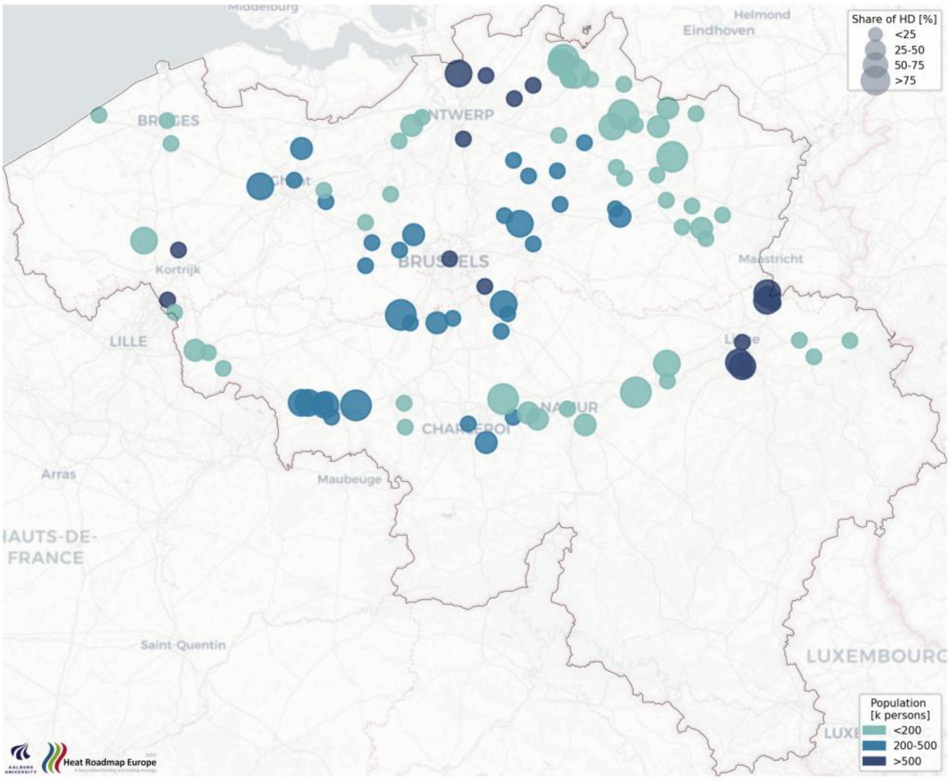


Figure 32: Medium temperature from industry for Belgium.

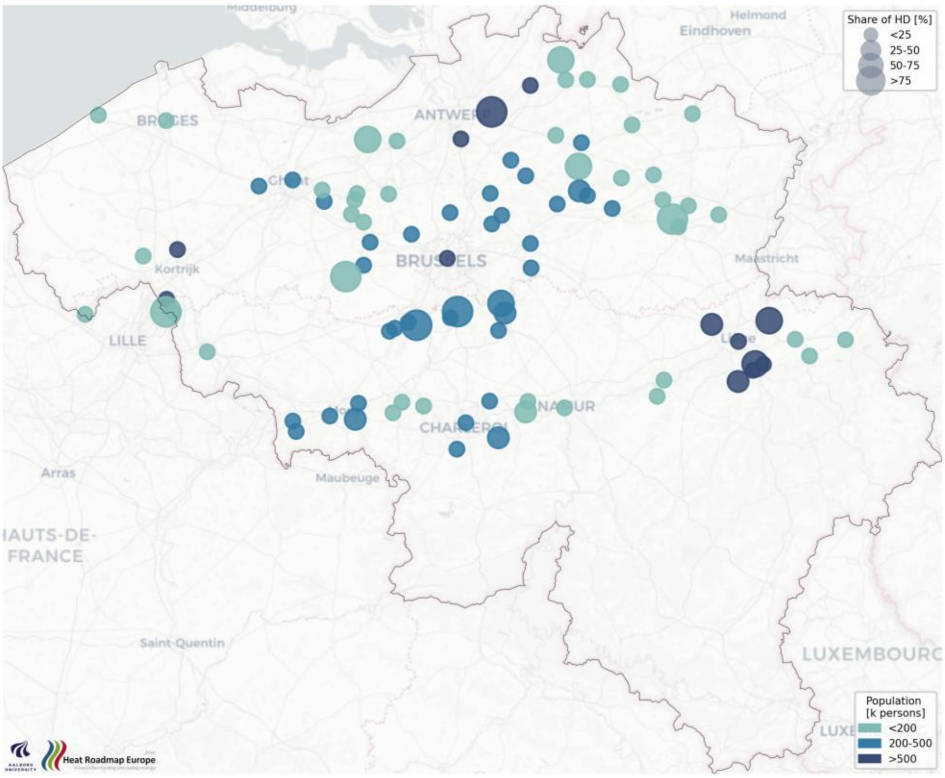


Figure 33: Medium temperature from wastewater treatment for Belgium.

5.3 Bulgaria

Table 28: District heating shares specific to Bulgaria and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Bulgaria	5	11,69	3,7	0,69	0	0,09	0,15	0	0,03	0,13	0	0	0,7	0,7
	10	11,69	3,7	0,69	0	0,09	0,15	0	0,03	0,13	0	0	0,7	0,7
	15	15,79	5	0,95	0,25	0,12	0,2	0	0,05	0,13	0	0	0,7	0,7
	20	20,71	6,55	1,21	0,25	0,16	0,26	0,04	0,06	0,13	0	0,06	0,9	0,7
	25	25,08	7,94	1,49	0,25	0,21	0,34	0,04	0,07	0,13	0	0,1	0,9	0,7
	30	30,73	9,72	1,81	0,37	0,27	0,43	0,05	0,08	0,13	0,04	0,15	0,9	0,7
	35	35,07	11,09	1,92	0,43	0,34	0,55	0,16	0,09	0,13	0,09	0,2	0,9	0,7
	40	40,25	12,73	1,92	0,43	0,41	0,65	0,22	0,11	0,13	0,2	0,31	0,9	0,7
	45	45,06	14,26	1,96	0,43	0,46	0,74	0,27	0,11	0,13	0,31	0,42	0,9	0,7
	50	50,04	15,83	1,97	0,47	0,52	0,84	0,37	0,12	0,13	0,41	0,53	0,9	0,7
	55	55,01	17,41	2,02	0,49	0,57	0,9	0,42	0,13	0,13	0,54	0,65	0,9	0,7
	60	57	18,03	2,02	0,49	0,59	0,94	0,44	0,13	0,13	0,59	0,7	0,9	0,7
	65	57	18,03	2,02	0,49	0,59	0,94	0,44	0,13	0,13	0,59	0,7	0,9	0,7

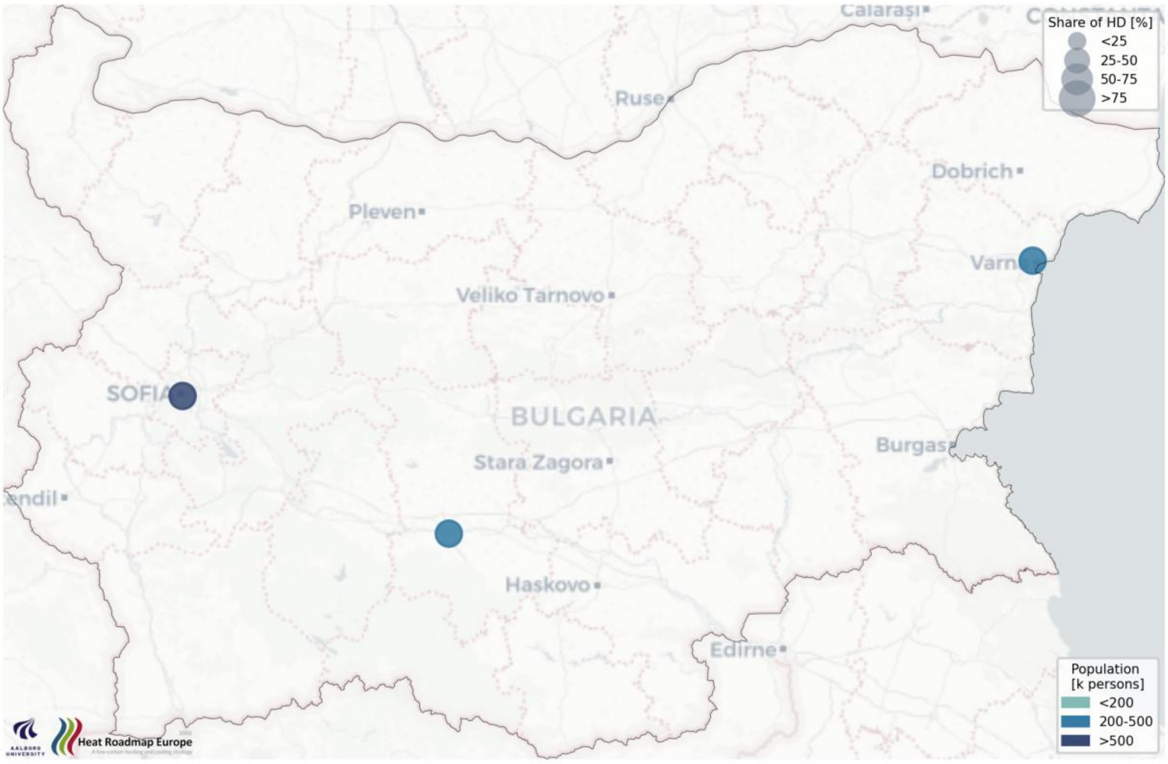


Figure 34: Geothermal energy for Bulgaria (Baseload of district heating area, capacity >40MW).

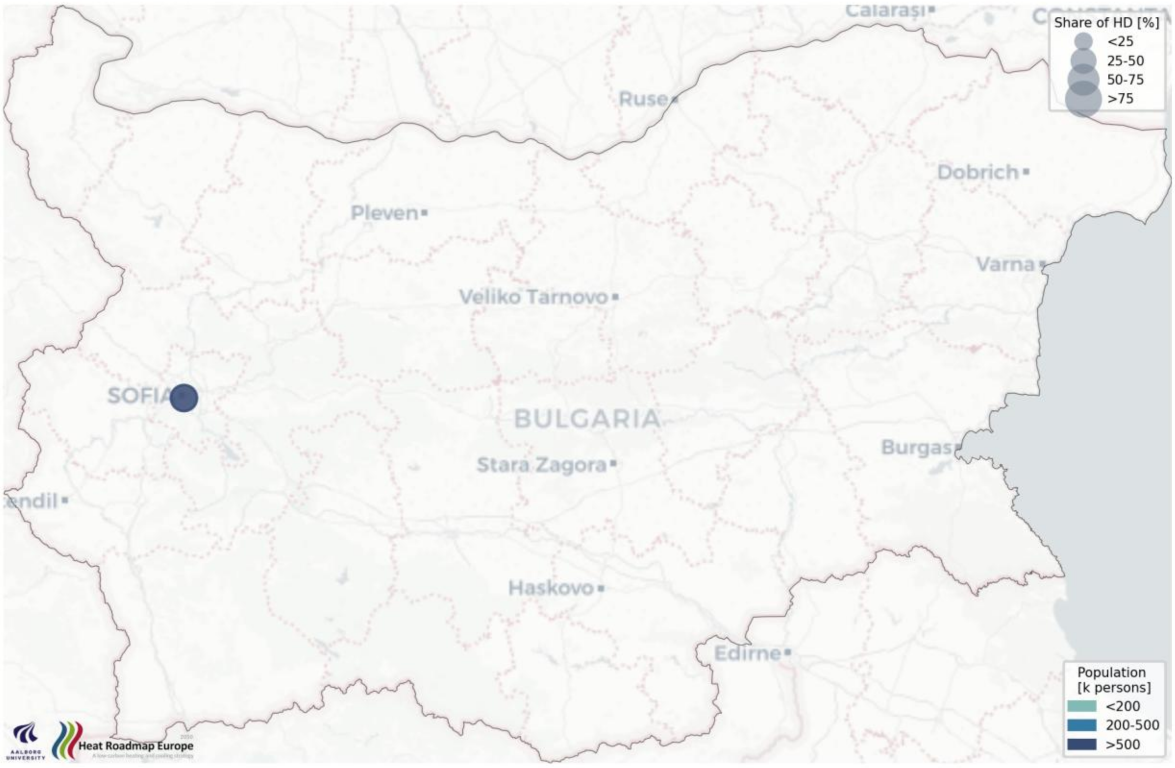


Figure 35: Geothermal energy for Bulgaria (Baseload of district heating area, capacity >70MW).

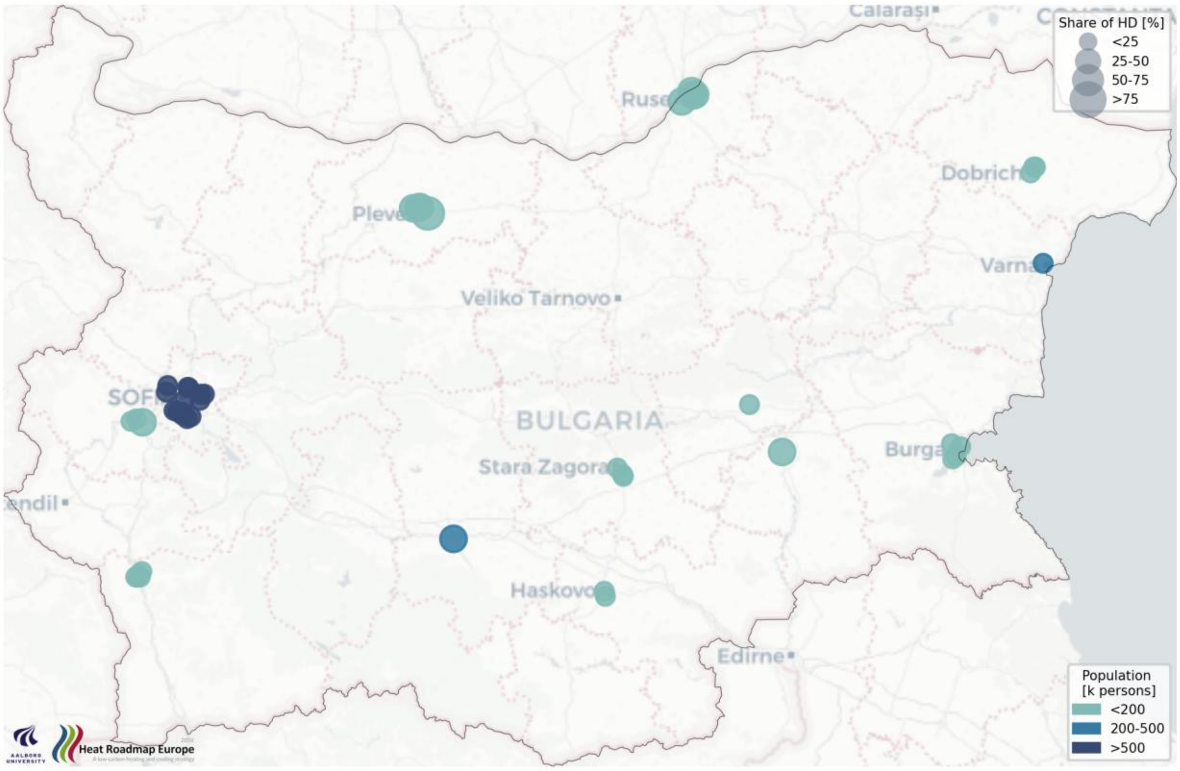


Figure 36: Baseload high temperature waste heat for Bulgaria.

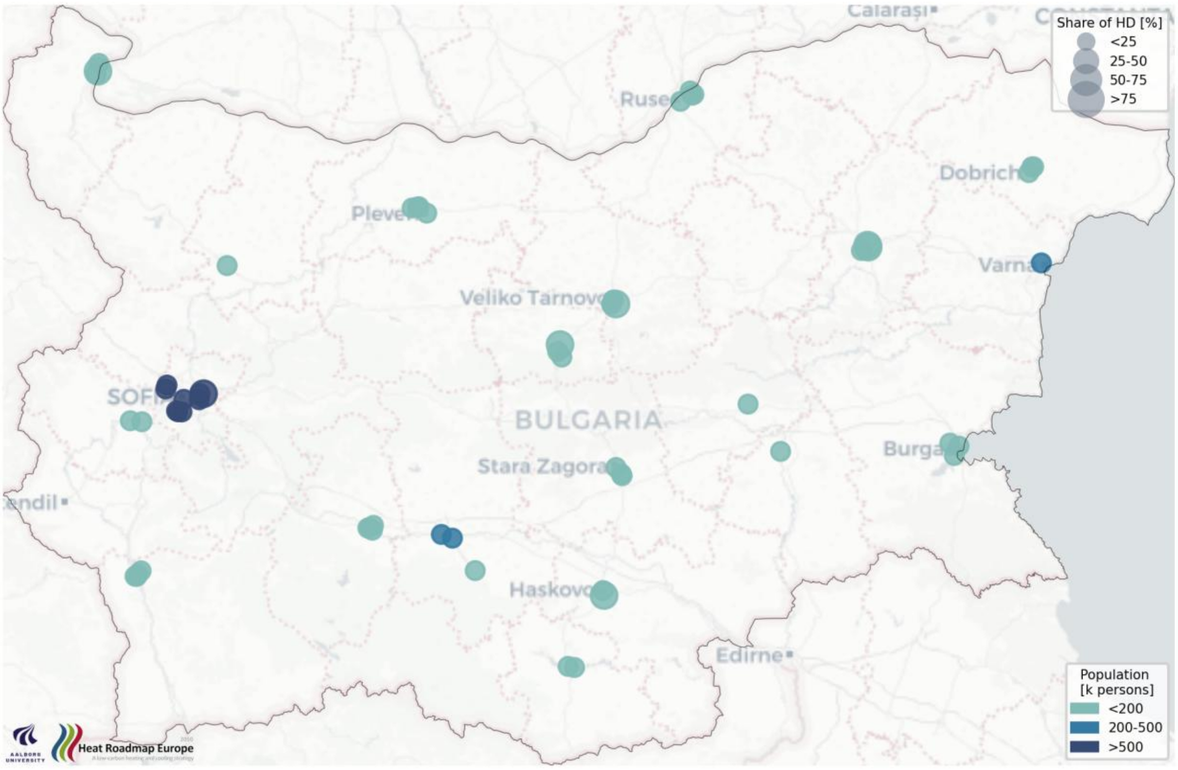


Figure 37: Baseload low temperature waste heat for Bulgaria.

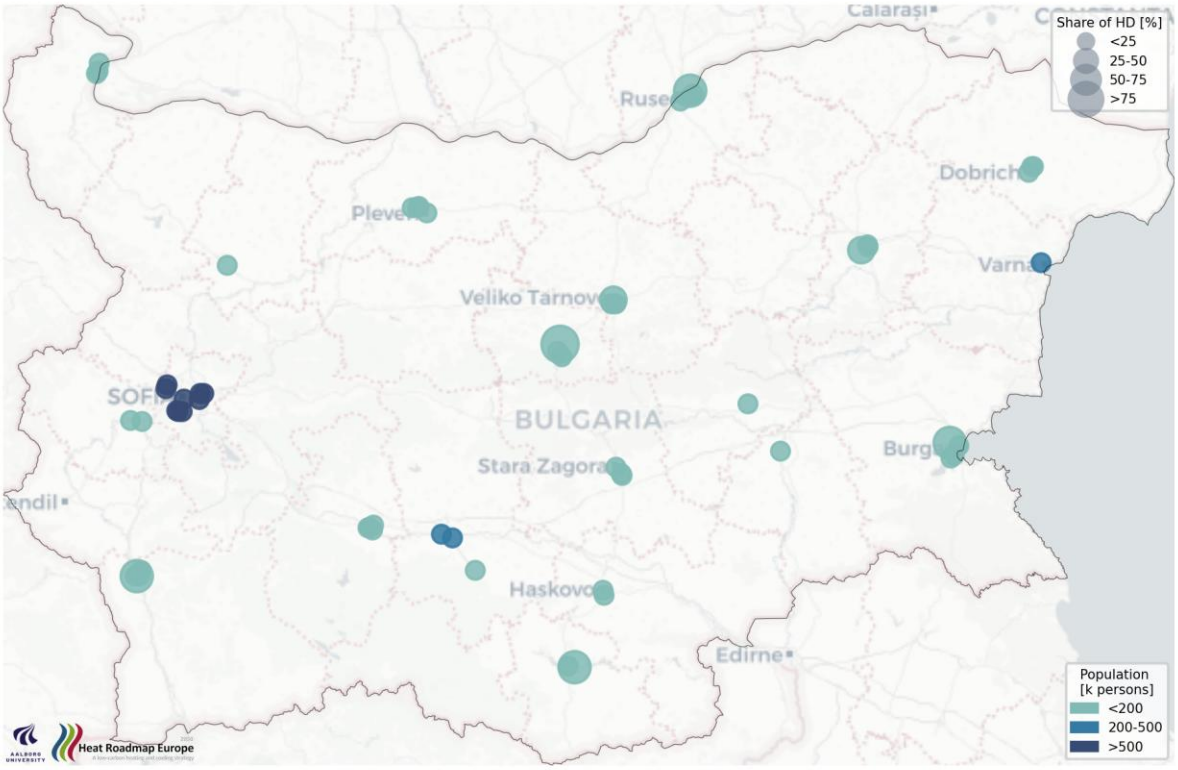


Figure 38: Baseload medium temperature waste heat for Bulgaria.

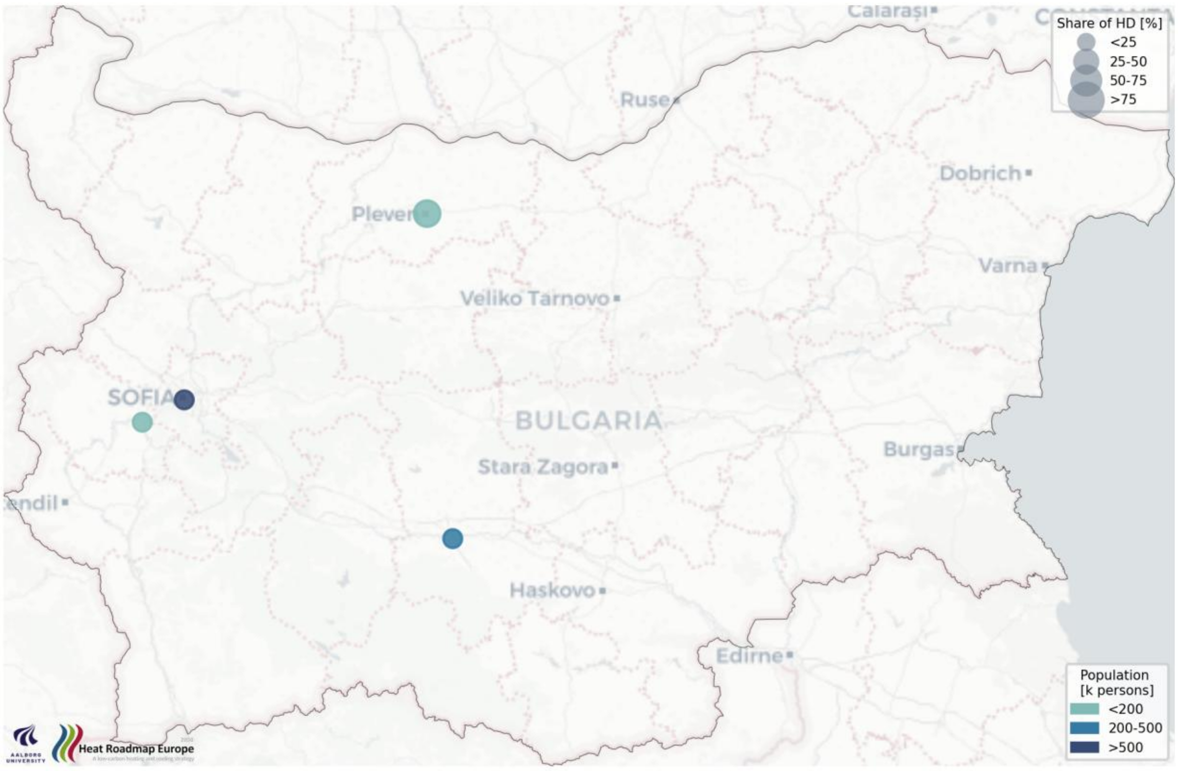


Figure 39: High temperature from industry for Bulgaria.

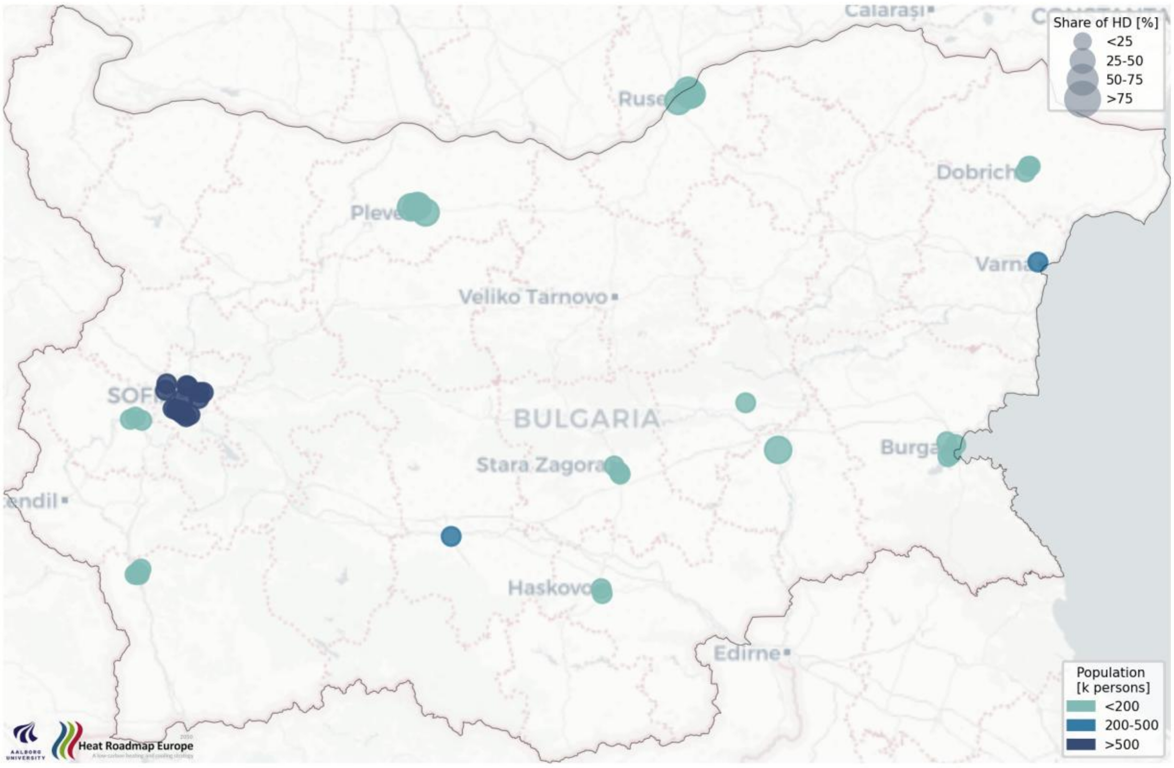


Figure 40: High temperature from waste-to-energy for Bulgaria.

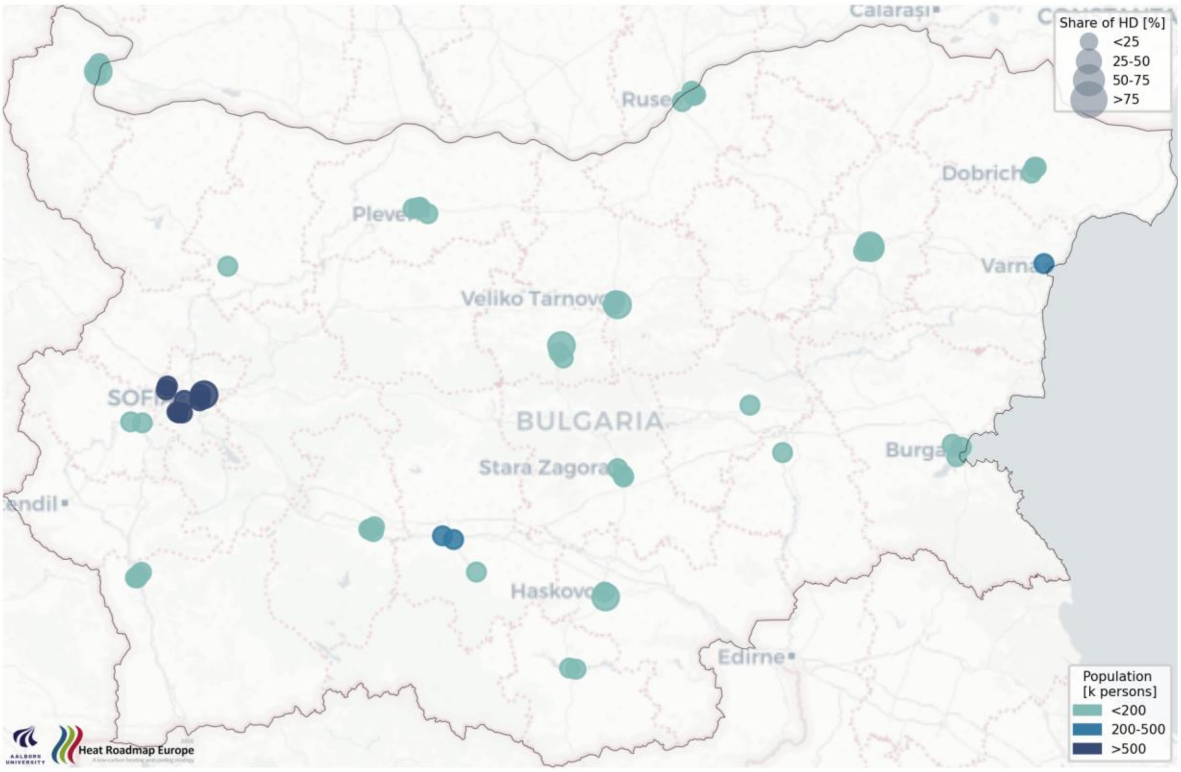


Figure 41: Low temperature from industry for Bulgaria.

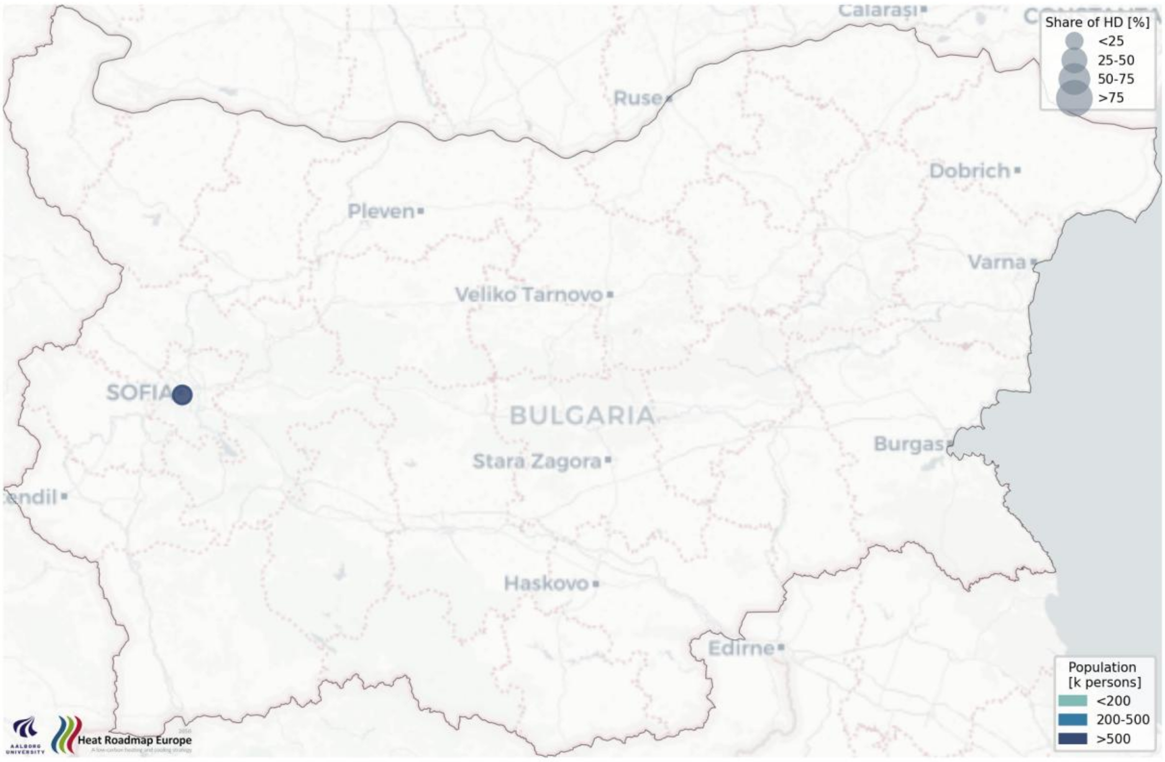


Figure 42: Low temperature from metros for Bulgaria.

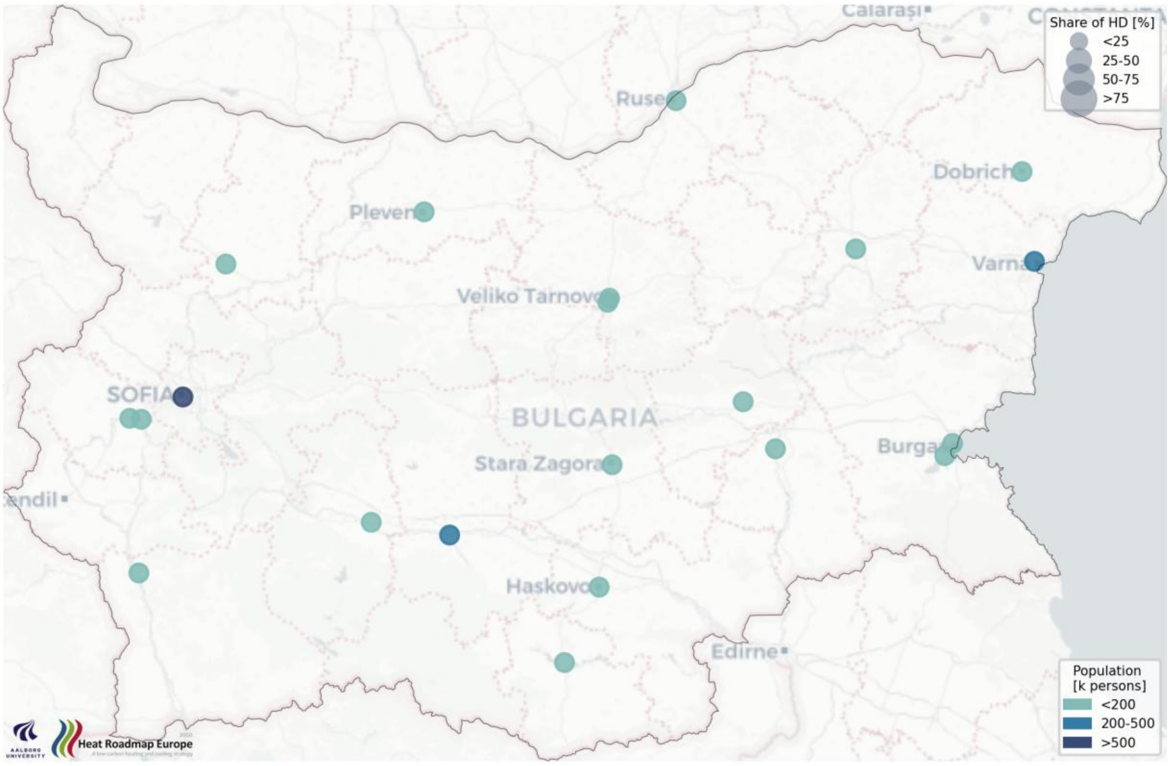


Figure 43: Low temperature from supermarkets for Bulgaria.

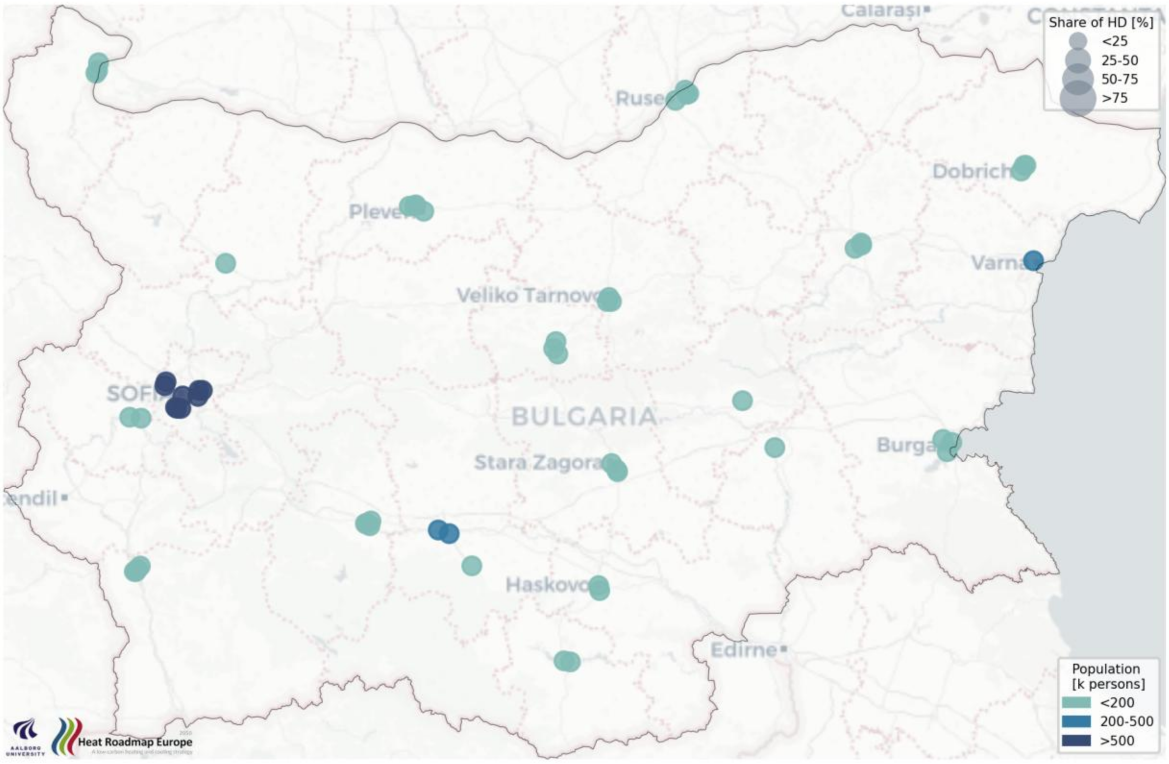


Figure 44: Medium temperature from industry for Bulgaria.

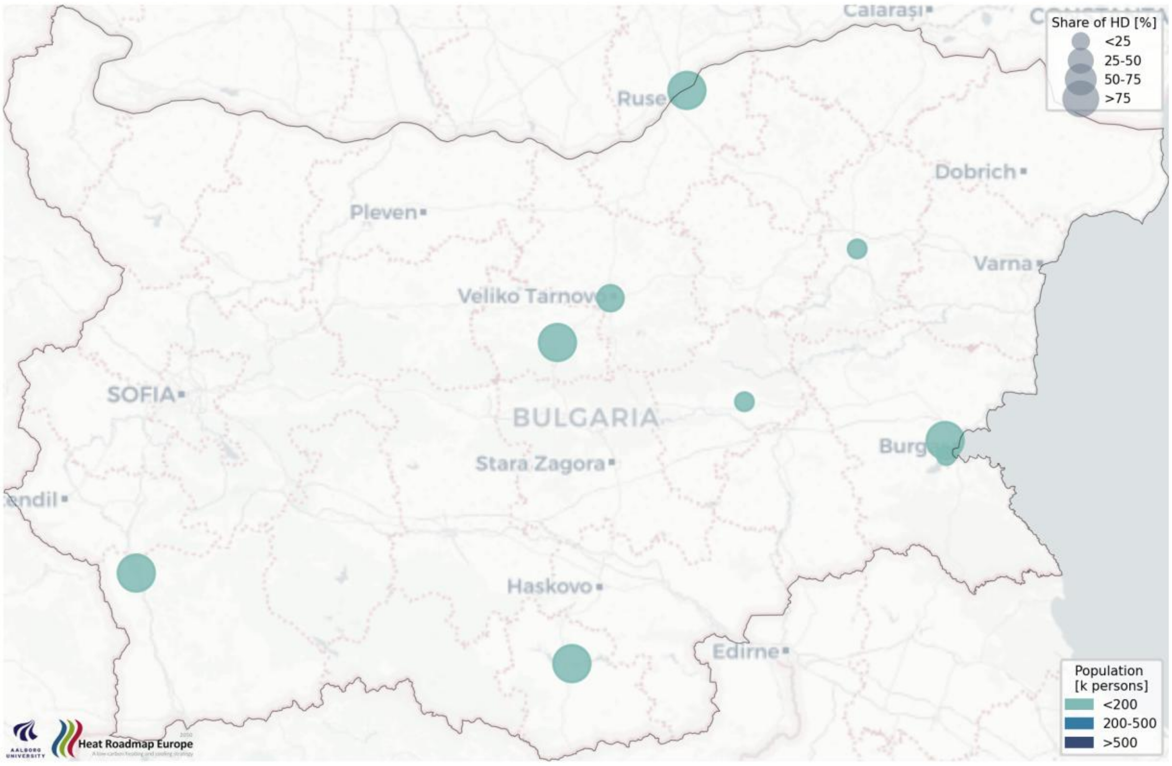


Figure 45: Medium temperature from wastewater treatment for Bulgaria.

5.4 Croatia

Table 29: District heating shares specific to Croatia and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Croatia	5	11,21	6,34	0,7	0	0,16	0,31	0,73	0,11	0,18	0	0	0,87	0,87
	10	11,21	6,34	0,7	0	0,16	0,31	0,73	0,11	0,18	0	0	0,87	0,87
	15	15,93	9,01	0,99	0	0,23	0,46	1,12	0,17	0,21	0	0,02	1,24	1,13
	20	20,11	11,37	1,22	0,05	0,3	0,58	1,38	0,23	0,21	0	0,09	1,5	1,13
	25	25,38	14,35	1,53	0,05	0,41	0,8	1,8	0,3	0,21	0	0,16	1,6	1,13
	30	30,38	17,18	1,65	0,05	0,51	0,97	2,1	0,37	0,21	0,06	0,27	1,6	1,13
	35	35,21	19,91	1,67	0,18	0,6	1,15	2,29	0,43	0,21	0,19	0,41	1,6	1,13
	40	40,17	22,71	1,73	0,29	0,67	1,28	2,6	0,51	0,21	0,33	0,55	1,6	1,13
	45	45,07	25,49	1,8	0,33	0,77	1,47	2,79	0,61	0,21	0,48	0,7	1,6	1,13
	50	50,01	28,28	1,82	0,33	0,85	1,61	2,98	0,71	0,21	0,67	0,89	1,6	1,13
	55	55	31,1	1,85	0,34	0,91	1,71	3,16	0,77	0,21	0,89	1,11	1,6	1,13
	60	55,66	31,48	1,85	0,34	0,93	1,72	3,18	0,77	0,21	0,91	1,13	1,6	1,13
	65	55,66	31,48	1,85	0,34	0,93	1,72	3,18	0,77	0,21	0,91	1,13	1,6	1,13

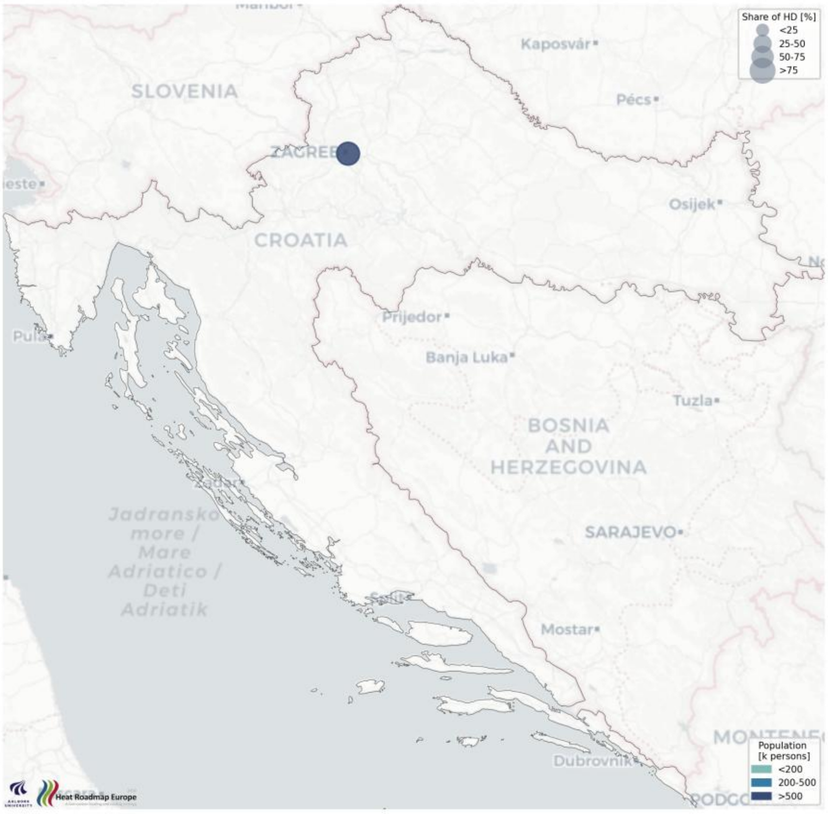


Figure 46: Geothermal energy for Croatia (Baseload of district heating area, capacity >40MW).

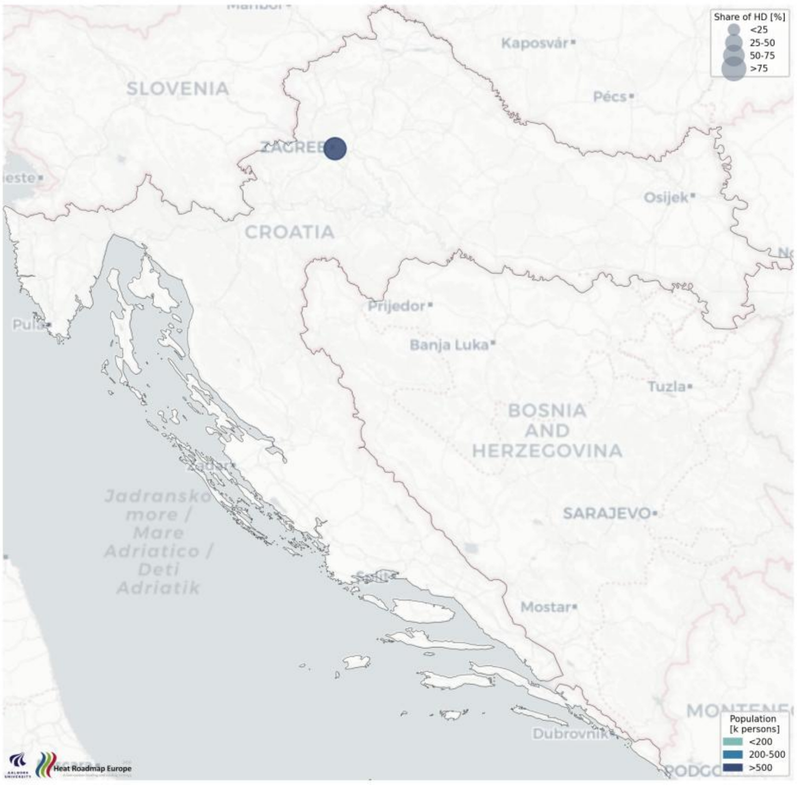


Figure 47: Geothermal energy for Croatia (Baseload of district heating area, capacity >70MW).

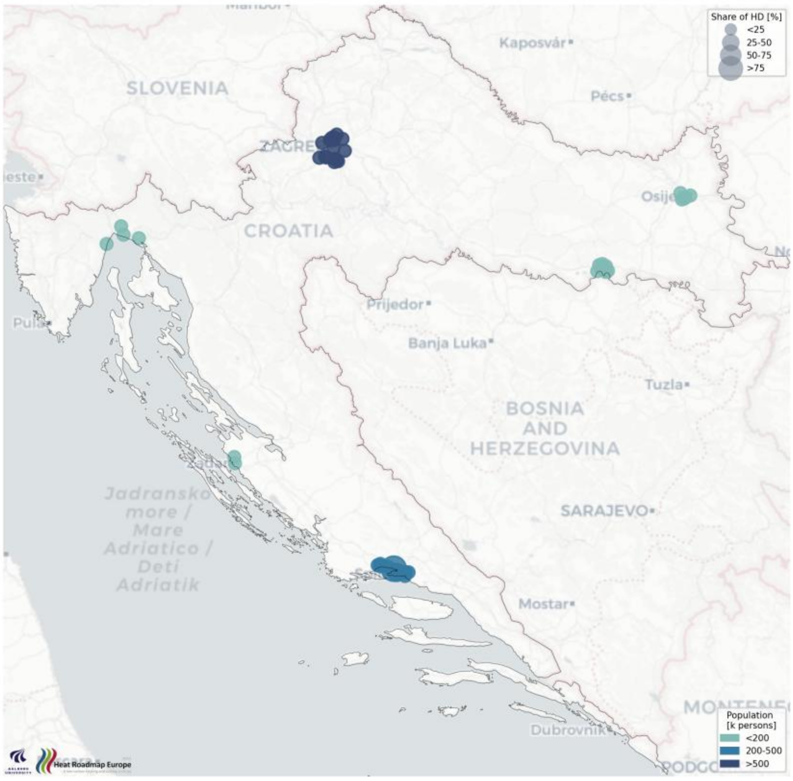


Figure 48: Baseload high temperature waste heat for Croatia.

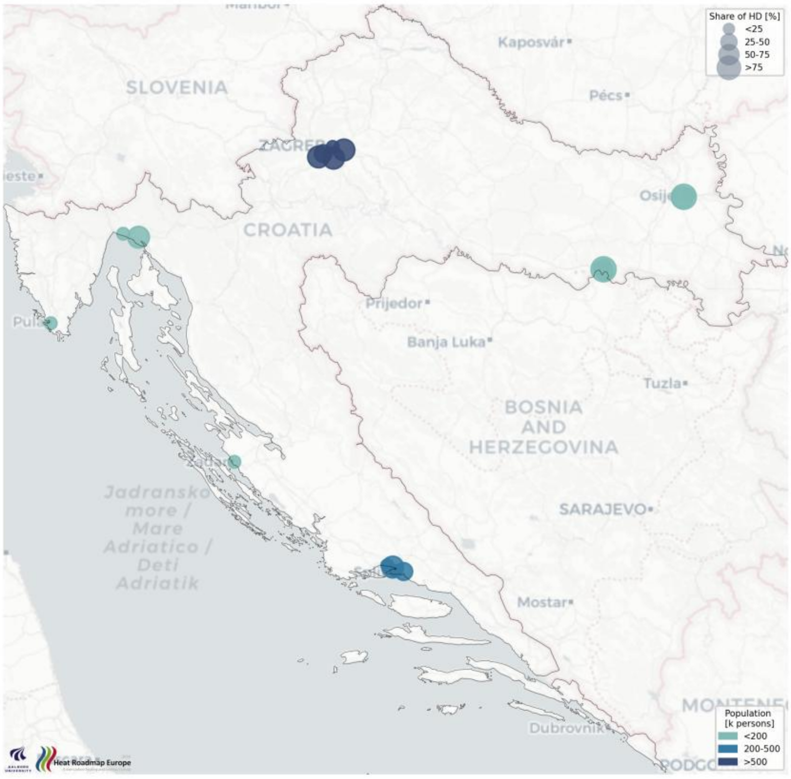


Figure 49: Baseload low temperature waste heat for Croatia.

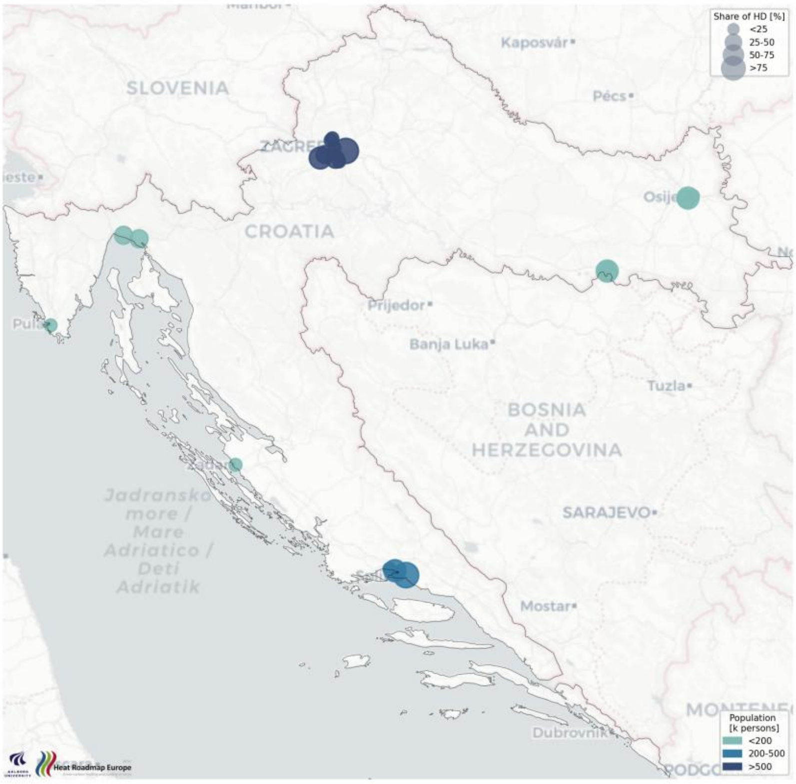


Figure 50: Baseload medium temperature waste heat for Croatia.

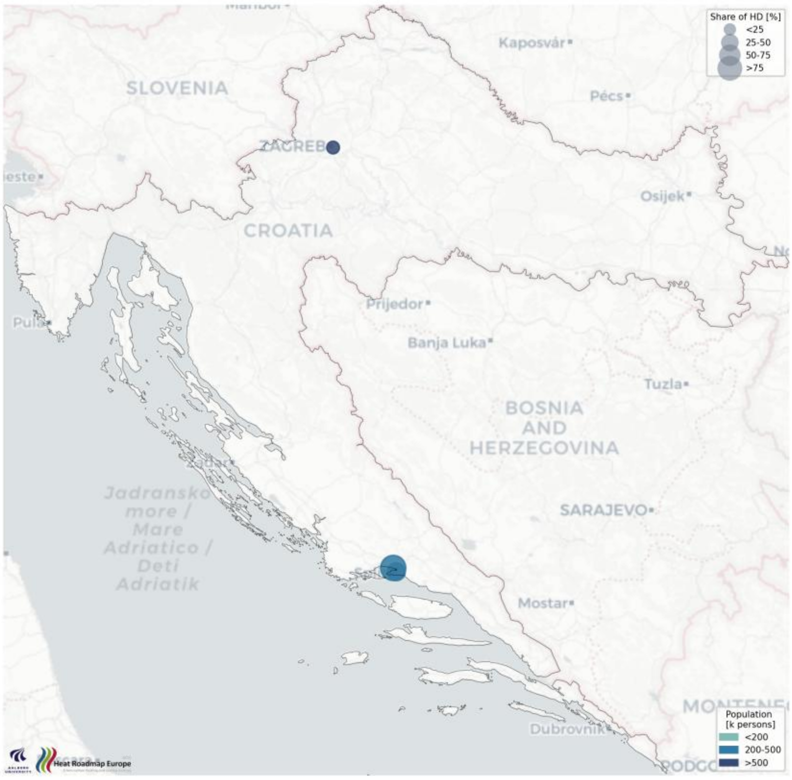


Figure 51: High temperature from industry for Croatia.

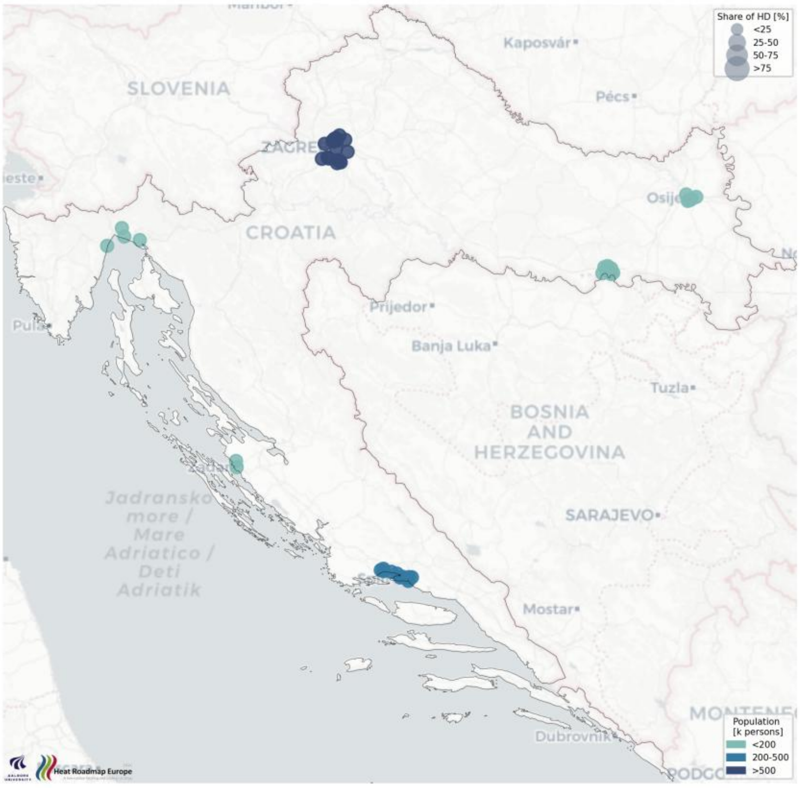


Figure 52: High temperature from waste-to-energy for Croatia.

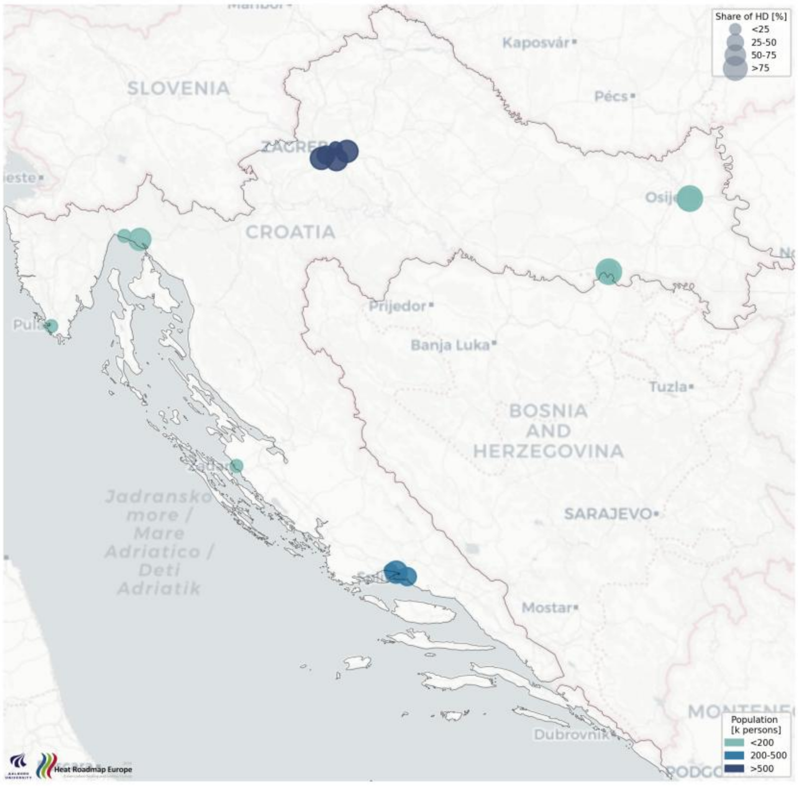


Figure 53: Low temperature from industry for Croatia.

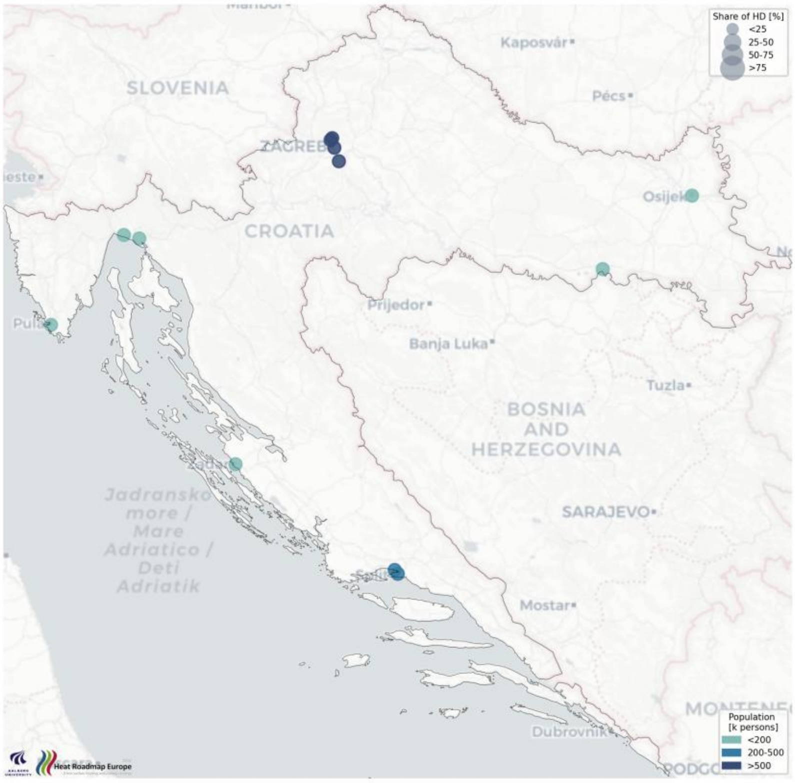


Figure 54: Low temperature from supermarkets for Croatia.

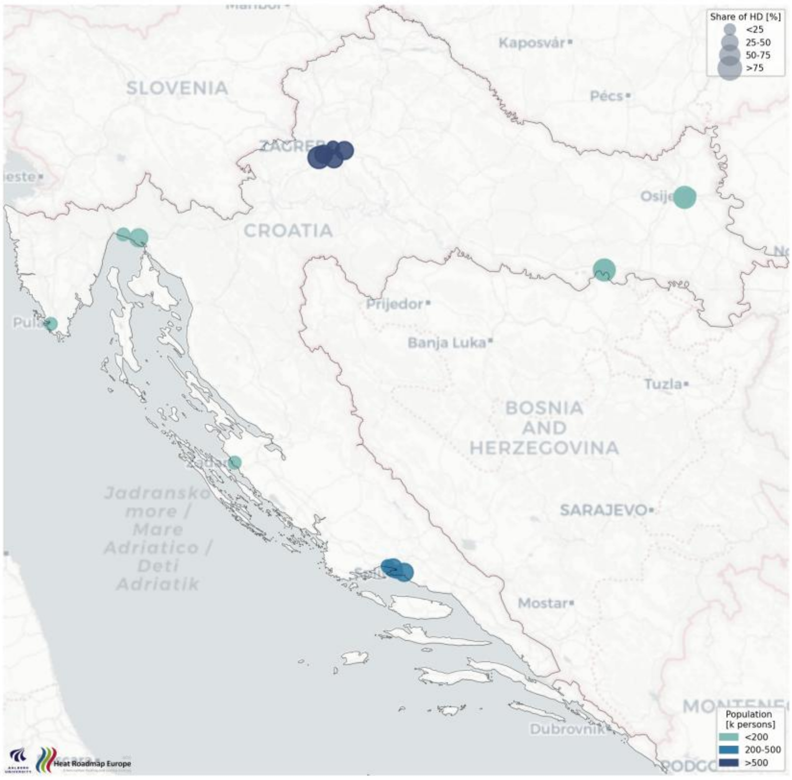


Figure 55: Medium temperature from industry for Croatia.

Figure 56: Medium temperature from wastewater treatment for Croatia.

5.5 Czech Republic

Table 30: District heating shares specific to Czech Republic and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Czechia	5	8,3	5,39	0,64	0	0,27	0,4	0,82	0,04	0,19	0	0	0	0
	10	11,05	7,18	0,88	0,56	0,27	0,4	0,82	0,04	0,19	0	0	0	0
	15	16,17	10,51	1,28	0,57	0,53	0,79	0,89	0,07	0,19	0	0,03	0,22	0,22
	20	20,18	13,11	1,53	0,57	0,72	1,08	1,11	0,1	0,19	0	0,07	0,22	0,22
	25	25,19	16,36	1,99	0,79	0,92	1,36	1,2	0,13	0,19	0,04	0,12	0,22	0,22
	30	30,11	19,56	2,13	0,85	1,13	1,68	1,46	0,18	0,19	0,13	0,21	0,22	0,22
	35	35,1	22,8	2,19	0,92	1,44	2,02	1,81	0,23	0,19	0,2	0,28	0,22	0,22
	40	40,03	26	2,23	0,96	1,71	2,39	2,02	0,31	0,19	0,31	0,39	0,22	0,22
	45	45,04	29,25	2,25	0,99	2,03	2,81	2,24	0,39	0,19	0,41	0,49	0,22	0,22
	50	50,01	32,48	2,29	1,01	2,37	3,15	2,42	0,43	0,19	0,53	0,61	0,22	0,22
	55	55	35,73	2,35	1,03	2,65	3,34	2,59	0,45	0,19	0,71	0,79	0,22	0,22
	60	56,78	36,88	2,37	1,03	2,73	3,37	2,64	0,45	0,19	0,79	0,87	0,22	0,22
	65	56,78	36,88	2,37	1,03	2,73	3,37	2,64	0,45	0,19	0,79	0,87	0,22	0,22

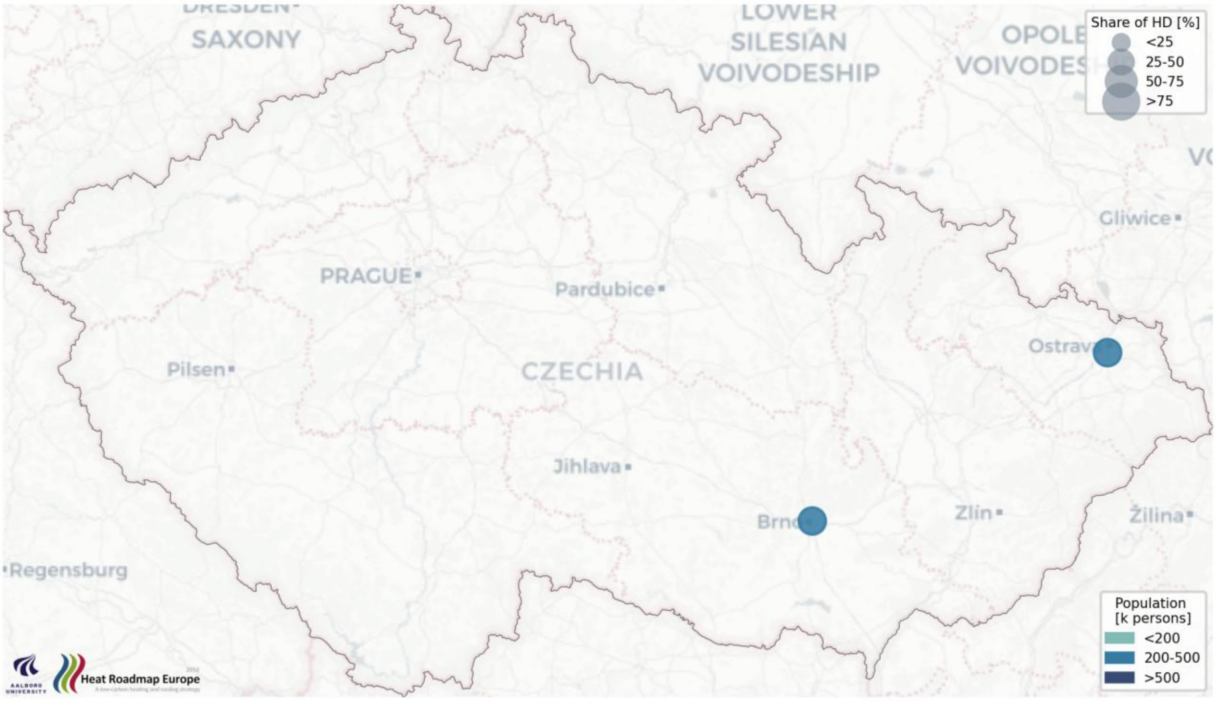


Figure 57: Geothermal energy for Czech Republic (Baseload of district heating area, capacity >40MW).

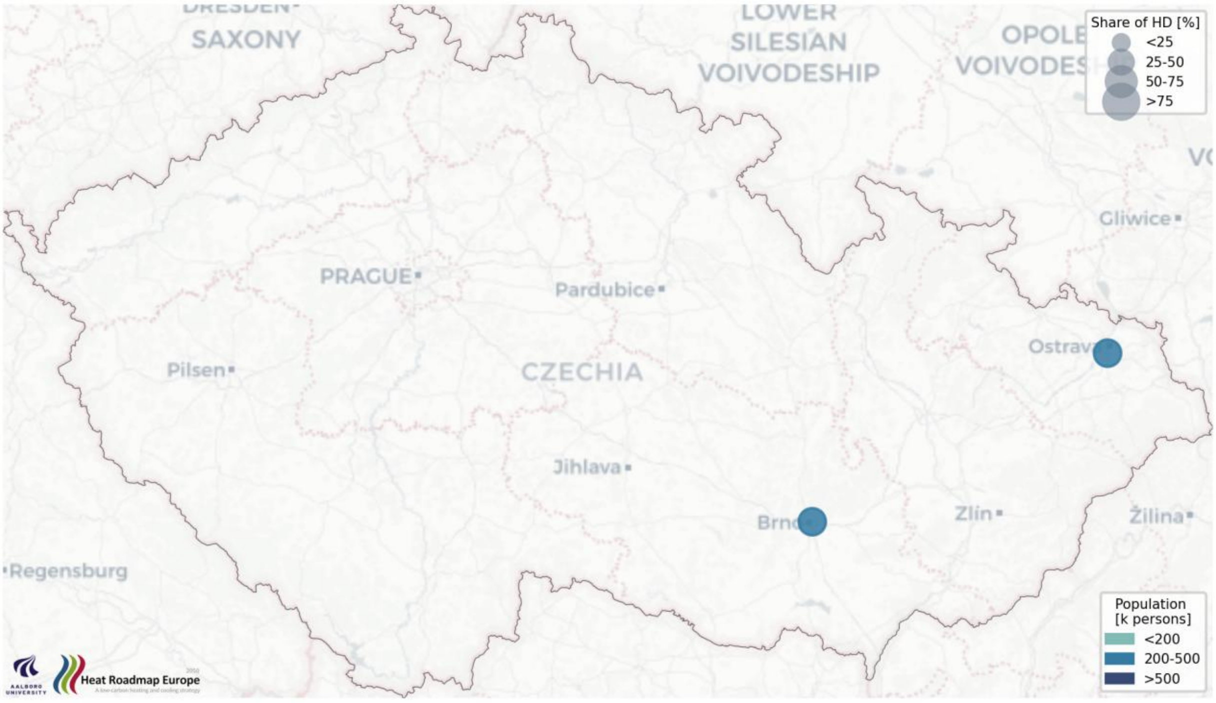


Figure 58: Geothermal energy for Czech Republic (Baseload of district heating area, capacity >70MW).

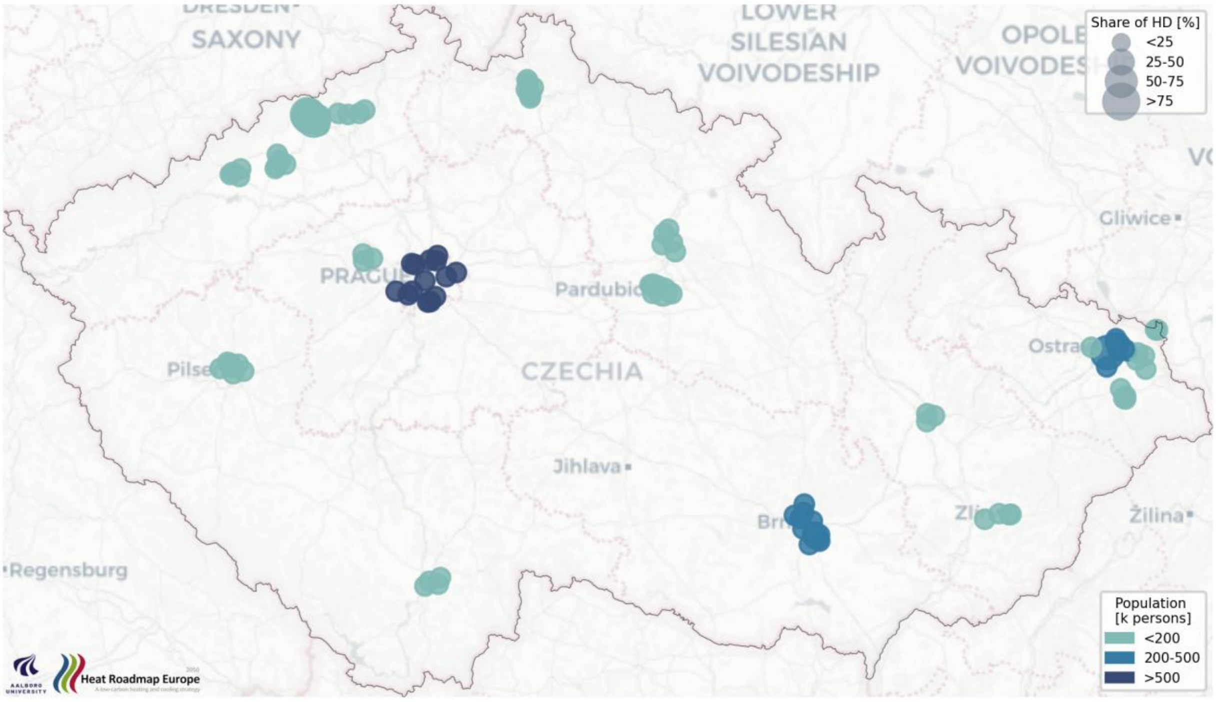


Figure 59: Baseload high temperature waste heat for Czech Republic.

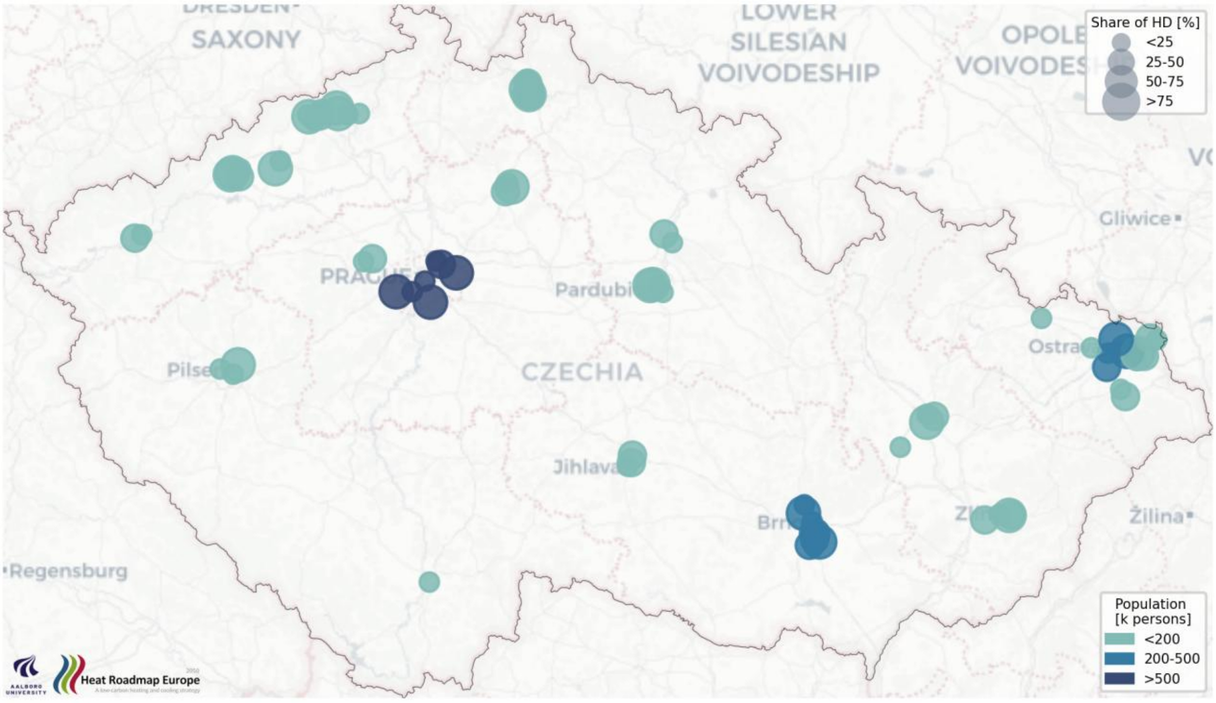


Figure 60: Baseload low temperature waste heat for Czech Republic.

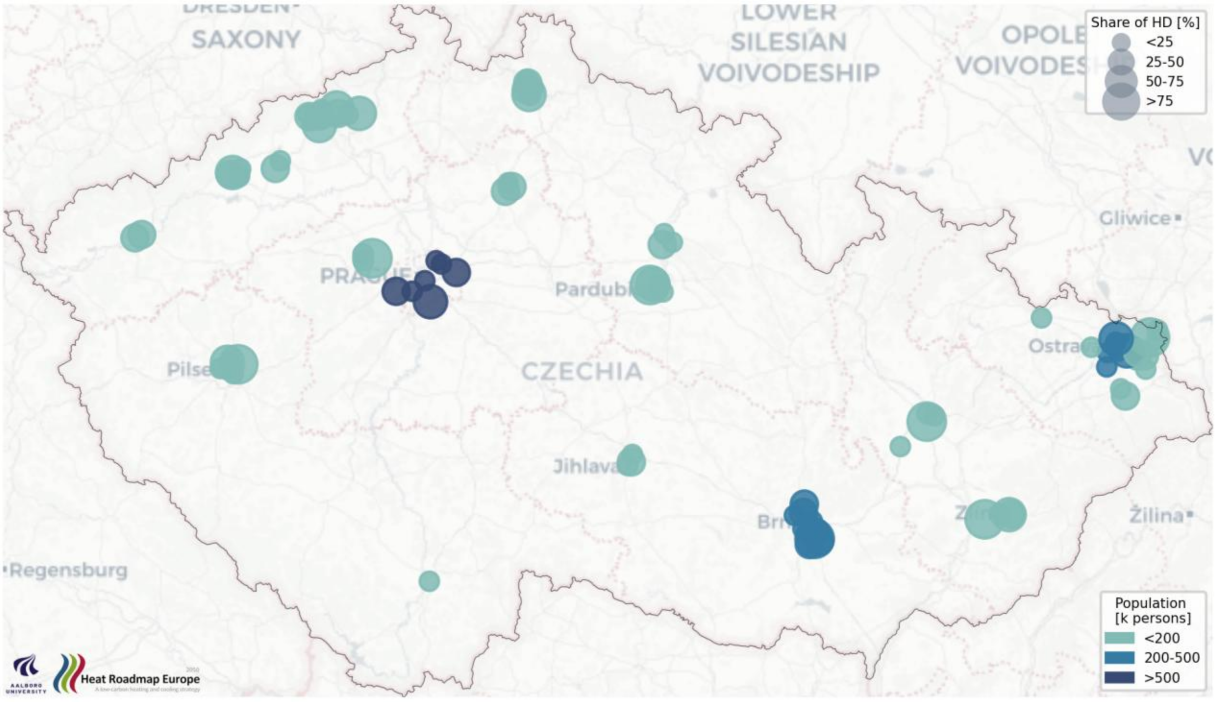


Figure 61: Baseload medium temperature waste heat for Czech Republic.

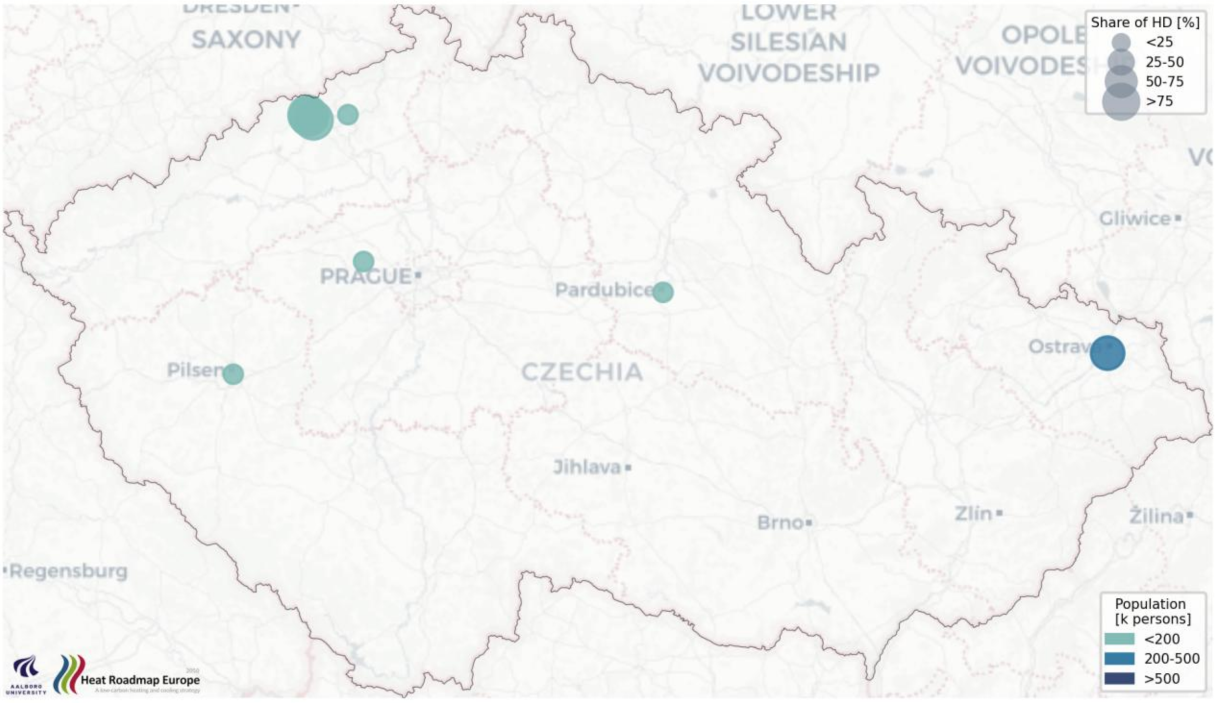


Figure 62: High temperature from industry for Czech Republic.

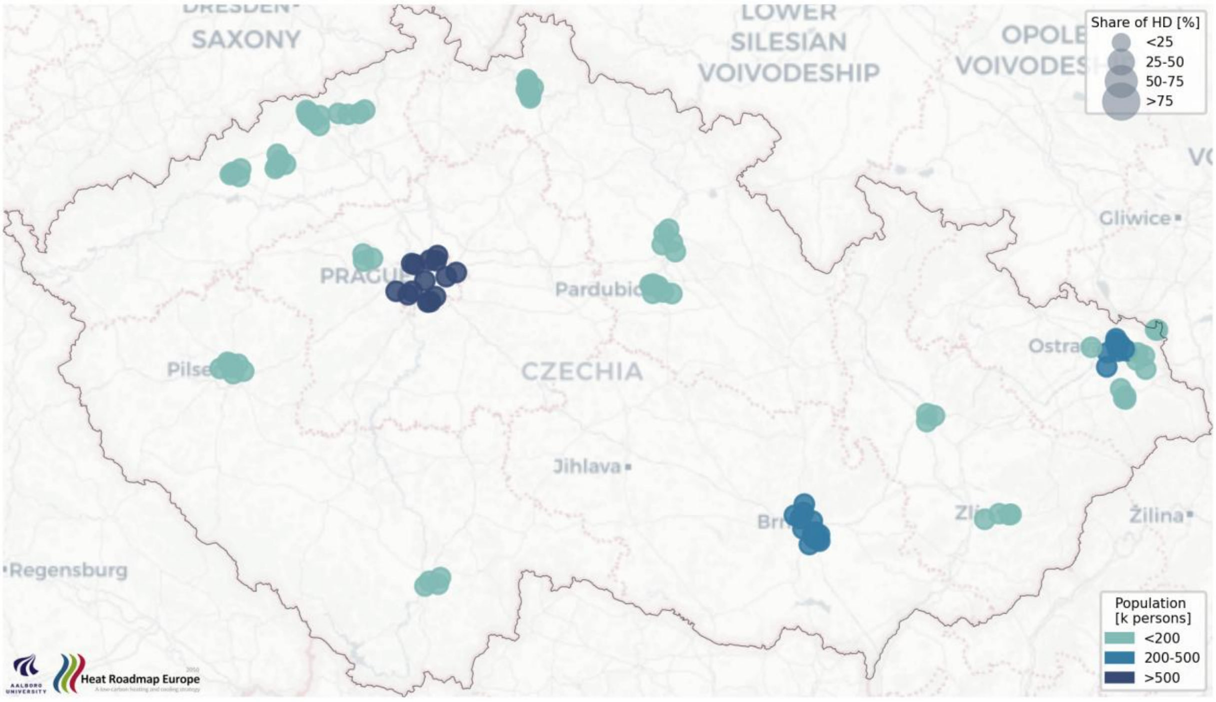


Figure 63: High temperature from waste-to-energy for Czech Republic.

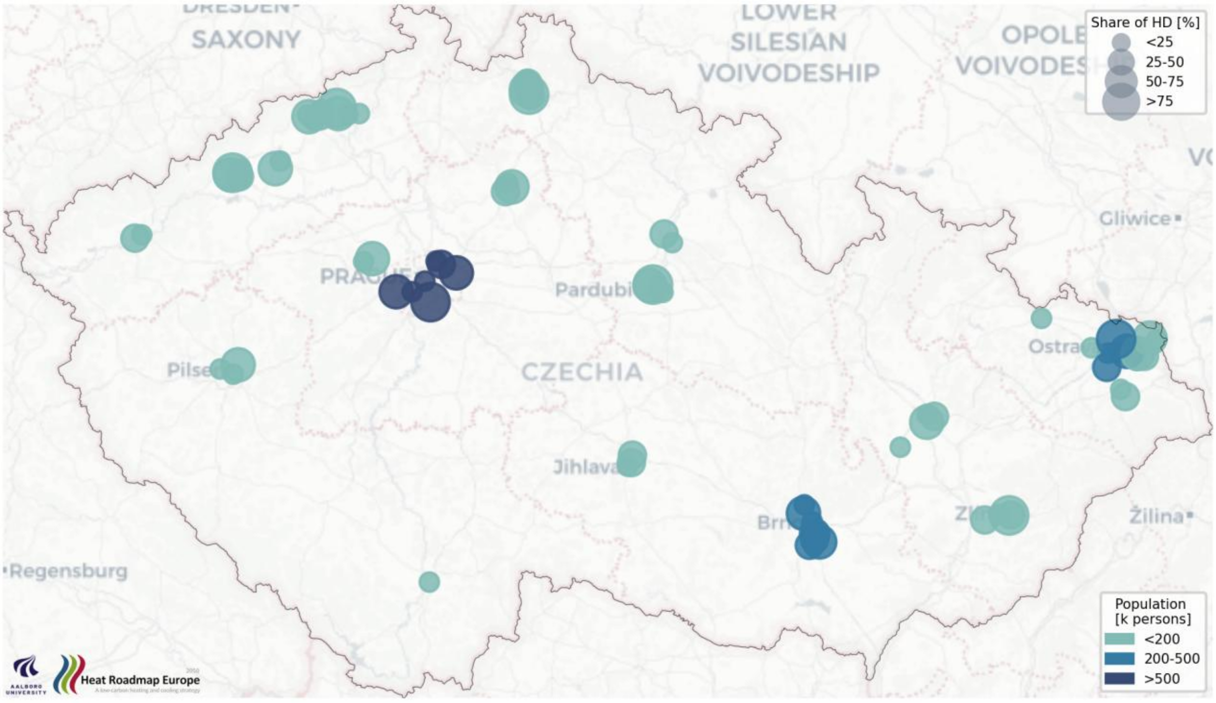


Figure 64: Low temperature from industry for Czech Republic.

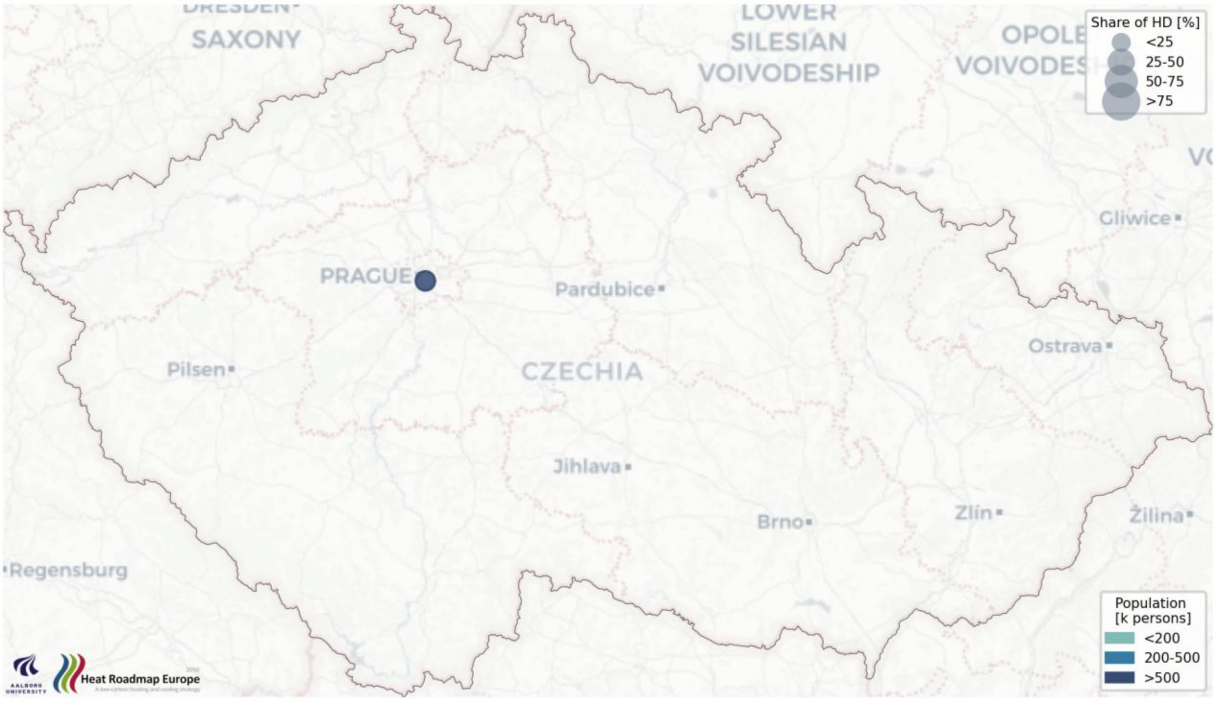


Figure 65: Low temperature from metros for Czech Republic.

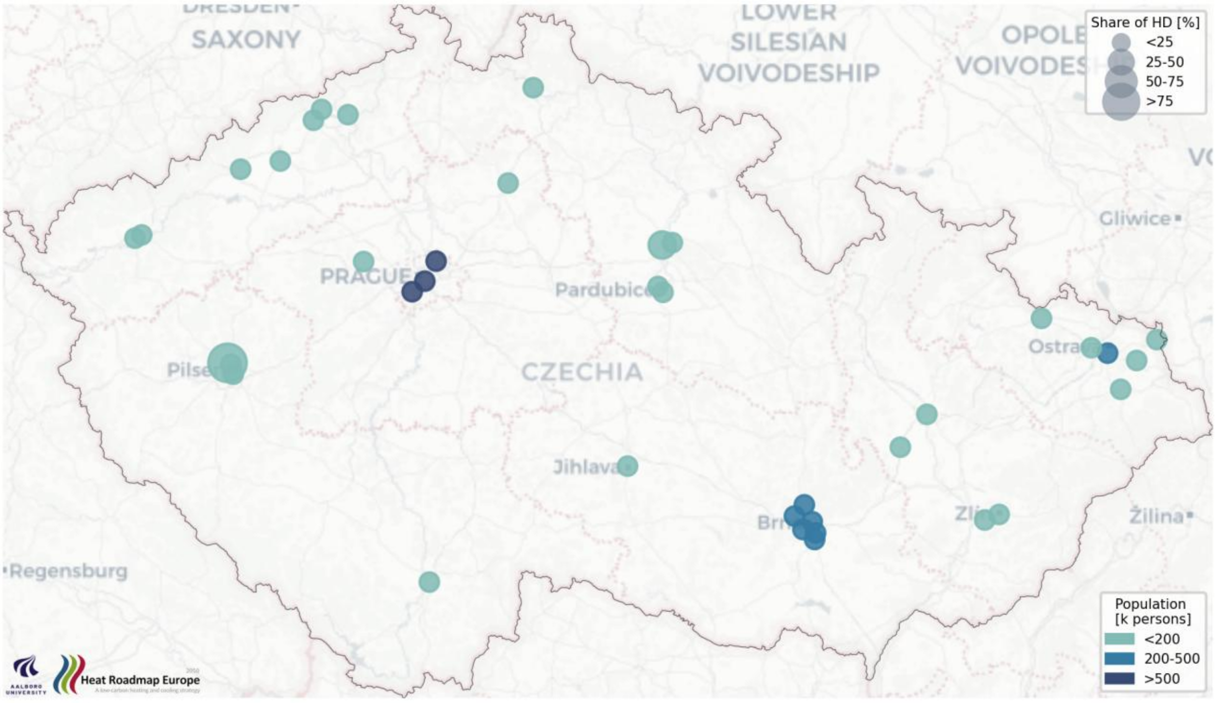


Figure 66: Low temperature from supermarkets for Czech Republic.

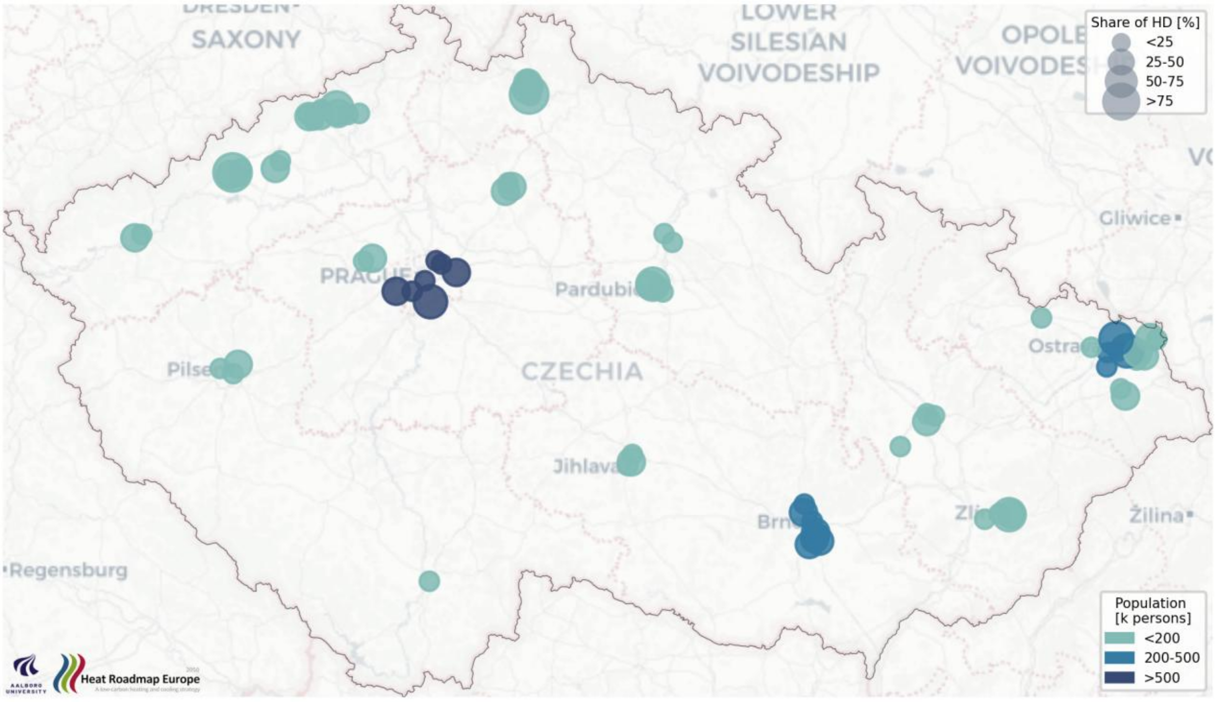


Figure 67: Medium temperature from industry for Czech Republic.

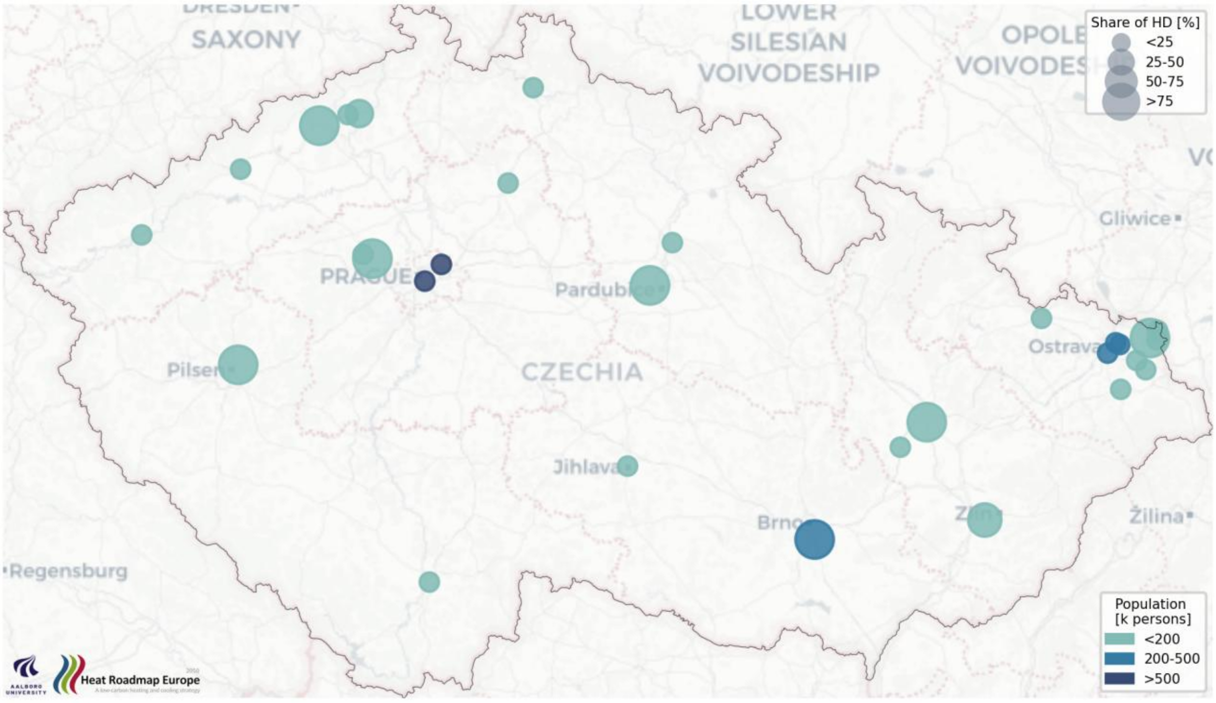


Figure 68: Medium temperature from wastewater treatment for Czech Republic.

5.6 Denmark

Table 31: District heating shares specific to Denmark and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Denmark	5	18,32	11,65	0,75	0	0,32	0,44	0,68	0,04	0,04	0	0	2,75	2,75
	10	18,32	11,65	0,75	0	0,32	0,44	0,68	0,04	0,04	0	0	2,75	2,75
	15	18,32	11,65	0,75	0	0,32	0,44	0,68	0,04	0,04	0	0	2,75	2,75
	20	22,6	14,38	0,94	0	0,46	0,65	0,86	0,06	0,04	0	0	3,26	3,26
	25	26,75	17,01	1,18	0,44	0,57	0,79	0,98	0,1	0,04	0	0	3,44	3,44
	30	30,18	19,2	1,58	0,44	0,74	0,97	1,07	0,12	0,04	0	0,03	3,44	3,44
	35	35,37	22,5	1,7	0,44	1,06	1,43	1,29	0,18	0,04	0	0,09	3,44	3,44
	40	40,29	25,63	1,7	0,65	1,36	1,84	1,49	0,24	0,04	0,04	0,15	3,44	3,44
	45	45,06	28,66	1,87	0,77	1,64	2,19	1,65	0,31	0,04	0,1	0,21	3,44	3,44
	50	50,15	31,9	2,01	0,77	1,96	2,58	1,96	0,4	0,04	0,16	0,27	3,44	3,44
	55	55,01	34,99	2,05	0,77	2,33	2,96	2,16	0,5	0,04	0,24	0,35	3,44	3,44
	60	60,03	38,18	2,11	0,79	2,6	3,28	2,33	0,65	0,04	0,35	0,46	3,44	3,44
	65	65	41,35	2,13	0,79	2,78	3,39	2,47	0,85	0,04	0,51	0,63	3,44	3,44

Figure 69: Geothermal energy for Denmark (Baseload of district heating area, capacity >40MW).

