Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

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4DH
4th Generation District Heating Technologies and Systems

4th INTERNATIONAL CONFERENCE ON

SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING

AALBORG, 13–14 NOVEMBER 2018

AALBORG UNIVERSITY
DENMARK

HALMSTAD UNIVERSITY

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SESSION 25

ENERGY PLANNING AND PLANNING TOOLS

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SESSION 25

HEAT ROADMAP EUROPE: HEAT DISTRIBUTION COSTS

KEYNOTE: URBAN PERSSON

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Background

- Second step
  - Developing a distribution capital cost model for assessing investment costs for district heating networks in a European context
  - Persson (HU), Wiechers (EUF), Möller (EUF), Werner (HU)
- First step
  - Persson and Werner (2011)
  - Theoretical reformulation of linear heat density
  - Model application to 83 cities (BE, DE, FR, and NL)
  - Three-fold feasible expansion from current levels

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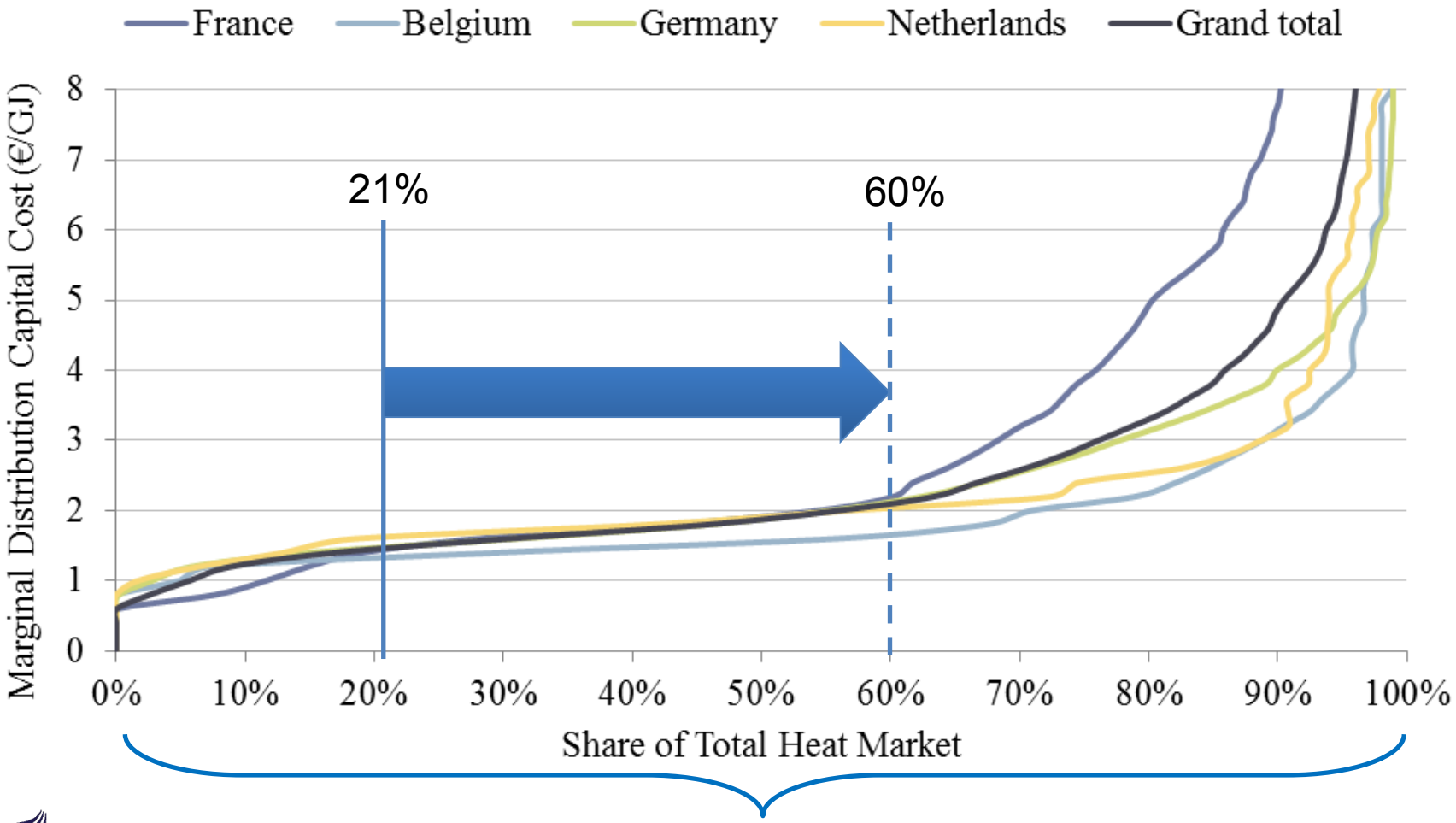
Persson, U., Werner, S., 2011. Heat distribution and the future competitiveness of district heating. Applied Energy 88, 568-576.



Urban heat market!

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Background

"Would it be possible to model the heat distribution capital cost for all of Europe?"

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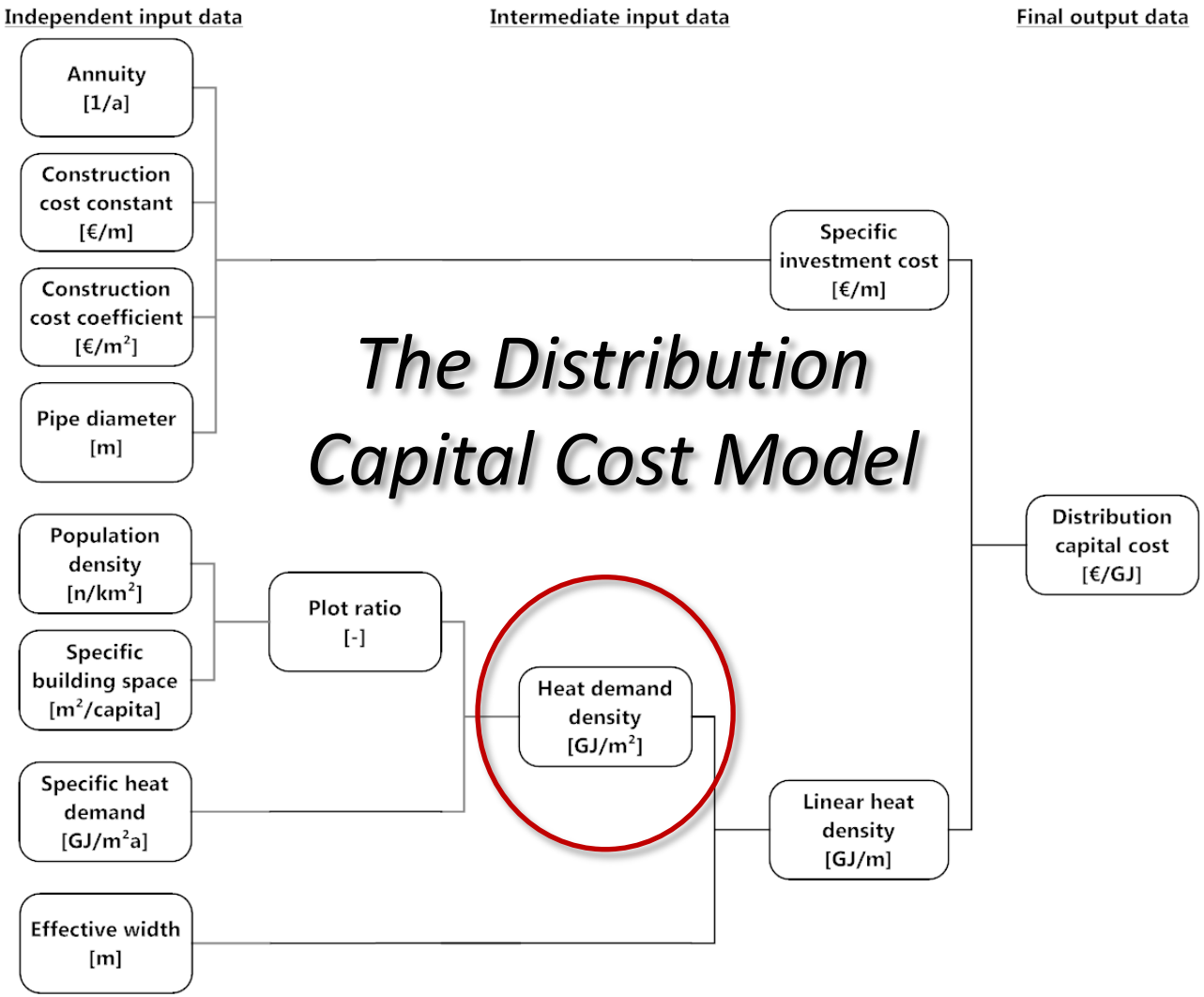

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Background

Yes!