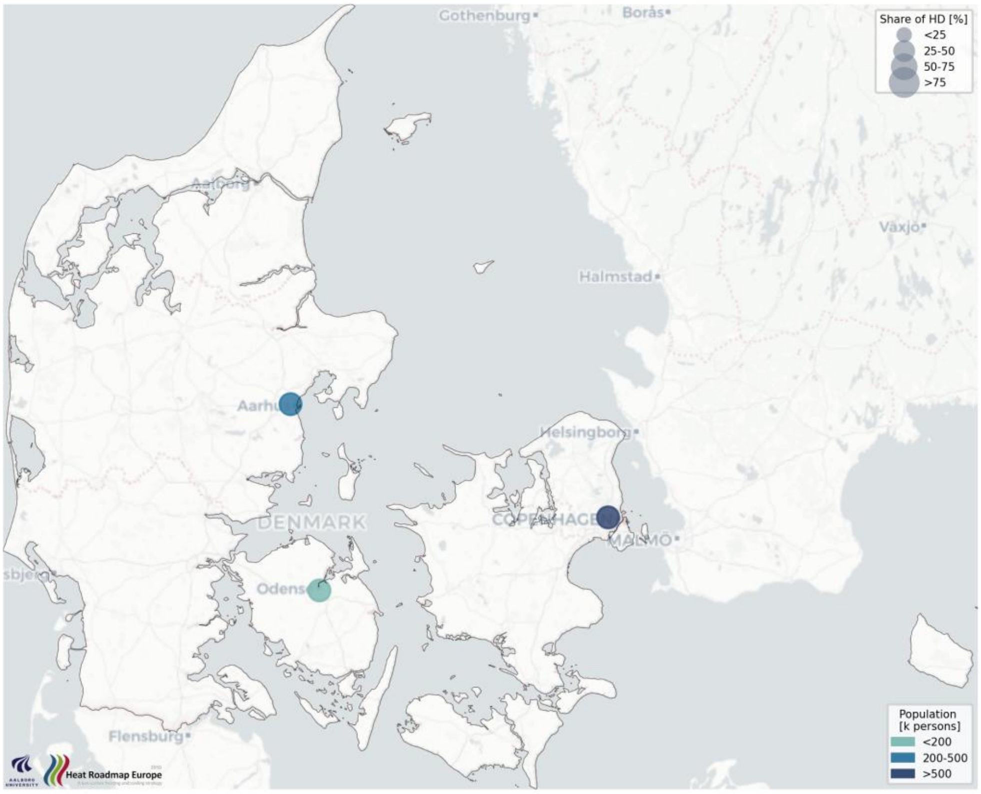


Figure 70: Geothermal energy for Denmark (Baseload of district heating area, capacity >70MW).

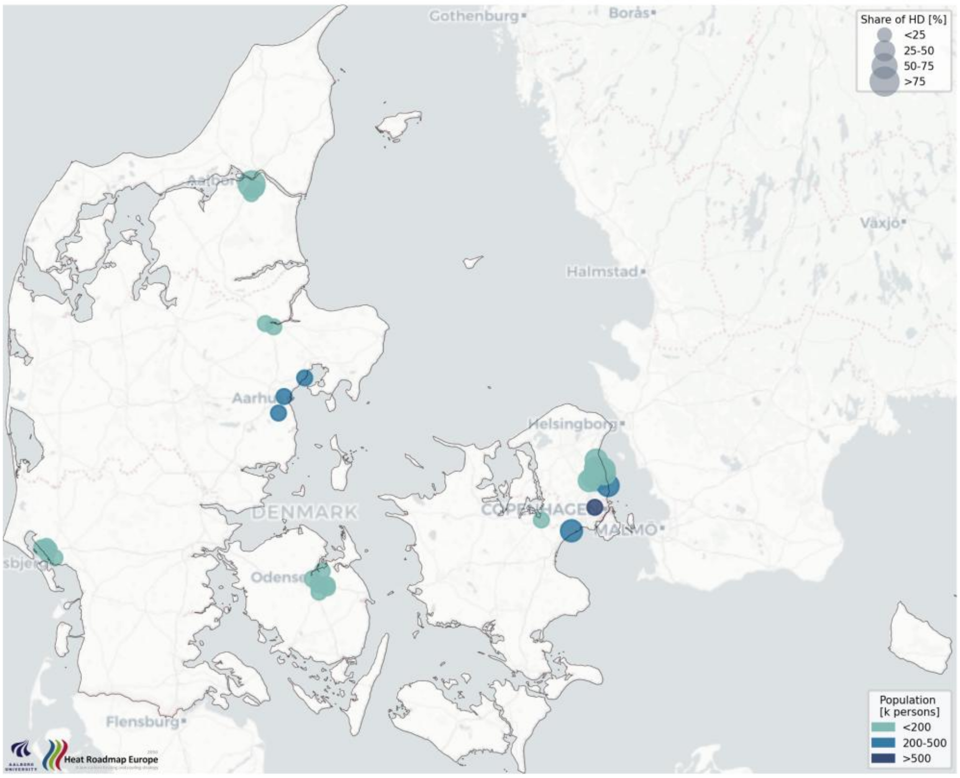


Figure 71: Baseload high temperature waste heat for Denmark.

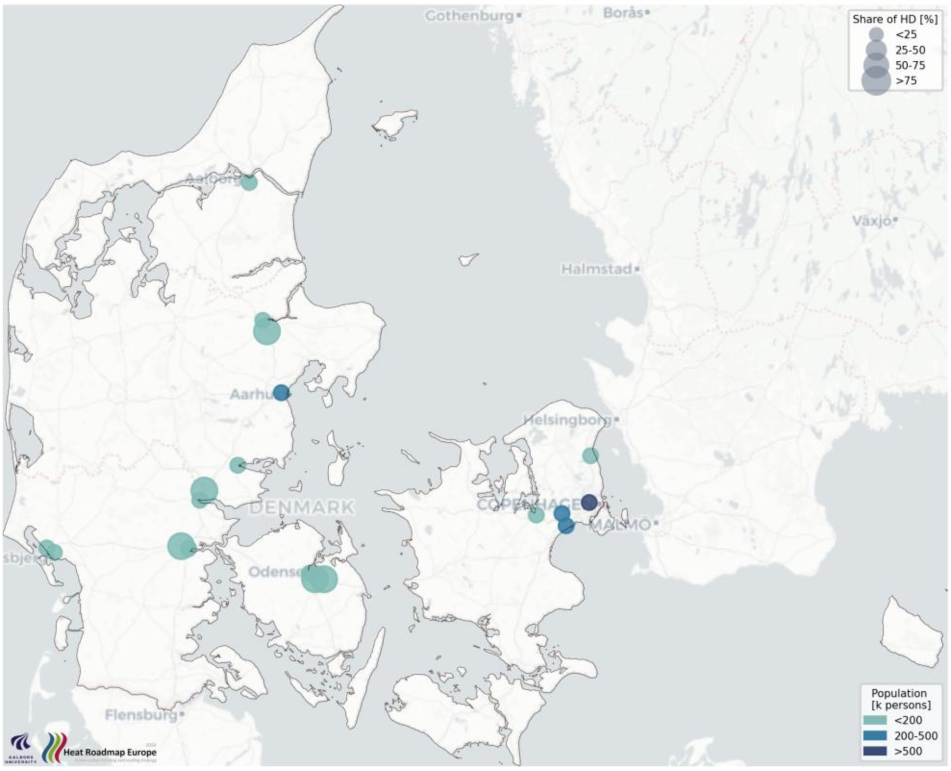


Figure 72: Baseload low temperature waste heat for Denmark.

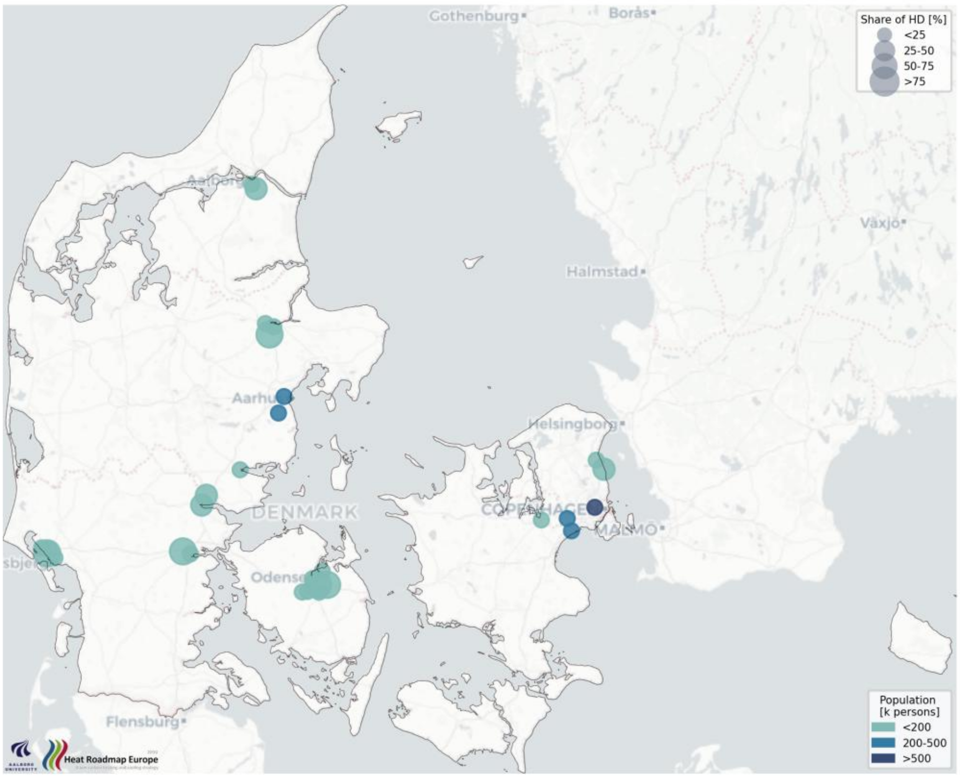


Figure 73: Baseload medium temperature waste heat for Denmark.

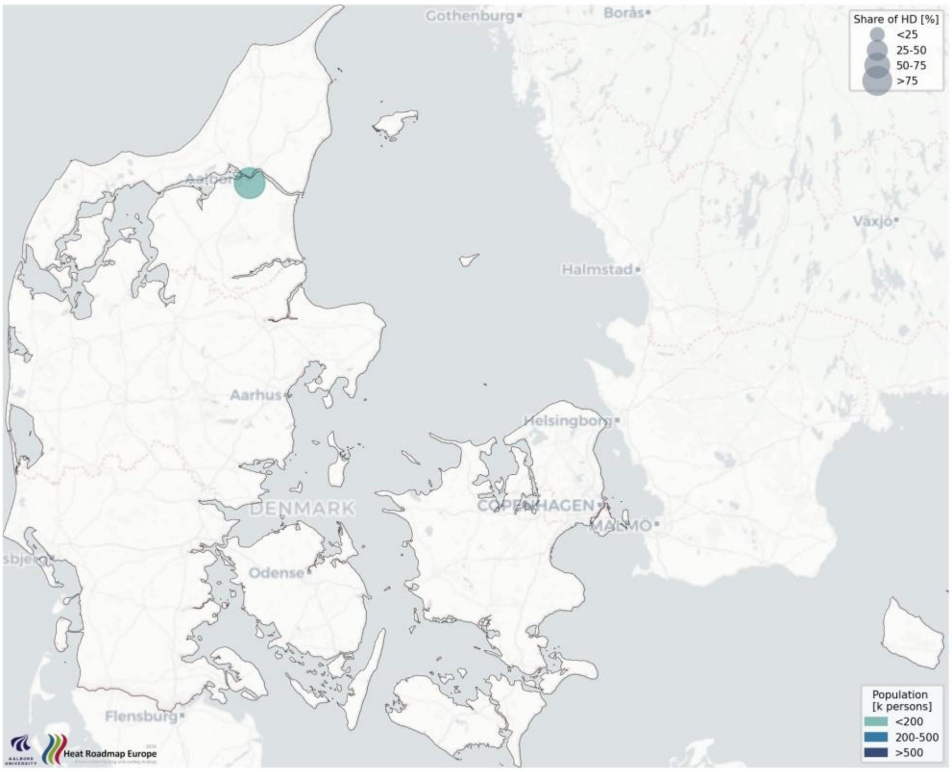


Figure 74: High temperature from industry for Denmark.

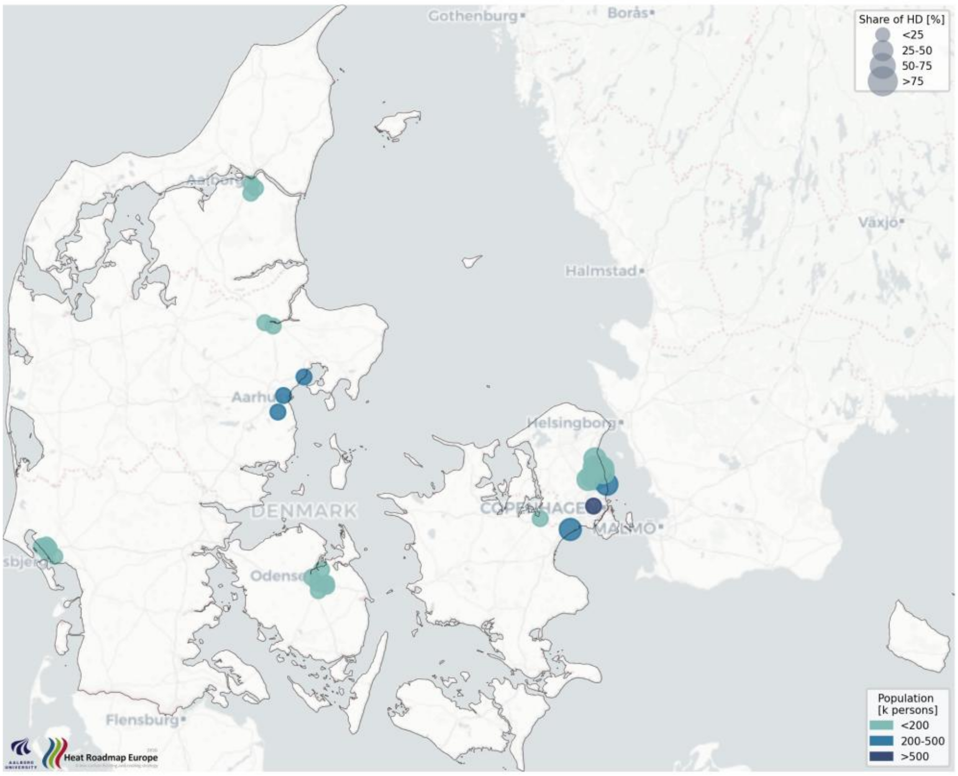


Figure 75: High temperature from waste-to-energy for Denmark.

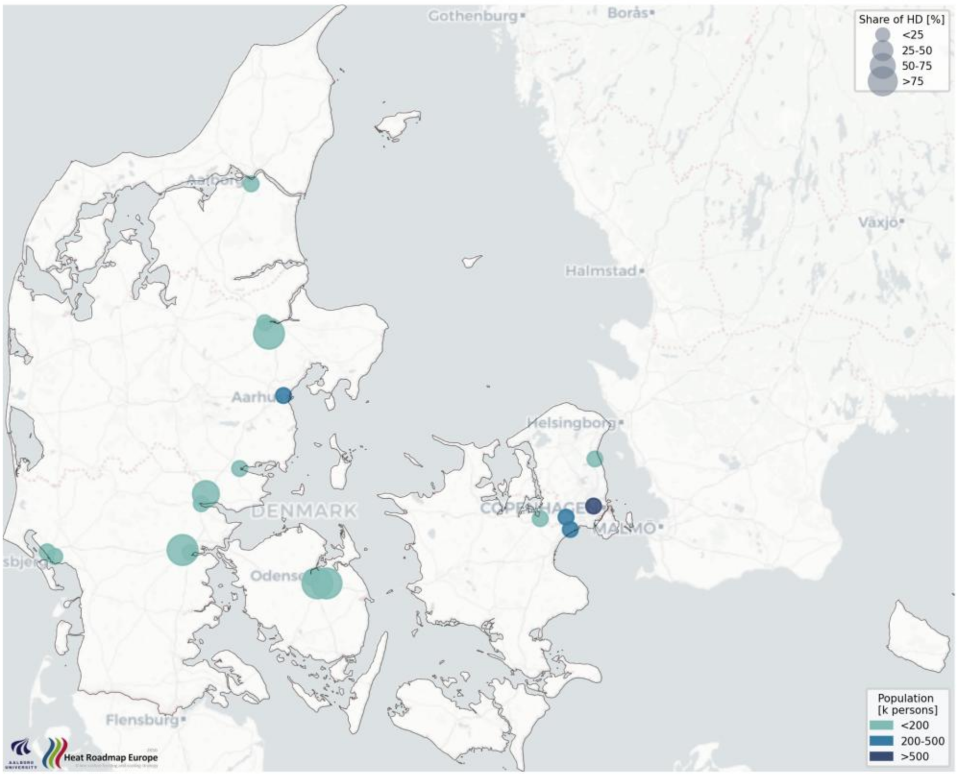


Figure 76: Low temperature from industry for Denmark.

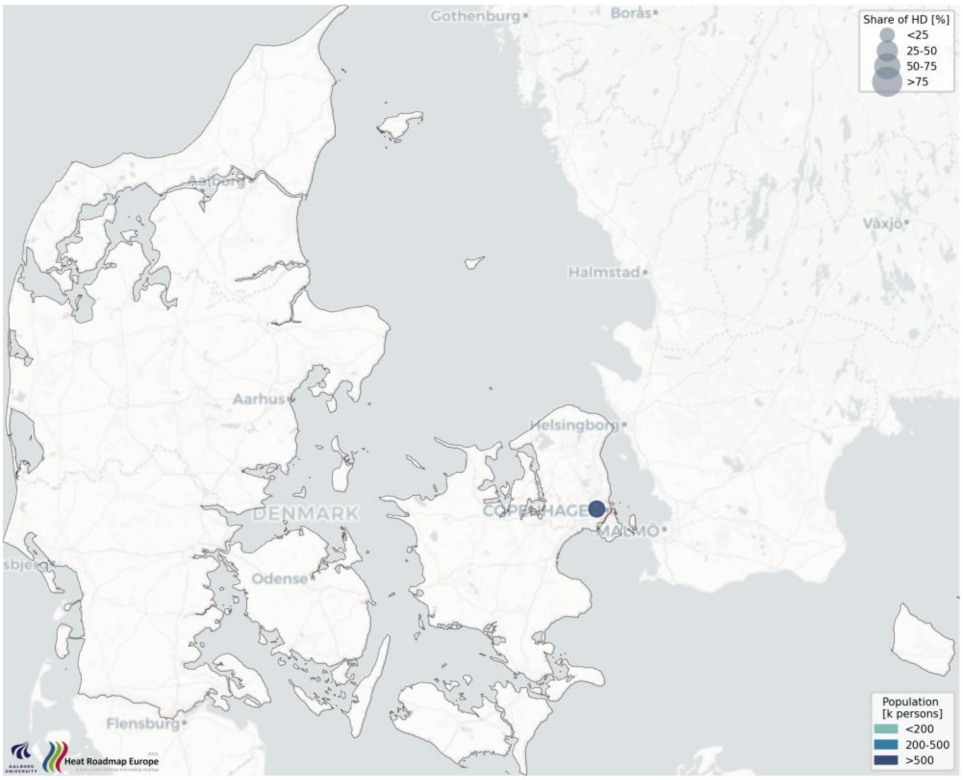


Figure 77: Low temperature from metros for Denmark.

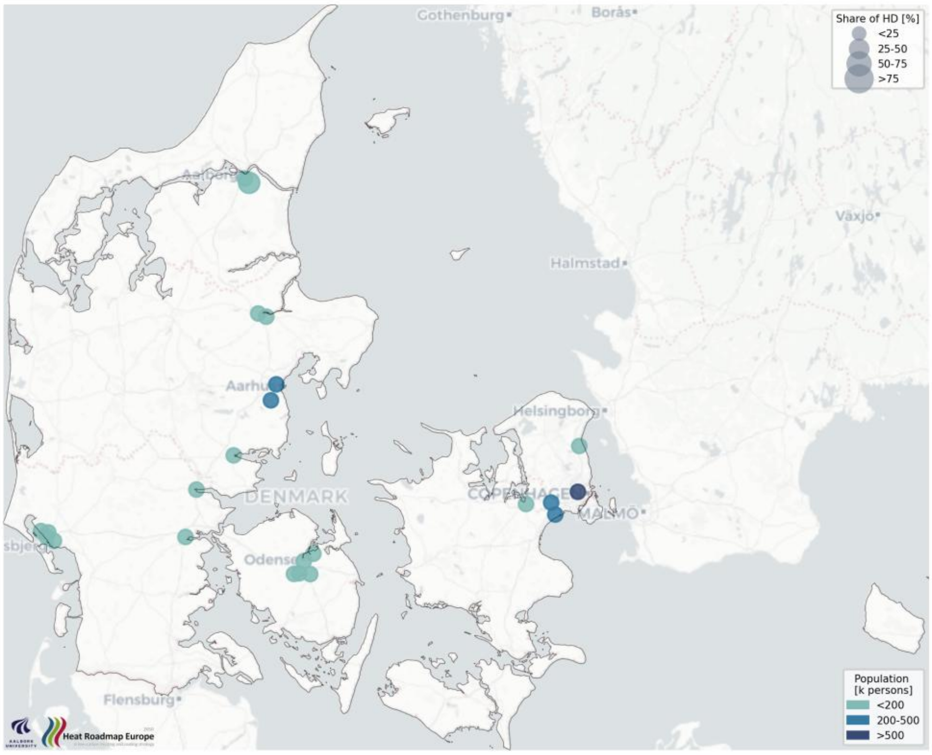


Figure 78: Low temperature from supermarkets for Denmark.

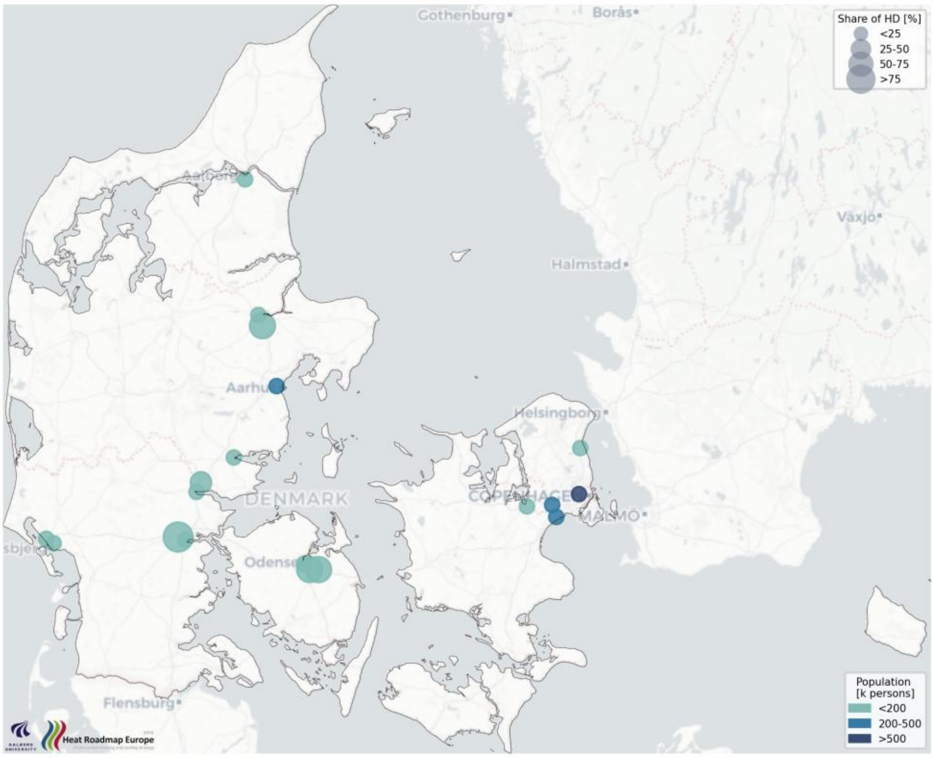


Figure 79: Medium temperature from industry for Denmark.

Figure 80: Medium temperature from wastewater treatment for Denmark.

5.7 Estonia

Table 32: District heating shares specific to Estonia and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Estonia	5	23,76	3,35	0,6	0	0,06	0,09	0	0,01	0	0	0	0	0
	10	23,76	3,35	0,6	0	0,06	0,09	0	0,01	0	0	0	0	0
	15	23,76	3,35	0,6	0	0,06	0,09	0	0,01	0	0	0	0	0
	20	23,76	3,35	0,6	0	0,06	0,09	0	0,01	0	0	0	0	0
	25	29,2	4,11	0,78	0	0,07	0,1	0,05	0,01	0	0	0,01	0	0
	30	32,48	4,58	0,78	0	0,08	0,11	0,08	0,02	0	0	0,03	0	0
	35	35,14	4,95	0,78	0	0,08	0,13	0,08	0,02	0	0,02	0,05	0	0
	40	40,17	5,66	0,78	0	0,1	0,15	0,08	0,02	0	0,06	0,09	0	0
	45	45,01	6,34	0,8	0	0,12	0,18	0,1	0,03	0	0,09	0,11	0	0
	50	50	7,04	0,83	0,01	0,15	0,22	0,13	0,04	0	0,11	0,14	0	0
	55	50,17	7,07	0,84	0,01	0,15	0,22	0,13	0,04	0	0,12	0,14	0	0
	60	50,17	7,07	0,84	0,01	0,15	0,22	0,13	0,04	0	0,12	0,14	0	0
	65	50,17	7,07	0,84	0,01	0,15	0,22	0,13	0,04	0	0,12	0,14	0	0

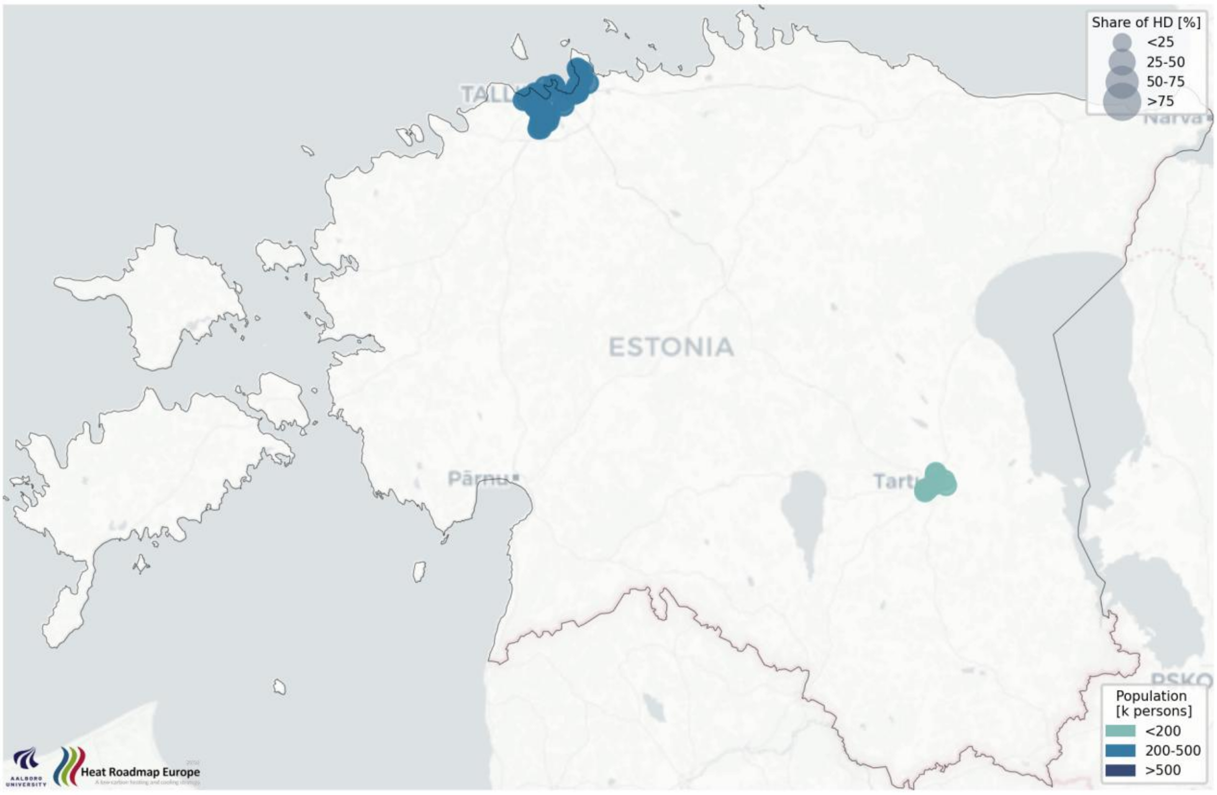


Figure 81: Baseload high temperature waste heat for Estonia.

Figure 82: Baseload low temperature waste heat for Estonia.

Figure 83: Baseload medium temperature waste heat for Estonia

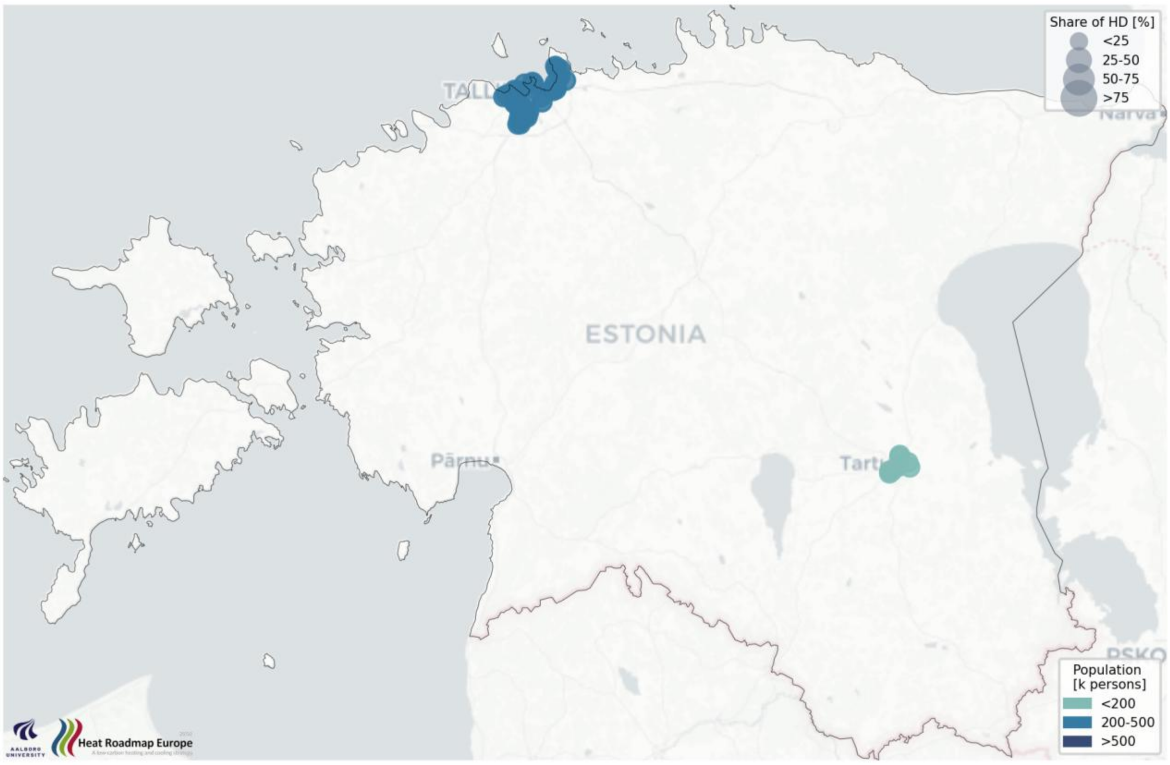


Figure 84: High temperature from waste-to-energy for Estonia.

Figure 85: Low temperature from industry for Estonia

Figure 86: Low temperature from supermarkets for Estonia

Figure 87: Medium temperature from industry for Estonia.

Figure 88: Medium temperature from wastewater treatment for Estonia.

5.8 Finland

Table 33: District heating shares specific to Finland and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Finland	5	11,06	7,75	1,25	0	0,2	0,47	0	0,02	0,03	0	0	0	0
	10	11,06	7,75	1,25	0	0,2	0,47	0	0,02	0,03	0	0	0	0
	15	18,01	12,63	2,09	0,01	0,41	0,95	0,4	0,04	0,03	0	0	0	0
	20	20,89	14,65	2,37	0,16	0,5	1,15	0,53	0,06	0,03	0	0	0	0
	25	25,03	17,55	2,74	0,16	0,62	1,43	0,66	0,07	0,03	0	0,06	0	0
	30	30,24	21,2	3	0,32	0,8	1,81	0,92	0,1	0,05	0	0,13	0	0
	35	35,14	24,64	3,24	0,45	0,96	2,18	1,01	0,11	0,05	0,07	0,22	0	0
	40	40,14	28,14	3,47	0,63	1,12	2,55	1,16	0,12	0,05	0,16	0,31	0	0
	45	45,05	31,59	3,63	0,76	1,36	3,1	1,27	0,15	0,05	0,25	0,39	0	0
	50	50,01	35,07	3,77	0,88	1,58	3,57	1,38	0,18	0,05	0,36	0,5	0	0
	55	55	38,56	3,88	0,92	1,77	3,96	1,49	0,22	0,05	0,5	0,64	0	0
	60	55,45	38,88	3,89	0,92	1,77	3,97	1,5	0,22	0,05	0,52	0,66	0	0
	65	55,45	38,88	3,89	0,92	1,77	3,97	1,5	0,22	0,05	0,52	0,66	0	0

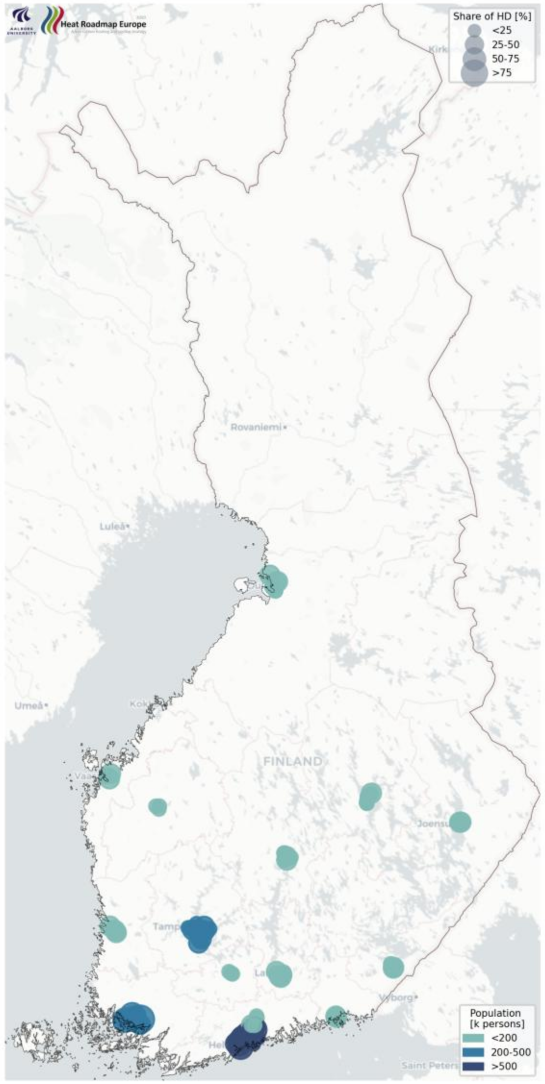


Figure 89: Baseload high temperature waste heat for Finland. Figure 90: Baseload low temperature waste heat for Finland.

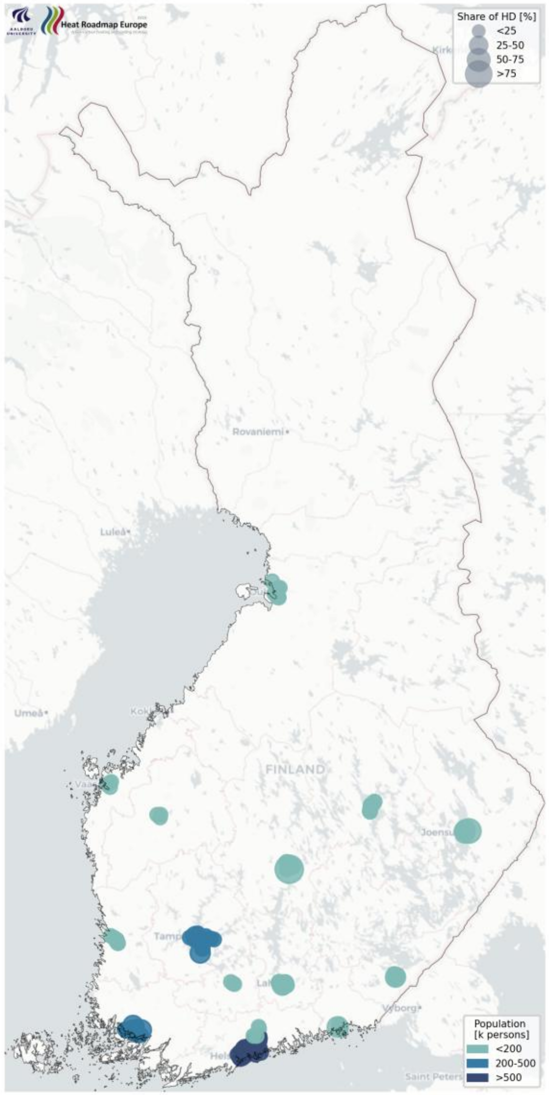


Figure 91: Baseload medium temperature waste heat for Finland.

Figure 92: High temperature from industry for Finland.

Figure 93: High temperature from waste-to-energy for Finland.

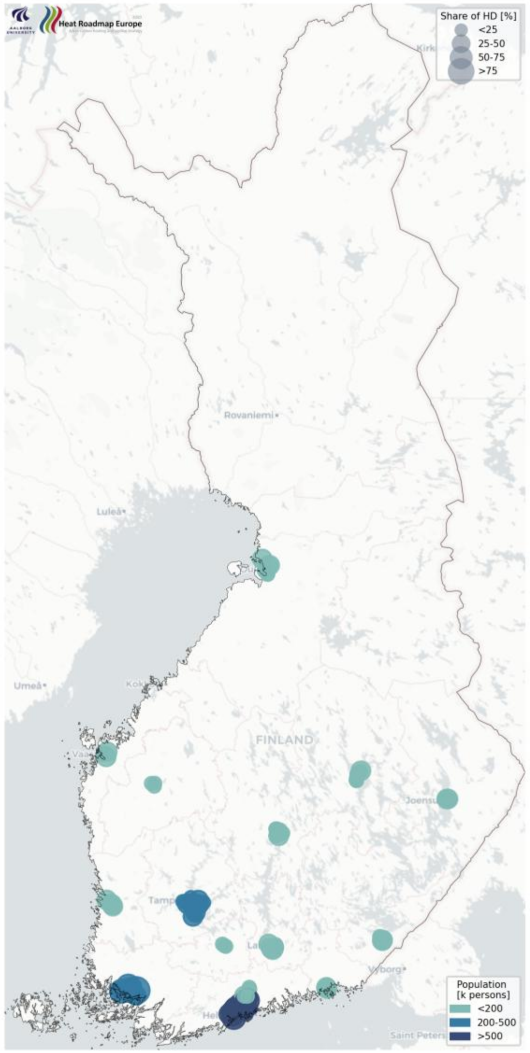


Figure 94: Low temperature from industry for Finland.

Figure 95: Low temperature from metros for Finland.

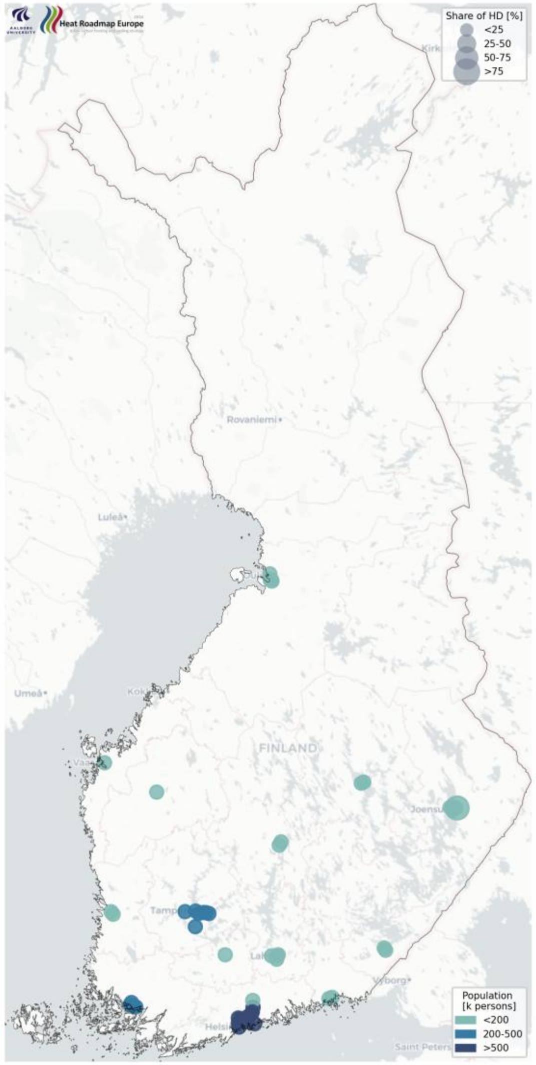
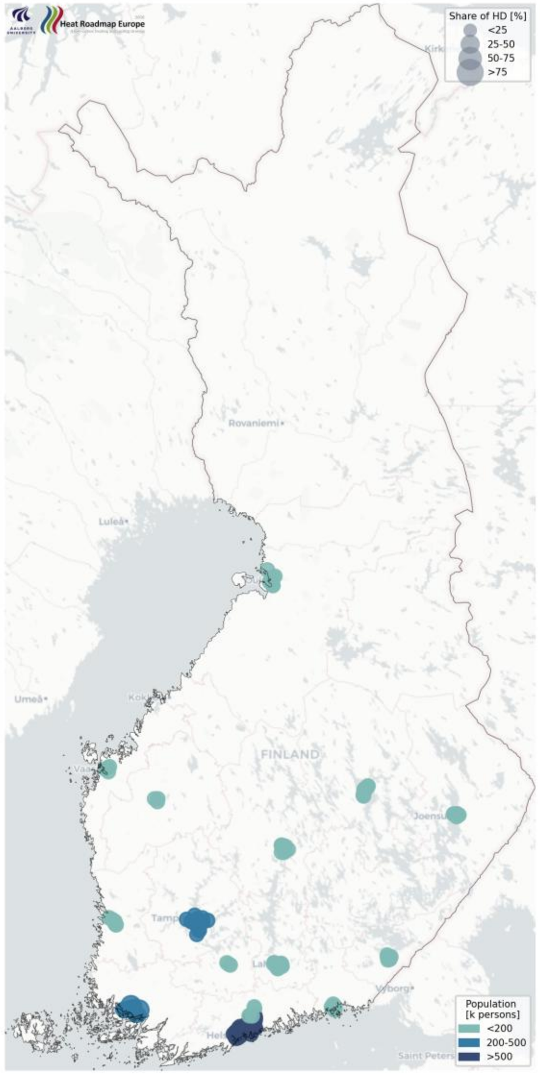


Figure 96: Low temperature from supermarkets for Finland.



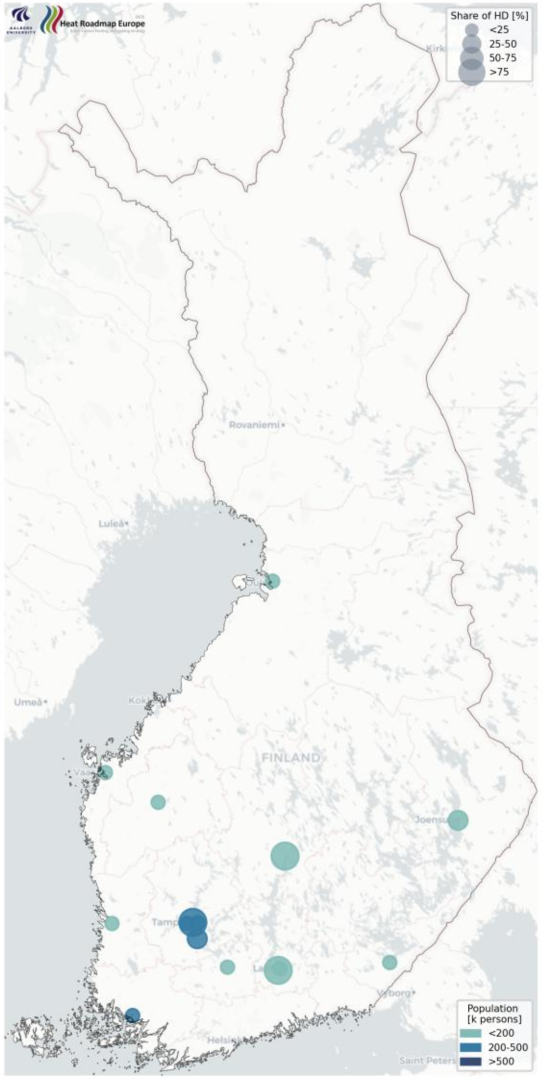


Figure 97: Medium temperature from industry for Finland. *Figure 98: Medium temperature from wastewater treatment for Finland*

5.9 France

Table 34: District heating shares specific to France and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
France	5	10,66	44,39	4,84	0,02	1,19	1,98	2,27	0,2	1,43	0	0	8,56	8,56
	10	10,66	44,39	4,84	0,02	1,19	1,98	2,27	0,2	1,43	0	0	8,56	8,56
	15	15,6	64,95	7,38	0,47	2,33	3,87	4,48	0,35	1,96	0	0	9,78	9,78
	20	20,55	85,57	10,08	1,28	3,61	5,83	5,96	0,52	1,96	0	0	11,14	11,1
	25	25,28	105,2	12,67	1,42	5,18	8,14	7,6	0,72	1,96	0	0	12,44	12,4
	30	30,01	124,9	15,95	2,96	6,62	10,1	8,91	0,86	1,96	0	0,17	12,96	12,4
	35	35,06	146	18,84	3,64	8,33	12,8	10,78	1,08	1,96	0	0,43	13,14	12,4
	40	40,02	166,6	20,45	4,28	10,23	15,62	12,7	1,35	1,96	0,16	0,87	13,14	12,4
	45	45,01	187,4	21,47	4,75	12,25	18,61	14,46	1,69	1,96	0,74	1,44	13,14	12,4
	50	50	208,2	22	5,21	14,31	21,46	16,03	2,17	1,96	1,47	2,17	13,14	12,4
	55	54,65	227,5	22,39	5,49	16,06	22,61	17,67	2,56	1,96	2,46	3,17	13,14	12,4
	60	54,65	227,5	22,39	5,49	16,06	22,61	17,67	2,56	1,96	2,46	3,17	13,14	12,4
	65	54,65	227,5	22,39	5,49	16,06	22,61	17,67	2,56	1,96	2,46	3,17	13,14	12,4

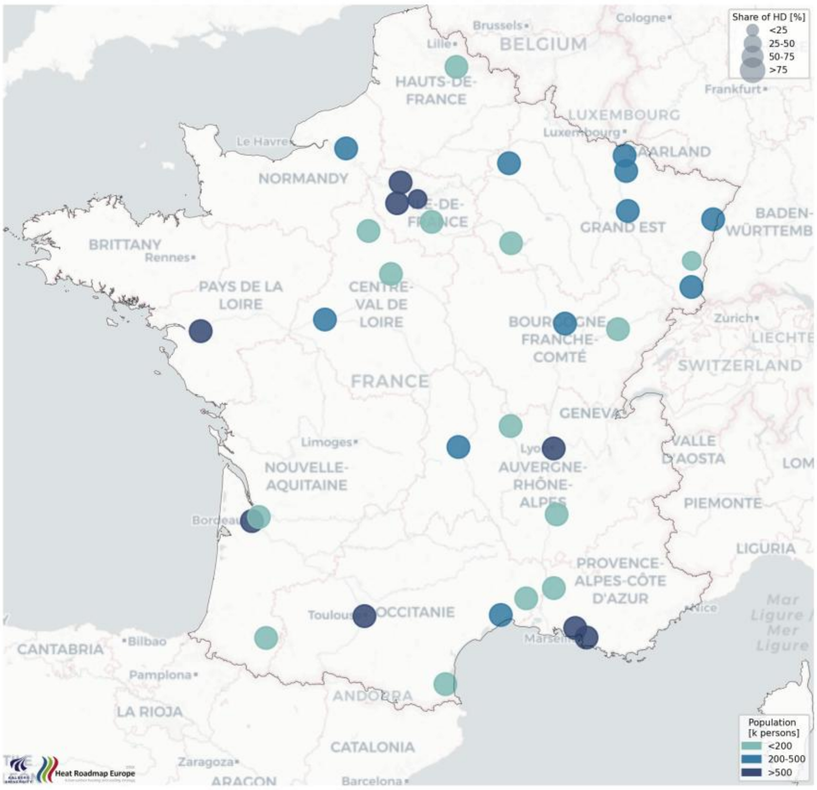


Figure 99: Geothermal energy for France (Baseload of district heating area, capacity >40MW).

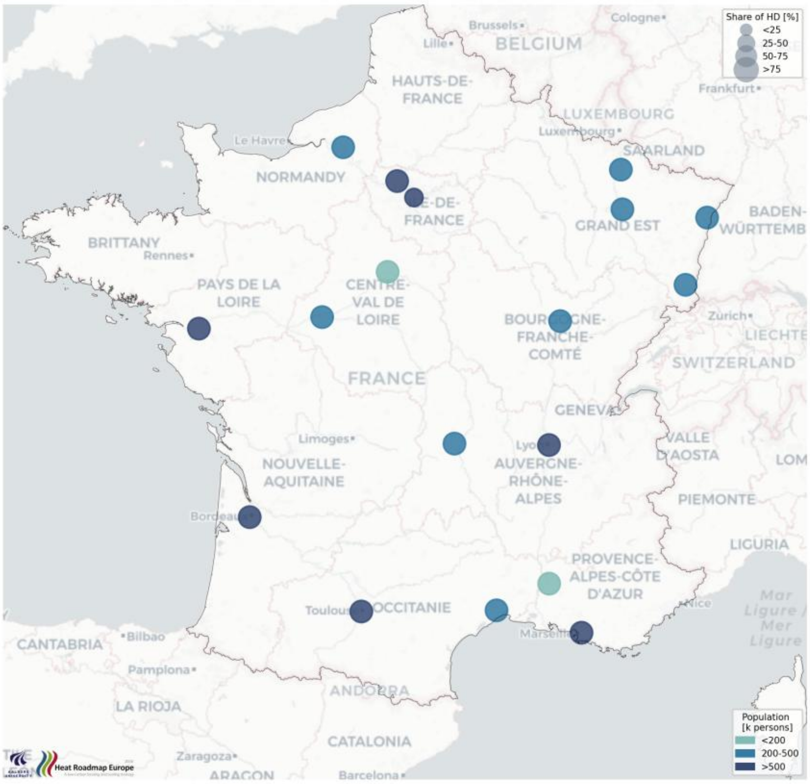


Figure 100: Geothermal energy for France (Baseload of district heating area, capacity >70MW).

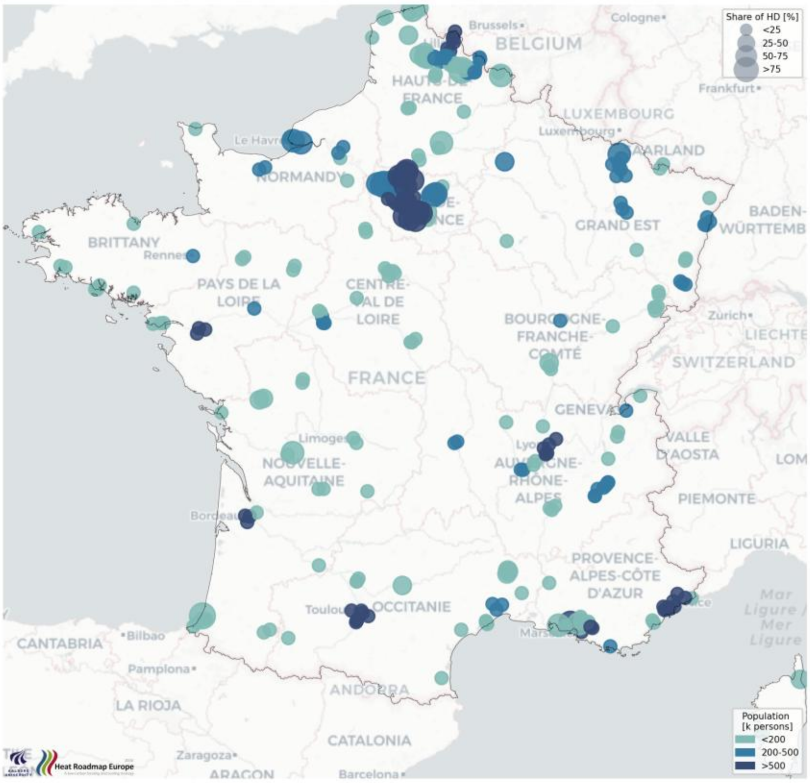


Figure 101: Baseload high temperature waste heat for France.

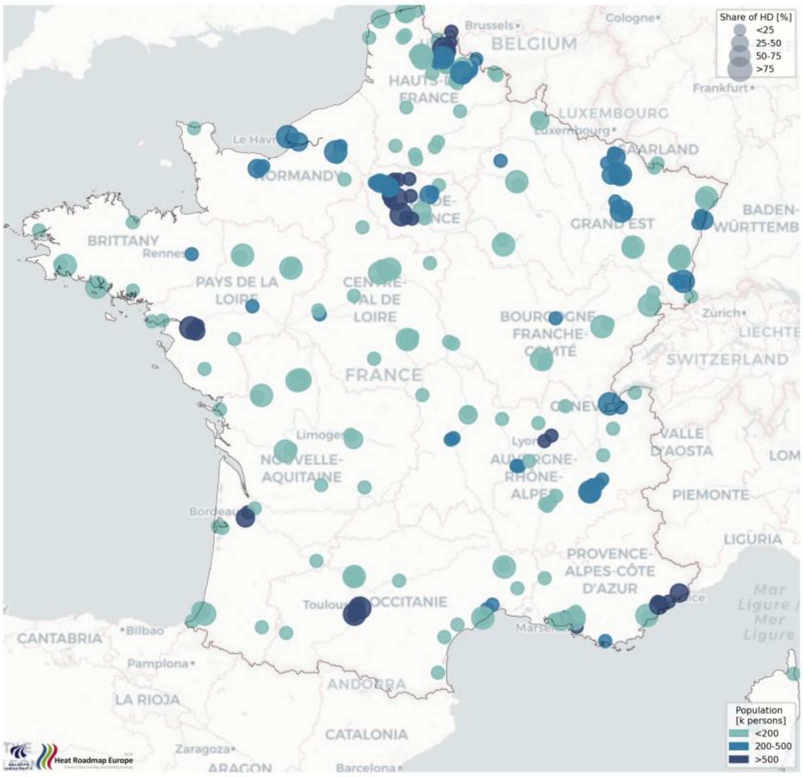


Figure 102: Baseload low temperature waste heat for France.

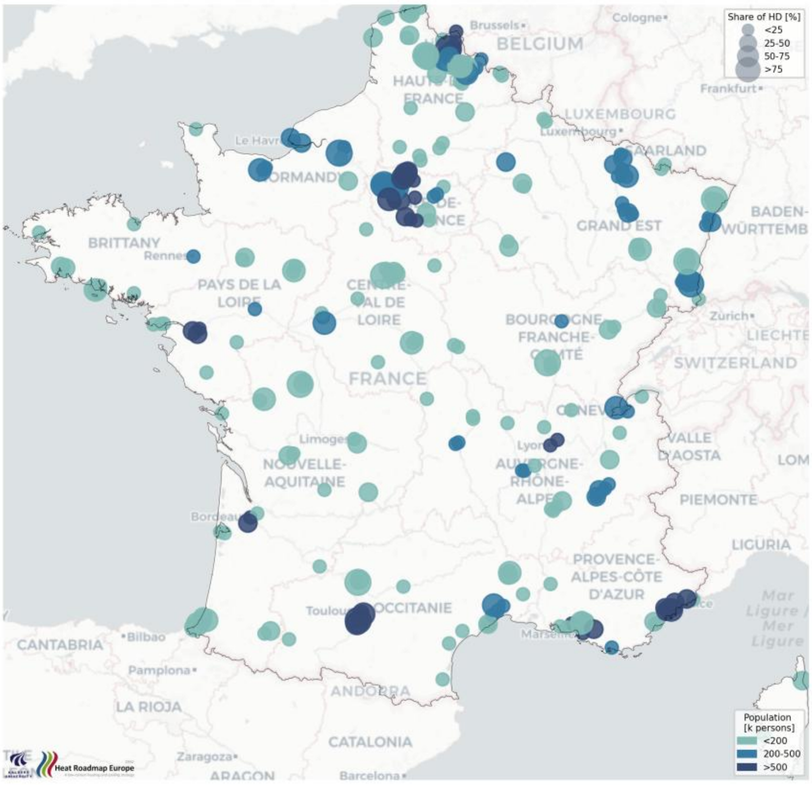


Figure 103: Baseload medium temperature waste heat for France.

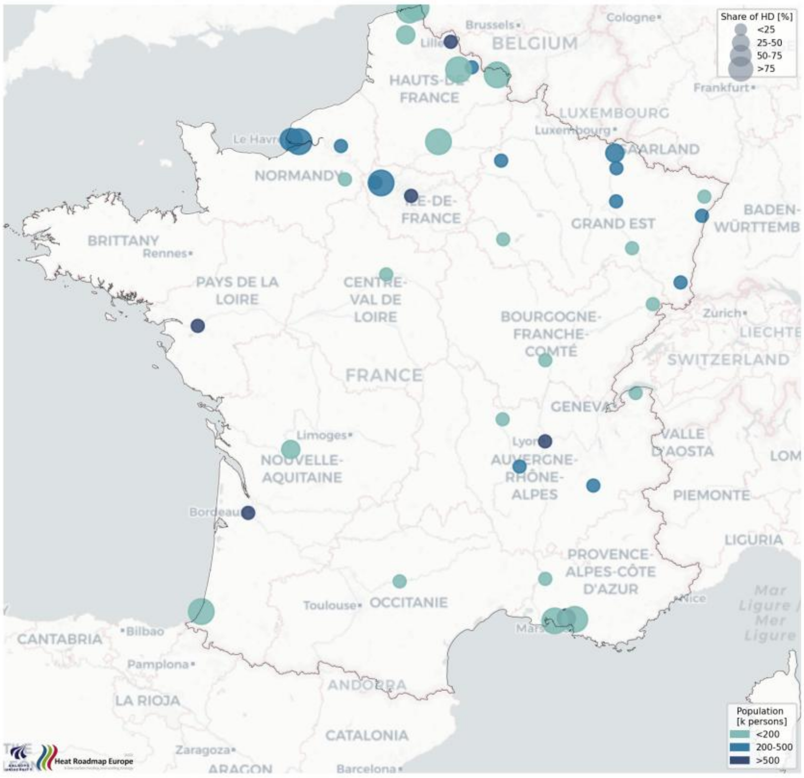


Figure 104: High temperature from industry for France.

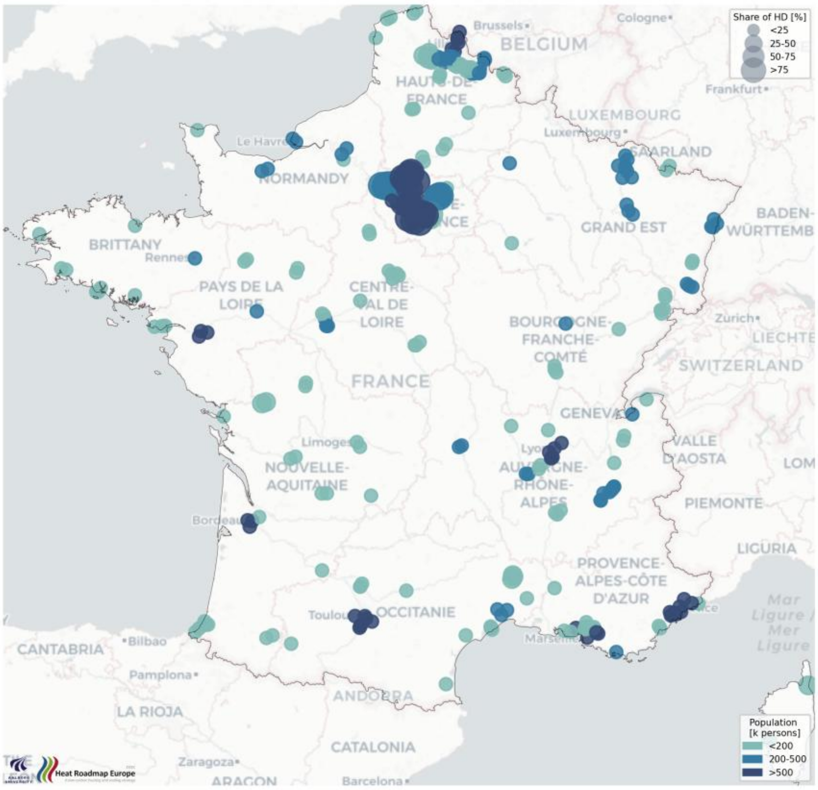


Figure 105: High temperature from waste-to-energy for France.

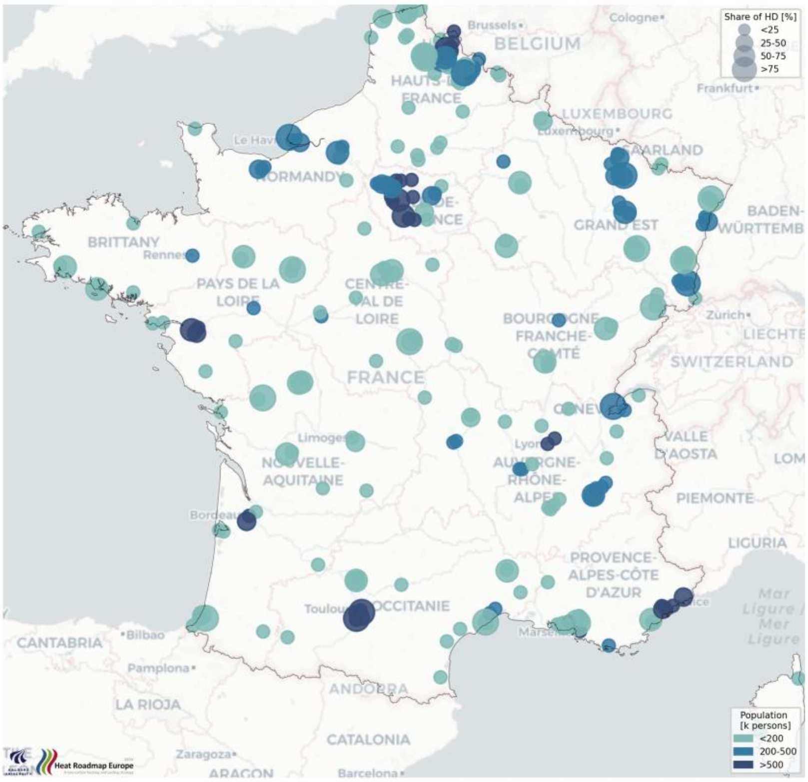


Figure 106: Low temperature from industry for France.

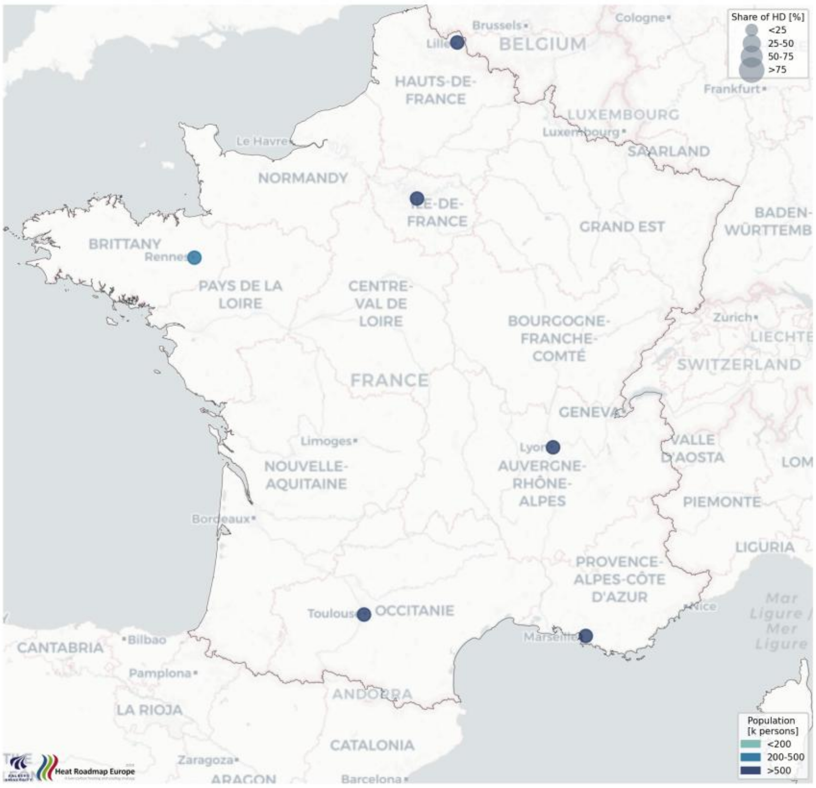


Figure 107: Low temperature from metros for France.

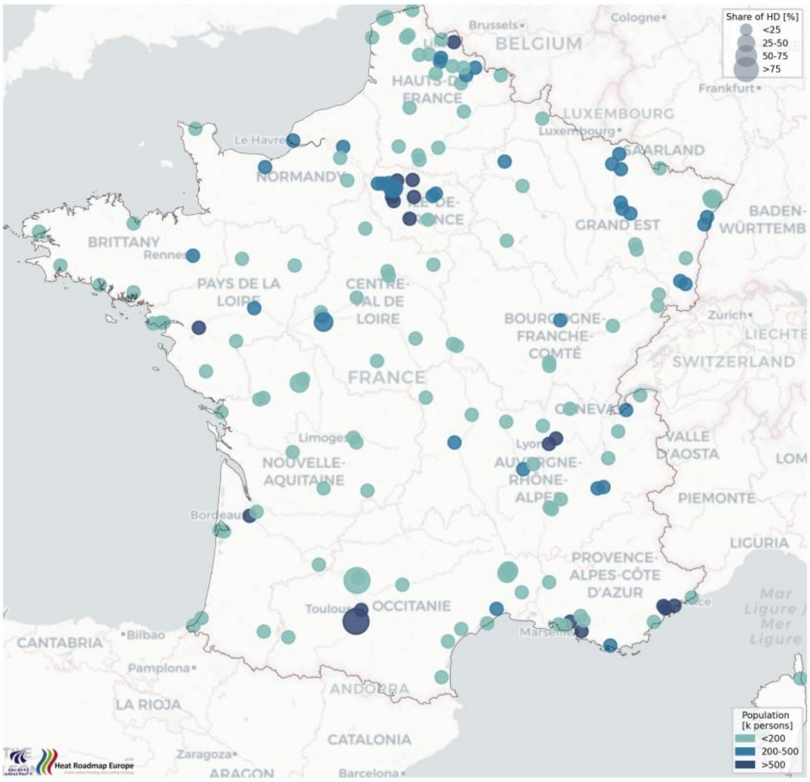


Figure 108: Low temperature from supermarkets for France.

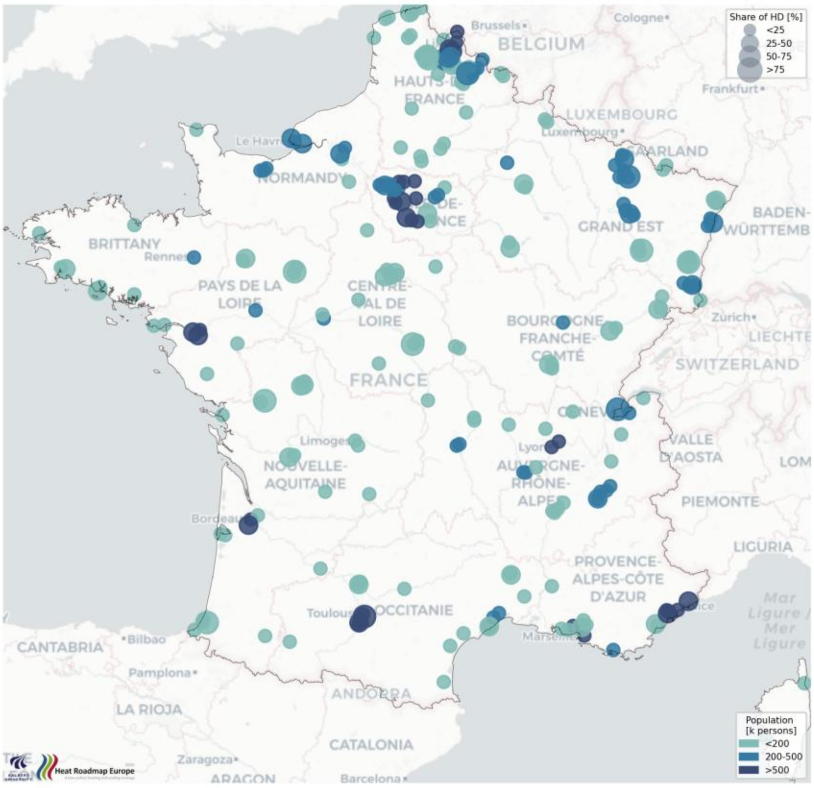


Figure 109: Medium temperature from industry for France.

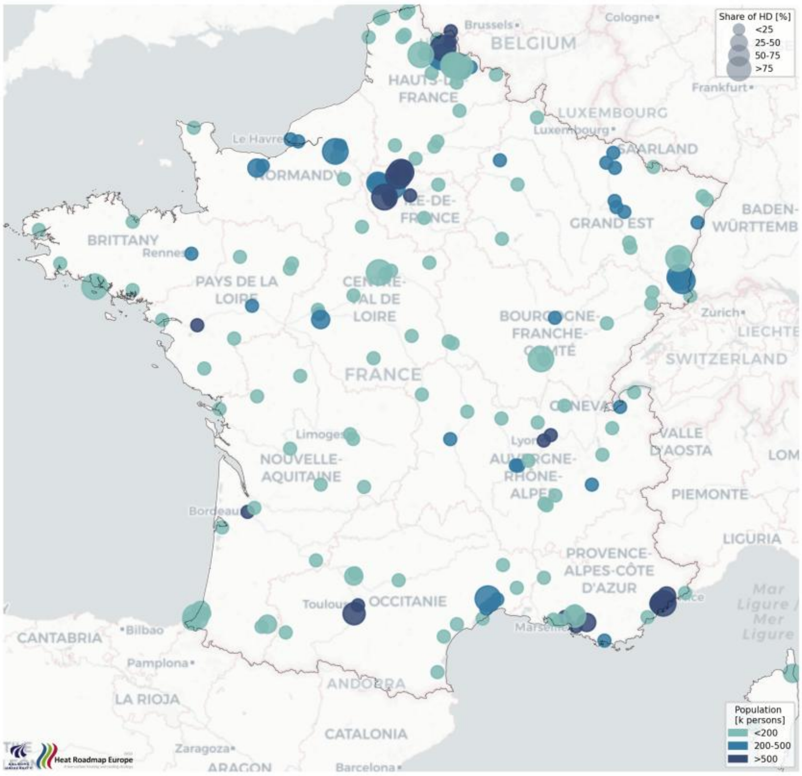


Figure 110: Medium temperature from wastewater treatment for France.

For the case of France, the recommended District heating share for 2050 is ~ 50% District heating which is illustrated below:

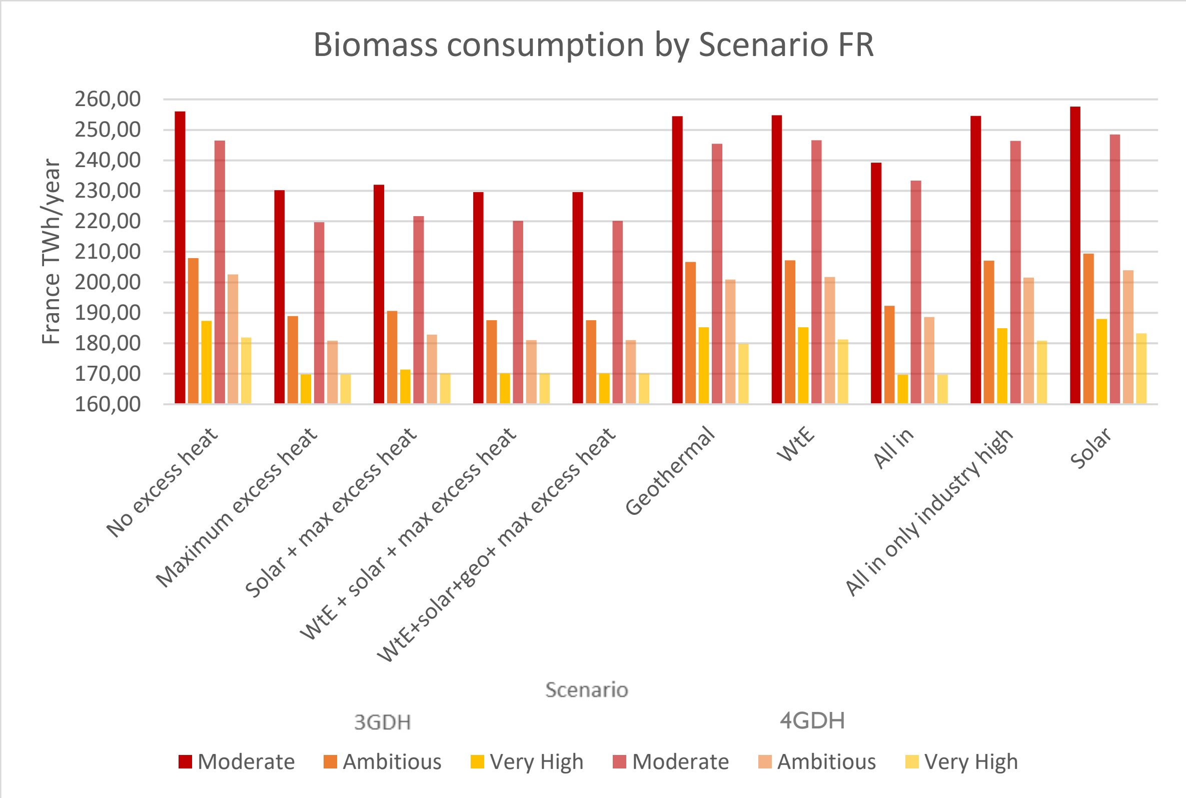


Figure 111: Biomass consumption in TWh/year for different district heating shares and heat source for 3GDH and 4GDH, in the case of France..

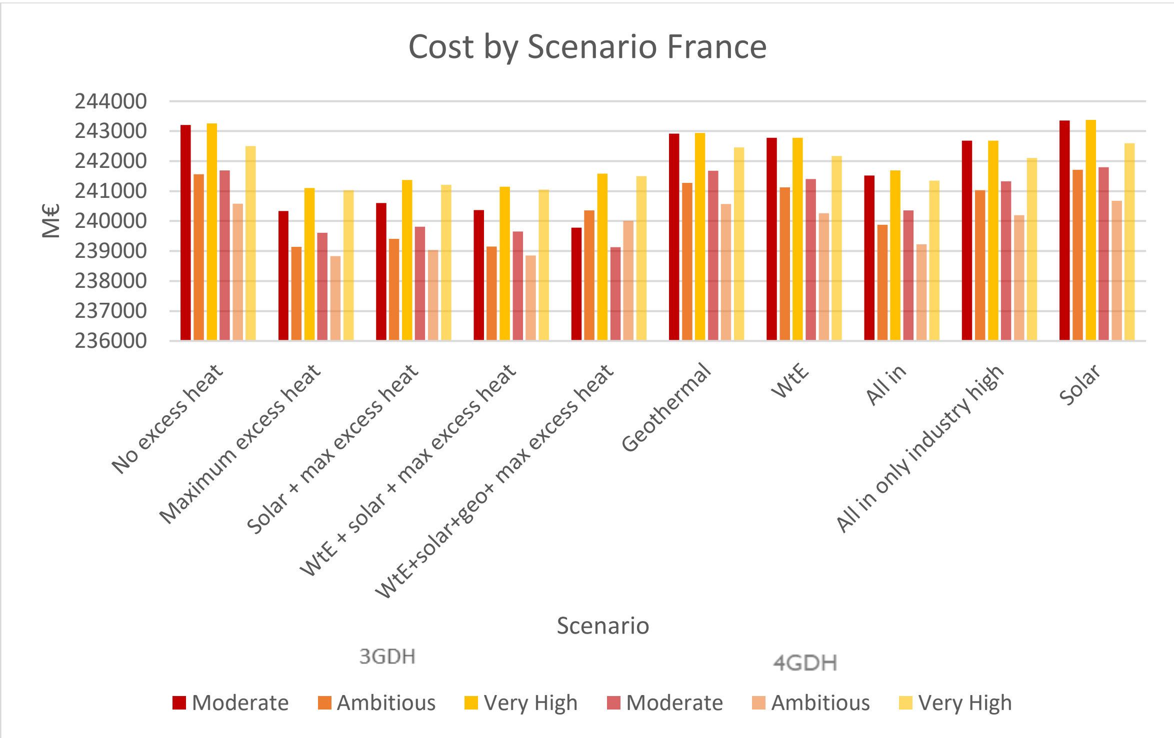


Figure 112: Cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of France.

There is a clear saving potential of the biomass use with measures to reduce the heat demand, that can be seen in all cases where the very high savings, have the lowest biomass consumption, while the Moderate savings scenarios just consume the most biomass. Regarding the cost, a valley is formed for both the 3rd and the 4th generations: the cheapest option in the different heat prioritization is the Ambitious savings, while an increase in the cost happens when the saving levels goes to the Very high levels due to all the measures to reduce the demand. On the other side, in the 4th generation, all of the cases are cheaper than their parallel in the 3rd generation, showing that even with the upgrade on the system, it will end up being cheaper after all. The most expensive system would be the just Solar due to the still big use of other technologies and insufficient solar potential alone to overcome the heat demand. On the contrary, the cheapest system is the mix of heat sources (All in), reducing the system's cost over all the saving scenarios and generations of the system.

Table 35: : Biomass consumption in TWh/year for different district heating shares and heat source for 3GDH and 4GDH, in the case of France and Cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of France.

48,35	3rd			4th		
Biomass	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	256,08	207,97	187,40	246,46	202,54	181,94
Maximum waste heat	230,16	188,92	169,81	219,73	180,86	169,77
Solar + max waste heat	231,96	190,63	171,35	221,70	182,82	170,11
WtE + solar + max waste heat	229,53	187,54	170,12	220,08	181,01	170,11
WtE+solar+geo+ max waste heat	229,53	187,54	170,12	220,08	181,01	170,11
Geothermal	254,46	206,70	185,22	245,47	200,92	179,75
WtE	254,81	207,24	185,28	246,64	201,73	181,22
All in	239,27	192,30	169,76	233,32	188,64	169,75
All in only industry high	254,54	207,05	184,98	246,38	201,51	180,87
Solar	257,58	209,36	188,03	248,43	203,90	183,23

	3rd			4th		
Cost	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	243.212	241.567	*243.263*	241.690	240.578	*242.500*
Maximum waste heat	240.333	239.144	*241.108*	239.608	238.832	*241.024*
Solar + max waste heat	240.602	239.411	*241.372*	239.810	239.032	*241.207*
WtE + solar + max waste heat	240.366	239.155	*241.146*	239.649	238.849	*241.056*
WtE+solar+geo+ max waste heat	239.785	240.355	*241.586*	239.132	240.002	*241.495*
Geothermal	242.915	241.276	*242.942*	241.684	240.575	*242.461*
WtE	242.782	241.126	*242.776*	241.401	240.265	*242.176*
All in	241.524	239.878	*241.688*	240.360	239.228	*241.345*
All in only industry high	242.689	241.033	*242.681*	241.332	240.197	*242.105*
Solar	243.359	241.709	*243.378*	241.803	240.677	*242.599*

As the previous tables show, the biggest difference in biomass consumption from the Moderate savings is found in the Very High savings, with a save close to 30% compared to the 20% of the Ambitious savings. An extra step on this is when the system is upgraded to a 4th generation system, allowing the system to save even more. When comparing the simulations with the scenario 0 as a starting point, the scenario with the biggest reduction, discarding the free heat scenarios, is the scenario D, with all the heat mix available which can reduce up to a 10%. In this case, the Very high savings scenario D in the 3rd generation allows for more savings than their parallel scenario in the 4th generation, this is due to the better starting point it is compared to from the beginning, so there is less room for improvement. However, it needs to be mentioned that upgrading the system's generation alone, does not benefit a lot as it only saves around a 3% of the biomass.

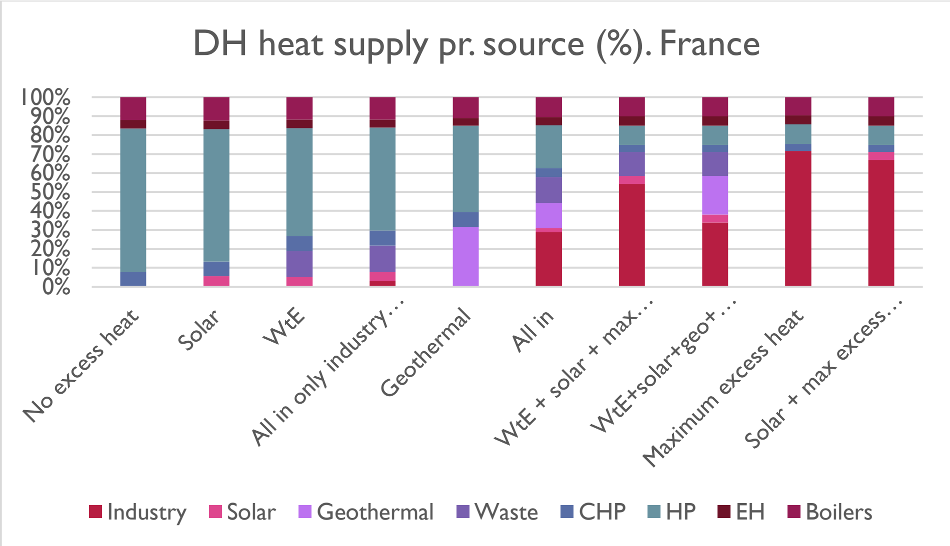


Figure 113: District heating heat supply pr. source in percentage for each scenario in the case of France.

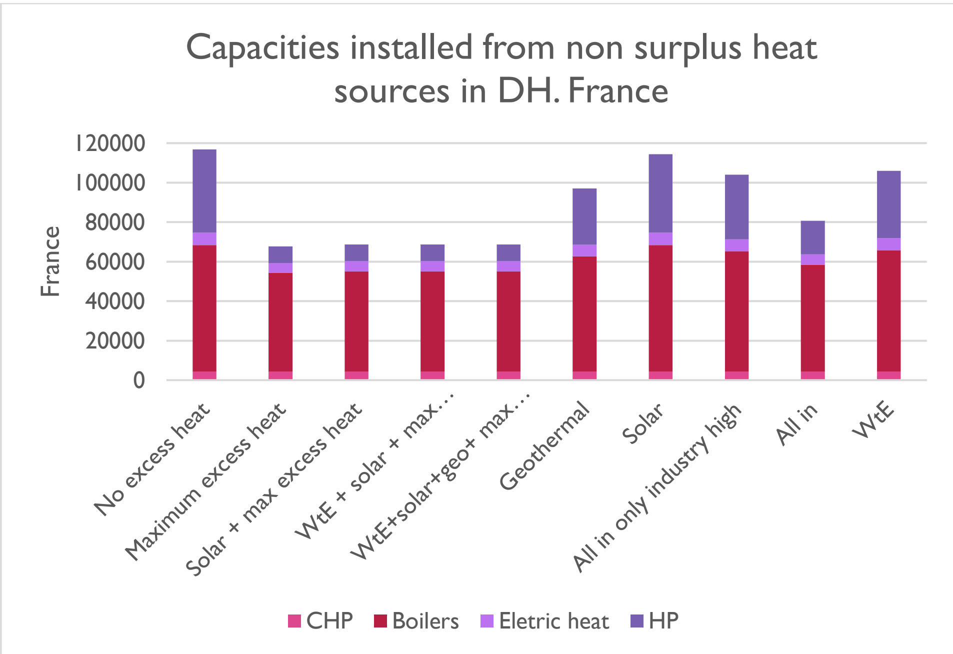


Figure 114: Installed capacities in MW from non surplus heat sources in district heating in France.

The scenarios where the lowest HP capacity is found in the scenarios with "free" surplus heat, however, when we take those scenarios out of the equation, the scenario All in where all the heat surplus sources are present has the lowest HP capacity installed. This highlights, once again, the importance of having a good mix of sources to use the available heat in a smart way.

5.10 Germany

Table 36: District heating shares specific to Germany and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Germany	5	7,16	49	5,41	6,08	1,97	1,43	2,42	0,38	0,61	0	0	4,83	4,83
	10	11,17	76,45	8,16	6,36	2,85	3,08	2,96	0,61	1,14	0	0	10,51	10,5
	15	15,86	108,6	11,51	7,03	4,2	5,62	5,01	0,87	1,32	0	0	13,56	13,6
	20	20,23	138,5	14,96	7,83	5,51	8,09	6,89	1,24	1,32	0	0	14,43	14,4
	25	25,05	171,5	18,51	9,24	6,96	10,73	8,96	1,62	1,32	0	0	17,83	17,8
	30	30,05	205,7	23,07	10,42	8,82	13,87	10,96	2,07	1,32	0	0,03	19,66	19,5
	35	35,03	239,8	27,47	10,71	10,95	17,61	13,32	2,62	1,32	0	0,44	21,58	19,9
	40	40	273,8	30,15	11,69	13,18	21,47	15,55	3,07	1,33	0,03	1,09	21,58	19,9
	45	45,03	308,2	31,84	12,83	15,55	25,48	18,07	3,68	1,33	0,56	1,89	21,58	19,9
	50	50,01	342,4	32,7	13,66	17,97	29,69	20,35	4,31	1,33	1,53	2,86	21,58	19,9
	55	55,01	376,6	33,44	14,23	20,53	34,16	22,57	5,13	1,33	2,55	3,88	21,58	19,9
	60	60	410,8	33,88	14,64	23,11	38,53	25	6,05	1,33	3,66	4,99	21,58	19,9
	65	65	445	34,43	15,14	25,71	42,49	27,11	7,21	1,33	4,93	6,26	21,58	19,9

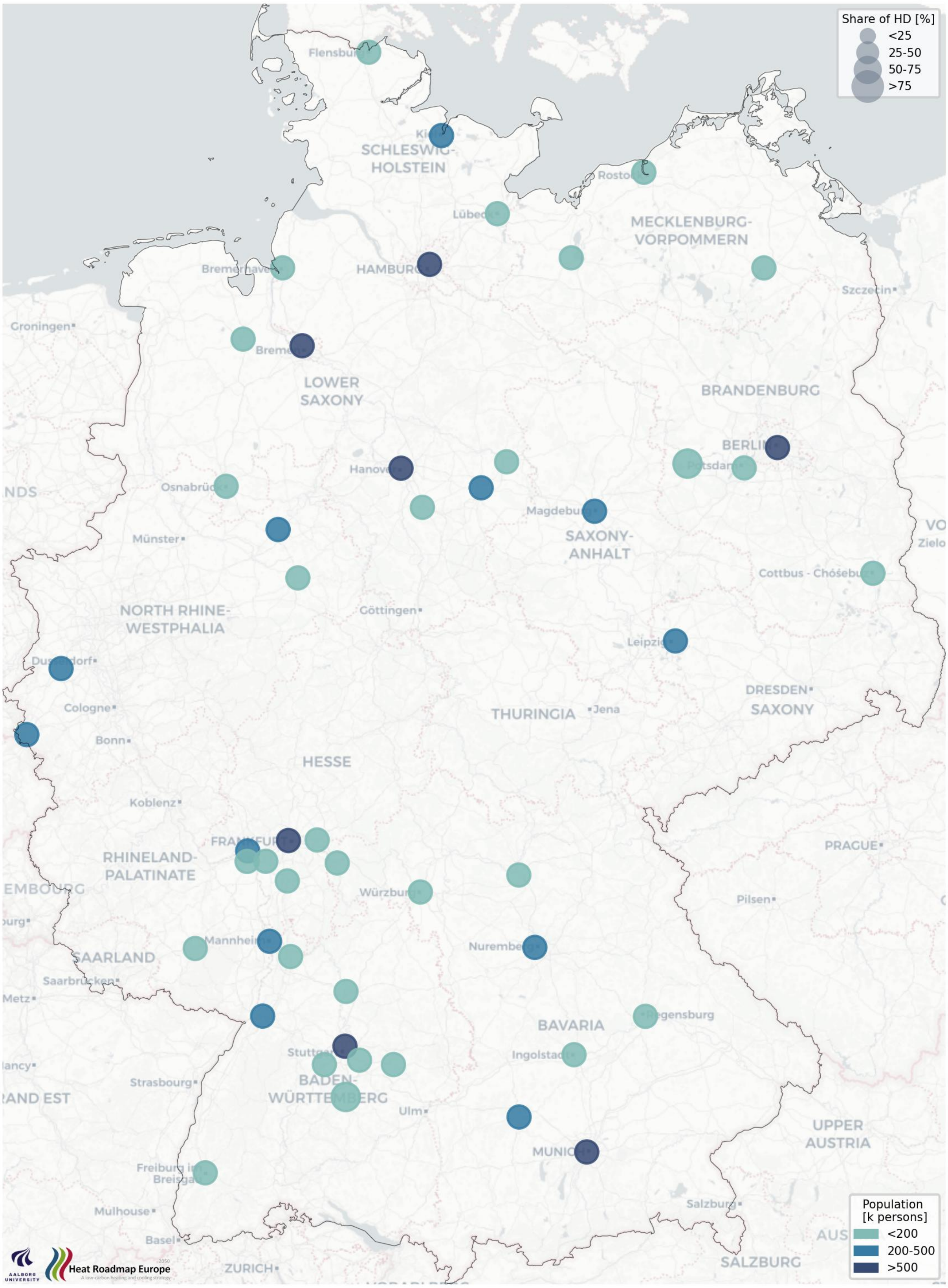


Figure 115: Geothermal energy for Germany (Baseload of district heating area, capacity >40MW).

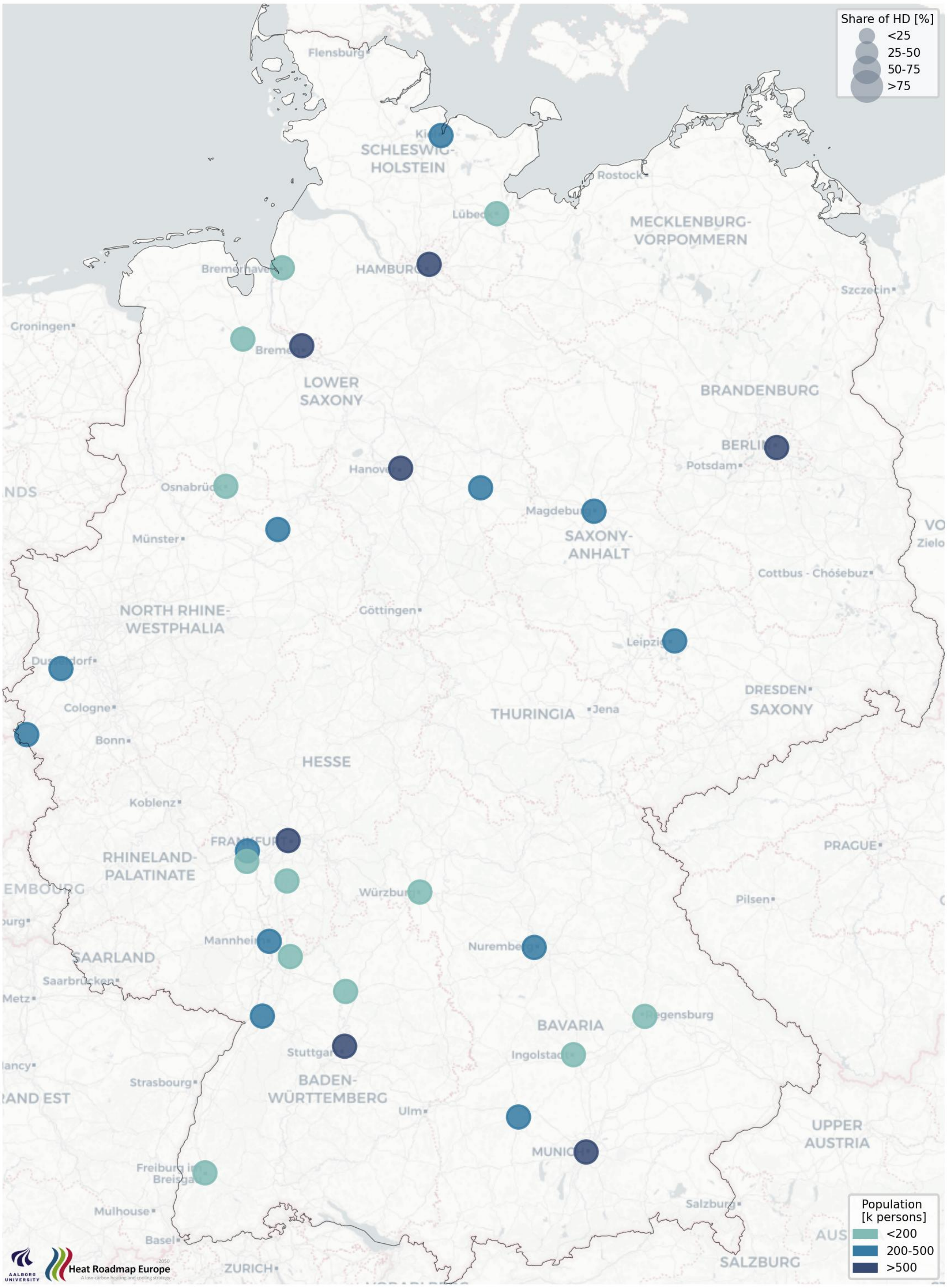


Figure 116: Geothermal energy for Germany (Baseload of district heating area, capacity >70MW).

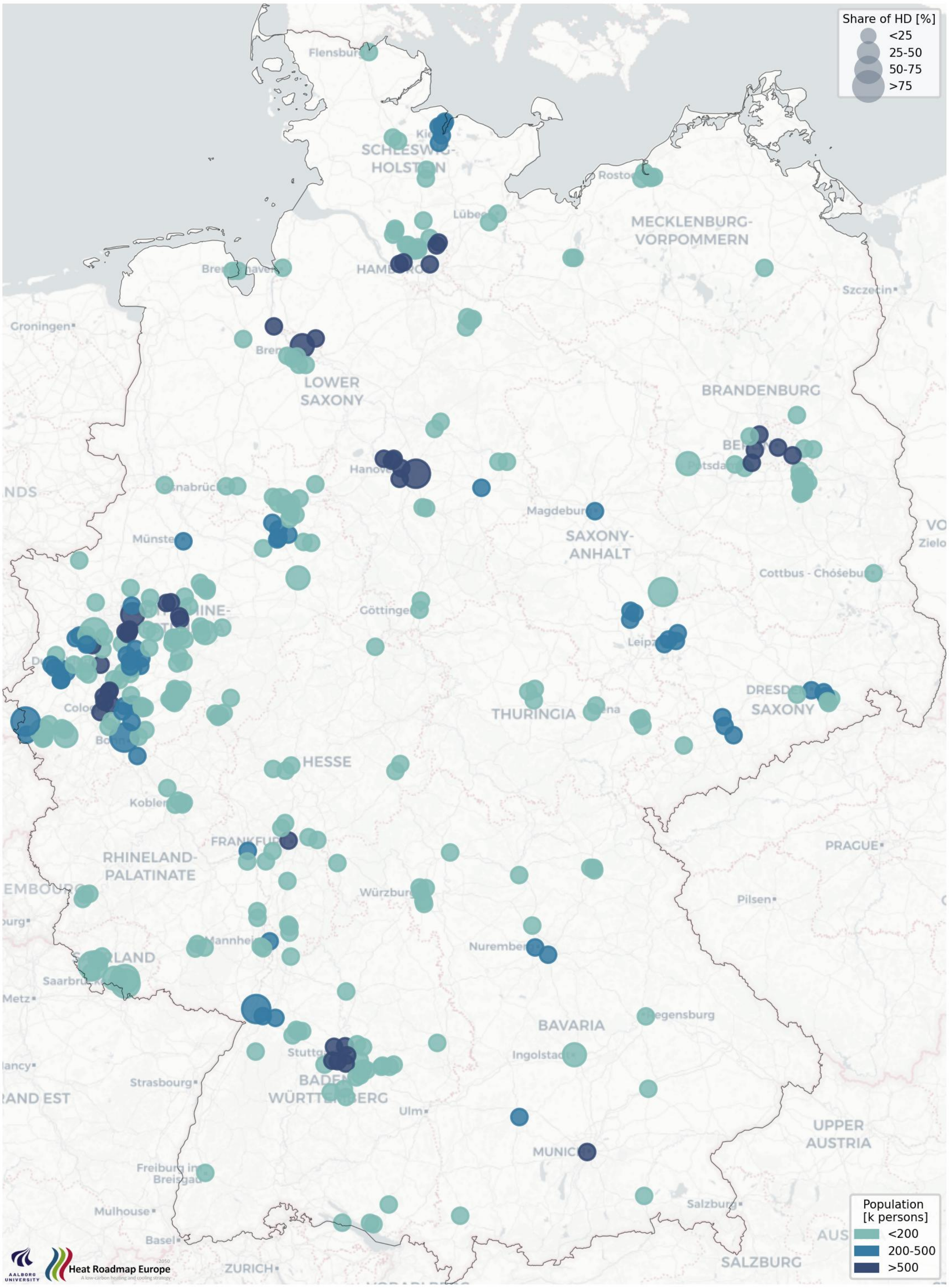


Figure 117: Baseload high temperature waste heat for Germany.

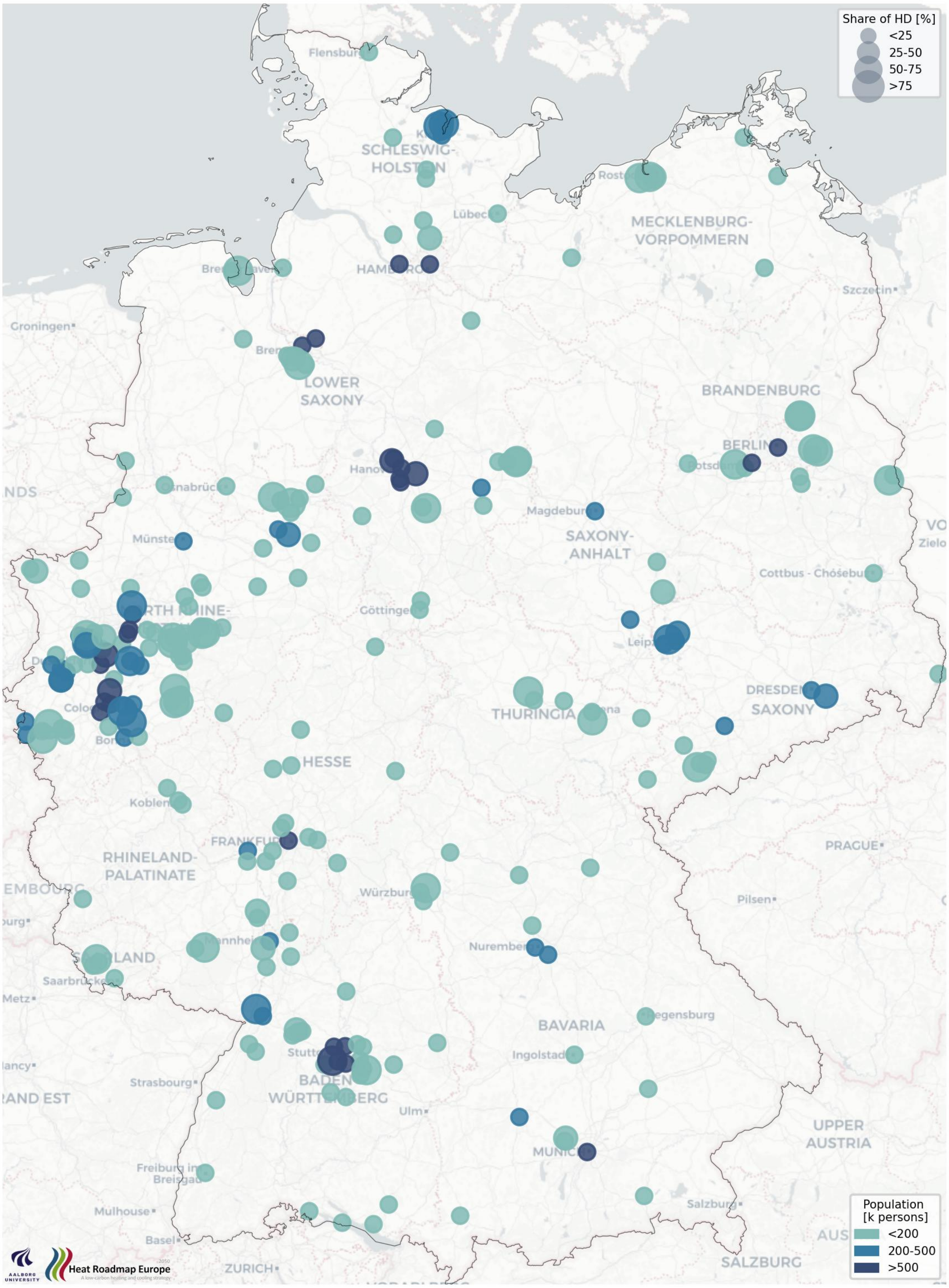


Figure 118: Baseload low temperature waste heat for Germany.