But then we need uniform input data on heat demand densities for all of Europe!

…This has been a main objective of the mapping activities in the Heat Roadmap Europe project from 2012 to now!

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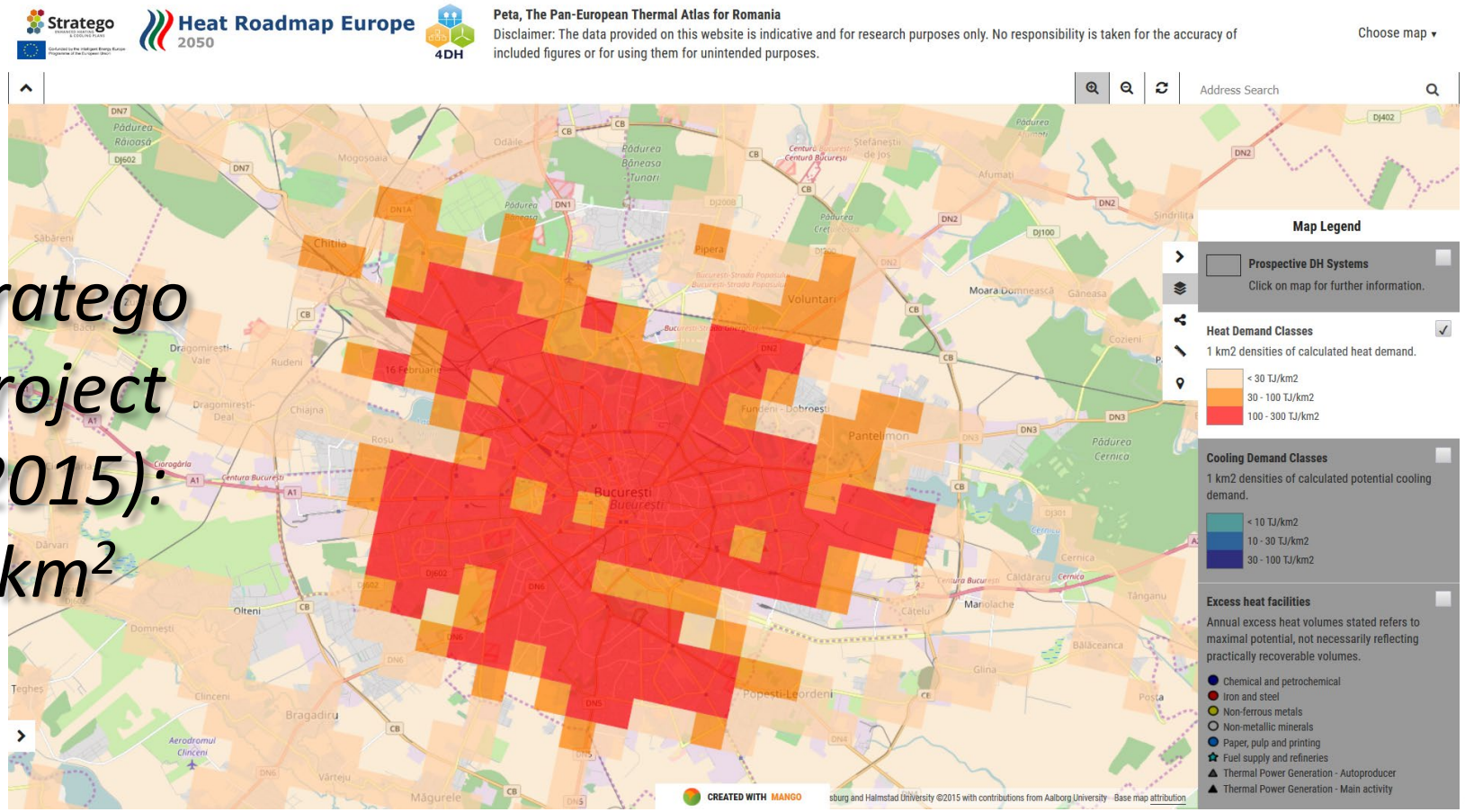
Background

- Raster representation of heat demand density

Stratego project (2015): km²



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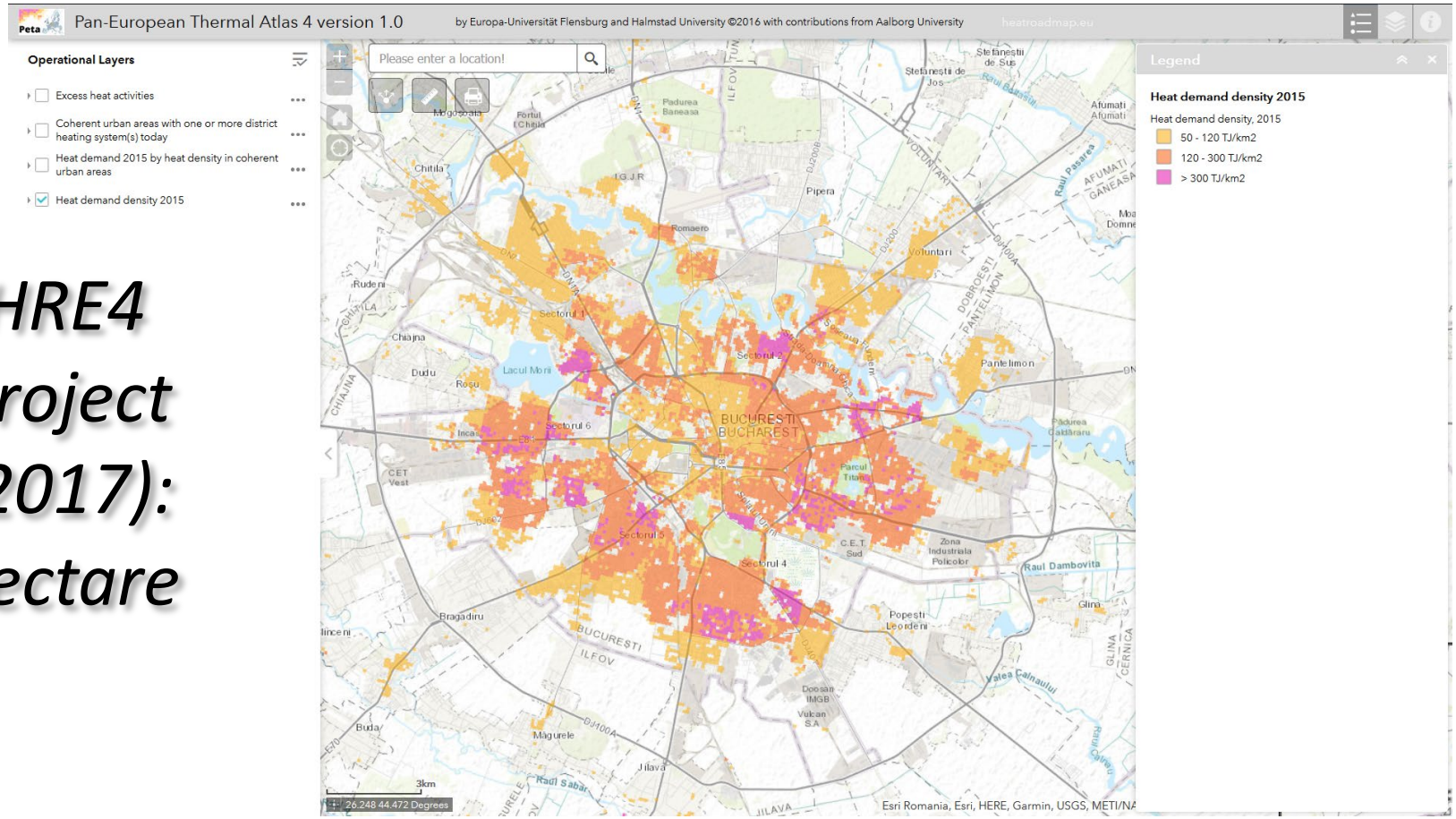

HRE4 project (2017): hectare

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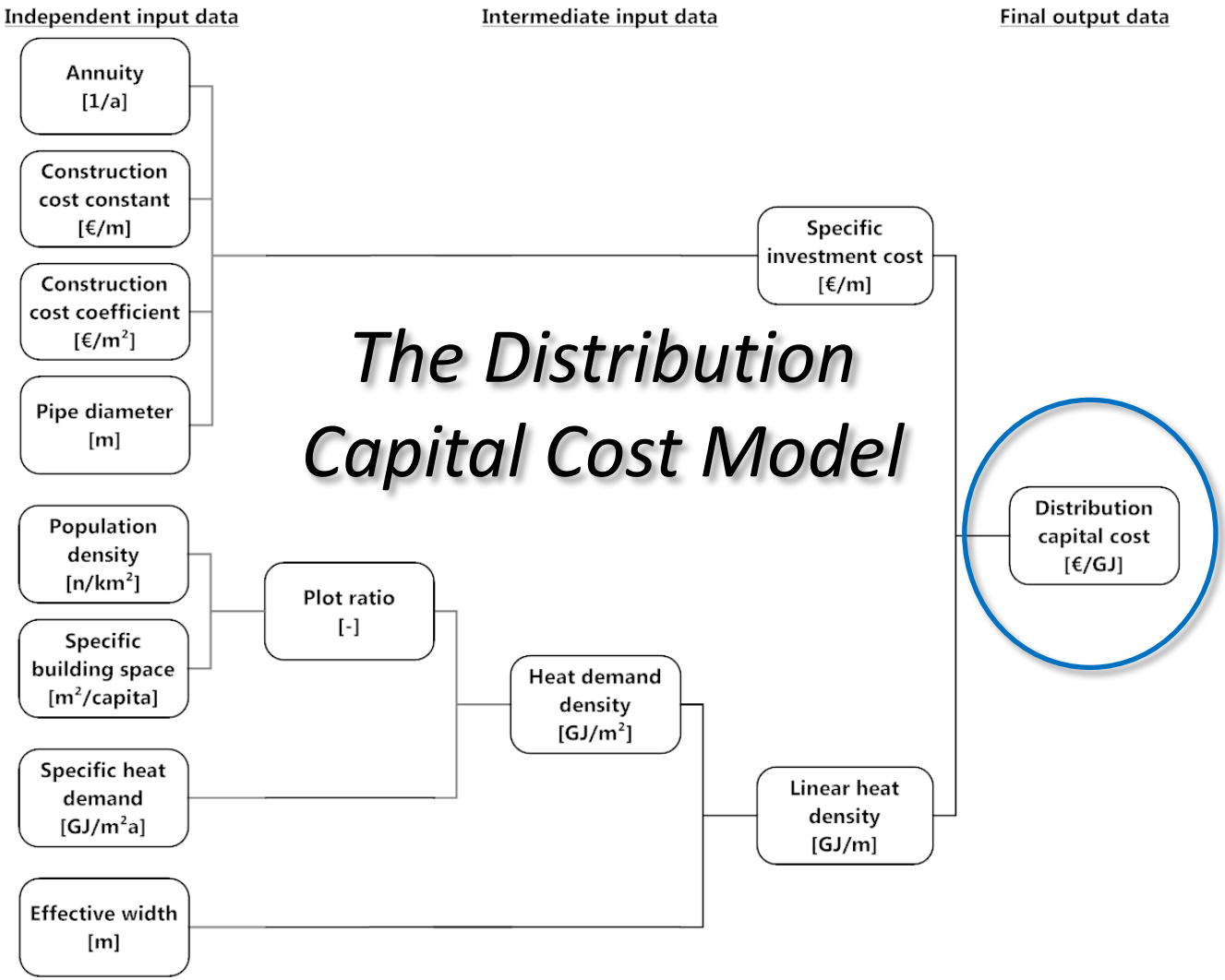

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Overview

- Some study concepts
  - Suitability concept
  - Heat demand density classification
- Research questions
- Specific heat demands
- Results
  - Land use area
  - Population
  - Physical suitability
  - Economic suitability
  - Current levels and saturation
- Conclusions
  - Aggregated answer
  - Suitability concepts…

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Some study concepts

- Suitability concept:
  - **Physical suitability**
    - Heat demand density
  - **Economic suitability**
    - Heat distribution capital cost

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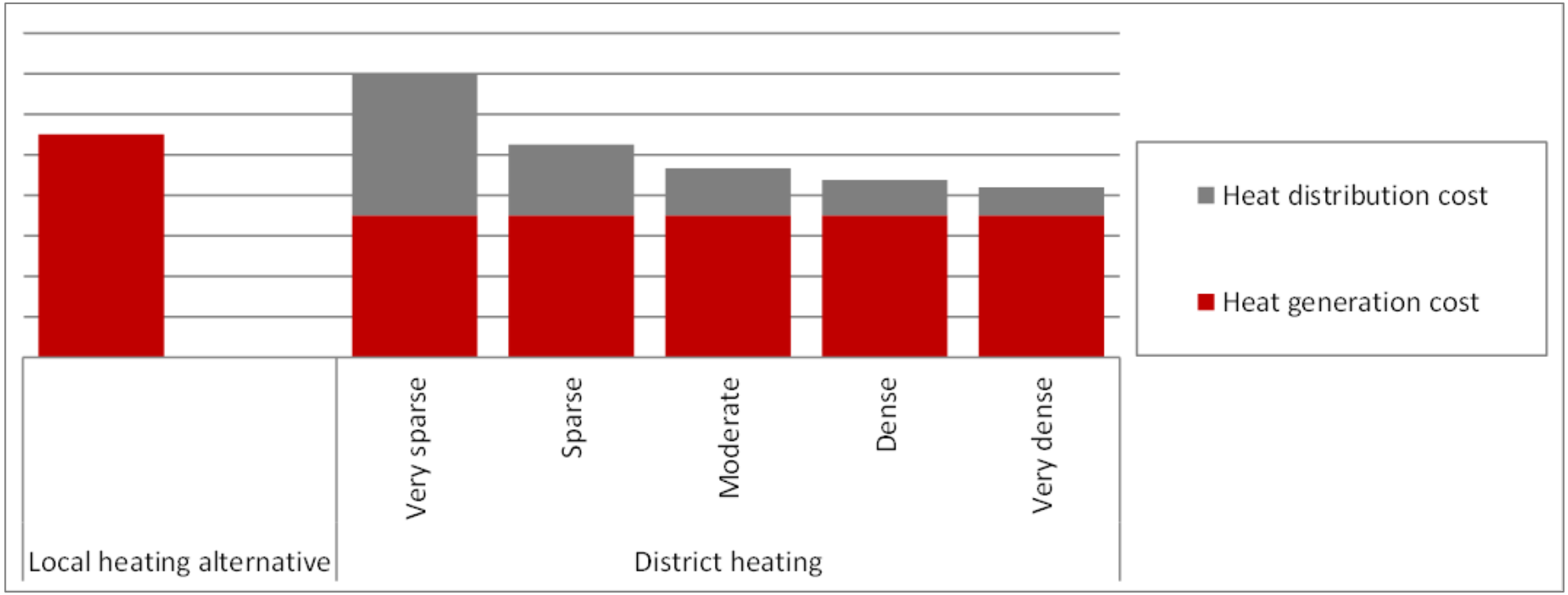
Some study concepts

- Heat demand density (q_L) **classification:**



Source: Persson, U. (2015). District heating in future Europe: Modelling expansion potentials and mapping heat synergy regions. Dissertation Thesis. Series Nr: 3769. Göteborg, Energy and Environment, Chalmers University of Technology.