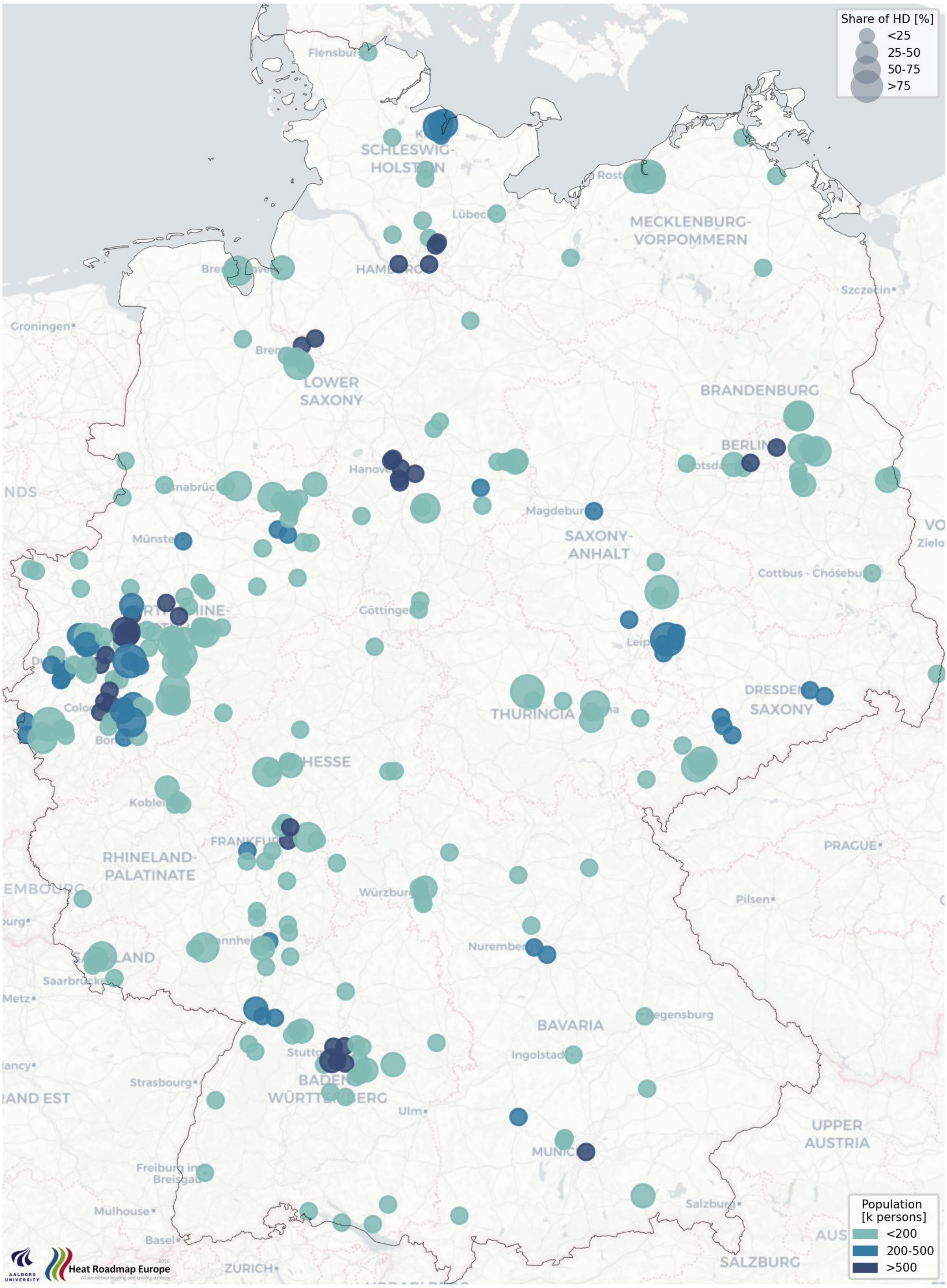


Figure 119: Baseload medium temperature waste heat for Germany.

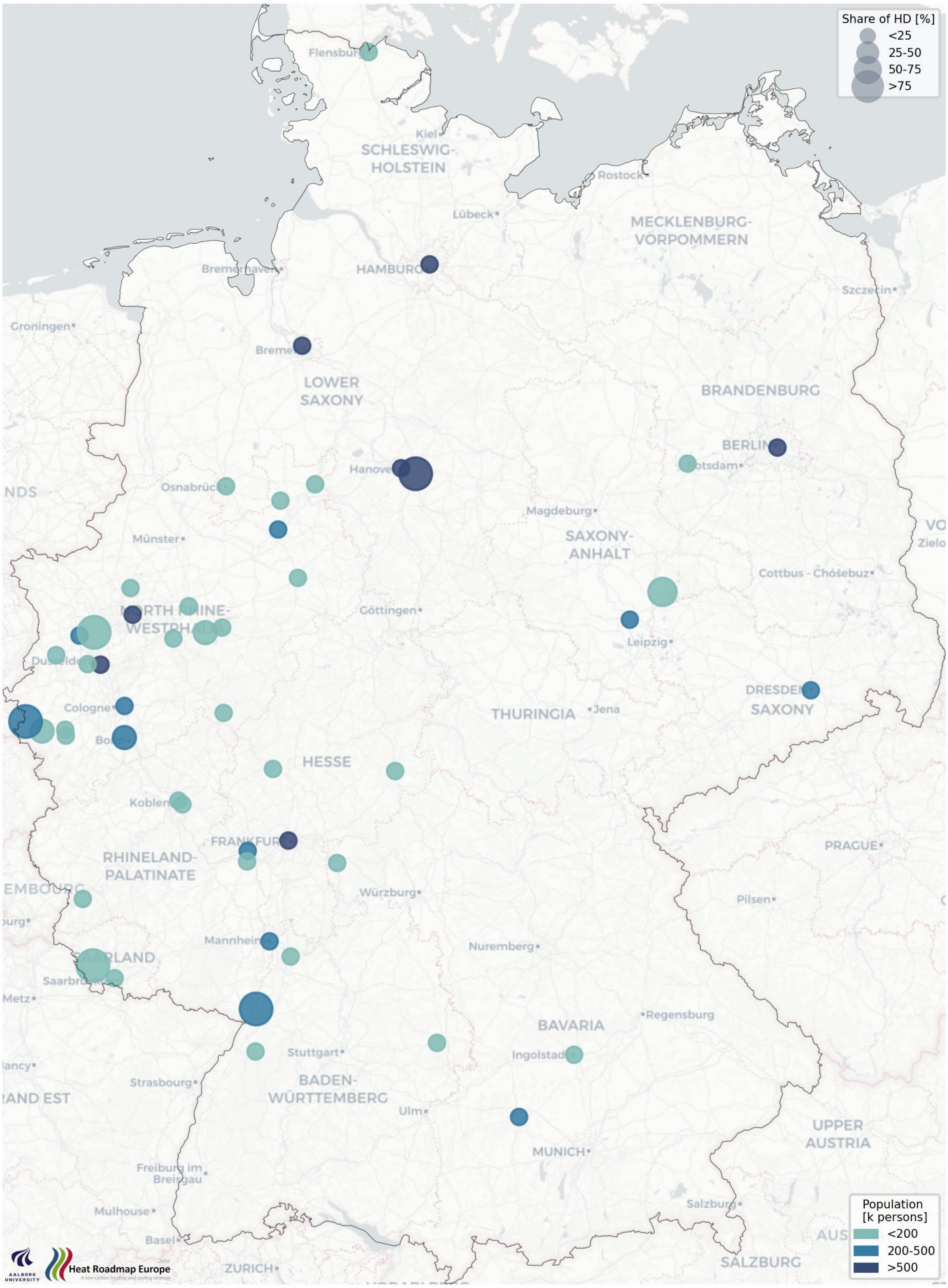


Figure 120: High temperature from industry for Germany.

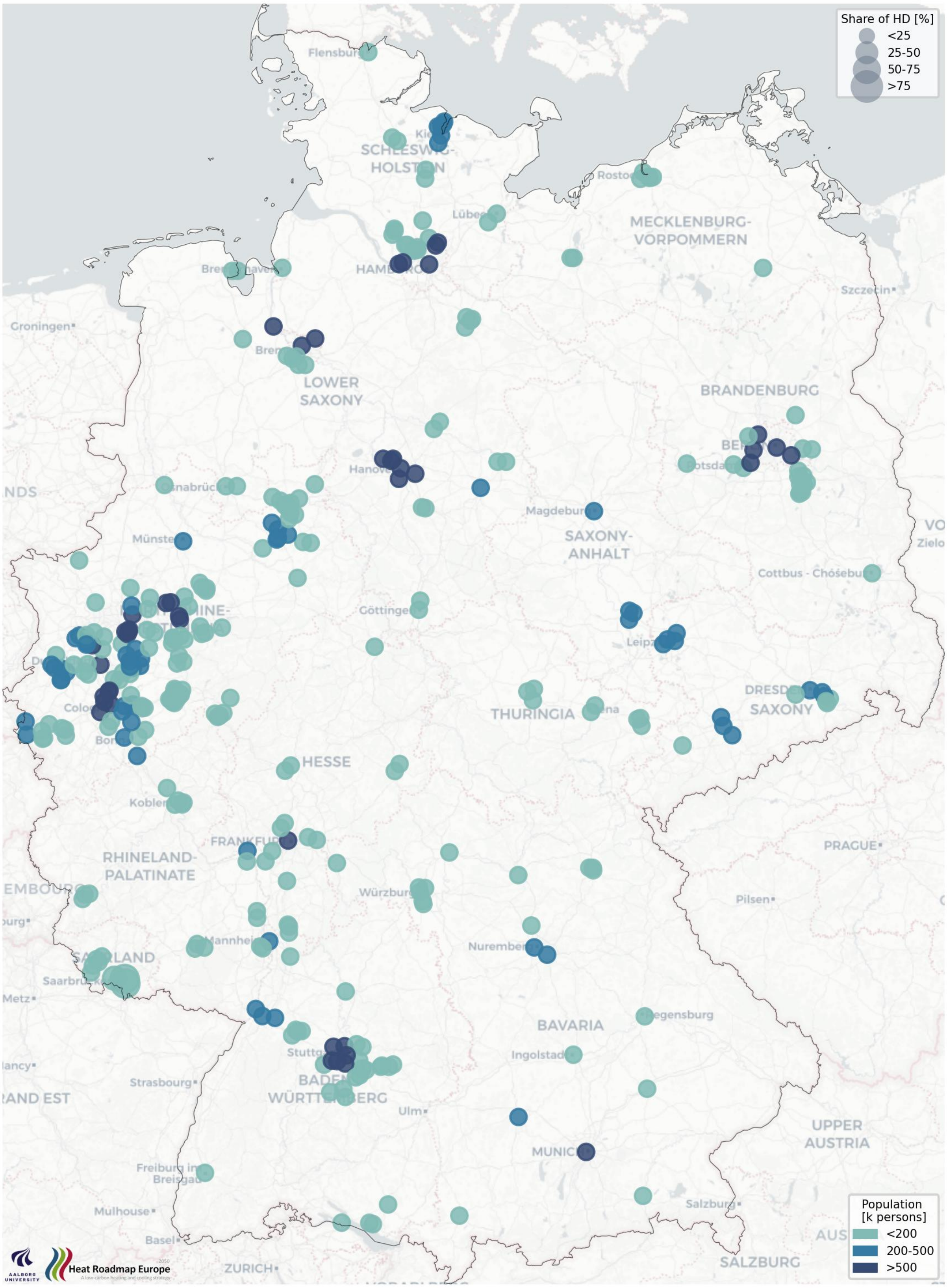


Figure 121: High temperature from waste-to-energy for Germany.

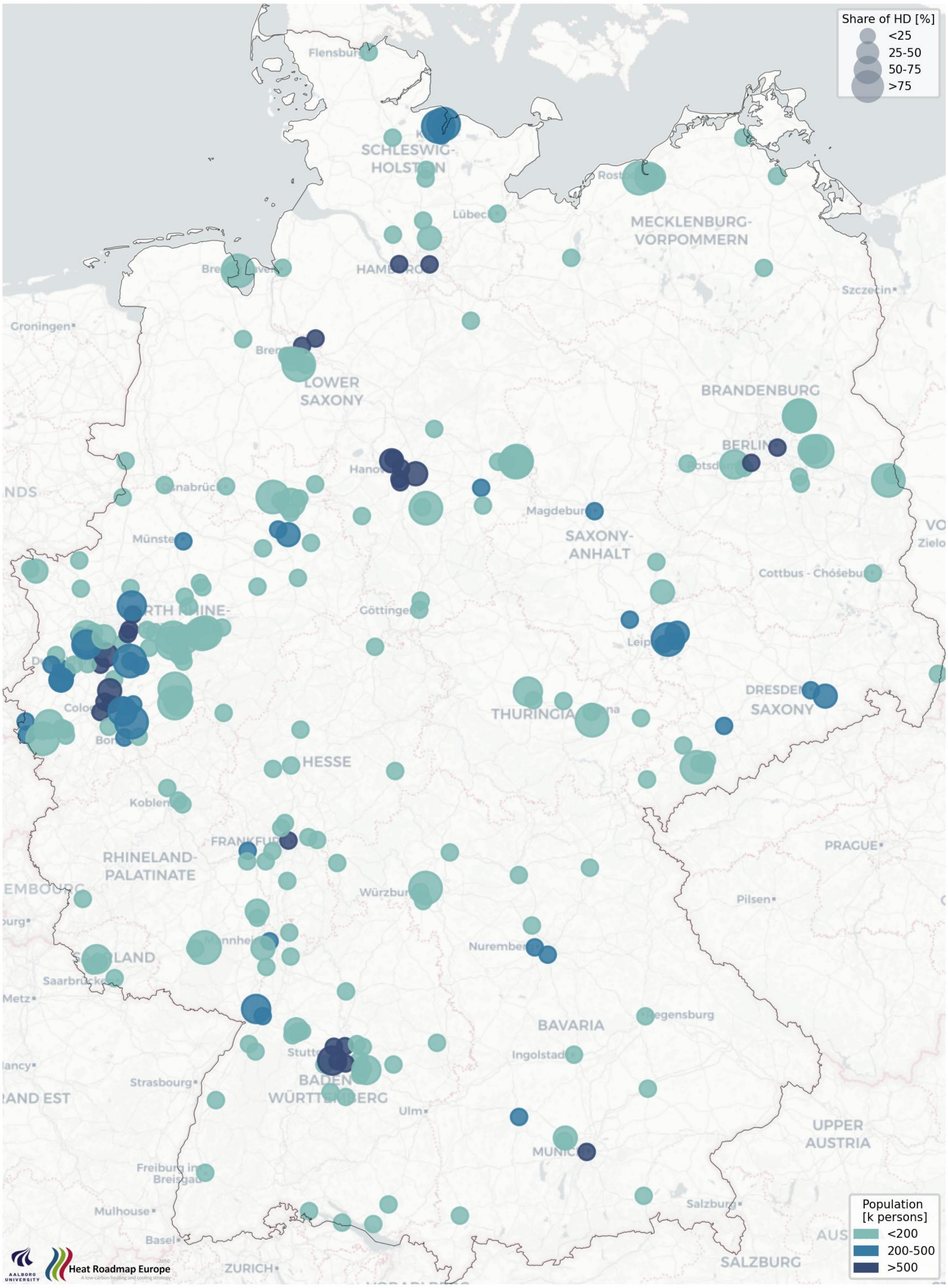


Figure 122: Low temperature from industry for Germany.

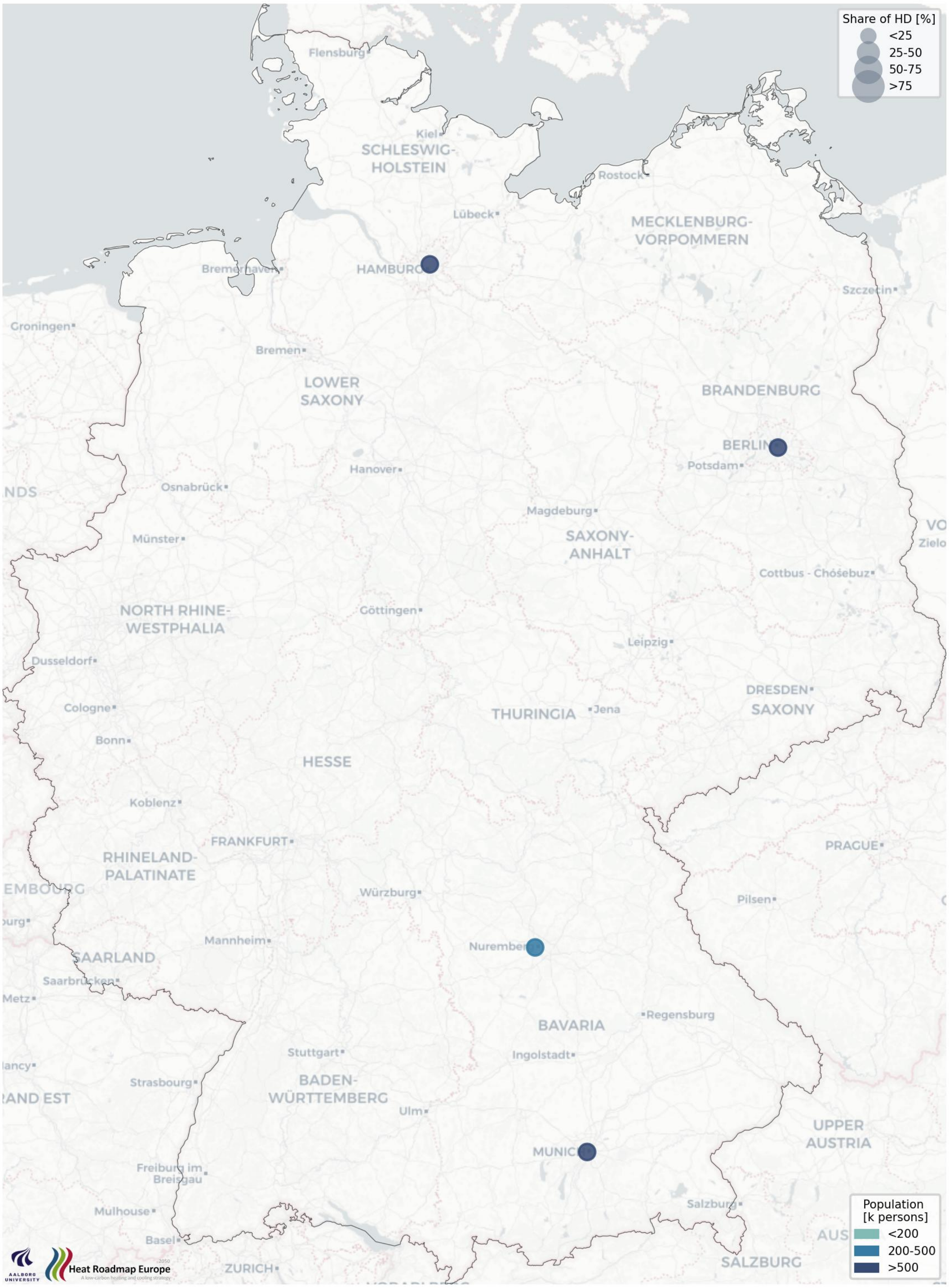


Figure 123: Low temperature from metros for Germany.

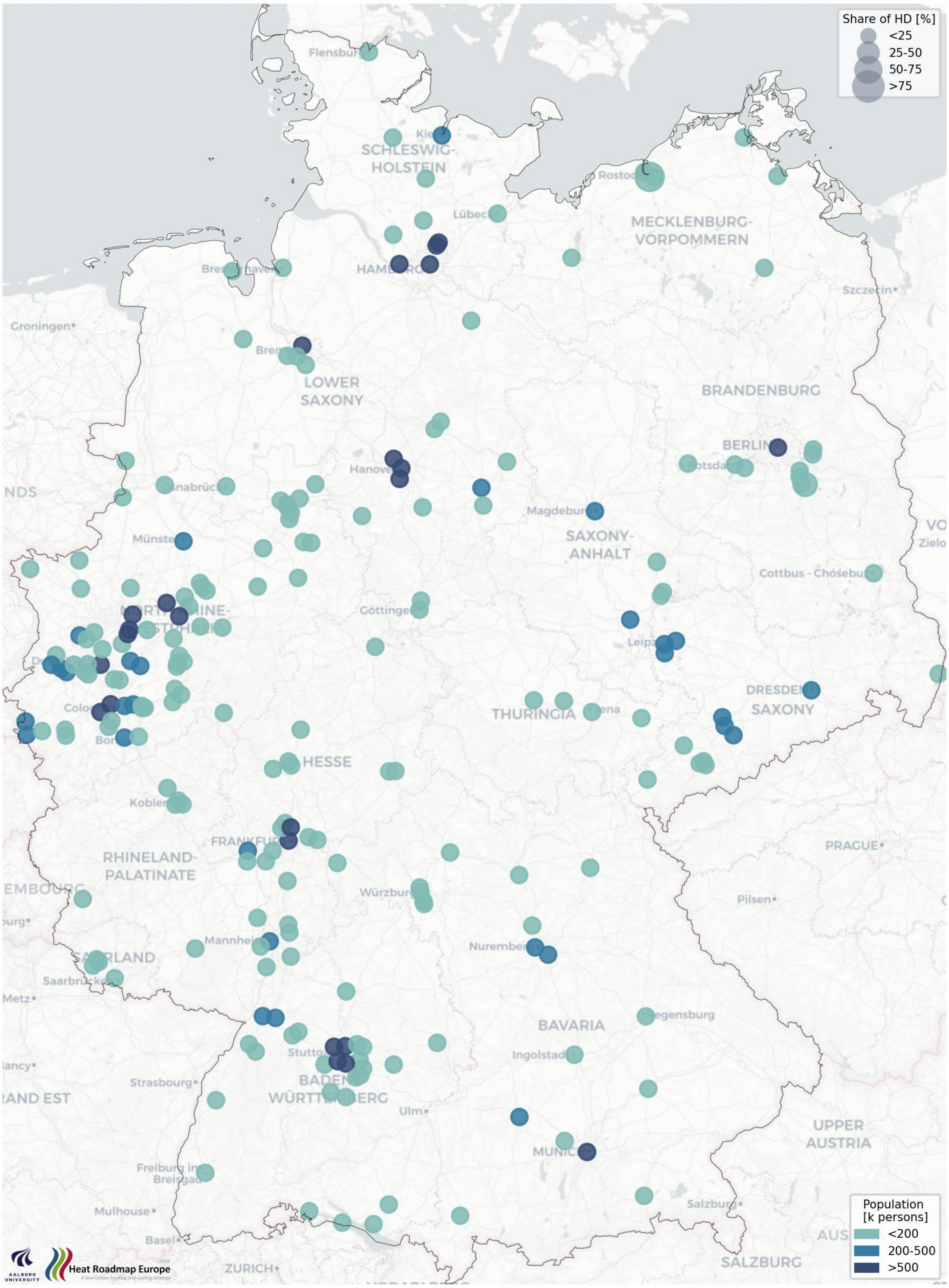


Figure 124: Low temperature from supermarkets for Germany.

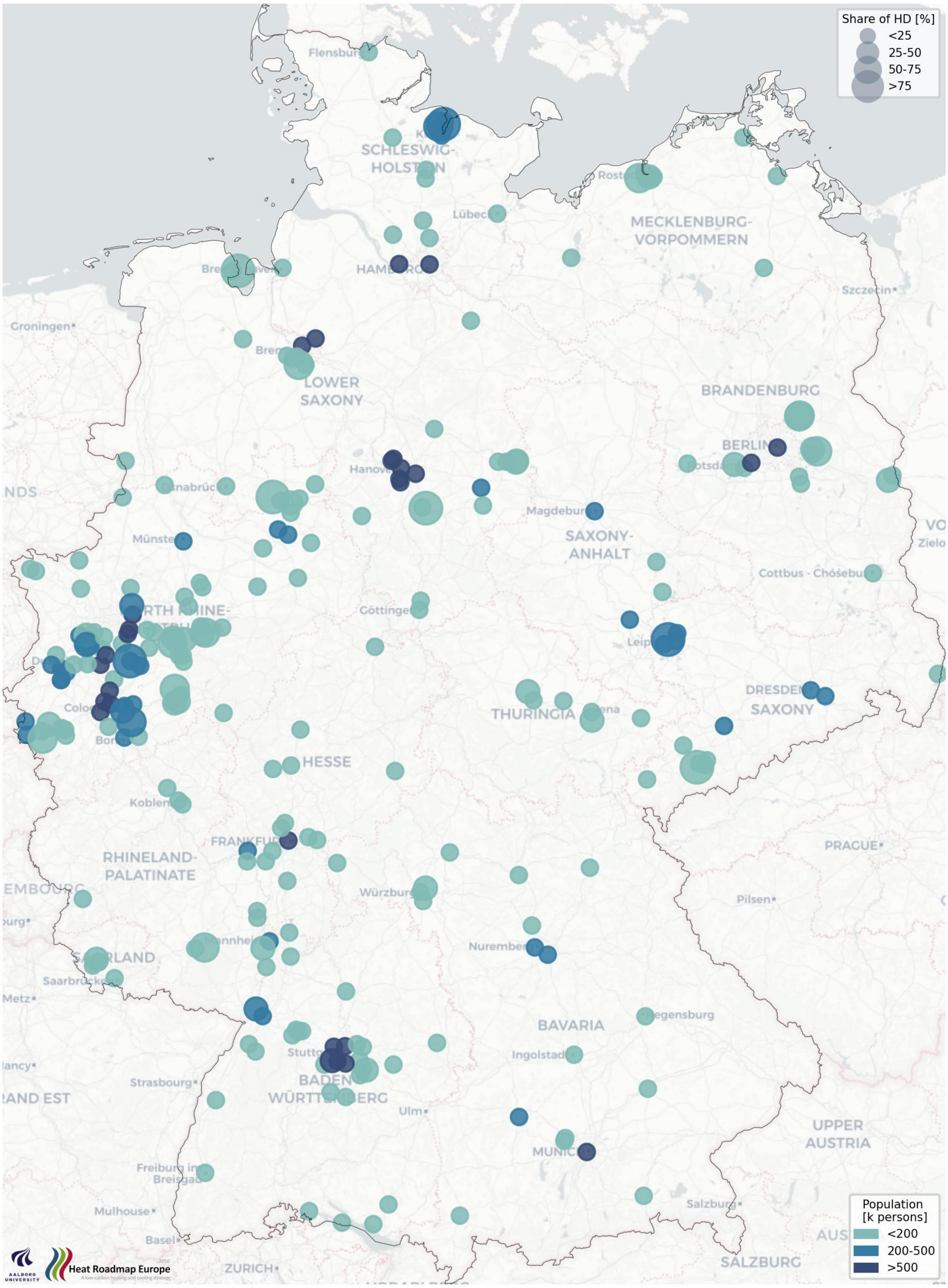


Figure 125: Medium temperature from industry for Germany.

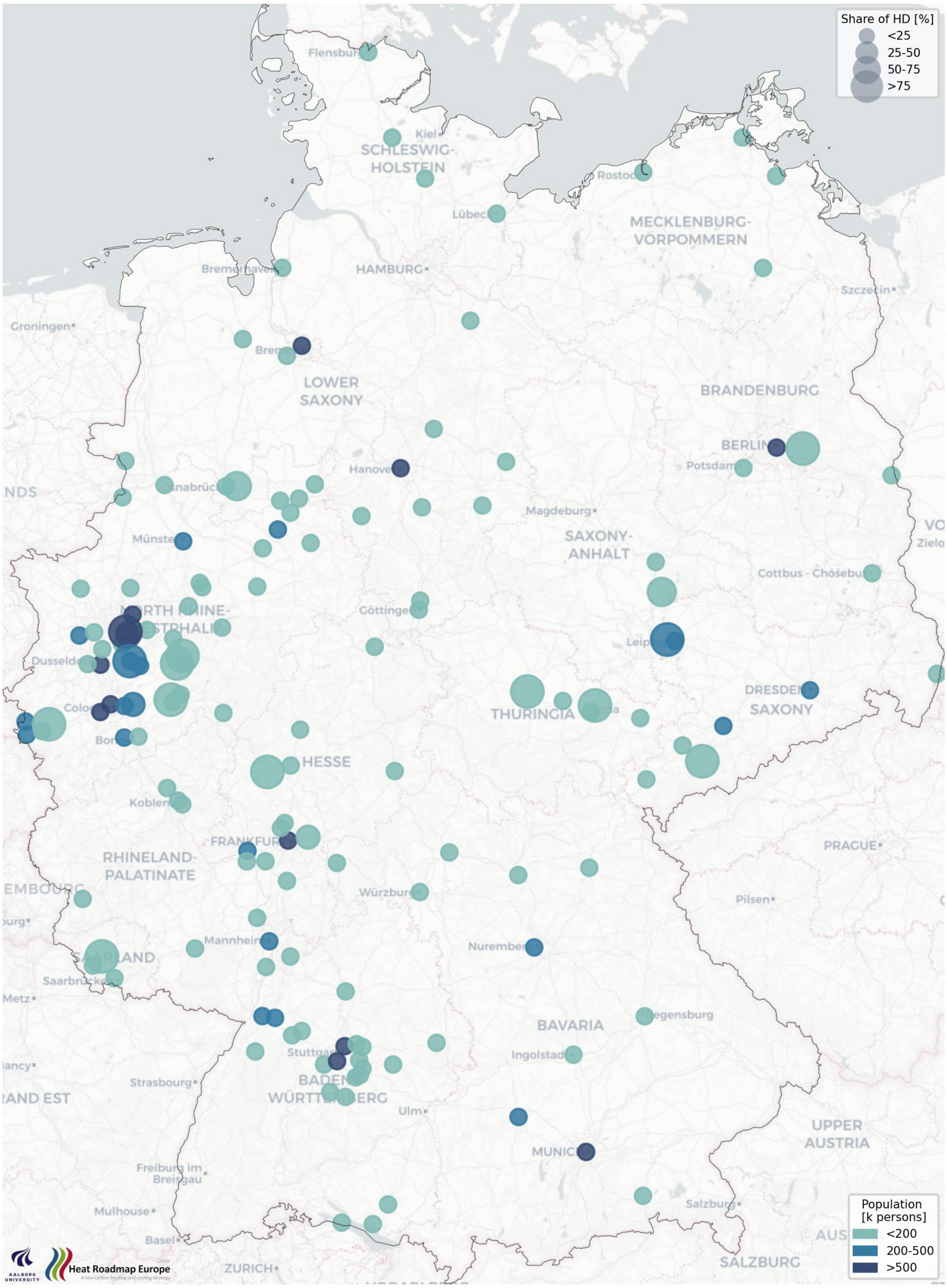


Figure 126: Medium temperature from wastewater treatment for Germany.

Germany: a recommended district heating share of 64,6. Results shown: simulation for 60% district heating share:

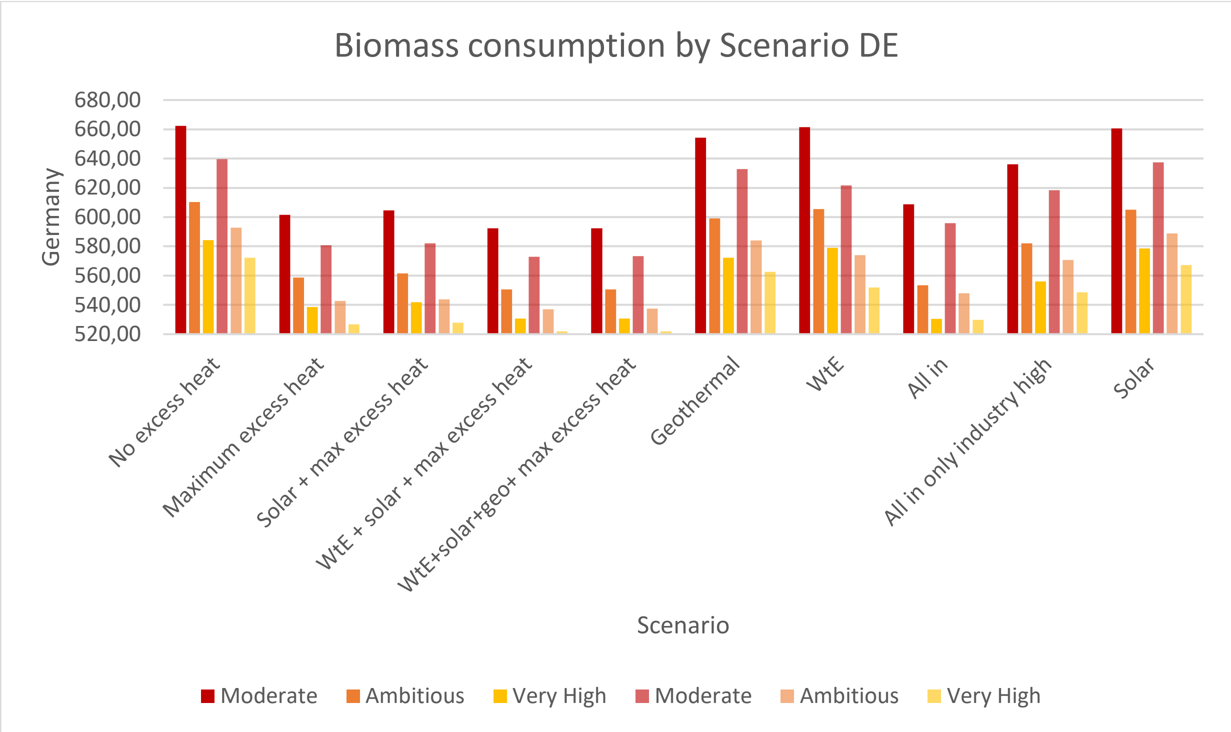


Figure 127: Biomass consumption in TWh/year for different district heating shares and heat source for 3GDH and 4GDH, in the case of Germany.

This graph represents the biomass consumption in the different scenarios for Germany. There is a clear trend that shows the higher the saving levels, so the lower de demand, the less biomass it is consumed. Also, a higher efficiency of the system, as the different district heating generations, affects the biomass consumption, as it can be seen, in any scenario, the more productive generation of the system, the lower the biomass consumption. So, basing the decision just and only on the biomass consumption, it would be sensible to say that the higher the saving level and in a 4th generation system is recommended, while mixing the most amount of heat sources (All in heat prioritization scenario), which brings a lower biomass level in any of the cases.

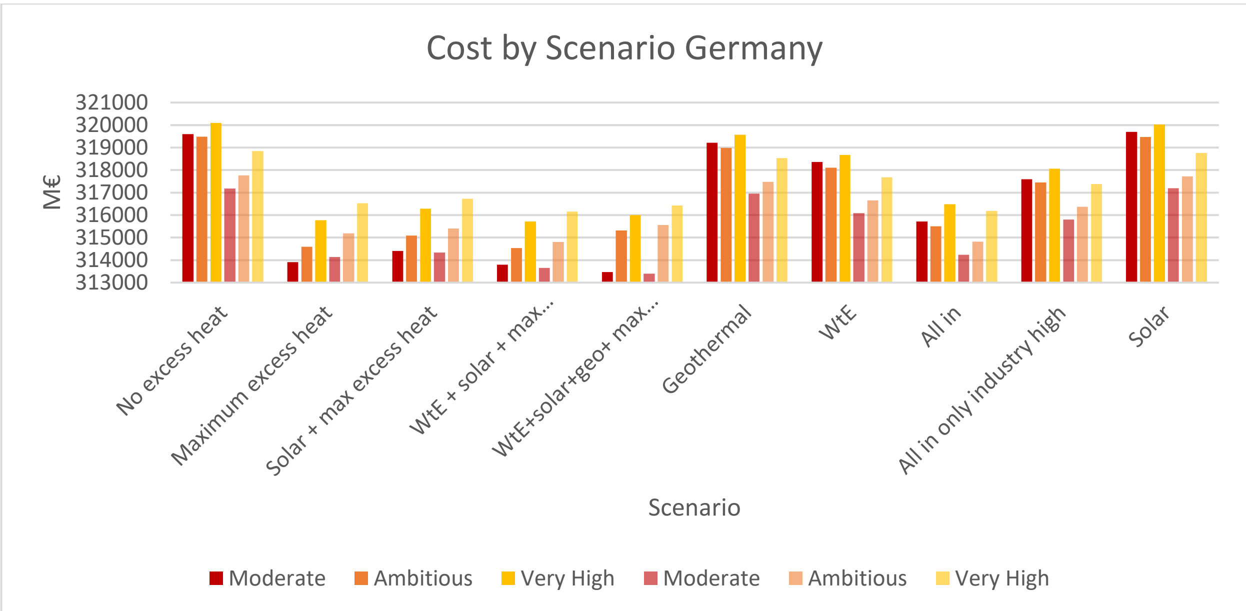


Figure 128: Cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of Germany.

In regards to the costs of the system, it can be seen that the cheapest system is the all mix available heat sources, compared to the other heat prioritization. When comparing the scenarios by themselves, it can be concluded that the Very High savings is the most expensive but there is not a relationship between the saving level and the cost directly, as the cheapest is not the scenario where less measures are done, it is the Ambitious savings for the 3rd generation district heating system. On the other hand, the 4th generation system has a more direct relation between the saving level and the cost as they increase with every saving level.

Table 37: Biomass consumption in TWh/year for different district heating shares and heat source for 3GDH and 4GDH, in the case of Germany and Cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of Germany.

64,60	3rd			4th		
Biomass	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	662,40	610,24	584,16	639,58	592,82	572,32
Maximum waste heat	601,61	558,71	538,58	580,74	542,81	526,85
Solar + max waste heat	604,56	561,53	541,92	582,15	543,89	527,79
WtE + solar + max waste heat	592,32	550,62	530,65	572,80	537,12	521,96
WtE+solar+geo+ max waste heat	592,32	550,62	530,65	573,33	537,45	522,00
Geothermal	654,30	599,07	572,17	632,73	584,08	562,68
WtE	661,41	605,56	578,91	621,58	573,93	551,90
All in	608,77	553,42	530,56	595,77	547,85	529,74
All in only industry high	636,09	581,97	555,95	618,37	570,67	548,56
Solar	660,52	605,04	578,59	637,50	588,89	567,21

	3rd			4th		
Cost	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	319.599	319.482	*320.097*	317.173	317.756	*318.850*
Maximum waste heat	313.906	314.592	*315.768*	314.140	315.190	*316.522*
Solar + max waste heat	314.401	315.090	*316.282*	314.339	315.396	*316.721*
WtE + solar + max waste heat	313.794	314.528	*315.709*	313.655	314.799	*316.152*
WtE+solar+geo+ max waste heat	313.471	315.317	*315.994*	313.397	315.562	*316.427*
Geothermal	319.219	318.992	*319.569*	316.958	317.475	*318.525*
WtE	318.364	318.105	*318.679*	316.092	316.653	*317.674*
All in	315.721	315.497	*316.487*	314.232	314.821	*316.191*
All in only industry high	317.590	317.448	*318.068*	315.806	316.367	*317.382*
Solar	319.700	319.463	*320.026*	317.198	317.718	*318.759*

For the biomass consumption, any action taken for a reduction of the demand is beneficial for reducing the biomass usage, also improving the system's generation. The most beneficial improvement to do would be to step up the generation of the system and also taking measures to reduce the system's heat demand. As an overall comparison, the All in heat prioritization is the one that uses less biomass across all heat saving scenarios.

Not only scenario All in is the cheapest standing in front of the others, but it is also the one that brings a biggest positive change, the biggest reduction compared to the no-surplus-heat scenario. This contrasts the scenario of only solar which has the biggest increase in all saving levels and generations. There it can be concluded, based on this, that only solar is not a feasible choice but the mix of the surplus heat sources helps to reduce the cost of the system. Regarding the saving level, it becomes cheaper to improve the generation of the system over taking measures to reduce the demand. In case that reducing the demand is the only option, it is recommended that only one step is taken to stay at the Ambitious savings.

Another result shown for EU27 is how the heat supply is formed with all the different sources. For the case of Germany:

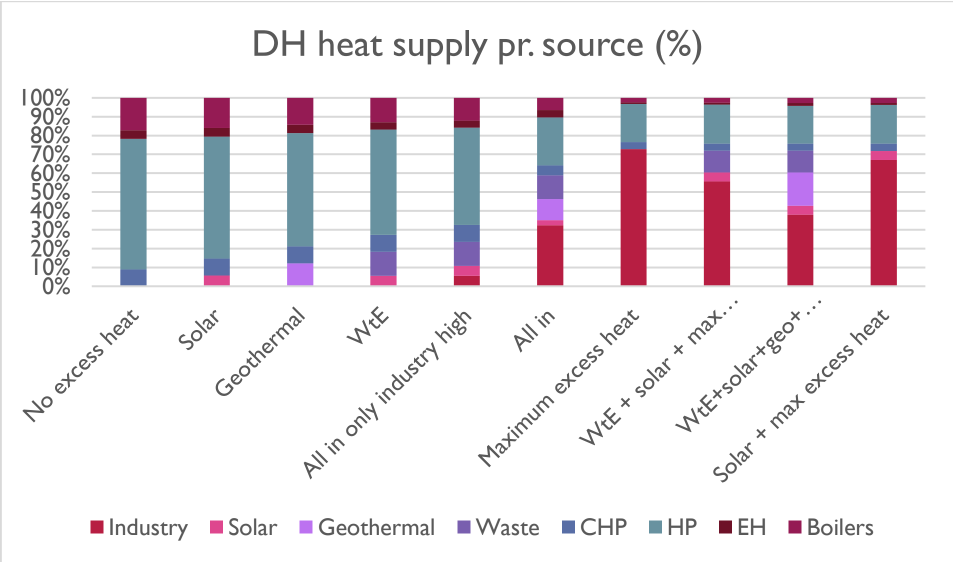


Figure 129: District heating heat supply pr. source in percentage for each scenario in the case of Germany.

This graph shows how the different heat sources are fueling the system. The light blue features the Waste to energy potential and in all the scenarios and priorities, it is used its full potential, highlighting its easiness to be integrated to the district heating system in any case. The scenarios Geothermal and Solar show that only solar and geothermal alone have not enough potential to even cover 15% of the demand. The scenario where there is less usage of heat pumps, is the scenario All in, where all the waste heat is available.

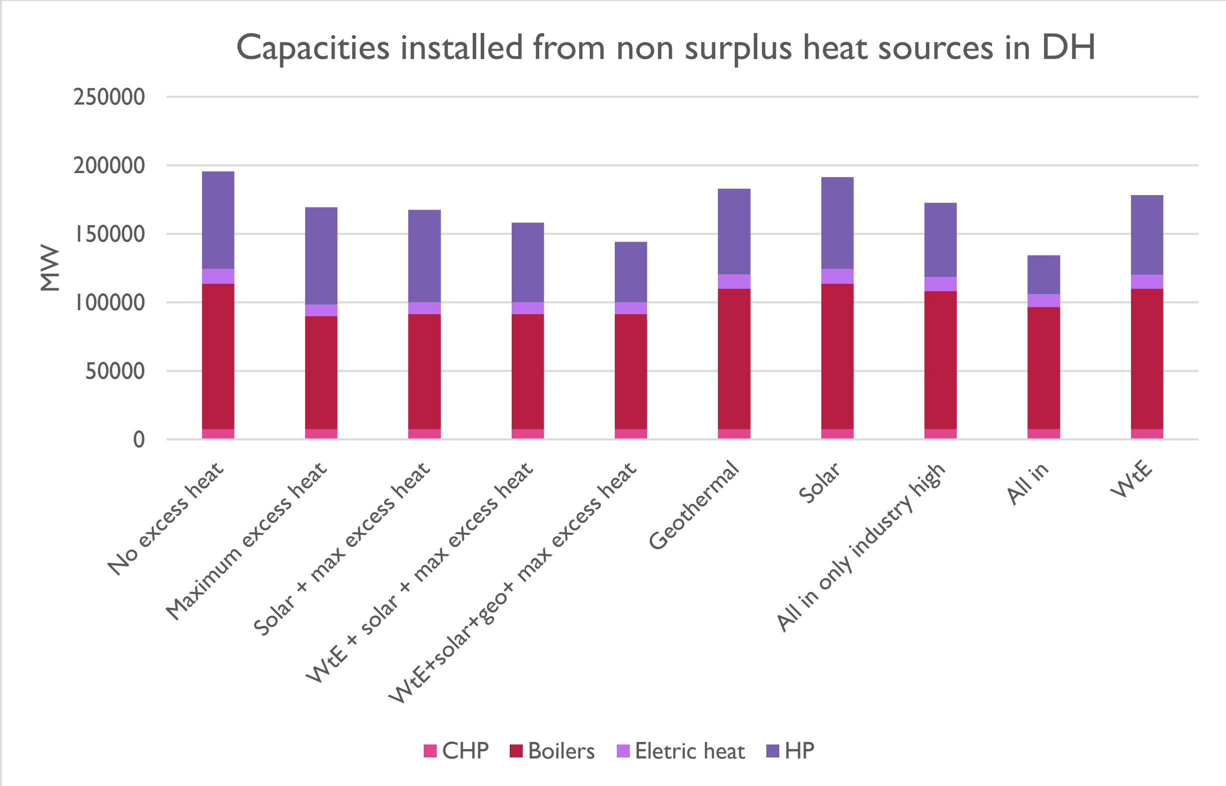


Figure 130: Installed capacities in MW from non surplus heat sources in district heating in Germany.

5.11 Greece

Table 38: District heating shares specific to Greece and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Greece	5	24,46	6,96	0,88	0,56	0,73	0,55	1,67	0,02	0	0	0	0	0
	10	24,46	6,96	0,88	0,56	0,73	0,55	1,67	0,02	0	0	0	0	0
	15	24,46	6,96	0,88	0,56	0,73	0,55	1,67	0,02	0	0	0	0	0
	20	24,46	6,96	0,88	0,56	0,73	0,55	1,67	0,02	0	0	0	0	0
	25	31,38	8,93	1,26	1,39	0,73	0,55	1,67	0,02	0	0	0	0	0
	30	31,38	8,93	1,26	1,39	0,73	0,55	1,67	0,02	0	0	0	0	0
	35	35,28	10,03	1,4	1,4	0,99	0,73	1,81	0,03	0	0	0	0	0
	40	40,02	11,38	1,6	1,67	1,12	0,81	1,84	0,04	0	0,02	0,04	0	0
	45	45,11	12,83	1,78	1,77	1,27	0,97	1,87	0,04	0	0,09	0,11	0	0
	50	50	14,22	1,88	1,83	1,55	0,99	1,97	0,05	0	0,17	0,2	0	0
	55	50,27	14,3	1,88	1,83	1,56	0,99	1,97	0,05	0	0,18	0,2	0	0
	60	50,27	14,3	1,88	1,83	1,56	0,99	1,97	0,05	0	0,18	0,2	0	0
	65	50,27	14,3	1,88	1,83	1,56	0,99	1,97	0,05	0	0,18	0,2	0	0

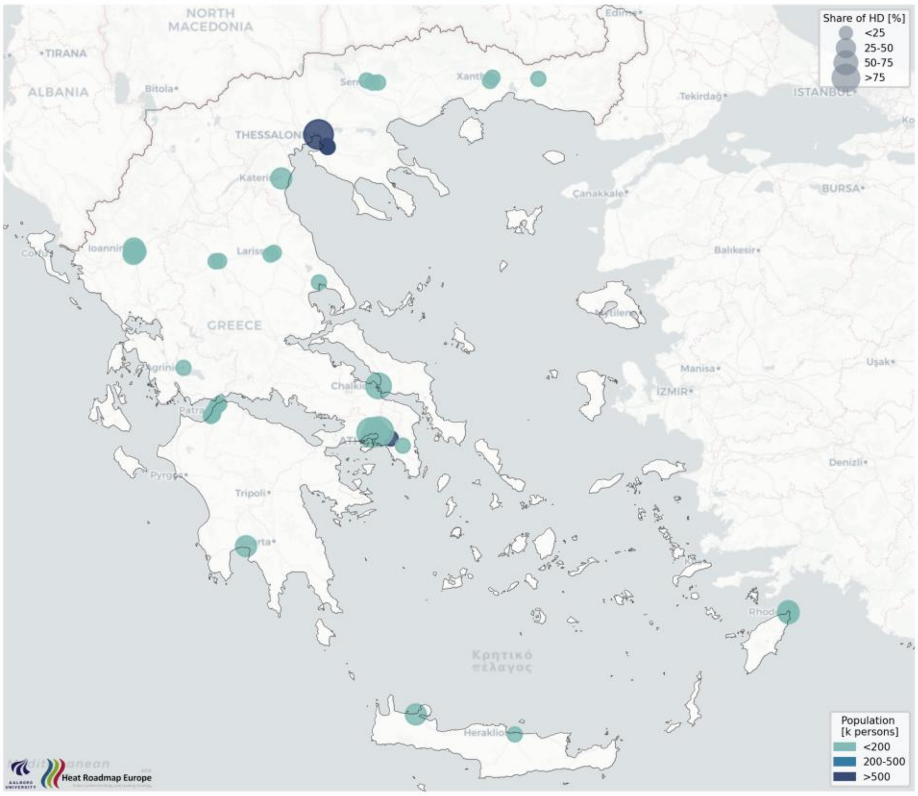


Figure 131: Baseload high temperature waste heat for Greece.

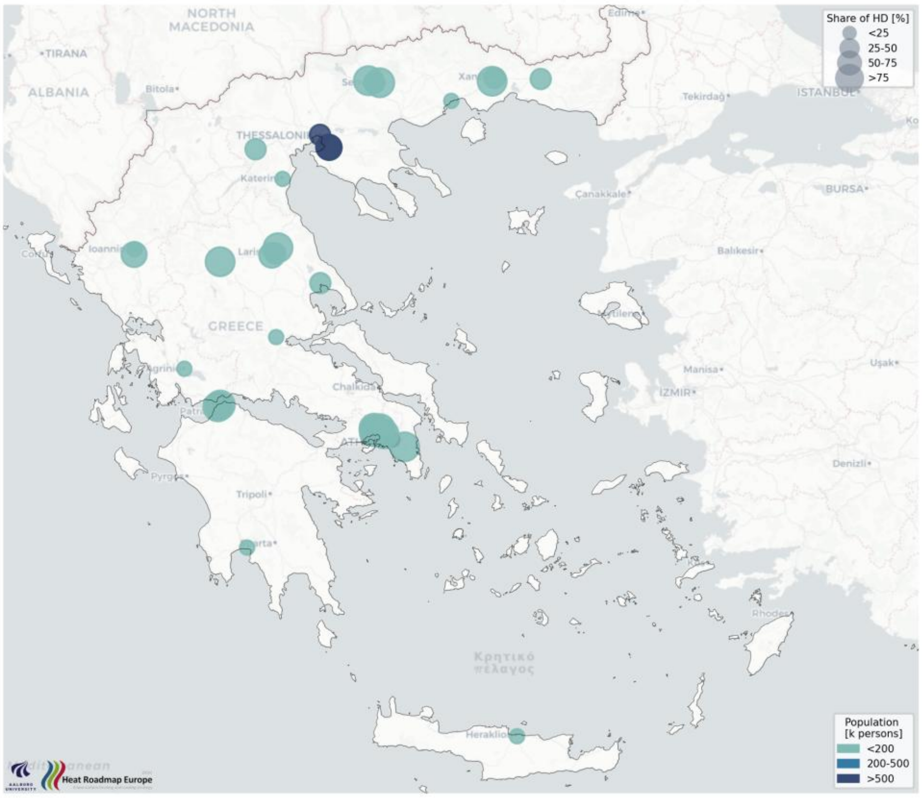


Figure 132: Baseload low temperature waste heat for Greece.

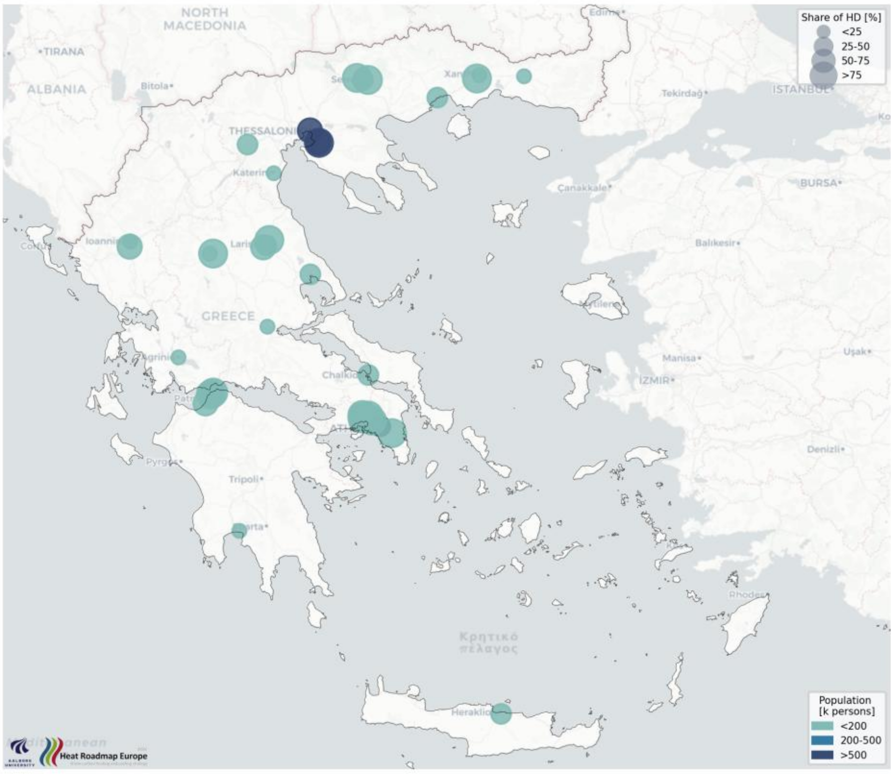


Figure 133: Baseload medium temperature waste heat for Greece.

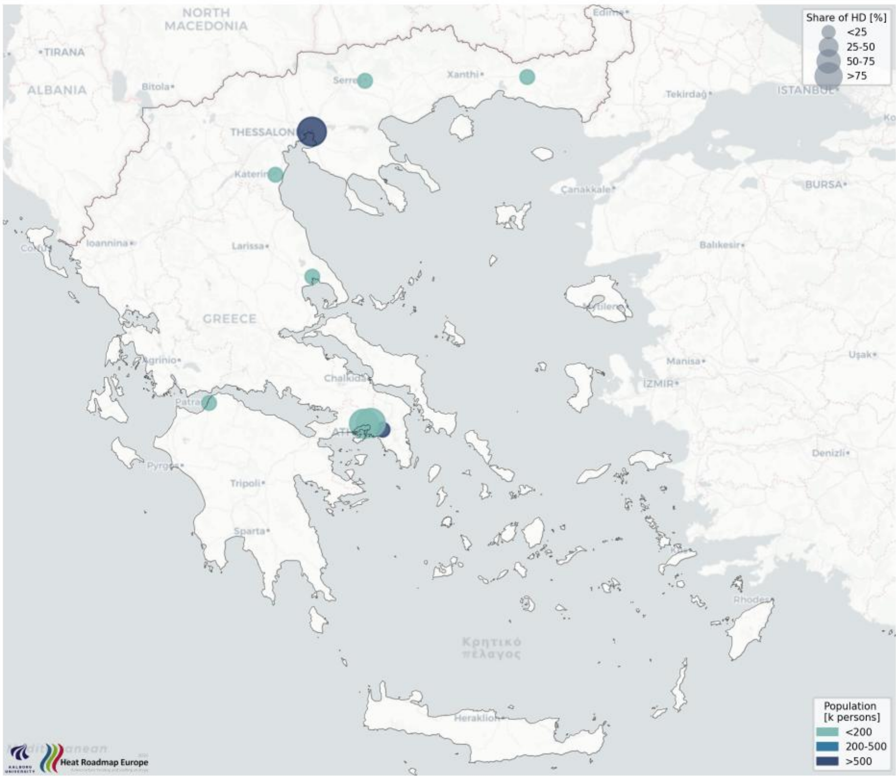


Figure 134: High temperature from industry for Greece.

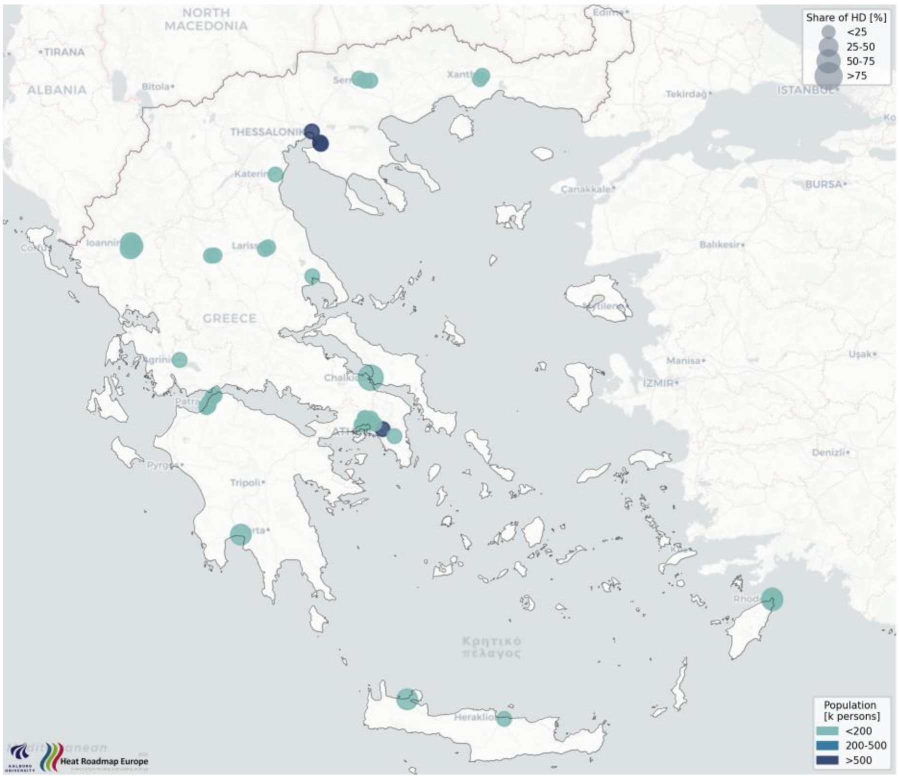


Figure 135: High temperature from waste-to-energy for Greece.

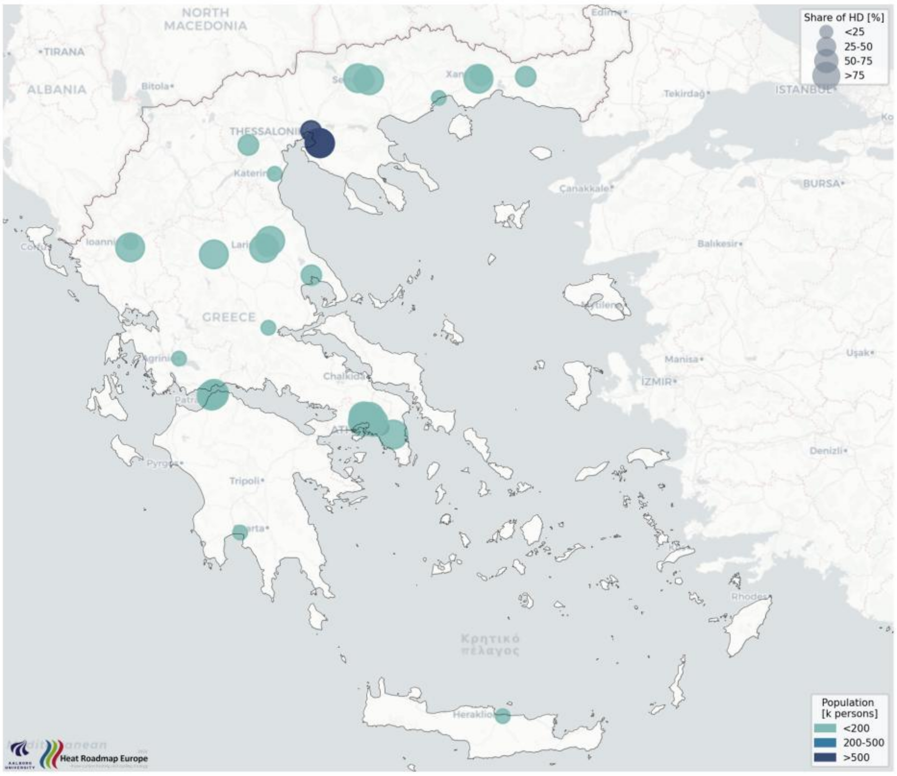


Figure 136: Low temperature from industry for Greece.

Figure 137: Low temperature from metros for Greece.

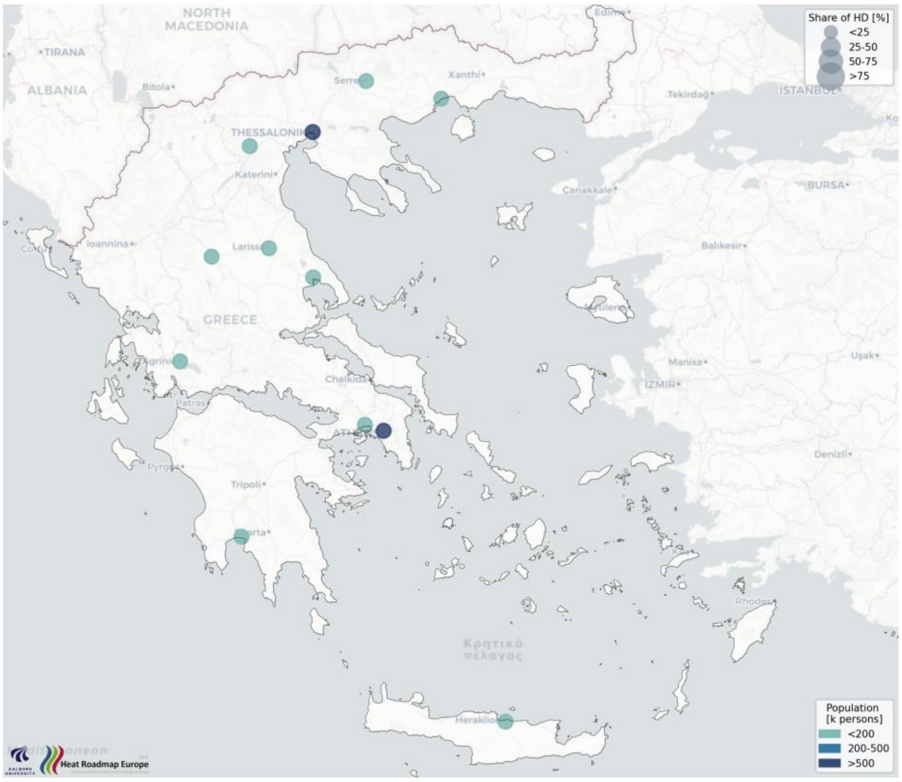


Figure 138: Low temperature from supermarkets for Greece.

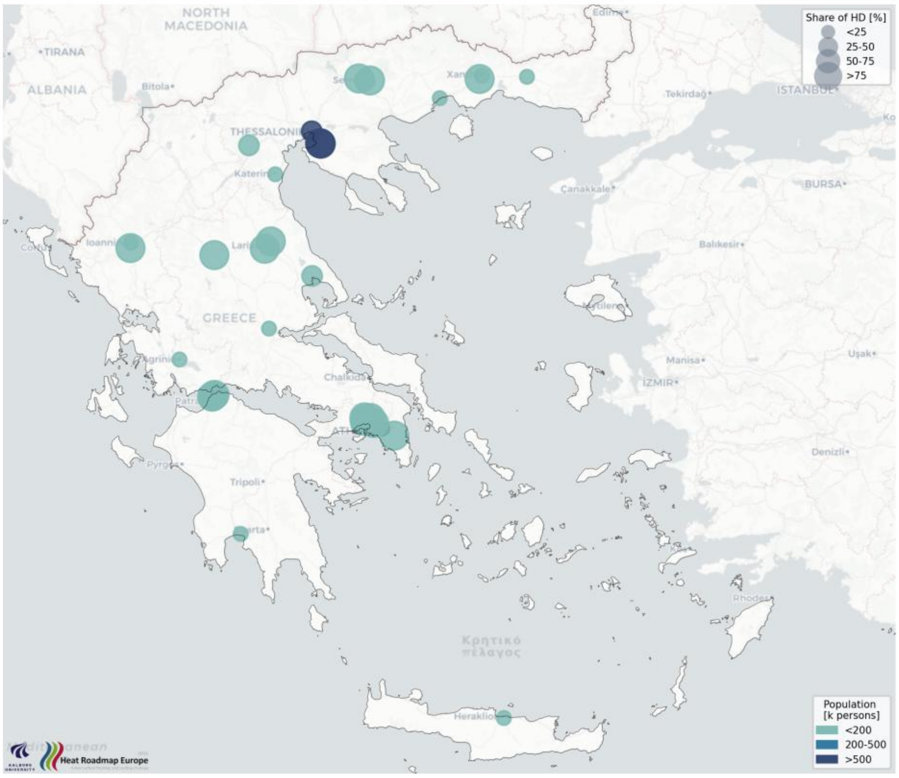


Figure 139: Medium temperature from industry for Greece.

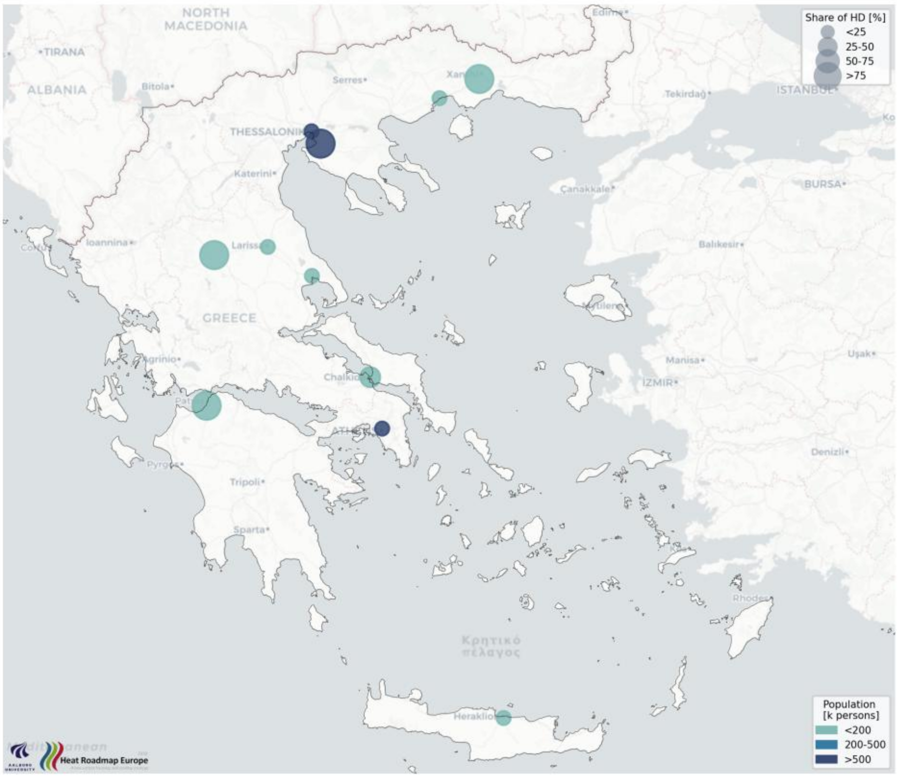


Figure 140: Medium temperature from wastewater treatment for Greece.

5.12 Hungary

Table 39: District heating shares specific to Hungary and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Hungary	5	11,21	6,34	0,7	0	0,16	0,31	0,73	0,11	0,18	0	0	0,87	0,87
	10	11,21	6,34	0,7	0	0,16	0,31	0,73	0,11	0,18	0	0	0,87	0,87
	15	15,93	9,01	0,99	0	0,23	0,46	1,12	0,17	0,21	0	0,02	1,24	1,13
	20	20,11	11,37	1,22	0,05	0,3	0,58	1,38	0,23	0,21	0	0,09	1,5	1,13
	25	25,38	14,35	1,53	0,05	0,41	0,8	1,8	0,3	0,21	0	0,16	1,6	1,13
	30	30,38	17,18	1,65	0,05	0,51	0,97	2,1	0,37	0,21	0,06	0,27	1,6	1,13
	35	35,21	19,91	1,67	0,18	0,6	1,15	2,29	0,43	0,21	0,19	0,41	1,6	1,13
	40	40,17	22,71	1,73	0,29	0,67	1,28	2,6	0,51	0,21	0,33	0,55	1,6	1,13
	45	45,07	25,49	1,8	0,33	0,77	1,47	2,79	0,61	0,21	0,48	0,7	1,6	1,13
	50	50,01	28,28	1,82	0,33	0,85	1,61	2,98	0,71	0,21	0,67	0,89	1,6	1,13
	55	55	31,1	1,85	0,34	0,91	1,71	3,16	0,77	0,21	0,89	1,11	1,6	1,13
	60	55,66	31,48	1,85	0,34	0,93	1,72	3,18	0,77	0,21	0,91	1,13	1,6	1,13
	65	55,66	31,48	1,85	0,34	0,93	1,72	3,18	0,77	0,21	0,91	1,13	1,6	1,13

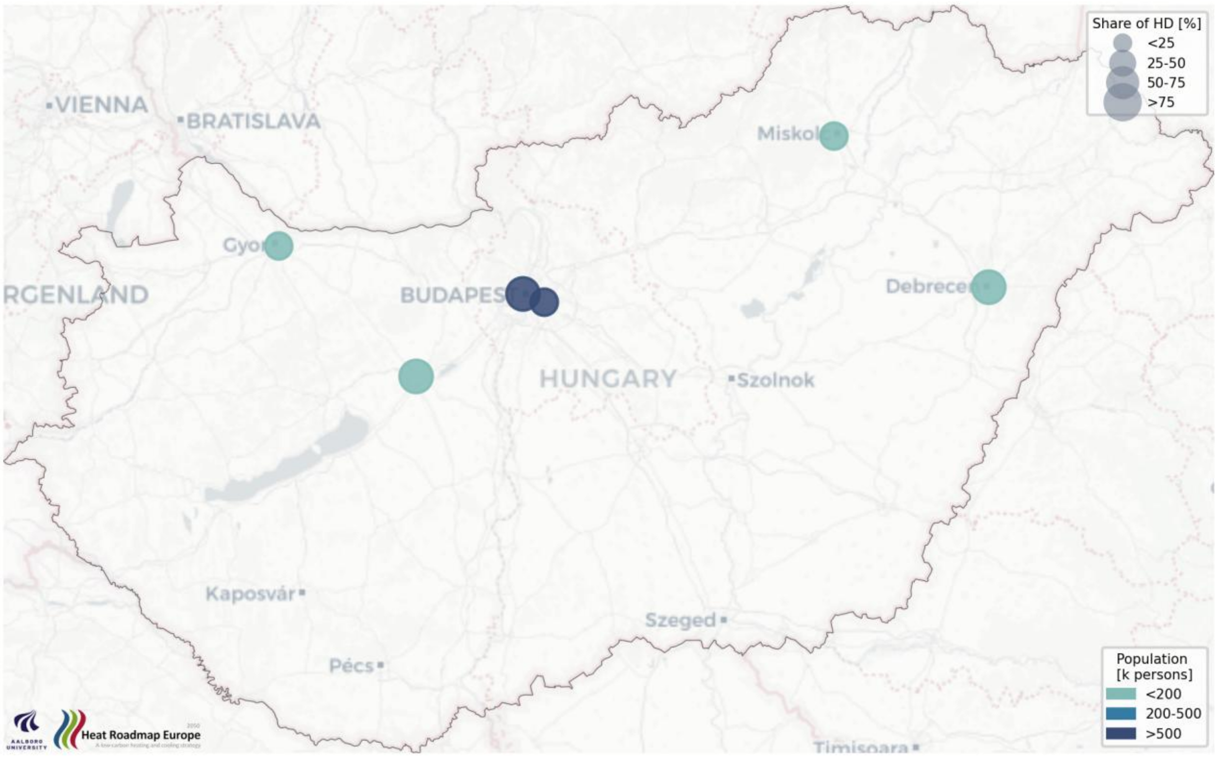


Figure 141: Geothermal energy for Hungary (Baseload of district heating area, capacity >40MW).

Figure 142: Geothermal energy for Hungary (Baseload of district heating area, capacity >70MW).

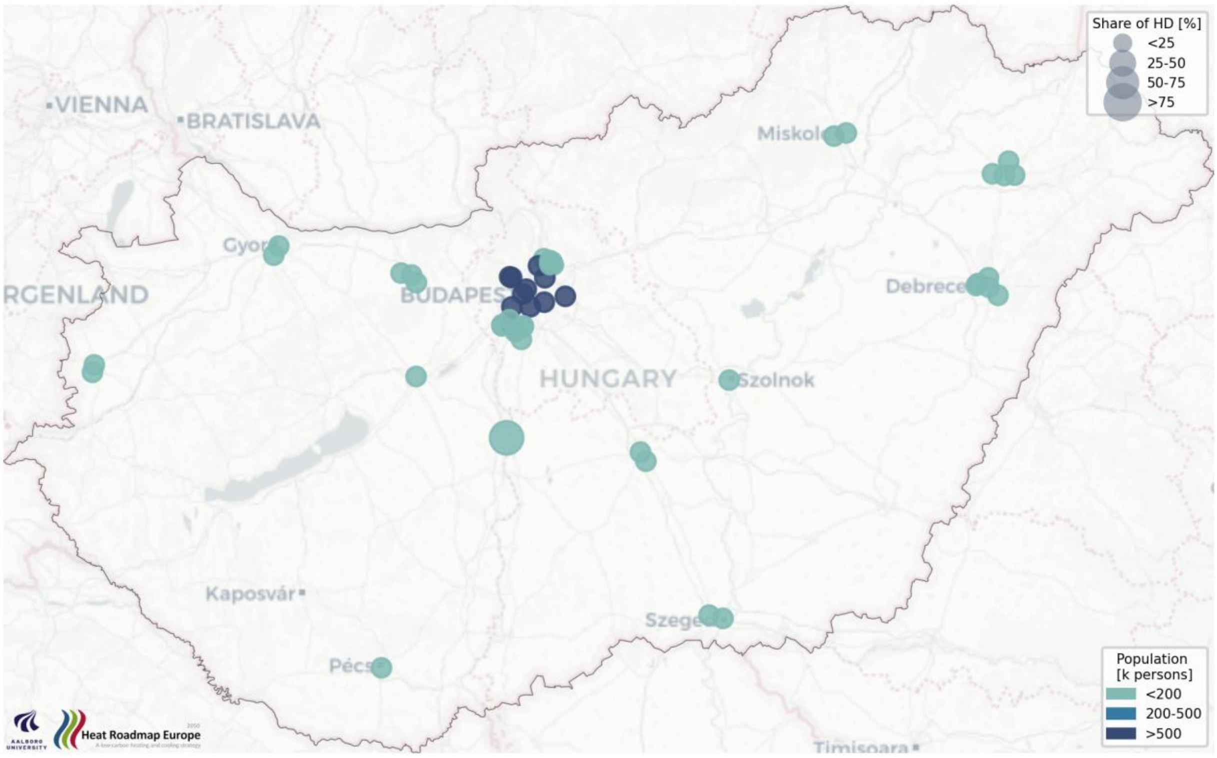


Figure 143: Baseload high temperature waste heat for Hungary.

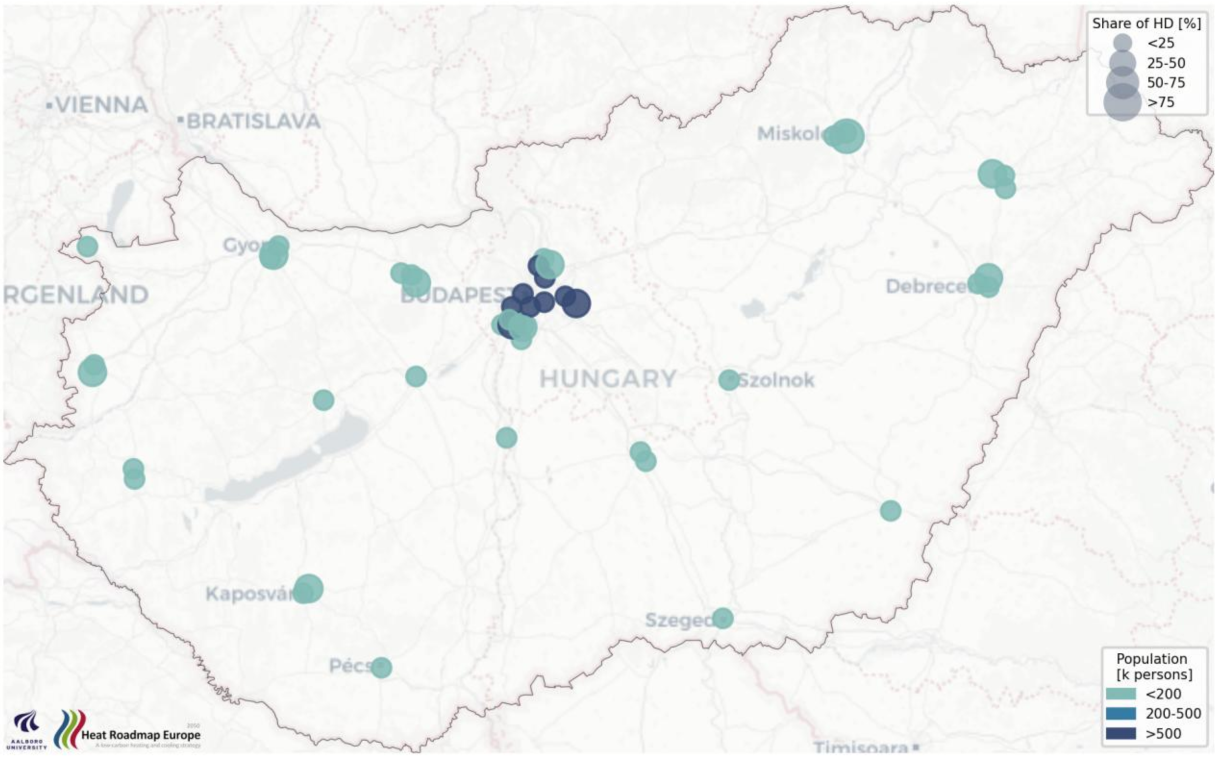


Figure 144: Baseload low temperature waste heat for Hungary.

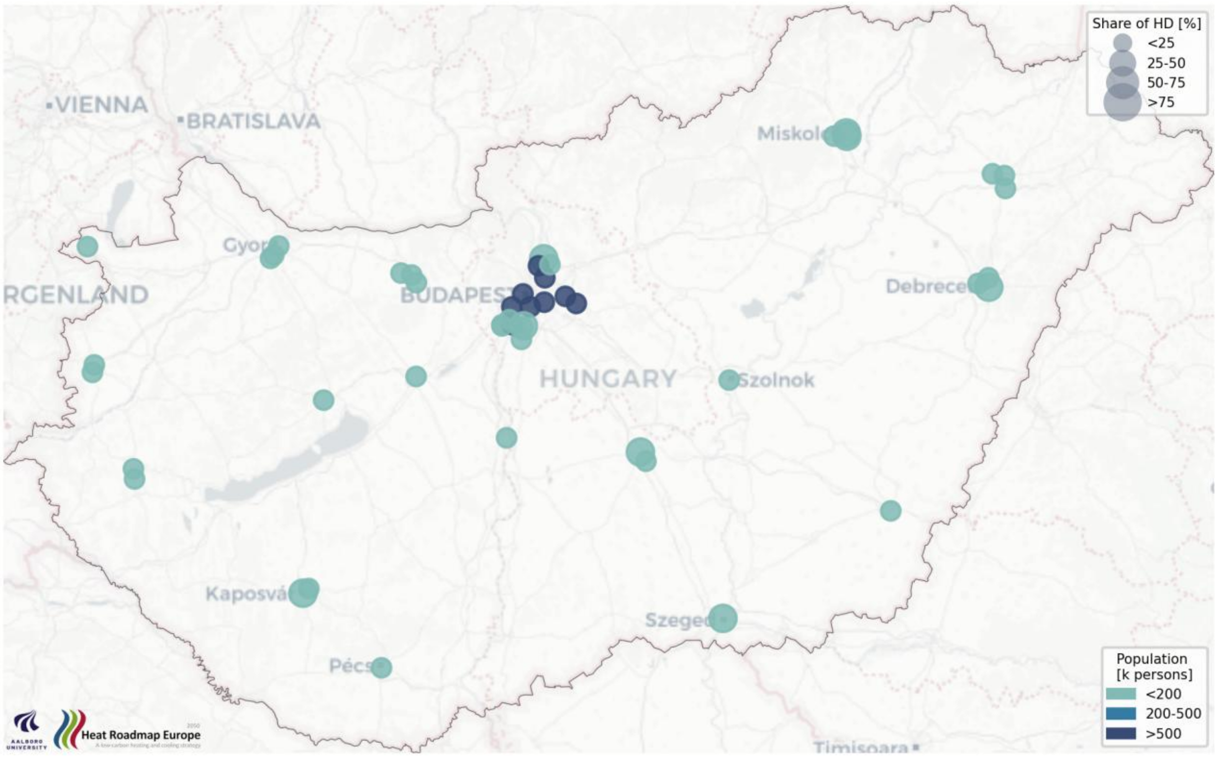


Figure 145: Baseload medium temperature waste heat for Hungary.

Figure 146: High temperature from industry for Hungary.

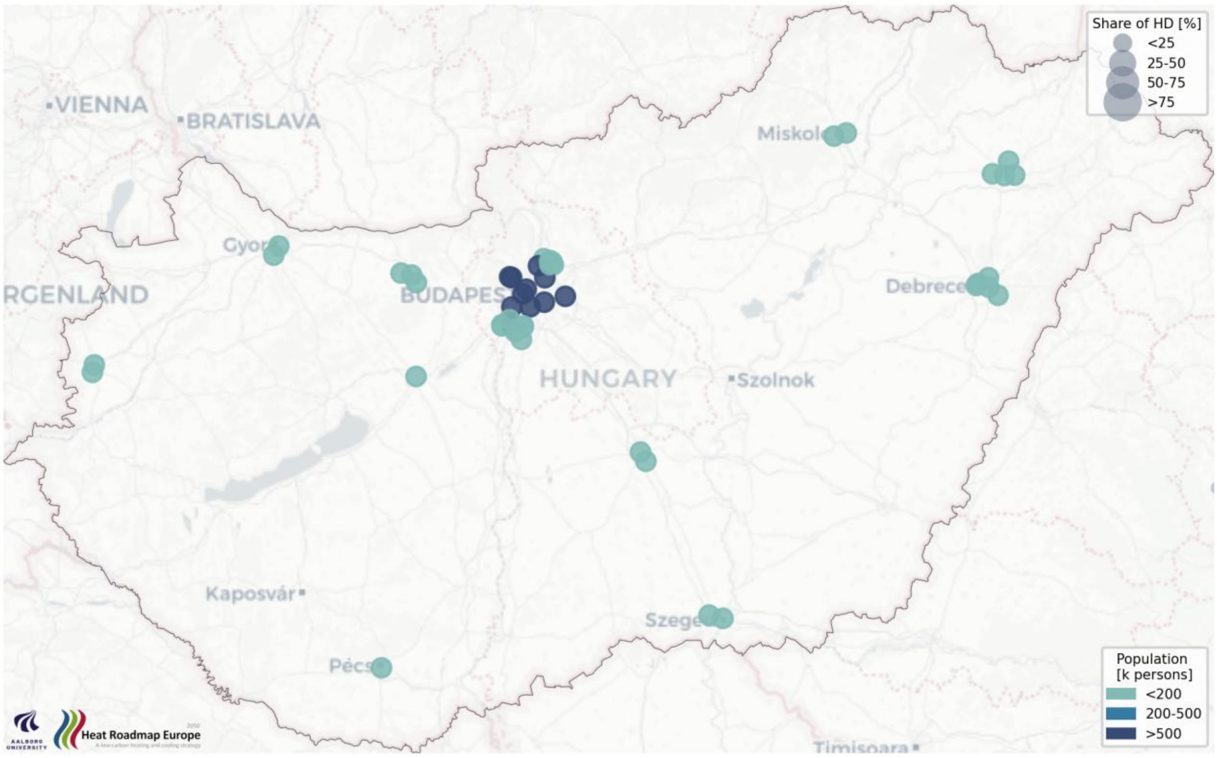


Figure 147: High temperature from waste-to-energy for Hungary.

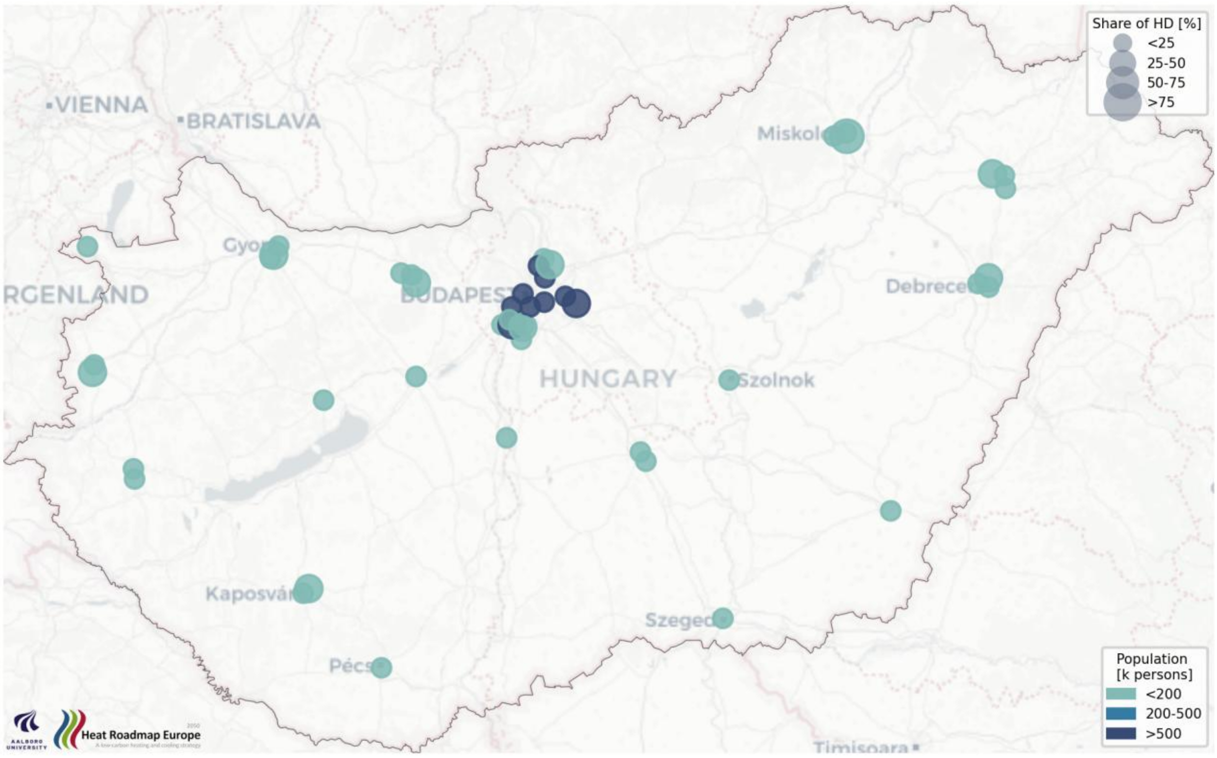


Figure 148: Low temperature from industry for Hungary.

Figure 149: Low temperature from metros for Hungary.

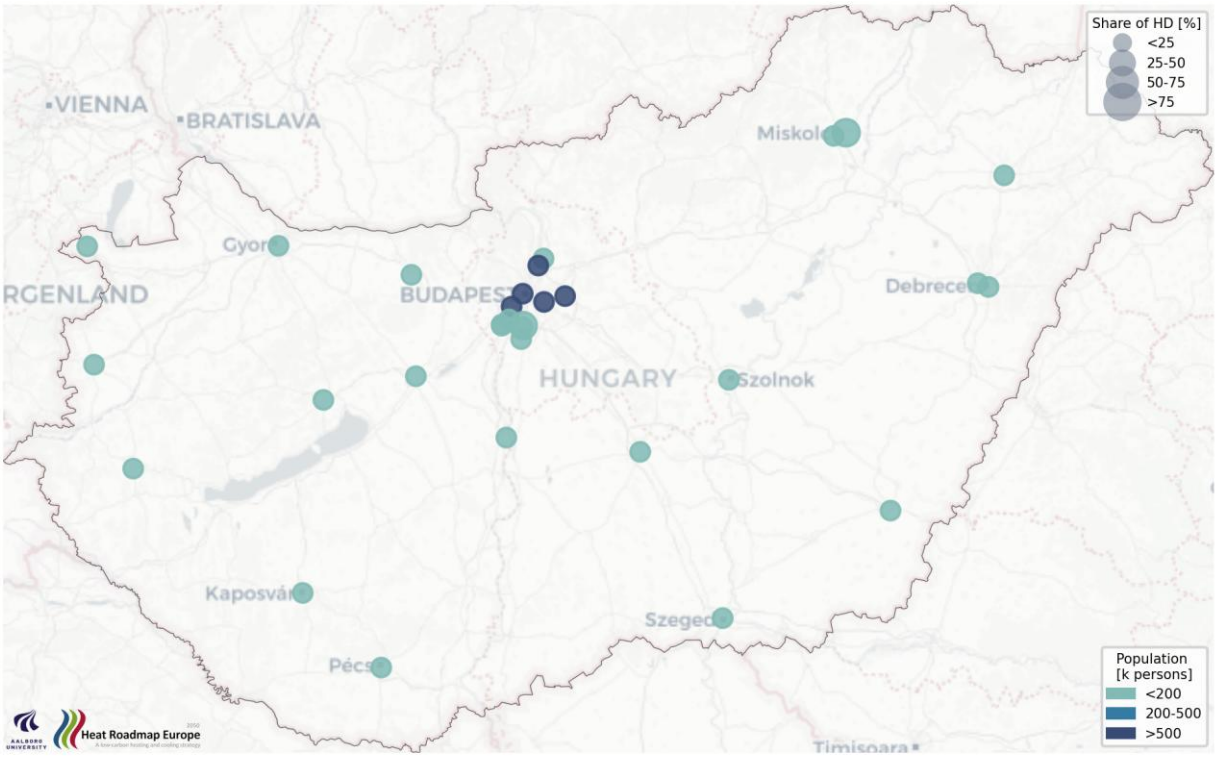


Figure 150: Low temperature from supermarkets for Hungary.

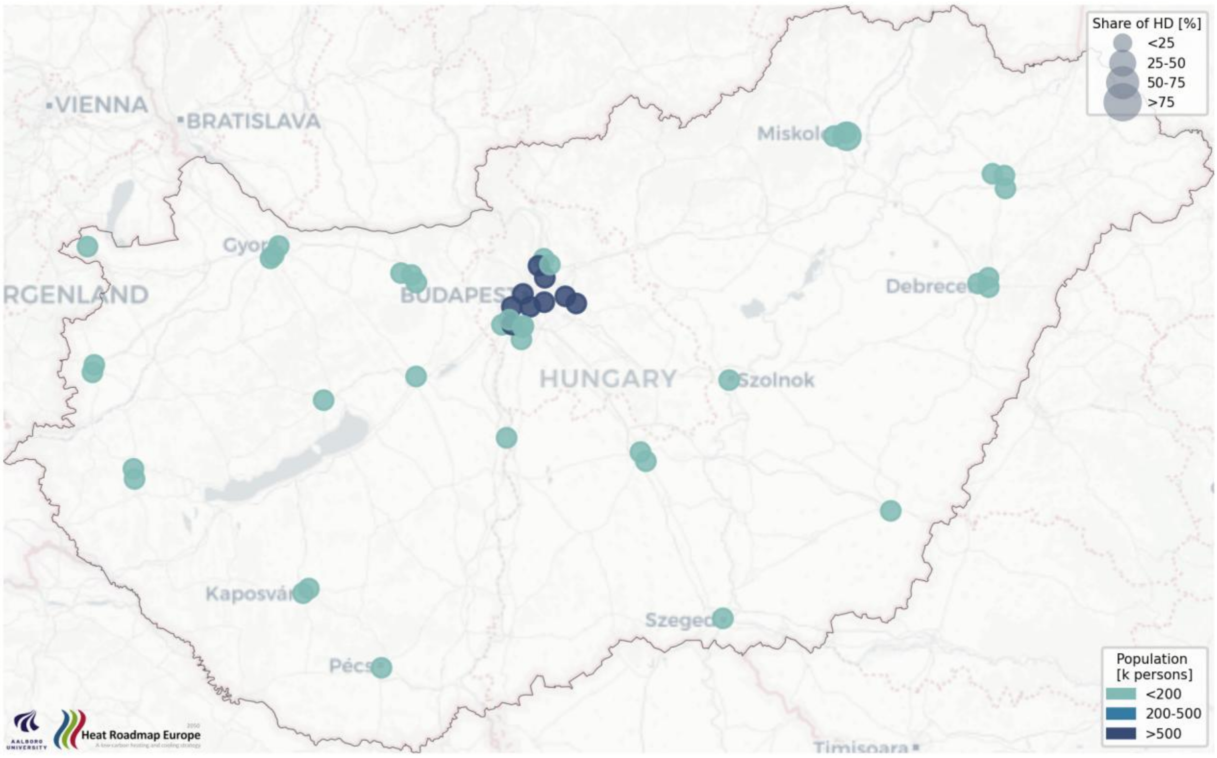


Figure 151: Medium temperature from industry for Hungary.

Figure 152: Medium temperature from wastewater treatment for Hungary

For Hungary the recommended district heating share is 46,59%, so the simulation for the 50% is taken.

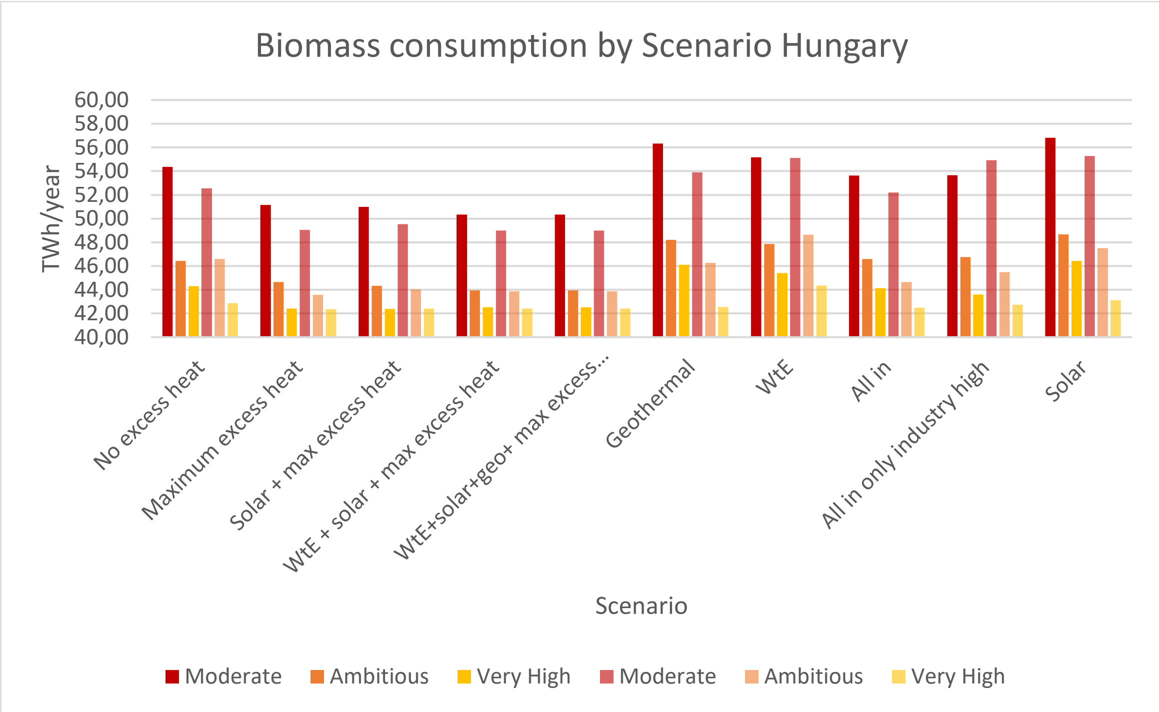


Figure 153: Biomass consumption in TWh/year for different district heating shares and heat source for 3GDH and 4GDH, in the case of Hungary.

As a rule, for Hungary, the consumption of the biomass is the minimum when the heat demand is. That happens across all scenarios and system generations. As it is logical, the high demand scenario are the ones with more biomass consumption.

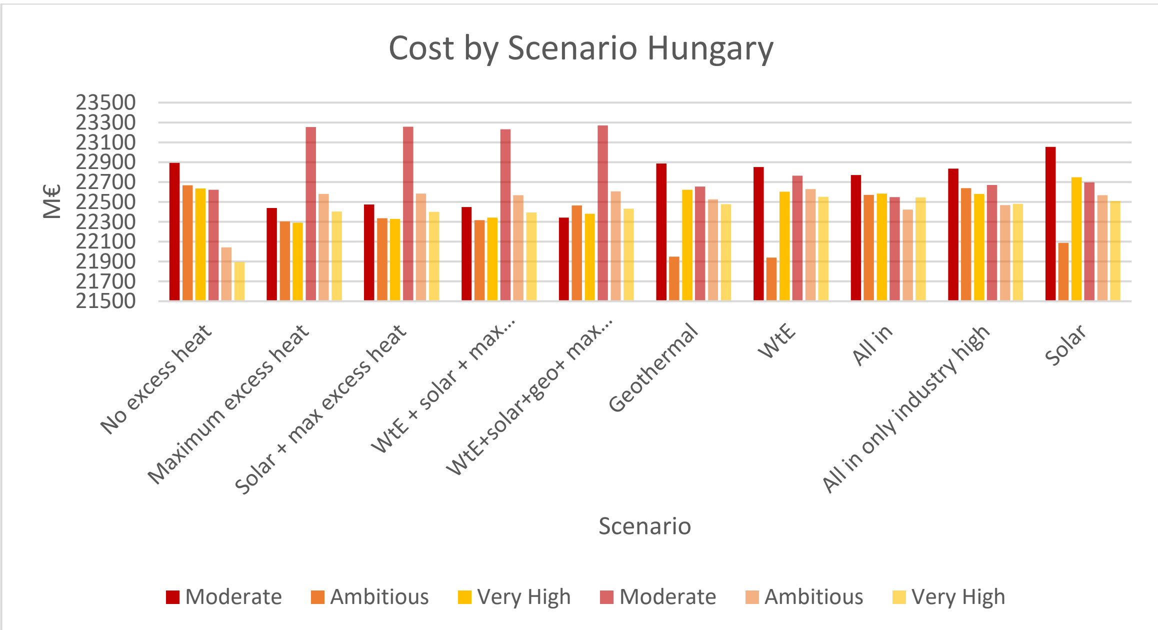


Figure 154: Cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of Hungary.

The high peaks on the 4th generation on the scenarios of max availability is due to the undersize of the biomass boiler, so a compensation is added. Discarding that, the more expensive scenarios are the ones with the higher heat demand. An anomaly is seen in the Ambitious saving for the scenarios with a single heat source for the 3rd generation. For the single heat source scenarios, there is the trend that brings the cost down as the demand goes down for the 4th generation.

Table 40: : Biomass consumption in TWh/year for different district heating shares and heat source for 3GDH and 4GDH, in the case of Hungary and cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of Hungary.

46,59	3rd			4th		
Biomass	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	54,35	46,44	44,29	52,55	46,60	42,88
Maximum waste heat	51,16	44,65	42,41	49,06	43,58	42,35
Solar + max waste heat	50,99	44,33	42,37	49,52	44,02	42,42
WtE + solar + max waste heat	50,33	43,94	42,51	49,00	43,85	42,41
WtE+solar+geo+ max waste heat	50,33	43,94	42,51	49,00	43,85	42,41
Geothermal	56,34	48,20	46,10	53,91	46,26	42,54
WtE	55,18	47,87	45,40	55,12	48,65	44,34
All in	53,62	46,60	44,14	52,20	44,64	42,49
All in only industry high	53,67	46,76	43,59	54,91	45,47	42,74
Solar	56,82	48,67	46,44	55,28	47,51	43,12

	3rd			4th		
Cost	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	22.893	22.667	*22.635*	22.622	22.043	*21.893*
Maximum waste heat	22.440	22.303	*22.291*	23.254	22.580	*22.402*
Solar + max waste heat	22.476	22.336	*22.330*	23.256	22.582	*22.399*
WtE + solar + max waste heat	22.450	22.317	*22.343*	23.231	22.568	*22.395*
WtE+solar+geo+ max waste heat	22.343	22.465	*22.382*	23.269	22.607	*22.433*
Geothermal	22.887	21.948	*22.624*	22.654	22.527	*22.478*
WtE	22.853	21.940	*22.604*	22.764	22.627	*22.552*
All in	22.769	22.571	*22.583*	22.549	22.424	*22.546*
All in only industry high	22835	22.638	*22.580*	22.671	22.468	*22.481*
Solar	23.055	22.088	*22.748*	22.698	22.567	*22.510*

In the case of the biomass, its consumption can be reduced up to a 24% if measures are taken to reduce the heat demand and if the generation of the system is improved. There is only one case of increasing the biomass: when the system generation is improved with no other measures to reduce the demand are implemented in the scenario All in only industry high, for the rest, any step means a reduction in the biomass consumption. For the cost it happens a similar pattern, in any heat prioritization whatever action is taken to improve the system or reduce the demand is translated into a reduction of the cost. However, the reduction is not a big step as the average reduction is lower than a 2% in the whole cost. Another way of justifying the actions to improve the system and the demand is that with that improvement there will be huge positive consequences for the biomass and for the environment and also for the economy.

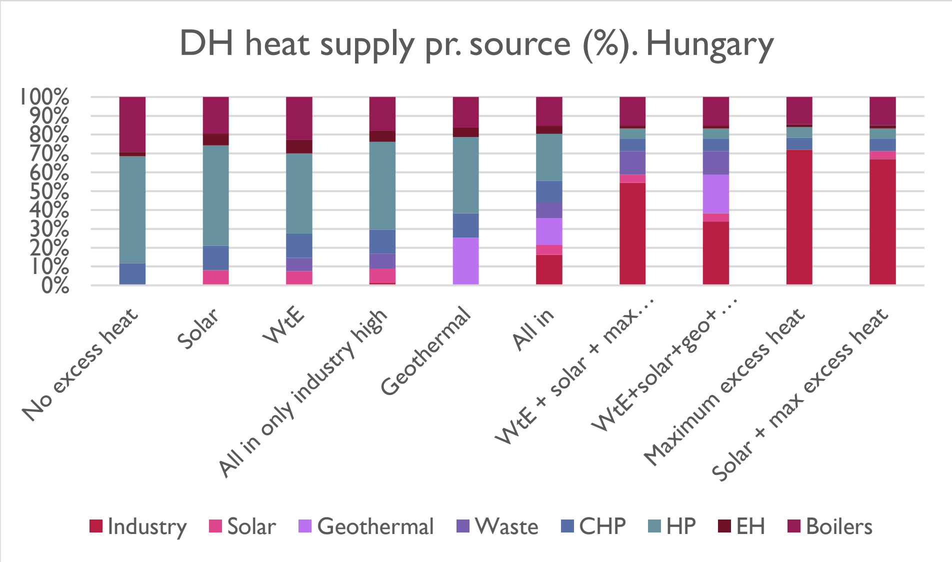


Figure 155: District heating heat supply pr. source in percentage for each scenario in the case of Hungary.

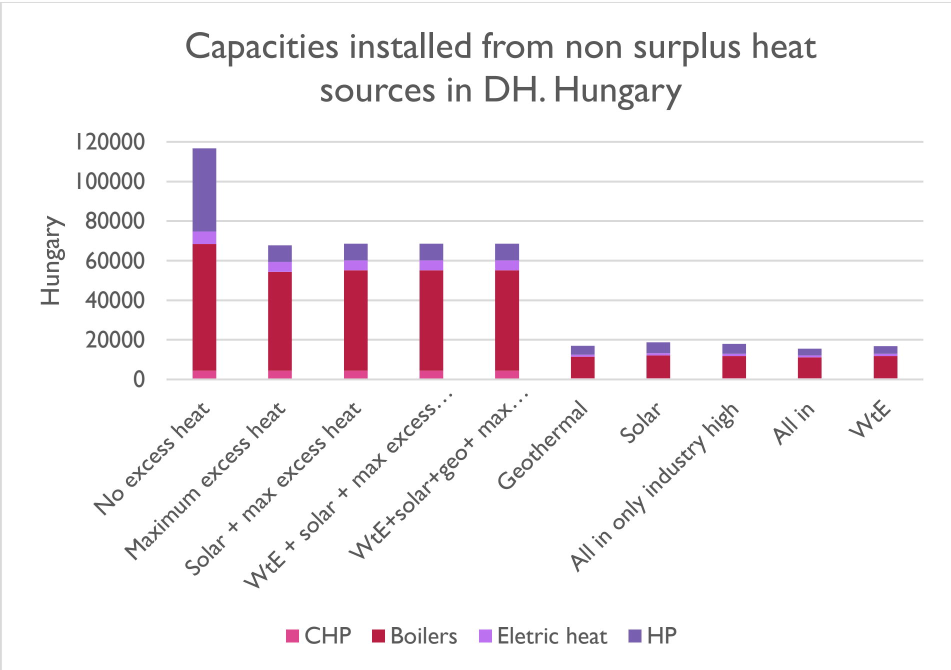


Figure 156: Installed capacities in MW from non-surplus heat sources in district heating in Hungary.

The case of Hungary resembles more to France than to Spain or Germany. In this case there is a lot of geothermal potential, that is why the geothermal scenario is the second with less HP installed (taking out the max availability scenarios). However, as it seems to be a rule now, the scenario heat prioritization with less HP installed is the one with the mix heat sources. Regarding that scenario, there is still some geothermal potential that is not exploited, that must be due to the criteria of choosing the cheapest option first, and it happens the same with the solar potential. As a standout, compared to other countries, the full potential of the waste to energy is not used in all the scenarios.

5.13 Ireland

Table 41: District heating shares specific to Ireland and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Ireland	5	23,38	6,8	1,41	0	1,75	1,14	1,07	0,05	0	0	0	0	0
	10	23,38	6,8	1,41	0	1,75	1,14	1,07	0,05	0	0	0	0	0
	15	23,38	6,8	1,41	0	1,75	1,14	1,07	0,05	0	0	0	0	0
	20	23,38	6,8	1,41	0	1,75	1,14	1,07	0,05	0	0	0	0	0
	25	26,83	7,8	1,66	0	2,07	1,43	1,07	0,06	0	0	0	0	0
	30	31,65	9,21	1,9	0	2,49	1,88	1,15	0,07	0	0	0	0	0
	35	35,67	10,37	1,95	0	2,91	2,27	1,25	0,08	0	0	0,01	0	0
	40	40,35	11,73	1,99	0	3,37	2,77	1,33	0,11	0	0,01	0,02	0	0
	45	45,02	13,09	2,05	0	3,82	3,22	1,4	0,14	0	0,03	0,03	0	0
	50	50,02	14,55	2,07	0,02	4,18	3,48	1,53	0,18	0	0,07	0,07	0	0
	55	51,19	14,89	2,07	0,02	4,22	3,51	1,57	0,19	0	0,08	0,09	0	0
	60	51,19	14,89	2,07	0,02	4,22	3,51	1,57	0,19	0	0,08	0,09	0	0
	65	51,19	14,89	2,07	0,02	4,22	3,51	1,57	0,19	0	0,08	0,09	0	0

Figure 157: Geothermal energy for Ireland (Baseload of district heating area, capacity >40MW).

Figure 158: Geothermal energy for Ireland (Baseload of district heating area, capacity >70MW).

Figure 159: Baseload high temperature waste heat for Ireland.

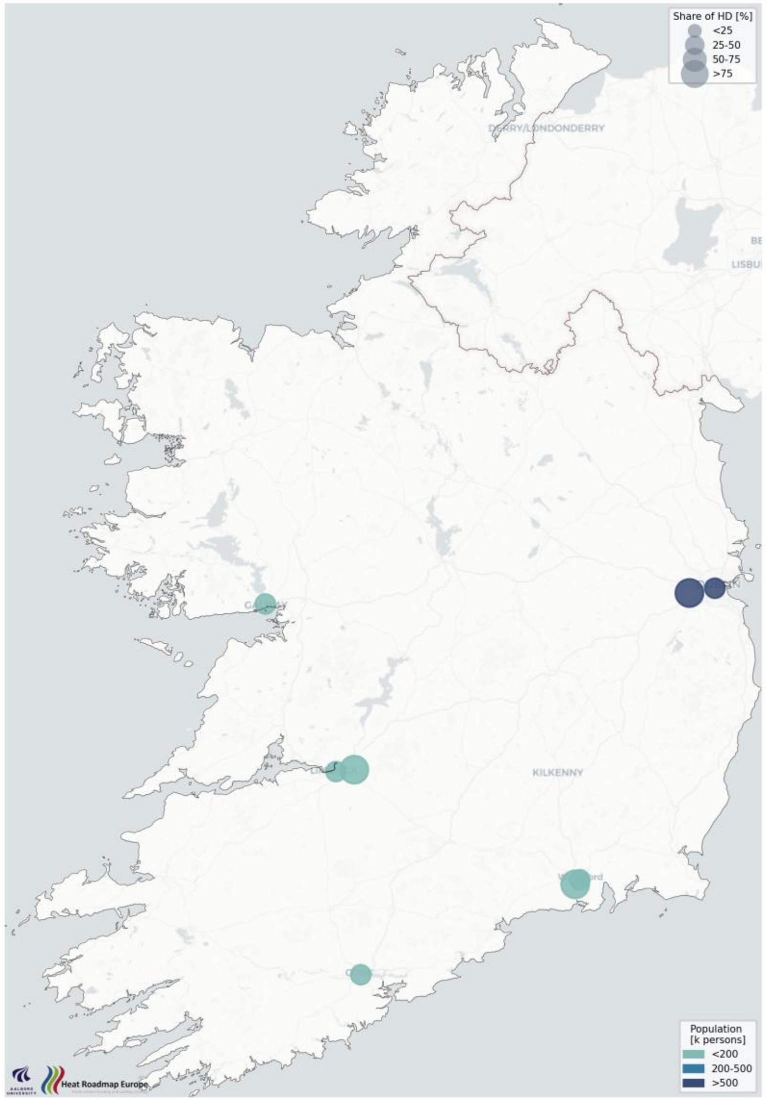


Figure 160: Baseload low temperature waste heat for Ireland.

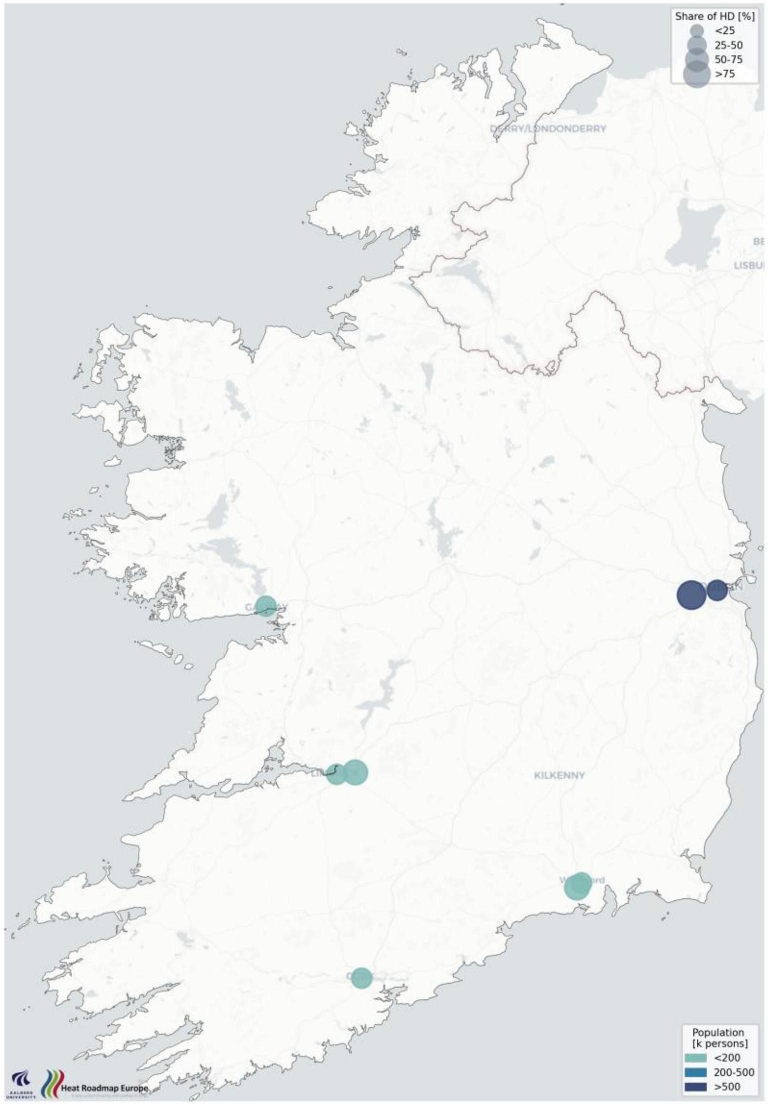


Figure 161: Baseload medium temperature waste heat for Ireland.

Figure 162: High temperature from waste-to-energy for Ireland.

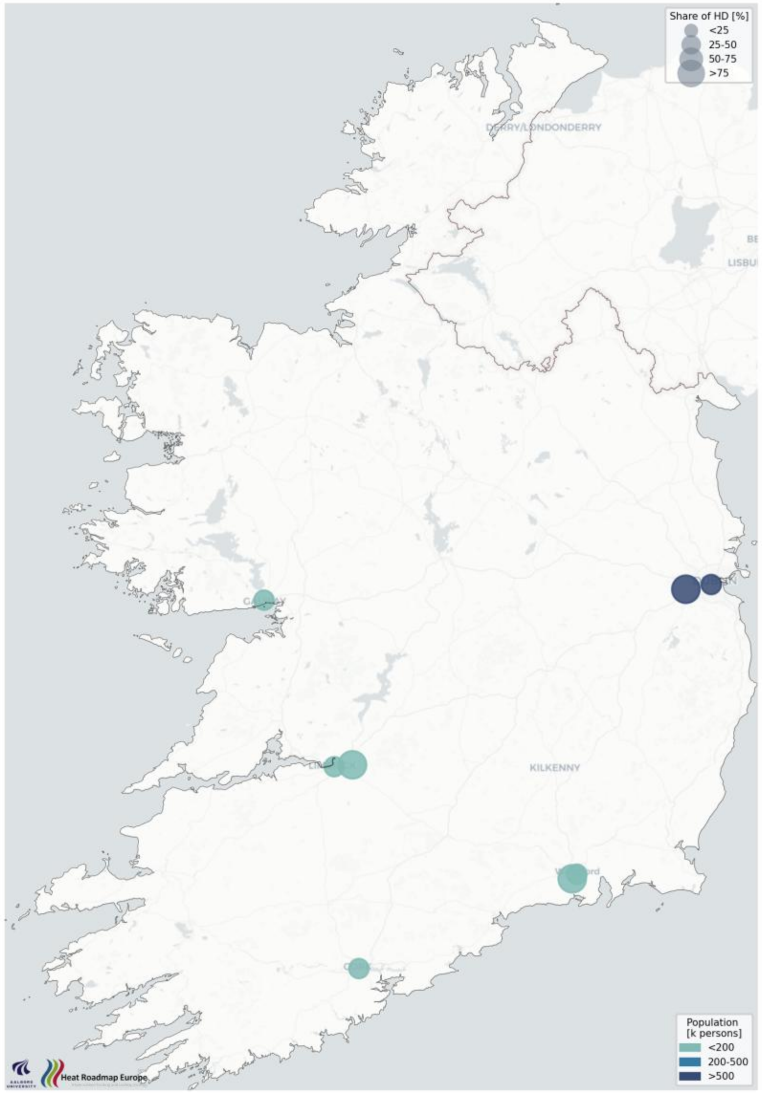


Figure 163: Low temperature from industry for Ireland.

Figure 1645: Low temperature from supermarkets for Ireland.

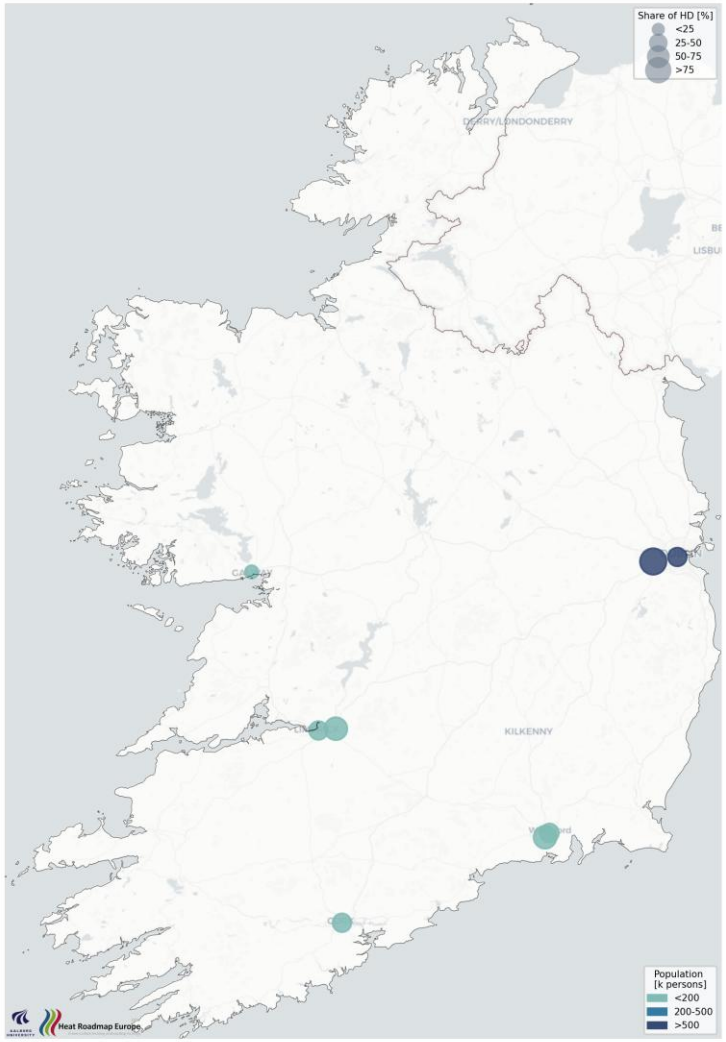


Figure 1656: Medium temperature from industry for Ireland.

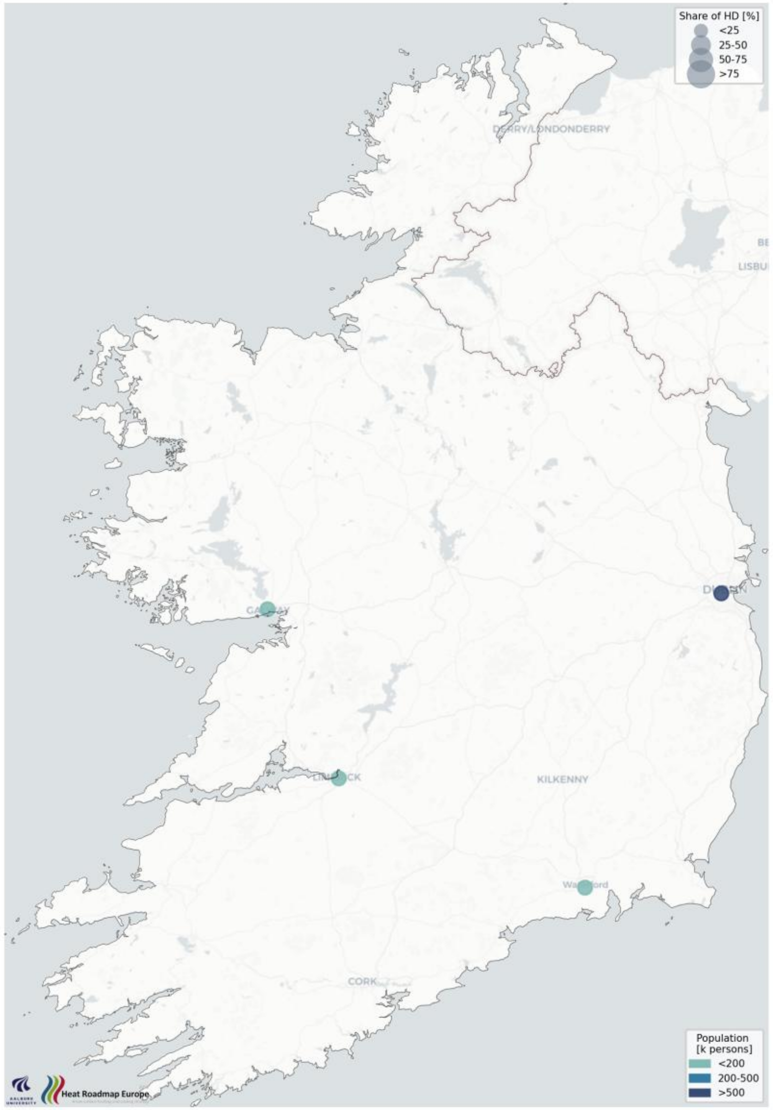


Figure 166: Medium temperature from wastewater treatment for Ireland.

5.14 Italy

Table 42: District heating shares specific to Italy and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Italy	5	5,26	18,75	0,7	0,42	0,58	1	1,24	0,11	0,48	0	0	3,52	3,52
	10	10,11	36,01	1,5	0,52	1,01	1,75	1,94	0,16	0,9	0	0	7,72	7,72
	15	15,09	53,76	2,38	0,52	1,43	2,47	2,61	0,2	1,04	0	0	12,14	12,1
	20	20,19	71,9	3,37	1,56	1,98	3,42	3,61	0,26	1,11	0	0,16	14,69	14,3
	25	25,08	89,32	4,31	2,46	2,65	4,54	4,51	0,31	1,17	0,03	0,75	16,28	14,6
	30	30,01	106,9	5,24	2,93	3,34	5,5	5,57	0,4	1,17	0,22	1,52	16,57	14,6
	35	35,04	124,8	6,24	3,27	3,98	6,5	6,61	0,49	1,17	1	2,39	16,57	14,6
	40	40,04	142,6	7,09	3,66	4,77	7,53	7,63	0,57	1,17	1,86	3,25	16,57	14,6
	45	45	160,3	7,83	4,19	5,56	8,56	8,56	0,63	1,17	2,79	4,18	16,57	14,6
	50	50	178,1	8,52	4,41	6,51	9,62	9,49	0,71	1,17	3,79	5,18	16,57	14,6
	55	55,01	195,9	9,13	4,53	7,44	10,62	10,34	0,79	1,17	4,91	6,3	16,57	14,6
	60	60	213,7	9,65	4,66	8,54	11,42	11,16	0,86	1,17	6,1	7,49	16,57	14,6
	65	65	231,5	10,13	4,74	9,53	11,87	11,96	0,9	1,17	7,45	8,84	16,57	14,6

Figure 167: Geothermal energy for Italy (Baseload of district heating area, capacity >40MW).

Figure 168: Geothermal energy for Italy (Baseload of district heating area, capacity >70MW).

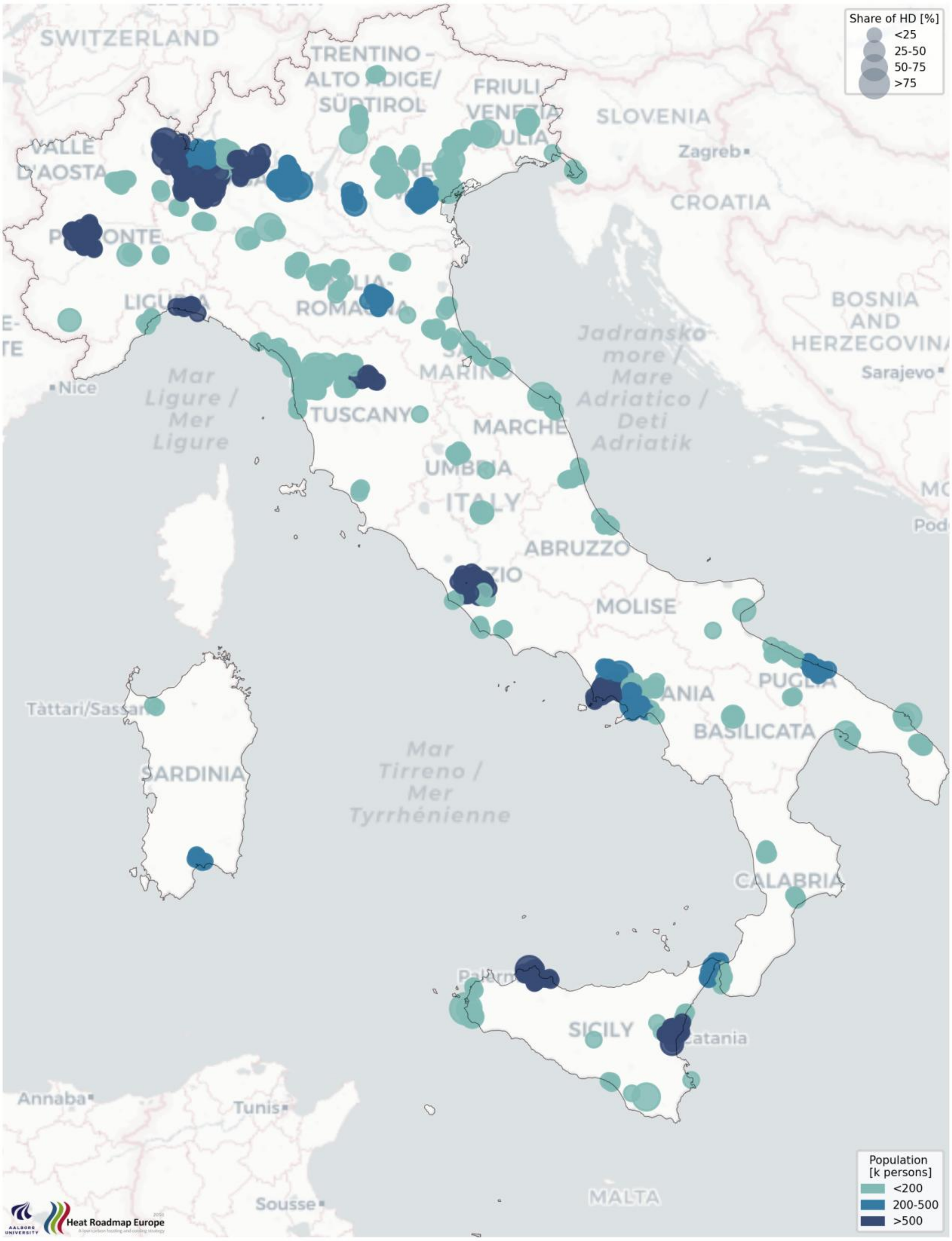


Figure 169: Baseload high temperature waste heat for Italy.

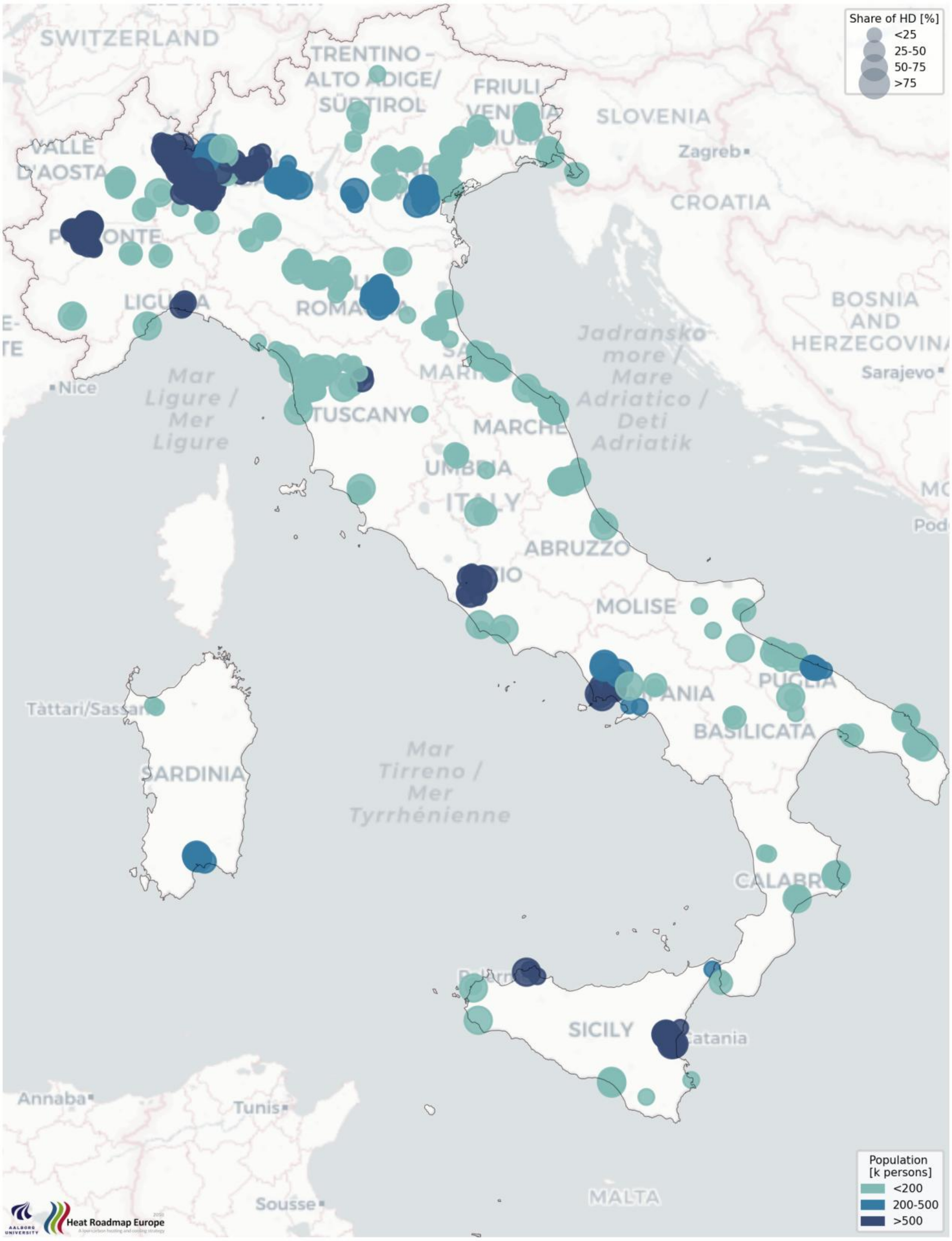


Figure 170: Baseload low temperature waste heat for Italy.

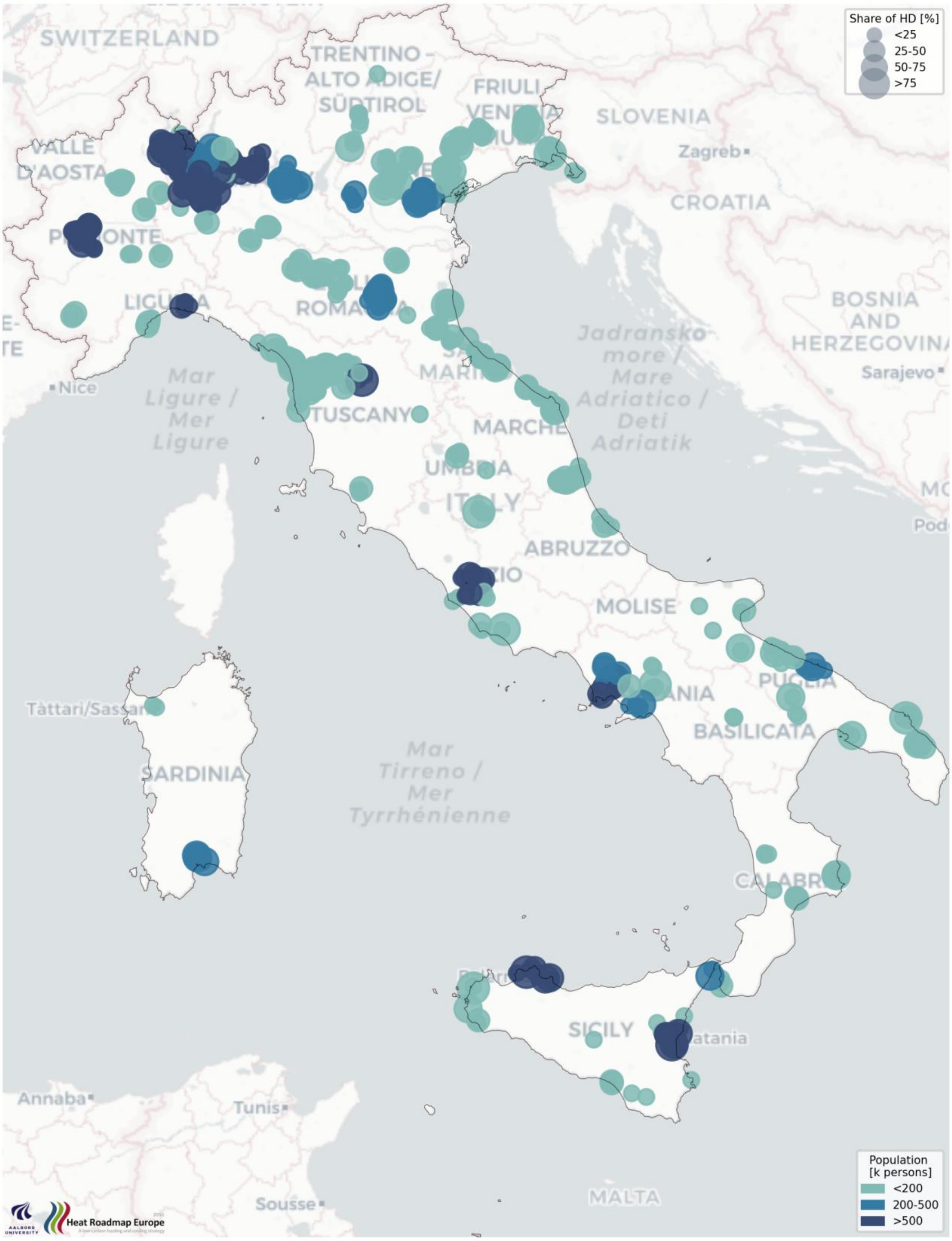


Figure 171: Baseload medium temperature waste heat for Italy.

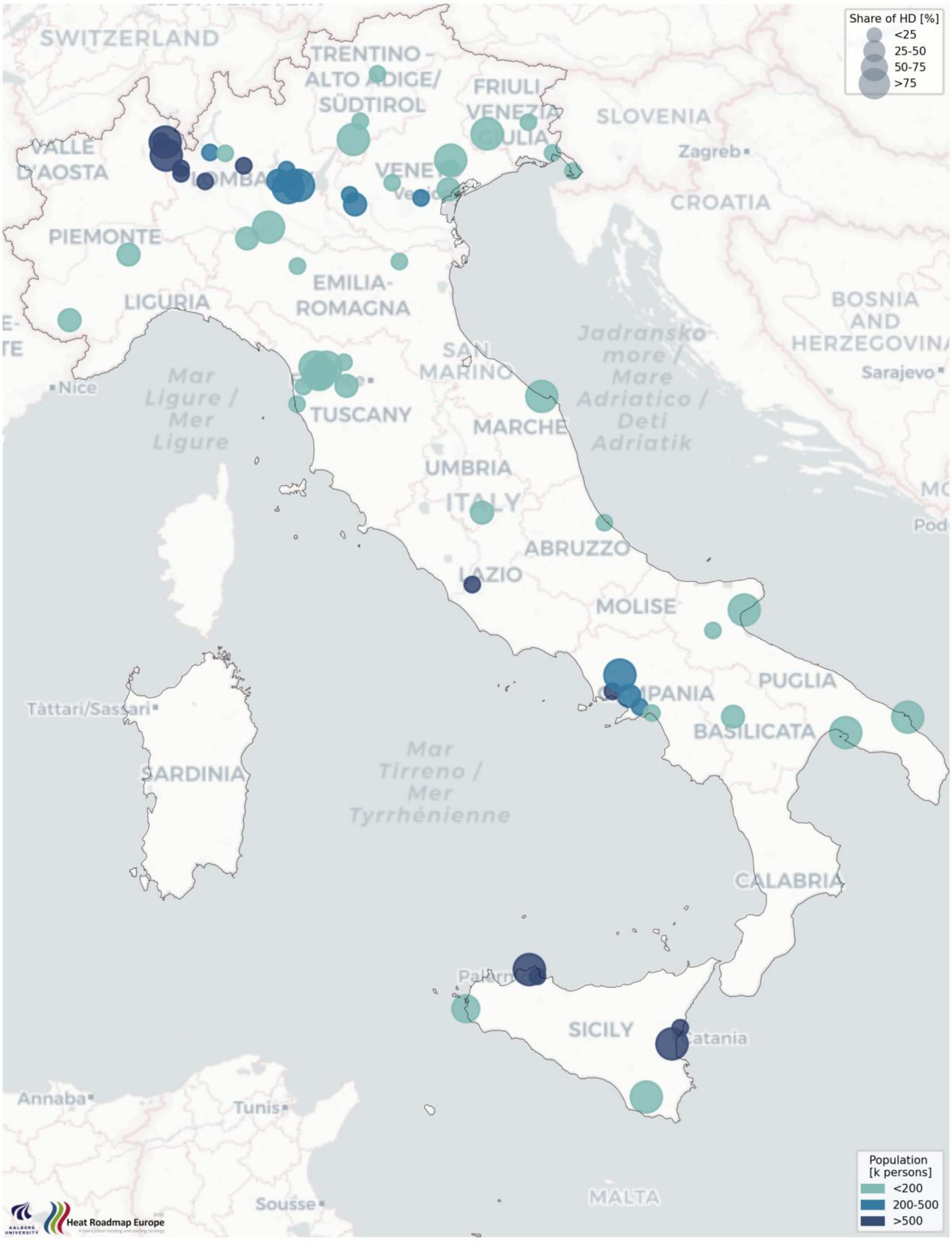


Figure 172: High temperature from industry for Italy.

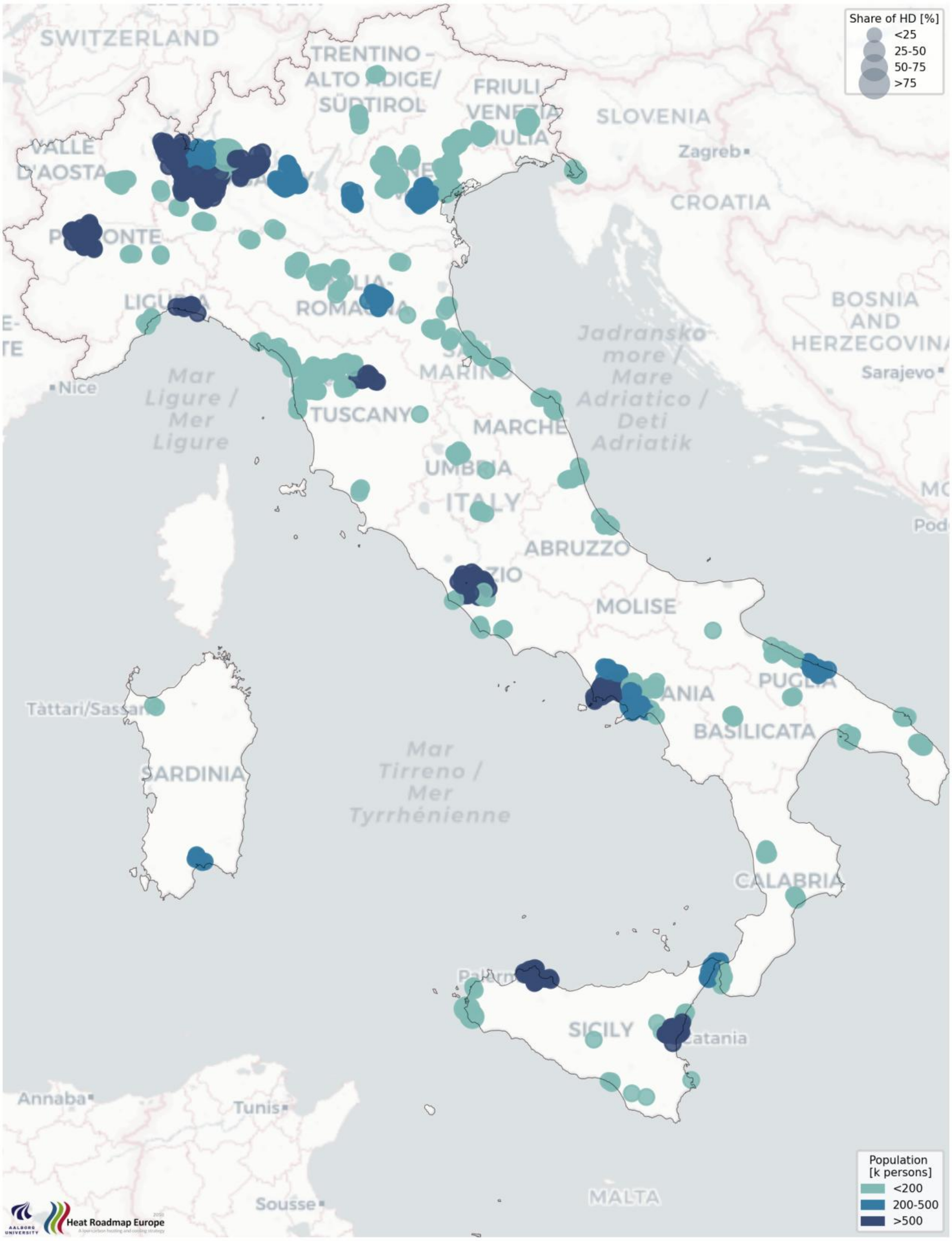


Figure 173: High temperature from waste-to-energy for Italy.

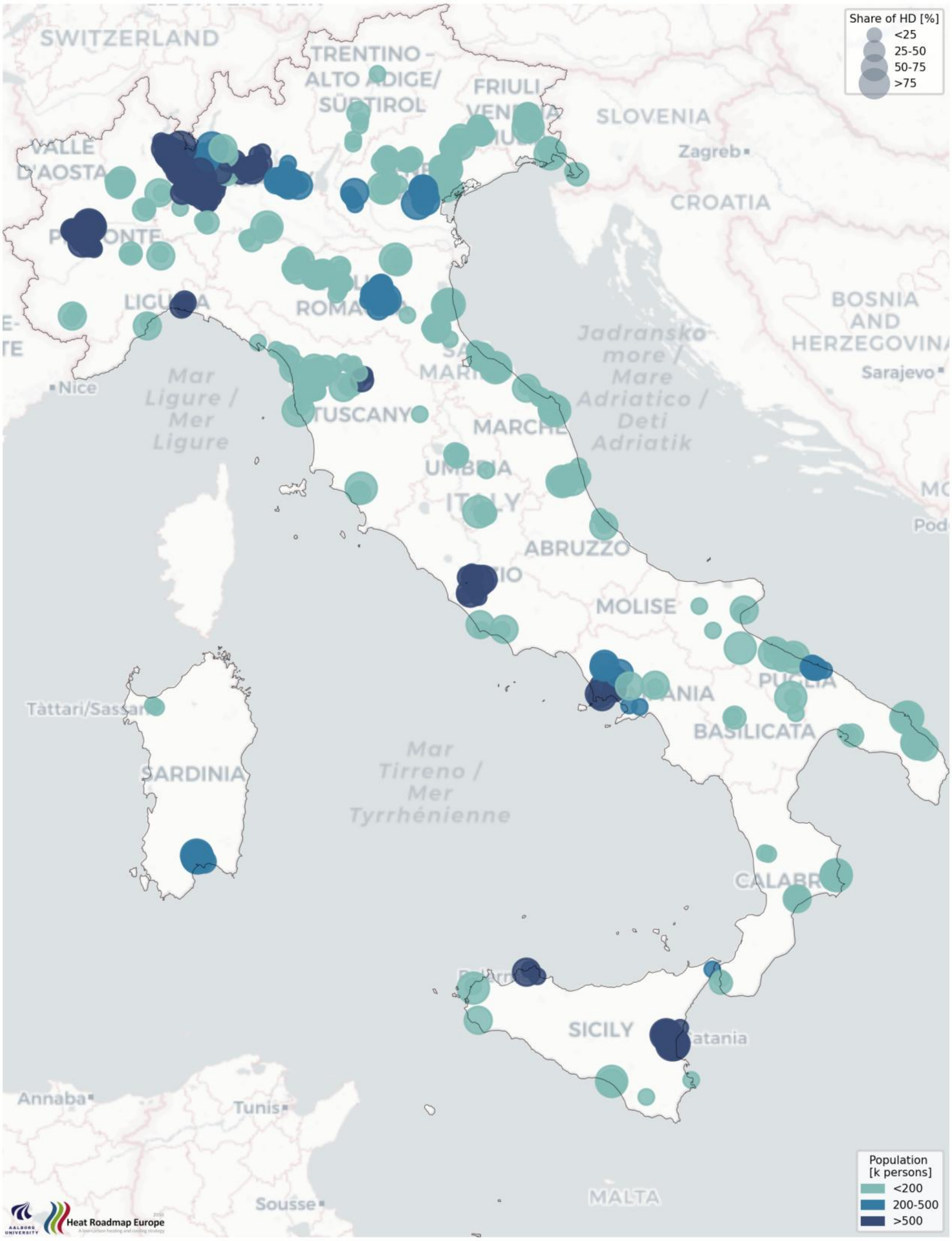


Figure 174: Low temperature from industry for Italy.

Figure 175: Low temperature from metros for Italy.

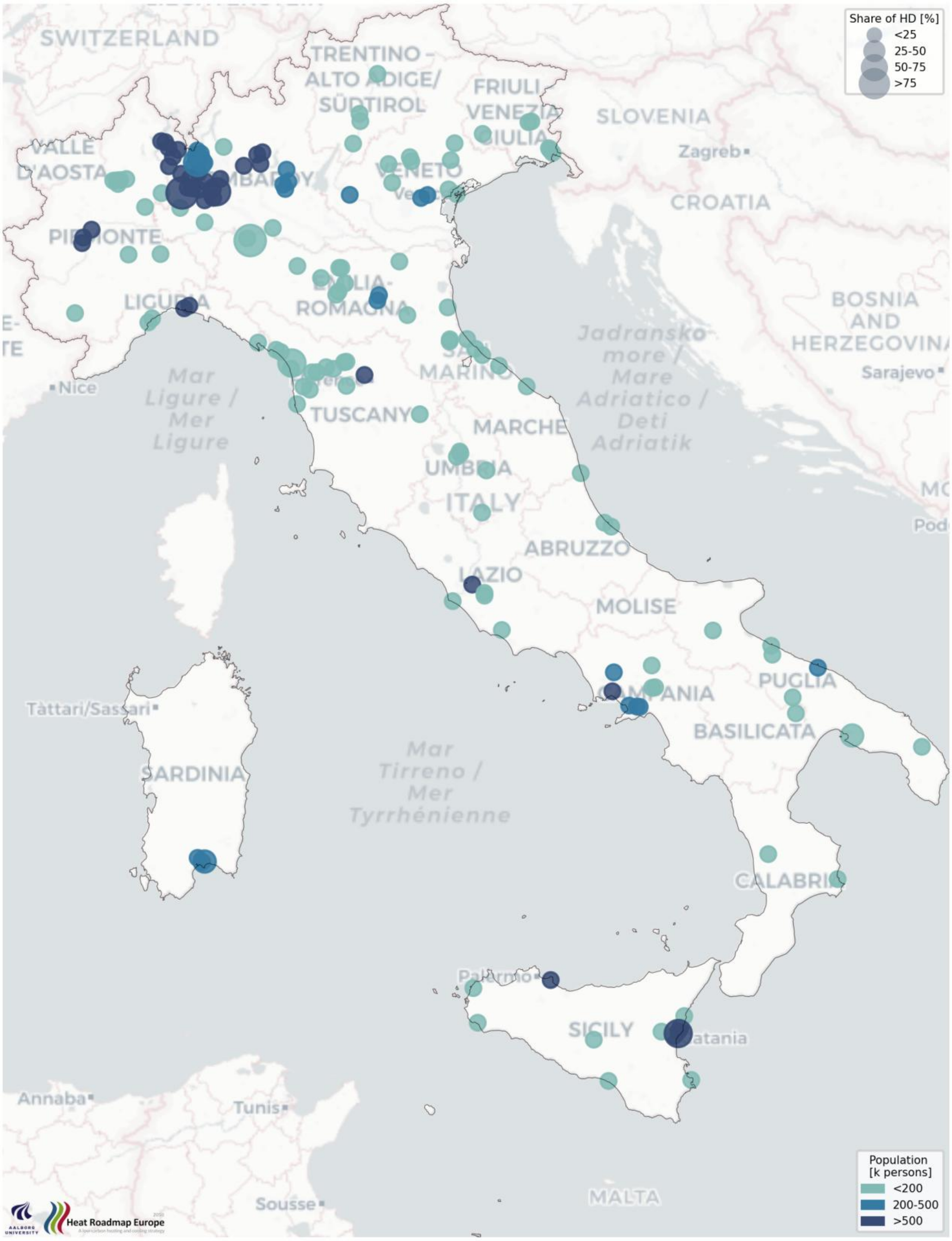


Figure 176: Low temperature from supermarkets for Italy.

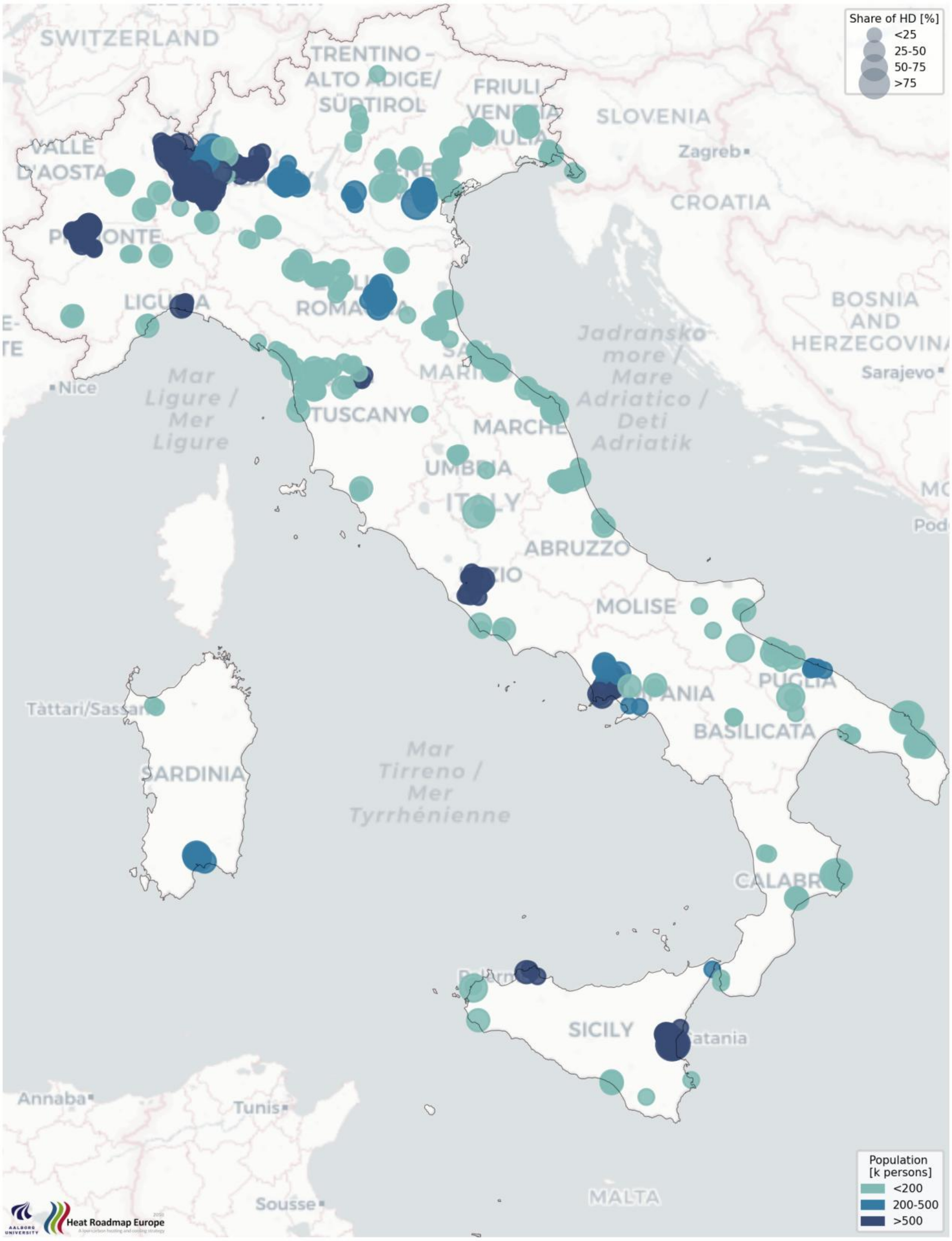


Figure 177: Medium temperature from industry for Italy.

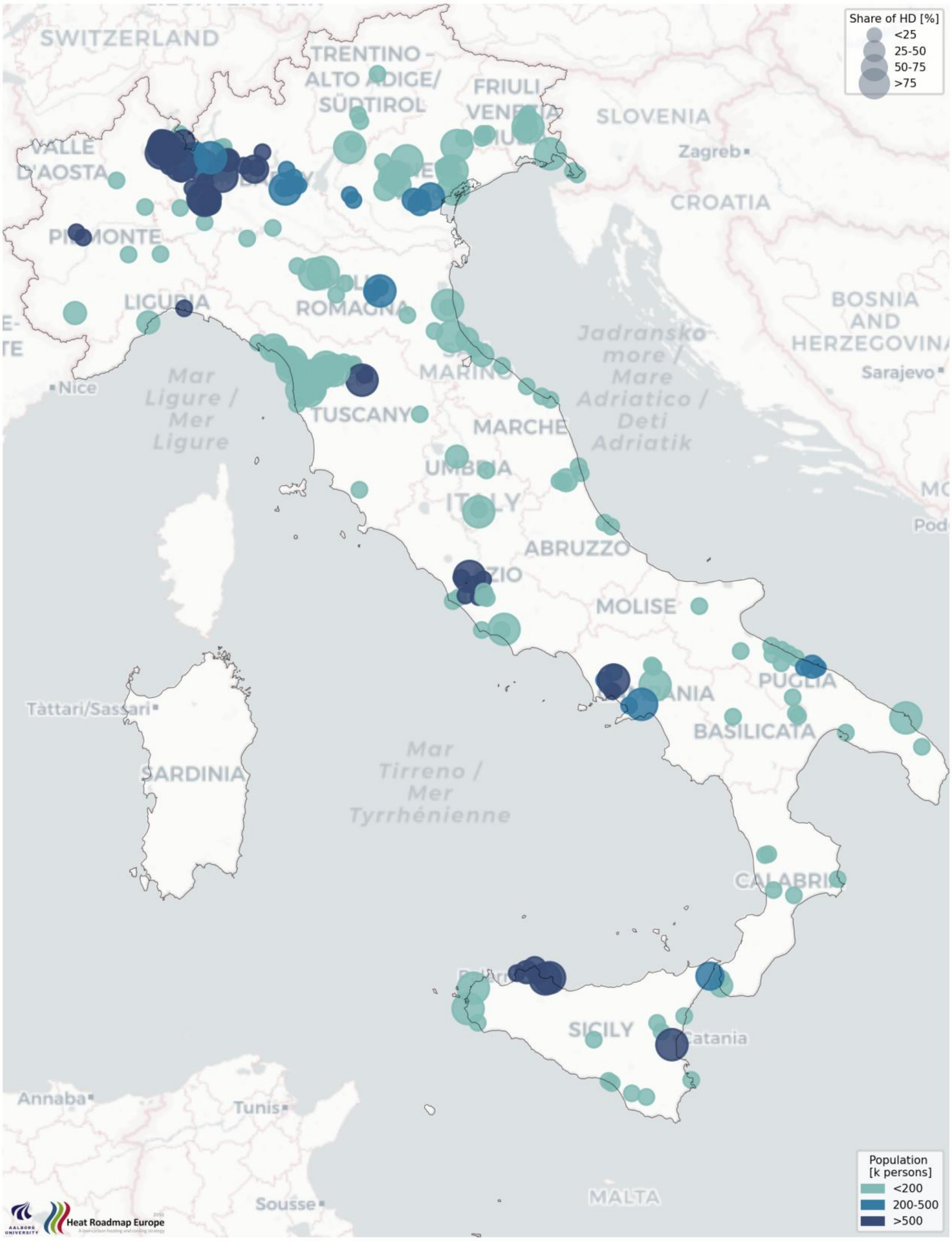


Figure 178: Medium temperature from wastewater treatment for Italy.

5.15 Latvia

Table 43: District heating shares specific to Latvia and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Latvia	5	19,86	4,38	0,18	0	0,07	0,1	0	0,02	0	0	0	0	0
	10	19,86	4,38	0,18	0	0,07	0,1	0	0,02	0	0	0	0	0
	15	19,86	4,38	0,18	0	0,07	0,1	0	0,02	0	0	0	0	0
	20	28,11	6,2	0,25	0	0,1	0,14	0	0,03	0	0	0	0	0
	25	28,11	6,2	0,25	0	0,1	0,14	0	0,03	0	0	0	0	0
	30	31,14	6,86	0,29	0,11	0,12	0,16	0	0,04	0	0	0,01	0	0
	35	35,4	7,8	0,34	0,11	0,14	0,19	0,05	0,05	0	0,01	0,04	0	0
	40	40,23	8,87	0,35	0,11	0,16	0,21	0,09	0,05	0	0,06	0,09	0	0
	45	45,37	10	0,35	0,11	0,18	0,24	0,11	0,07	0	0,12	0,15	0	0
	50	50,06	11,03	0,36	0,11	0,2	0,28	0,16	0,09	0	0,16	0,19	0	0
	55	55,01	12,12	0,37	0,11	0,23	0,32	0,18	0,1	0	0,21	0,24	0	0
	60	57,42	12,66	0,37	0,11	0,25	0,33	0,2	0,1	0	0,24	0,27	0	0
	65	57,42	12,66	0,37	0,11	0,25	0,33	0,2	0,1	0	0,24	0,27	0	0

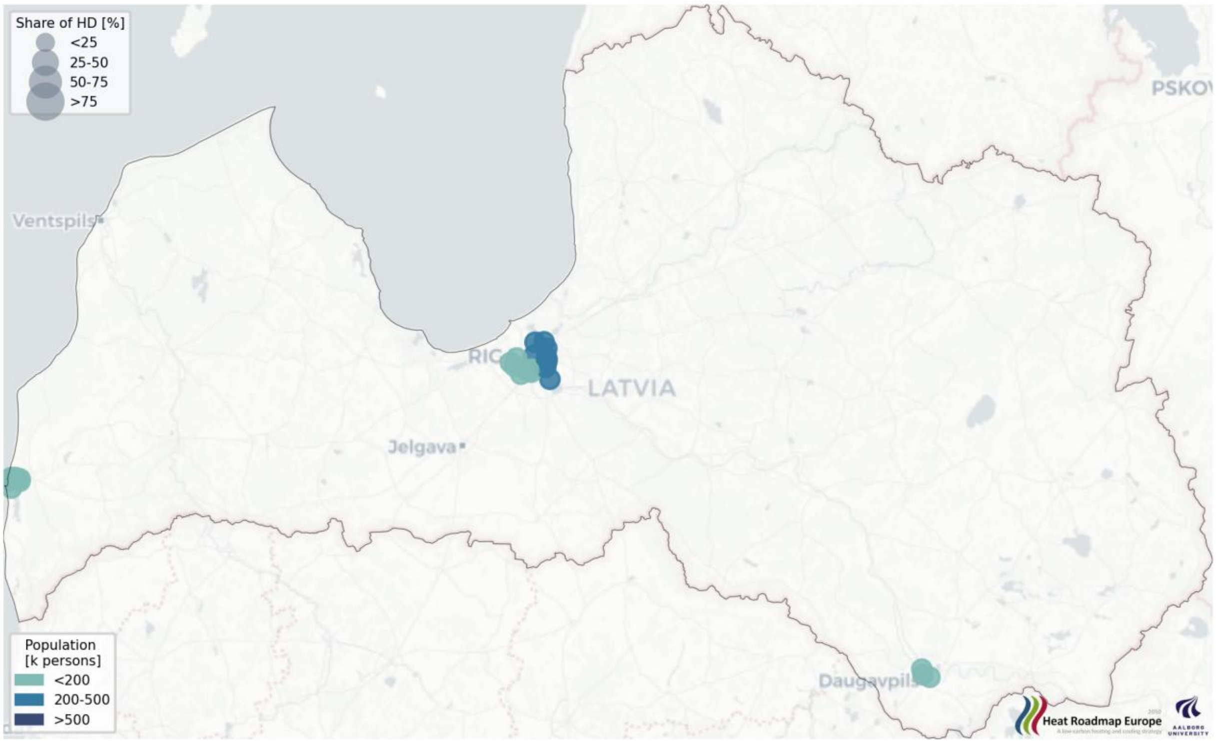


Figure 179: Baseload high temperature waste heat for Latvia.

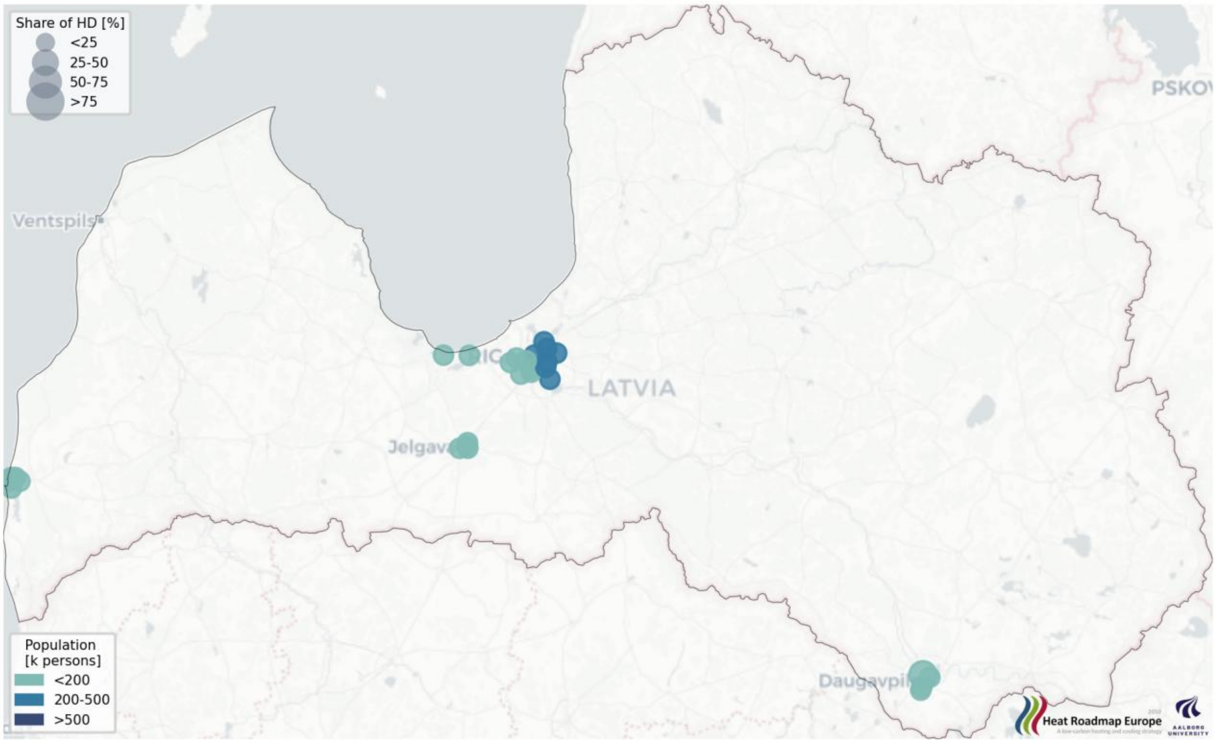


Figure 180: Baseload low temperature waste heat for Latvia.

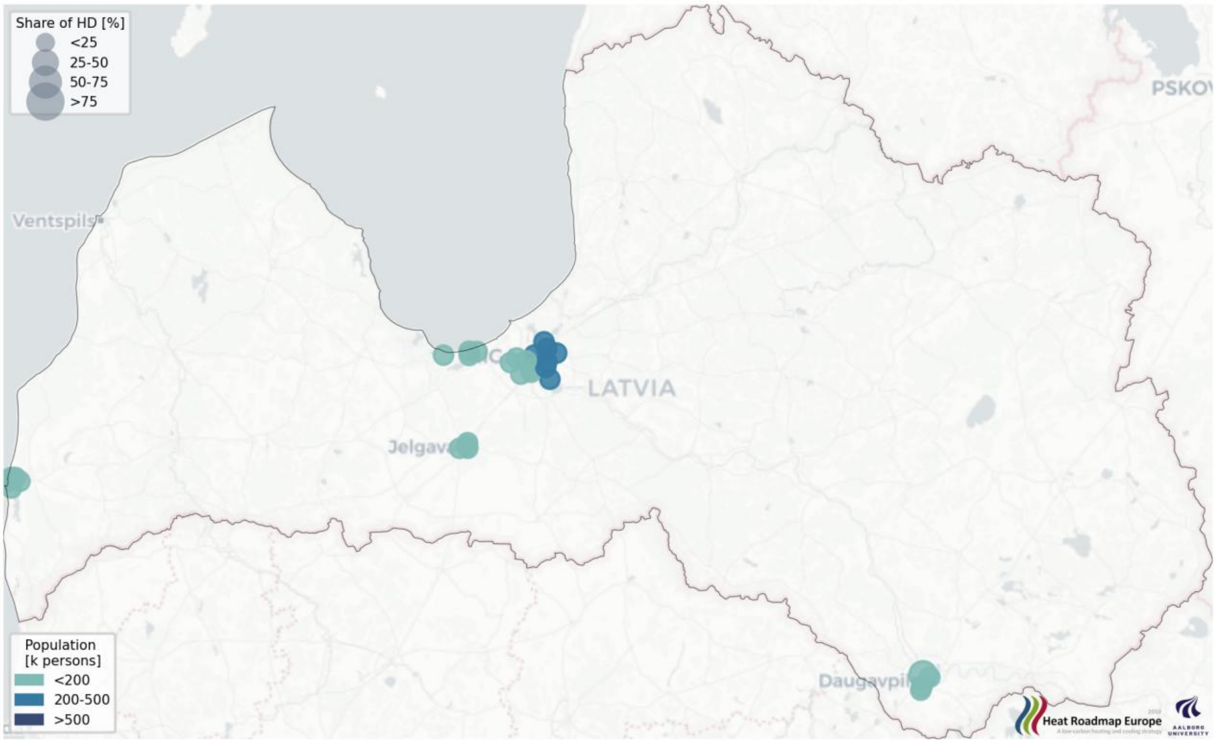


Figure 181: Baseload medium temperature waste heat for Latvia.

Figure 182: High temperature from industry for Latvia.

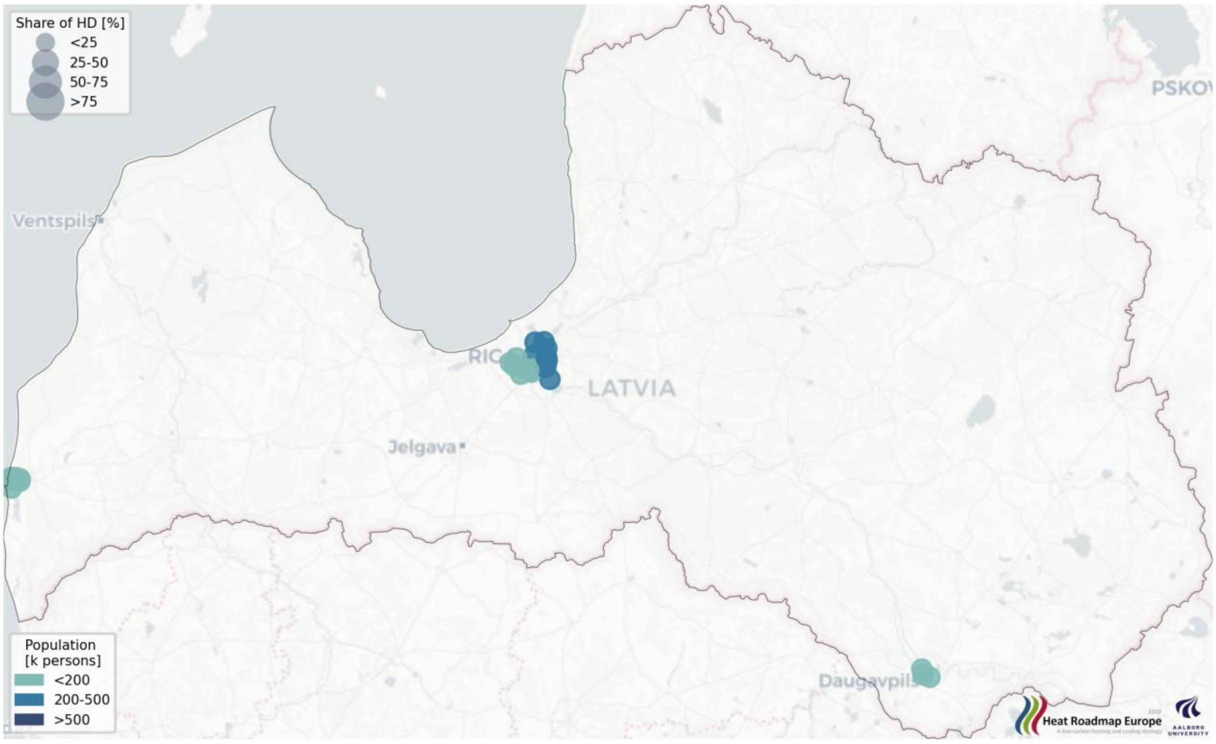


Figure 183: High temperature from waste-to-energy for Latvia.

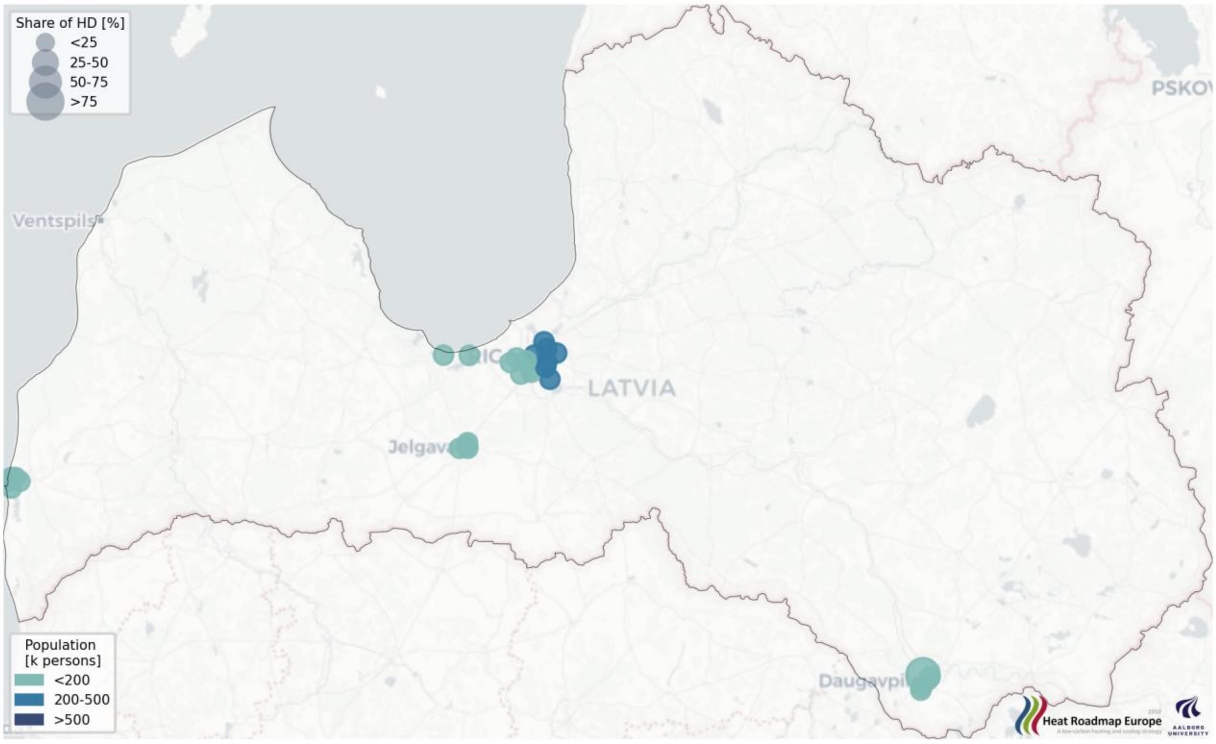


Figure 184: Low temperature from industry for Latvia.

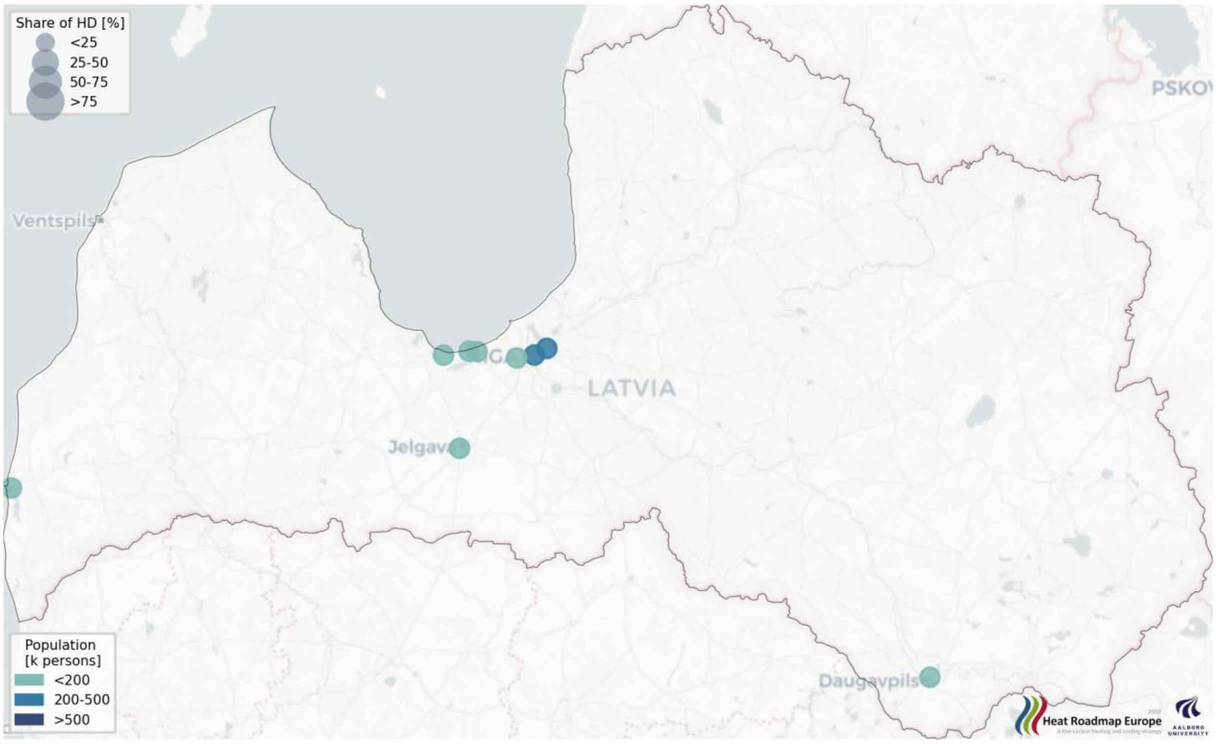


Figure 185: Low temperature from supermarkets for Latvia.

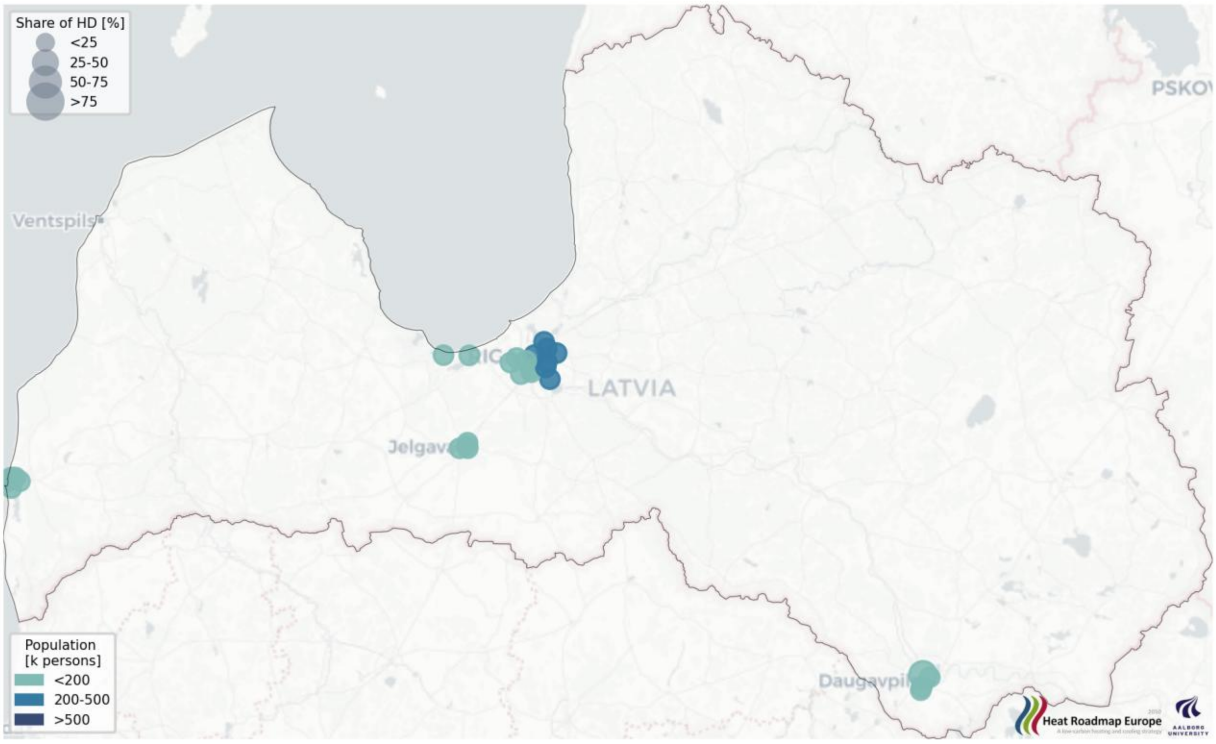


Figure 186: Medium temperature from industry for Latvia.

Figure 187: Medium temperature from wastewater treatment for Latvia.

5.16 Lithuania

Table 44: District heating shares specific to Lithuania and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Lithuania	5	8,54	2,45	0,13	0	0,02	0,04	0	0,06	0	0	0	0	0
	10	14,45	4,15	0,22	0,03	0,04	0,08	0	0,1	0	0	0	0	0
	15	18,59	5,34	0,27	0,04	0,05	0,1	0,1	0,12	0	0	0,05	0	0
	20	21,35	6,13	0,31	0,04	0,06	0,13	0,15	0,15	0	0	0,08	0	0
	25	25,38	7,29	0,38	0,07	0,08	0,16	0,15	0,18	0	0	0,13	0	0
	30	30,37	8,72	0,38	0,07	0,1	0,21	0,29	0,22	0	0,04	0,19	0	0
	35	35,15	10,09	0,4	0,07	0,13	0,26	0,38	0,26	0	0,11	0,26	0	0
	40	40,04	11,5	0,4	0,09	0,15	0,31	0,45	0,31	0	0,18	0,33	0	0
	45	45,01	12,92	0,41	0,11	0,19	0,38	0,51	0,37	0	0,25	0,4	0	0
	50	46,76	13,43	0,42	0,11	0,21	0,41	0,52	0,38	0	0,28	0,43	0	0
	55	46,76	13,43	0,42	0,11	0,21	0,41	0,52	0,38	0	0,28	0,43	0	0
	60	46,76	13,43	0,42	0,11	0,21	0,41	0,52	0,38	0	0,28	0,43	0	0
	65	46,76	13,43	0,42	0,11	0,21	0,41	0,52	0,38	0	0,28	0,43	0	0

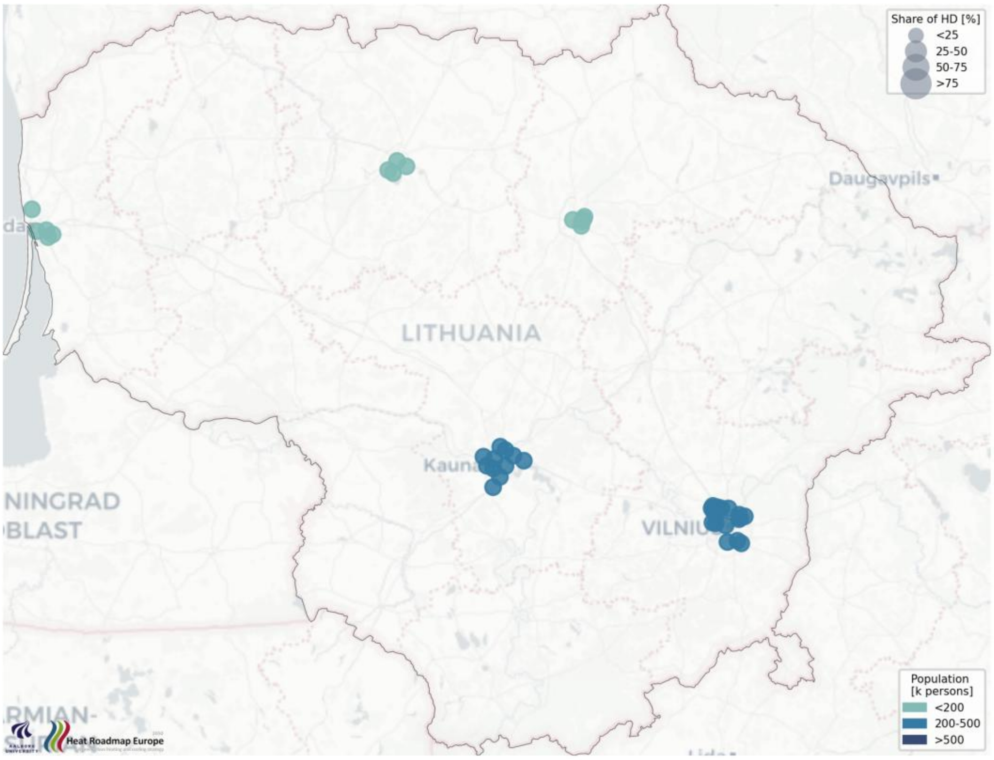


Figure 188: Baseload high temperature waste heat for Lithuania.

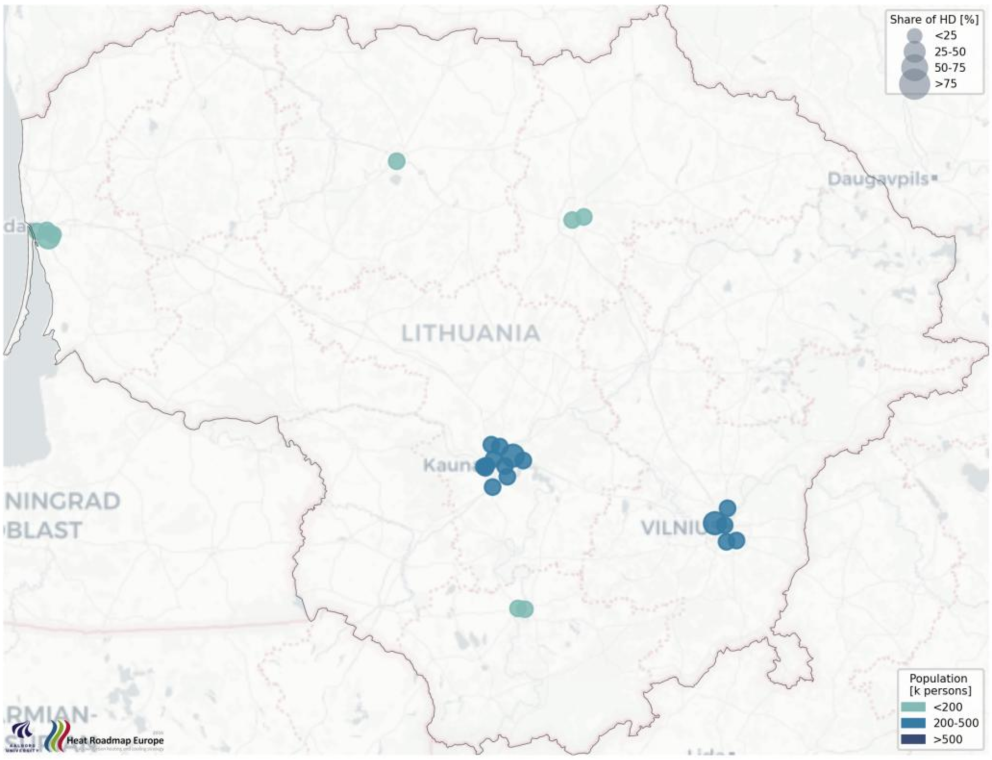


Figure 189: Baseload low temperature waste heat for Lithuania.

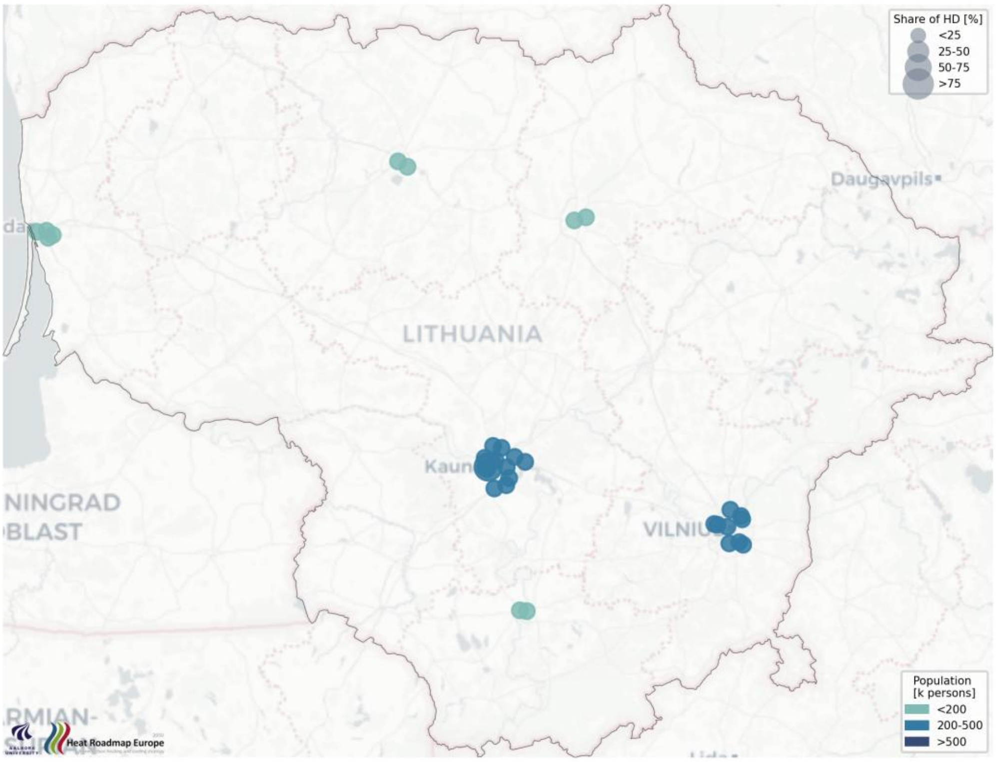


Figure 190: Baseload medium temperature waste heat for Lithuania.

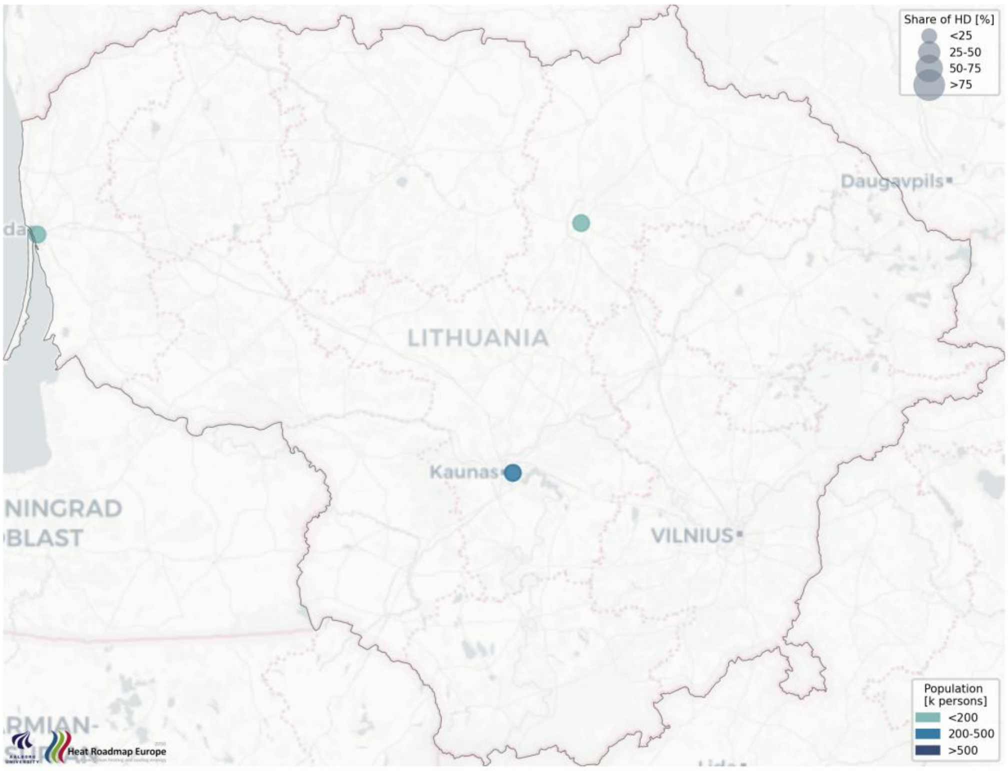


Figure 191: High temperature from industry for Lithuania.

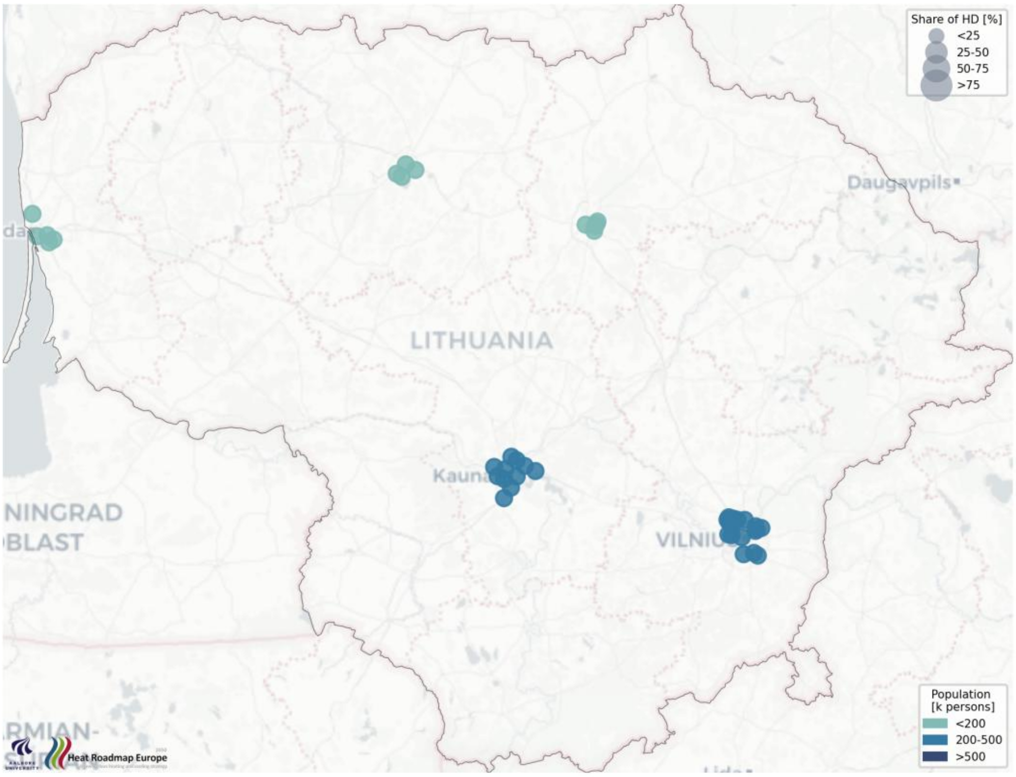


Figure 192: High temperature from waste-to-energy for Lithuania.

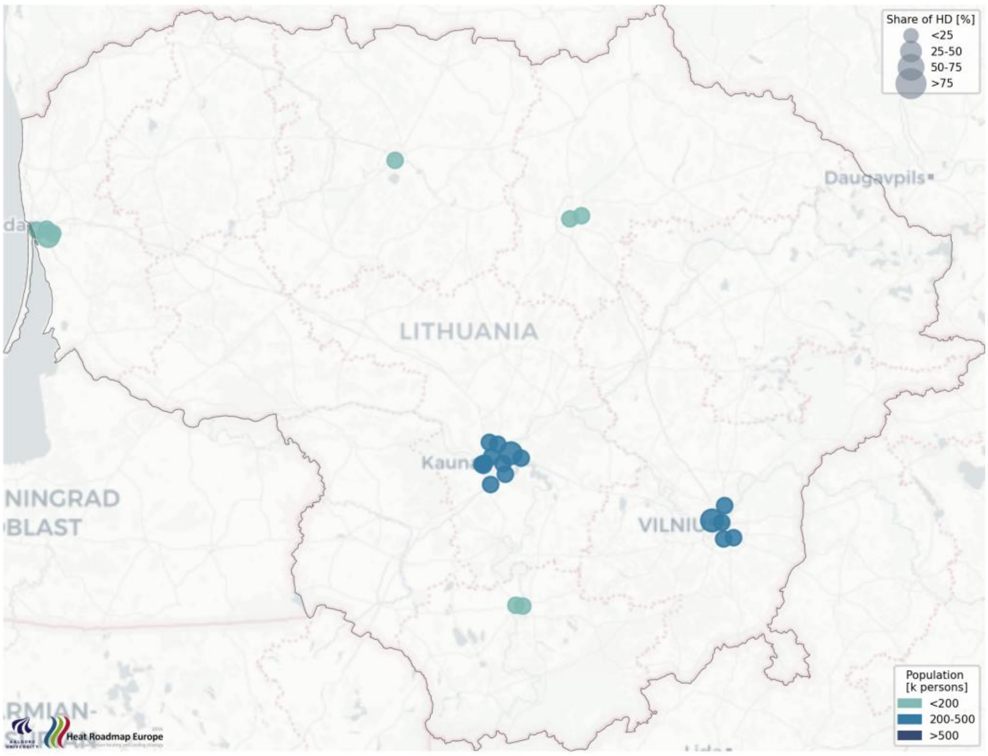


Figure 193: Low temperature from industry for Lithuania.

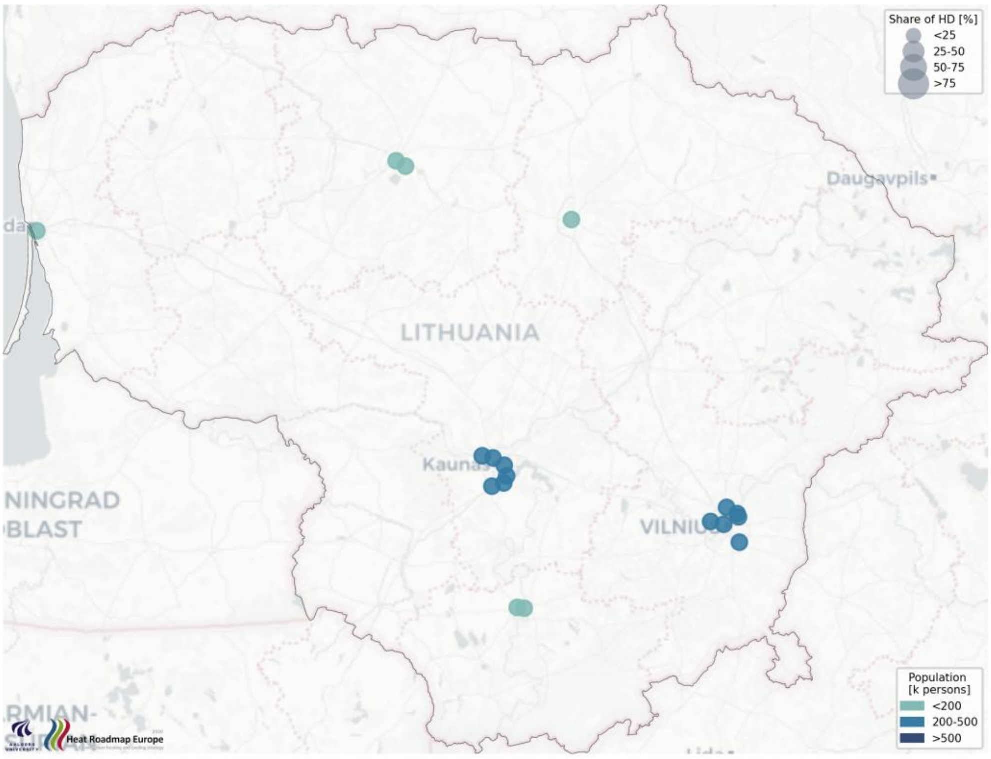


Figure 194: Low temperature from supermarkets for Lithuania.

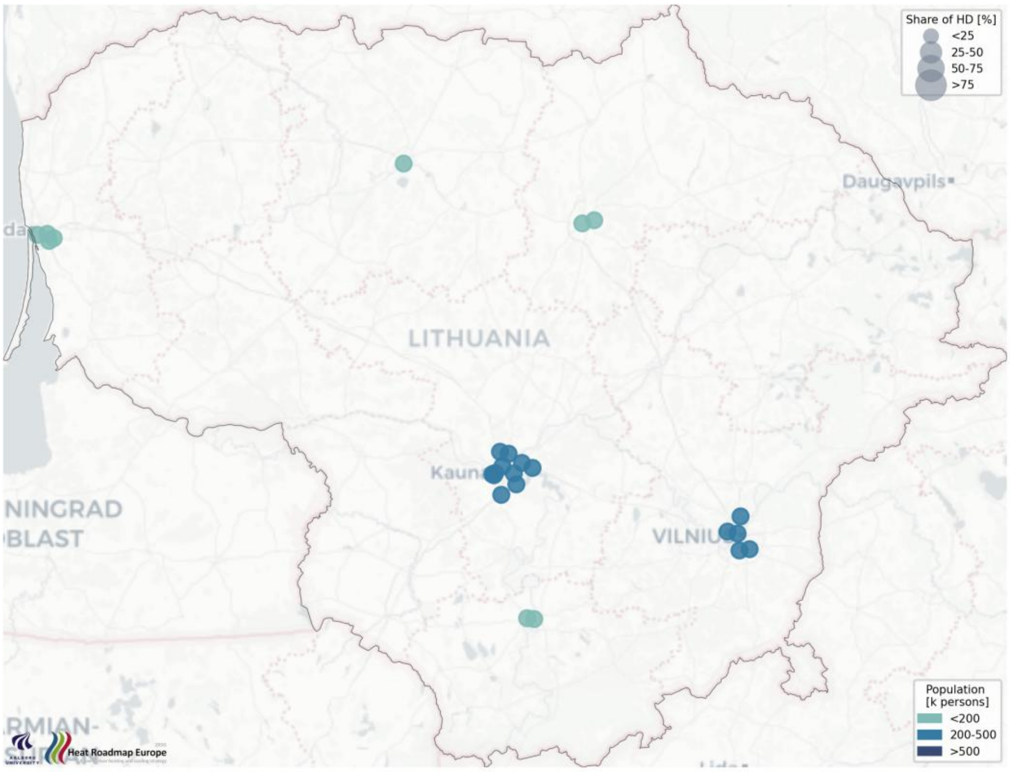


Figure 195: Medium temperature from industry for Lithuania.

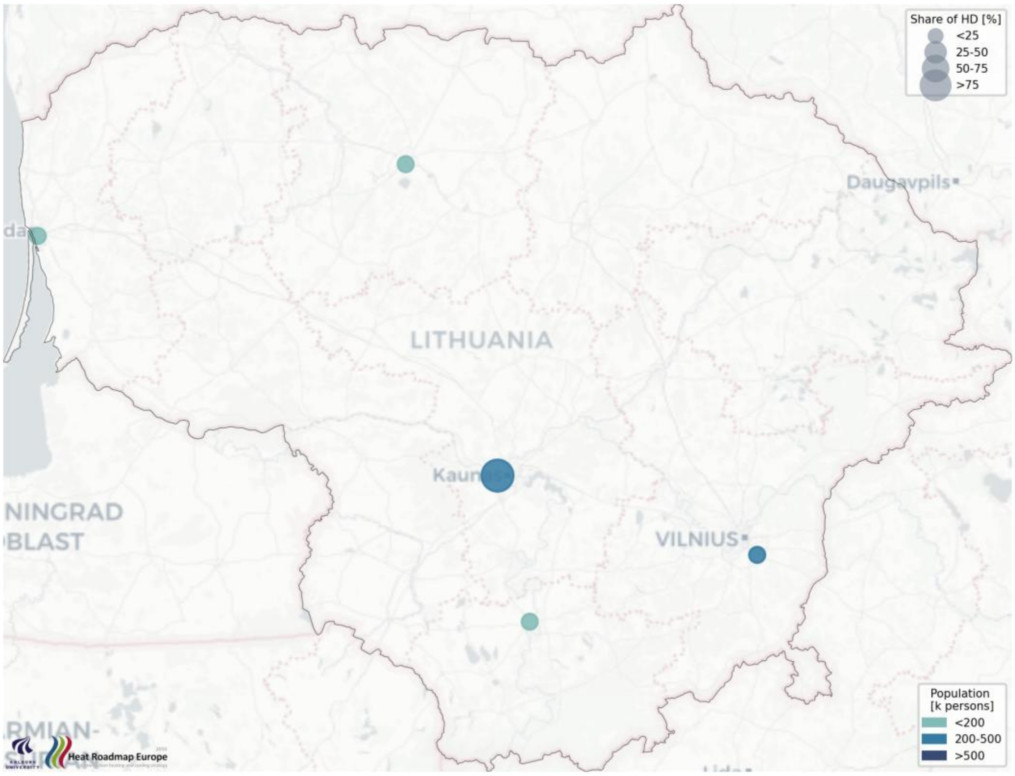


Figure 196: Medium temperature from wastewater treatment for Lithuania.

5.17 Luxembourg

Table 45: District heating shares specific to Luxembourg and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Luxembourg	5	27,04	2,7	0,12	0	0,14	0,2	0,08	0,02	0	0	0	0	0
	10	27,04	2,7	0,12	0	0,14	0,2	0,08	0,02	0	0	0	0	0
	15	27,04	2,7	0,12	0	0,14	0,2	0,08	0,02	0	0	0	0	0
	20	27,04	2,7	0,12	0	0,14	0,2	0,08	0,02	0	0	0	0	0
	25	27,04	2,7	0,12	0	0,14	0,2	0,08	0,02	0	0	0	0	0
	30	42,74	4,27	0,19	0,21	0,29	0,4	0,12	0,02	0	0	0	0	0
	35	42,74	4,27	0,19	0,21	0,29	0,4	0,12	0,02	0	0	0	0	0
	40	42,74	4,27	0,19	0,21	0,29	0,4	0,12	0,02	0	0	0	0	0
	45	48,45	4,84	0,19	0,43	0,34	0,4	0,12	0,02	0	0	0	0	0
	50	52,77	5,27	0,21	0,61	0,34	0,4	0,12	0,02	0	0	0	0	0
	55	55,57	5,55	0,21	0,61	0,34	0,41	0,13	0,03	0	0,02	0,02	0	0
	60	60,64	6,06	0,21	0,61	0,41	0,46	0,16	0,03	0	0,03	0,03	0	0
	65	65,49	6,55	0,21	0,61	0,47	0,48	0,2	0,04	0	0,04	0,04	0	0

Figure 197: Baseload high temperature waste heat for Luxembourg.