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Some study concepts

- Heat demand density (q_L) **classification:**

Class	q_L [GJ/ha]	q_L [TJ/km²]	Character
0	0	0	No heat demand
1	$0 < q_L < 200$	$0 < q_L < 20$	Very sparse
2	$200 \leq q_L < 500$	$20 \leq q_L < 50$	Sparse
3	$500 \leq q_L < 1200$	$50 \leq q_L < 120$	Moderate
4	$1200 \leq q_L < 3000$	$120 \leq q_L < 300$	Dense
5	$q_L \geq 3000$	$q_L \geq 300$	Very dense

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Research questions

- What is the **physical suitability** for DH concerning heat densities in residential and service sector areas?
- What is the **economic suitability** for DH heat distribution costs in residential and service sector areas?
- How do **current deployment levels** of DH relate to economically suitable levels and what is the **magnitude of an EU28 DH market if saturated to its full extent** according to physical and economic suitability?
- What is the **aggregated answer to why district heating can be viable concerning physical suitability?**

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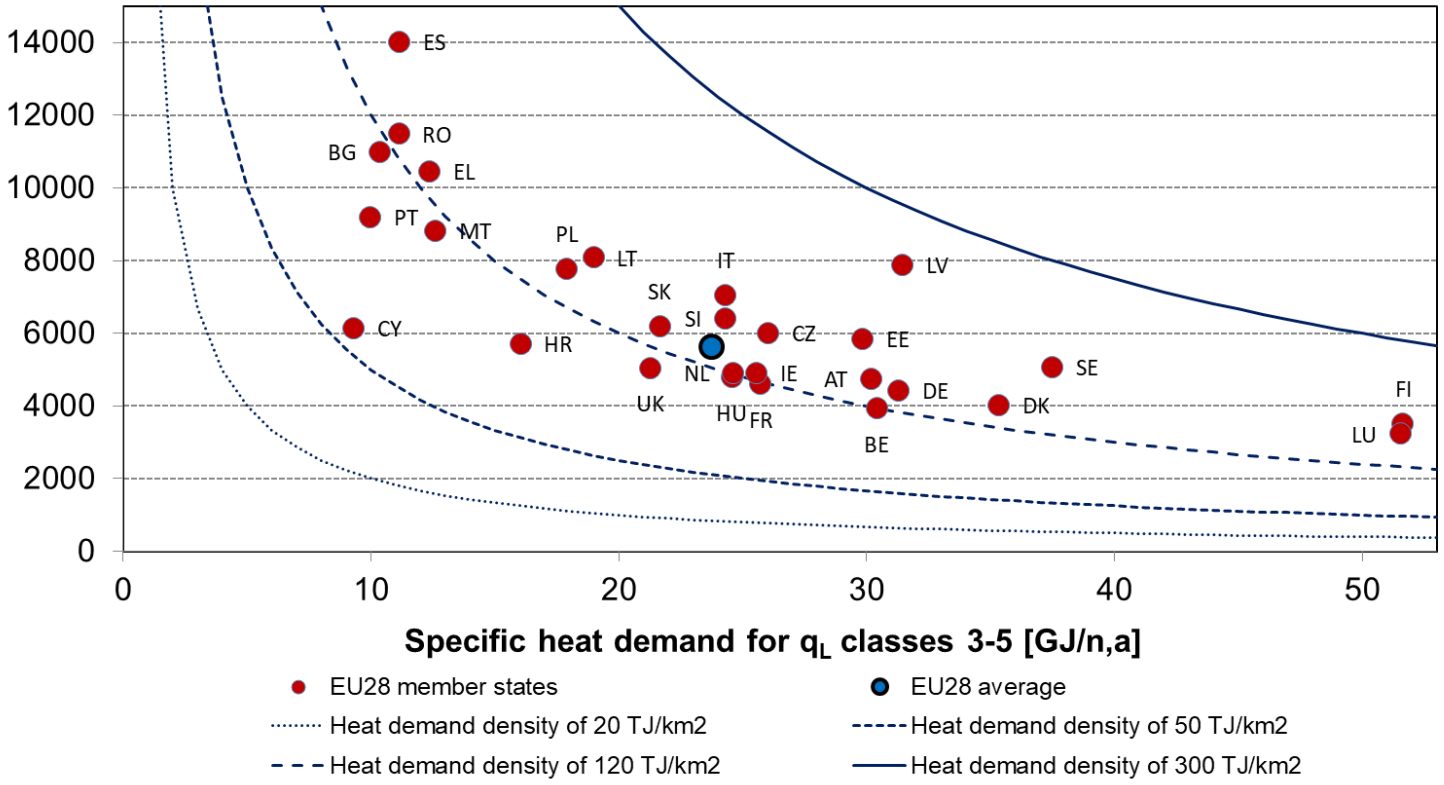
Specific heat demands

- Specific heat demands by population density

EU28 average (3-5): 23.7 GJ/na, 5635 n/km²
EU28 average (1-5): 21.8 GJ/na, 1230 n/km²



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Results

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Results

- Land use areas

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Results

- Land use areas

	Land area by heat demand density class [kkm²]							Land area by heat demand density class [%]					
MS	0	1	2	3	4	5	Total	0	1	2	3	4	5
AT	74.8	6.7	1.2	0.83	0.22	0.13	83.9	89%	8%	1.4%	1.0%	0.3%	0.16%
BE	23.8	3.2	1.5	1.69	0.31	0.16	30.7	78%	11%	4.8%	5.5%	1.0%	0.53%
BG	105.7	4.6	0.4	0.22	0.11	0.00	111.0	95%	4%	0.3%	0.2%	0.1%	0.00%
CY	8.0	1.1	0.1	0.02	0.00	0.00	9.2	86%	12%	1.5%	0.2%	0.0%	0.00%
CZ	70.3	6.2	1.2	0.60	0.39	0.13	78.9	89%	8%	1.6%	0.8%	0.5%	0.17%
DE	300.6	36.2	6.5	9.66	4.03	1.35	358.3	84%	10%	1.8%	2.7%	1.1%	0.38%
DK	35.0	6.5	0.8	0.57	0.20	0.08	43.2	81%	15%	1.8%	1.3%	0.5%	0.20%
EE	42.8	2.3	0.1	0.07	0.04	0.02	45.3	94%	5%	0.3%	0.2%	0.1%	0.05%
EL	124.8	5.9	0.7	0.33	0.18	0.03	131.9	95%	4%	0.5%	0.3%	0.1%	0.02%
ES	483.0	10.9	2.1	1.26	0.92	0.26	498.5	97%	2%	0.4%	0.3%	0.2%	0.05%
FI	329.2	6.5	0.9	0.62	0.18	0.12	337.5	98%	2%	0.3%	0.2%	0.1%	0.03%
FR	469.6	62.1	8.0	6.72	2.25	0.49	549.1	86%	11%	1.5%	1.2%	0.4%	0.09%
HR	50.9	4.7	0.6	0.28	0.07	0.00	56.5	90%	8%	1.1%	0.5%	0.1%	0.01%
HU	85.3	4.6	2.1	0.77	0.14	0.10	93.0	92%	5%	2.2%	0.8%	0.1%	0.11%
IE	60.1	9.4	0.6	0.42	0.01	0.04	70.6	85%	13%	0.9%	0.6%	0.0%	0.06%
IT	261.7	29.7	3.6	3.06	2.40	0.82	301.3	87%	10%	1.2%	1.0%	0.8%	0.27%
LT	60.0	5.1	0.2	0.09	0.08	0.01	65.4	92%	8%	0.3%	0.1%	0.1%	0.02%
LU	2.2	0.2	0.1	0.08	0.04	0.02	2.6	87%	6%	2.2%	3.0%	1.5%	0.69%
LV	61.8	3.5	0.1	0.06	0.05	0.04	65.5	94%	5%	0.1%	0.1%	0.1%	0.07%
MT	0.1	0.1	0.0	0.01	0.01	0.00	0.3	46%	43%	5.1%	3.6%	2.0%	0.04%
NL	26.9	7.1	0.7	1.95	1.18	0.05	37.8	71%	19%	1.8%	5.1%	3.1%	0.12%
PL	277.1	29.3	4.6	1.83	0.79	0.31	313.9	88%	9%	1.5%	0.6%	0.3%	0.10%
PT	79.6	8.6	0.3	0.26	0.06	0.00	88.8	90%	10%	0.4%	0.3%	0.1%	0.00%
RO	223.0	14.2	1.2	0.36	0.30	0.01	239.1	93%	6%	0.5%	0.2%	0.1%	0.00%
SE	436.3	11.1	1.3	0.68	0.27	0.21	449.9	97%	2%	0.3%	0.2%	0.1%	0.05%
SI	18.9	1.1	0.2	0.07	0.05	0.02	20.3	93%	5%	1.0%	0.4%	0.2%	0.08%
SK	45.3	2.5	0.7	0.27	0.17	0.03	49.0	92%	5%	1.4%	0.6%	0.3%	0.06%
UK	220.1	13.6	2.8	9.03	1.89	0.35	247.8	89%	5%	1.1%	3.6%	0.8%	0.14%
EU28	**3966.9**	**297.0**	**42.6**	**41.80**	**16.34**	**4.81**	**4369.4**	**91%**	**7%**	**1.0%**	**1.0%**	**0.4%**	**0.11%**

EU28: **~9%** of the total land use area hosts areas with building heat demands

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EU28: **~1.5%** of the total land use area constitutes density class 3-5 areas

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LU	2.2	0.2	0.1	0.08	0.04	0.02	2.6	87%	6%	2.2%	3.0%	1.5%	0.69%
LV	61.8	3.5	0.1	0.06	0.05	0.04	65.5	94%	5%	0.1%	0.1%	0.1%	0.07%
MT	0.1	0.1	0.0	0.01	0.01	0.00	0.3	46%	43%	5.1%	3.6%	2.0%	0.04%
NL	26.9	7.1	0.7	1.95	1.18	0.05	37.8	71%	19%	1.8%	5.1%	3.1%	0.12%
PL	277.1	29.3	4.6	1.83	0.79	0.31	313.9	88%	9%	1.5%	0.6%	0.3%	0.10%
PT	79.6	8.6	0.3	0.26	0.06	0.00	88.8	90%	10%	0.4%	0.3%	0.1%	0.00%
RO	223.0	14.2	1.2	0.36	0.30	0.01	239.1	93%	6%	0.5%	0.2%	0.1%	0.00%
SE	436.3	11.1	1.3	0.68	0.27	0.21	449.9	97%	2%	0.3%	0.2%	0.1%	0.05%
SI	18.9	1.1	0.2	0.07	0.05	0.02	20.3	93%	5%	1.0%	0.4%	0.2%	0.08%
SK	45.3	2.5	0.7	0.27	0.17	0.03	49.0	92%	5%	1.4%	0.6%	0.3%	0.06%
UK	220.1	13.6	2.8	9.03	1.89	0.35	247.8	89%	5%	1.1%	3.6%	0.8%	0.14%
EU28	**3966.9**	**297.0**	**42.6**	**41.80**	**16.34**	**4.81**	**4369.4**	**91%**	**7%**	**1.0%**	**1.0%**	**0.4%**	**0.11%**

EU28: **~0.5%** of the total land use area constitutes density class 4-5 areas

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4DH
4th Generation District Heating Technologies and Systems

Results

- Land use areas

MS	0	1	2	3	4	5
AT	74.8	6.7	1.2	0.83	0.22	0.13
BE	23.8	3.2	1.5	1.69	0.31	0.16
BG	105.7	4.6	0.4	0.22	0.11	0.00
CY	8.0	1.1	0.1	0.02	0.00	0.00
CZ	70.3	6.2	1.2	0.60	0.39	0.13
DE	300.6	36.2	6.5	9.66	4.03	1.35
DK	35.0	6.5	0.8	0.57	0.20	0.08
EE	42.8	2.3	0.1	0.07	0.04	0.02
EL	124.8	5.9	0.7	0.33	0.18	0.03
ES	483.0	10.9	2.1	1.26	0.92	0.26
FI	329.2	6.5	0.9	0.62	0.18	0.12
FR	469.6	62.1	8.0	6.72	2.25	0.49
HR	50.9	4.7	0.6	0.28	0.07	0.00
HU	85.3	4.6	2.1	0.77	0.14	0.10
IE	60.1	9.4	0.6	0.42	0.01	0.04
IT	261.7	29.7	3.6	3.06	2.40	0.82
LT	60.0	5.1	0.2	0.09	0.08	0.01
LU	2.2	0.2	0.1	0.08	0.04	0.02
LV	61.8	3.5	0.1	0.06	0.05	0.04
MT	0.1	0.1	0.0	0.01	0.01	0.00
NL	26.9	7.1	0.7	1.95	1.18	0.05
PL	277.1	29.3	4.6	1.83	0.79	0.31
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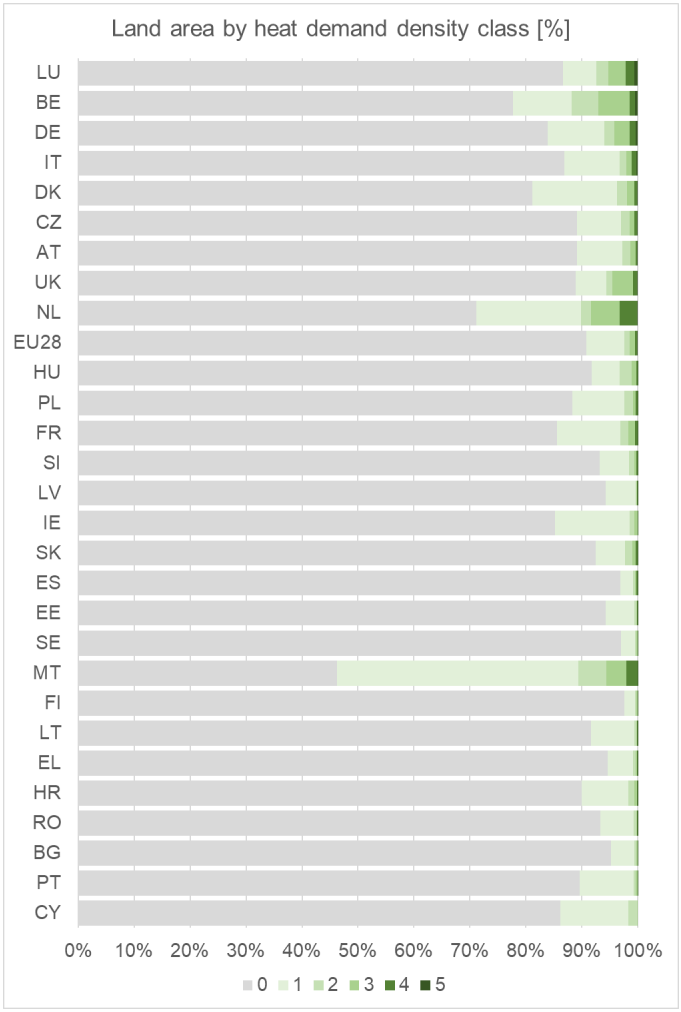
SE	436.3	11.1	1.3	0.68	0.27	0.21
SI	18.9	1.1	0.2	0.07	0.05	0.02
SK	45.3	2.5	0.7	0.27	0.17	0.03
UK	220.1	13.6	2.8	9.03	1.89	0.35
EU28	**3966.9**	**297.0**	**42.6**	**41.80**	**16.34**	**4.81**