Figure 198: Baseload low temperature waste heat for Luxembourg.

Figure 199: Baseload medium temperature waste heat for Luxembourg.

Figure 200: High temperature from industry for Luxembourg.

Figure 201: High temperature from waste-to-energy for Luxembourg.

Figure 202: Low temperature from industry for Luxembourg.

Figure 203: Low temperature from supermarkets for Luxembourg.

Figure 204: Medium temperature from industry for Luxembourg.

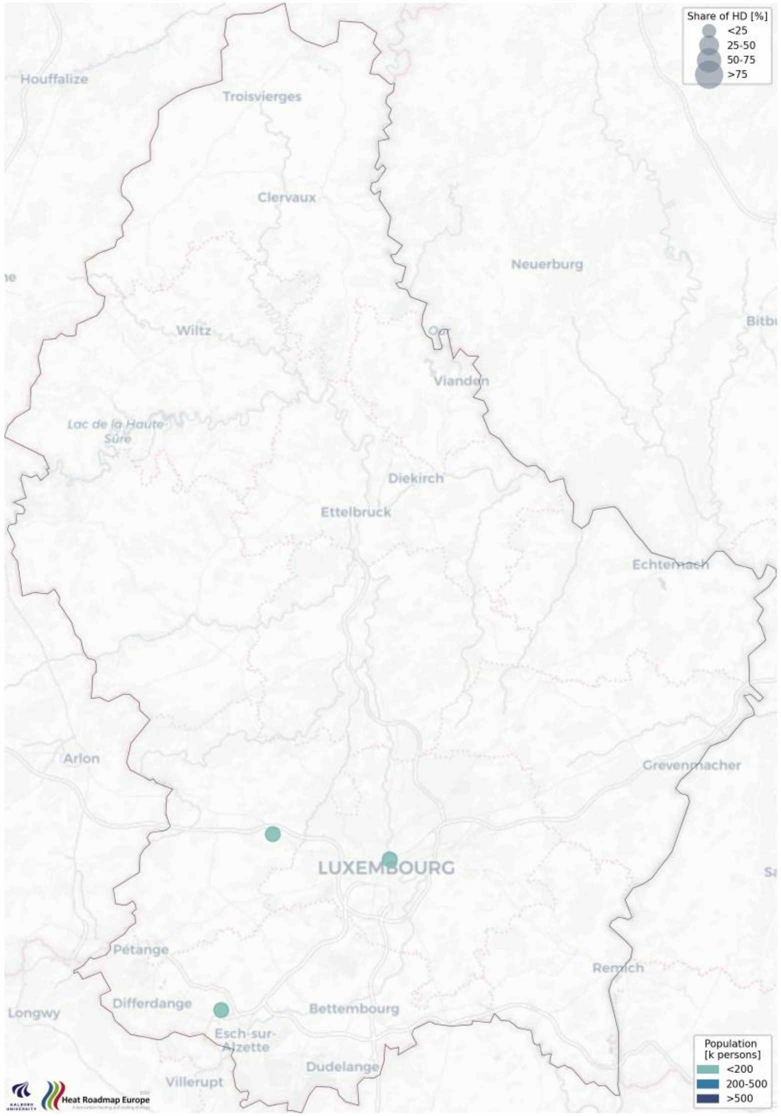


Figure 205: Medium temperature from wastewater treatment for Luxembourg.

5.18 Malta

Table 46: District heating shares specific to Malta and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Malta	5	41,37	1,61	0,08	1,9	0	0	0	0	0	0	0	0	0
	10	41,37	1,61	0,08	1,9	0	0	0	0	0	0	0	0	0
	15	41,37	1,61	0,08	1,9	0	0	0	0	0	0	0	0	0
	20	41,37	1,61	0,08	1,9	0	0	0	0	0	0	0	0	0
	25	41,37	1,61	0,08	1,9	0	0	0	0	0	0	0	0	0
	30	41,37	1,61	0,08	1,9	0	0	0	0	0	0	0	0	0
	35	41,37	1,61	0,08	1,9	0	0	0	0	0	0	0	0	0
	40	41,37	1,61	0,08	1,9	0	0	0	0	0	0	0	0	0
	45	45,05	1,75	0,08	2,05	0	0	0	0	0	0	0	0	0
	50	45,93	1,79	0,08	2,08	0	0	0	0	0	0	0	0	0
	55	45,93	1,79	0,08	2,08	0	0	0	0	0	0	0	0	0
	60	45,93	1,79	0,08	2,08	0	0	0	0	0	0	0	0	0
	65	45,93	1,79	0,08	2,08	0	0	0	0	0	0	0	0	0

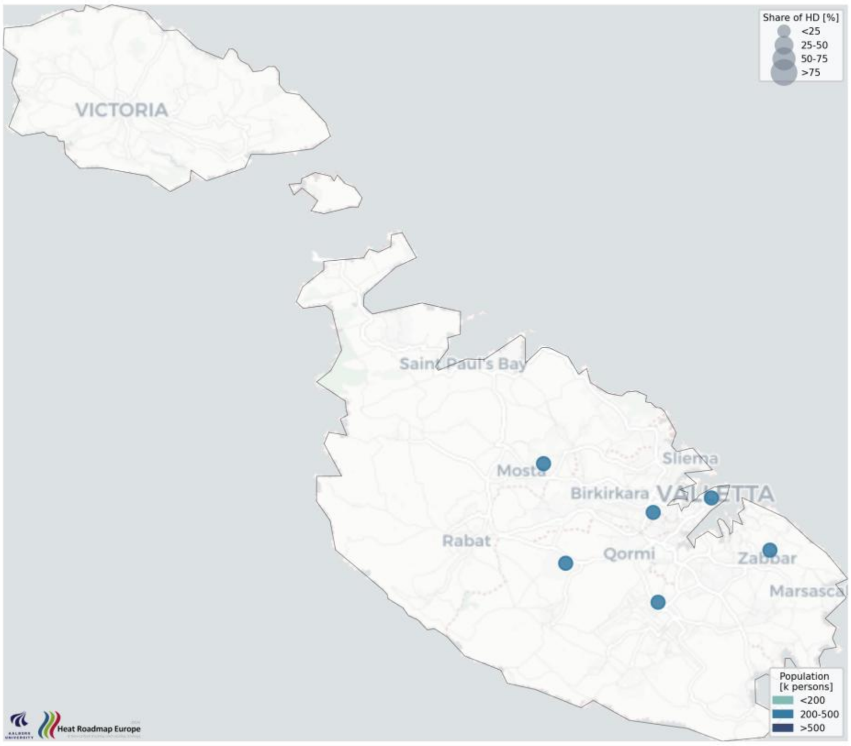


Figure 206: Baseload high temperature waste heat for Malta.

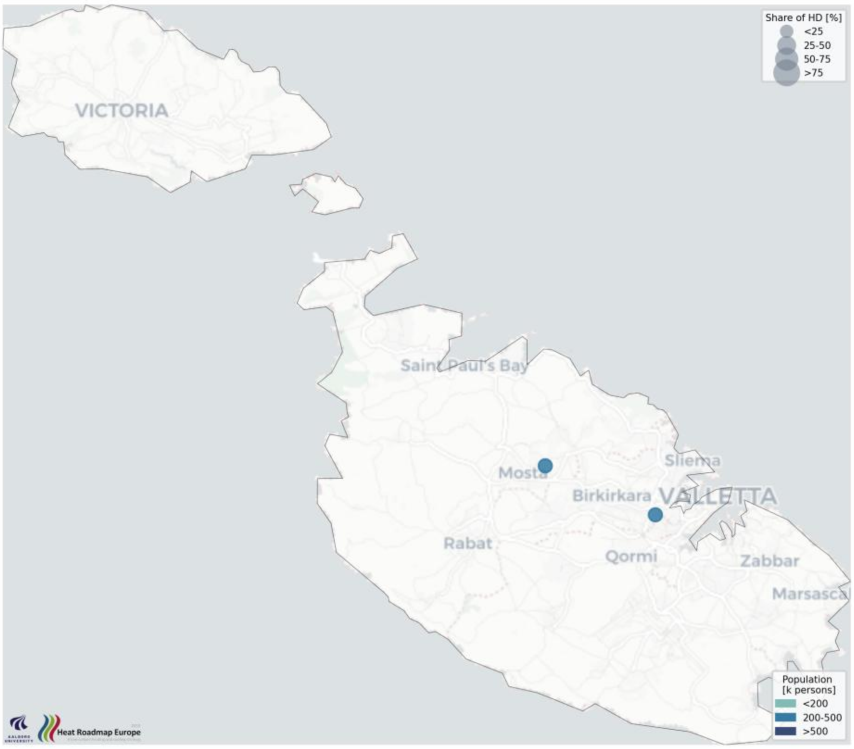


Figure 207: Baseload low temperature waste heat for Malta.

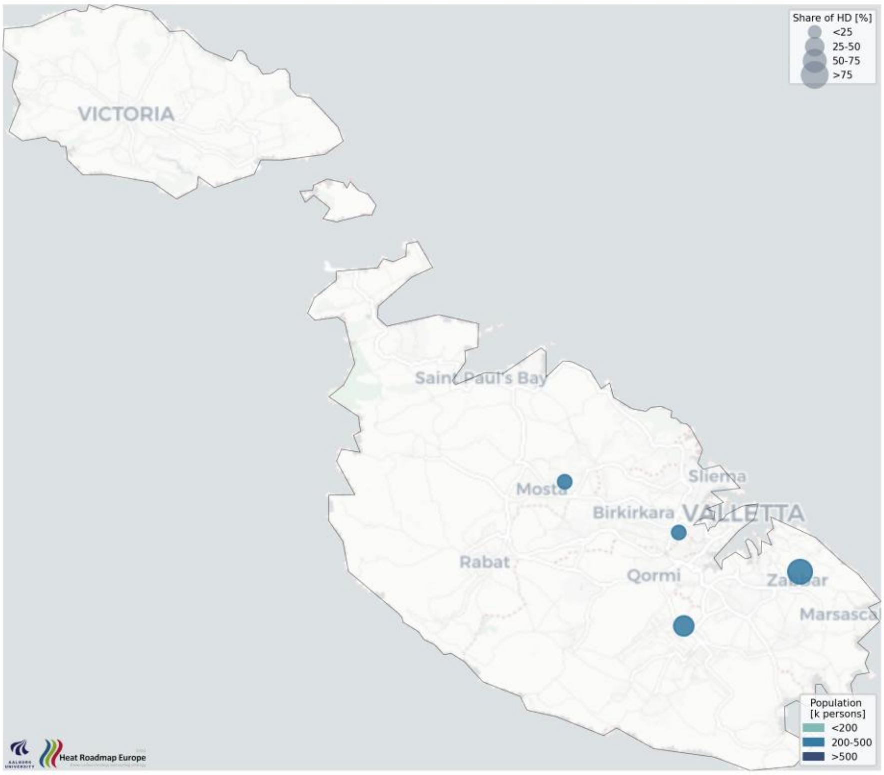


Figure 208: Baseload medium temperature waste heat for Malta.

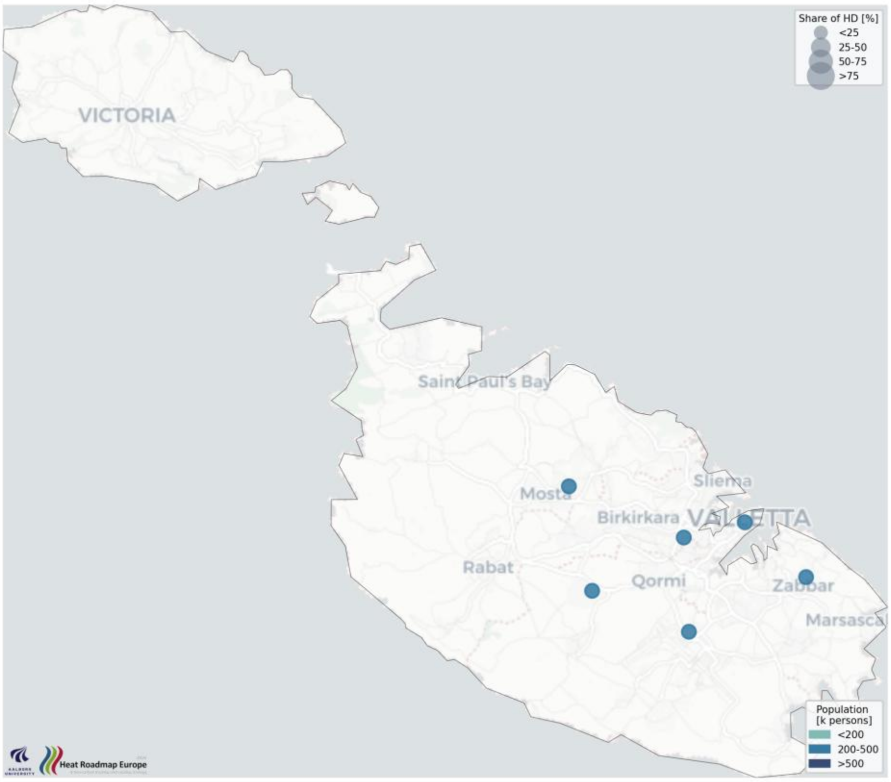


Figure 209: High temperature from waste-to-energy for Malta.

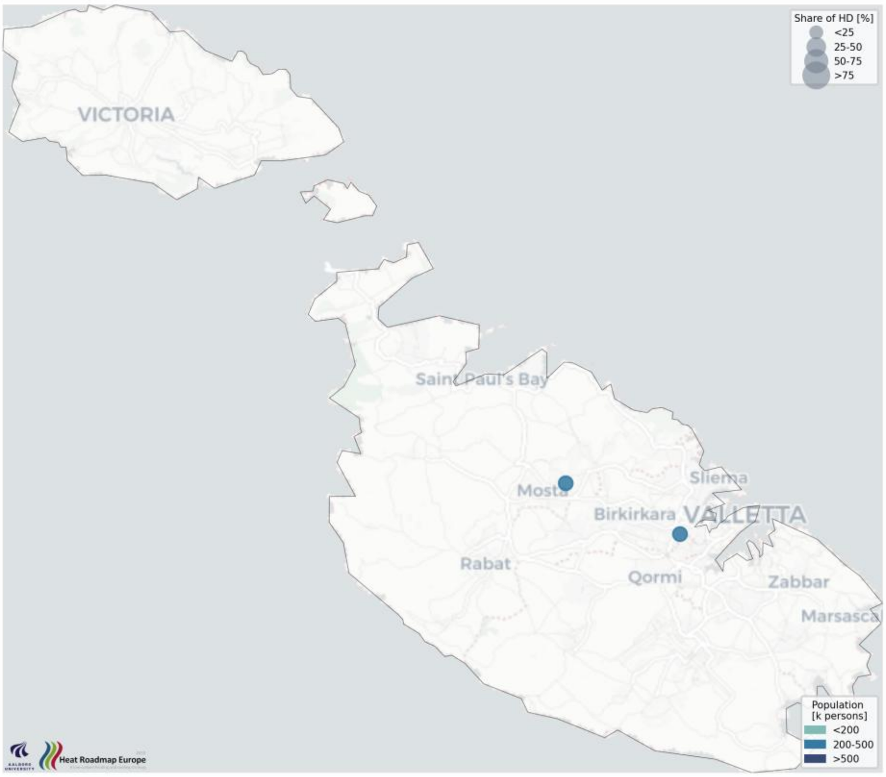


Figure 210: Low temperature from industry for Malta.

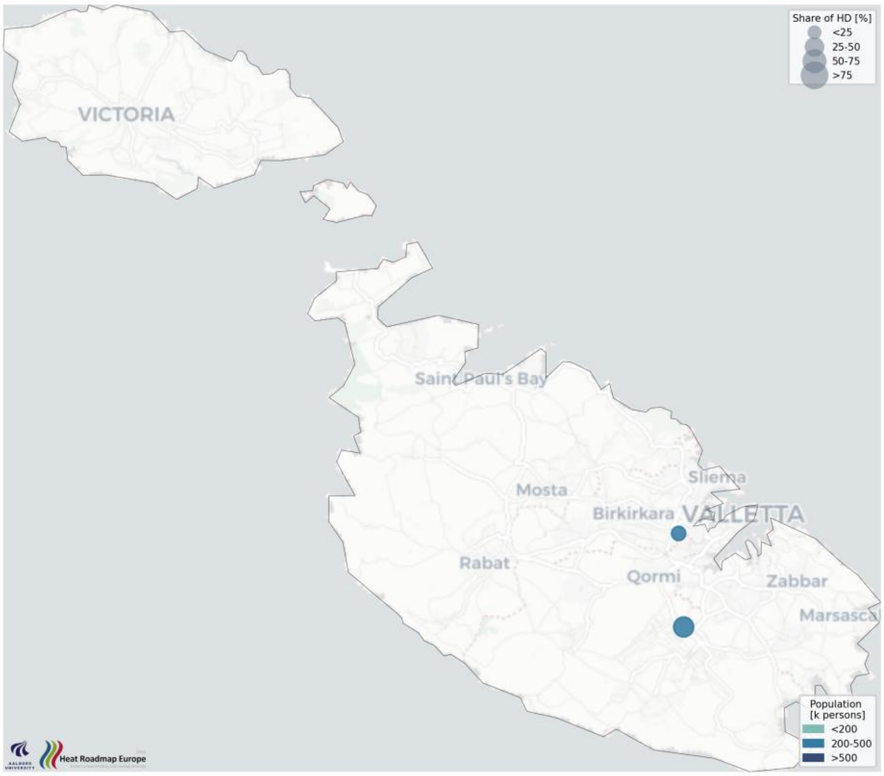


Figure 211: Low temperature from supermarkets for Malta.

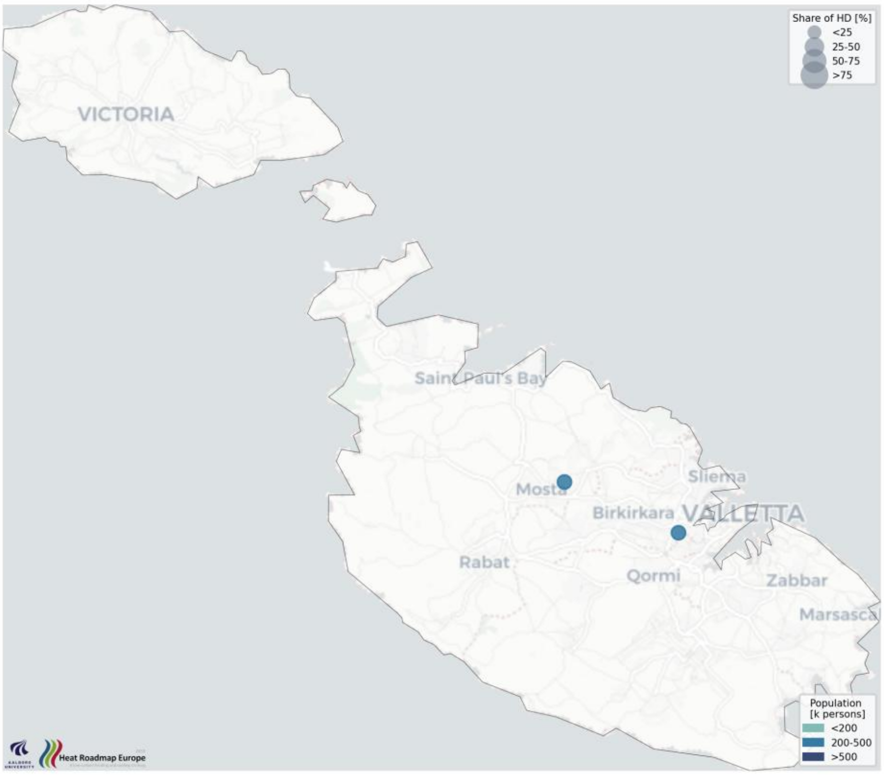


Figure 212: Medium temperature from industry for Malta.

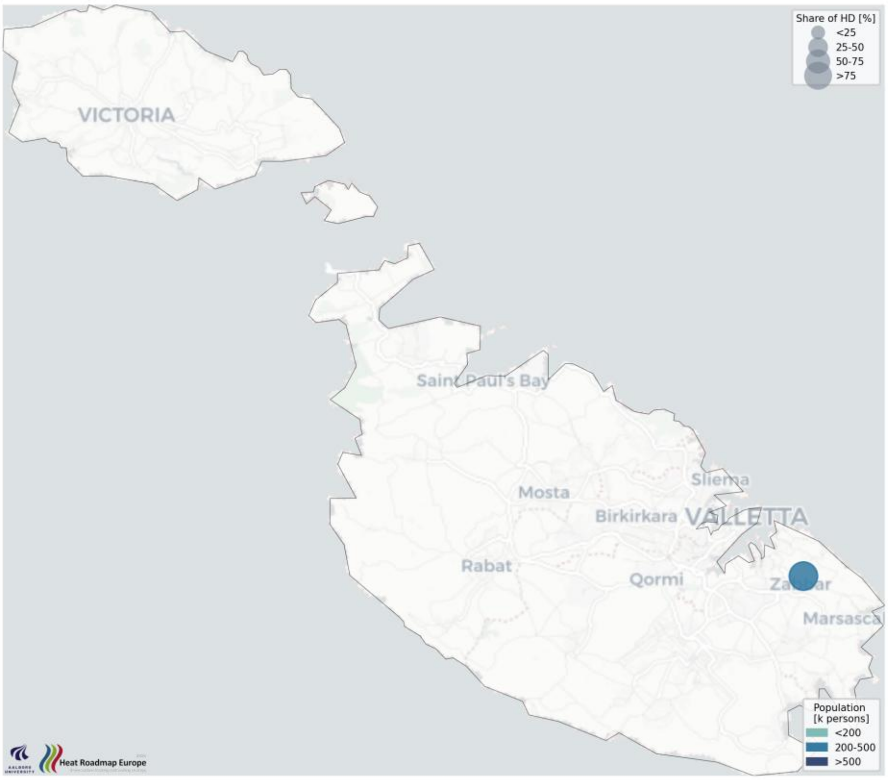


Figure 213: Medium temperature from wastewater treatment for Malta.

5.19 Netherlands

Table 47: District heating shares specific to Netherlands and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Netherlands	5	11,05	13,08	1,88	1,27	0,54	1,14	1,04	0,02	0,07	0	0	1,11	1,11
	10	11,05	13,08	1,88	1,27	0,54	1,14	1,04	0,02	0,07	0	0	1,11	1,11
	15	18,14	21,48	3,09	1,27	1,02	2,13	1,9	0,04	0,11	0	0	2,25	2,25
	20	20,18	23,89	3,37	1,27	1,19	2,49	2,16	0,04	0,11	0	0	2,49	2,49
	25	25,81	30,55	4,26	1,44	1,83	3,62	2,67	0,06	0,11	0	0	3,03	3,03
	30	30,74	36,39	4,99	1,44	2,37	4,75	3,2	0,06	0,11	0	0,05	3,47	3,09
	35	35,38	41,88	5,72	2,18	2,75	5,53	3,65	0,07	0,11	0	0,08	3,64	3,09
	40	40,13	47,5	6,54	2,4	3,2	6,38	3,93	0,09	0,11	0	0,18	4,11	3,09
	45	45,28	53,6	7,34	2,43	3,84	7,56	4,52	0,1	0,11	0	0,23	4,13	3,09
	50	50,09	59,3	7,89	2,43	4,38	8,65	4,83	0,13	0,11	0,03	0,36	4,13	3,09
	55	55,02	65,13	8,22	2,69	4,97	9,77	5,16	0,15	0,11	0,16	0,49	4,13	3,09
	60	60,01	71,03	8,45	2,69	5,64	10,95	5,55	0,17	0,11	0,31	0,64	4,13	3,09
	65	65,04	76,99	8,62	2,86	6,11	11,87	5,93	0,2	0,11	0,53	0,86	4,13	3,09

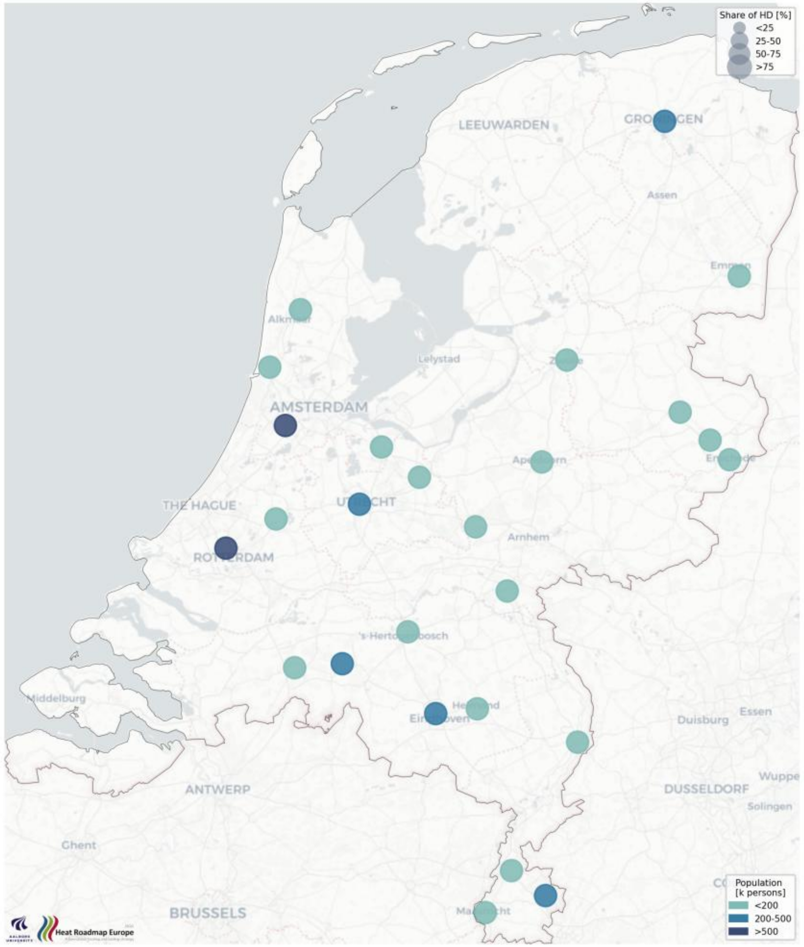


Figure 214: Geothermal energy for the Netherlands

(Baseload of district heating area, capacity >40MW).

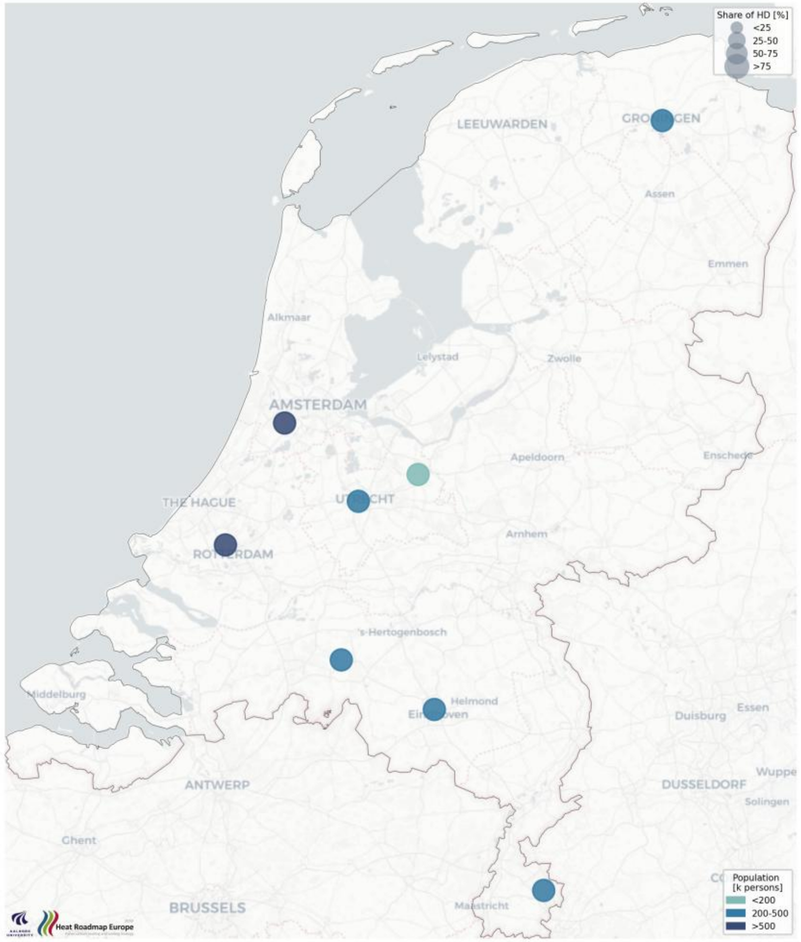


Figure 215: Geothermal energy for the Netherlands

(Baseload of district heating area, capacity >70MW).

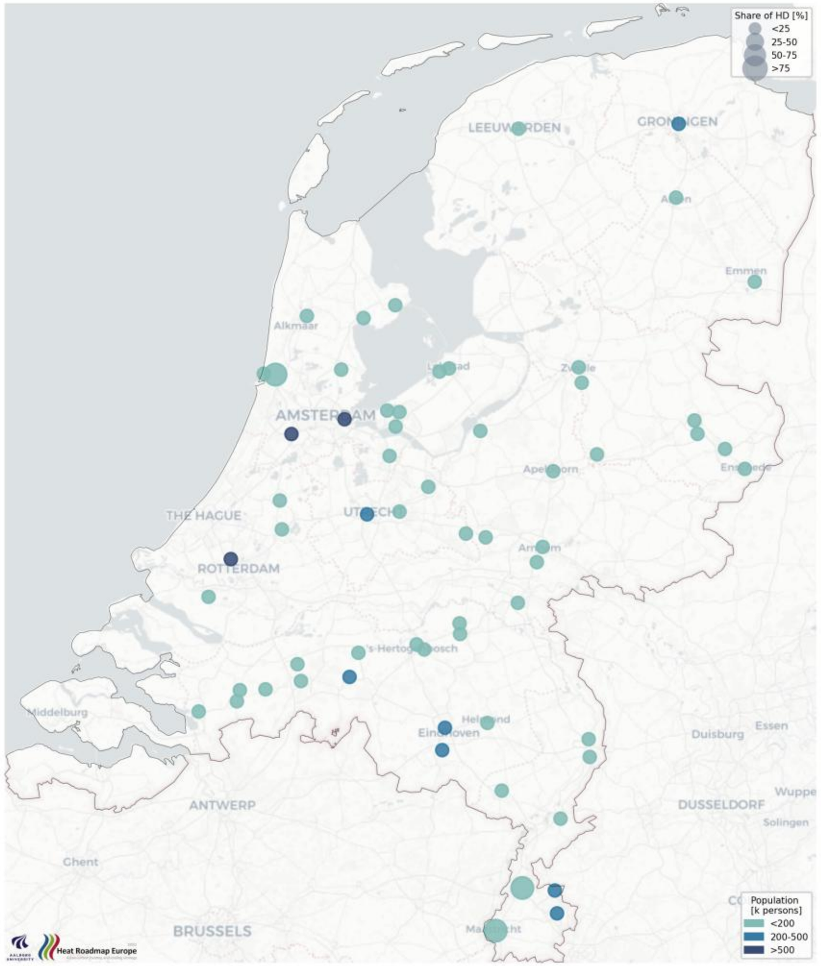


Figure 216: Baseload high temperature waste heat for the Netherlands.

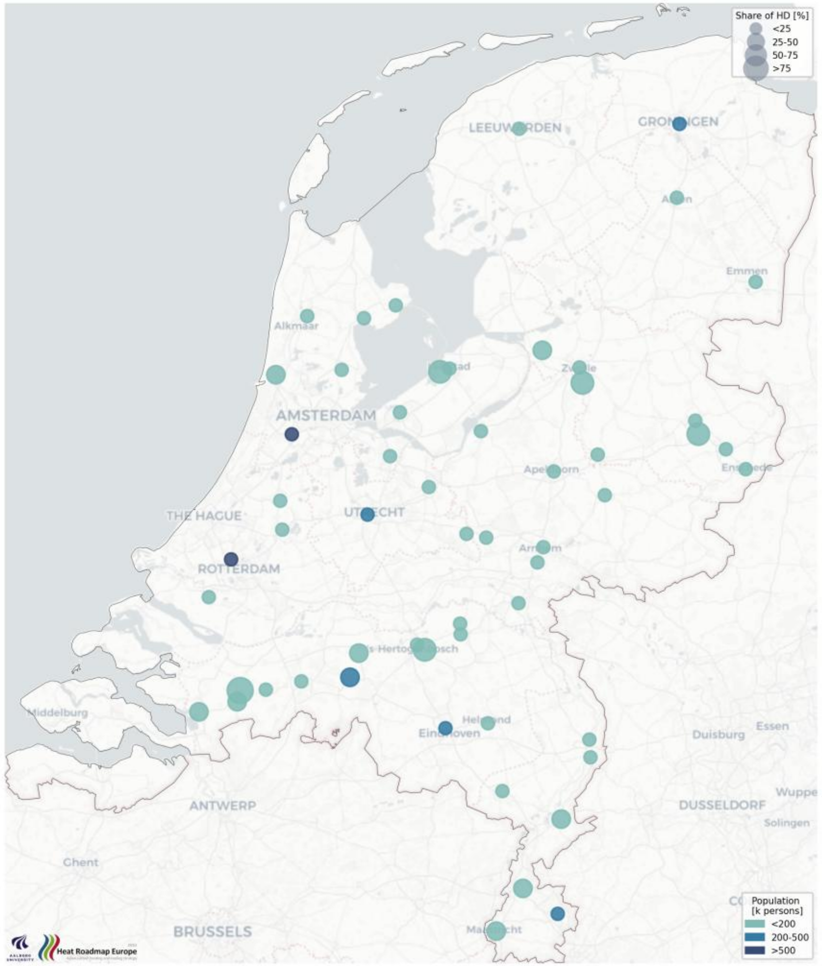


Figure 217: Baseload low temperature waste heat for the Netherlands.

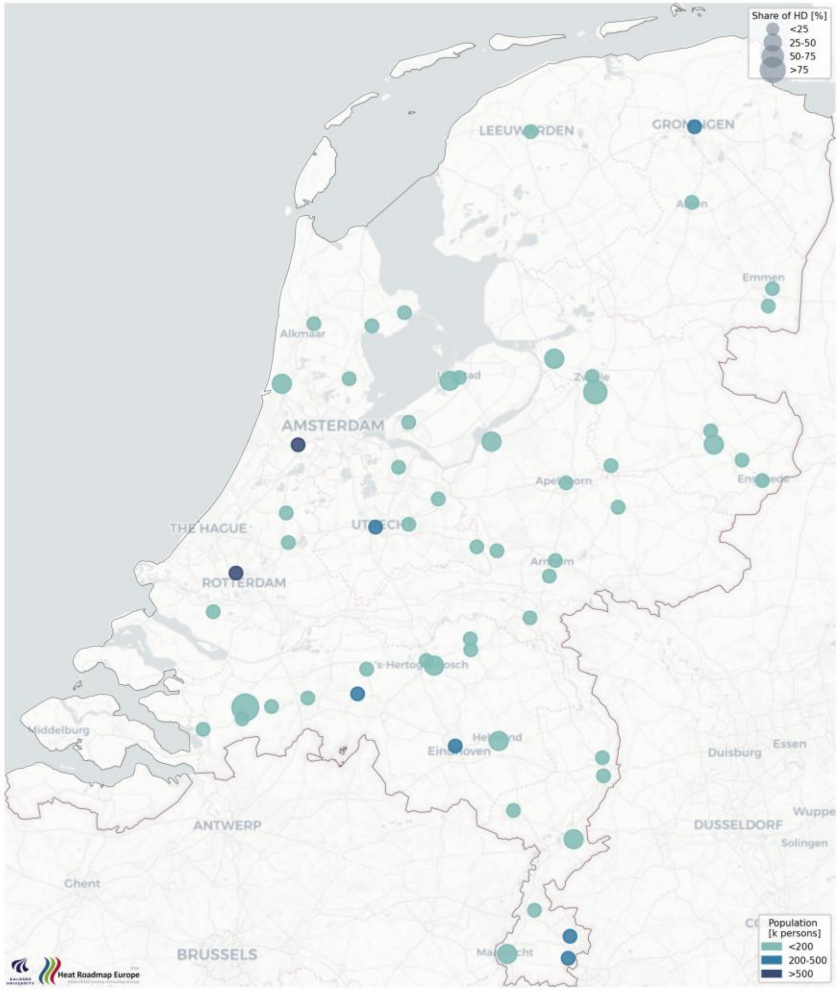


Figure 218: Baseload medium temperature waste heat for the Netherlands.

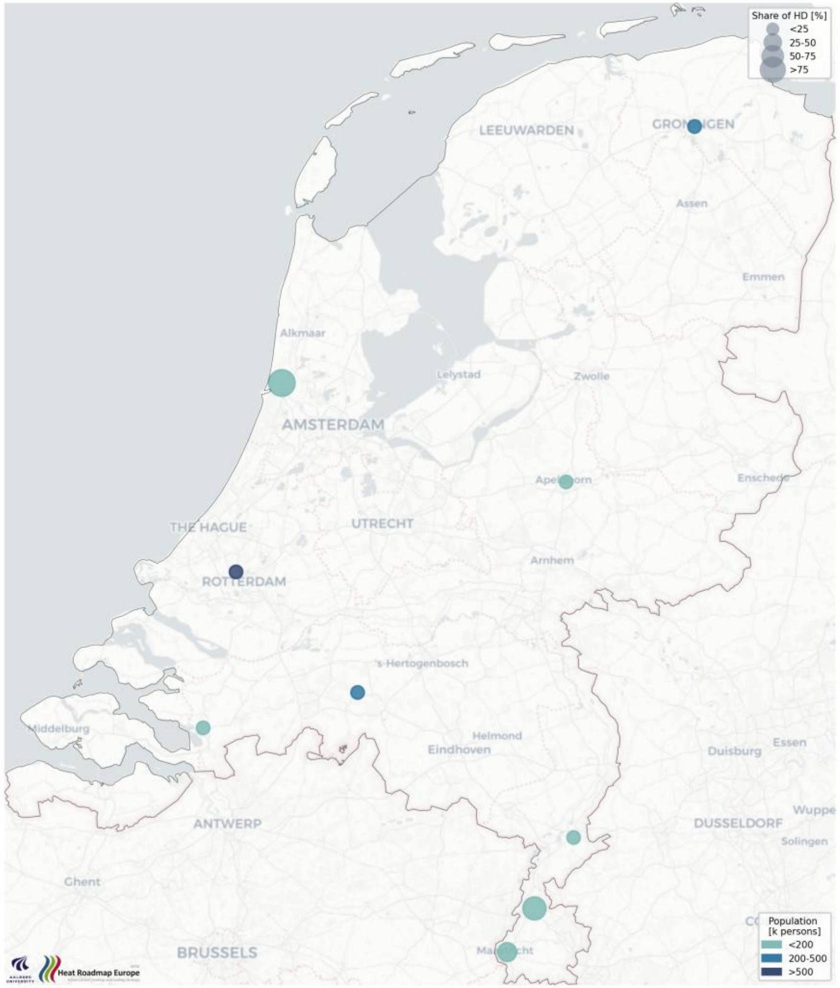


Figure 219: High temperature from industry for the Netherlands.

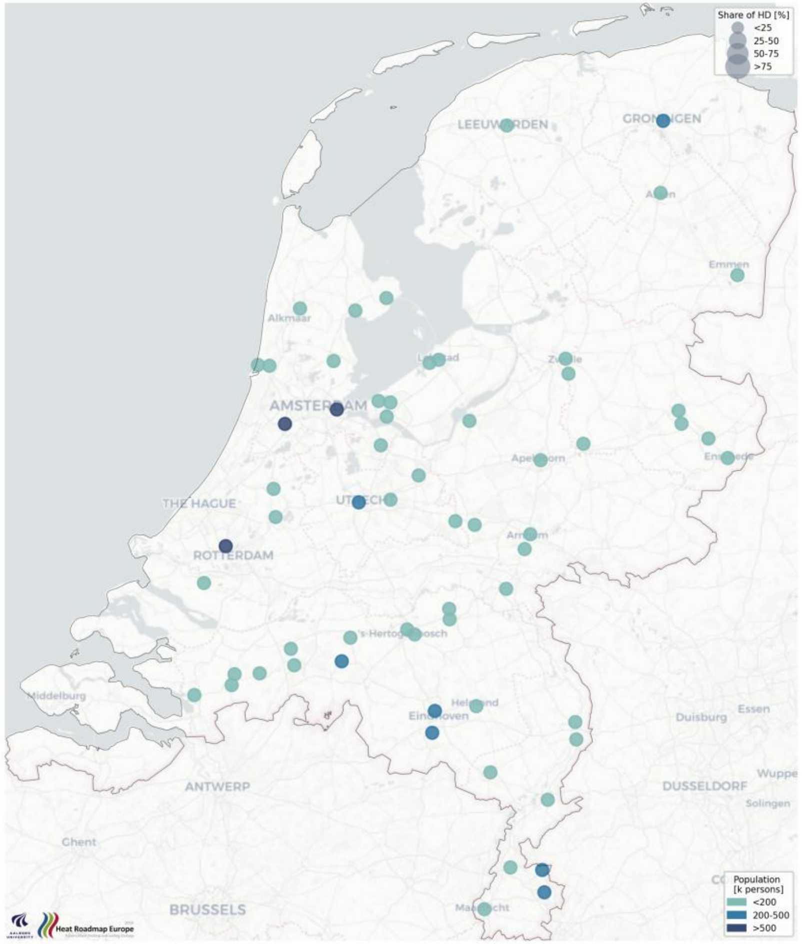


Figure 220: High temperature from waste-to-energy for the Netherlands.

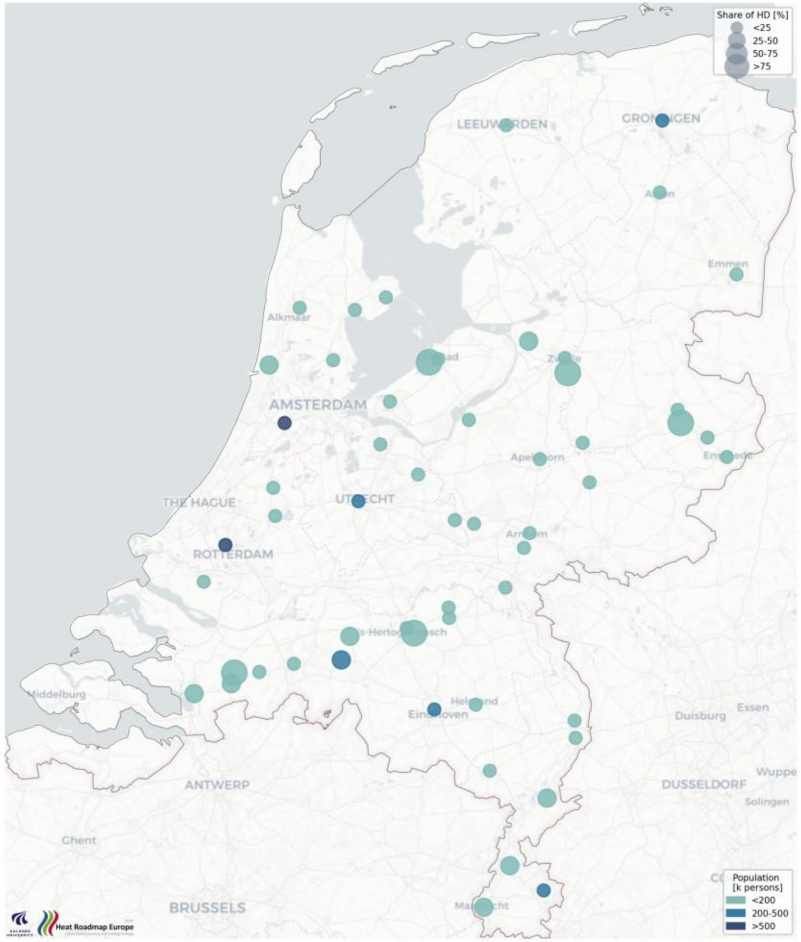


Figure 221: Low temperature from industry for the Netherlands.

Figure 222: Low temperature from metros for the Netherlands.

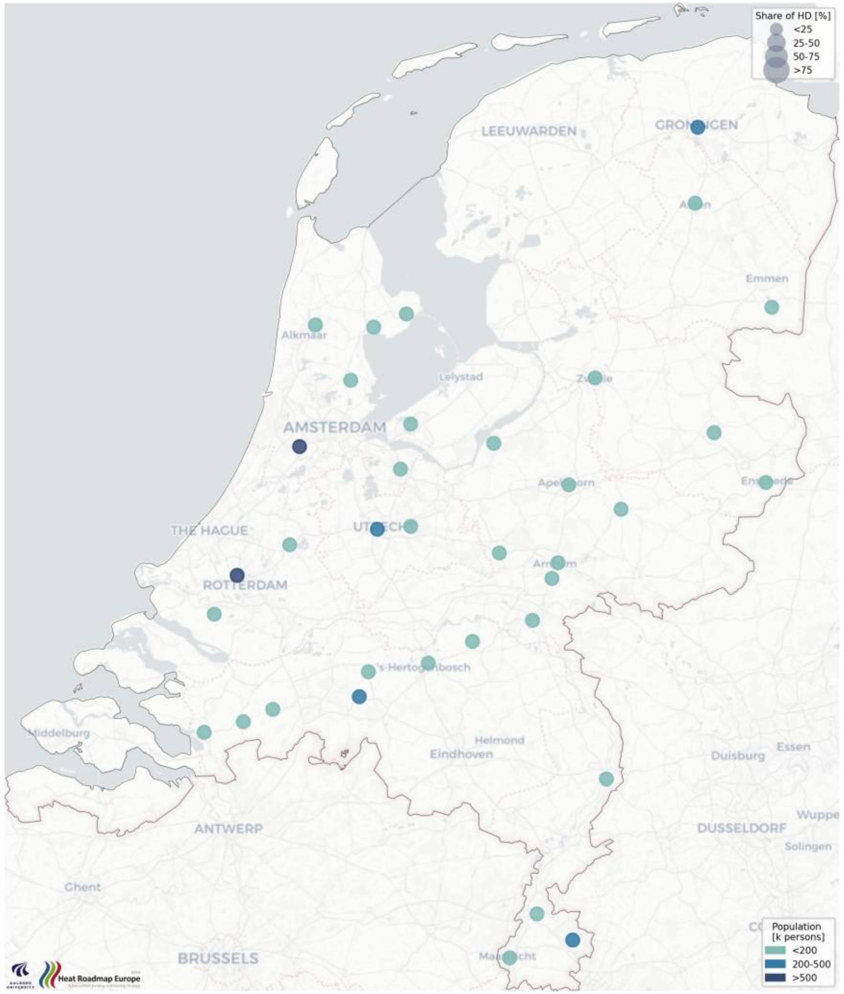


Figure 223: Low temperature from supermarkets for the Netherlands.

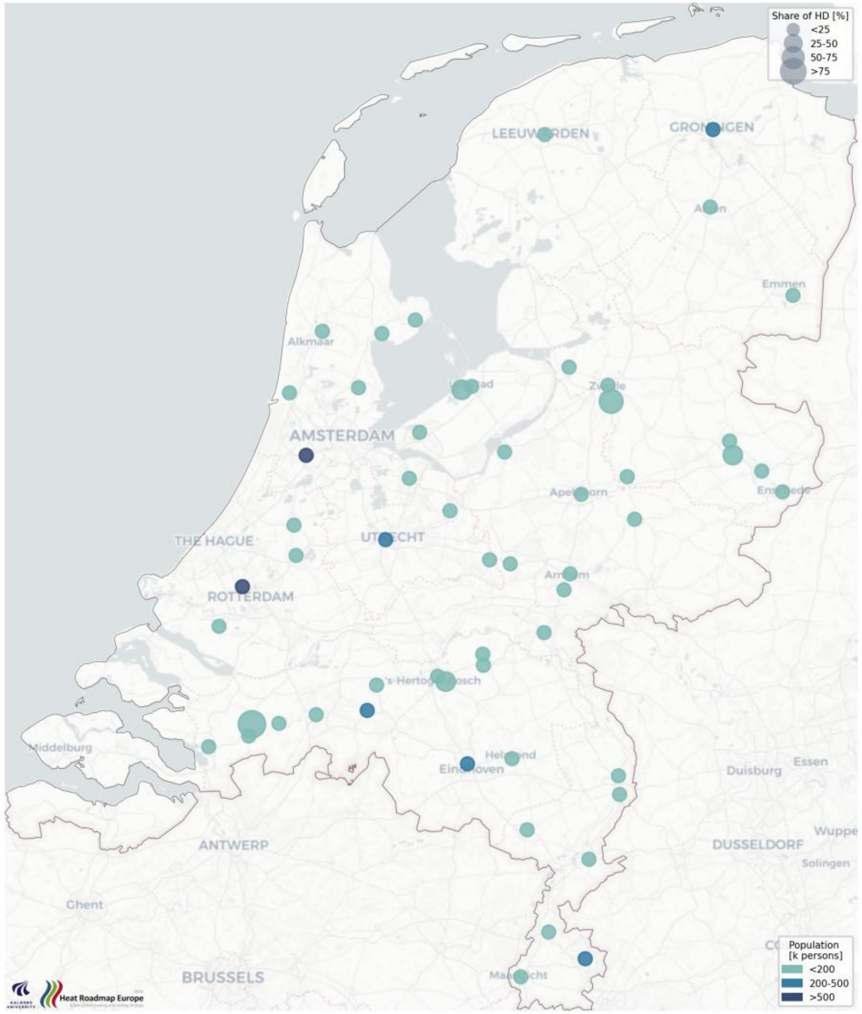


Figure 224: Medium temperature from industry for the Netherlands.

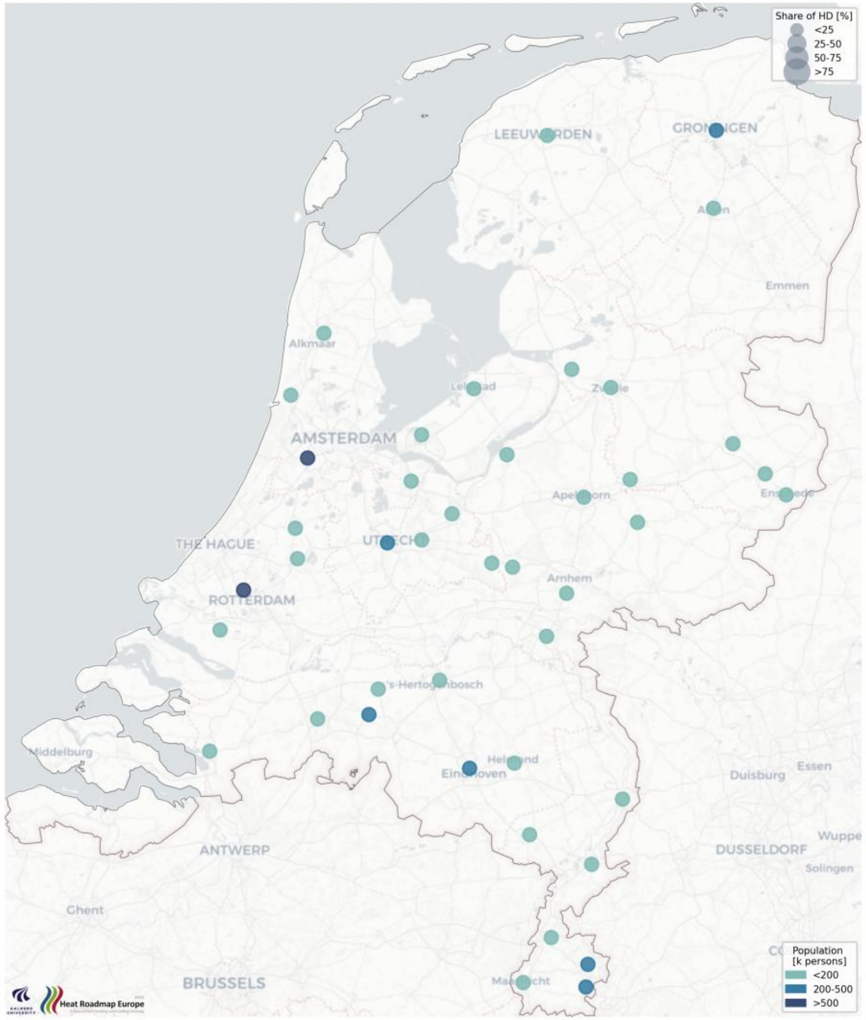


Figure 225: Medium temperature from wastewater treatment for the Netherlands.

5.20 Poland

Table 48: District heating shares specific to Poland and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Poland	5	6,42	11,4	0,7	0,03	0,37	0,66	0,35	0,12	0,07	0	0	2,78	2,78
	10	10,17	18,08	1,02	0,03	0,6	1,06	0,63	0,18	0,08	0	0	4,09	4,09
	15	15,07	26,77	1,64	0,04	0,99	1,73	1,19	0,3	0,08	0	0,05	5,17	4,86
	20	20,39	36,24	2,3	0,17	1,38	2,4	1,6	0,42	0,08	0	0,36	5,75	4,86
	25	25,04	44,5	2,86	0,36	1,66	2,89	1,95	0,55	0,1	0,03	0,62	5,75	4,86
	30	30,05	53,4	3,38	0,41	2,03	3,49	2,77	0,72	0,1	0,27	0,87	5,75	4,86
	35	35,06	62,3	3,7	0,43	2,39	4,04	3,48	0,89	0,1	0,6	1,2	5,75	4,86
	40	40,05	71,17	3,99	0,69	2,71	4,52	4,33	1,1	0,1	0,91	1,51	5,75	4,86
	45	45	79,97	4,21	0,91	3,1	4,99	5,2	1,31	0,1	1,23	1,83	5,75	4,86
	50	50,01	88,86	4,45	1,03	3,62	5,4	5,88	1,54	0,1	1,61	2,21	5,75	4,86
	55	54,04	96,04	4,63	1,09	4,12	5,61	6,35	1,63	0,1	1,99	2,59	5,75	4,86
	60	54,04	96,04	4,63	1,09	4,12	5,61	6,35	1,63	0,1	1,99	2,59	5,75	4,86
	65	54,04	96,04	4,63	1,09	4,12	5,61	6,35	1,63	0,1	1,99	2,59	5,75	4,86

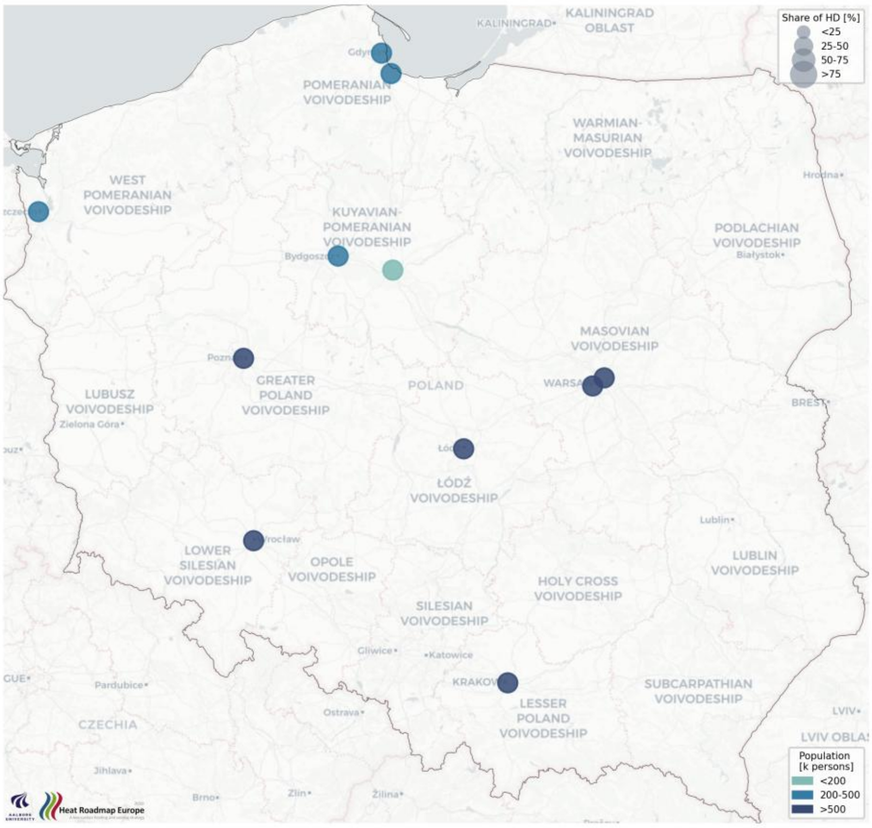


Figure 226: Geothermal energy for Poland (Baseload of district heating area, capacity >40MW).

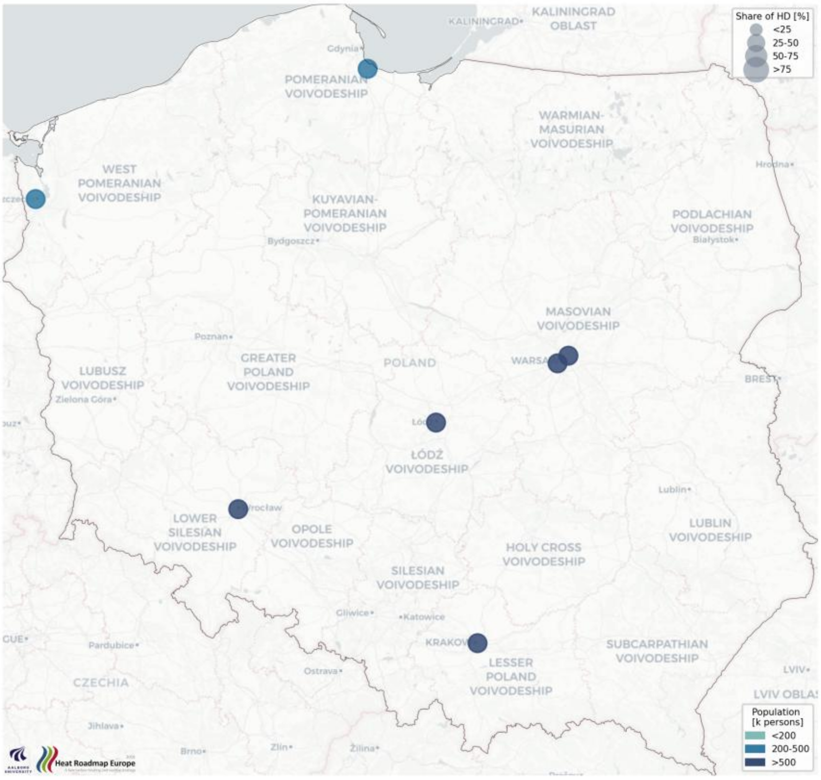


Figure 227: Geothermal energy for Poland (Baseload of district heating area, capacity >70MW).

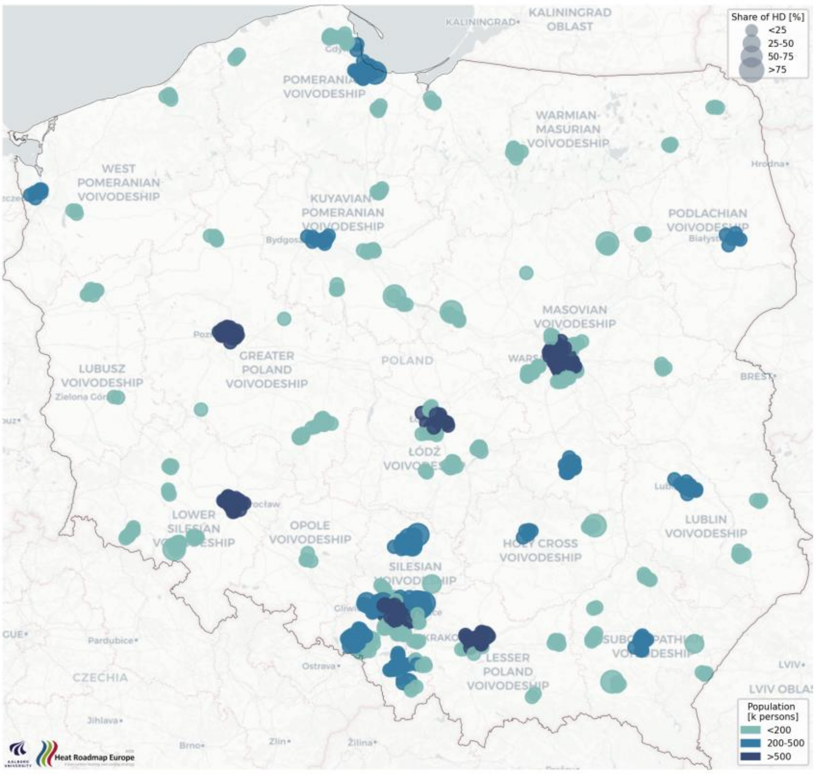


Figure 228: Baseload high temperature waste heat for Poland.

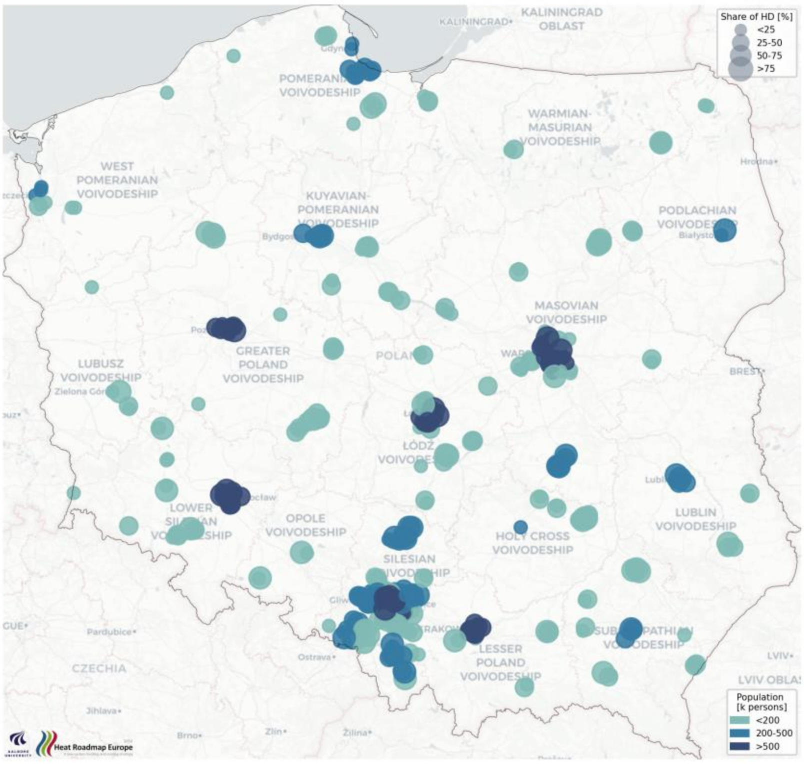


Figure 229: Baseload low temperature waste heat for Poland.

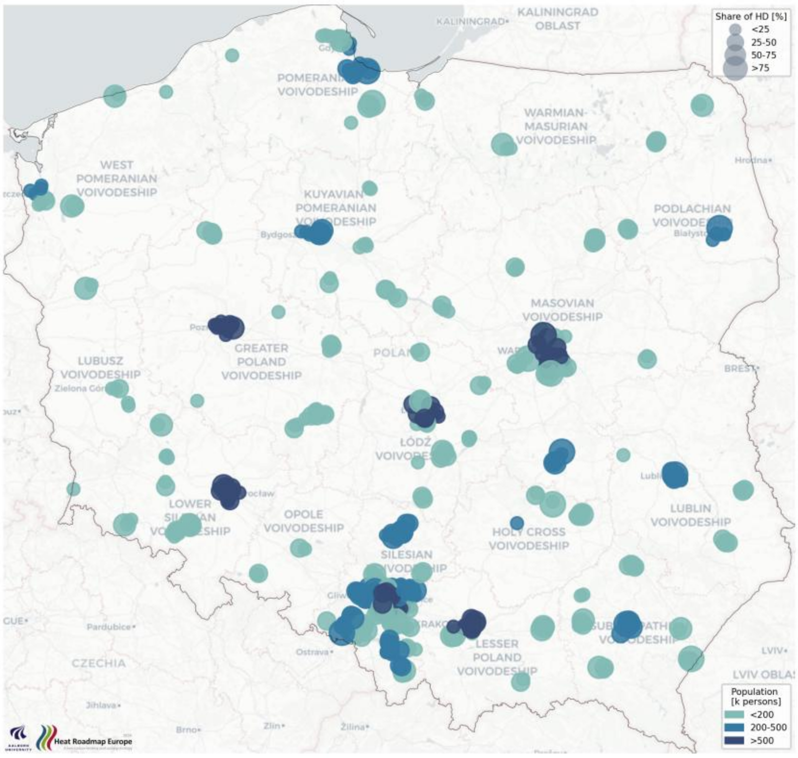


Figure 230: Baseload medium temperature waste heat for Poland.

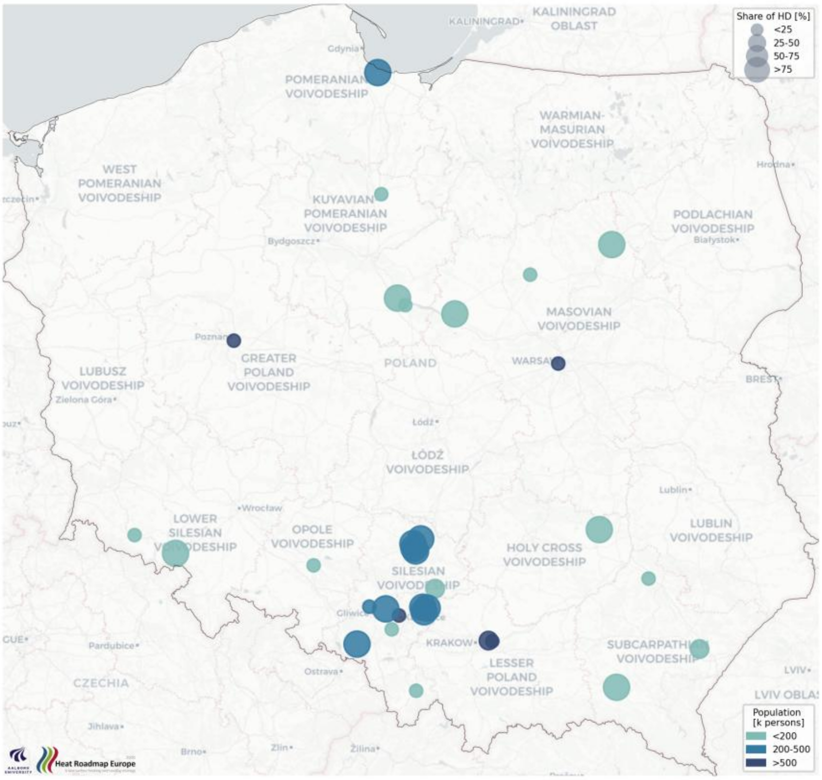


Figure 231: High temperature from industry for Poland.

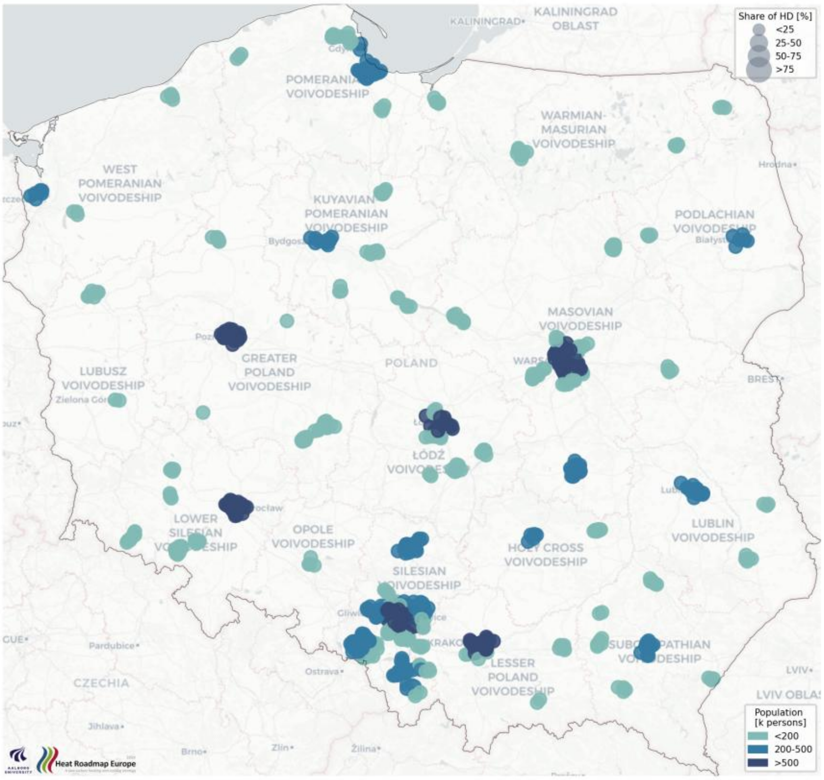


Figure 232: High temperature from waste-to-energy for Poland.

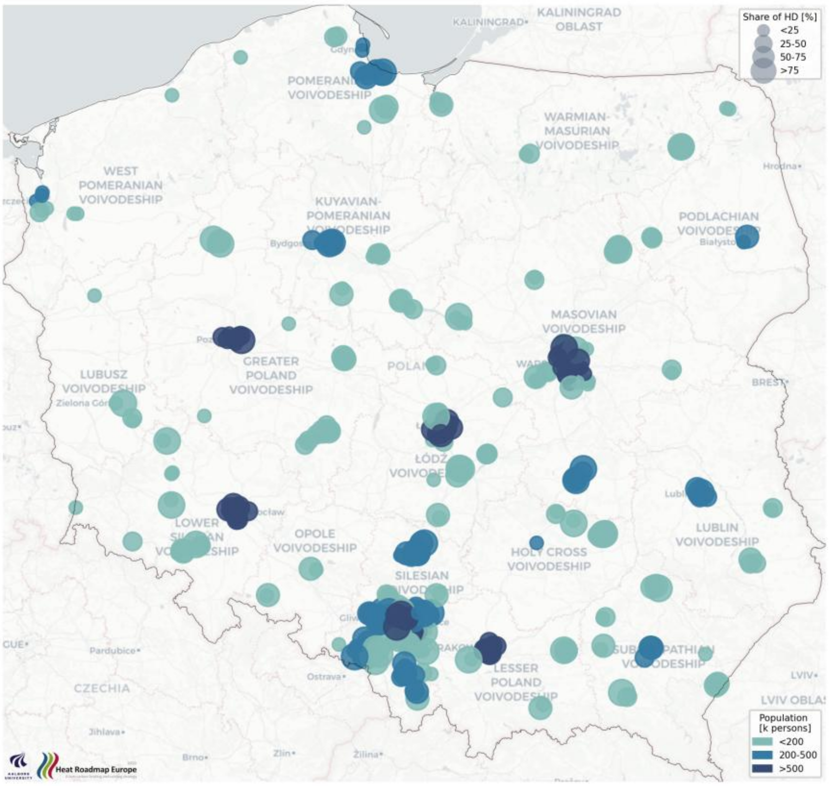


Figure 233: Low temperature from industry for Poland.

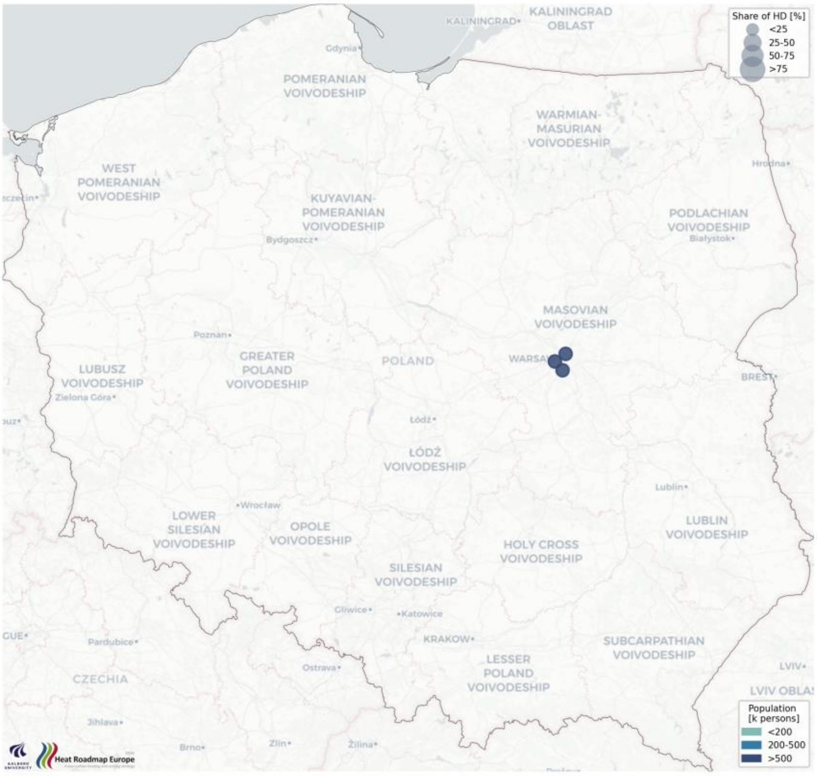


Figure 234: Low temperature from metros for Poland.

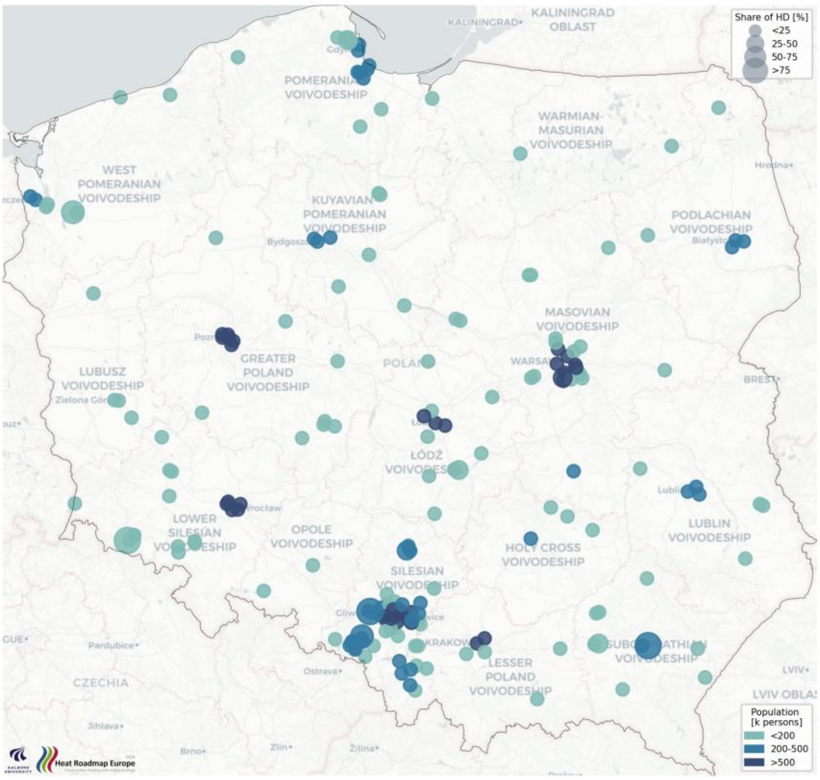


Figure 235: Low temperature from supermarkets for Poland.

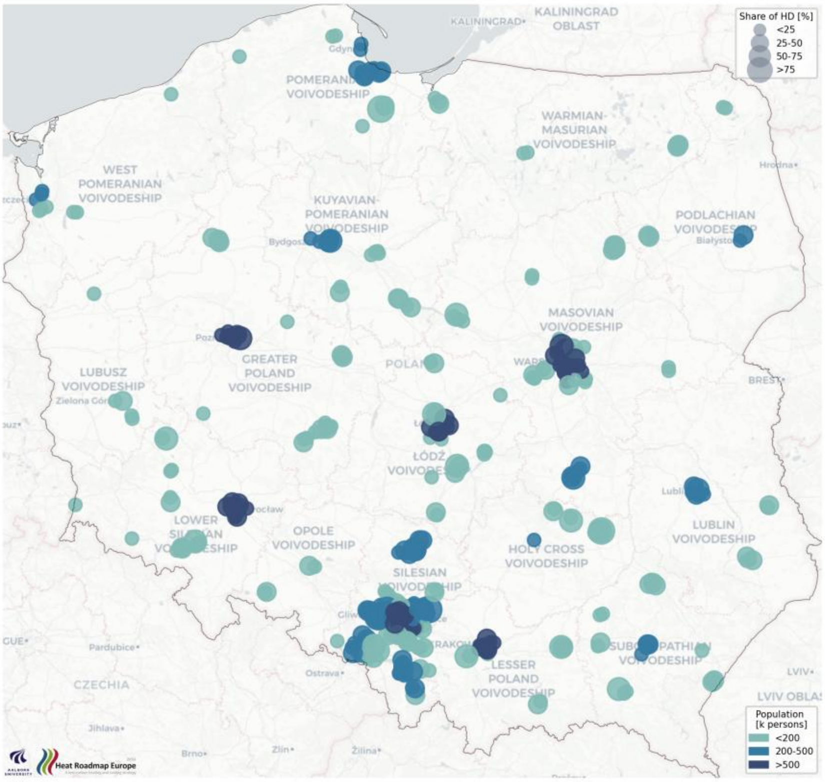


Figure 236: Medium temperature from industry for Poland.

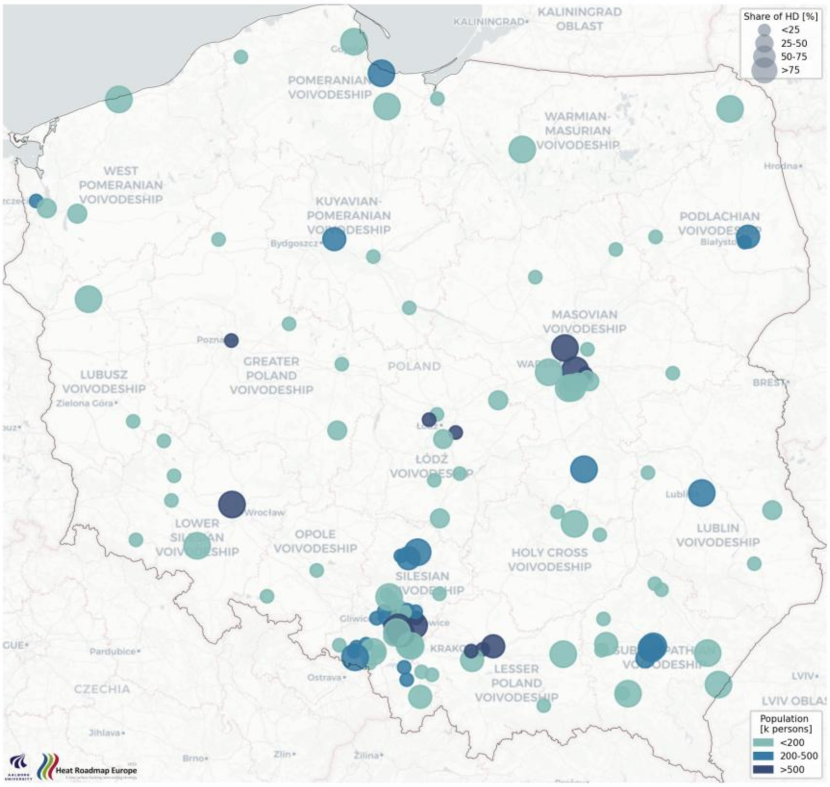


Figure 237: Medium temperature from wastewater treatment for Poland.

For Poland, the recommended district heating share is 47,58% so the one being used from the simulations is 50%.

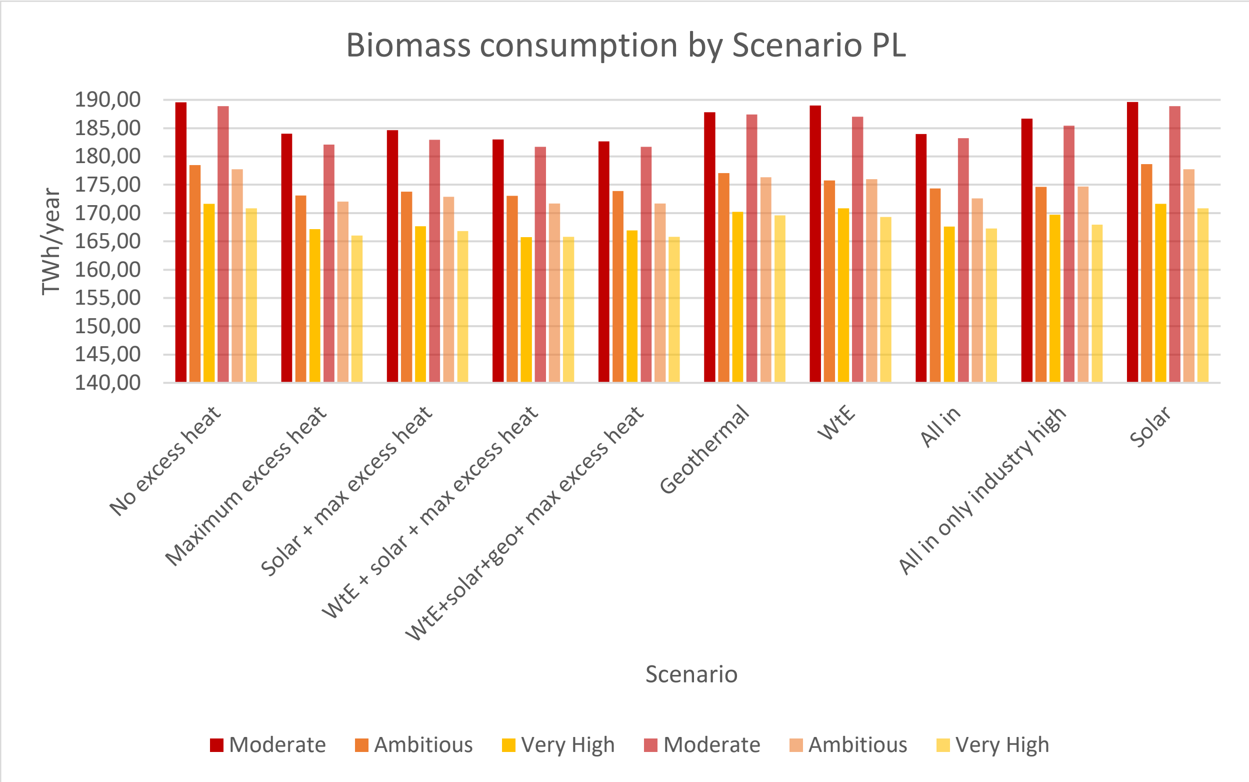


Figure 238: Biomass consumption in TWh/year for different district heating shares and heat source for 3GDH and 4GDH, in the case of Poland.

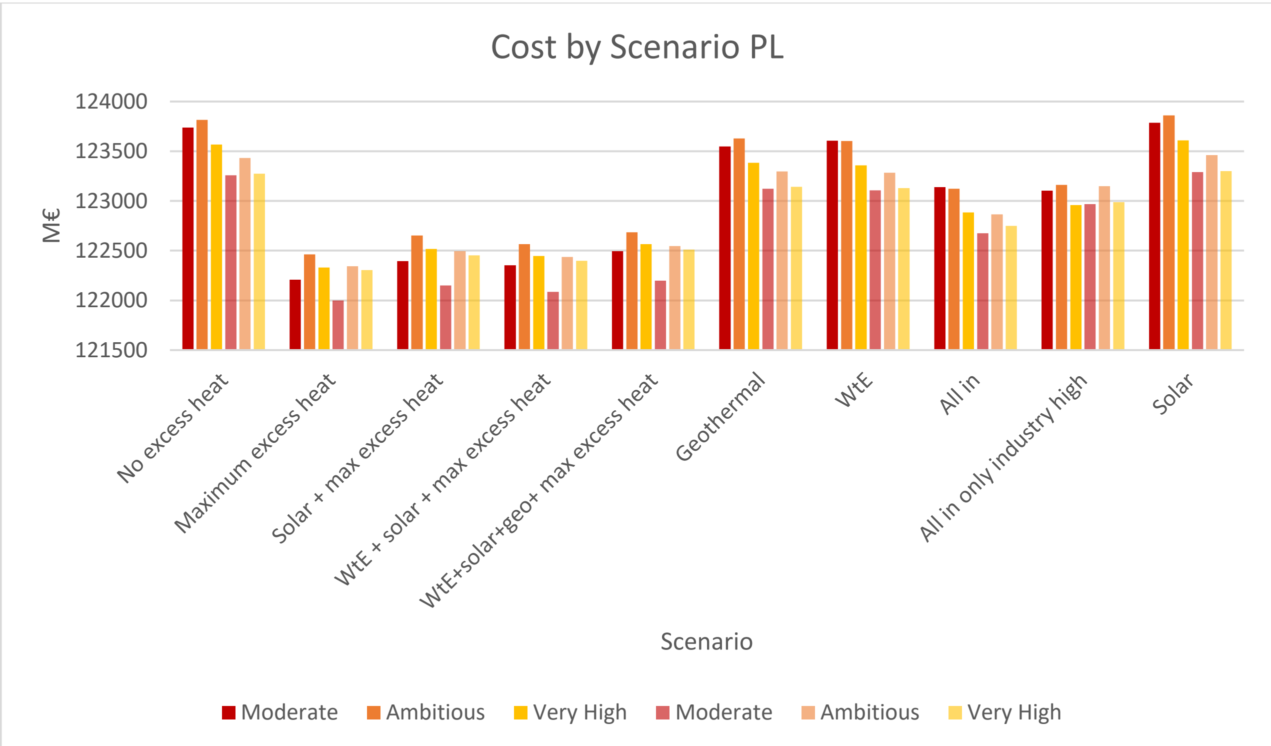


Figure 239: Cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of Poland.

In the case of Poland, the biomass consumption peaks at the Moderate saving in all cases and gets reduced with any upgrade, either a higher saving level or a better generation for the district heating system, being the lowest the Very High savings from the 4th generation, and more specifically the ones from the mix heat prioritization scenario. As just mentioned, all action taken benefit the biomass consumption, however, if a single action should be taken, then a heat demand improvement should be the way to go as it has a greater effect on the biomass consumption, which is less when a step is taken in the demand reduction when compared to the previous one than comparing it to their parallel scenario in the 4th generation district heating.

In the case of Poland, the costs are differently affected compared to the other countries. Here it can be seen that an upgrade to the 4th generation is economically beneficial in any case. However, when comparing the different generations the results differ: in the case of the 3rd generation it is cheaper to go fer the very high savings, while in the 4th generation the moderate savings are just a bit cheaper than the very high savings. In any case, the mix heat prioritization is the cheapest option, it is the one that reduces more the cost followed by the All in only industry high case which holds the second most number of heat sources.

Table 49: Biomass consumption in TWh/year for different district heating shares and heat source for 3GDH and 4GDH, in the case of Poland and cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of Poland.

47,58	3rd			4th		
Biomass	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	189,55	178,50	171,62	188,90	177,73	170,85
Maximum waste heat	184,01	173,08	167,14	182,09	172,00	166,05
Solar + max waste heat	184,62	173,80	167,66	182,95	172,89	166,83
WtE + solar + max waste heat	182,99	173,04	165,73	181,68	171,70	165,80
WtE+solar+geo+ max waste heat	182,68	173,87	166,94	181,68	171,70	165,80
Geothermal	187,83	177,04	170,24	187,41	176,30	169,60
WtE	188,99	175,79	170,85	187,02	176,01	169,31
All in	183,95	174,33	167,60	183,21	172,56	167,28
All in only industry high	186,68	174,65	169,71	185,45	174,66	167,94
Solar	189,63	178,62	171,61	188,90	177,76	170,85

	3rd			4th		
Cost	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	123.737	123.814	*123.568*	123.257	123.431	*123.275*
Maximum waste heat	122.209	122.463	*122.332*	122.000	122.345	*122.304*
Solar + max waste heat	122.395	122.653	*122.519*	122.149	122.496	*122.453*
WtE + solar + max waste heat	122.354	122.567	*122.445*	122.085	122.436	*122.399*
WtE+solar+geo+ max waste heat	122.495	122.685	*122.565*	122.198	122.548	*122.512*
Geothermal	123.549	123.630	*123.385*	123.123	123.296	*123.141*
WtE	123.606	123.604	*123.357*	123.108	123.284	*123.129*
All in	123.139	123.123	*122.885*	122.675	122.866	*122.749*
All in only industry high	123.102	123.160	*122.959*	122.968	123.150	*122.987*
Solar	123.785	123.862	*123.610*	123.289	123.460	*123.301*

For the biomass consumption there is a clear tendency towards lower levels of its use, the higher the heat savings are, also there is a slight upgrade between the 3rd generation and the 4th generation. When quantifying these improvements, they range from 1%, when upgrading the generation of the system, to 10% when upgrading up to Very High savings. However, it is cheaper to upgrade the system than to improve the saving measures, even though the differences are so small that they could be neglected.

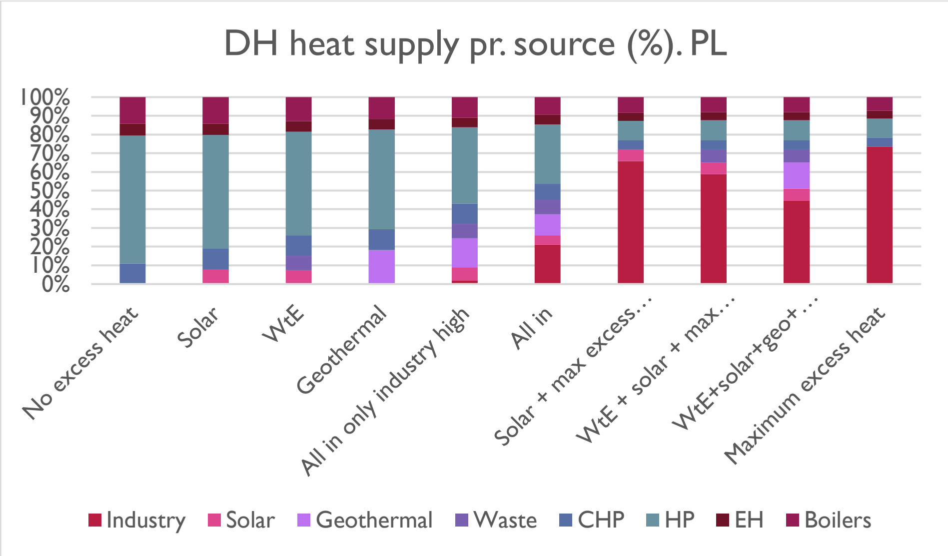


Figure 240: District heating heat supply pr. source in percentage for each scenario in the case of Spain.

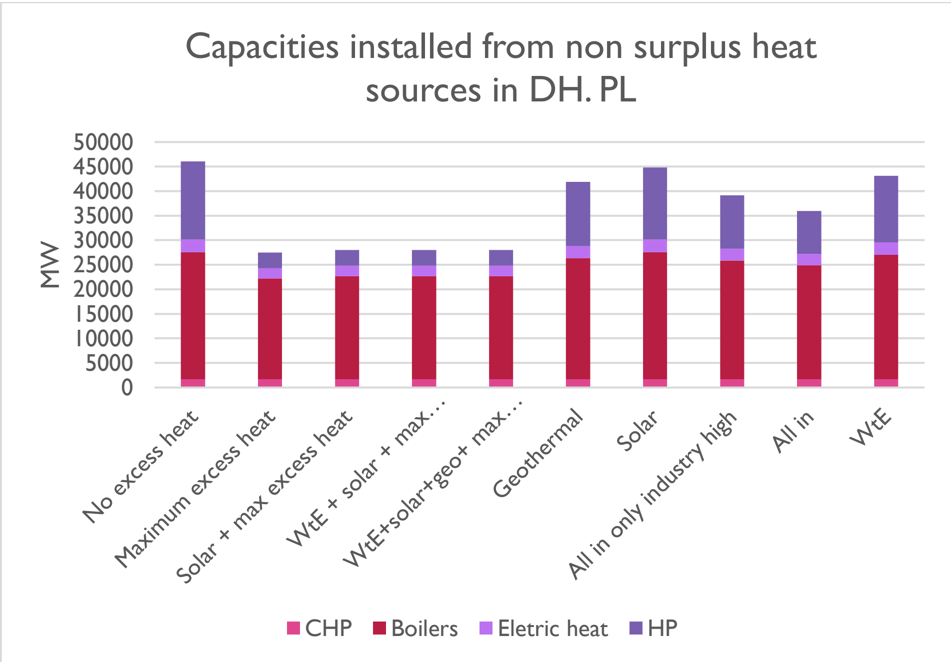


Figure 241: Installed capacities in MW from non surplus heat sources in district heating in Poland.

The HP capacity installed follows the same pattern as the cost reduction. The lowest is the surplus heat mix sources followed by All in only industry high, which is the prioritization with the second most number of surplus heat sources. Also, the highest happens to be the scenario Solar where only solar is used both in HP capacity and cost.

5.21 Portugal

Table 50: District heating shares specific to Portugal and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Portugal	5	9,26	1,97	0,26	0,16	0,2	0,26	0,43	0,05	0	0	0	0	0
	10	13,05	2,78	0,51	0,16	0,25	0,33	0,58	0,08	0	0	0	0	0
	15	15,61	3,33	0,64	0,16	0,3	0,33	0,75	0,09	0	0	0	0	0
	20	20,1	4,29	0,92	0,24	0,37	0,36	0,8	0,1	0	0,03	0,03	0	0
	25	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0
	30	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0
	35	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0
	40	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0
	45	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0
	50	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0
	55	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0
	60	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0
	65	25	5,33	1,18	0,25	0,5	0,39	0,9	0,12	0	0,07	0,07	0	0

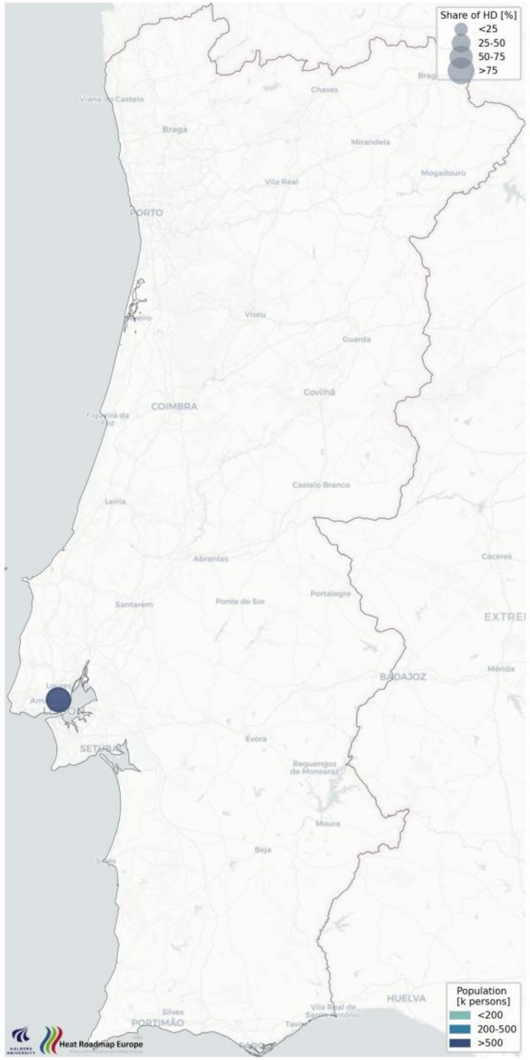


Figure 242: Geothermal energy for Portugal (Baseload of district heating area, capacity >40MW).

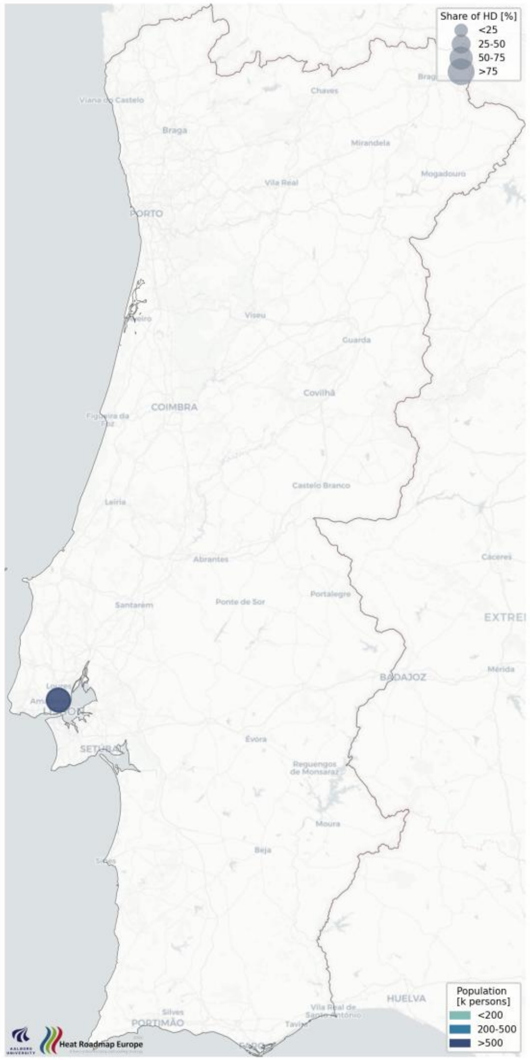


Figure 243: Geothermal energy for Portugal (Baseload of district heating area, capacity >70MW).

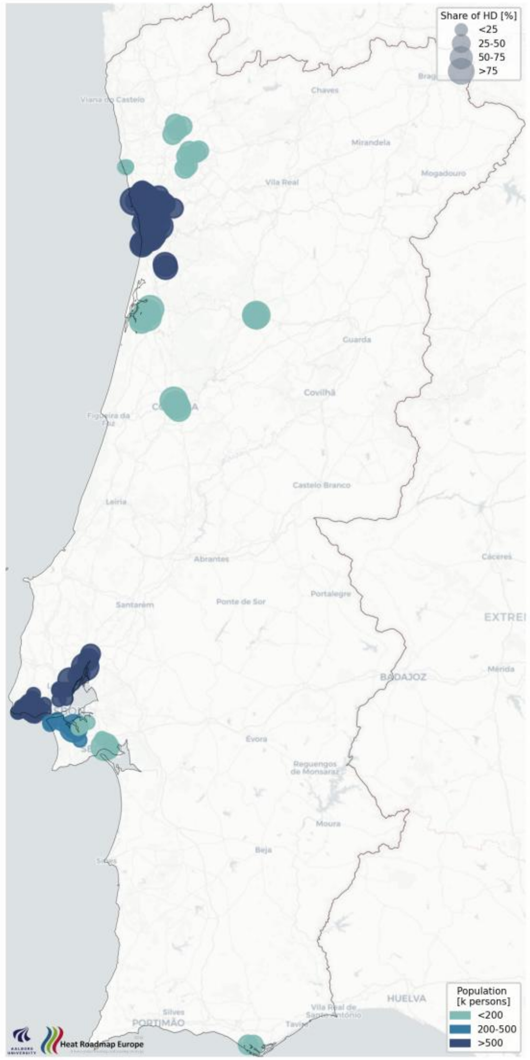


Figure 244: Baseload high temperature waste heat for Portugal

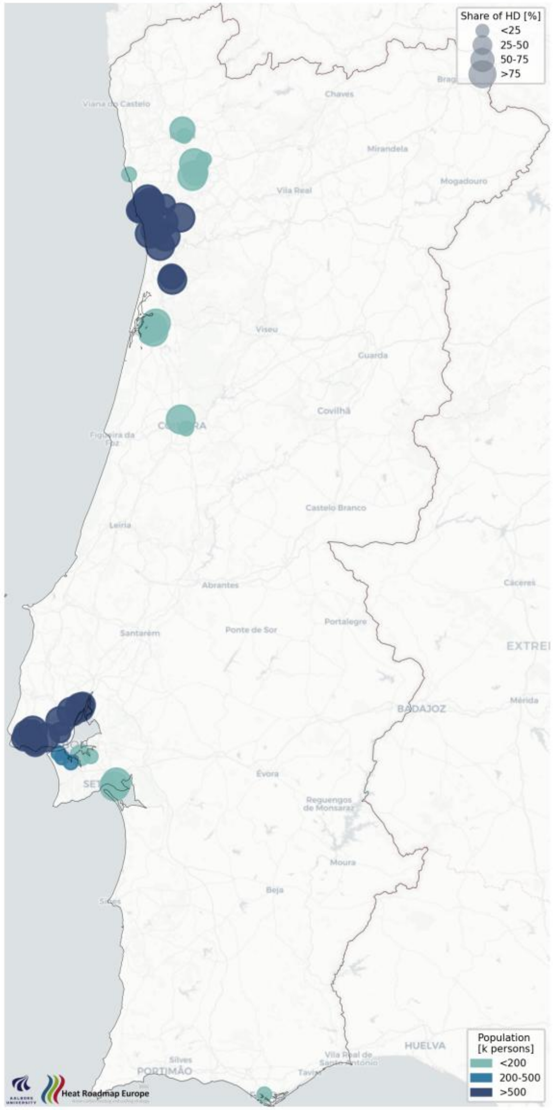


Figure 245: Baseload low temperature waste heat for Portugal.