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CZ	70.3	6.2	1.2	0.60	0.39	0.13
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DK	35.0	6.5	0.8	0.57	0.20	0.08
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FI	329.2	6.5	0.9	0.62	0.18	0.12
FR	469.6	62.1	8.0	6.72	2.25	0.49
HR	50.9	4.7	0.6	0.28	0.07	0.00
HU	85.3	4.6	2.1	0.77	0.14	0.10
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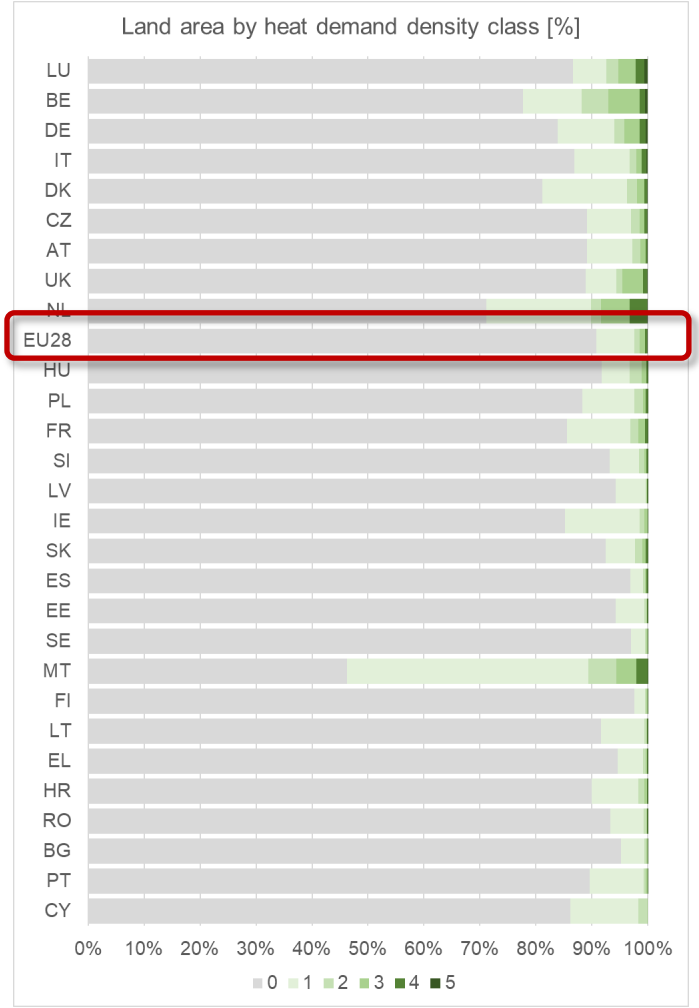
SK	45.3	2.5	0.7	0.27	0.17	0.03
UK	220.1	13.6	2.8	9.03	1.89	0.35
EU28	**3966.9**	**297.0**	**42.6**	**41.80**	**16.34**	**4.81**



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HU	85.3	4.6	2.1	0.77	0.14	0.10
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UK	220.1	13.6	2.8	9.03	1.89	0.35
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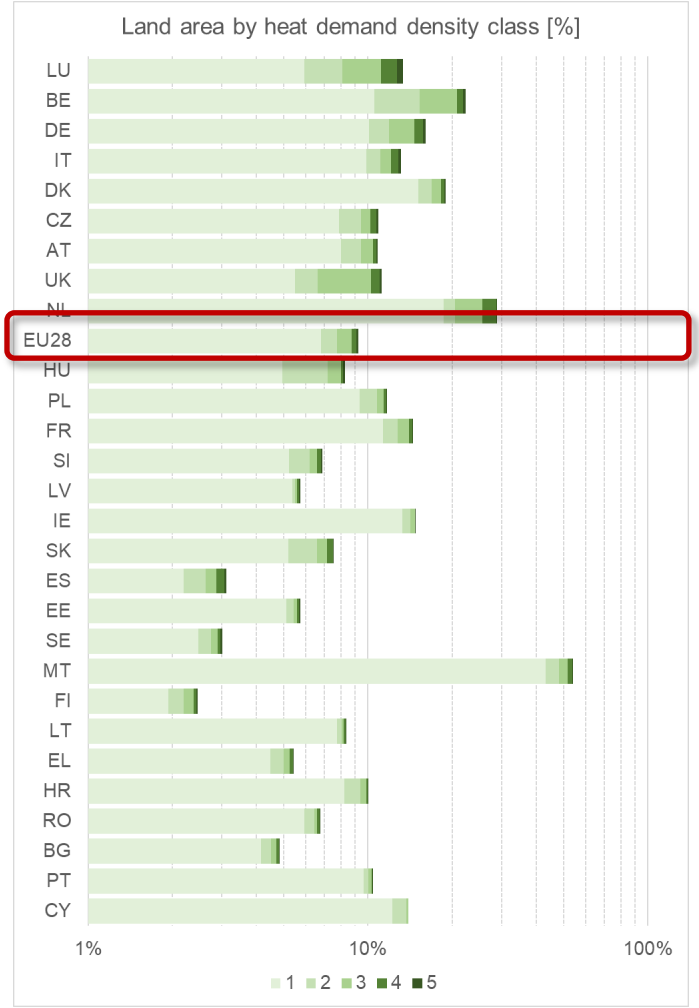

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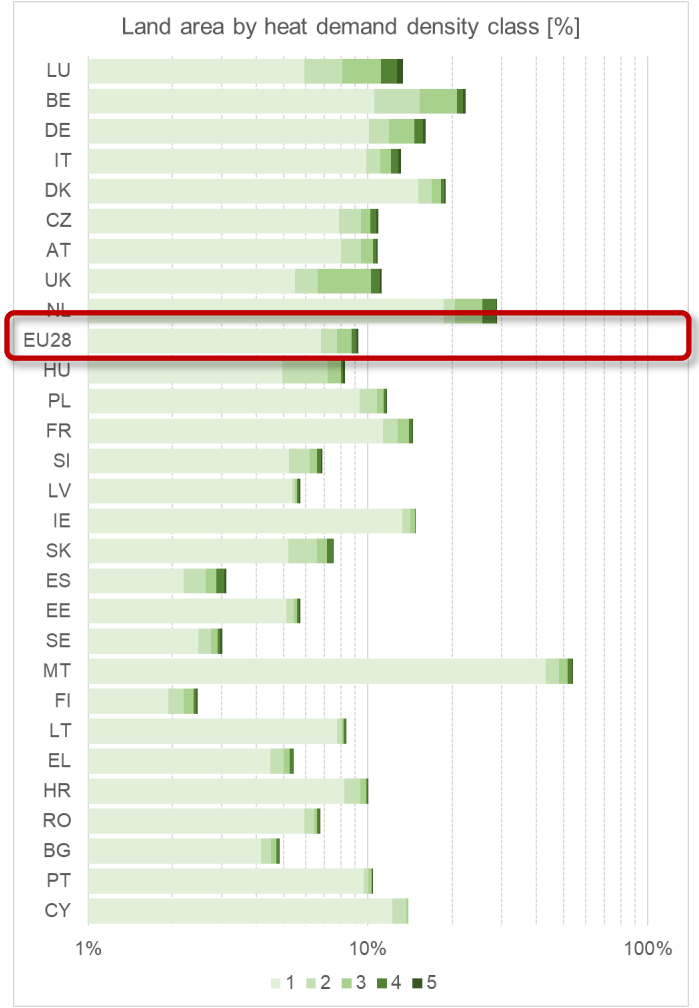

Low shares (1-5): Finland (~2%), Sweden (~3%), and Spain (~3%)

High shares (1-5): Malta (54%), Netherlands (29%), and Belgium (22%)

AALBORG UNIVERSITY DENMARK

HALMSTAD UNIVERSITY

Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

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Results

- Population

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4DH
4th Generation District Heating Technologies and Systems