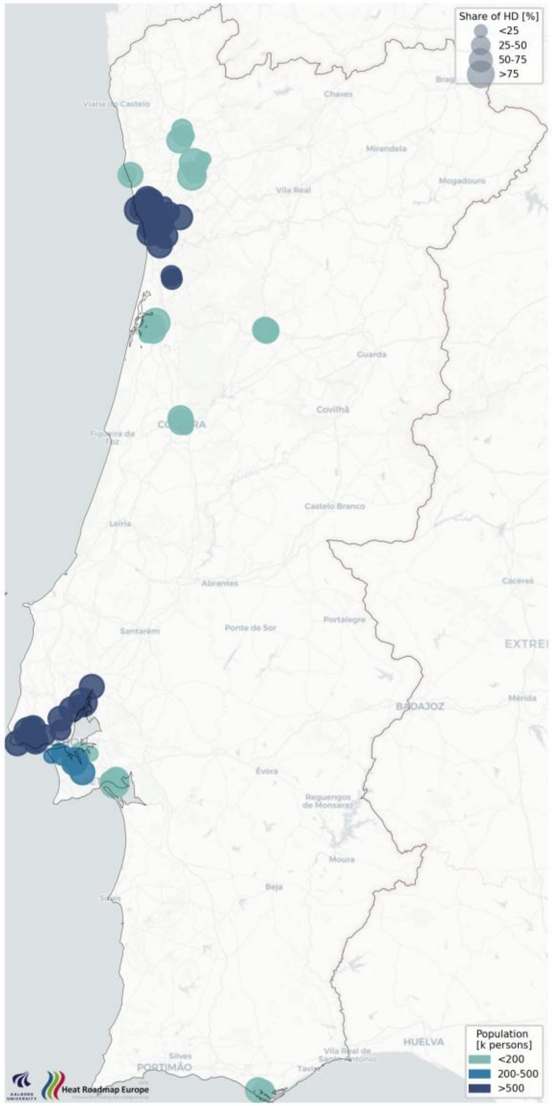


Figure 246: Baseload medium temperature waste heat for Portugal.

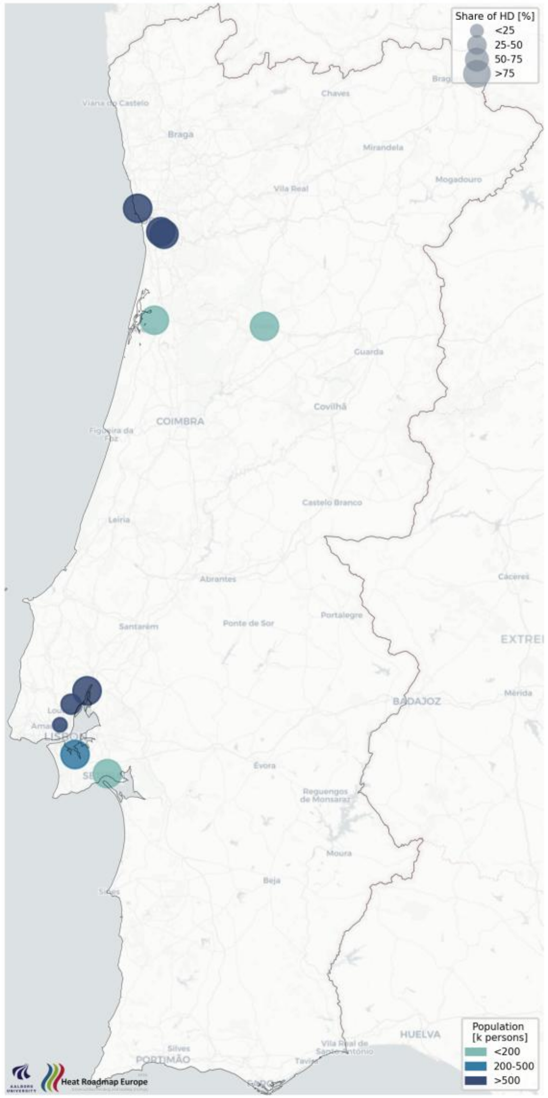


Figure 247: High temperature from industry for Portugal.

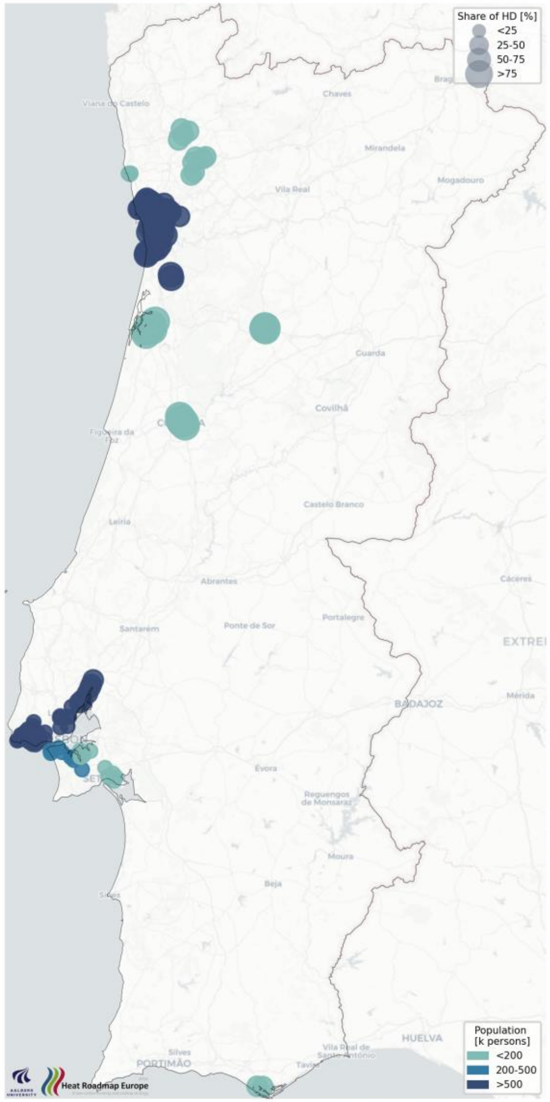


Figure 248: High temperature from waste-to-energy for Portugal.

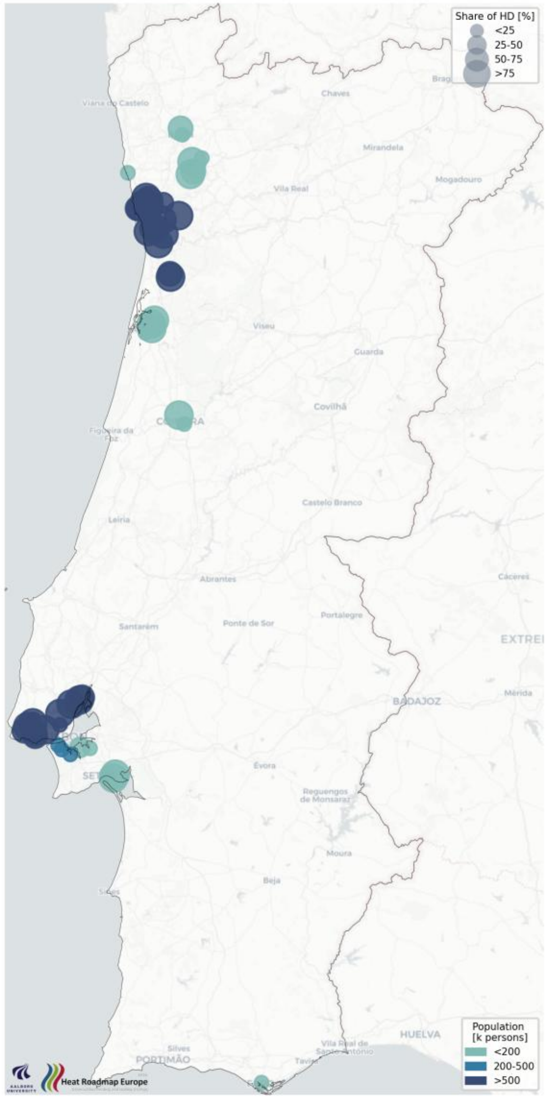


Figure 249: Low temperature from industry for Portugal.

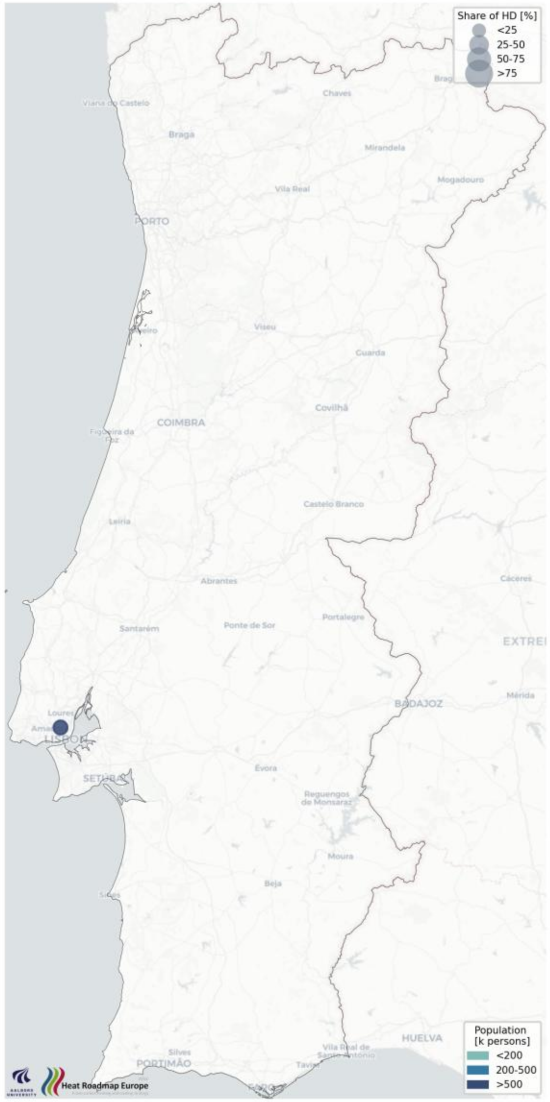


Figure 250: Low temperature from metros for Portugal.

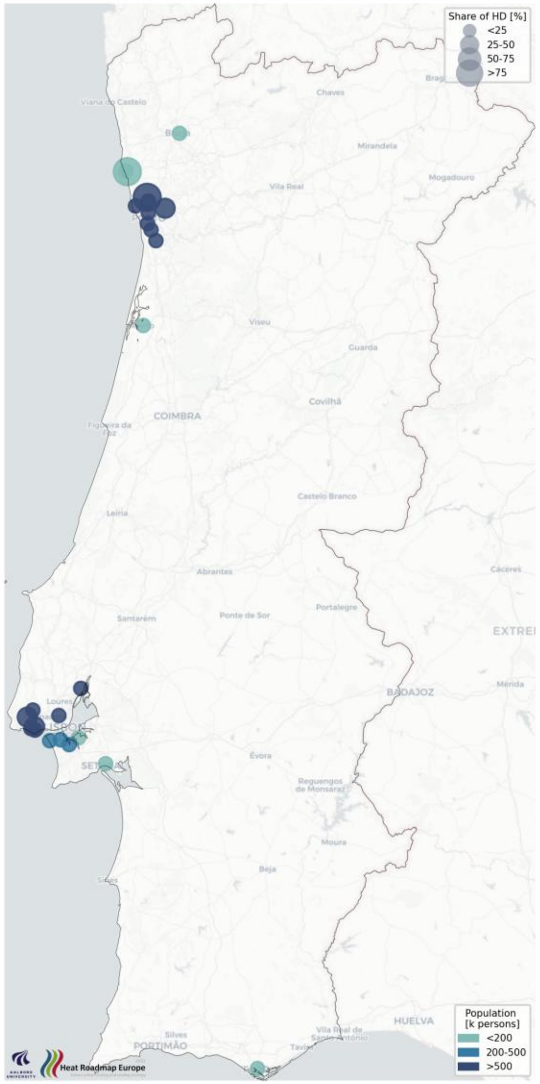


Figure 251: Low temperature from supermarkets for Portugal.

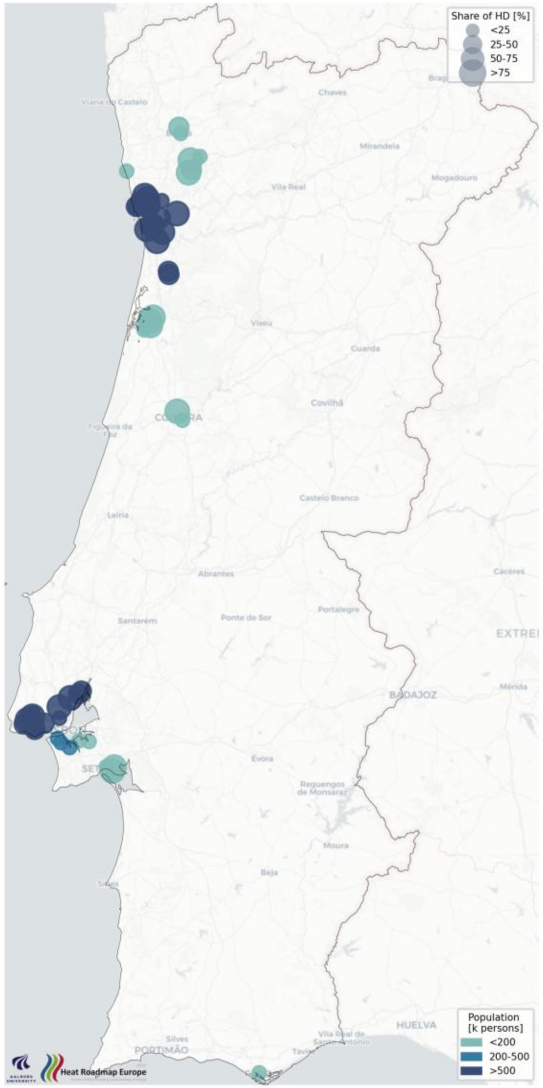


Figure 252: Medium temperature from industry for Portugal.

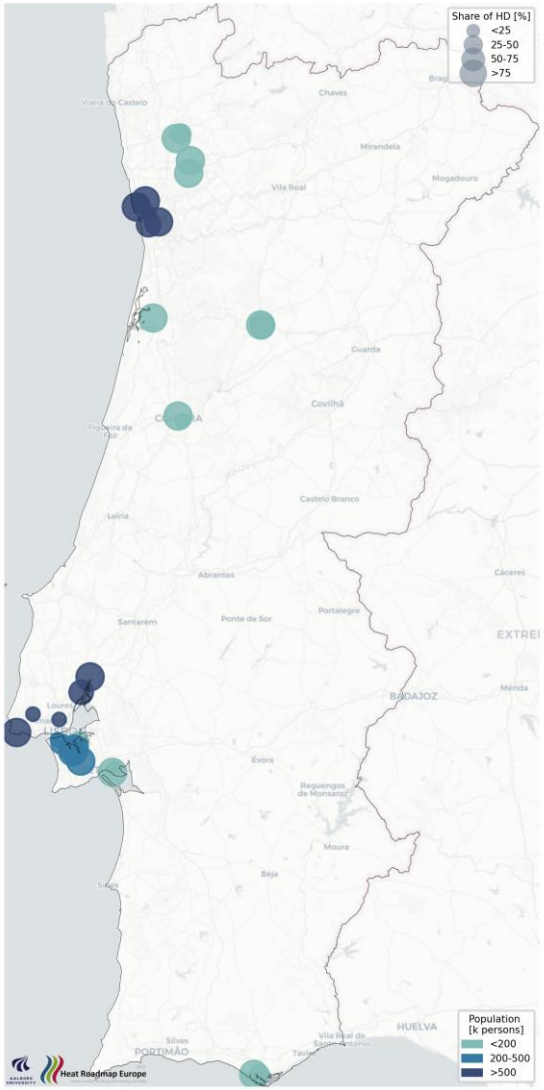


Figure 253: Medium temperature from wastewater treatment for Portugal.

5.22 Romania

Table 51: District heating shares specific to Romania and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Romania	5	9,01	4,55	0,72	0,11	0,12	0,21	0	0,1	0,2	0	0	0,89	0,89
	10	10,48	5,3	0,85	0,11	0,15	0,21	0,22	0,1	0,2	0	0	0,89	0,89
	15	15,61	7,89	1,35	0,11	0,25	0,33	0,45	0,14	0,2	0	0,08	1,2	0,89
	20	20,15	10,19	1,79	0,25	0,32	0,41	0,7	0,18	0,2	0	0,12	1,2	0,89
	25	25,21	12,74	2,45	0,38	0,4	0,42	1,29	0,2	0,2	0	0,12	1,2	0,89
	30	30,15	15,24	2,82	0,45	0,52	0,53	1,61	0,25	0,2	0,07	0,19	1,2	0,89
	35	35,01	17,69	2,98	0,5	0,62	0,66	1,93	0,32	0,2	0,19	0,3	1,2	0,89
	40	36,61	18,5	3,03	0,52	0,69	0,71	2,01	0,33	0,2	0,22	0,34	1,2	0,89
	45	36,61	18,5	3,03	0,52	0,69	0,71	2,01	0,33	0,2	0,22	0,34	1,2	0,89
	50	36,61	18,5	3,03	0,52	0,69	0,71	2,01	0,33	0,2	0,22	0,34	1,2	0,89
	55	36,61	18,5	3,03	0,52	0,69	0,71	2,01	0,33	0,2	0,22	0,34	1,2	0,89
	60	36,61	18,5	3,03	0,52	0,69	0,71	2,01	0,33	0,2	0,22	0,34	1,2	0,89
	65	36,61	18,5	3,03	0,52	0,69	0,71	2,01	0,33	0,2	0,22	0,34	1,2	0,89

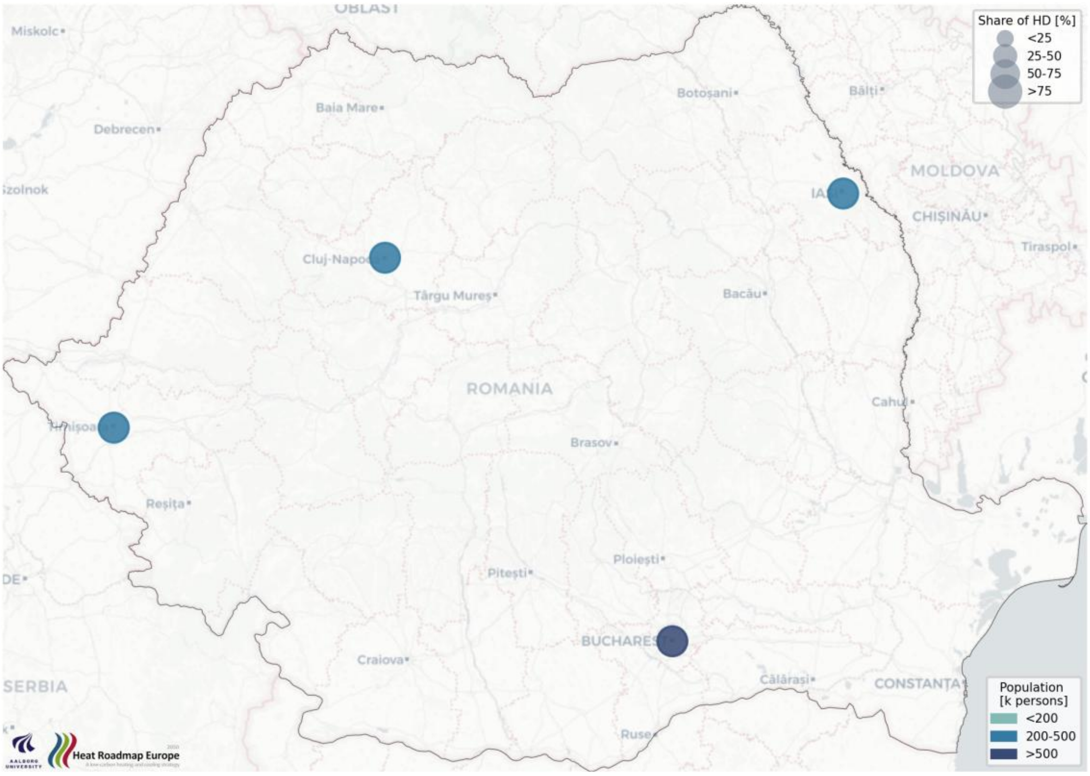


Figure 254: Geothermal energy for Romania (Baseload of district heating area, capacity >40MW).

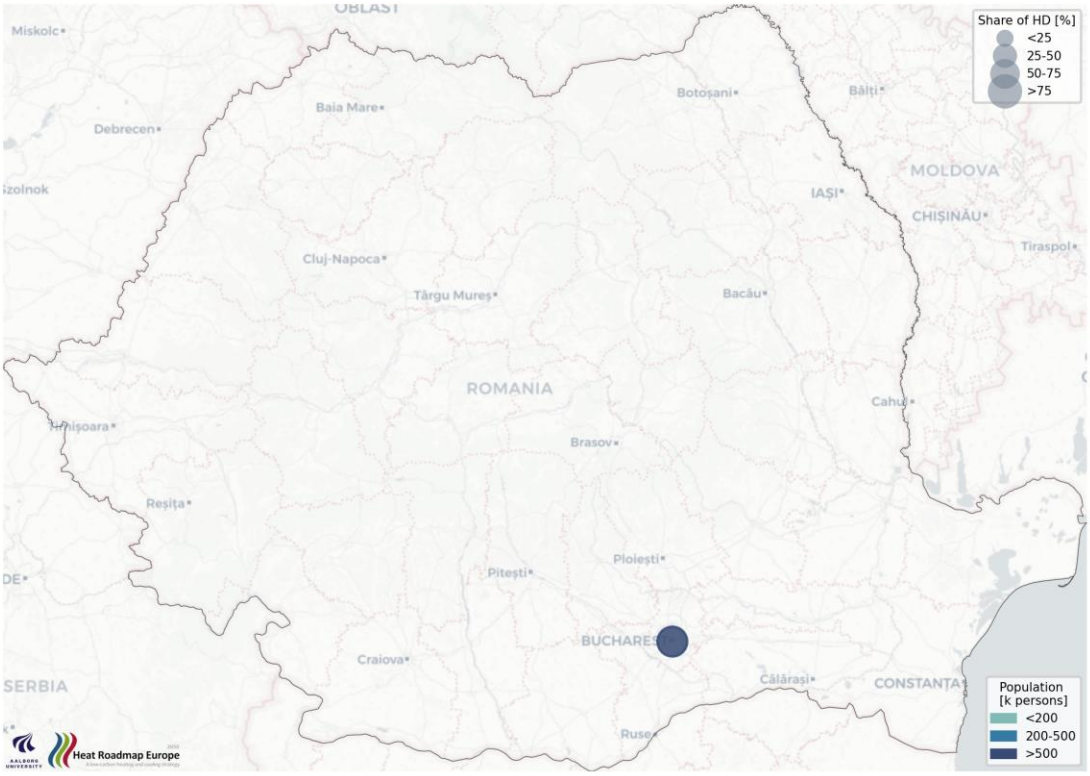


Figure 255: Geothermal energy for Romania (Baseload of district heating area, capacity >70MW).

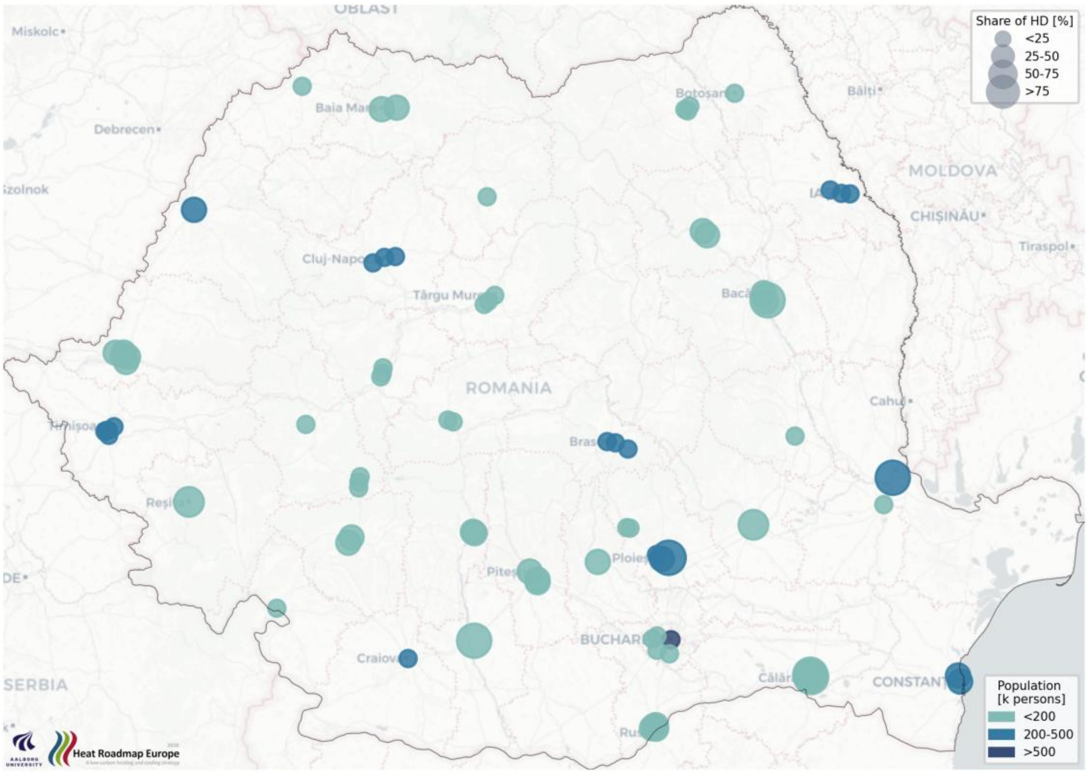


Figure 256: Baseload high temperature waste heat for Romania.

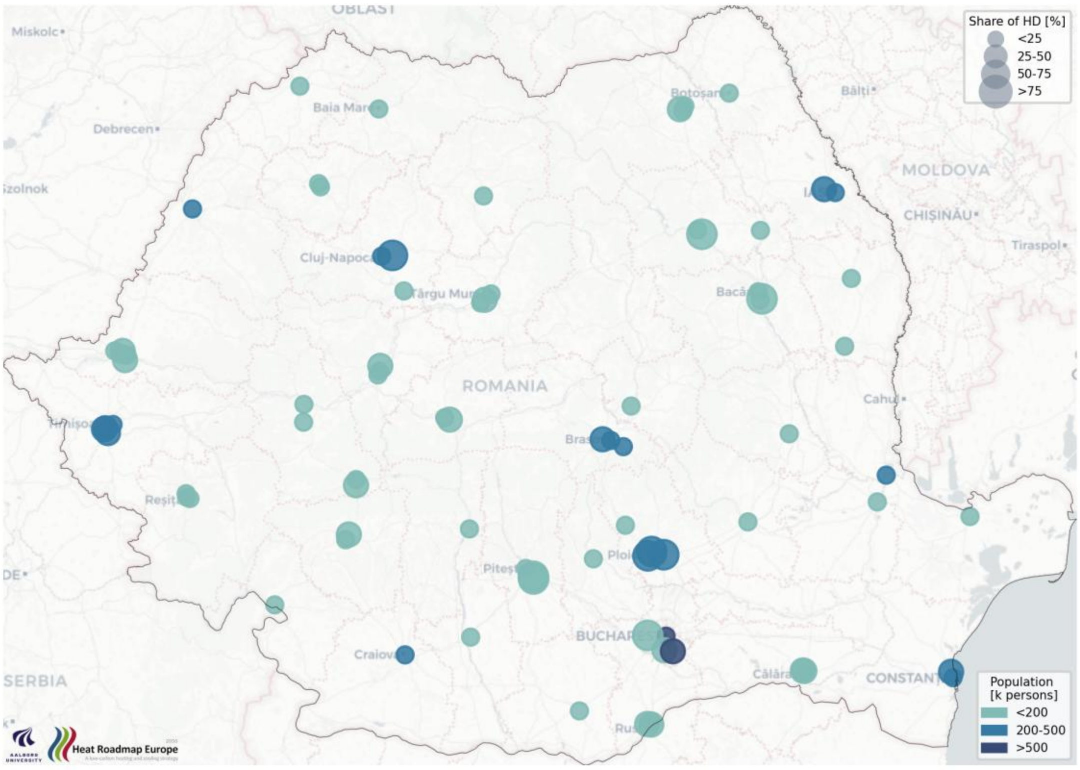


Figure 257: Baseload low temperature waste heat for Romania.

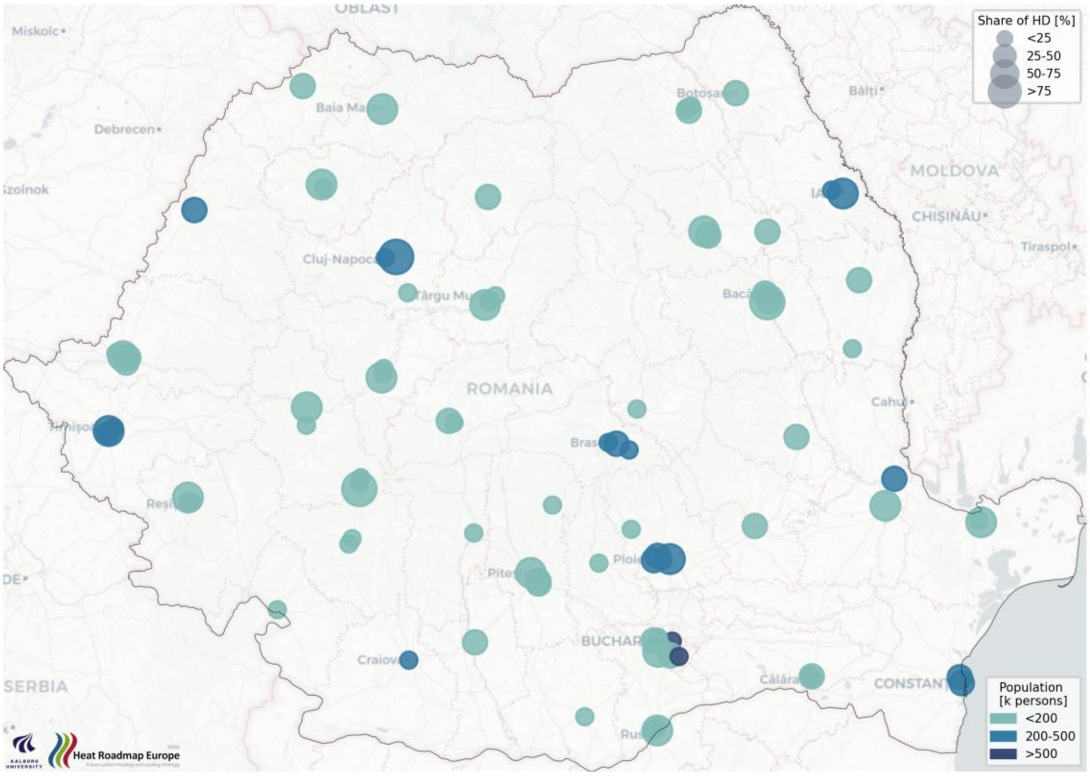


Figure 258: Baseload medium temperature waste heat for Romania.

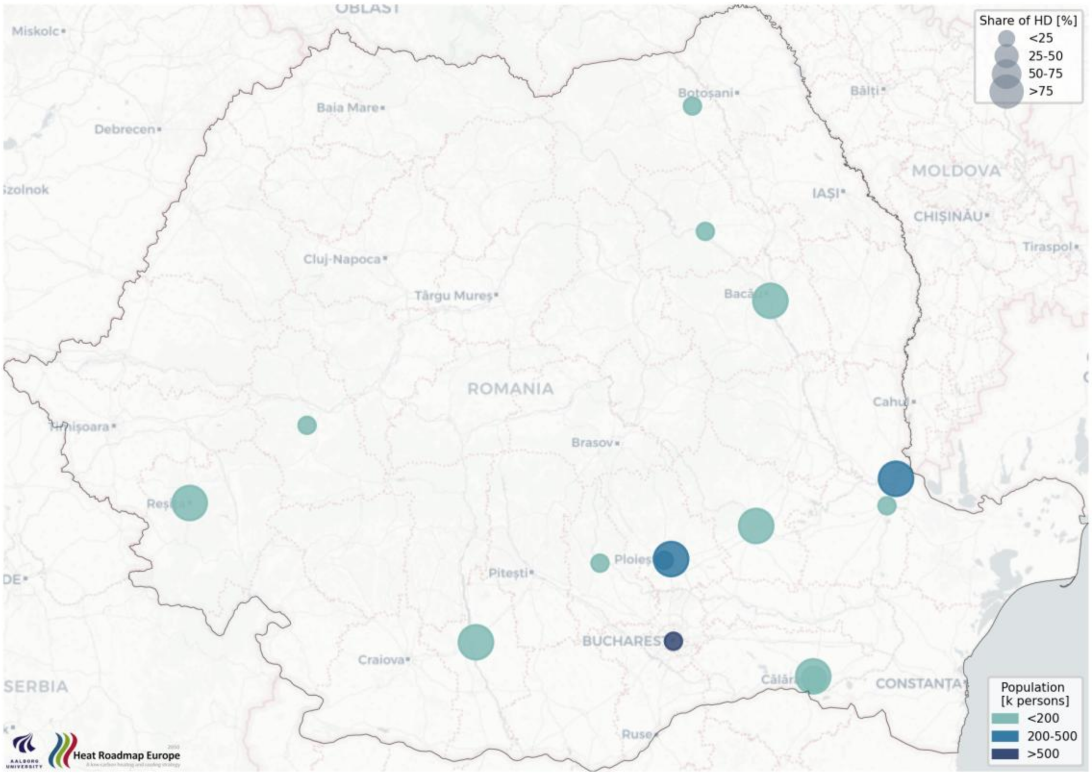


Figure 259: High temperature from industry for Romania.

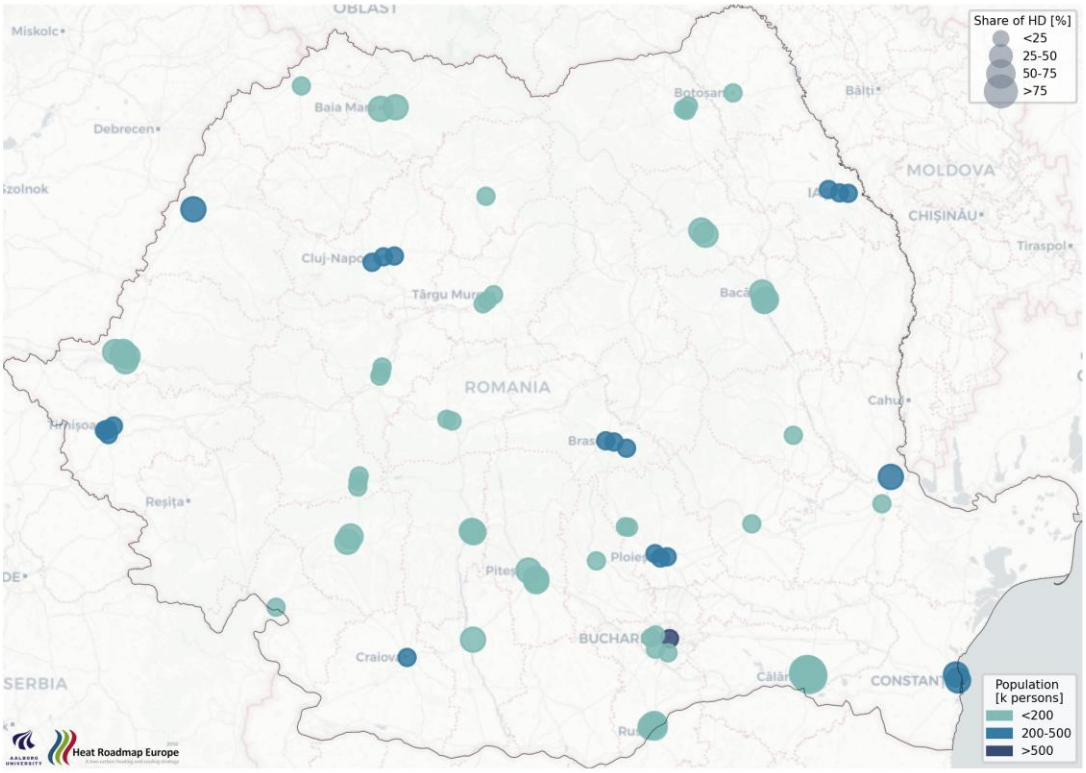


Figure 260: High temperature from waste-to-energy for Romania.

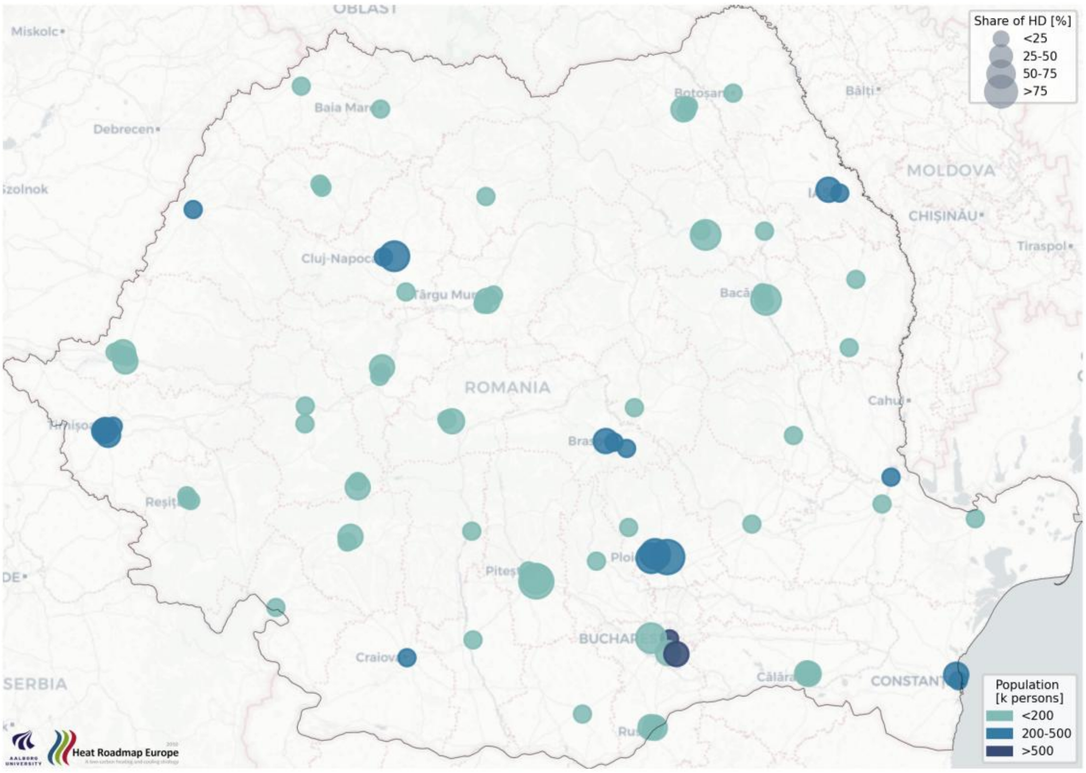


Figure 261: Low temperature from industry for Romania.

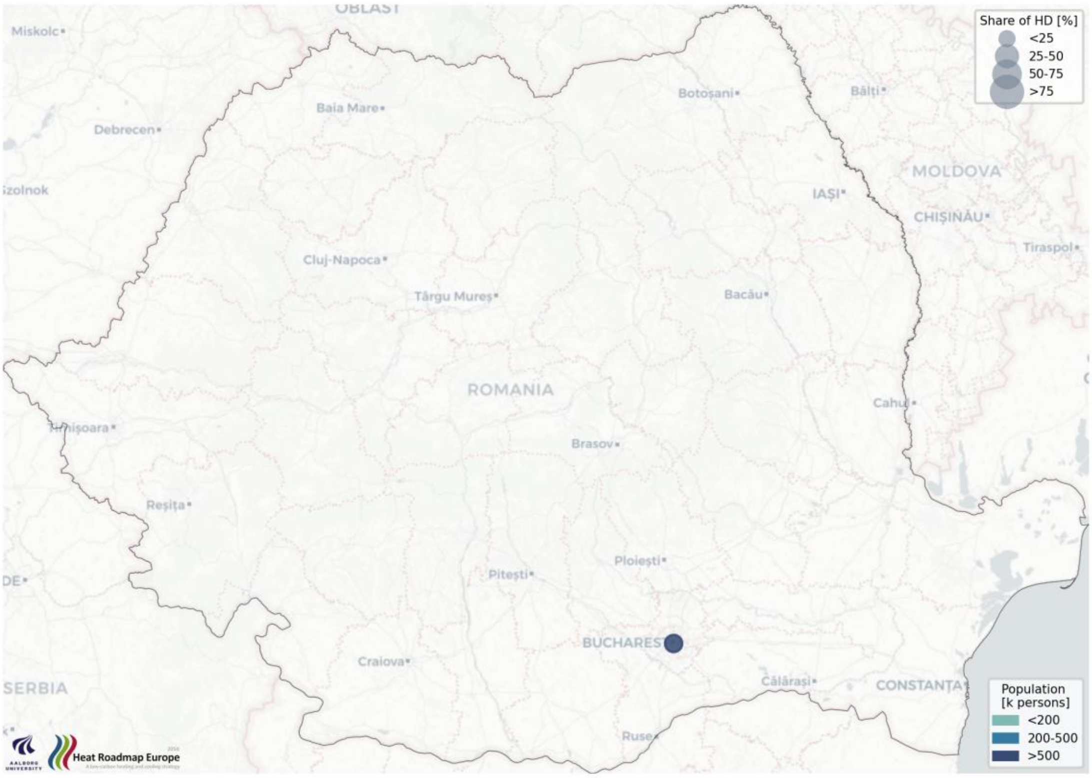


Figure 262: Low temperature from metros for Romania.

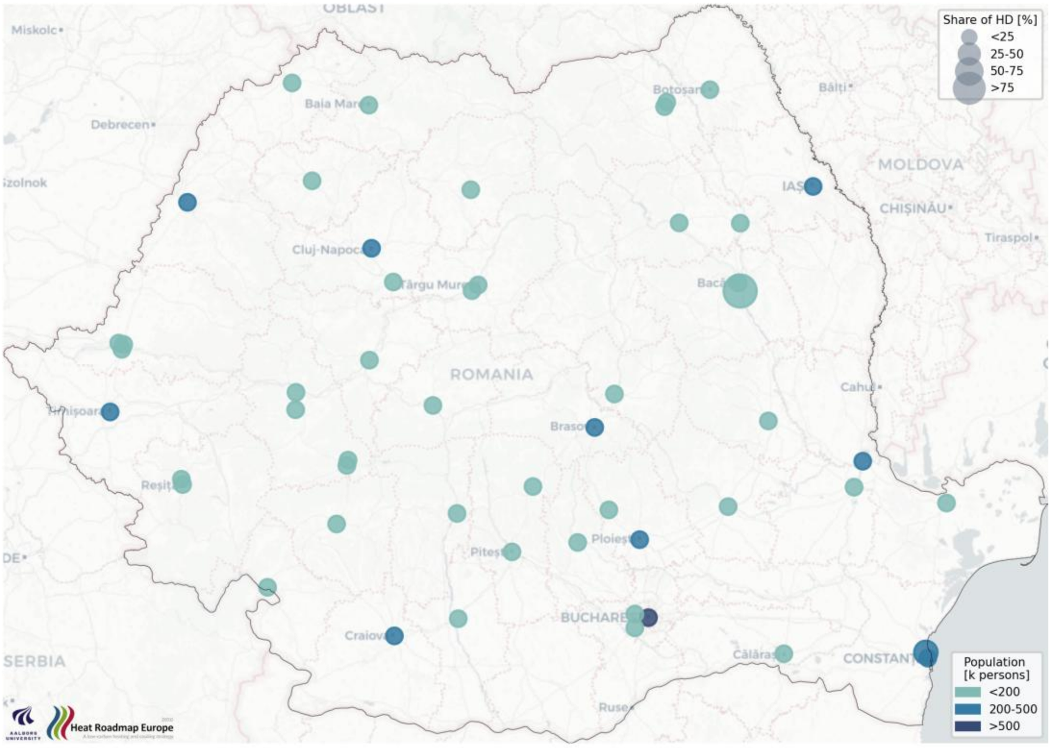


Figure 263: Low temperature from supermarkets for Romania.

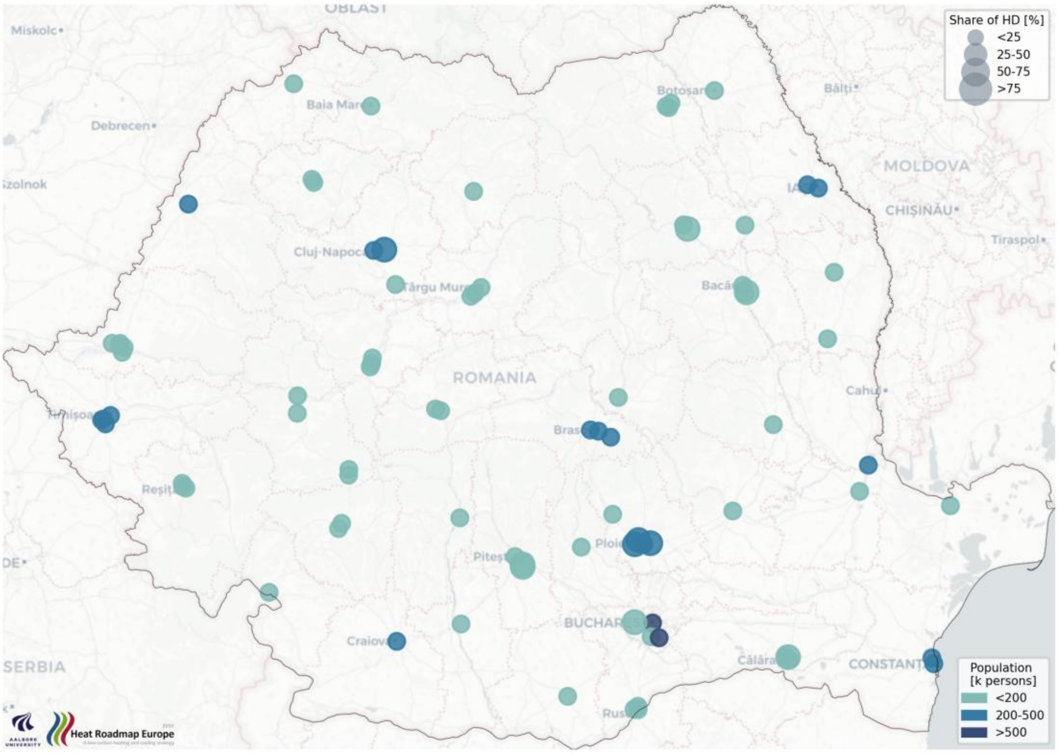


Figure 264: Medium temperature from industry for Romania.

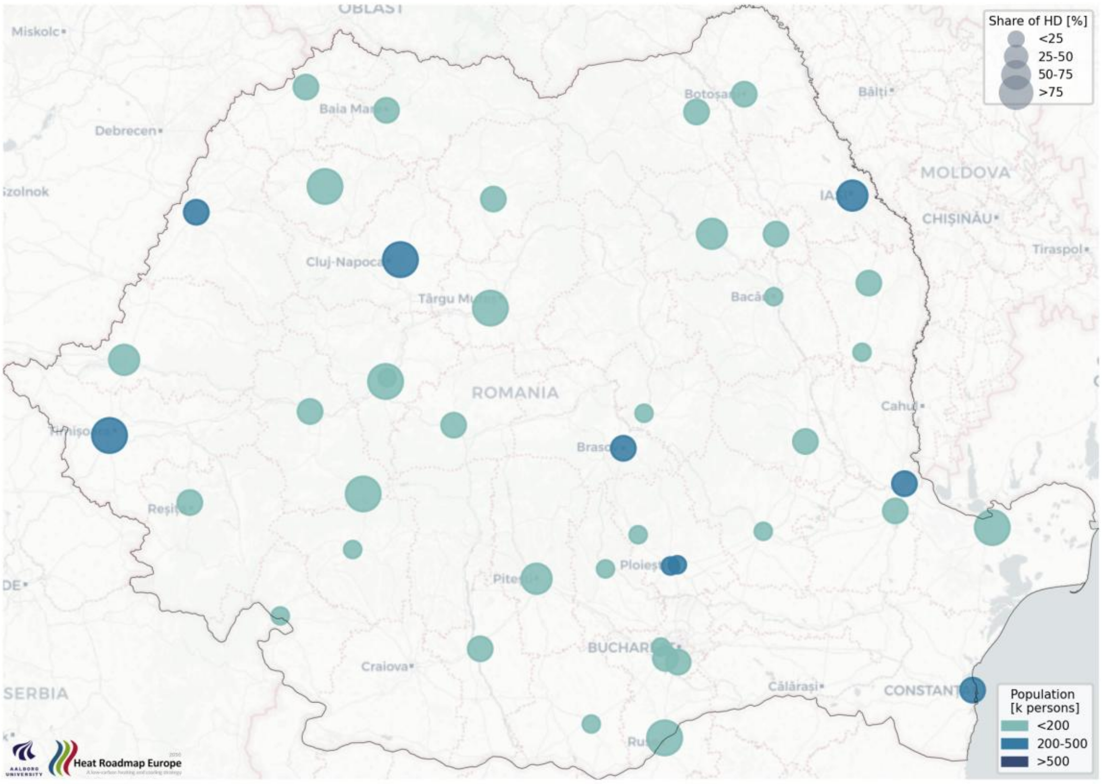


Figure 265: Medium temperature from wastewater treatment for Romania.

5.23 Slovakia

Table 52: District heating shares specific to Slovakia and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Slovakia	5	5,92	1,56	0,31	0,21	0,16	0	0,16	0,03	0	0	0	0	0
	10	10,94	2,87	0,58	0,22	0,26	0,16	0,16	0,05	0	0	0,03	0,1	0
	15	15,01	3,95	0,81	0,22	0,37	0,28	0,25	0,08	0	0	0,03	0,1	0
	20	20,52	5,39	0,97	0,22	0,51	0,49	0,34	0,1	0	0,03	0,06	0,1	0
	25	25,69	6,75	1,06	0,32	0,64	0,67	0,43	0,14	0	0,05	0,09	0,1	0
	30	30,27	7,96	1,06	0,42	0,75	0,82	0,57	0,16	0	0,08	0,12	0,1	0
	35	35,1	9,22	1,06	0,42	0,89	1,05	0,65	0,2	0	0,13	0,16	0,1	0
	40	40,19	10,56	1,08	0,45	1,05	1,27	0,75	0,25	0	0,17	0,2	0,1	0
	45	45,01	11,83	1,1	0,51	1,17	1,42	0,82	0,3	0	0,22	0,25	0,1	0
	50	50,01	13,14	1,1	0,56	1,31	1,55	0,88	0,33	0	0,29	0,32	0,1	0
	55	51,69	13,59	1,11	0,56	1,37	1,58	0,91	0,34	0	0,32	0,35	0,1	0
	60	51,69	13,59	1,11	0,56	1,37	1,58	0,91	0,34	0	0,32	0,35	0,1	0
	65	51,69	13,59	1,11	0,56	1,37	1,58	0,91	0,34	0	0,32	0,35	0,1	0

Figure 266: Geothermal energy for Slovakia (Baseload of district heating area, capacity >40MW).

Figure 267: Baseload high temperature waste heat for Slovakia.

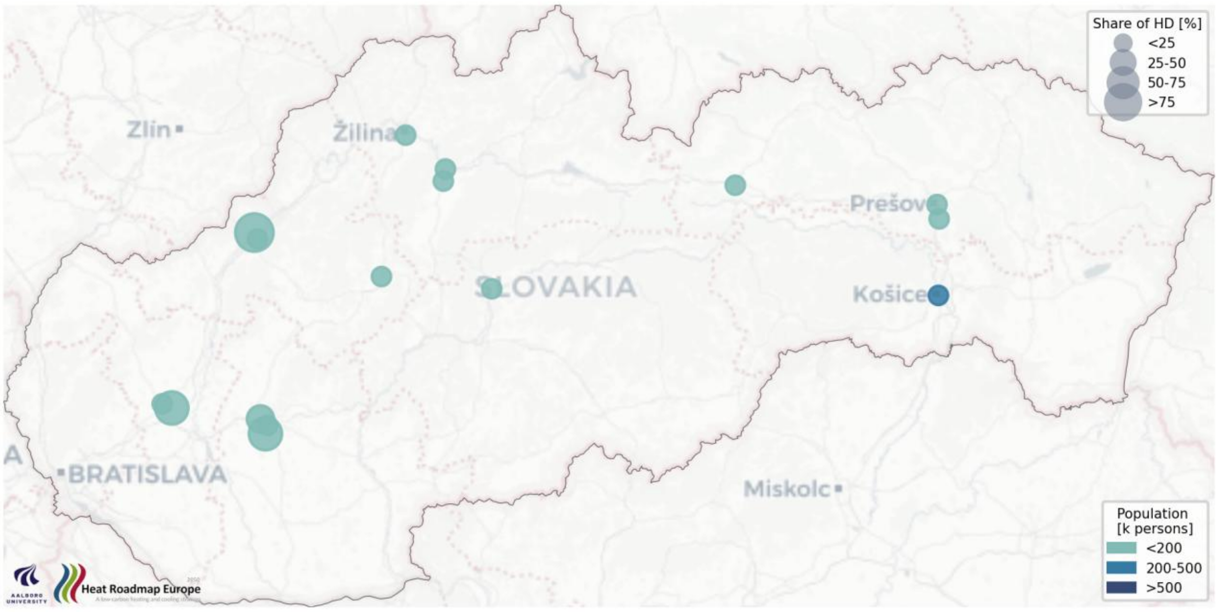


Figure 268: Baseload low temperature waste heat for Slovakia.

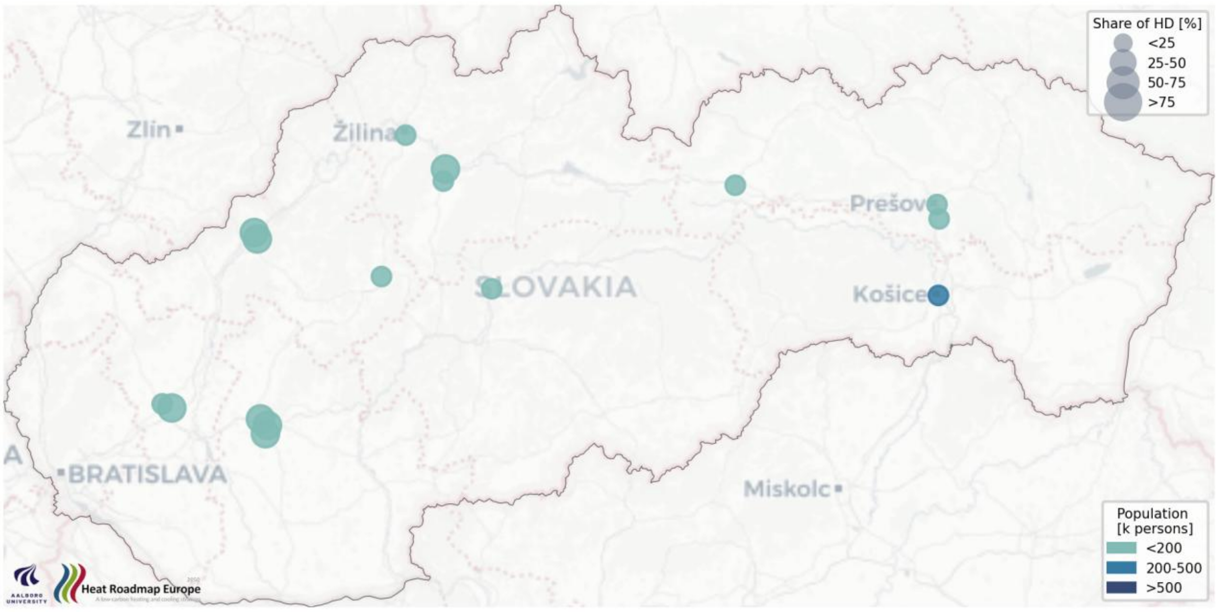


Figure 269: Baseload medium temperature waste heat for Slovakia.

Figure 270: High temperature from industry for Slovakia.

Figure 271: High temperature from waste-to-energy for Slovakia.

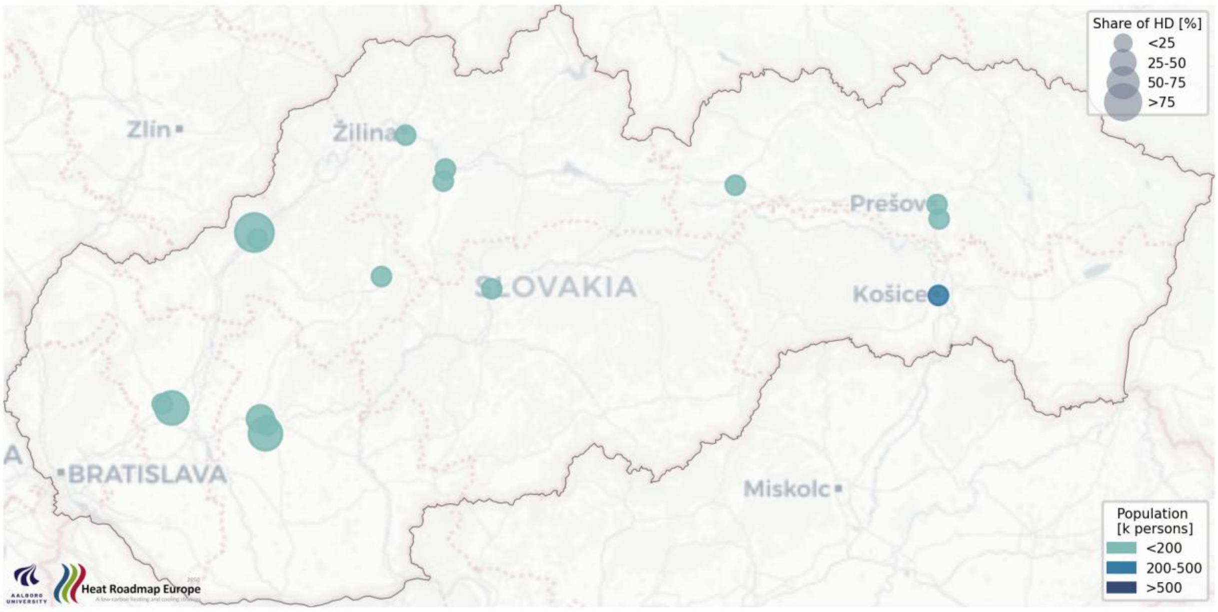


Figure 272: Low temperature from industry for Slovakia.

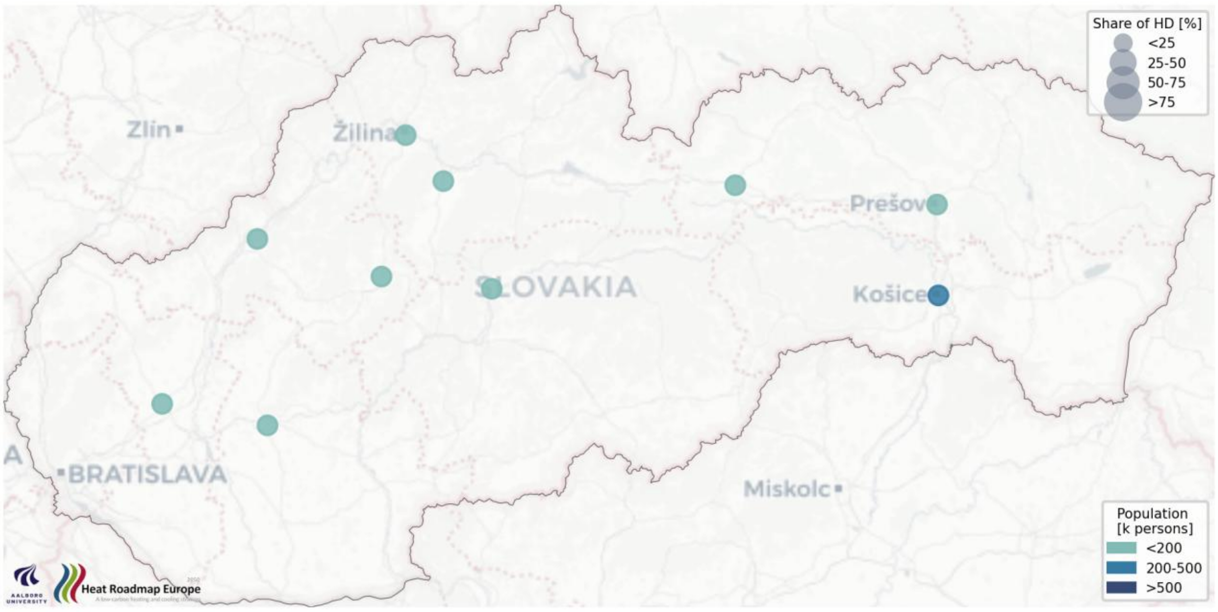


Figure 273: Low temperature from supermarkets for Slovakia.

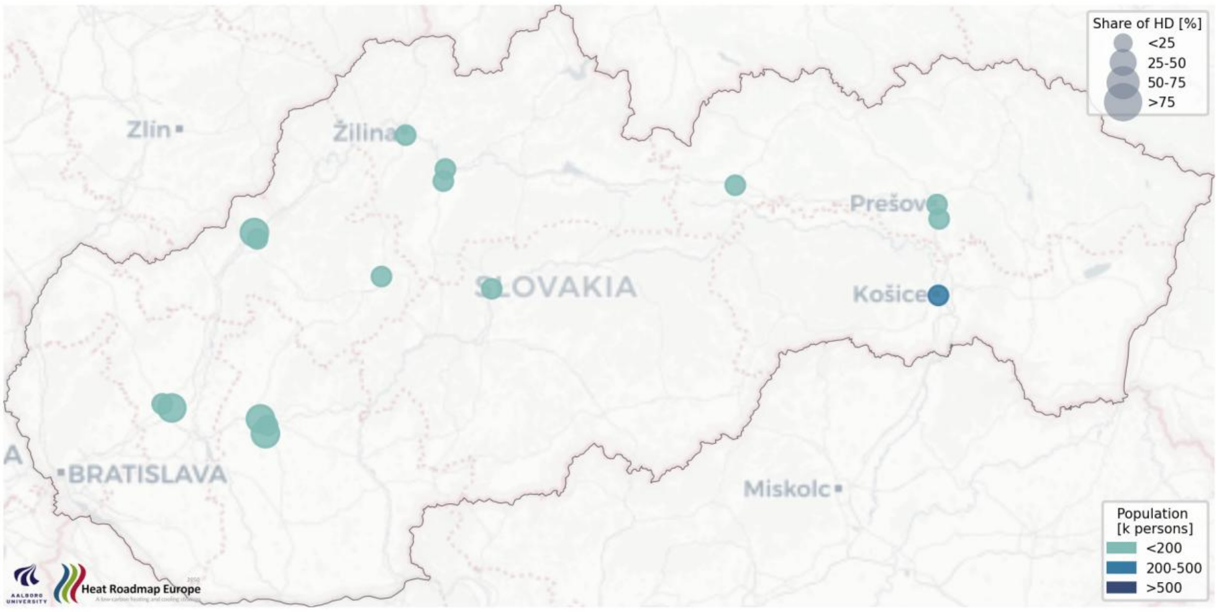


Figure 274: Medium temperature from industry for Slovakia.

Figure 275: Medium temperature from wastewater treatment for Slovakia.

5.24 Slovenia

Table 53: District heating shares specific to Slovenia and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Slovenia	5	12,68	2,67	0,16	0,01	0,19	0,26	0,17	0,05	0	0	0	0,43	0,43
	10	12,68	2,67	0,16	0,01	0,19	0,26	0,17	0,05	0	0	0	0,43	0,43
	15	17,71	3,73	0,22	0,01	0,29	0,39	0,17	0,07	0	0	0,04	0,65	0,43
	20	22,07	4,65	0,25	0,04	0,43	0,59	0,2	0,08	0	0	0,05	0,65	0,43
	25	25,61	5,39	0,25	0,13	0,51	0,68	0,23	0,1	0	0,01	0,07	0,65	0,43
	30	30,06	6,33	0,26	0,16	0,62	0,81	0,28	0,12	0	0,04	0,1	0,65	0,43
	35	35,3	7,43	0,28	0,2	0,76	0,98	0,31	0,16	0	0,07	0,13	0,65	0,43
	40	40,01	8,42	0,28	0,28	0,88	1,12	0,32	0,21	0	0,1	0,15	0,65	0,43
	45	45,03	9,48	0,29	0,29	1,02	1,24	0,36	0,25	0	0,14	0,2	0,65	0,43
	50	50	10,53	0,29	0,3	1,1	1,28	0,38	0,28	0	0,21	0,27	0,65	0,43
	55	50,19	10,57	0,29	0,3	1,1	1,28	0,38	0,28	0	0,22	0,28	0,65	0,43
	60	50,19	10,57	0,29	0,3	1,1	1,28	0,38	0,28	0	0,22	0,28	0,65	0,43
	65	50,19	10,57	0,29	0,3	1,1	1,28	0,38	0,28	0	0,22	0,28	0,65	0,43

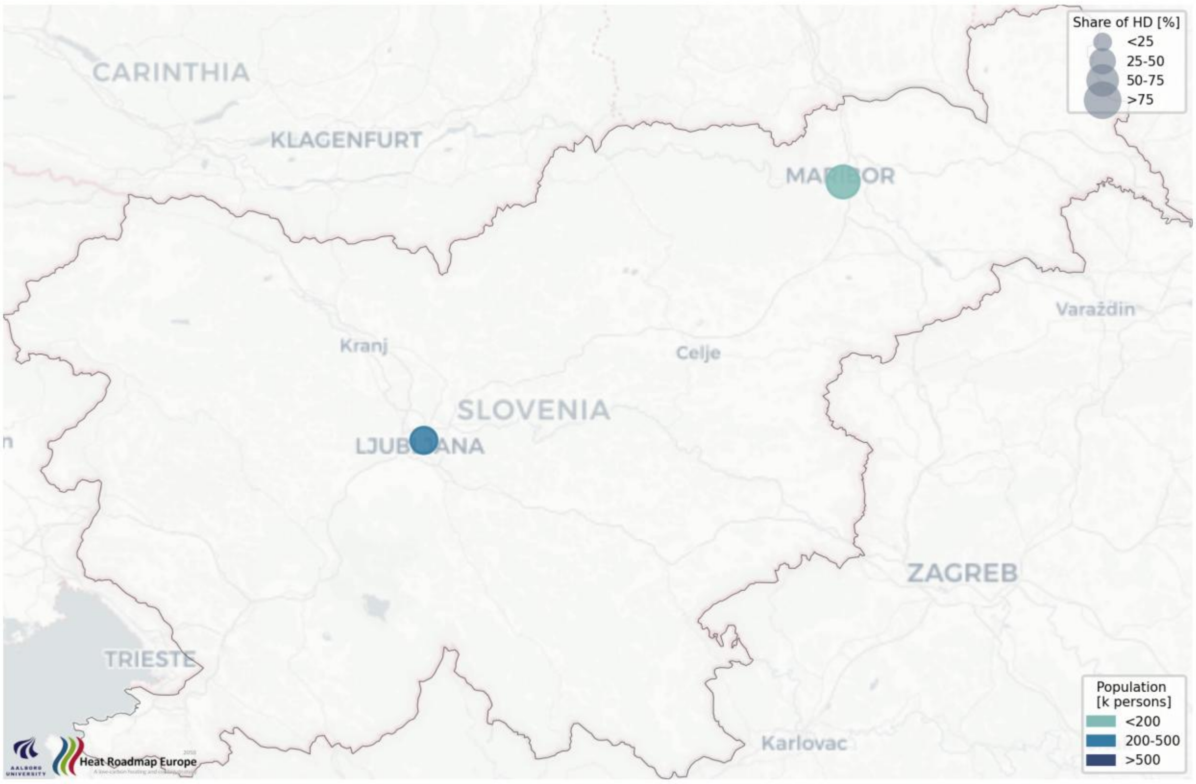


Figure 276: Geothermal energy for Slovenia (Baseload of district heating area, capacity >40MW).

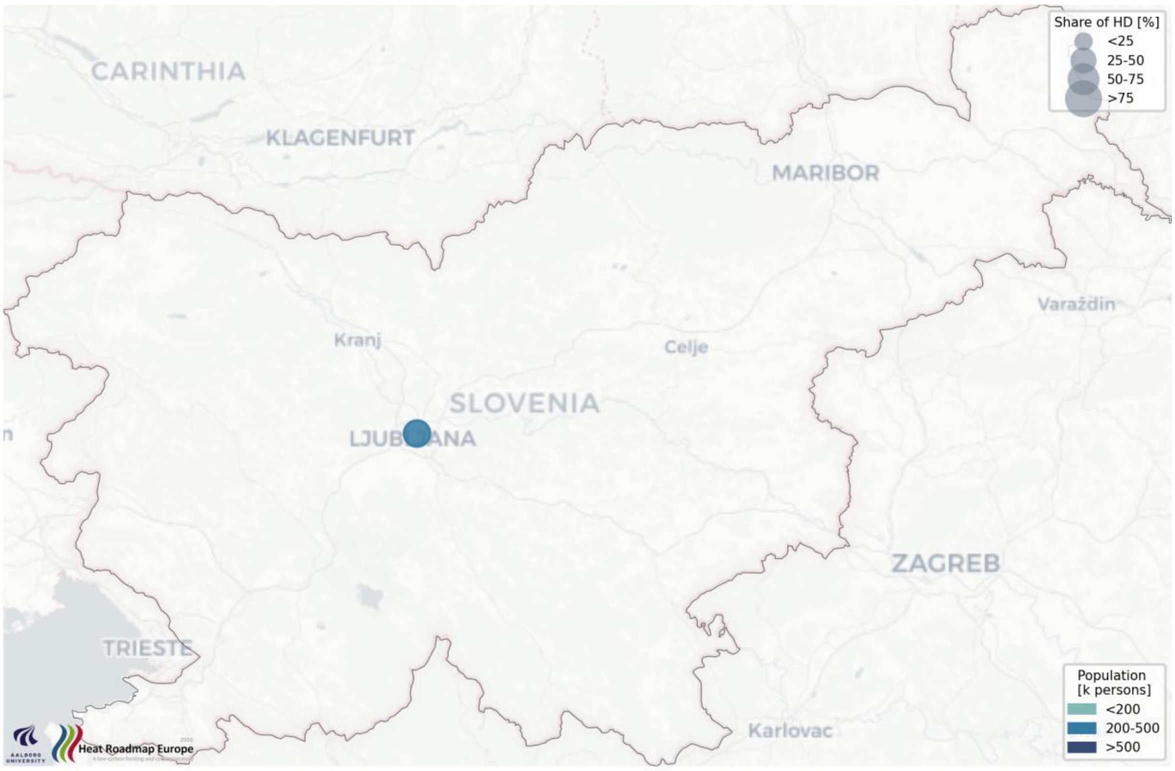


Figure 277: Geothermal energy for Slovenia (Baseload of district heating area, capacity >70MW).

Figure 278: Baseload high temperature waste heat for Slovenia.

Figure 279: Baseload low temperature waste heat for Slovenia.

Figure 280: Baseload medium temperature waste heat for Slovenia.

Figure 281: High temperature from industry for Slovenia.

Figure 282: High temperature from waste-to-energy for Slovenia.

Figure 283: Low temperature from industry for Slovenia.

Figure 284: Low temperature from supermarkets for Slovenia.

Figure 285: Medium temperature from industry for Slovenia.

Figure 286: Medium temperature from wastewater treatment for Slovenia

5.25 Spain

Table 54: District heating shares specific to Spain and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Spain	5	8,57	21,01	1,77	0,08	0,97	1,54	1,17	0,2	1,1	0	0	0	0
	10	15,79	38,72	3,3	1,25	2,04	3,25	2,82	0,3	1,95	0	0	0,14	0,14
	15	15,79	38,72	3,3	1,25	2,04	3,25	2,82	0,3	1,95	0	0	0,14	0,14
	20	20,06	49,2	4,6	1,65	2,91	4,05	4,1	0,38	1,95	0	0	0,22	0,22
	25	25,22	61,86	5,44	2,06	3,63	4,86	5,08	0,47	1,95	0	0	0,35	0,35
	30	30,38	74,51	6,65	3,1	4,57	5,95	6,09	0,6	1,95	0	0,06	0,63	0,63
	35	35,26	86,49	7,86	3,9	5,44	6,89	7,01	0,68	1,95	0	0,15	0,63	0,63
	40	40,14	98,44	9,12	4,21	6,37	8,29	7,9	0,84	1,95	0,01	0,4	0,83	0,63
	45	45,1	110,6	10,38	4,73	7,39	9,65	8,83	0,99	1,96	0,09	0,63	0,83	0,63
	50	50,01	122,7	11,02	5,01	8,52	11	9,8	1,15	1,96	0,38	1,02	0,83	0,63
	55	55	134,9	11,35	5,4	9,71	12,49	10,67	1,36	1,97	0,82	1,47	0,83	0,63
	60	60,01	147,2	11,63	5,7	10,99	13,85	11,45	1,56	1,97	1,36	2	0,83	0,63
	65	65	159,4	11,83	5,8	12,26	15,03	12,16	1,74	1,98	2,05	2,69	0,83	0,63

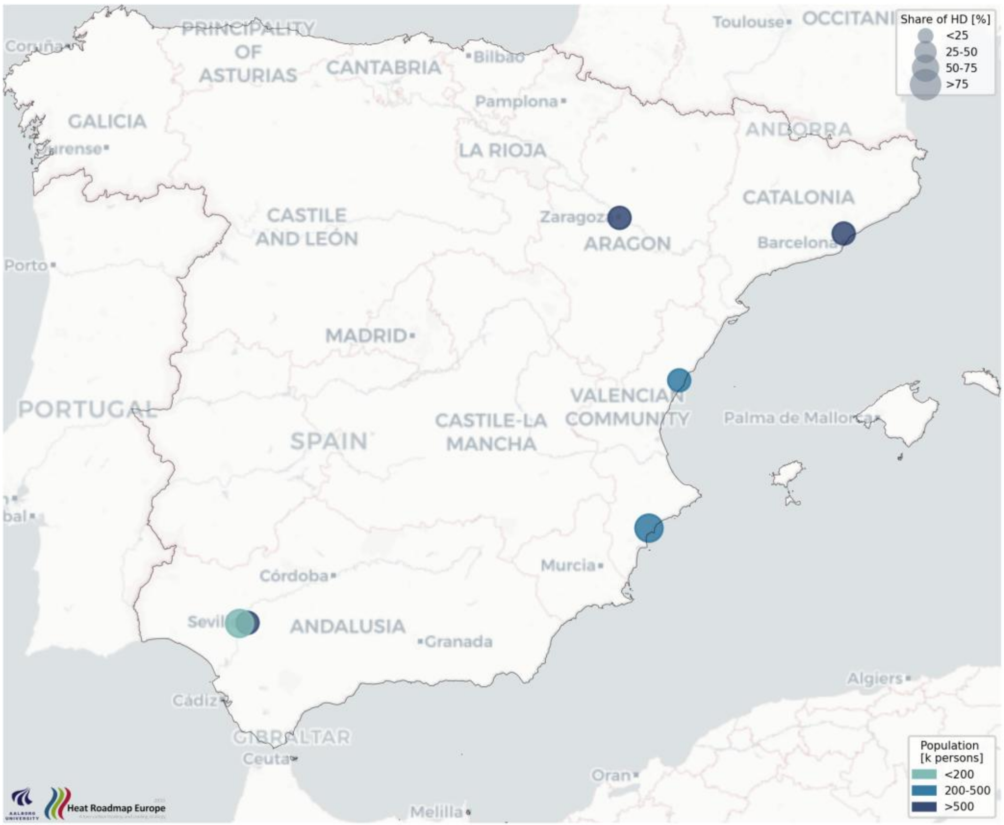


Figure 287: Geothermal energy for Spain (Baseload of district heating area, capacity >40MW).

Figure 288: Geothermal energy for Spain (Baseload of district heating area, capacity >70MW).

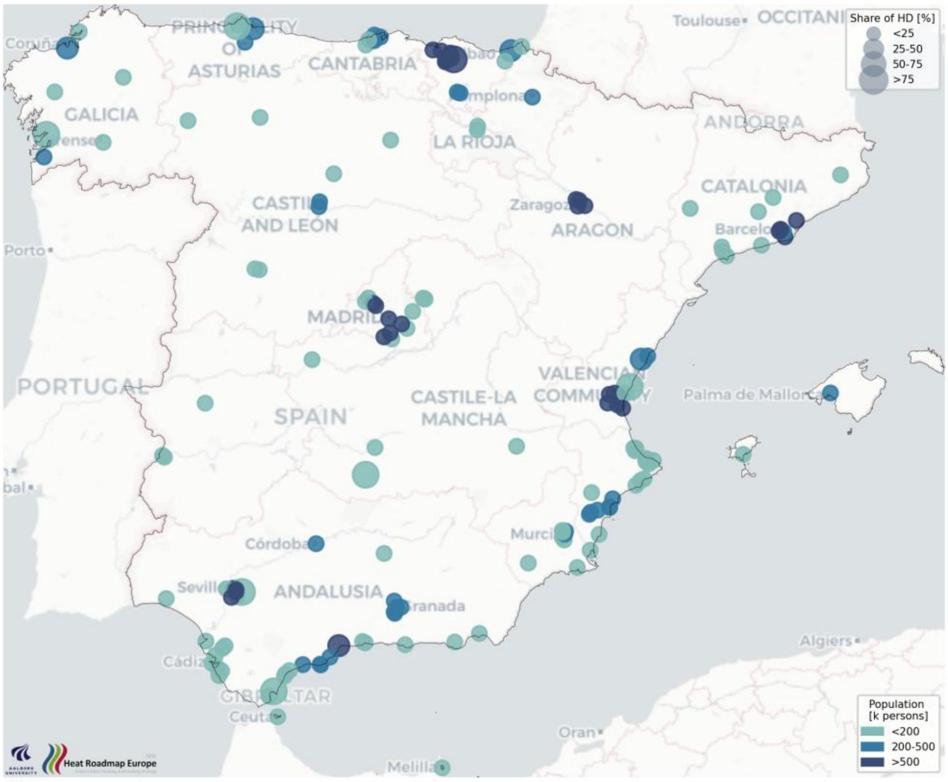


Figure 289: Baseload high temperature waste heat for Spain.

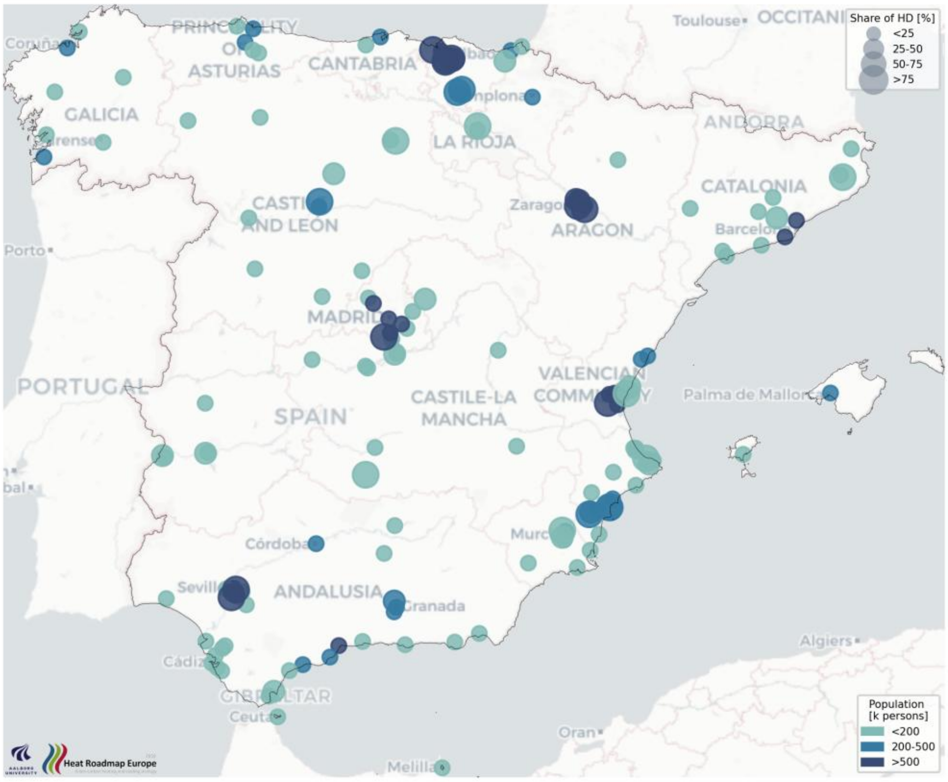


Figure 290: Baseload low temperature waste heat for Spain.

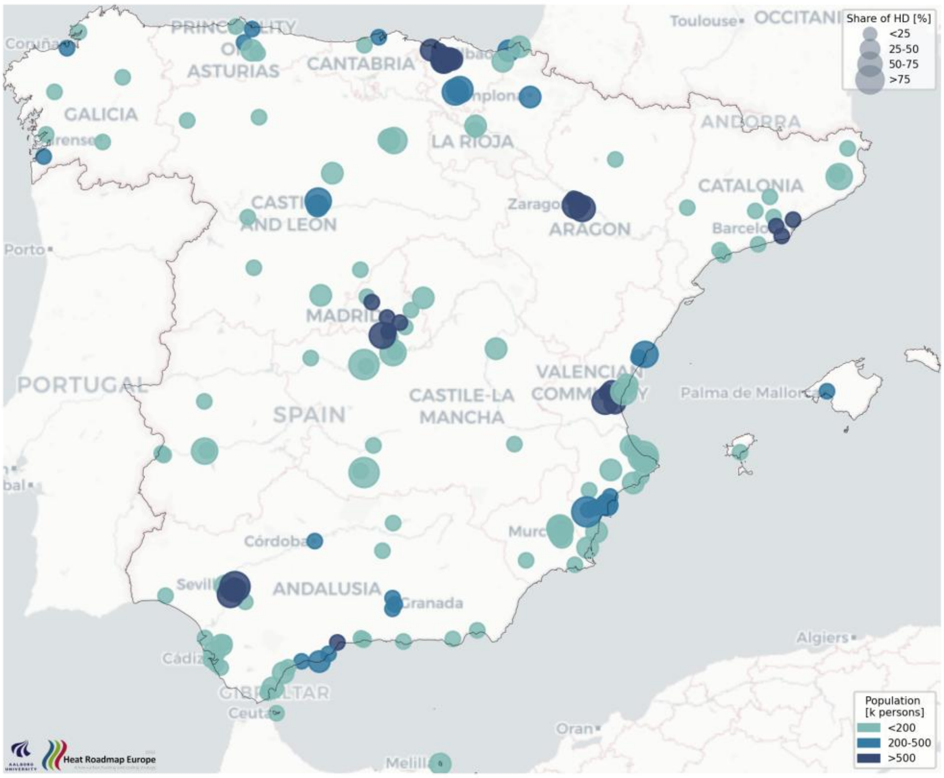


Figure 291: Baseload medium temperature waste heat for Spain.

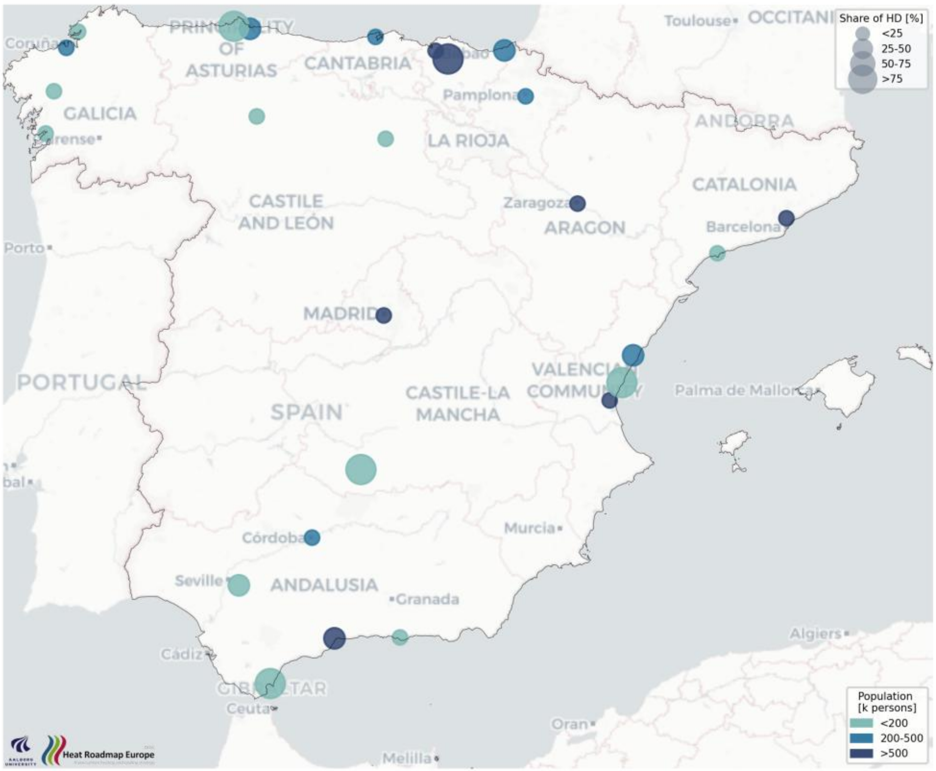


Figure 292: High temperature from industry for Spain.

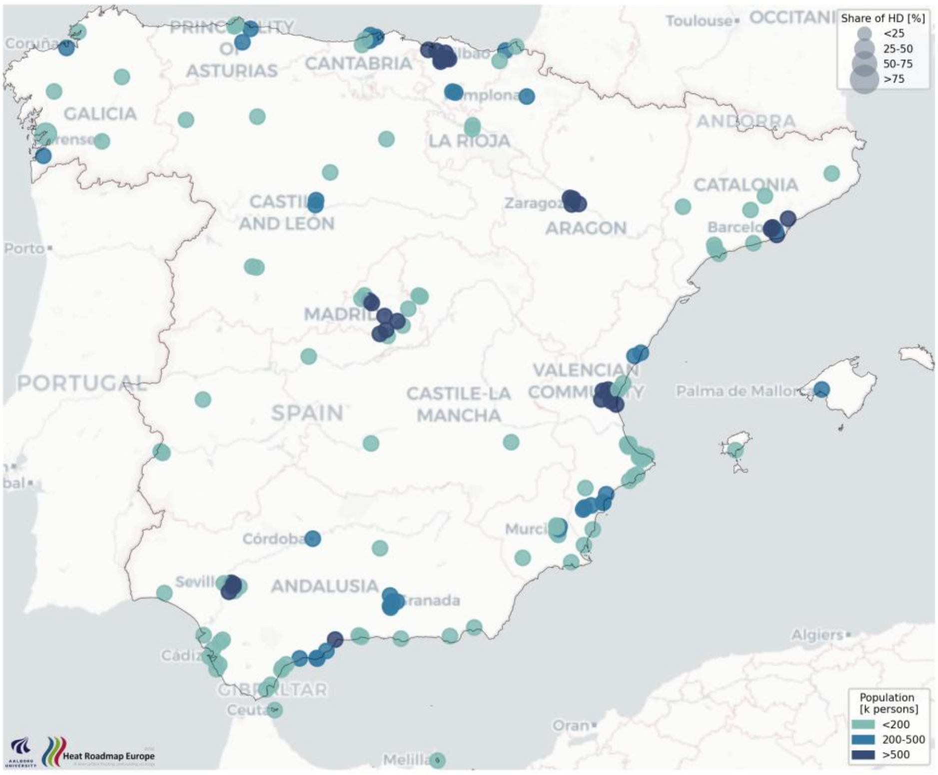


Figure 293: High temperature from waste-to-energy for Spain.

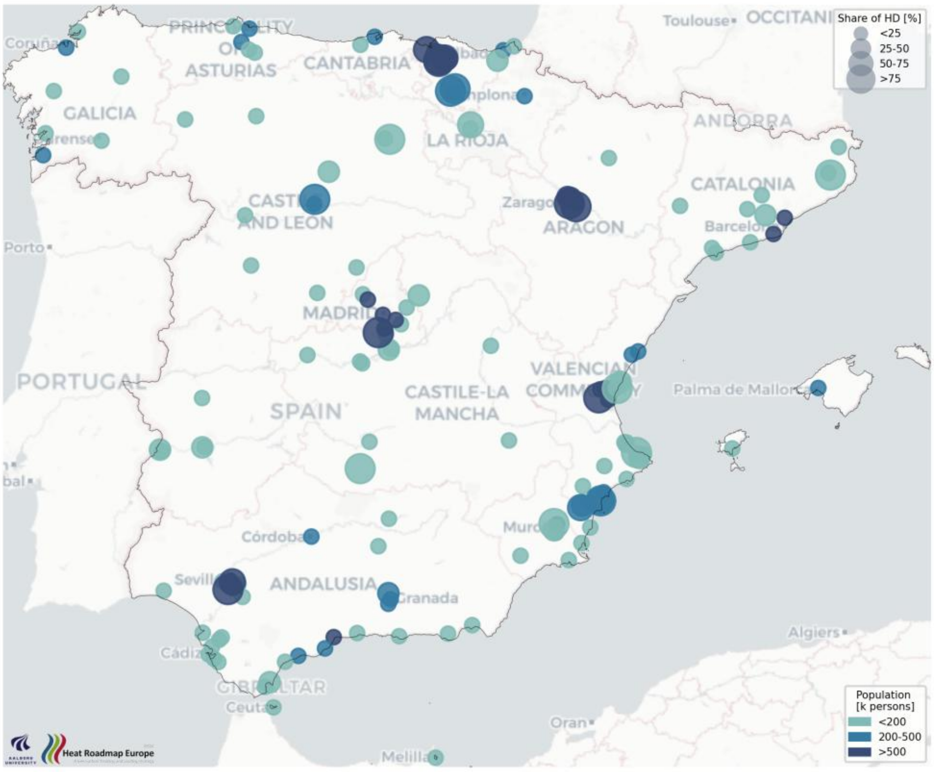


Figure 294: Low temperature from industry for Spain.

Figure 295: Low temperature from metros for Spain.

Figure 296: Low temperature from supermarkets for Spain.

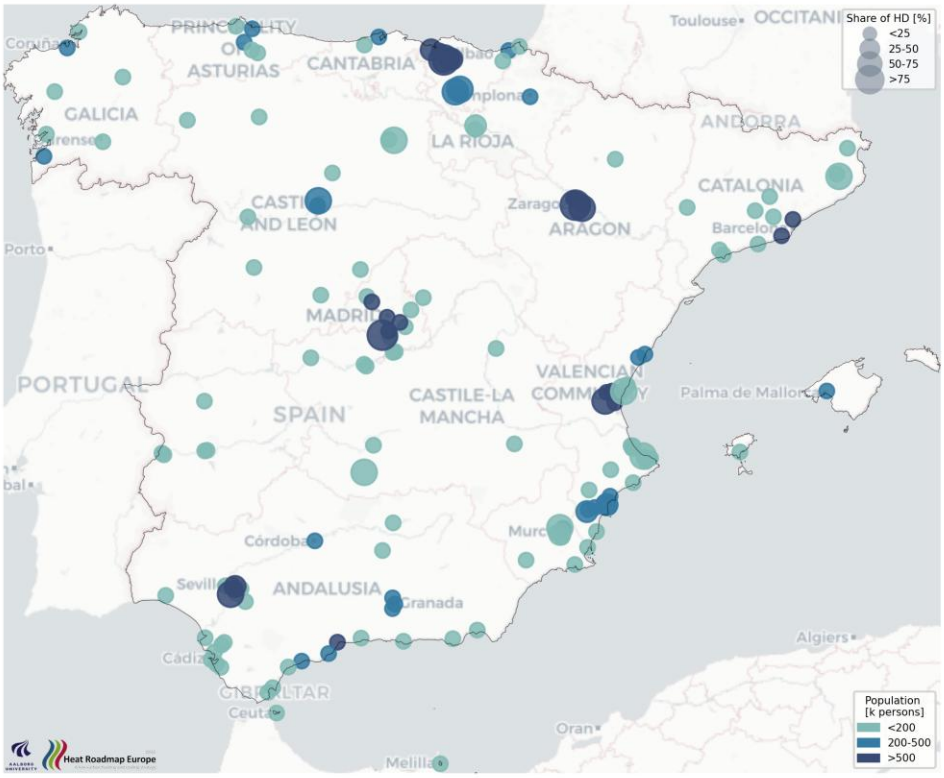


Figure 297: Medium temperature from industry for Spain.

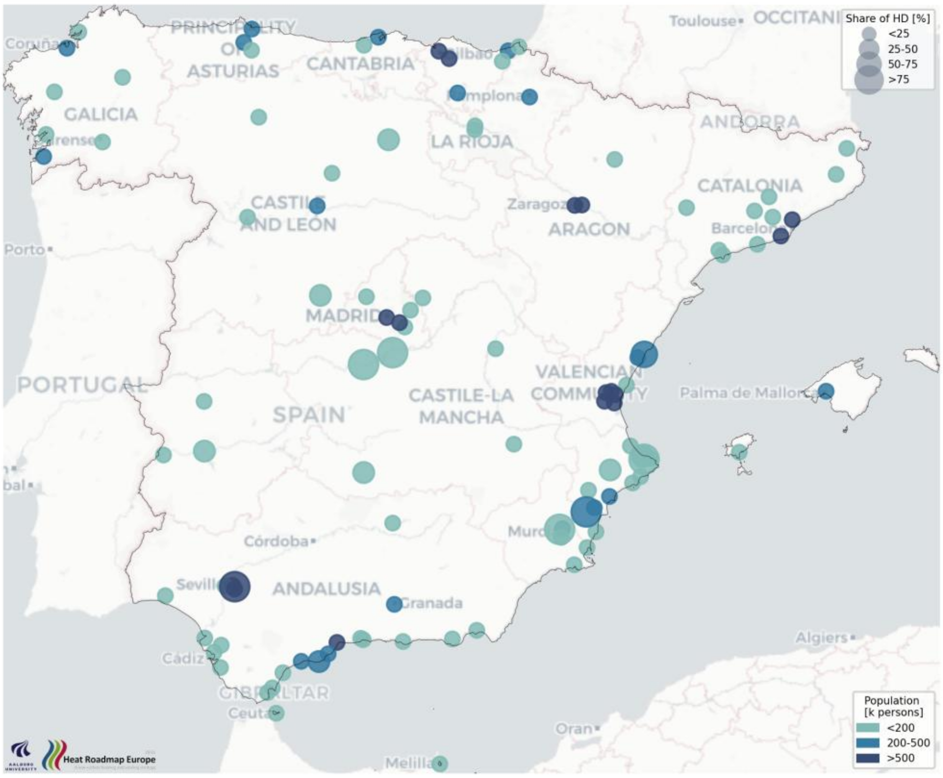


Figure 298: Medium temperature from wastewater treatment for Spain.

For Spain, the recommended District heating share for 2050 is 61,29 so the results from the simulations are taken from the 60% District heating share:

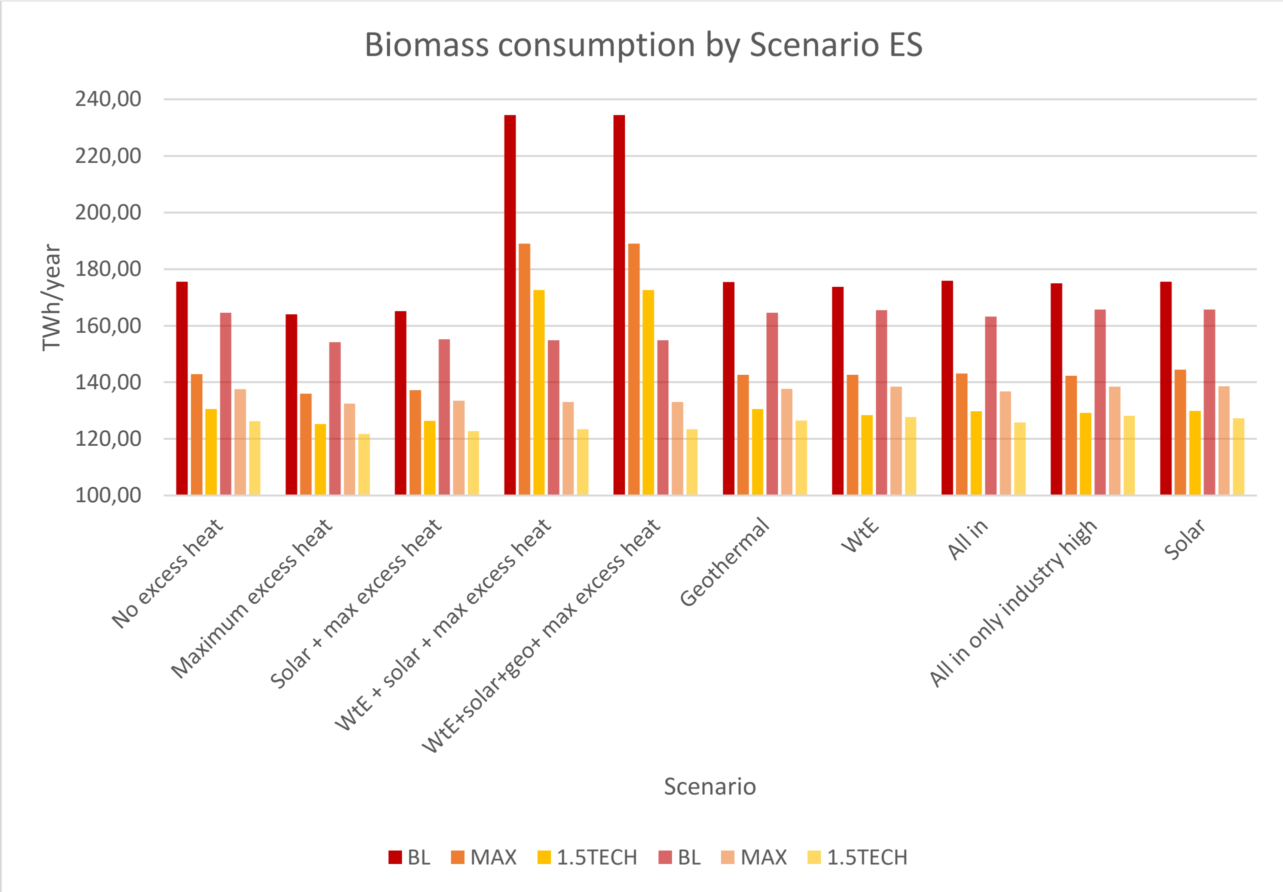


Figure 299: Biomass consumption in TWh/year for different district heating shares and heat for 3GDH and 4GDH, in the case of Spain.

In the case of Spain, for the biomass consumption, there is a pattern for all the scenarios, where the lowest heat saving scenario has the highest biomass consumption and it gets lowered the higher the saving demand is. There is not such big differences between the same saving levels across scenarios comparing with the case of Germany, for instance. The main impact on the biomass consumption is not the heat prioritization, then, it is the saving level and the generation of the grid generation. Spain highlights the importance of having a robust system, both in efficiency in the delivery of heat and in the demand side. Between these two aspects, the system's generation and the saving level, it is more effective to increase the saving level than upgrading the grid generation if only one action should be taken. Of course, this is only based on the biomass consumption, with a multicriteria analysis, the conclusion would be different.

The lowest of all the cases is in the 4th generation and in the scenario with max availability, followed by the scenario of all heat sources and the very high saving levels.

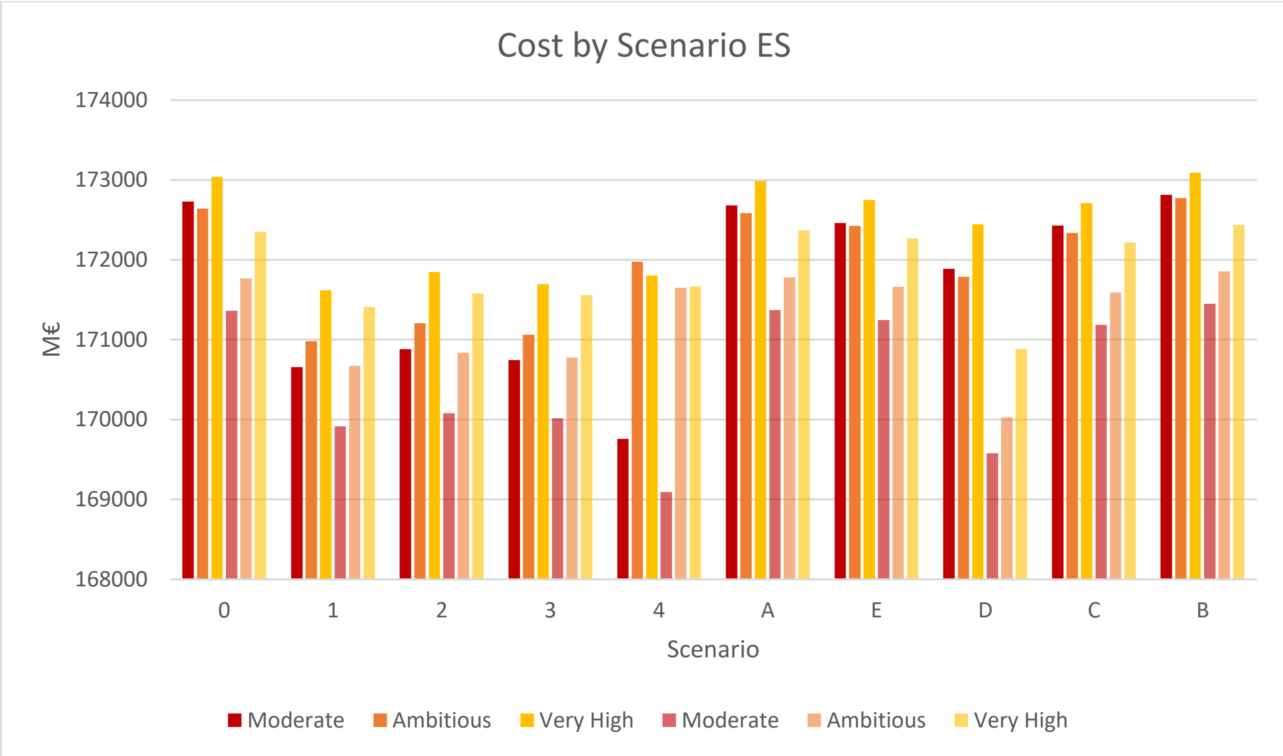


Figure 300: Cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of Spain.

In the case of the cost, in contrast with the biomass consumption, it can be said that upgrading the generation of the system is cheaper than the saving levels for its benefits to the system. For the 3rd generation system, it tends to be that the moderate savings are a bit higher than the ambitious savings and then the very high savings is the highest of them all. On the other hand, there is the 4th generation, where the trend changes to the higher the saving level, the higher the cost for all scenarios.

Table 55: Biomass consumption in TWh/year for different district heating shares and heat for 3GDH and 4GDH, in the case of Spain and cost in M€ for each scenario of district heating system at 50% district heating share for both 3GDH and 4GDH, in the case of Spain.

61,29	3rd			4th		
Biomass	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	175,54	142,90	130,55	164,55	137,54	126,31
Maximum waste heat	164,02	136,01	125,22	154,19	132,43	121,78
Solar + max waste heat	165,20	137,18	126,35	155,23	133,47	122,80
WtE + solar + max waste heat	234,44	188,98	172,59	154,81	133,00	123,49
WtE+solar+geo+ max waste heat	234,44	188,98	172,59	154,81	133,00	123,49
Geothermal	175,46	142,64	130,56	164,63	137,70	126,53
WtE	173,77	142,65	128,46	165,48	138,52	127,76
All in	175,92	143,13	129,80	163,23	136,78	125,76
All in only industry high	175,03	142,31	129,24	165,76	138,49	128,14
Solar	175,53	144,50	129,90	165,68	138,62	127,32

	3rd			4th		
Cost	*Moderate*	*Ambitious*	*Very High*	*Moderate*	*Ambitious*	*Very High*
No waste heat	172.728	172.642	*173.037*	171.361	171.769	*172.355*
Maximum waste heat	170.656	170.981	*171.621*	169.915	170.674	*171.412*
Solar + max waste heat	170.881	171.206	*171.847*	170.079	170.839	*171.578*
WtE + solar + max waste heat	170.744	171.062	*171.696*	170.014	170.779	*171.560*
WtE+solar+geo+ max waste heat	169.759	171.978	*171.804*	169.092	171.650	*171.667*
Geothermal	172.681	172.584	*172.986*	171.372	171.780	*172.370*
WtE	172.463	172.424	*172.752*	171.248	171.665	*172.268*
All in	171.890	171.787	*172.443*	169.579	170.029	*170.886*
All in only industry high	172.429	172.336	*172.708*	171.185	171.592	*172.216*
Solar	172.812	172.776	*173.091*	171.452	171.855	*172.438*

As mentioned before, in the case of the biomass, upgrading the saving measures saves up more than just upgrading the generation of the system. Taking the depart point as the moderate saving for both system's generation, in the case of the 3rd it is saved up to 18% to 26%, whether it is applied ambitious or very high saving measures, respectively. Changing the priorities of the heat supply would only save a 6% as a maximum compared to the scenario of not using any surplus heat.

In the case of the cost, there are not big differences between scenarios, by upgrading the generation it can be saved up to a 1%, so the difference is not as big compared to the base line %wise, however when speaking of small percentage in that type of scales it becomes a large number at the end.

Spain has way less industrial waste heat potential compared to Germany, that leads to a higher HP and boilers installed. The waste to energy is still running at its full potential, showing it is a valuable surplus heat source that can be integrated in any type of system.

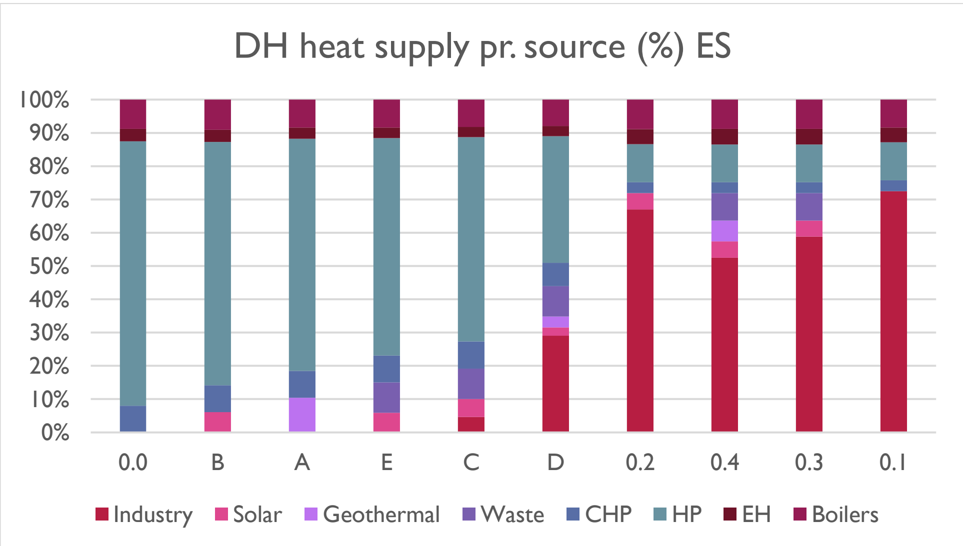


Figure 301: District heating heat supply pr. source in percentage for each scenario in the case of Spain.

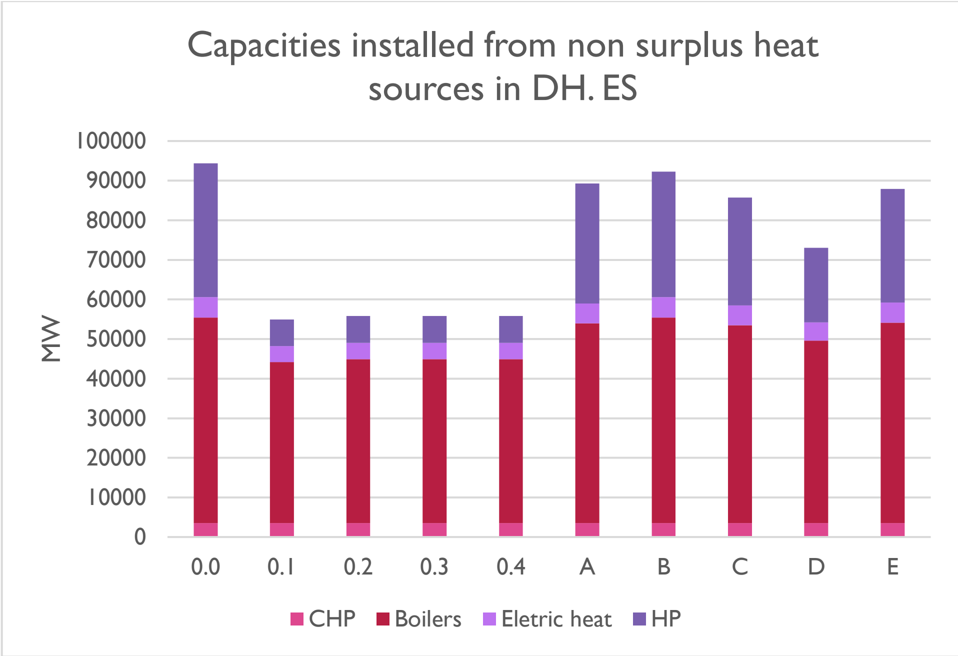


Figure 302: Installed capacities in MW from non surplus heat sources in district heating in Spain.

As it can be seen in this graph, the scenarios with less surplus heat potentials, have more installed capacity from non-waste heat sources, as it is logical.

5.26 Sweden

Table 56: District heating shares specific to Sweden and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
Sweden	5	9,54	7,5	1,2	0	0,26	0,55	0,57	0,02	0,16	0	0	0	0
	10	16	12,58	1,97	0,24	0,55	1,19	0,94	0,04	0,16	0	0	0	0
	15	16	12,58	1,97	0,24	0,55	1,19	0,94	0,04	0,16	0	0	0	0
	20	21,19	16,66	2,54	0,24	0,74	1,58	1,26	0,05	0,16	0	0,01	0	0
	25	25,34	19,92	2,92	0,35	0,96	2,07	1,42	0,07	0,16	0	0,04	0	0
	30	30,86	24,26	3,65	0,37	1,24	2,61	1,7	0,1	0,16	0	0,08	0	0
	35	35,22	27,69	4,12	0,62	1,45	2,96	1,92	0,11	0,16	0	0,11	0	0
	40	40,1	31,52	4,33	0,94	1,74	3,53	2,07	0,13	0,16	0,02	0,16	0	0
	45	45,02	35,39	4,58	0,97	2,02	4,02	2,3	0,16	0,16	0,1	0,27	0	0
	50	50,07	39,36	4,61	1,31	2,33	4,64	2,55	0,2	0,16	0,17	0,35	0	0
	55	55,03	43,26	4,69	1,51	2,72	5,36	2,82	0,25	0,16	0,24	0,41	0	0
	60	60,01	47,17	4,7	1,57	3,21	6,15	3,06	0,31	0,16	0,33	0,5	0	0
	65	65,01	51,11	4,71	1,69	3,65	6,77	3,32	0,38	0,16	0,44	0,61	0	0

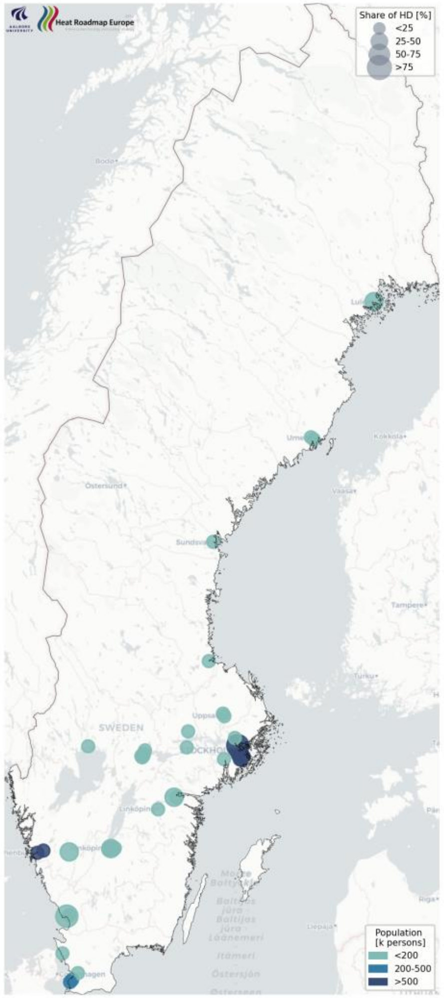
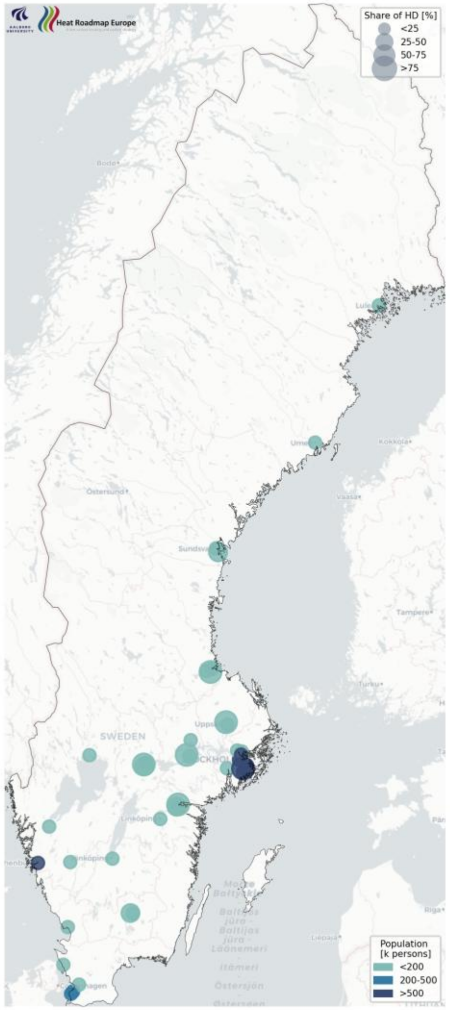


Figure 303: Baseload high temperature waste heat for Sweden



. Figure 304: Baseload low temperature waste heat. for Sweden

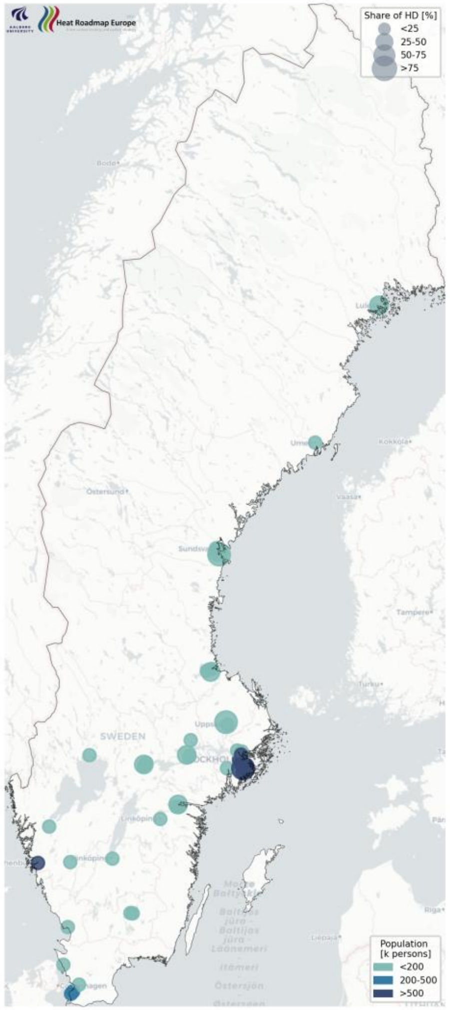


Figure 305: Baseload medium temperature waste heat for Sweden.

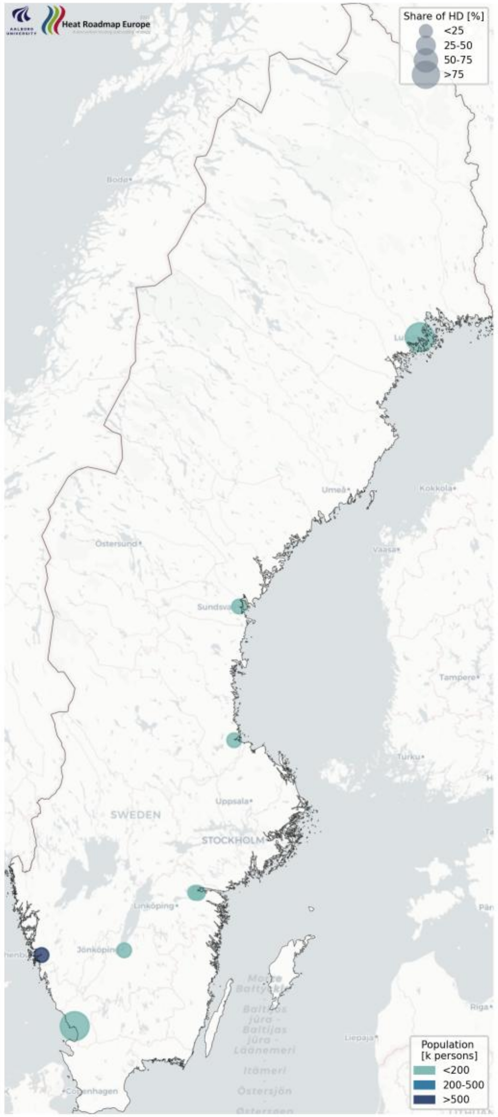


Figure 306: High temperature from industry for Sweden.

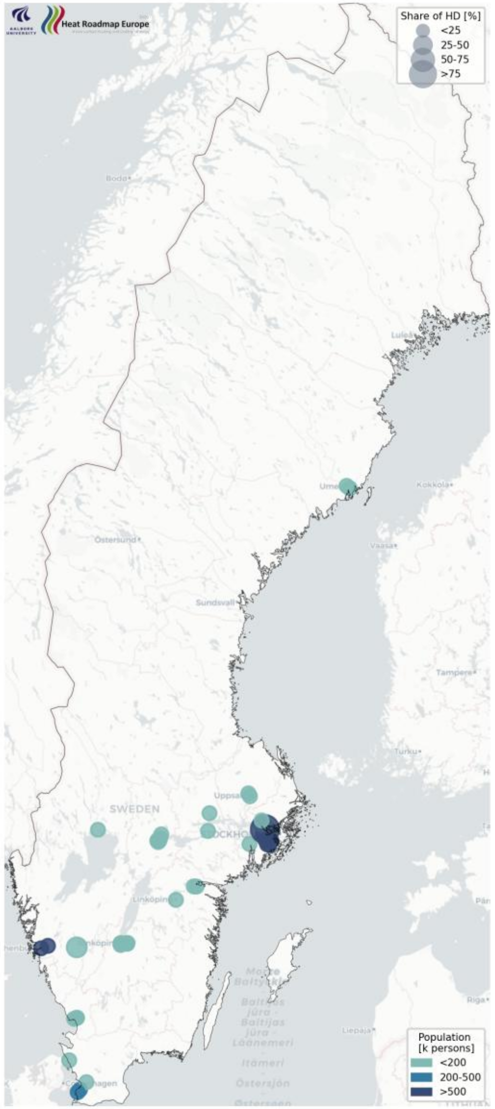


Figure 307: High temperature from waste-to-energy for Sweden.

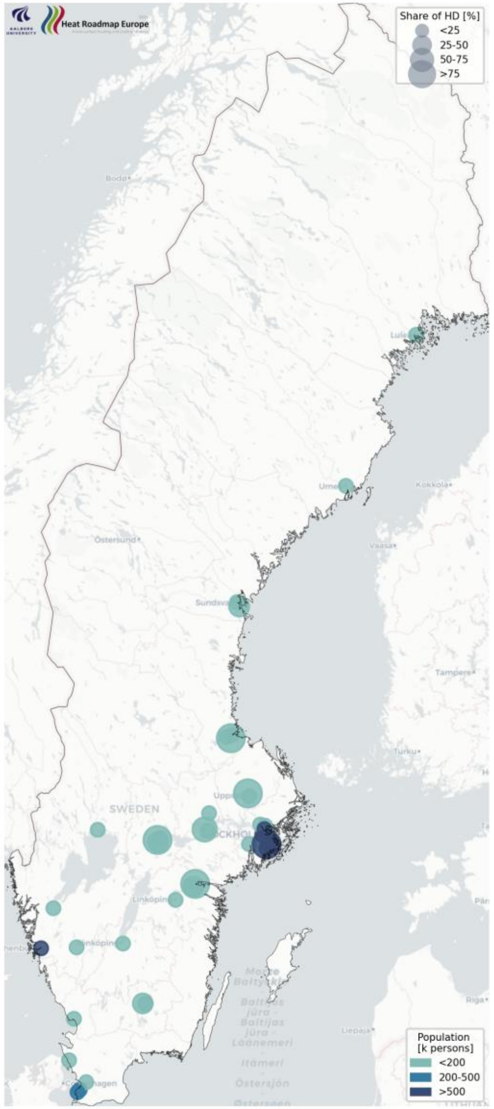


Figure 308: Low temperature from industry for Sweden.

Figure 309: Low temperature from metros for Sweden

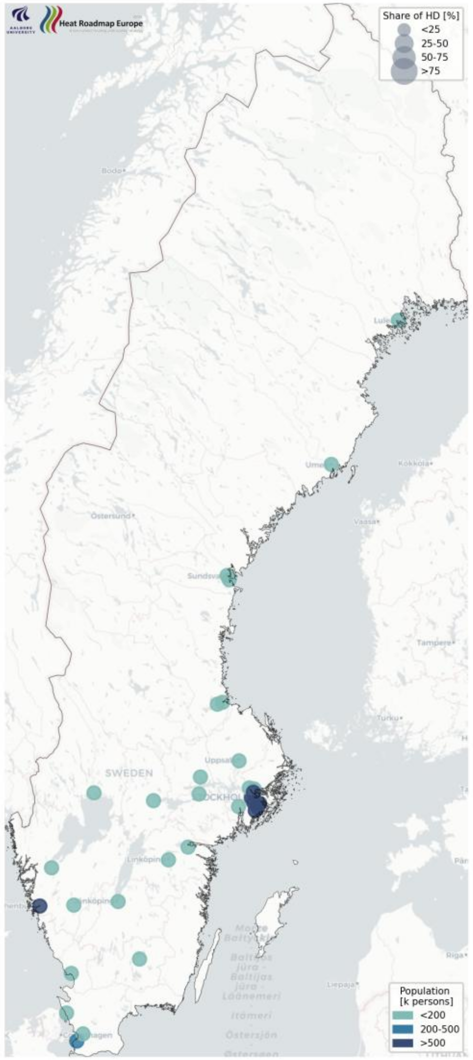


Figure 310: Low temperature from supermarkets for Sweden.

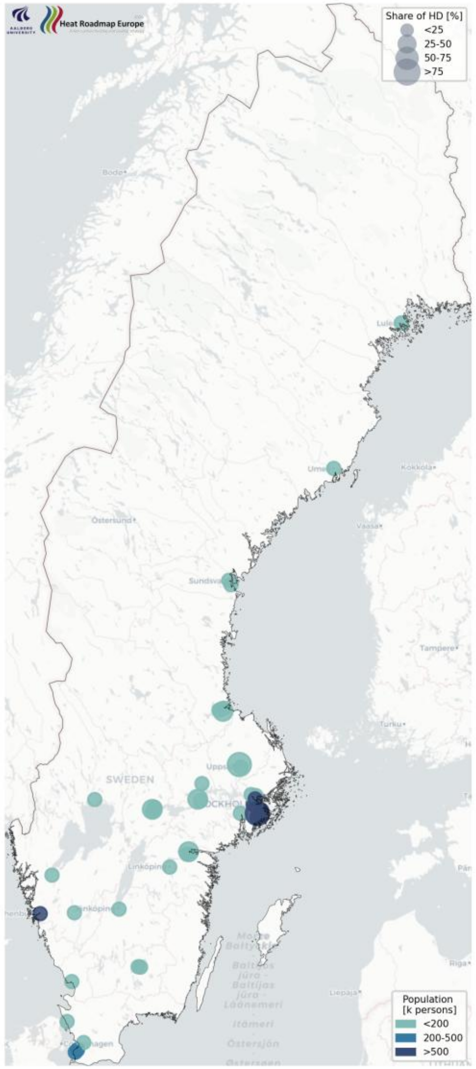


Figure 311: Medium temperature from industry for Sweden.

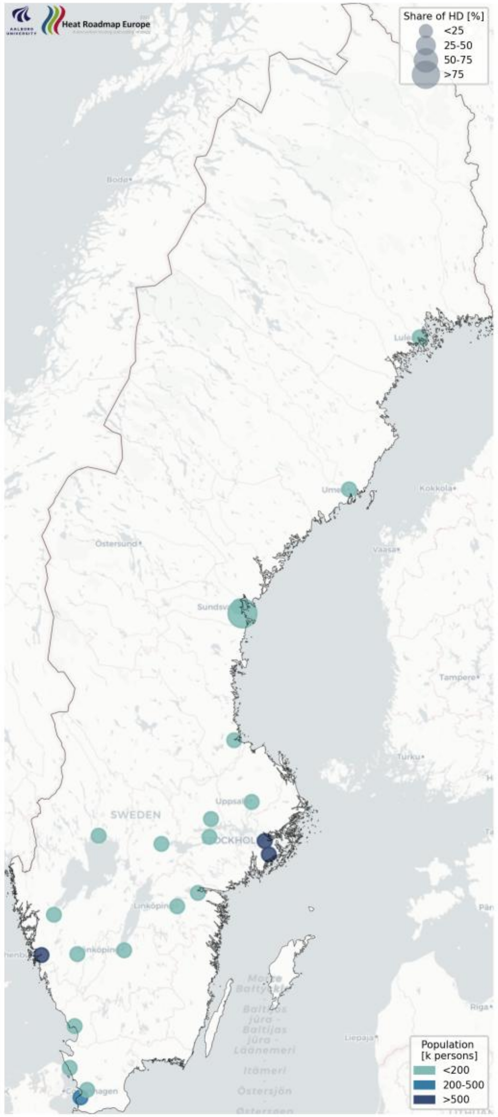


Figure 312: Medium temperature from wastewater treatment for Sweden.

5.27 United Kingdom

Table 57: District heating shares specific to United Kingdom and the corresponding heat sources to the heat demand.

Country	District heating_shares_goal [%]	District heating_shares_closest [%]	Heat demand [TWh]	Waste to energy (TWh)	Industrial Waste High Temp (TWh)	Industrial Waste Medium Temp (TWh)	Industrial Waste Low Temp (TWh)	Waste Water Treatment (TWh)	Waste heat from Supermarkets (TWh)	Waste heat from Metros (TWh)	District heating Solar Thermal (TWh, c=20MW)	District heating Solar Thermal (TWh, c=70MW)	District heating Geothermal (TWh, c=40MW)	District heating Geothermal (TWh, c=70MW)
The United Kingdom	5	11,77	45,07	2,5	0	0,28	0,42	4,93	0,35	0,51	0	0	13,37	13,4
	10	11,77	45,07	2,5	0	0,28	0,42	4,93	0,35	0,51	0	0	13,37	13,4
	15	16,04	61,39	3,46	0,01	0,47	0,72	5,93	0,51	0,51	0	0	13,37	13,4
	20	21,02	80,46	4,73	0,06	0,72	1,1	8,17	0,65	0,51	0	0	13,37	13,4
	25	25,17	96,37	5,82	0,24	0,96	1,45	9,83	0,77	0,59	0	0	14,81	14,8
	30	30,16	115,5	7,09	2,13	1,26	1,9	11,47	0,95	0,59	0	0	14,81	14,8
	35	35,1	134,4	8,35	2,14	1,48	2,24	12,84	1,16	0,59	0	0	17,96	18
	40	40,11	153,6	9,63	2,17	1,75	2,64	14,06	1,34	0,59	0	0,07	18,78	18,8
	45	45,2	173	11,15	2,37	2,1	3,17	15,42	1,54	0,59	0,01	0,48	19,8	19,5
	50	50,08	191,7	12,56	2,54	2,45	3,7	16,71	1,74	0,59	0,03	1,26	20,58	19,5
	55	55,04	210,7	13,85	2,9	2,75	4,14	18,35	1,96	0,59	0,06	2,03	20,58	19,5
	60	60,01	229,7	14,77	3,05	3,11	4,66	19,75	2,25	0,59	0,6	2,9	20,58	19,5
	65	65,02	248,9	15,18	3,05	3,43	5,14	21	2,61	0,59	1,62	3,93	20,58	19,5

5.28 EU27

Table 58: EU 27 level results for waste heat and renewable heat from 5-60% district heating market share and the corresponding heat sources.

	District heating_shares_goal	**Heat demand [TWh]**	**Waste heat from WtE**	**Industry_High**	**Industry_Medium**	**Waste heat from WWT**	**Waste heat from Supermarkets**	**Industry_Low**	**Waste heat from Metros**	**Solar (20MW)**	**Solar (70MW)**	**District heating Geothermal (TWh,**	**District heating Geothermal**
EU27	5	170	12	3	7	9	1	11	1	1	1	14	14
	10	328	24	8	13	18	2	23	4	1	2	28	28
	15	480	38	11	20	25	4	33	6	2	3	44	43
	20	638	53	17	28	34	5	46	7	3	6	54	50
	25	797	66	28	37	43	7	58	7	5	8	58	53
	30	957	77	32	48	54	9	74	7	8	12	62	56
	35	1.117	87	35	60	65	12	90	8	11	16	65	59
	40	1.276	97	41	72	77	14	108	8	14	20	68	62
	45	1.435	108	45	86	90	17	126	8	18	24	70	64
	50	1.595	118	50	101	101	20	144	8	23	29	71	64
	55	1.754	125	53	113	113	22	157	8	30	37	72	64
	60	1.789	127	53	115	116	23	159	8	32	39	72	64

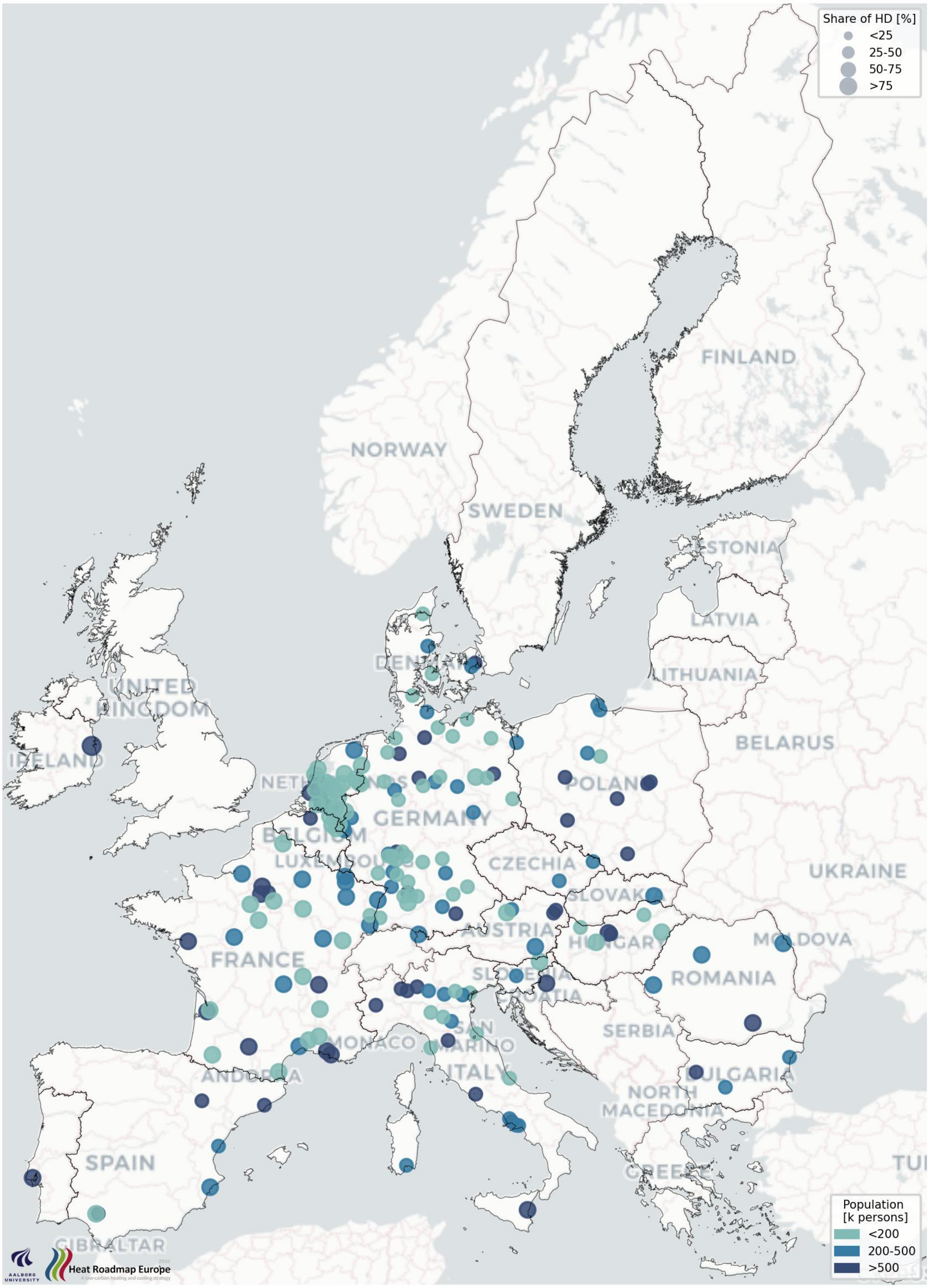


Figure 313: Geothermal energy for EU27 (Baseload of district heating area, capacity >40MW

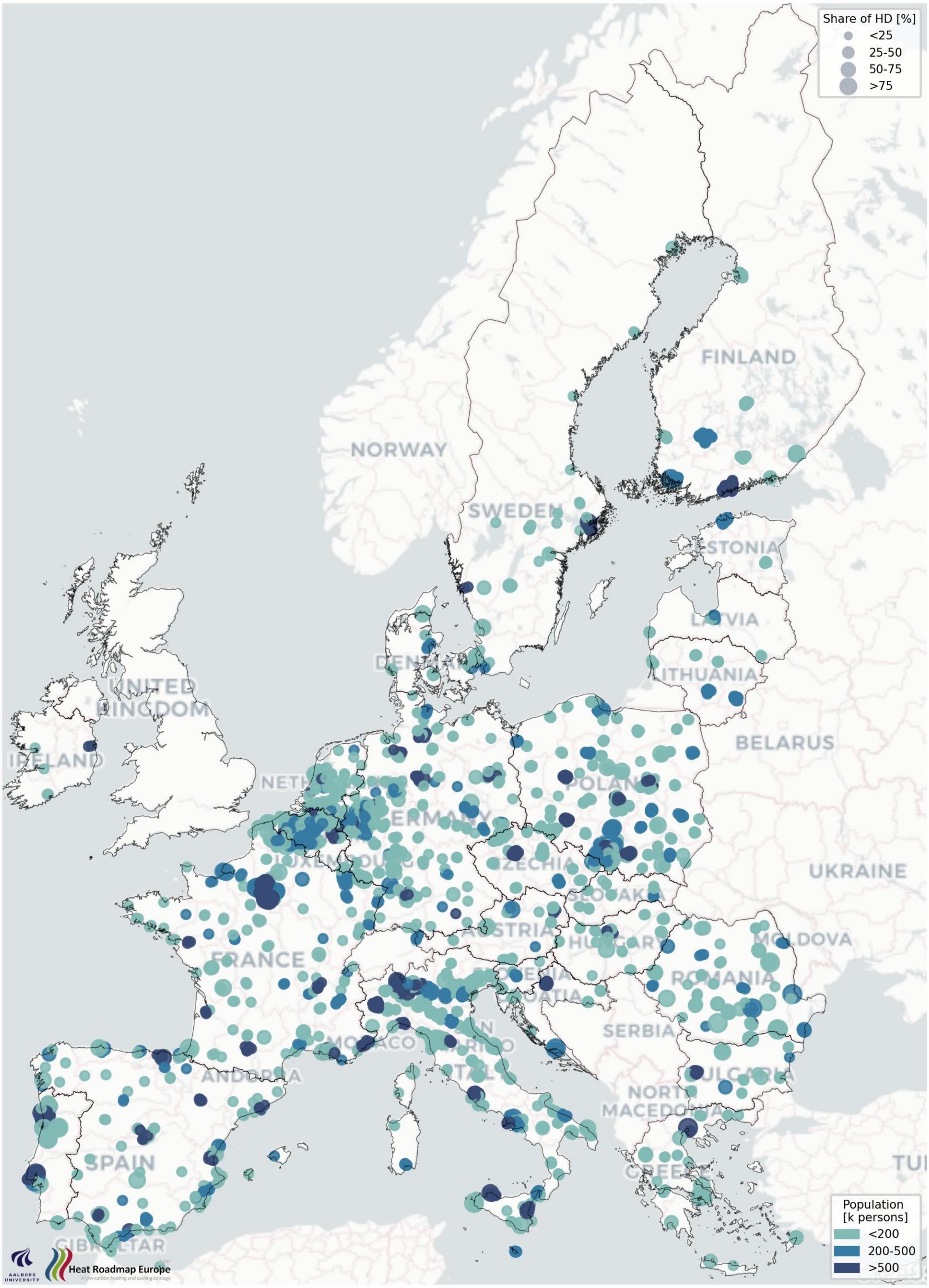


Figure 314: Geothermal energy for EU27 (Baseload of district heating area, capacity >70MW).

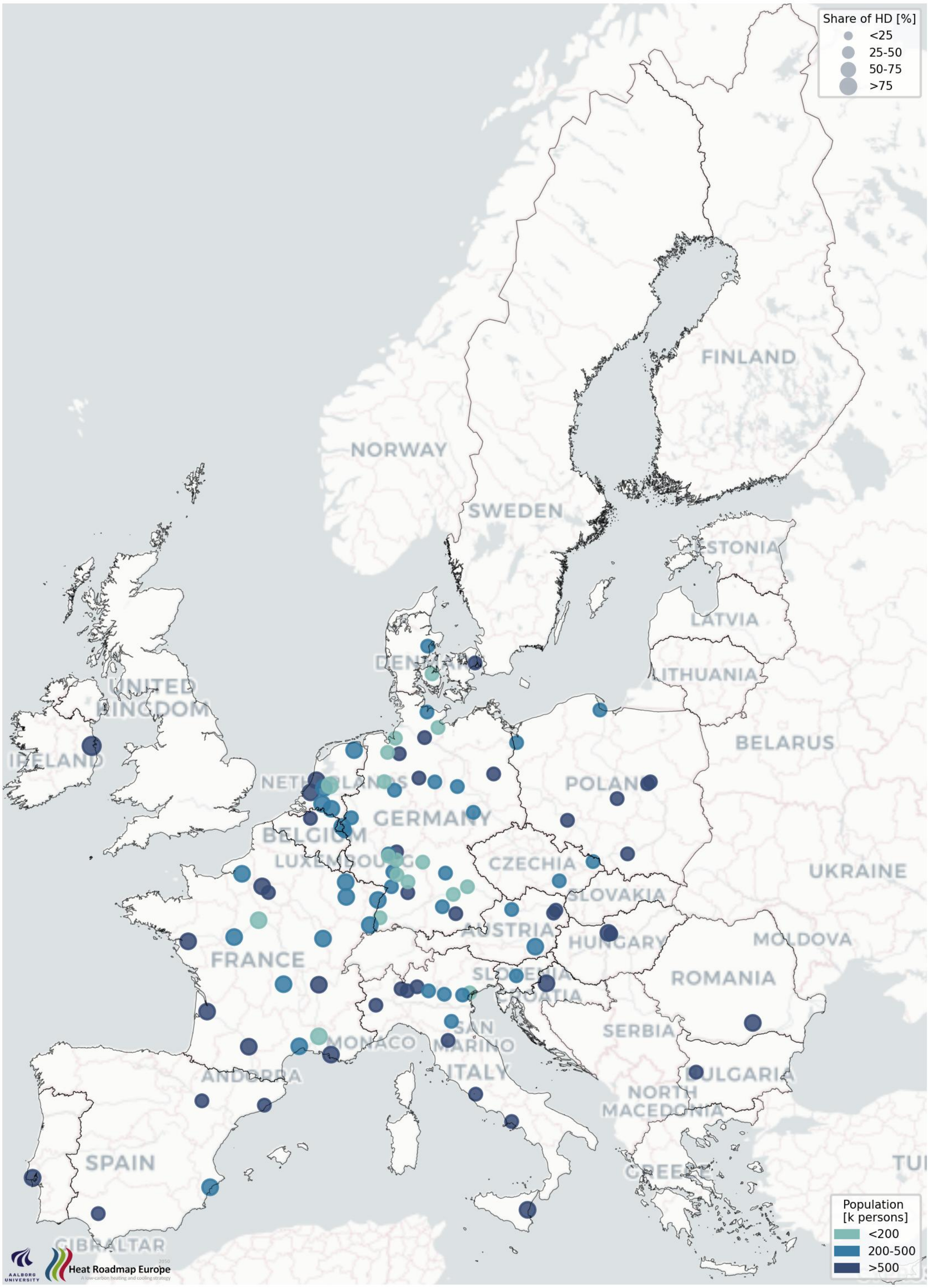


Figure 315: Baseload high temperature waste heat for EU27.

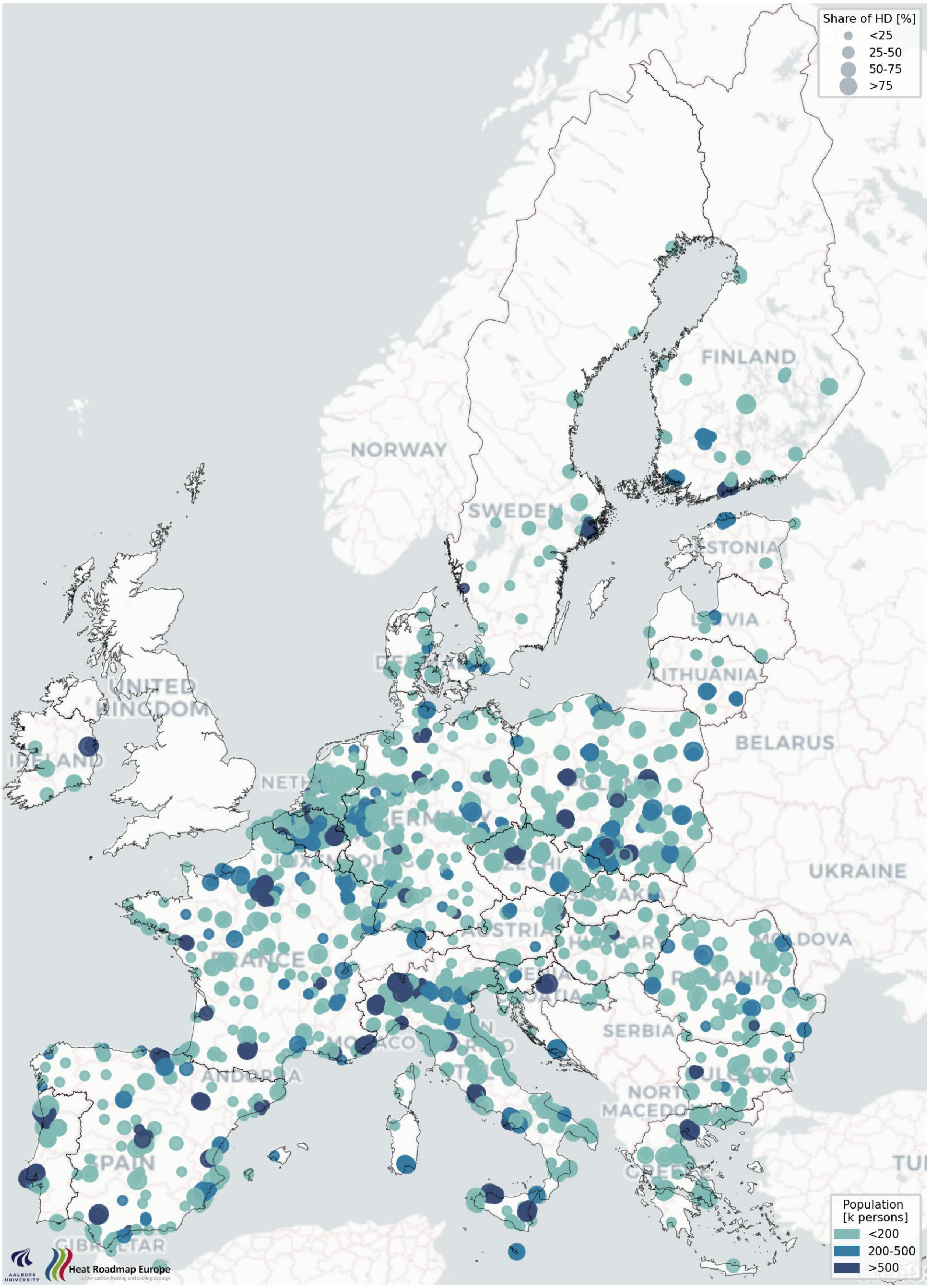


Figure 316: Baseload low temperature waste heat for EU27.

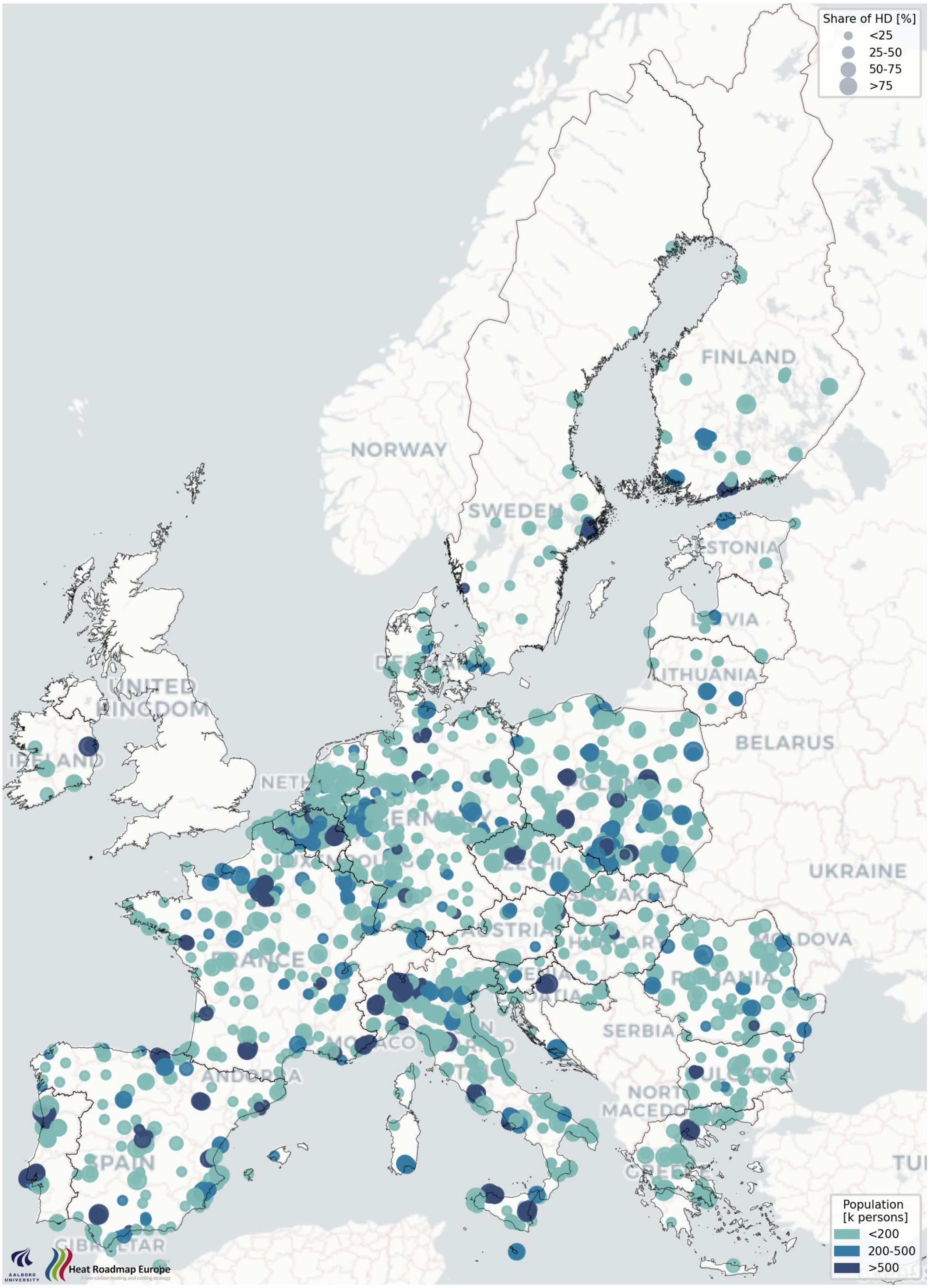


Figure 317: Baseload medium temperature waste heat for EU27.

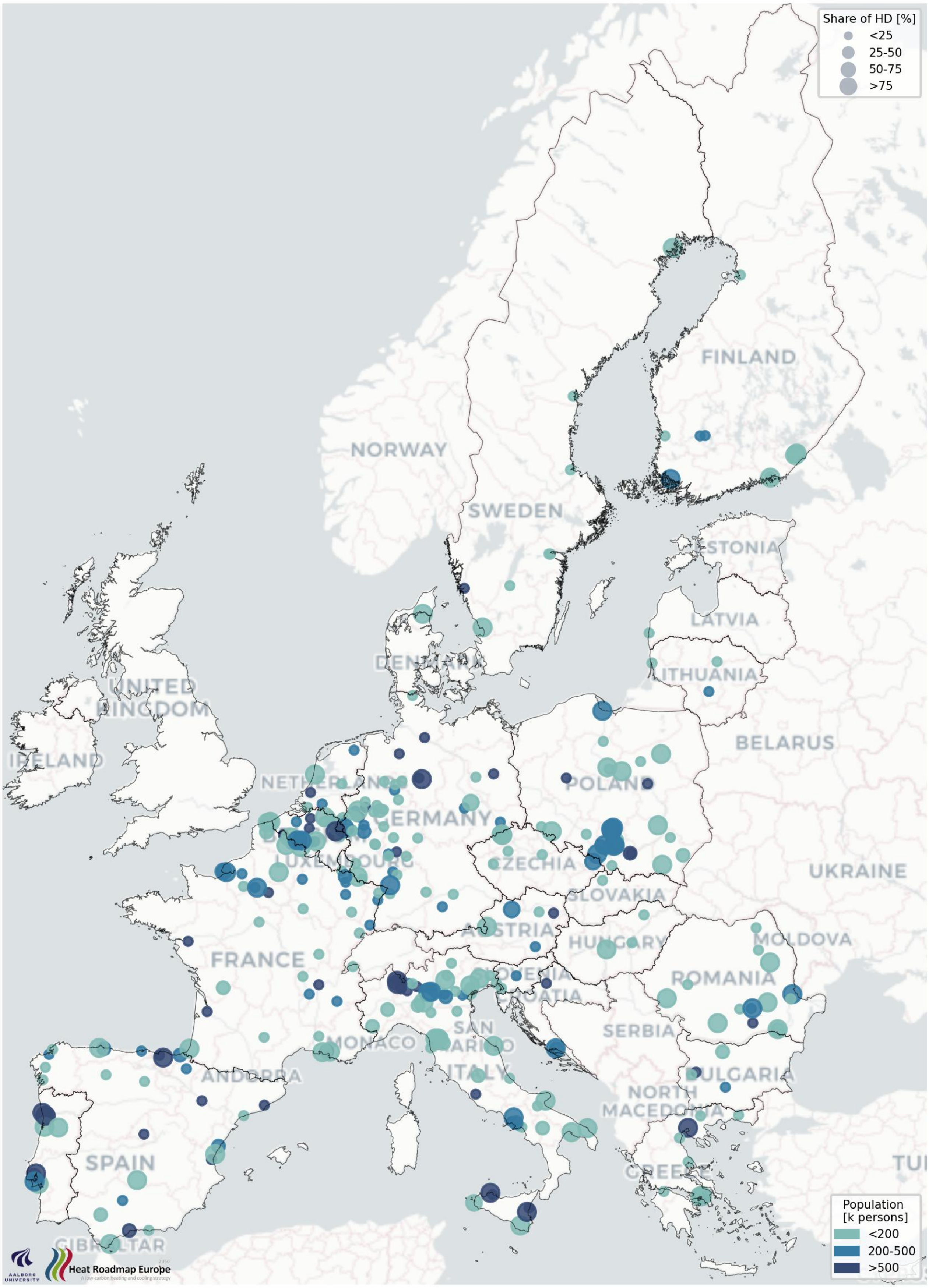


Figure 318: High temperature from industry for EU27.

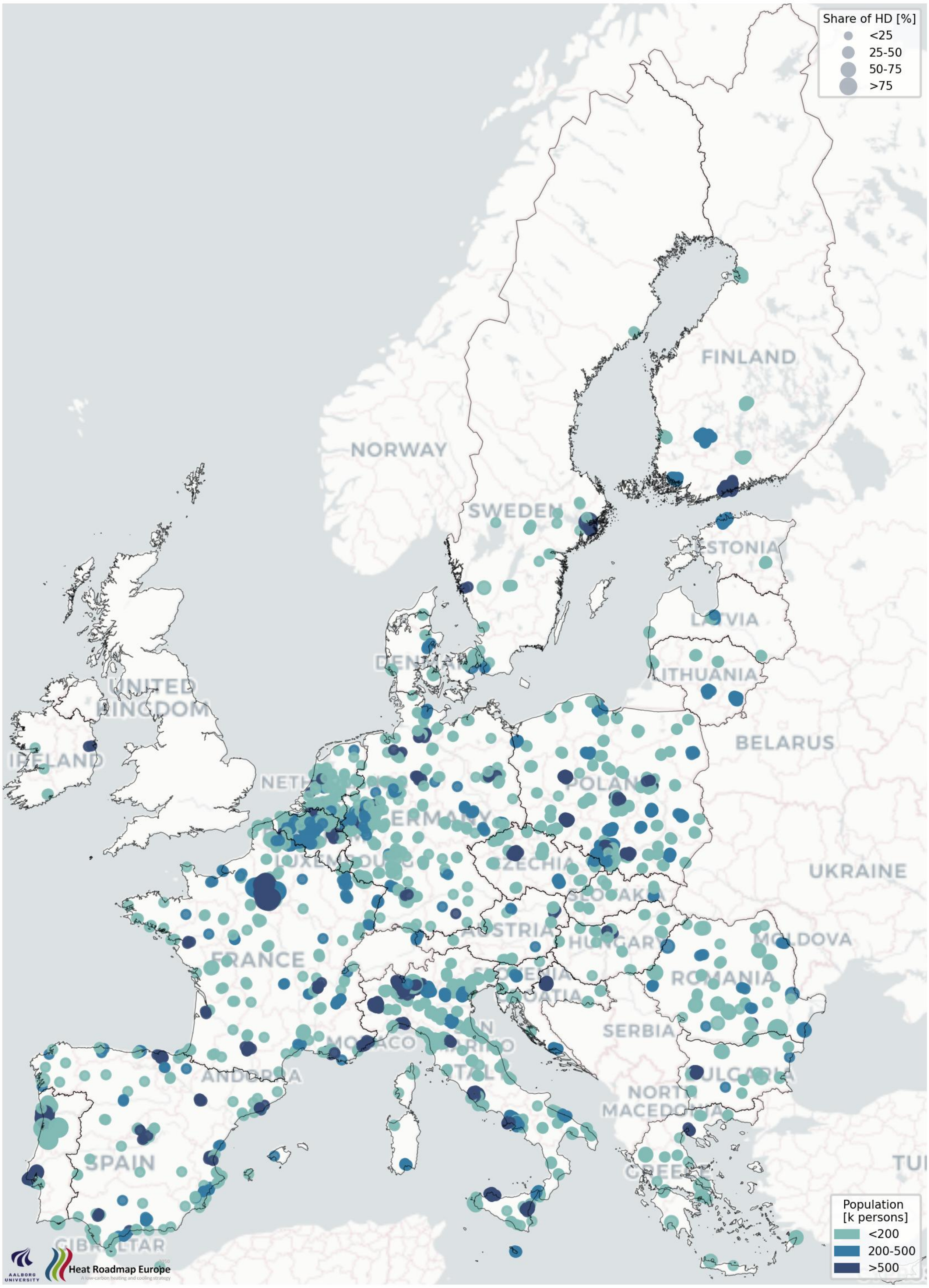


Figure 319: High temperature from waste-to-energy for EU27.

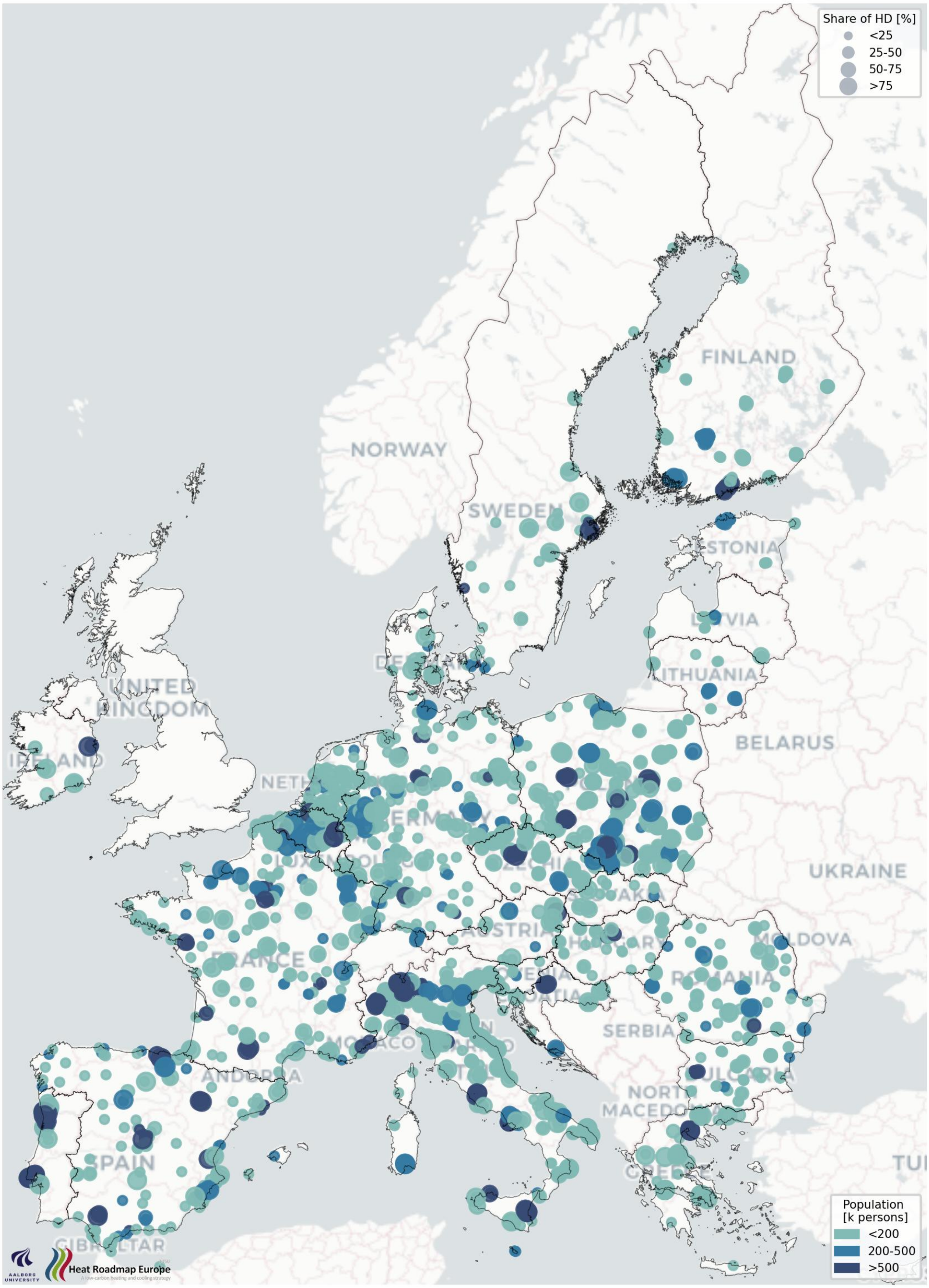


Figure 320: Low temperature from industry for EU27.

Figure 321: Low temperature from metros for EU27.

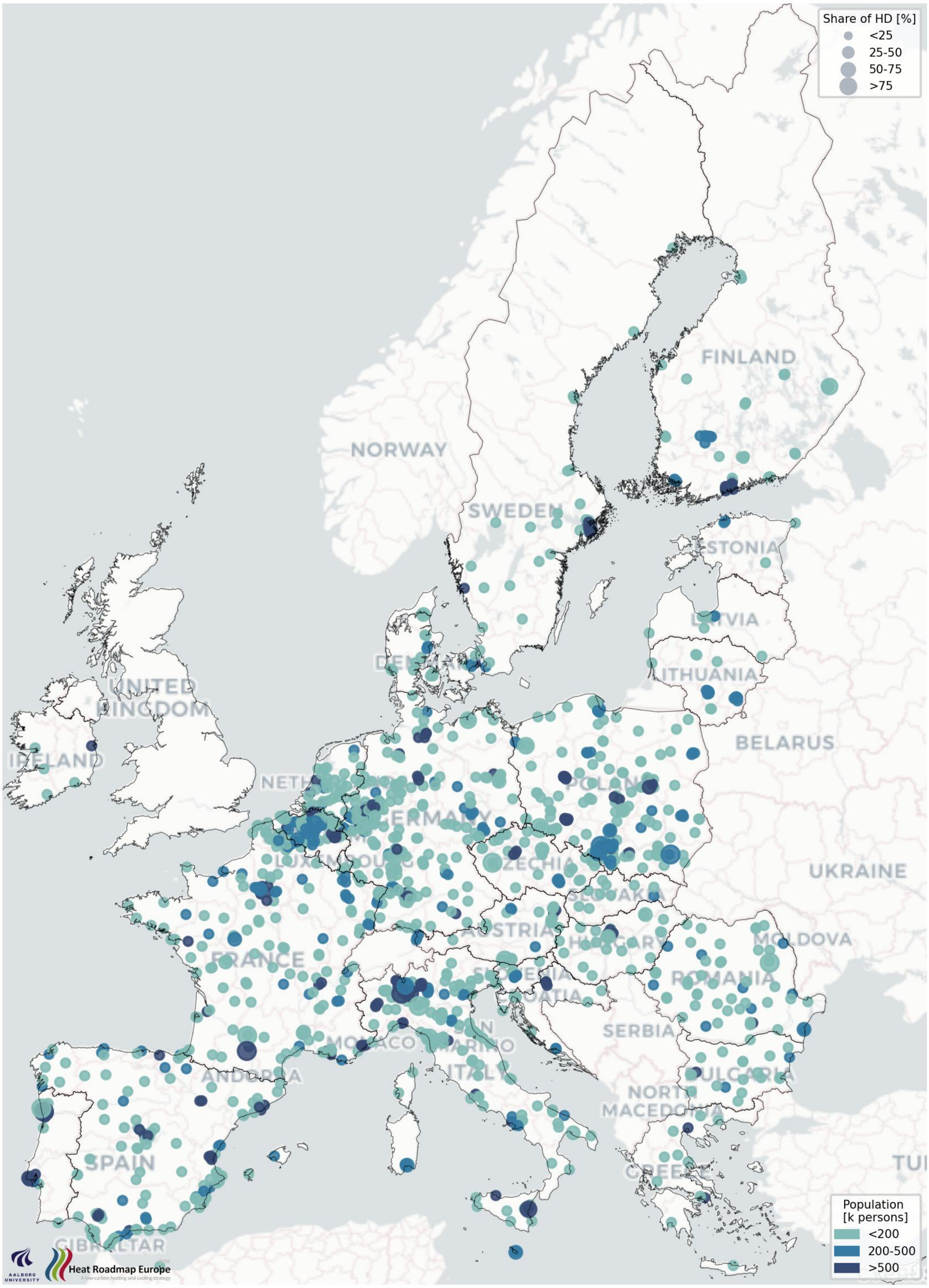


Figure 322: Low temperature from supermarkets for EU27.

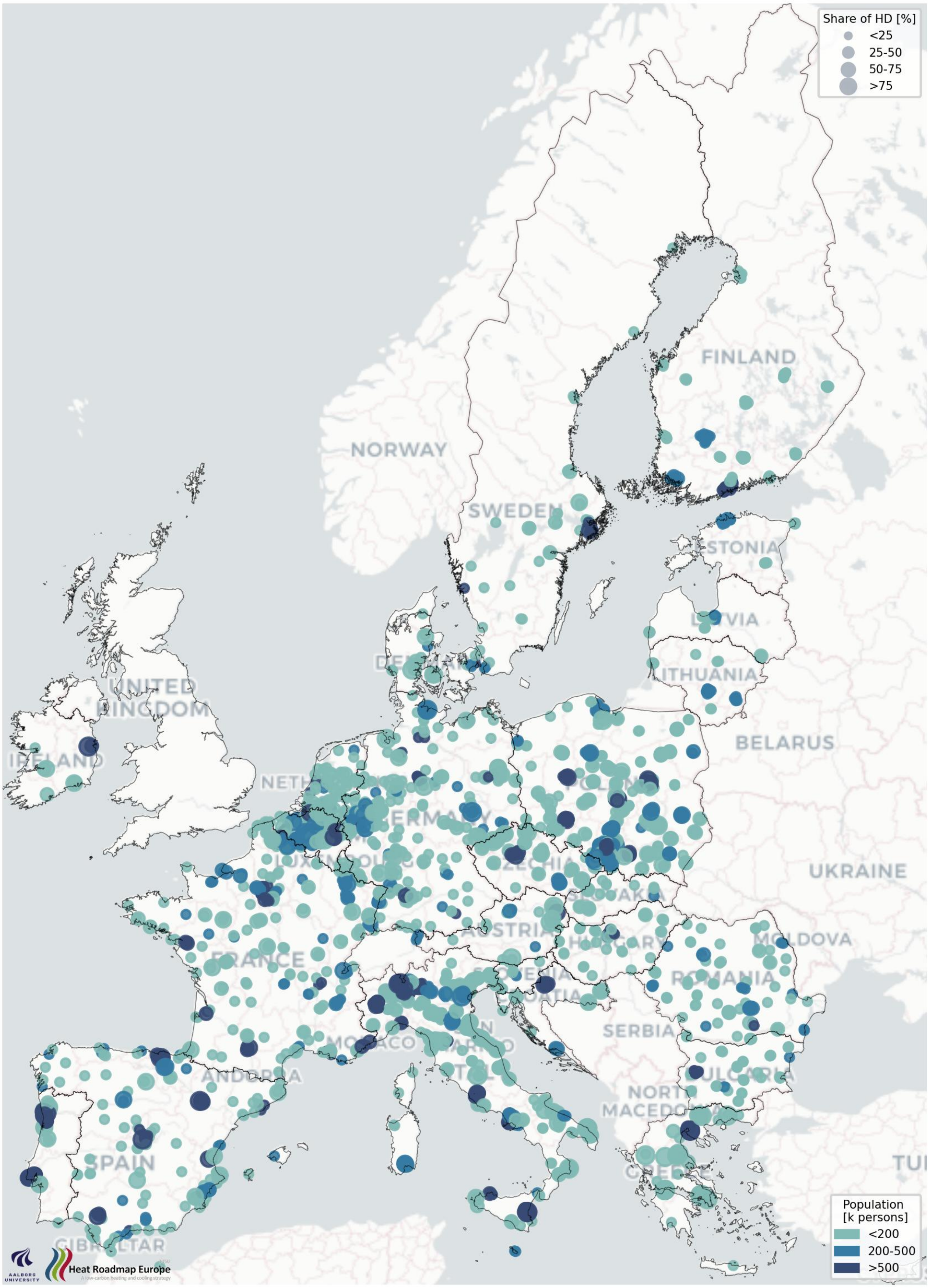


Figure 323: Medium temperature from industry for EU27.

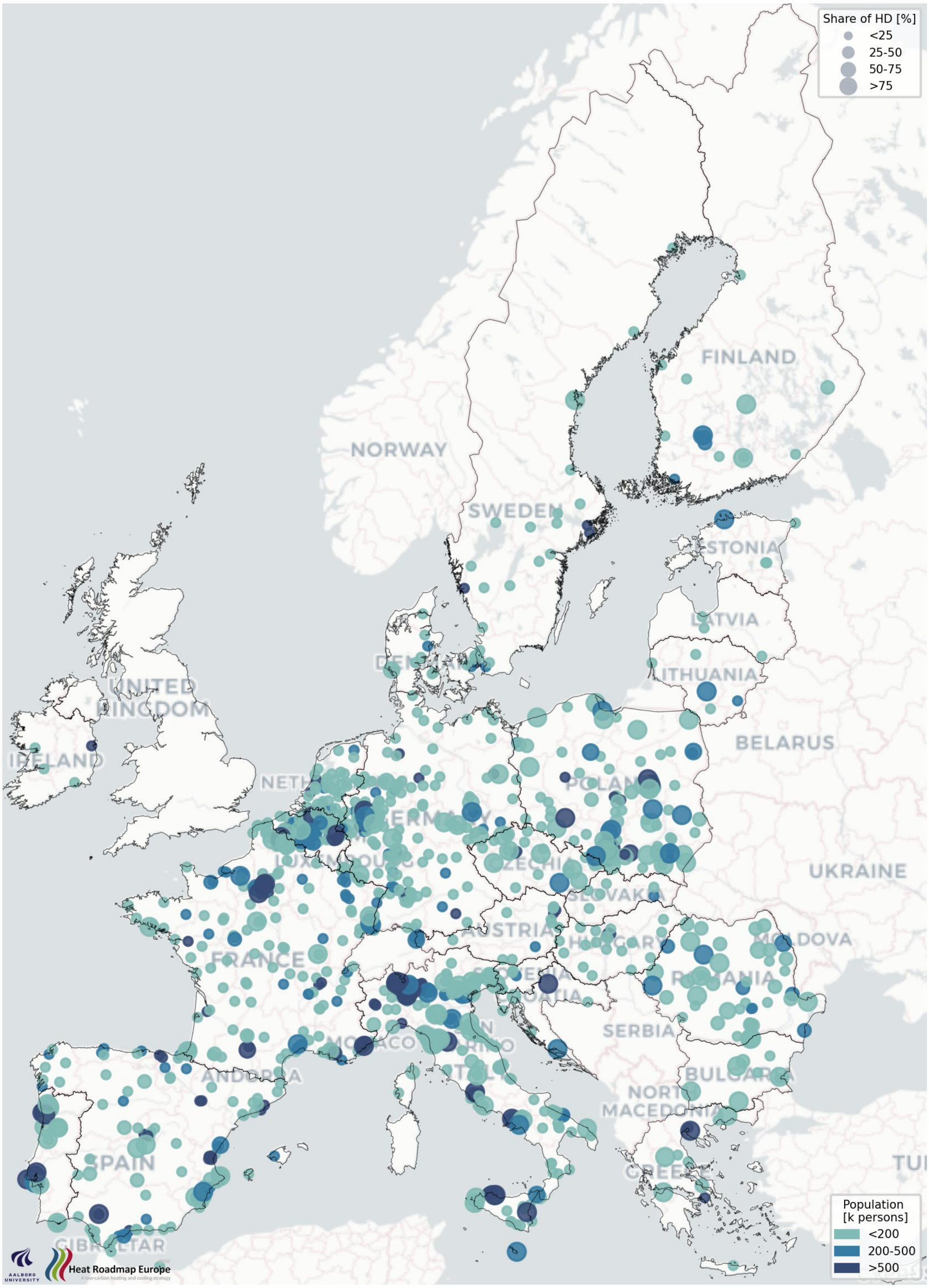


Figure 324: Medium temperature from wastewater treatment for EU27.

6 Spatial modelling

This appendix describes the methods used to map the heat demand in residential and service buildings in Europe, the distribution of district heating areas based on the above, and the heat potential from waste heat sources. The models, originally developed in the Heat Roadmap Europe project (Persson et al., 2017), were improved in the sEEnergies project (Möller et al., 2022) and are now being further improved with a focus on an open-access development approach. The models are developed in Python using open-source libraries and are made openly through github. Each of the models is described in detail in the following subsections, along with the required data and data sources.

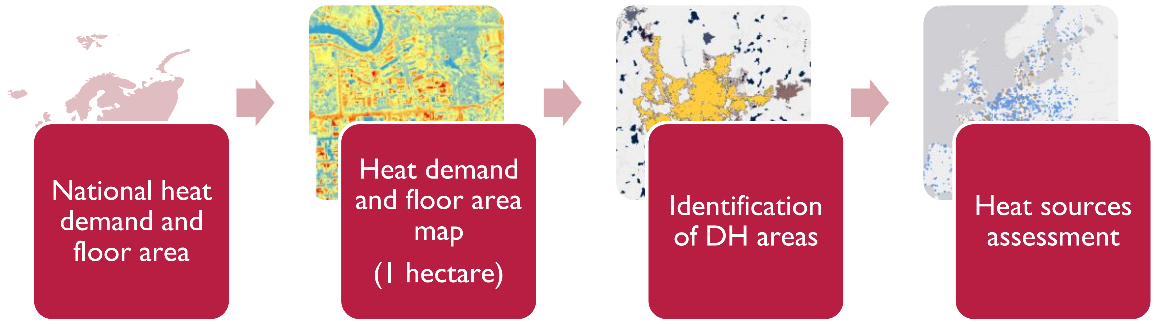


Figure 325 Workflow of GIS analysis including heat mapping, mapping district heating areas and heat sources.

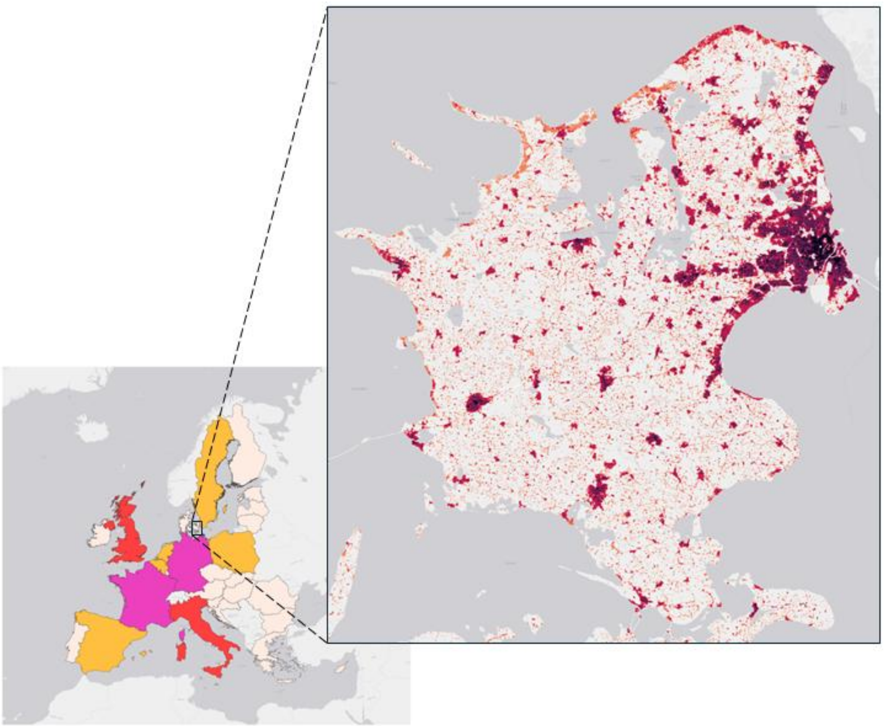


Figure 326 Disaggregation of heat demands.

6.1 Heat demands

The present heat demand model estimates detailed representations of current heat demands. It takes into account the building age classes (i.e. the proportion of buildings in the area built before 1975, between 1997 and 1990, between 1990 and 2015 and after) and therefore allows for the inclusion of energy efficiency potential by construction period. The method is based on the downscaling of the national counts of heat demands and floor area to the 1 ha grid level using the methods of the sEEnergies project (Möller et al., 2022). The code is openly available at https://github.com/mgeorgati/heatingatlas. Two scenarios are examined in this case, namely the baseline scenario and the frozen efficiency, where no efficiency potentials are assumed. The data necessary for the estimation of the heat demands at European level is presented in Table 1.

Specifically, the national counts of heat demand and floor area (presented in Figure 327, Figure 328 and Figure 329) are downscaled to the finer resolution of 1 hectare for each building sector and construction period. Then the heat demand per square meter of floor area is calculated for each sector and construction period. This involves integrating additional data representing the built-up area factor (GHS_BUILT) – a dataset produced by the Hotmaps project (Mueller, 2019) based on the Global Human Settlement Layer (GHSL) by the Joint Research Centre (JRC (EC)., 2022).

Table 59 Overview of the data used in the spatial model for energy demands.

Data	Abbreviation	Spatial resolution	Source	Description
Heat demand	HD	Country	HRE (Persson et al., 2017)	Divided by buildings sector and construction period
Floor area	FA	Country	HRE (Persson et al., 2017)	Divided by buildings sector and construction period
Floor area	FA100	100 x 100m	sEEnergies/HRE (Persson et al., 2017)	Guide for disaggregating national FA for the estimation of plot ratios
Building shares by age class	GHS_BUILT	100 x 100m	Hotmaps (Mueller, 2019)/JRC (JRC (EC)., 2022)	Contains the estimated share of gross floor area per construction period
Heating index	NHI	NUTS3	sEEnergies/HRE (Persson et al., 2017) — refined to complete spatial coverage	Based on the European Heating
Corine Land Cover	CLC	100 x 100m	Copernicus (*CORINE Land Cover — Copernicus Land Monitoring Service.*, 2021)	European land-use and land-cover classification dataset
GHSL population distribution	GHS POP	100 x 100m	(JRC (EC)., 2022)	Gridded population estimates
EUROPOP19	EUROPOP19	NUTS3	(Eurostat, 2022)	EU regional population forecasts

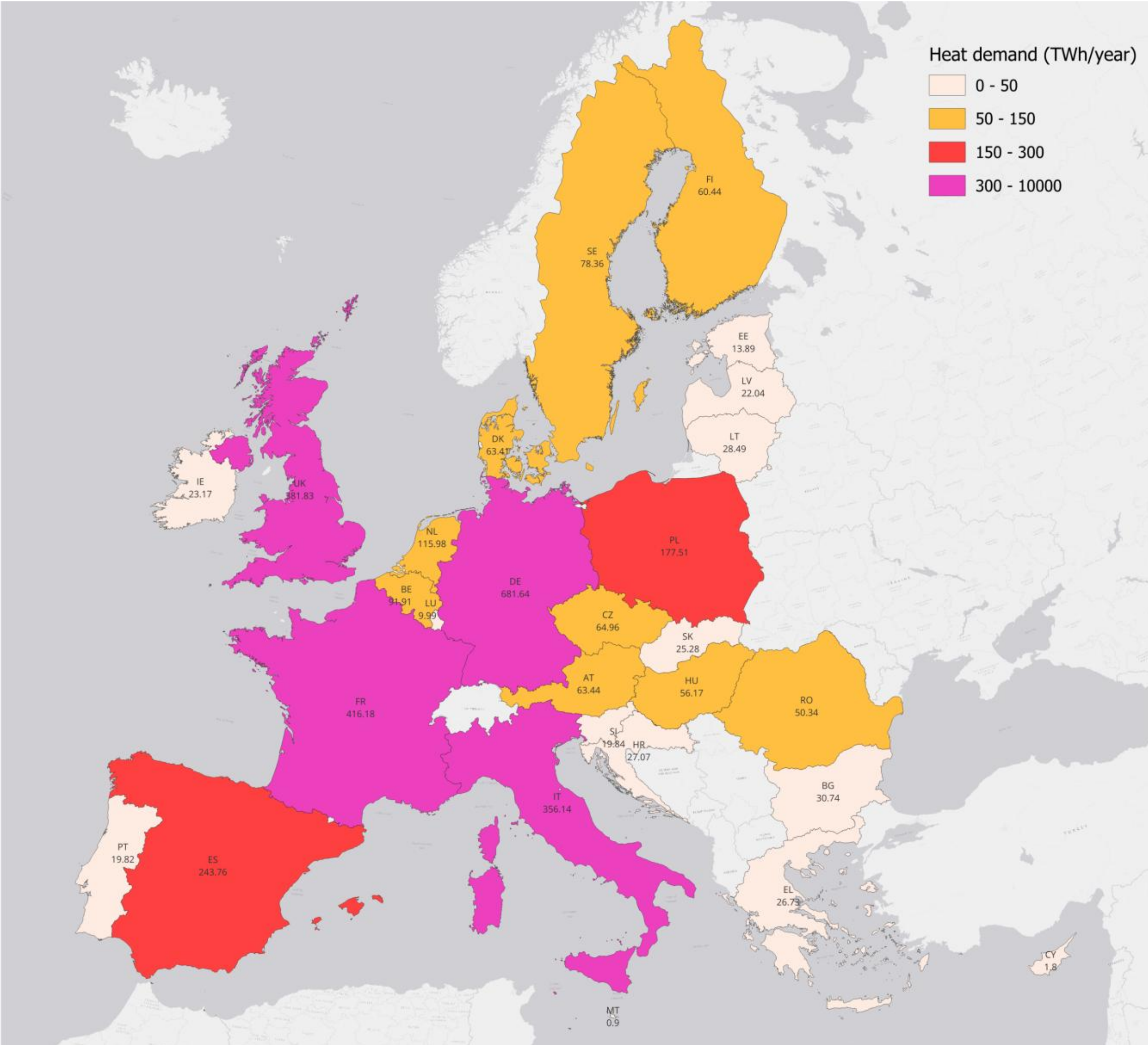


Figure 327 Estimated national heat demands in EU27 + United Kingdom in 2015.

The outcome is a set of raster layers indicating the heating demand per square meter or each sector and construction period. In the following step, the methodology refines the heat demand estimates by integrating factors, such as the national heat demand, floor area ratios and heating indices at a regional level. For the estimation of the floor area ratios, the sEEnergies floor area local estimates were used as guides for the production of an enhanced layer based on dasymetric mapping. The total heat demand for each grid cell is then calculated by summing the adjusted heat demand values across all sectors. Figure 330 and Figure 331 illustrate the heat demand densities in 2015 in Copenhagen, Denmark; Madrid, Spain; and Hamburg, Germany.

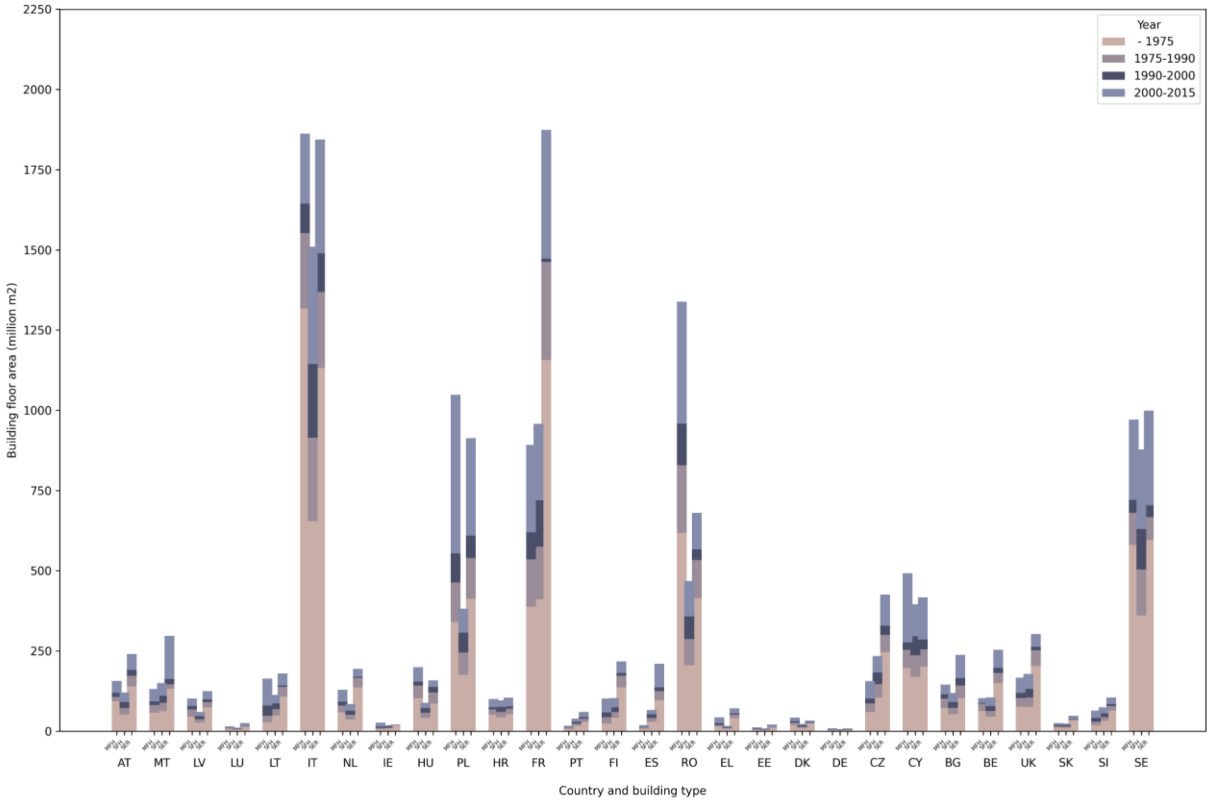


Figure 328 Floor area by country, building type and construction period in 2015.

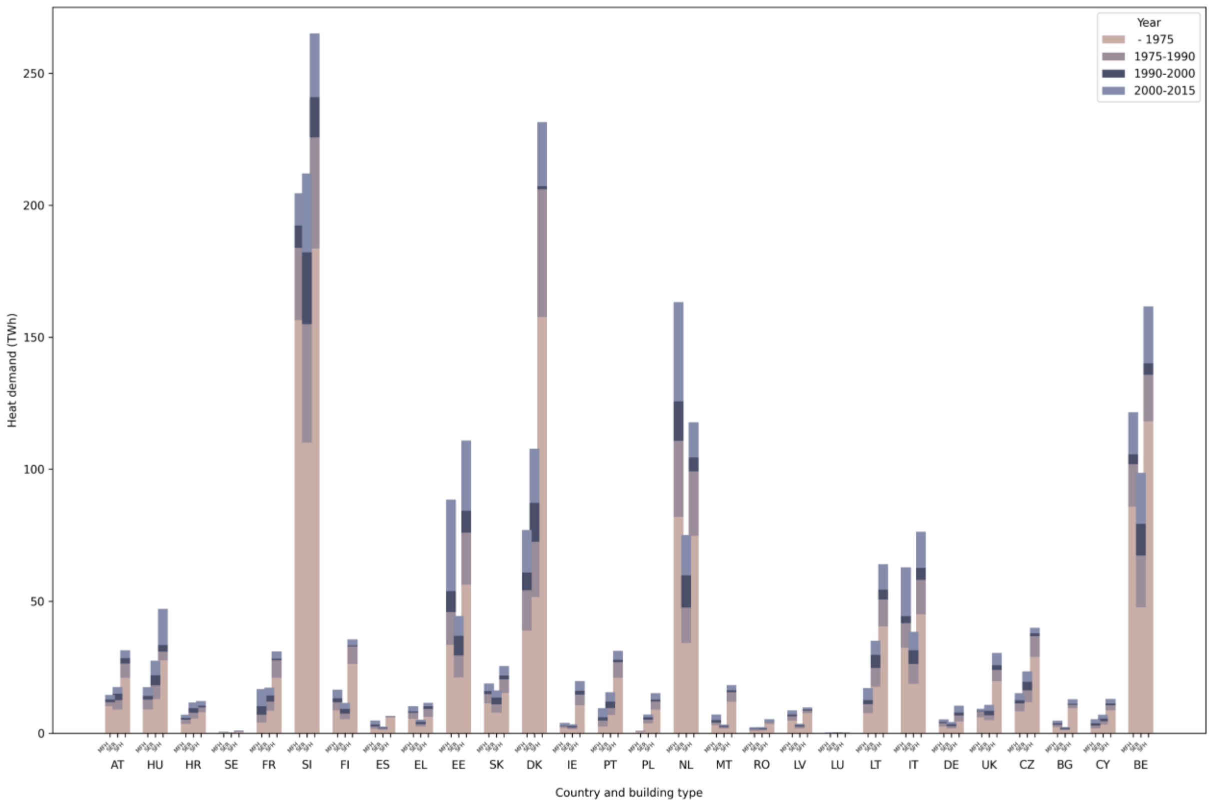


Figure 329 Heat demand by country, building type and construction period in 2015.

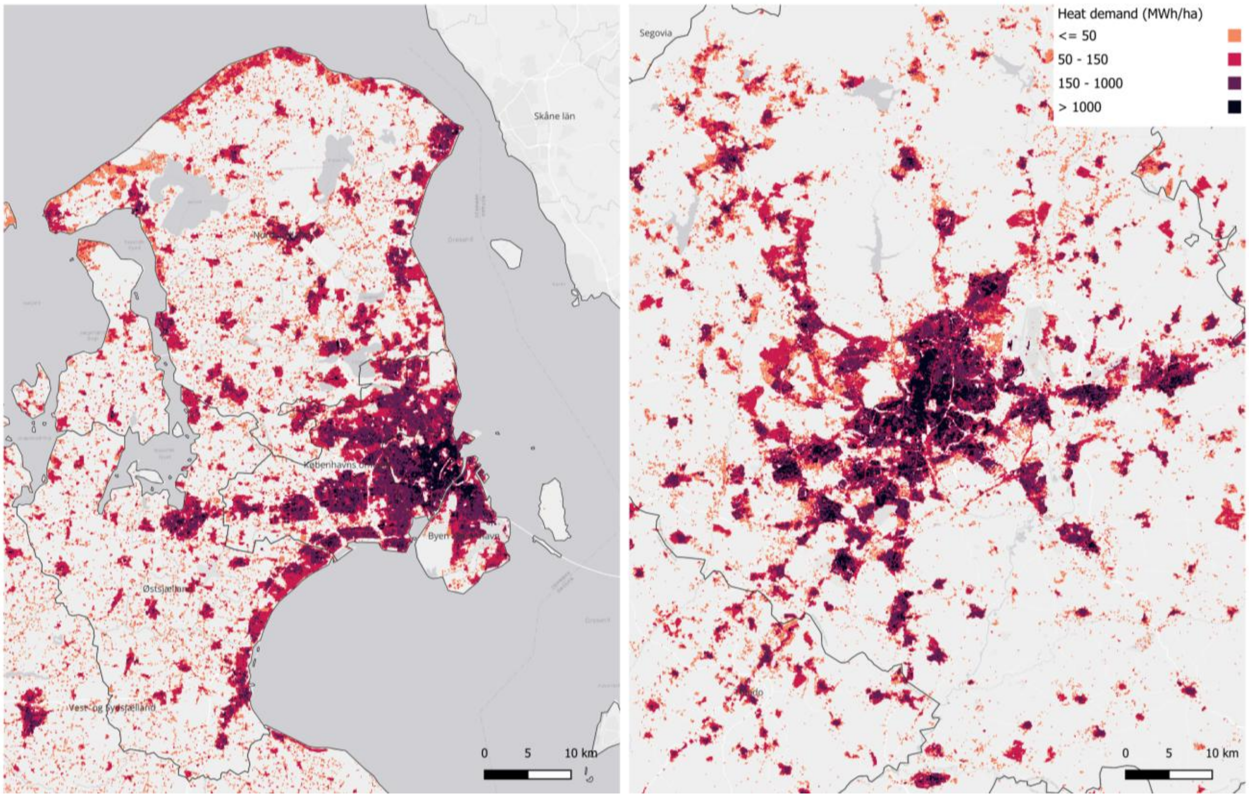


Figure 330 Heat demand in Zealand, Denmark (left) and Madrid, Spain (right).

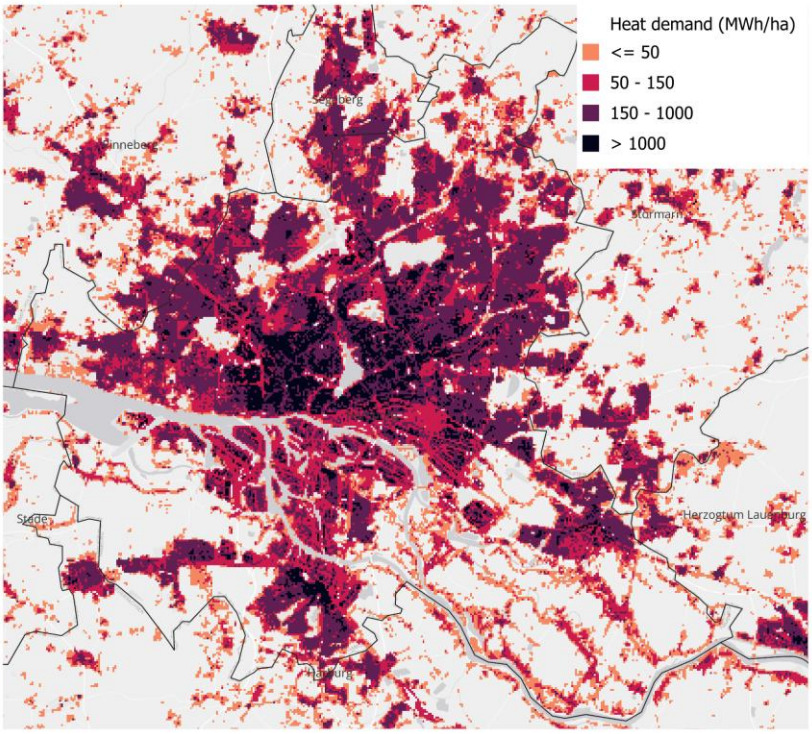
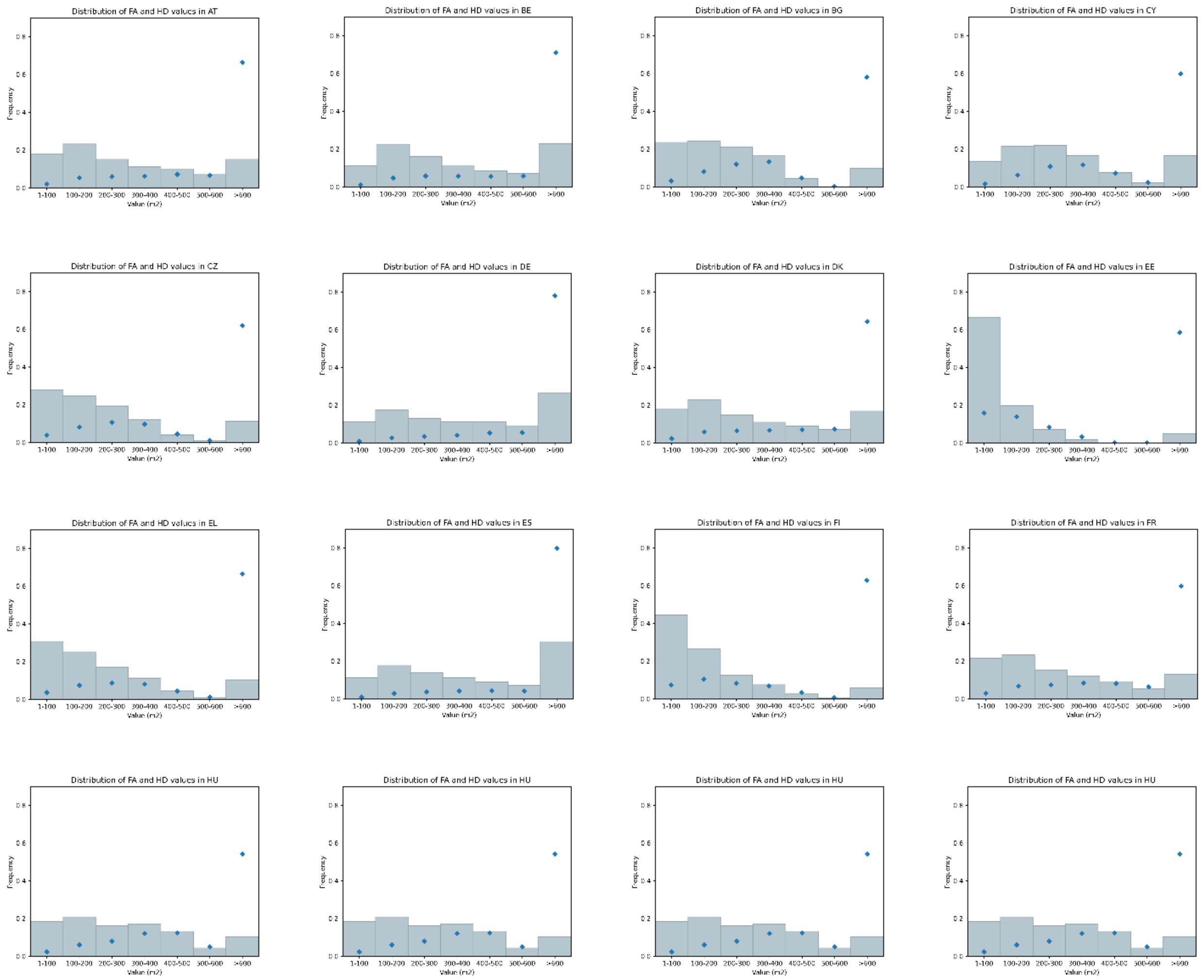
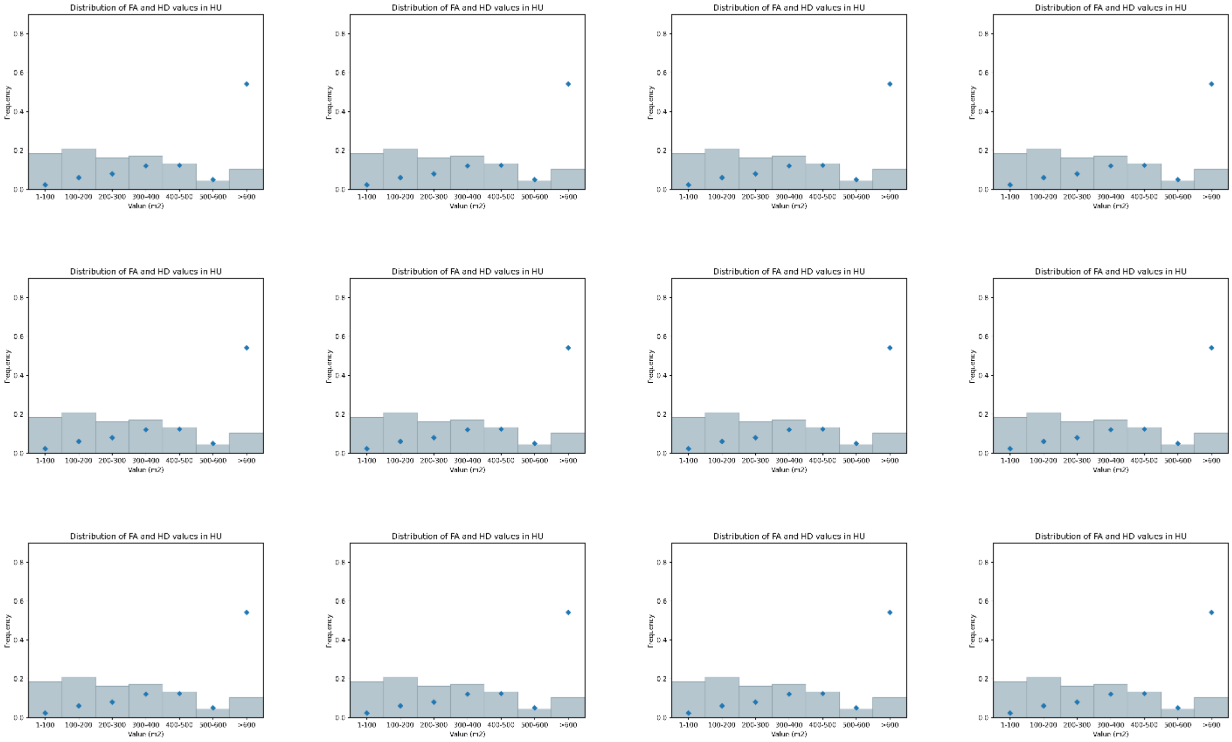


Figure 331 Heat demand in Hamburg, Germany.

6.2 District heating modelling

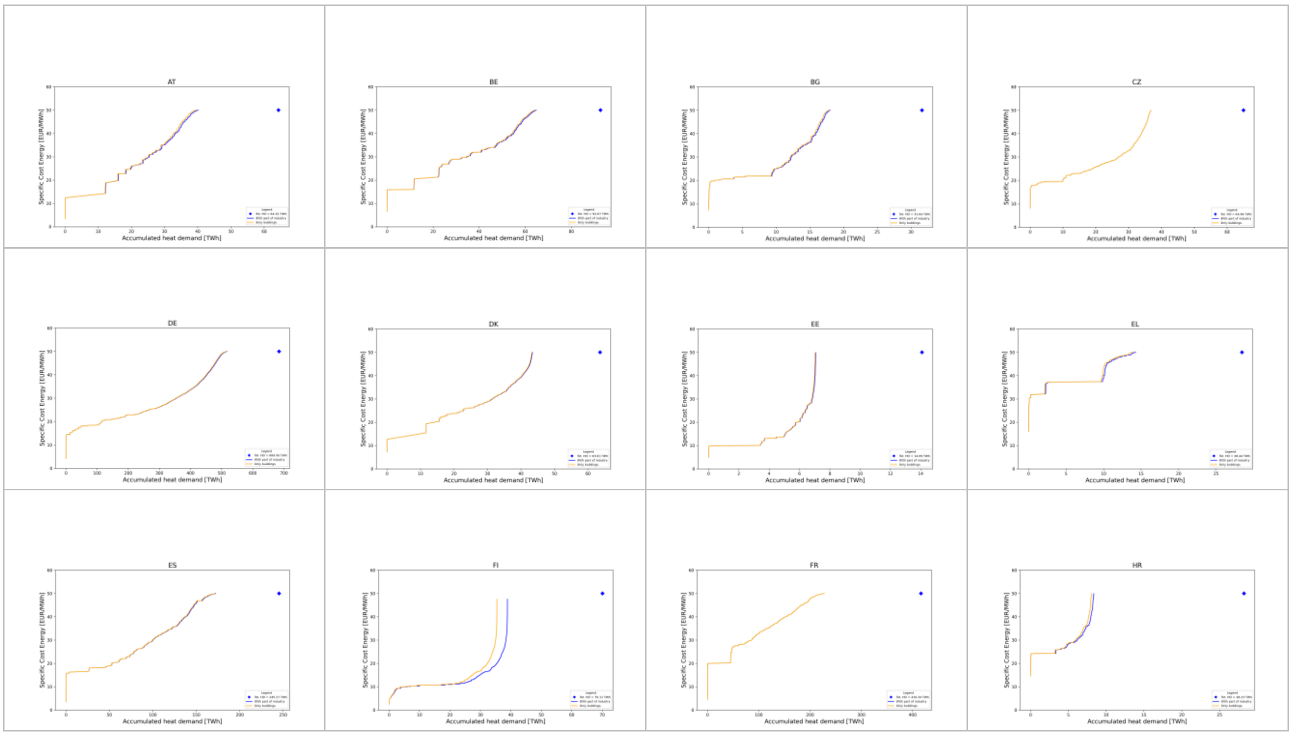
The approach for estimating district heating potential is based on the methodology described in (Fallahnejad et al., 2024) and calculated using the module available in (Fallahnejad, 2022). The module requires two grid layers representing the distribution of heat demand and floor area for the year under consideration to calculate the district heating potential. The module can run the calculation by using a heat demand in the beginning and another heat demand at the end of the year, representing e.g. implementing energy efficiency measures in buildings and lowering the demand over time. Since the energy efficiency in buildings is modeled in another model, this part is not considered in the district heating assessment module. Thus, the start- and end-year input data are based on the same heat density and floor area map for each country. Due to the spatial continuity of heat demand densities in several countries, such as the Netherlands, which resulted in the calculation of continuously connected district heating systems, we examined the distribution of district heating by FA and decided to exclude grid cells with a floor area of less than 400 m² from the district heating potential analysis.

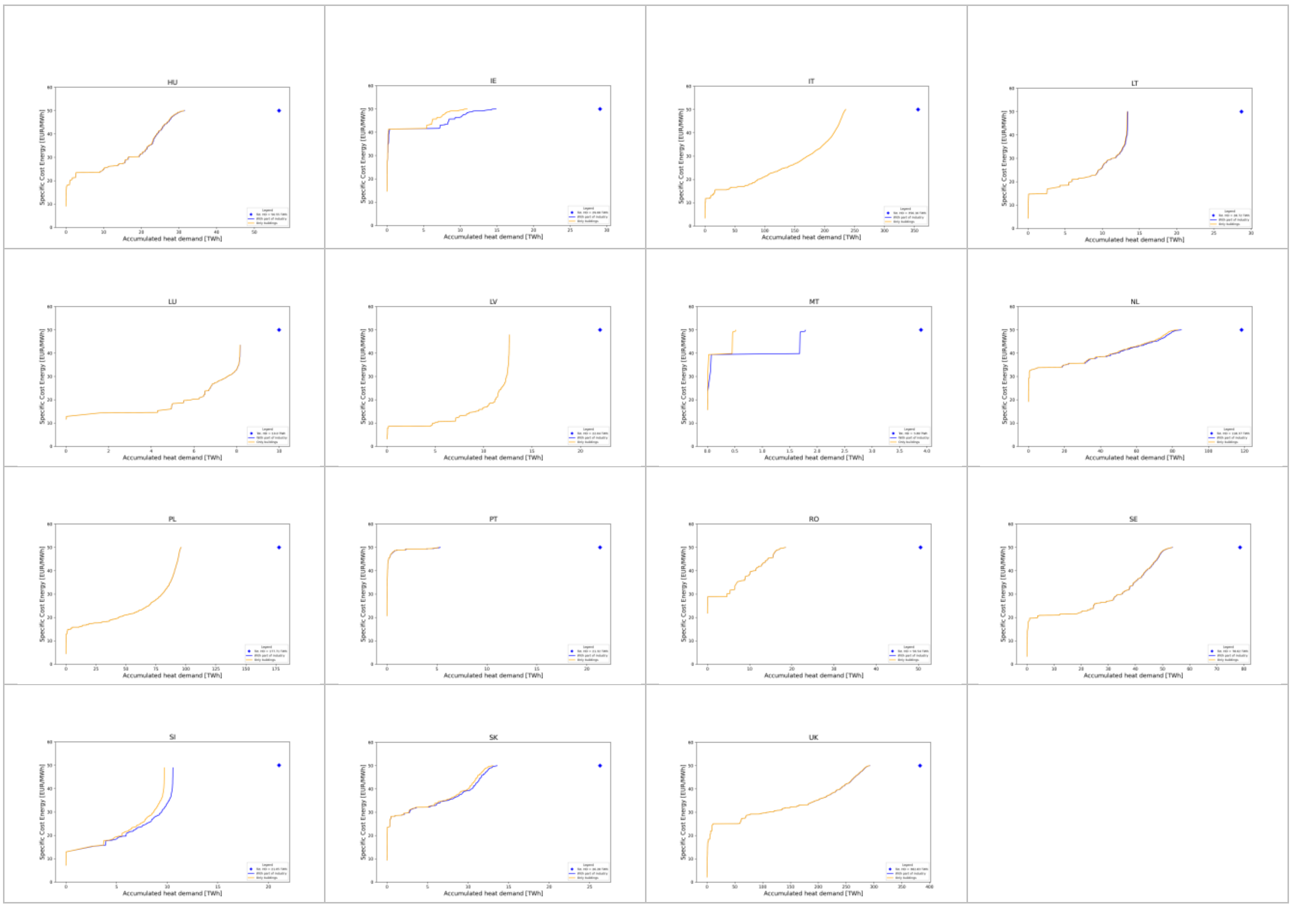




Further the model utilizes the accumulated heat demand by specific cost energy for industry, residential and service building, as shown on graphs in Table 60Table 60.

Table 60: Accumulated heat demand by specific cost energy for industry, residential and service building.





The model requires district heating pipe costs as input; in the model, these are simplified to two factors c1 [€/m] and c2 [€/m2]. In practice, the costs vary between countries and cities, but to make the costs consistent with the energy system models, the district heating assessment is done with the same costs for all countries. The costs used for c1 and c2 are 664 €/m and 2610 €/m^{2,} respectively, and are based on the updated German costs from (Sánchez-García et al., 2022). The costs in €/m for various countries are illustrated in Figure 332, the dotted red line for Germany 2020 is the one used in this report. In the sEEnergies report (Sánchez-García et al., 2022), more cost curves can also be found to give a more detailed look into the costs.

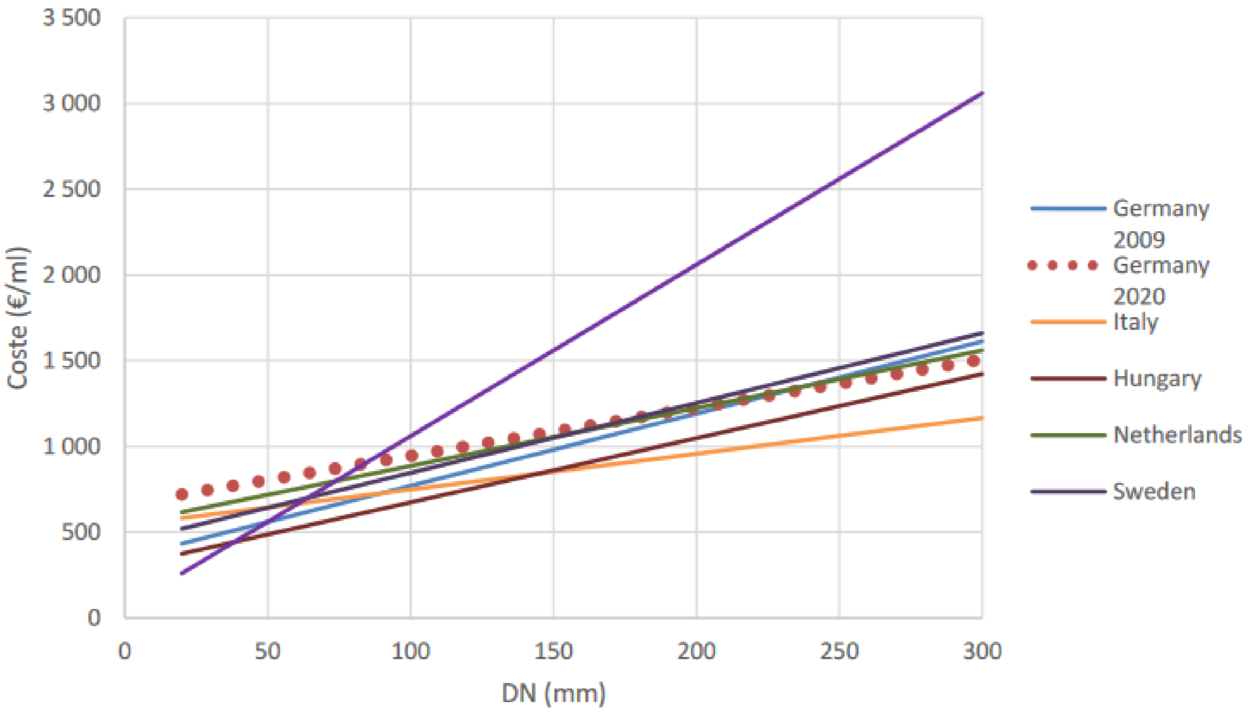


Figure 332 District heating costs in different countries. In this report the dotted line from Germany is used. The figure is taken from (Sánchez-García et al., 2022).

The aim of the analysis is to be able to identify potential district heating areas and create district heating cost curves per country to be used in the energy system analysis; in this aspect, we want to find the maximum district heating potential and then afterwards decide on how much district heating is feasible based on the energy system analysis. Therefore, in the mapping of district heating potentials, we only remove areas that would most likely never be relevant for district heating, while we keep areas that could have a potential if e.g. there are a lot of cheap heat sources.

The model identifies potential district heating areas based on two conditions: the average distribution grid costs in the area are below a predefined cost ceiling per country, and the annual heat demand in the area is above a predefined threshold. In this case, a cost ceiling of 50 €/MWh and an annual heat demand of 1 GWh to ensure that even small areas can be considered in the modelling. The model can also include different district heating connection rates, e.g., for a new district heating area starting at 0% in the beginning year and going to 80% connection rate in the end year. In this analysis, a connection rate of 88% at the start and 90% at the end of the year is assumed for all countries. This is done as the analysis aims to identify the technical potential of district heating, and using a lower connection rate would not identify the technical district heating potential.

In Figure 333 and Figure 334the three different examples of identified potential district heating areas are shown.

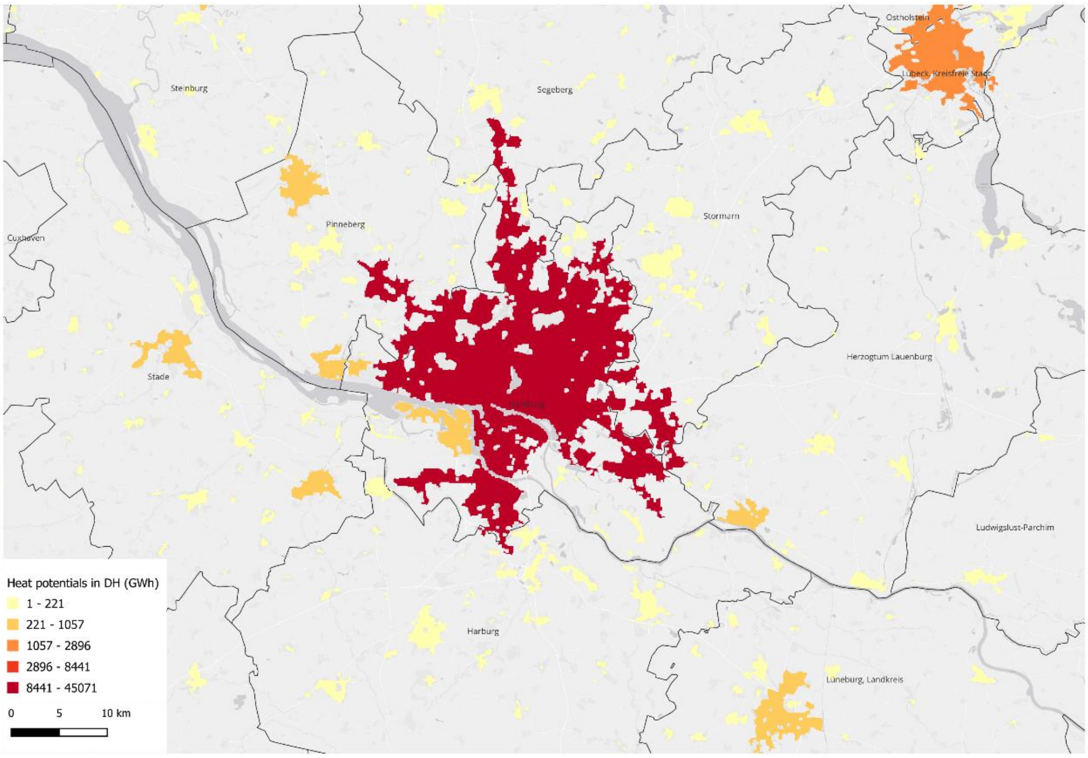


Figure 333 Identified district heating areas and heat potentials in Hamburg, Germany.

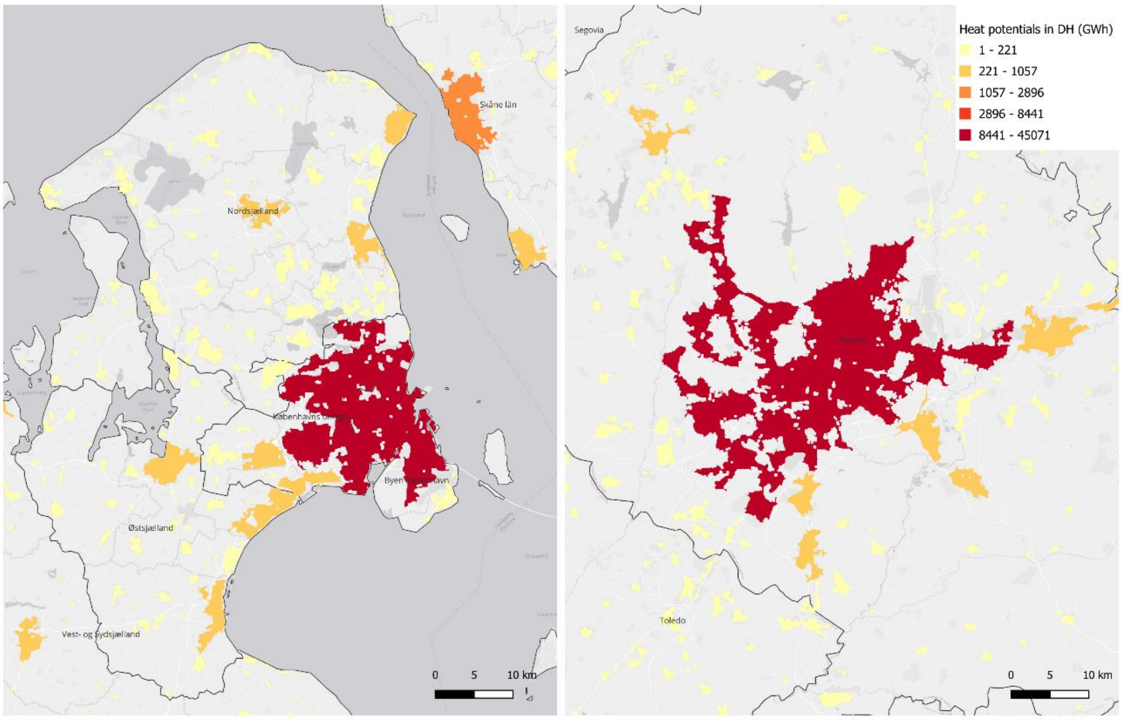


Figure 334 Identified district heating areas and heat potentials in Zealand, Denmark (left) and Madrid, Spain (right).

The original district heating model was not developed to examine the difference between 3rd and 4th-generation district heating or include heat losses. Therefore, we added these calculations to the model, so it now produces investment cost estimates and heat losses for 3rd and 4th-generation district heating. Heat loss for 3rd generation district heating was calculated using the linear heat density, calculated as the annual heat demand [GWh] divided by the district heating network length of both distribution and service pipes. The linear heat density is shown in Figure 9.

The formula from (Nussbaumer & Thalmann, 2014) was used to estimate the annual heat loss in 3rd generation district heating:

Annual heat distribution losses in [%/a] = $17 \cdot (\text{linear heat density})^{-0.5}$

As there are also other losses than the distribution losses a 5% heat loss for district heating substations and heat exchangers was added to the heat distribution loss.

Figure 9 illustrates the heat loss as a function of linear heat density, including the 5% heat loss.

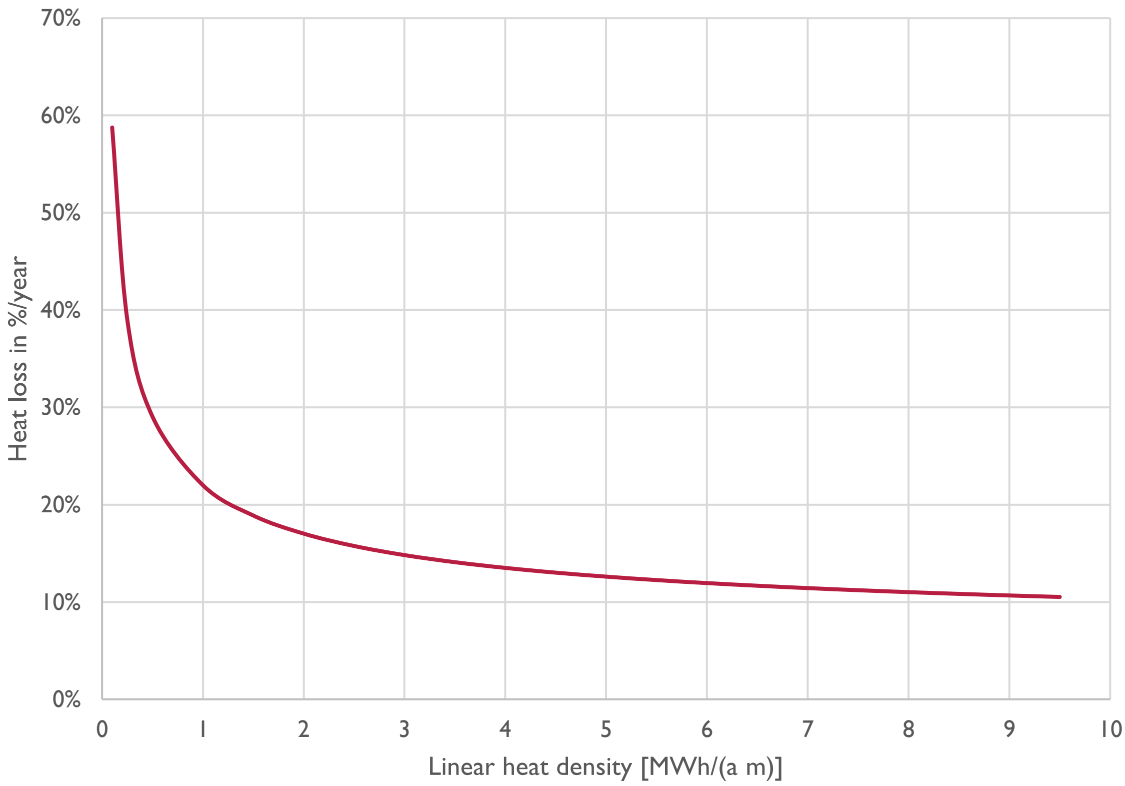


Figure 335 Heat loss as a function of linear heat density

The calculations for 4th generation district heating were done in a simplified way, based on the results from Heat Plan Denmark 2021 (Mathiesen, B. V. et al., 2021), where the 4th generation district heating heat loss was on average 3.1% lower than 3rd generation and the investment cost was on average 2.41% higher. The same averages have been applied in this model.

The output of the district heating model summarizes the heat potentials, grid investment costs and heat losses in each district heating area both for 3rd and 4th generation district heating.

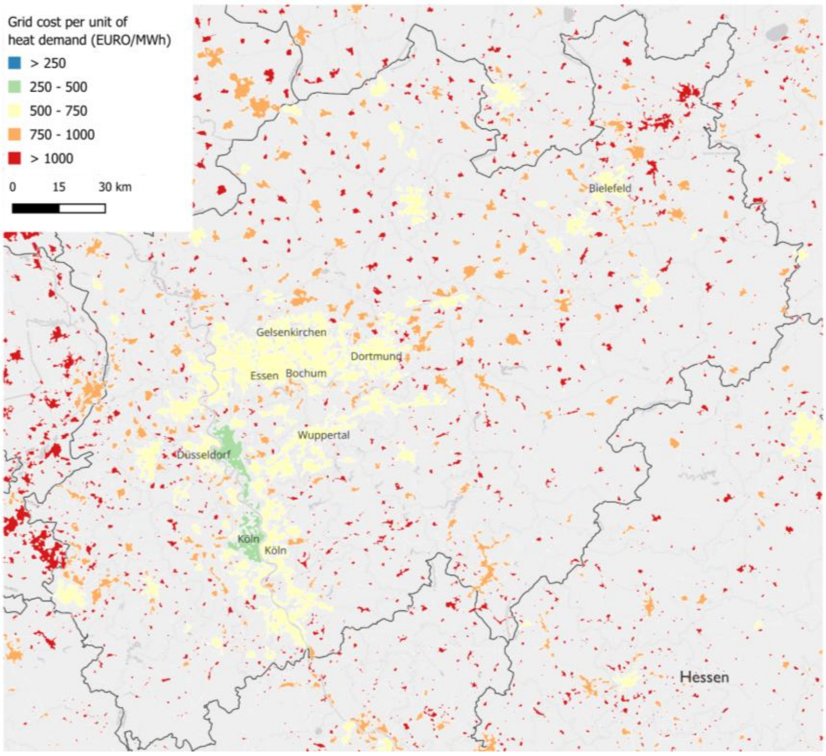


Figure 336 Mapping the grid cost per unit of heat demand in Nordrhein-Westfalen, Germany.

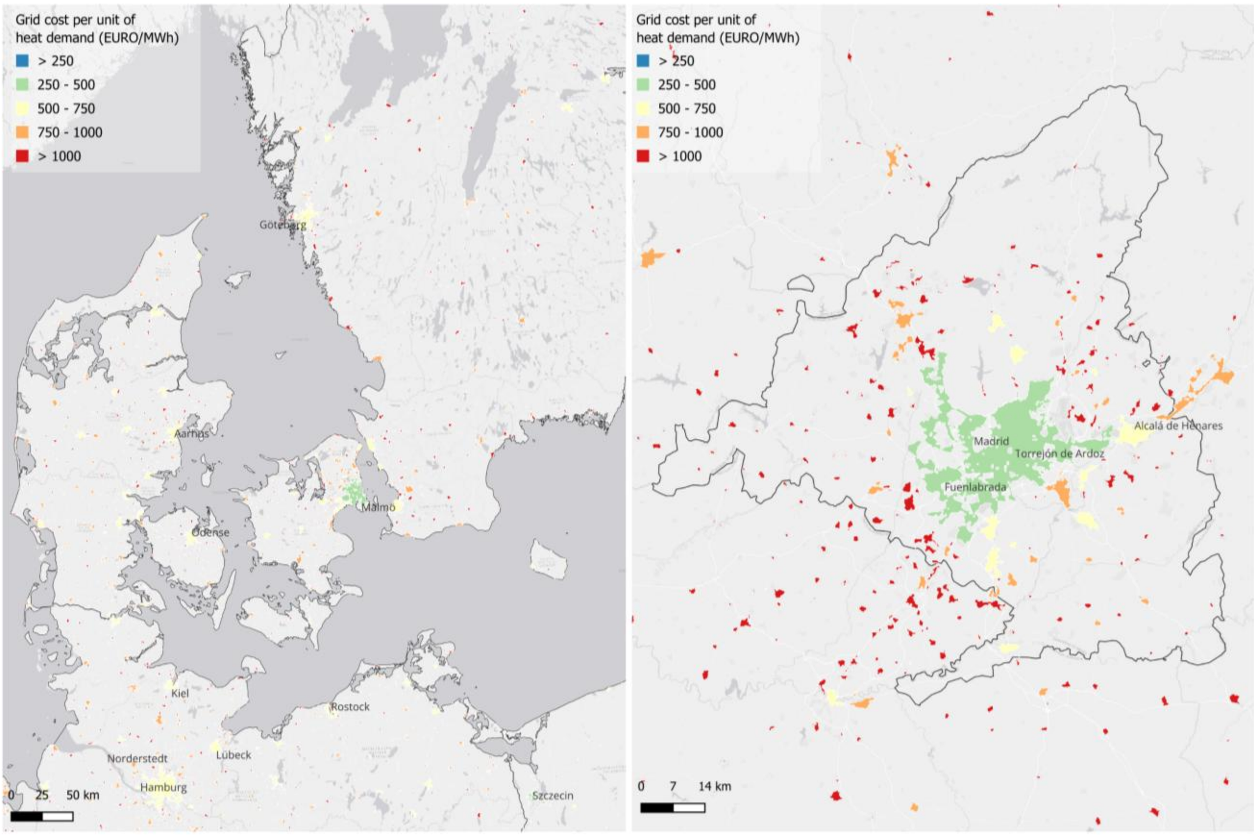


Figure 337 Grid cost per unit of heat demand in district heating systems in Denmark, southern Sweden and northern Germany (left) and Madric, Spain (right).

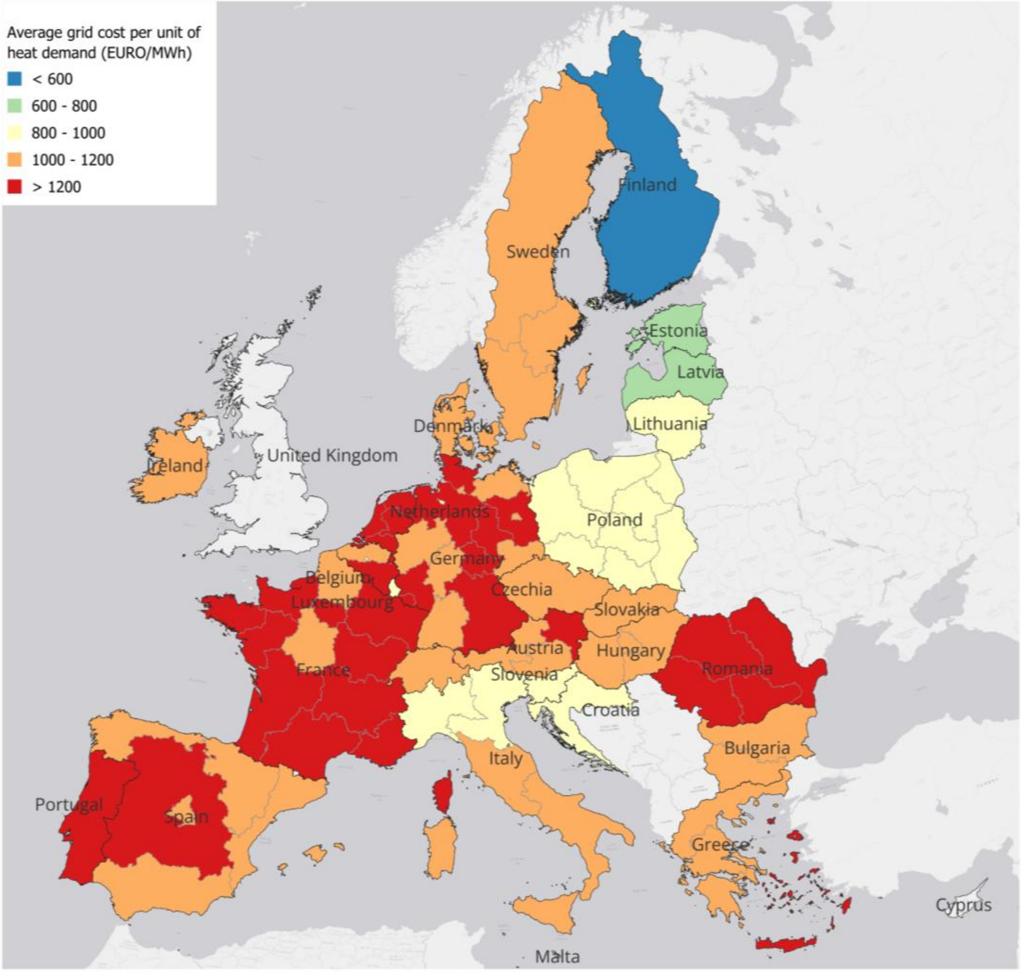


Figure 338 Grid cost per unit of heat demand aggregated at NUTS2 level as the mean of the grid cost per unit of heat demand in the district heating systems in the area.

Besides estimating the heat demand for the residential and service sectors, the district heating areas were further processed these results to include the heat demand for the industry in the corresponding district heating areas. We utilised the areas associated with industrial uses from the CORINE land cover (code 121) and distributed the national industrial heat demand (from EnergyPLAN) proportionally to the areas overlapping with the district heating areas. Section 3 shows the accumulated heat potentials in the district heating areas together with the specific energy costs for the residential and service buildings and for the industrial uses. The requirements for the formation of a district heating system are not met for Cyprus, so the district heating model does not produce the corresponding output areas.

6.3 Insights into the data of the district heating areas

Having modeled and mapped the potential district heating areas offers advantages in a comprehensive analysis of a gradual energy transition. However, these areas vary significantly in their geographic distribution, size, and capacity. For this reason, this section focuses on a holistic statistical presentation of the modeled areas and their characteristics, while section 3 takes a step further to assess the most suitable areas to prioritize based on their lower investment costs and their higher heat demand. This essentially means that the present section shows the maximum mapped and modeled potentials, while the results in the following section have been obtained after a prioritization analysis of the most suitable areas at the EU-27 level.

Section 3.1-3.3 present national summary statistics on the modeled areas and their corresponding attributes, such as heat demand (including the industrial demand), specific energy costs and total investment costs in the estimated district heating systems, (i.e., the average and median demand and costs encountered in the district heating areas of each country). Figure 12 shows the total number of the district heating areas modeled, the heat demand covered in these areas in relation to the current national district heating levels. This graph essentially shows the maximum potential of the modeled district heating areas based on the described district heating model and shows that the majority of the heat demand in most of the EU27 and United Kingdom countries can be covered by the modeled district heating areas. However, it is important to note cases such as Finland, Latvia and Estonia, where the maximum modeled potentials do not exceed or slightly exceed the current district heating levels.

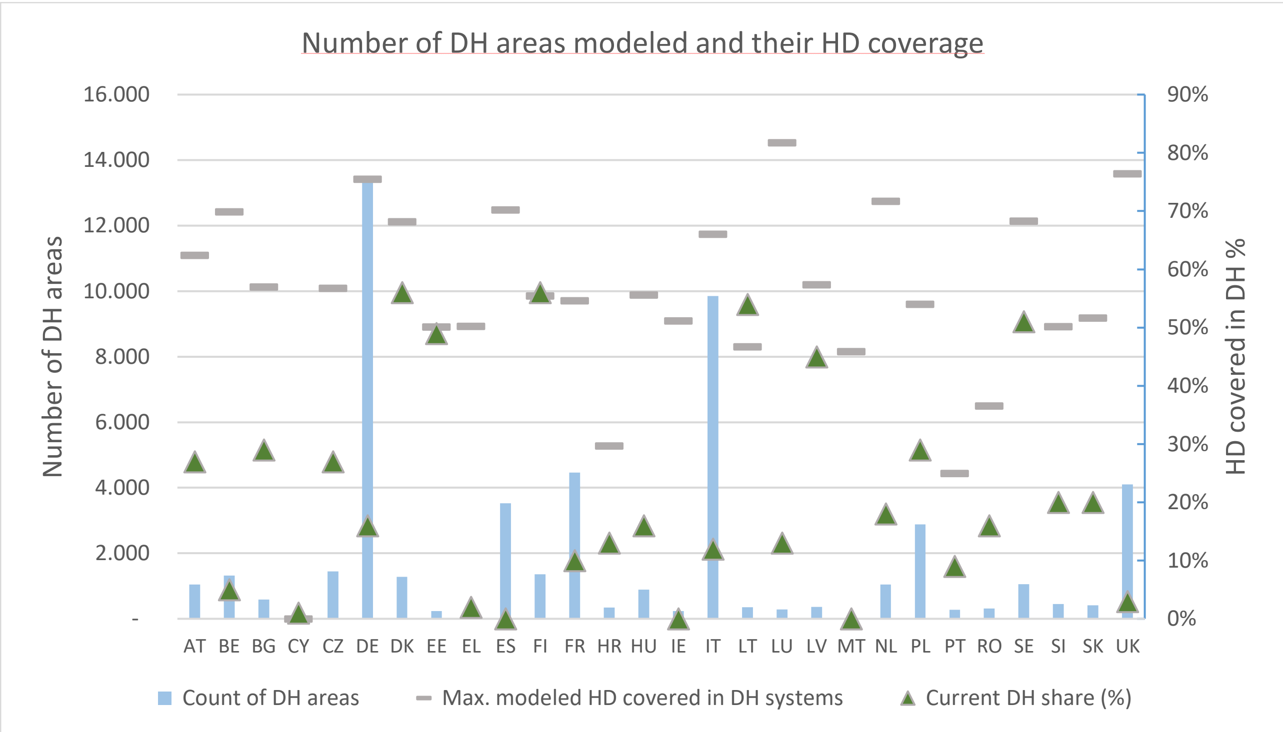


Figure 339 Number of estimated district heating areas by country and the gray linear markers show the proportion of heat demand that can potentially be covered out of the total future heat demands (incl. industrial demand). The green markers indicate the current district heating shares by country.

Specifically, based on section 3.4 and 3.5, the number of the estimated district heating systems and their coverage of total heat demand varies significantly between countries, with Malta having the smallest number of district heating systems (14 in total) covering 46% of its demand, and Italy and Germany having 9,853 and 13,435 systems, respectively, covering 66% and 75% of their annual heat demand. The capacity of individual district heating systems also varies among the countries with the largest systems found in the United Kingdom

(UK, 45.07 TWh), France (44.39 TWh) and Germany (24,56 TWh). On a national average, the largest systems are found in Malta, the Netherlands, the UK, Greece, and Ireland, while the lowest dispersion is noticed in Slovakia, Portugal, Slovenia and the Czech Republic. The low standard deviation values, where the values of heat demand in the national district heating systems are clustered closely around the mean, indicate consistent demand with relatively small fluctuations across locations and a national system with low variability, which could be easier to manage.

In terms of total investment costs, the lowest national costs per unit of heat demand are found in Malta, Finland, Latvia and Estonia. On a national average, the lowest specific energy costs are found in Latvia, Estonia, and Luxembourg (below 30 €/MWh) section 3.6 and 3.7. Again it is important to note that the results presented in this section do not respond to any proposed developments but summarize the maximum potentials of the characteristics modelled in the district heating model and represent a case where district heating would to be developed in all these areas— a case that is almost economically impossible.

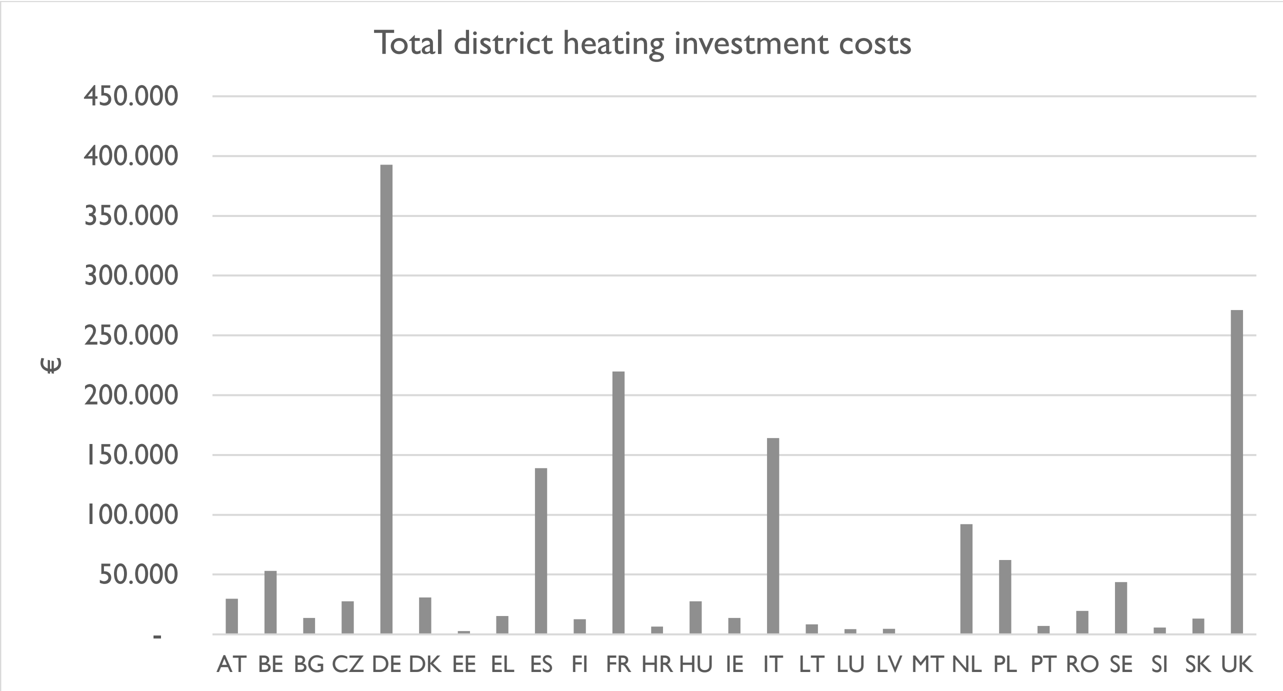


Figure 340 Total investments in district heating networks until 2050 per country.

Another aspect of the report is to estimate how many district heating systems would be required to achieve higher district heating shares. The methodology used here follows a principle tested in (Mathiesen, Brian Vad, Wild et al., 2023), which assumes that "*larger urban areas will start with more district heating systems and develop gradually into larger unified systems*". After estimating the geographic distribution and heat demand capacity of the district heating areas, the number of district heating plants required is estimated based on the volume of the heat demand in the area. Specifically, it is assumed that the district heating areas with a final heat demand of less than 10 PJ need to develop 1 district heating plant per 1 PJ, while the areas with a final heat demand between 10 -20 PJ and over 20 PJ need to develop 1 district heating plant per 2 PJ and 4 PJ, respectively.

Using this methodology, the required district heating plants have been estimated for all modeled areas and are included as a national count. As an example of the application for a city the size of Prague, 10 different district heating systems would have to be developed if district heating were to start there from nothing today. However, this assumption of the numbers of district heating systems is an approximation based on the demand of the modeled areas, while the actual number of district heating plants depends on various settings in each area. District heating cities for each country are also distinguished in relation to waste heat ratio found in section 2.2.

6.4 Assessment of district heating systems at EU level

An effective strategy for phasing out natural gas and fossil fuel imports requires a comprehensive transformation of the energy system, with increased integration of district heating at both national and EU levels. This analysis assesses the required future market shares of district heating in different countries, based on a common EU27 assessment of the district heating shares and heat network systems required to meet the 2050 targets. The assessment aggregates district heating systems across the EU27 and ranks them according to their estimated costs, with the ranking criterion defined by the ratio of specific energy costs to heat demand within each corresponding district heating area. In contrast to previous similar exercises, which prioritized areas with the lowest specific energy costs, resulting in the selection of very small areas with low heat demand first, we now incorporate the size of the area into this factor, prioritizing larger areas with high heat demand and relatively higher costs. This is a more realistic approach because investments in such small, low heat density district heating systems are not as cost-effective as the larger ones.

The systems are grouped into intervals of 5% or 10% based on the achieved heat demand shares at the EU27 level, with the heat demand covered and the associated grid costs accumulated at each successive interval. Since these estimates depend on specific geographic regions with varying heat demands and costs, and the accumulation process follows a stair-step curve rather than a smooth trend, we apply an adjusted polynomial function to fit the provided data and estimate heat demand and costs at predefined intervals. However, we acknowledge limitations at higher levels of heat demand shares, as an upper cost limit of 50 €/MWh has been set at the district heating model. This constraint restricts the creation of regions with energy costs exceeding the threshold, thereby limiting further district heating expansion, and consequently the cost estimate for shares above 70%.

The results of this analysis are presented in . This table summarizes the heat demand, the specific energy cost and the grid cost for the 3rd and 4th generation of district heating at each interval of district heating share. Specifically, the first column shows the theoretical intervals and in parentheses the intervals achieved in practice, after ranking the district heating areas by the factor that takes into account the size of the heat demand. Then, the sum of heat demand covered by the district heating areas included in each interval is given, along with the average size of these areas. Correspondingly, the average value of the specific cost of energy is given together with the total and average values of the grid costs for the 3rd and 4th generation of district heating.

Table 15 shows the number of district heating areas included in the corresponding interval, the number of unique countries included, and provides an overview of the population that could benefit from the expansion of these district heating areas in the EU27, the population density of the systems, and their sizes in square kilometers.

Taken together, these two tables provide valuable insight into the characteristics of the selected district heating areas over different intervals. An example is provided to aid interpretation. Specifically, in the first interval, only five district heating areas - Madrid, Paris, Milan, Berlin and Essen - are needed to reach a 5% district heating share, spread over four countries. To reach the next 5% (for a cumulative 10% district heating share), an additional 13 systems are estimated to be required, spread across eight countries.

The 'Heat demand [GWh]' column shows the total and average heat demand of these systems. Notably, the 13 systems required to increase the district heating coverage from 5% to 10% add approximately 4 TWh of heat demand. However, these systems have significantly lower average heat demand (10,5 TWh) - less than half that of the first five (26,6 TWh). The 'Specific cost [€/MWh]' column shows the average specific cost of the systems, indicating that areas contributing to the 5-10% range are less expensive. This comes because of the ranking factor, which serves as the basis for sorting and prioritizes areas based on their lowest specific cost per unit of heat demand. The additional columns provide population statistics based on the GHS-POP 2020 dataset, along with the average system size in square kilometers and the average national district heating shares covered within each interval. From this we can see that the firstly selected five areas are significantly larger in size and population compared to the rest of the areas selected in the following intervals.

Table 61 Suggested national level of district heating by 2030 (20% EU27), 2040 (33% EU27), and 2050 (55% EU27).

Year / EU market share / Country	2030 (20%)	2040 (33%)	2050 (55%)
Austria	26,64	38,09	53,54
Belgium	30,02	42,29	62,44
Bulgaria	11,69	25,08	48,84
CY	-	-	-
Czechia	11,05	19,00	46,81
Germany	25,99	39,45	64,60
Denmark	22,60	35,98	57,98
Estonia	23,76	32,48	44,52
Greece	24,46	31,38	46,27
Spain	23,10	40,14	61,29
Finland	23,78	34,73	49,66
France	16,41	31,45	48,35
Croatia	9,52	13,98	23,69
Hungary	11,21	26,20	46,59
Ireland	23,38	26,83	46,69
Italy	17,32	28,38	52,73
Lithuania	8,54	26,87	41,91
Luxembourg	42,74	52,77	69,02
Latvia	28,11	39,43	52,02
Malta	-	41,37	44,17
Netherlands	18,14	36,06	66,40
Poland	13,05	25,65	47,58
Portugal	-	9,26	19,09
Romania	9,01	13,25	32,89
Sweden	19,59	36,59	60,24
Slovenia	12,68	23,93	41,65
Slovakia	-	9,14	43,55
United Kingdom	26,64	38,09	53,54

While the selection process does not prioritize systems with the lowest network or specific costs, the methodology ensures that the cheapest systems in terms of cost per heat demand are selected first. These systems tend to be larger in area and serve densely populated regions with higher heat demand, maximizing the efficiency of district heating expansion.

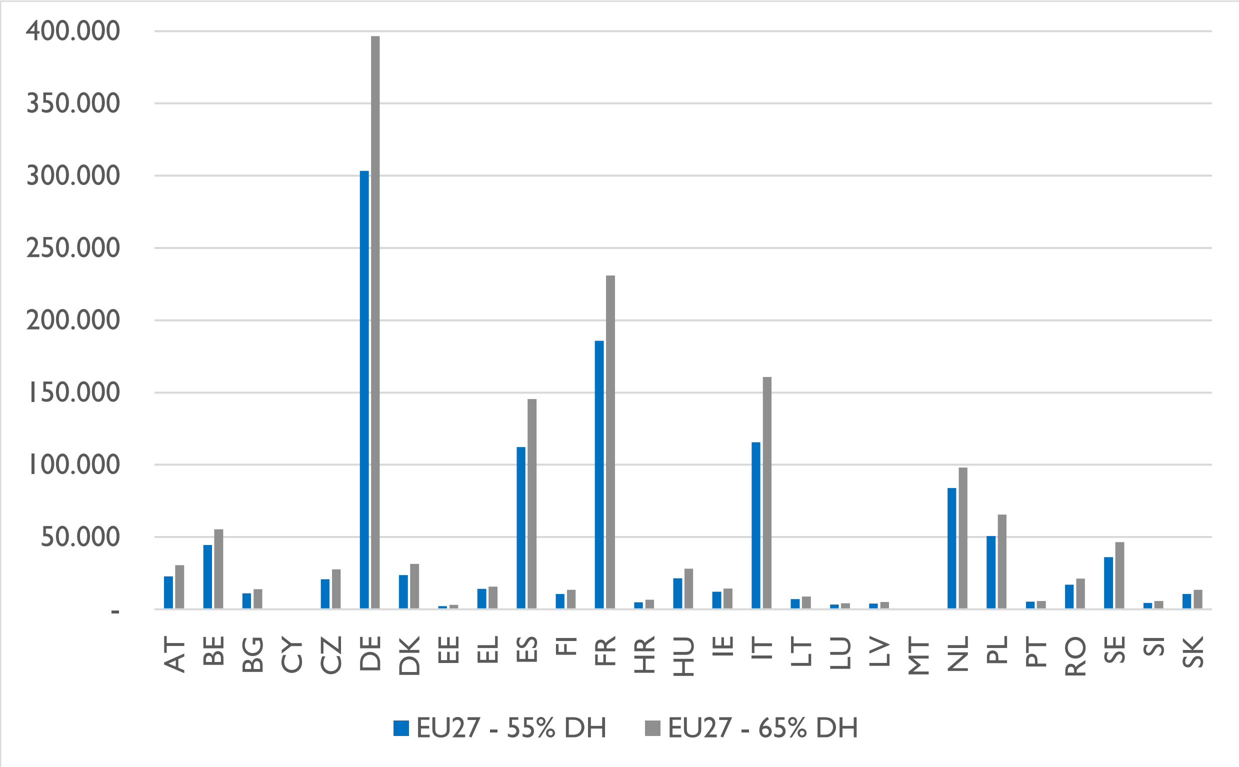


Figure 341 District heating grid cost per market share at 55% and 65%.

Having analyzed the distribution of district heating areas, heat demand values and grid costs at the individual district heating levels, the EU27 assessment follows a process of accumulated district heating shares and grid costs as presented in sections 3.6-3.7. The first table presents the national district heating shares achieved for the corresponding EU27 district heating level goals. The second table shows the associated accumulated grid costs at national level for achieving the EU27 levels. Table 2 shows the national shares of district heating suggested to be achieved by 2030, 2040 and 2050

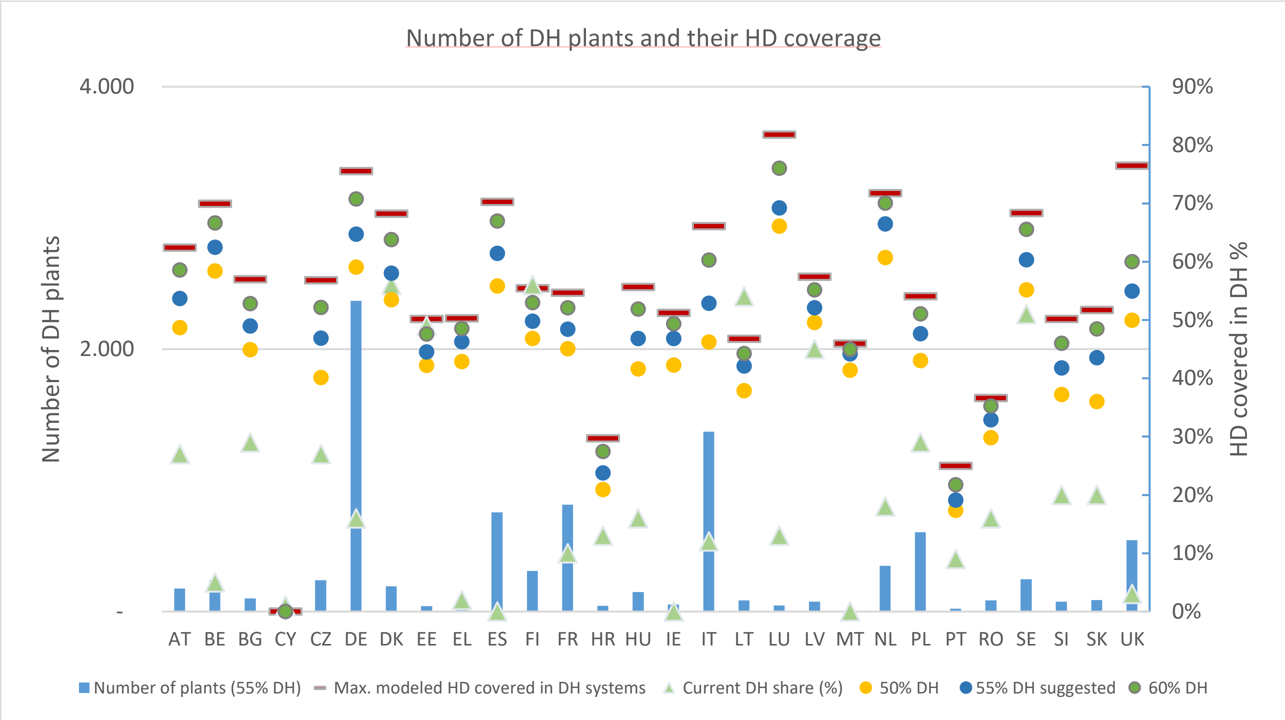


Figure 342 Number of estimated district heating plants by country at a 55% district heating EU27 level. and the gray linear markers show the proportion of heat demand that can potentially be covered out of the total future heat demands (incl. industrial demand). The green markers indicate the current district heating shares by country

6.5 Surplus and renewable heat sources

Several surplus heat sources can be used in district heating systems, either directly in the case of high and medium temperature heat sources, or in combination with heat pumps in the case of low temperature heat sources. The potential is limited to spatial availability and proximity to the district heating demand. In order to define the technical and utilization potentials of each of the sources for the district heating systems estimated, we first produce or pre-process existing datasets for the examined sources, then perform a spatial analysis and match the sources to the district heating areas, allocating their technical potentials based on an estimation of the baseload heat demand and a temperature and cost investment prioritization process. Then, the utilization potentials are calculated in several different waste heat scenarios, as described below.

6.6 Data and workflow

This appendix presents the data on waste heat potential and their spatial distribution in Europe. We have analyzed several heat sources and processed, combined or complemented existing datasets on their spatial distribution and potentials to produce a more complete dataset.

Table 2 provides an overview of the data on heat sources and details on the spatial and temporal resolution and their sources, divided into existing and potential future plants. Data on the location of existing plants has been provided by sEEnergies as point datasets together with the current waste heat potential. However, as the primary objective of this exercise was to produce datasets for the waste heat potentials in 2050, a top-down approach was followed spatially allocating national estimates for a series of waste heat sources to the estimated district heating areas. The newly estimated datasets and the production process are described below by category, including visualizations of the products. Since estimating the future locations of wastewater treatment plants, supermarkets, and metros is very challenging, we assume that their spatial distribution may change, but their technical potential will remain unchanged in the boundaries of the estimated district heating systems.

Table 62 Overview of waste heat potentials considered for district heating (DH).

Plant status and data production process	Heat source	Spatial resolution	Temporal resolution	Considered source temperature	Maximum distance from source	Data source
Existing plants Bottom-up	Waste-to-Energy (WtE)	Points	Annual	High	Intersecting DH area	sEEnergies
	Industrial waste heat high °C	Points	Annual	High	National total distributed in DH area	sEEnergies
	Industrial waste heat medium °C	Points	Annual	Medium	Intersecting DH area	sEEnergies
	Industrial waste heat low °C	Points	Annual	Low	Intersecting DH area	sEEnergies
	Wastewater	Points	Annual	Medium	Within DH area	PETA5.2
	Supermarkets	Points	Annual	Medium	Within DH area	PETA 5.2/ ReUseHeat(Moreno et al., 2022)
	Metros	Points	Annual	Low	Within DH area	PETA 5.2/ ReUseHeat
	Gasification & electrolysis	National	Annual		Non-applicable	sEEnergies/Energy PLAN

	Nuclear	Points	Annual		Proximity of DH areas/cities up to 50km radius around the points	(WNA, 2024), (IAEA, 2024) (Esri India Technologies Ltd, 2024; Nucleareurope)
Future plants Top-down	Waste-to-Energy (WtE)	Polygons	Annual	High	National total distributed in DH area	industryPLAN/ sEEnergies/ CLC
	Industrial waste heat high °C	Polygons	Annual	High	National total distributed in DH area	industryPLAN/CLC
	Industrial waste heat medium °C	Polygons	Annual	Medium	National total distributed in DH area	industryPLAN/CLC
	Industrial waste heat low °C	Polygons	Annual	Low	Within DH area	industryPLAN/CLC
	Geothermal / Hydrothermal	Polygons	Annual, baseload hours considered	GT: 2km, >90°C GT: 1km, >60°C HT: High °C HT: Low °C Neogene basins	Intersecting DH area	GeoDH(GeoDH European Geothermal Energy Council, 2024)
	Solar thermal collectors	Country	Annual, baseload hours considered		In DH areas	
	Gasification & electrolysis	National	Annual		Non-applicable	sEEnergies/Energy PLAN
	Nuclear	Points	Annual		Proximity of DH areas/cities up to 50km radius around the points	(WNA, 2024), (IAEA, 2024) (Esri India Technologies Ltd, 2024; Nucleareurope)

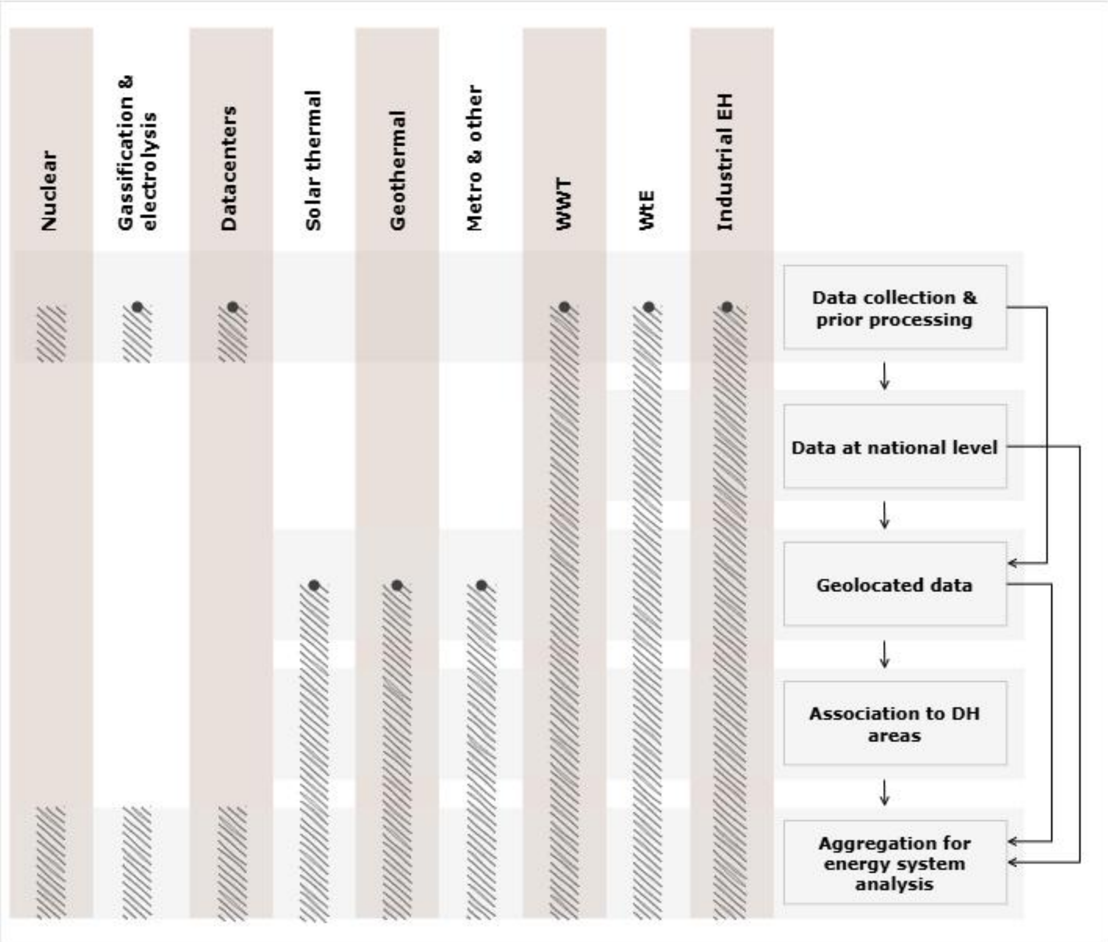


Figure 343 Workflow for surplus and renewable heat sources

6.7 Mapping future heat sources and individual technical potentials

This appendix presents the potential spatial matching of surplus and renewable heat sources to district heating areas. We have analyzed several heat sources and processed, combined or complemented existing datasets on their spatial distribution and technical potentials to produce a more complete dataset.

Table 2 provides an overview of the data on heat sources and details on the spatial and temporal resolution and their sources, divided into existing and potential future plants. Data on the location of existing plants has been provided by sEEnergies as point datasets together with the current waste heat potentials. However, as the primary objective of this exercise was to produce datasets for the waste heat potentials in 2050, a top-down approach was followed spatially allocating national estimates for a series of waste heat sources to the estimated district heating areas. The newly estimated datasets and the production process are described below by category, including visualizations of the products. Since estimating the future locations of wastewater treatment plants, supermarkets, and metros is very challenging, we assume that their spatial distribution may change, but their technical potentials will remain unchanged in the boundaries of the estimated district heating systems.

i. Waste-to-Energy (WtE) and Industrial waste heat

Point datasets of the locations and capacities of existing sources of high, medium and low temperatures were available by sEEnergies. The estimation however of the geographical distribution and potentials of future heat sources required the production of new datasets based on the already estimated district heating areas, where a top-down approach was followed. Specifically, the pre-processing approach for these different heat source datasets, spatial matching to the district heating areas and technical potentials is as follows:

Waste-to-Energy (WtE)

In general, cities with large populations ensure the economic viability of a WtE plant while also having sufficient demand for heat and electricity, which increases the efficiency of the plant through cogeneration systems. In order to identify suitable areas for the development of future WtE plants, we examined cases of different city sizes (ranging from 45,000 to 80,000) and compared their future waste heat potentials to the current WtE potentials. The results of this sensitivity analysis examined by experts led to the selection of cities of at 60,000 inhabitants.

Specifically, the process first included the estimation of the cities sizes and boundaries using the continuously inhabited grid cells from the GHS POP layer (2020). The overlapping area of industrial uses from the CORINE land cover layer was then estimated on top of the city boundaries and a factor normalizing the population and the aerial size of the industrial areas was used to downscale the national WtE potentials to the city boundaries. Figure 13 illustrates the suitable areas for WtE plants and their potential waste heat in the corresponding district heating areas of Nordrhein-Westfalen in western Germany. As the WtE areas may overlap with more than one district heating area – as shown in the case of Koln, where the large WtE area overlaps not only with the district heating area with the highest demand, but also with some of the smaller surrounding district heating areas– the allocation of the waste heat is estimated in proportion to the heat demand of each district heating area.

Industrial waste heat

Divided into three categories of high, medium and low temperature, referred to here as industry (H), industry (M), and industry (L), the annual national technical potentials are estimated by IndustryPLAN (Johannsen et al., 2023; Mathiesen, Brian Vad, Johannsen et al., 2023) and allocated directly to district heating areas. The allocation of high temperature sources follows as a primary guide the locations of the existing high temperature industrial sources, while the medium and low temperature sources were allocated in proportion to the size of areas characterized by industrial uses in the CORINE land cover layer overlapping with district heating areas. Figure 14, Figure 15, and Figure 16 present examples of the distribution and size of the different categories of industrial waste heat in the estimated district heating systems in Germany and the Netherlands.

Other low and medium temperature waste heat sources

Point datasets for WWT plants, supermarkets, and metros are provided from PETA5.2 and the ReUseHeat project. Figure 16 (right) and Figure 17 show the distribution of these medium and low waste heat sources in the Netherlands and Czech Republic. Their potential technical volume of waste heat was allocated to the district heating areas by spatial intersection.

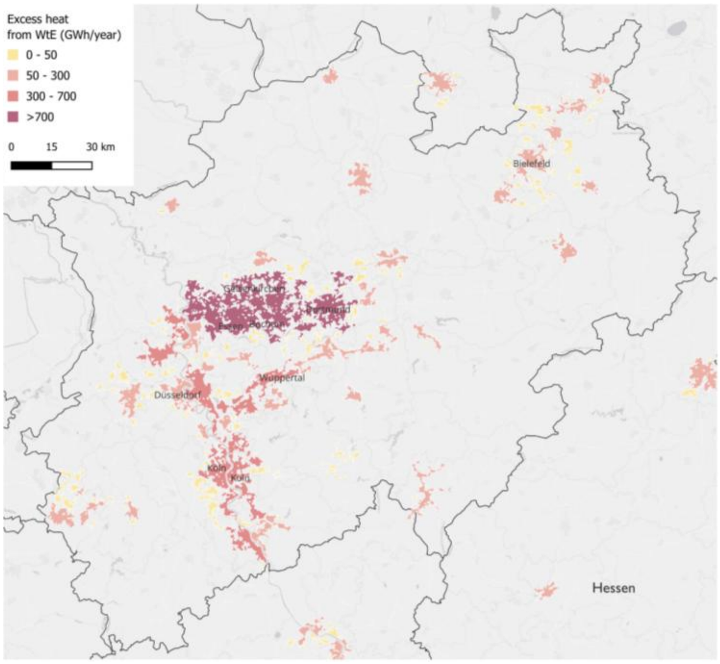


Figure 344 Waste heat from WtE in district heating areas in Nordrhein-Westfalen, Germany.

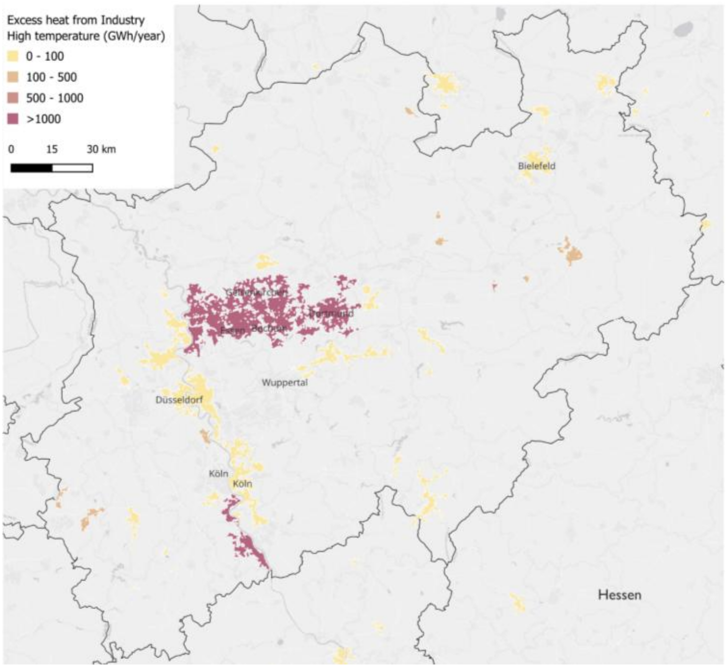


Figure 345 High temperature industrial waste heat in district heating areas in Nordrhein-Westfalen, Germany.

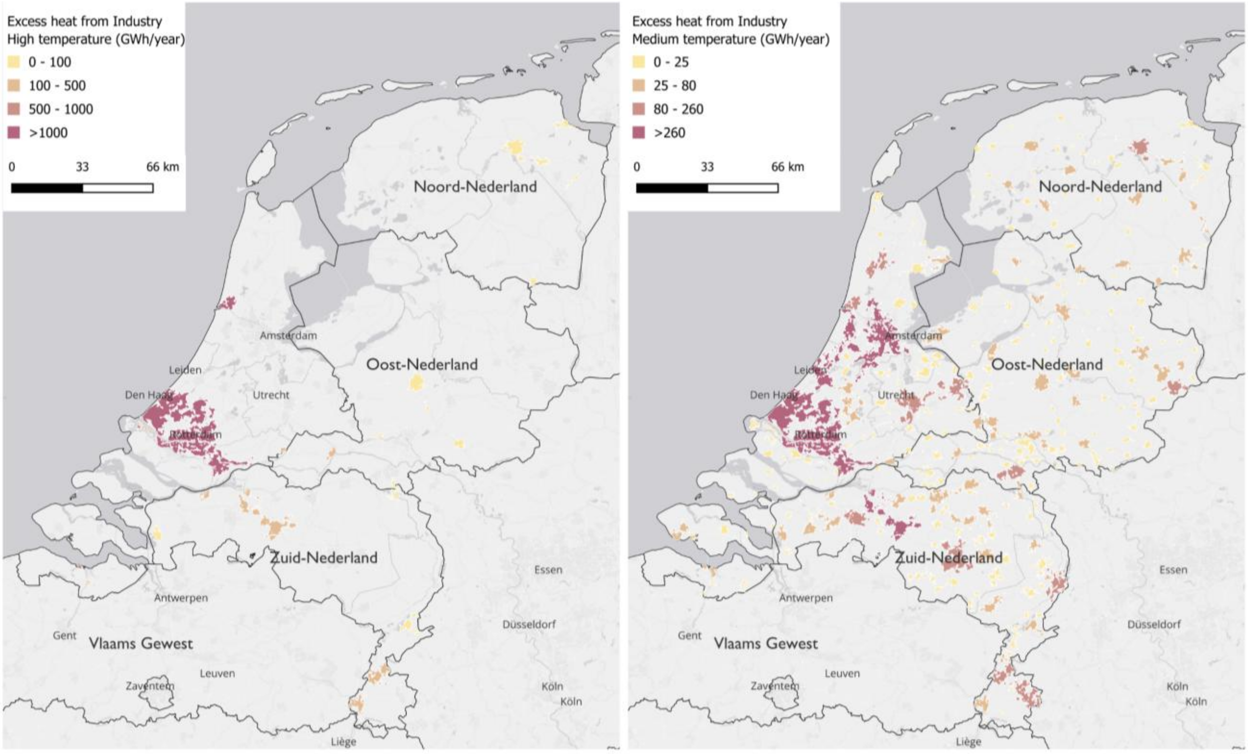


Figure 346 Industrial waste heat of high and medium temperatures in district heating areas in the Netherlands.

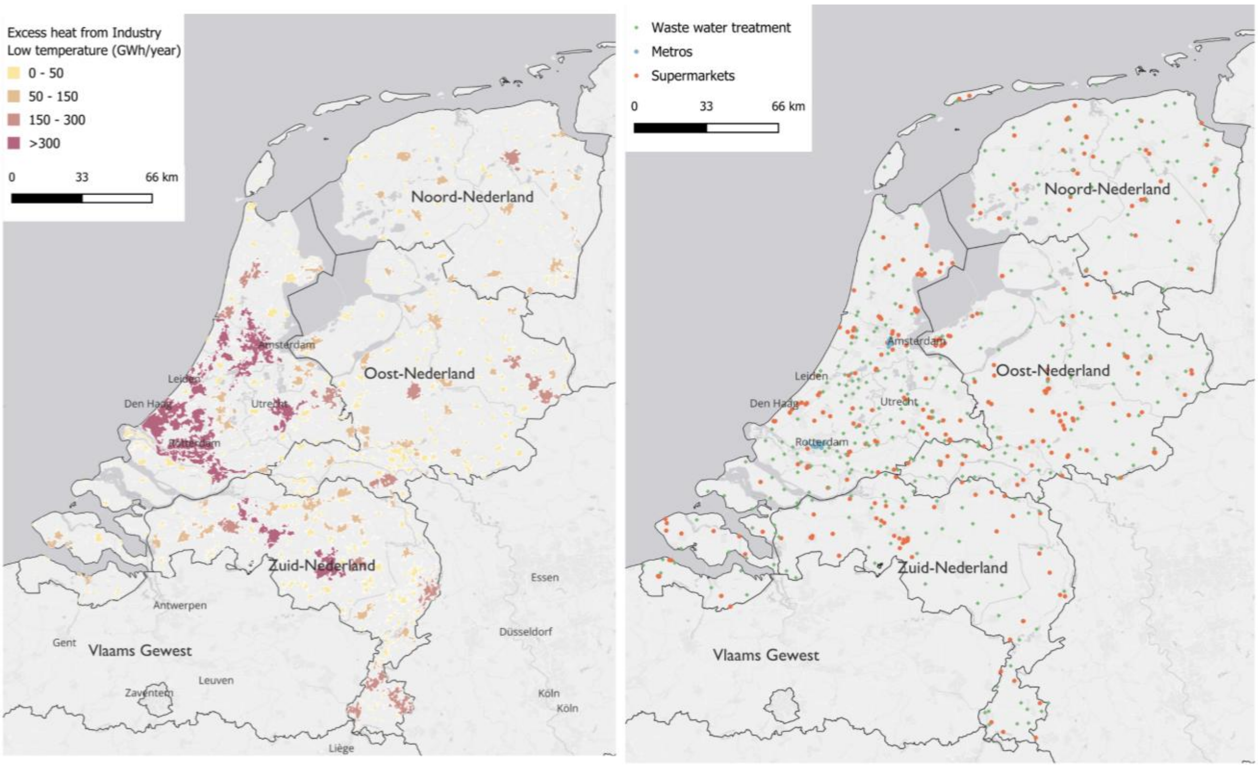


Figure 347 Low temperature excess heat in district heating areas in the Netherlands

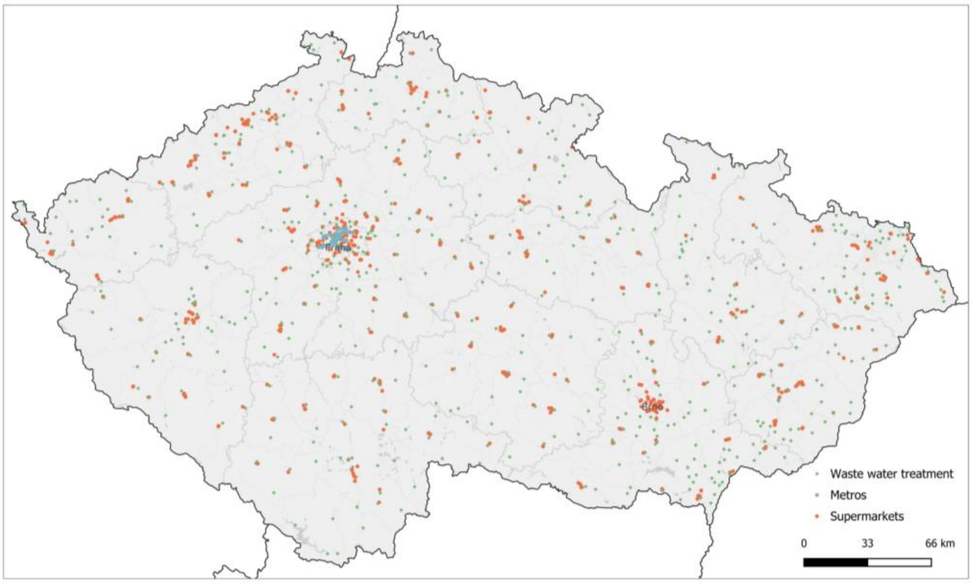


Figure 348 Distribution of heat sources of low and medium temperatures in Czech Republic.

ii. Geothermal and solar thermal energy

The full potential of geothermal energy is estimated proportionally to the population and the heat demand allocated in areas with geothermal resources.

Since the technical potentials of geothermal and solar thermal energy cannot be assessed in the same way as the above industrial and non-industrial sources - since their feasibility is not strictly limited by the location of existing industrial activities - the estimation approach for these sources is instead based on the evaluation of the baseload heat demand within each district heating area. Consequently, we first estimate the share of heat demand from residential and service buildings required for hot water. This is set at 20% of the heat demand for all countries except the southern European countries (i.e. Cyprus, Greece, Malta, Portugal) where it is set at 25%. The hot water demand is calculated by adjusting the district heating demand with the industrial heat demand within the district heating areas, multiplied by the above share. Finally, the base load heat demand is estimated by summing the district heating losses, estimated by district heating model, the hot water demand and the industrial heat demand within the district heating areas and then applying a factor of 1.1 to account for additional load considerations.

Regarding geothermal potentials, primary layers on areas suitable for hydrothermal and geothermal heat are retrieved from GeoDH map including also areas of Neogene basins. Due to the uncertainty of the accuracy of these layers and in order to keep track of the potential of the different types and sources of geothermal energy, six different categories/ layers were created and processed in the technical and utilization waste heat analysis. These categories are high and low temperature geothermal energy (hereof mentioned as Geo1, Geo 2), high and low temperature hydrothermal energy (referred to as Geo3, Geo 4), additional high and low temperature geothermal and hydrothermal areas (referred to as Geo5) and Neogene basins (referred to as Geo6). Figure 349 shows the distribution of the different types of geothermal energy in Europe.

The estimation of the technical potential of geothermal sources for each district heating system is based on the spatial intersection of the district heating system with the identified areas of geothermal potential and the assignment of the base load heat demand, assuming that the maximum heat demand of the system can be met by the appropriate geothermal sources. An additional criterion for estimating geothermal energy has been introduced based on the size of the district heating system, as investments in geothermal potential are not recommended in small district heating systems due to their high cost. This criterion involves systems of minimum 40MW and 70MW capacity base load. The capacity is estimated as the base load per number of hours in a year. Table 23 presents the technical potentials by category of geothermal source when the restriction of 70MW is implemented at the size of the cities. The Data report includes the table for the corresponding potentials when the restriction of 40MW is implemented.

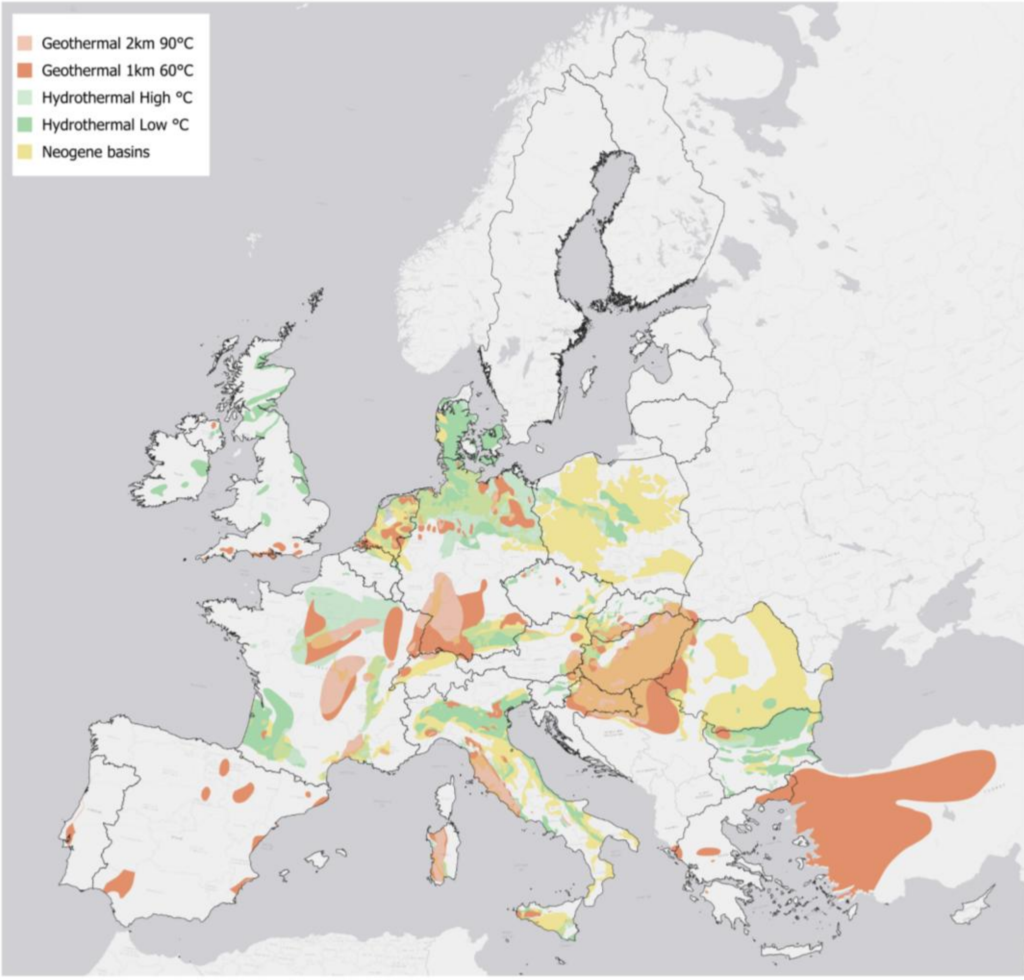


Figure 349 Areas of geothermal potentials in Europe.

Table 63 Technical potentials in TWh of different types of geothermal sources in the district heating systems of minimum capacity of 70MW of each country.

Country	heat	High temp. geothermal (Geo1)	Low temp. geothermal (Geo2)	High temp. hydrothermal (Geo3)	Low temp. hydrothemal (Geo4)	Additional high/low temp. geothermal and hydro-thermal (Geo5)	Neogene basins (Geo6)
Austria		1,32	5,27	2,55	-	8,95	-
Belgium		-	-	4,80	4,80	4,80	-
Bulgaria		-	-	-	1,80	-	-
Czechia		-	-	-	0,76	1,55	-
Germany		14,07	21,77	38,29	19,39	44,96	0,72
Denmark		-	-	-	6,99	1,27	5,73
Estonia		-	-	-	-	-	-
Greece		-	-	-	-	-	-
Spain		-	11,63	-	-	-	-
Finland		-	-	-	-	-	-
France		4,28	2,50	36,09	7,38	10,55	-
Croatia		1,41	1,41	-	-	1,41	-
Hungary		4,02	4,02	-	-	4,02	-
Ireland		-	-	-	5,43	-	5,43
Italy		4,28	10,05	9,48	19,91	24,41	3,96
Lithuania		-	-	-	-	-	-
Luxembourg		-	-	-	-	-	-
Latvia		-	-	-	-	-	-
Malta		-	-	-	-	-	-
Netherlands		-	7,14	17,64	9,20	17,64	0,81
Poland		-	-	0,73	1,31	7,96	-
Portugal		-	1,35	-	-	-	-
Romania		-	-	-	2,34	2,34	2,34
Sweden		-	-	-	-	-	-
Slovenia		-	-	-	-	-	1,27
Slovakia		-	0,88	0,88	0,88	0,88	-
United Kingdom		-	26,45	-	-	-	6,03
EU27		29,38	66,04	110,46	80,19	130,73	20,26

Table 64: Technical potentials in TWh of different types of geothermal sources in the district heating systems of minimum capacity of 40MW of each country.

Country	High temp. geothermal (Geo1)	Low temp. geothermal (Geo2)	High temp. hydrothermal (Geo3)	Low temp. hydrothemal (Geo4)	Additional areas (Geo5)	Neogene basins (Geo6)
Austria	1,32	5,63	3,34	-	9,74	-
Belgium	-	-	4,80	4,80	5,58	-
Bulgaria	-	-	-	2,83	1,04	0,43
Czechia	-	-	-	0,76	1,55	-
Germany	17,78	24,45	41,66	20,40	47,75	0,72
Denmark	-	-	0,54	7,38	1,27	6,12
Estonia	-	-	-	-	-	-
Greece	-	-	-	-	-	-
Spain	-	12,86	-	-	-	-
Finland	-	-	-	-	-	-
France	5,15	4,44	39,97	8,58	13,25	0,97
Croatia	1,41	1,41	-	-	1,41	-
Hungary	5,67	4,02	0,41	-	5,67	-
Ireland	-	-	-	5,43	-	5,43
Italy	4,71	11,09	10,52	23,67	27,50	5,85
Lithuania	-	-	-	-	-	-
Luxembourg	-	-	-	-	-	-
Latvia	-	-	-	-	-	-
Malta	-	-	-	-	-	-
Netherlands	0,85	11,28	21,85	9,63	25,99	1,38
Poland	-	-	0,73	1,68	9,84	-
Portugal	-	1,35	-	-	-	-
Romania	-	0,37	-	2,34	3,47	2,34
Sweden	-	-	-	-	-	-
Slovenia	-	0,53	-	-	0,53	1,27
Slovakia	0,45	1,33	1,33	0,88	1,33	-

Correspondingly, given the national hourly solar thermal distribution, a solar factor is estimated as the fraction of the sum of the hourly distributions by the maximum. The solar factor is then multiplied by the hourly base load to obtain the solar thermal capacity per district heating area.

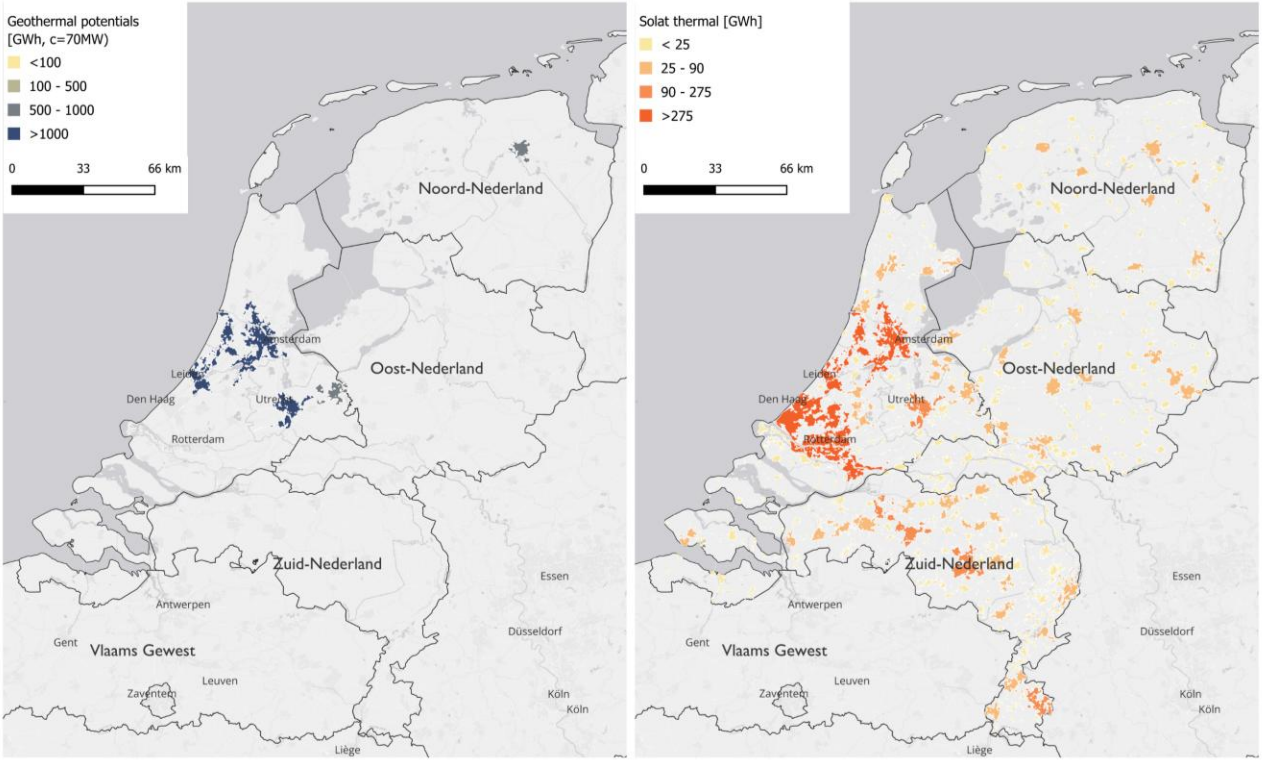


Figure 350 Geothermal (left) and solar (right) potentials in the Netherlands.

iii. Nuclear energy

Nuclear energy is an important but controversial part of the energy mix. In order to form a holistic overview of the sources and capacities of surplus heat, we also examined the distribution of nuclear powerplants in Europe. For the assessment of the technical potentials of nuclear energy being used in district heating systems, we downscaled the national estimates retrieved from the World Nuclear Association's (WNA, 2024) and the International Atomic Energy Agency's databases (IAEA, 2024) based on the point datasets retrieved from Nucleareurope and (Esri India Technologies Ltd, 2024; Nucleareurope).

The allocation of national estimates of the net capacity of the plants is based on the gross power of the plants while the technical potentials are estimated on the assumption that 66% of the waste heat could potentially be used in nearby district heating grids. For each nuclear power plant, the closest city with a population exceeding 45,000 was identified. If a city was located within a 50 km radius of a power plant, the share of the heat demand that could be supplied by the powerplant was estimated (Table 4). In cases where no large city (with population larger than 45,000) fell within the 50 km radius, the potential heat coverage was estimated for the modelled district heating areas—irrespective of size and cost—within the same radius. These outcomes are shown on Table 65 and as brown plant symbols on the map on Figure 351.

From these tables, it becomes evident that the surplus heat of nuclear power plants based on their current capacities could sufficiently cover the heat demand of nearby district heating systems. Some important remarks should be made though on the basis of the above tables and analysis. First, in the case of Cattenom in France and Krško NPP in Slovenia, their close distance to the national borders highlights the potential of providing heat potentials to cities in neighboring countries, as in the case of Schifflange in Luxembourg and Zagreb in Croatia. However, if this cross-border cooperation is not feasible, the distance from the Krško nuclear power plant to Ljubljana is above the threshold set at 79 km, while its low capacity, providing less than 12% of the district heating demand in either Zagreb or Ljubljana, makes it potentially not a suitable source for district heating.

A second note that should be made is about the plants that are not directly connected to a large city at a distance lower than 50km. In this case, and if the 50 km threshold is not strictly to be implemented, another 6 out of the 9 remaining plants have a distance between 50-70 km from a large city, which with their current capacities could cover an extension over 45% of the cities' district heating demand (e.g. Pauel - Le Havre (52km); Belleville - Chalette-sur-Loing (56km); Kozloduy - Vratsa (62km); Penly - Rouen (62km)).

Table 65 Relation of nuclear power plant to their closest city of at least 45000 inhabitants and the heat demand covered by the technical potentials of the plant.

Powerplant	Country	Closest city	Distance (km)	Share of heat covered by NPP 2023 (%)	Share of heat covered by NPP 2050 (%)
Tihange	Belgium	Huy	1,06	486,31	-
Blayais	France	Perigueux	7,79	552,36	-
Gravelines	France	Dunkirk	14,65	232,51	-
Bohunice Nuclear Power Plant	Slovakia	Trnava	15,16	119,17	-
Doel	Belgium	Beveren	17,69	101,64	-
Saint-Alban	France	Rive-de-Gier	18,49	271,05	-
Golfech	France	Agen	19,44	295,46	295,46
Cattenom	France	Schifflange (LU)	21,83	151,60	75,80
		Metz (FR)	23,00	84,96	42
Flamanville	France	Cherbourg	21,96	202,13	123,86
Saint-Laurent	France	Blois	23,29	207,47	-
Temelín	Czech Republic	Ceske Budejovice	23,60	123,72	123,72
Civaux	France	Poitiers	27,61	200,03	200,03
Mochovce Nuclear Power Plant	Slovakia	Nitra	28,16	105,76	219,82
Vandellòs Nuclear Power Plant	Spain	Tarragona	29,93	39,55	-
Olkiluoto	Finland	Pori	33,00	137,16	75,16
Bugey	France	Lyon	33,35	22,57	-
Dampierre	France	Chalette-sur-Loing	33,82	578,15	-
Cruas	France	Bourg-les-Valence	34,08	185,13	-
Loviisa	Finland	Kotka	34,19	112,76	-
Dukovany	Czech Republic	Brno	35,98	42,22	-
Chooz	France	Charleville-Mezieres	37,15	359,62	359,62
Krško Nuclear Power Plant	Slovenia	Zagreb (HR)	39,56	10,63	-
		Ljubliana (SL)	79,31	11	-
Borssele	Netherlands	Bergen op Zoom	40,11	56,91	-
Tricastin	France	Avignon	41,59	166,22	-
Chinon	France	Tours	42,30	132,03	-
Paks Nuclear Power Plant	Hungary	Dunaujvaros	43,06	315,30	-
Ascó Nuclear Power Plant	Spain	Reus	45,41	203,84	-
Nogent	France	Troyes	47,73	174,77	-
Cernavodă Nuclear Power Plant	Romania	Constanta	48,12	142,97	142,97
Trillo Nuclear Power Plant	Spain	Guadalajara	49,20	100,74	-

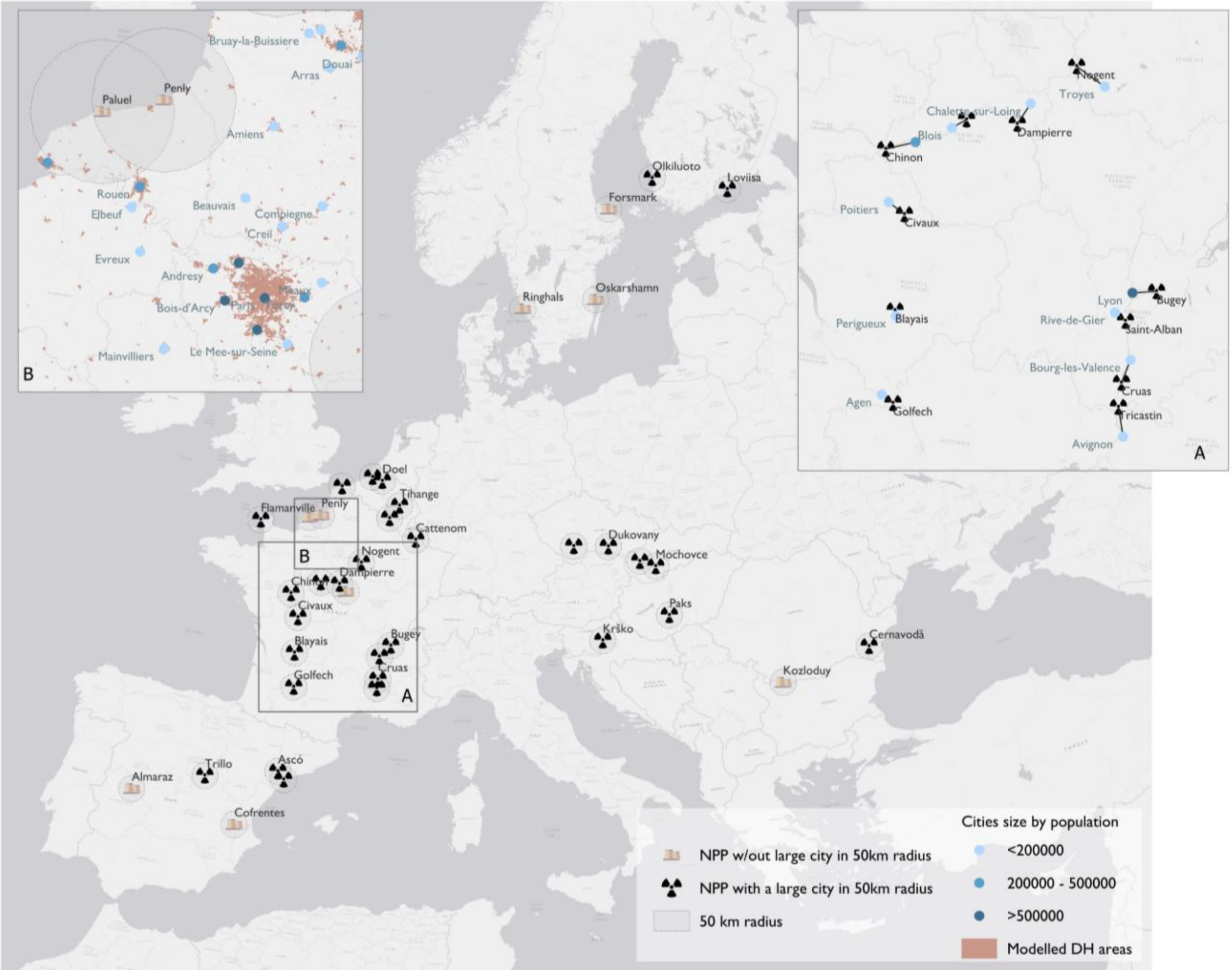


Figure 351 The distribution of nuclear power plants in Europe based on their spatial match to large cities.

Table 66 Relation of nuclear power plant to their closest modeled district heating areas and the heat demand covered by the technical potentials of the plant.

Power plant	Country	Number of countries with district heating areas in 50km radius OF NPP	Number of district heating areas in 50km radius of NPP	Share of heat covered by NPP 2023 (%)	Share of heat covered by NPP 2050 (%)
Ringhals Nuclear Power Plant	Sweden	1	29	16,39	-
Paluel	France	1	40	45,82	-
Belleville	France	1	19	391,80	-
Cofrentes Nuclear Power Plant	Spain	1	52	48,12	-
Kozloduy	Bulgaria	2	36	230,59	118,24
Penly	France	1	22	210,25	105,13
Forsmark Nuclear Power Plant	Sweden	1	18	546,73	-
Almaraz Nuclear Power Plant	Spain	1	37	163,30	-
Oskarshamn Nuclear Power Plant	Sweden	1	12	132,98	-

6.8 Summary of full and technical potentials of waste heat sources

This appendix presents the full and the technical potentials at 55% of market share.

Table 67 Full potentials of waste heat by country.

	WTE [TWh]	Industry H [TWh]	Industry M [TWh]	WWT [TWh]	Supermarkets [TWh]	Industry L [TWh]	Food production [TWh]	Metro stations [TWh]	Full geothermal [TWh]	Solar thermal [TWh]
Austria	2,64	5,55	6,88	5,75	1,51	12,72	0,02	0,22	42,96	5,30
Belgium	3,28	6,54	8,27	3,23	1,07	16,12	0,21	0,23	17,13	7,87
Bulgaria	2,02	2,15	2,54	2,15	0,15	4,25	0,00	0,13	22,24	2,65
Cyprus	0,26	0,28	0,34	0,29	0,03	0,45	-	-	1,61	
Czechia	2,37	5,00	6,09	3,92	0,57	9,07	0,01	0,21	6,59	4,76
Germany	35,37	34,73	43,09	46,07	10,80	81,23	0,46	1,34	0,41	63,75
Denmark	2,18	3,32	3,84	3,12	1,11	5,38	0,14	0,04	3,44	4,85
Estonia	0,84	0,71	0,86	0,64	0,09	1,30	0,01	-	-	0,65
Greece	1,88	12,82	13,89	3,10	0,15	16,90	0,00	0,23	9,89	2,91
Spain	12,01	20,24	24,13	17,83	2,10	38,44	0,17	2,15	165,11	27,77
Finland	3,89	4,15	5,25	3,32	0,54	12,18	0,08	0,06	32,65	3,95
France	25,12	23,12	28,13	25,13	4,11	46,73	0,50	2,19	-	32,20
Croatia	0,52	1,86	2,17	1,12	0,27	3,07	0,01	-	18,24	1,30
Hungary	1,85	2,00	2,46	3,75	1,04	4,82	0,03	0,22	51,70	4,54
Ireland	2,07	5,83	6,34	1,85	0,30	8,69	0,28	-	8,38	2,20
Italy	10,24	21,02	25,25	22,50	1,39	43,48	0,08	1,25	248,24	34,32
Lithuania	0,42	0,48	0,62	1,23	0,46	1,27	0,02	-	19,77	1,41
Luxembourg	0,21	0,64	0,73	0,27	0,05	1,05	0,00	-	0,00	0,88
Latvia	0,37	0,82	0,96	0,60	0,14	1,32	0,00	-	18,50	1,12
Malta	0,08	0,03	0,03	0,12	0,01	0,04	-	-	-	0,78
Netherlands	8,80	6,72	8,54	7,45	0,28	17,84	0,33	0,11	110,29	11,14
Poland	4,63	11,61	14,15	15,14	2,28	24,94	0,16	0,11	146,13	11,07
Portugal	1,69	4,16	5,05	3,07	0,79	8,47	0,02	0,32	13,51	1,17
Romania	3,05	3,27	4,13	4,87	0,66	7,40	0,02	0,22	3,79	2,81
Sweden	6,01	4,81	5,90	4,58	0,61	12,65	0,05	0,18	28,84	6,24
Slovenia	0,29	1,47	1,64	0,62	0,33	2,24	0,00	-	9,90	1,50
Slovakia	1,11	2,26	2,81	1,52	0,46	4,50	0,00	-	17,97	2,09
EU27	133,20	185,60	224,09	183,25	31,32	386,54	2,60	9,21	997,27	239,22

Table 68 Technical potentials at 55% market share.

	WTE [TWh]	Industry H [TWh]	Industry M [TWh]	WWT [TWh]	Supermarkets/Food retail	Industry L [TWh]	Metro stations [TWh]	Solar thermal [TWh]	Geothermal [TWh,	Geothermal [TWh,
Austria	2,61	2,68	4,42	3,29	0,82	7,90	0,22	2,70	9,74	8,95
Belgium	1,85	2,63	5,94	2,80	0,79	11,38	0,23	4,28	5,58	4,80
Bulgaria	1,97	0,53	0,54	0,37	0,12	0,90	0,13	1,38	2,83	1,80
Czechia	2,25	1,33	2,45	2,61	0,43	3,65	0,19	2,31	1,55	1,55
Germany	34,40	16,02	26,87	29,44	7,88	50,53	1,33	32,51	70,29	61,43
Denmark	2,09	0,87	2,67	2,63	0,64	3,74	0,04	2,47	7,92	6,99
Estonia	0,80	-	0,12	0,10	0,03	0,18	-	0,35	-	-
Greece	1,83	2,26	2,41	2,27	0,05	2,84	0,23	1,62	-	-
Spain	11,68	6,04	12,24	12,77	1,74	19,33	2,14	14,54	12,86	11,63
Finland	3,77	0,88	1,66	1,41	0,19	3,86	0,05	2,17	-	-
France	21,80	5,65	14,80	16,60	2,13	24,57	2,19	17,42	49,46	42,38
Croatia	0,49	0,18	0,43	0,37	0,14	0,60	-	0,63	1,41	1,41
Hungary	1,80	0,33	0,84	2,91	0,66	1,65	0,21	2,28	5,67	4,02
Ireland	2,05	-	4,00	1,53	0,15	5,49	-	1,24	5,43	5,43
Italy	8,85	4,79	7,51	10,73	0,78	12,78	1,17	15,93	32,95	28,37
Lithuania	0,41	0,11	0,18	0,48	0,34	0,37	-	0,76	-	-
Luxembourg	0,21	0,62	0,57	0,25	0,05	0,80	-	0,45	-	-
Latvia	0,36	0,11	0,21	0,17	0,09	0,29	-	0,62	-	-
Malta	0,08	-	0,01	-	0,00	0,02	-	0,48	-	-
Netherlands	8,68	3,06	6,66	6,26	0,22	13,88	0,11	6,37	25,99	17,64
Poland	4,32	1,06	3,65	5,97	1,50	6,28	0,10	5,85	10,57	8,69
Portugal	0,88	0,28	0,37	0,96	0,14	0,63	0,28	0,55	1,35	1,35
Romania	2,90	0,69	0,62	2,55	0,44	1,11	0,20	1,55	3,47	2,34
Sweden	4,70	1,72	3,53	3,26	0,34	7,53	0,18	3,32	-	-
Slovenia	0,28	0,29	0,99	0,37	0,23	1,35	-	0,75	1,80	1,27
Slovakia	1,10	0,48	1,25	0,83	0,29	2,00	-	1,02	1,33	0,88
EU27	122,18	52,65	104,97	110,94	20,18	183,65	8,99	123,58	250,19	210,93

6.9 Prioritization pathways for waste heat sources in district heating systems

After ensuring the spatial matching of future heat sources and their technical potentials to the estimated district heating systems, a scenario-based prioritization analysis is investigated. Specifically, the process of estimating the utilization potential of each waste heat source by scenario involves the sequential allocation of heat demand from different sources along with the assessment of the remaining base load heat demand. For example, if waste heat from waste incinerators is allocated first, followed by each subsequent source (e.g., high and medium temperature industrial heat, WWT, supermarkets, metros), the waste heat from these sources is assessed to determine if the remaining base load heat demand can accommodate the full potential of the source. If so, the full potential is allocated, otherwise the remaining baseload capacity is allocated. This continues for all sources considered in the scenario, ensuring that the total allocated potential does not exceed the baseload heat demand and that all sources are prioritized in the order given. An exception is considered for the solar thermal potentials, which are estimated independently of the prioritization of other sources as the total technical potentials for two different cases - for cities with capacity lower than 20MW and 40MW. However, solar thermal is prioritized and included in the assessment of the following sources.

Six different scenarios (A-F) are studied and produce inputs for the energy system modeling, as shown in Table 69. The results of only three of them are presented in this series of reports, namely scenarios A, C and D. Specifically, Table 5 shows the waste heat sources considered in the corresponding scenario, indicated by X when it refers to the use of 100% of the potentials, while with 50% when the potentials are considered with losses of this magnitude. The order of the rows indicates the priority order of the sources. Results for each country by national district heating level with the corresponding levels of waste heat are included in the data report.

Table 69 Scenarios and waste heat sources c

onsidered: An 'X' indicates 100% utilization of the source potential, while '50%' reflects the consideration of the source with 50% losses. The rows are arranged by priority order of the sources.

Sources		Scenario A	Scenario B	Scenario C	Scenario D (EE)	Scenario E (RE)	Scenario F (EE+ RE)
1. WtE				X	X	X	X
2. Industry (H)			X	X	X		X
3. Industry (M)					X		50%
4. WWT					X		50%
5. Supermarkets					X		50%
6. Industry (L)					X		50%
7. Metros					X		50%
Solar thermal	<20MW		X	X	X	X	X
	<70MW		X	X	X	X	X
Residue demand	<20 MW	X	X	X	X	X	X
	<70 MW	X	X	X	X	X	X
8. Geo 1	>40 MW	X	X	X	X	X	X
	>70 MW	X	X	X	X	X	X
9. Geo 2	>40 MW	X	X	X	X	X	X
	>70 MW	X	X	X	X	X	X
10. Geo 3	>40 MW	X	X	X	X	X	X
	>70 MW	X	X	X	X	X	X
11. Geo 4	>40 MW	X	X	X	X	X	X
	>70 MW	X	X	X	X	X	X
12. Geo 5	>40 MW	X	X	X	X	X	X
	>70 MW	X	X	X	X	X	X
13. Geo 6	>40 MW	X	X	X	X	X	X
	>70 MW	X	X	X	X	X	X

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