Results

- Population

Population by heat demand density class [Mn]								Population by heat demand density class [%]					
MS	0[a]	1	2	3	4	5	Total	0	1	2	3	4	5
AT	0.19	1.08	1.74	2.91	1.15	1.52	8.58	2%	13%	20%	34%	13%	18%
BE	0.27	0.58	1.90	5.59	1.45	1.45	11.24	2%	5%	17%	50%	13%	13%
BG	-0.13	2.15	1.47	1.67	1.83	0.20	7.20	-2%	30%	20%	23%	25%	3%
CY	-0.26	0.45	0.55	0.10	0	0	0.85	-30%	54%	65%	12%	0%	0%
CZ	0.11	1.34	2.34	2.38	2.48	1.89	10.54	1%	13%	22%	23%	24%	18%
DE	1.02	4.38	9.11	33.12	20.44	13.12	81.20	1%	5%	11%	41%	25%	16%
DK	0.21	0.78	1.26	1.78	0.78	0.85	5.66	4%	14%	22%	31%	14%	15%
EE	0.03	0.27	0.21	0.26	0.28	0.26	1.31	2%	20%	16%	20%	21%	20%
EL	0.68	2.50	1.98	2.23	2.64	0.83	10.86	6%	23%	18%	21%	24%	8%
ES	2.00	3.21	7.00	9.44	13.82	10.97	46.45	4%	7%	15%	20%	30%	24%
FI	0.49	0.91	0.85	1.46	1.09	0.67	5.47	9%	17%	15%	27%	20%	12%
FR	3.82	7.79	11.30	21.85	12.25	9.45	66.46	6%	12%	17%	33%	18%	14%
HR	0.07	0.82	1.31	1.24	0.72	0.07	4.23	2%	19%	31%	29%	17%	2%
HU	-0.07	0.93	4.17	3.66	0.52	0.64	9.86	-1%	9%	42%	37%	5%	6%
IE	0.17	0.99	1.20	2.11	0.08	0.13	4.68	4%	21%	26%	45%	2%	3%
IT	1.93	6.82	7.83	13.30	17.97	12.95	60.80	3%	11%	13%	22%	30%	21%
LT	-0.09	1.00	0.55	0.51	0.69	0.26	2.92	-3%	34%	19%	17%	24%	9%
LU	0.05	0.02	0.05	0.19	0.19	0.07	0.56	9%	4%	9%	33%	33%	12%
LV	-0.08	0.66	0.22	0.26	0.40	0.53	1.99	-4%	33%	11%	13%	20%	27%
MT	0.04	0.10	0.15	0.10	0.05	0.00	0.44	8%	22%	34%	23%	12%	0%
NL	0.26	0.53	0.58	6.79	8.20	0.55	16.90	2%	3%	3%	40%	49%	3%
PL	-0.38	5.77	9.74	9.99	8.40	4.48	38.01	-1%	15%	26%	26%	22%	12%
PT	0.54	5.01	1.82	2.04	0.97	0.00	10.37	5%	48%	18%	20%	9%	0%
RO	-0.21	7.83	4.47	2.72	4.63	0.44	19.87	-1%	39%	22%	14%	23%	2%
SE	0.33	1.55	1.98	2.39	1.76	1.74	9.75	3%	16%	20%	24%	18%	18%
SI	0.13	0.61	0.45	0.31	0.29	0.27	2.06	6%	29%	22%	15%	14%	13%
SK	0.02	0.82	1.66	1.22	1.18	0.51	5.42	0%	15%	31%	23%	22%	9%
UK	2.31	1.54	4.09	45.47	10.10	1.37	64.88	4%	2%	6%	70%	16%	2%
EU28	**13.46**	**60.43**	**79.95**	**175.10**	**114.39**	**65.22**	**508.54**	**3%**	**12%**	**16%**	**34%**	**22%**	**13%**

EU28: **69%** of the total population (~350 Mn) is located in density class 3-5 areas

[a] Negative values due partly to different reference years (and total volumes) in two used datasets, and due partly to aggregation mechanisms in zonal statistics operations.

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MS	0[a]	1	2	3	4	5	Total	0	1	2	3	4	5
AT	0.19	1.08	1.74	2.91	1.15	1.52	8.58	2%	13%	20%	34%	13%	18%
BE	0.27	0.58	1.90	5.59	1.45	1.45	11.24	2%	5%	17%	50%	13%	13%
BG	-0.13	2.15	1.47	1.67	1.83	0.20	7.20	-2%	30%	20%	23%	25%	3%
CY	-0.26	0.45	0.55	0.10	0	0	0.85	-30%	54%	65%	12%	0%	0%
CZ	0.11	1.34	2.34	2.38	2.48	1.89	10.54	1%	13%	22%	23%	24%	18%
DE	1.02	4.38	9.11	33.12	20.44	13.12	81.20	1%	5%	11%	41%	25%	16%
DK	0.21	0.78	1.26	1.78	0.78	0.85	5.66	4%	14%	22%	31%	14%	15%
EE	0.03	0.27	0.21	0.26	0.28	0.26	1.31	2%	20%	16%	20%	21%	20%
EL	0.68	2.50	1.98	2.23	2.64	0.83	10.86	6%	23%	18%	21%	24%	8%
ES	2.00	3.21	7.00	9.44	13.82	10.97	46.45	4%	7%	15%	20%	30%	24%
FI	0.49	0.91	0.85	1.46	1.09	0.67	5.47	9%	17%	15%	27%	20%	12%
FR	3.82	7.79	11.30	21.85	12.25	9.45	66.46	6%	12%	17%	33%	18%	14%
HR	0.07	0.82	1.31	1.24	0.72	0.07	4.23	2%	19%	31%	29%	17%	2%
HU	-0.07	0.93	4.17	3.66	0.52	0.64	9.86	-1%	9%	42%	37%	5%	6%
IE	0.17	0.99	1.20	2.11	0.08	0.13	4.68	4%	21%	26%	45%	2%	3%
IT	1.93	6.82	7.83	13.30	17.97	12.95	60.80	3%	11%	13%	22%	30%	21%
LT	-0.09	1.00	0.55	0.51	0.69	0.26	2.92	-3%	34%	19%	17%	24%	9%
LU	0.05	0.02	0.05	0.19	0.19	0.07	0.56	9%	4%	9%	33%	33%	12%
LV	-0.08	0.66	0.22	0.26	0.40	0.53	1.99	-4%	33%	11%	13%	20%	27%
MT	0.04	0.10	0.15	0.10	0.05	0.00	0.44	8%	22%	34%	23%	12%	0%
NL	0.26	0.53	0.58	6.79	8.20	0.55	16.90	2%	3%	3%	40%	49%	3%
PL	-0.38	5.77	9.74	9.99	8.40	4.48	38.01	-1%	15%	26%	26%	22%	12%
PT	0.54	5.01	1.82	2.04	0.97	0.00	10.37	5%	48%	18%	20%	9%	0%
RO	-0.21	7.83	4.47	2.72	4.63	0.44	19.87	-1%	39%	22%	14%	23%	2%
SE	0.33	1.55	1.98	2.39	1.76	1.74	9.75	3%	16%	20%	24%	18%	18%
SI	0.13	0.61	0.45	0.31	0.29	0.27	2.06	6%	29%	22%	15%	14%	13%
SK	0.02	0.82	1.66	1.22	1.18	0.51	5.42	0%	15%	31%	23%	22%	9%
UK	2.31	1.54	4.09	45.47	10.10	1.37	64.88	4%	2%	6%	70%	16%	2%
EU28	**13.46**	**60.43**	**79.95**	**175.10**	**114.39**	**65.22**	**508.54**	**3%**	**12%**	**16%**	**34%**	**22%**	**13%**

EU28: **35%** of the total population (~180 Mn) is located in density class 4-5 areas

[a] Negative values due partly to different reference years (and total volumes) in two used datasets, and due partly to aggregation mechanisms in zonal statistics operations.

Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

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4DH
4th Generation District Heating Technologies and Systems

Results

- Population

Population by heat demand density class [Mn]						
MS	0[a]	1	2	3	4	5
AT	0.19	1.08	1.74	2.91	1.15	1.52
BE	0.27	0.58	1.90	5.59	1.45	1.45
BG	-0.13	2.15	1.47	1.67	1.83	0.20
CY	-0.26	0.45	0.55	0.10	0	0
CZ	0.11	1.34	2.34	2.38	2.48	1.89
DE	1.02	4.38	9.11	33.12	20.44	13.12
DK	0.21	0.78	1.26	1.78	0.78	0.85
EE	0.03	0.27	0.21	0.26	0.28	0.26
EL	0.68	2.50	1.98	2.23	2.64	0.83
ES	2.00	3.21	7.00	9.44	13.82	10.97
FI	0.49	0.91	0.85	1.46	1.09	0.67
FR	3.82	7.79	11.30	21.85	12.25	9.45
HR	0.07	0.82	1.31	1.24	0.72	0.07
HU	-0.07	0.93	4.17	3.66	0.52	0.64
IE	0.17	0.99	1.20	2.11	0.08	0.13
IT	1.93	6.82	7.83	13.30	17.97	12.95
LT	-0.09	1.00	0.55	0.51	0.69	0.26
LU	0.05	0.02	0.05	0.19	0.19	0.07
LV	-0.08	0.66	0.22	0.26	0.40	0.53
MT	0.04	0.10	0.15	0.10	0.05	0.00
NL	0.26	0.53	0.58	6.79	8.20	0.55
PL	-0.38	5.77	9.74	9.99	8.40	4.48
PT	0.54	5.01	1.82	2.04	0.97	0.00
RO	-0.21	7.83	4.47	2.72	4.63	0.44
SE	0.33	1.55	1.98	2.39	1.76	1.74
SI	0.13	0.61	0.45	0.31	0.29	0.27
SK	0.02	0.82	1.66	1.22	1.18	0.51
UK	2.31	1.54	4.09	45.47	10.10	1.37
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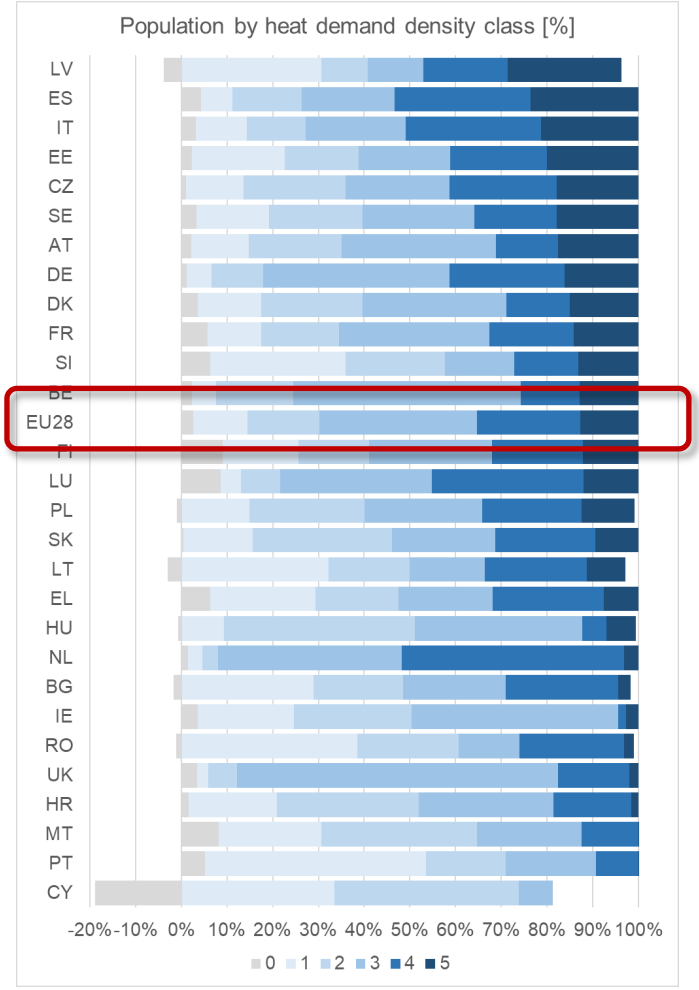

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DK	0.21	0.78	1.26	1.78	0.78	0.85
EE	0.03	0.27	0.21	0.26	0.28	0.26
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HR	0.07	0.82	1.31	1.24	0.72	0.07
HU	-0.07	0.93	4.17	3.66	0.52	0.64
IE	0.17	0.99	1.20	2.11	0.08	0.13
IT	1.93	6.82	7.83	13.30	17.97	12.95
LT	-0.09	1.00	0.55	0.51	0.69	0.26
LU	0.05	0.02	0.05	0.19	0.19	0.07
LV	-0.08	0.66	0.22	0.26	0.40	0.53
MT	0.04	0.10	0.15	0.10	0.05	0.00
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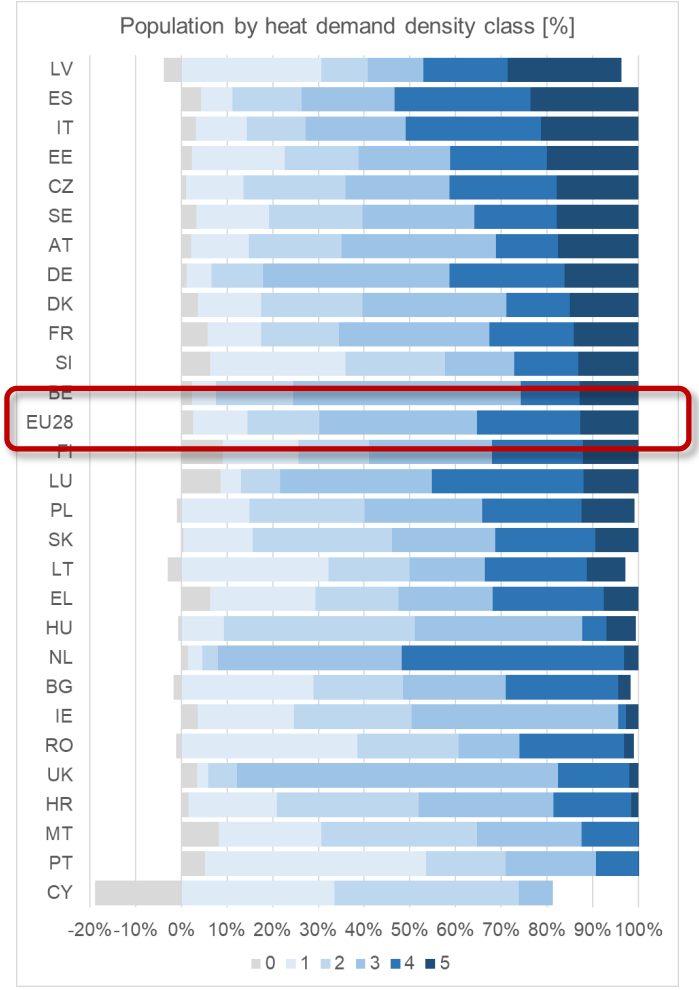

Shares (3-5): NL (40%, 49%, **3%**), UK (70%, 16%, **2%**), and BG (23%, 25%, and **3%**)

Shares (3-5): LV (13%, 20%, **27%**), ES (20%, 30%, **24%**), and IT (22%, 30%, **21%**)

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- Physical suitability

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Results

- Physical suitability

	Heat demand by heat demand density class [PJ]						Heat demand by heat demand density class [%]				
MS	1	2	3	4	5	Total	1	2	3	4	5
AT	25	39	59	41	69	232	11%	17%	25%	17%	30%
BE	16	50	122	59	77	324	5%	15%	38%	18%	24%
BG	18	12	17	19	2	68	27%	17%	25%	29%	2%
CY	3	4	1	0	0	8	41%	48%	11%	0%	0%
CZ	22	39	45	74	56	237	9%	17%	19%	31%	24%
DE	106	222	736	766	583	2413	4%	9%	31%	32%	24%
DK	16	27	42	37	42	164	10%	16%	25%	22%	26%
EE	5	4	5	8	11	34	16%	13%	16%	24%	31%
EL	25	21	26	34	10	116	22%	18%	22%	29%	9%
ES	37	71	98	172	111	489	8%	14%	20%	35%	23%
FI	31	29	48	33	86	226	14%	13%	21%	15%	38%
FR	179	263	496	403	221	1562	11%	17%	32%	26%	14%
HR	14	21	20	12	1	68	20%	31%	29%	17%	1%
HU	20	71	48	29	41	210	10%	34%	23%	14%	19%
IE	24	21	27	2	30	104	23%	20%	26%	2%	28%
IT	94	114	249	445	381	1283	7%	9%	19%	35%	30%
LT	12	6	7	15	6	46	25%	14%	15%	34%	12%
LU	1	2	7	7	10	26	4%	7%	26%	26%	37%
LV	6	2	5	9	23	46	14%	5%	11%	21%	50%
MT	0	0	1	1	0	3	16%	16%	33%	34%	2%
NL	20	23	169	198	16	426	5%	5%	40%	47%	4%
PL	97	152	126	153	130	658	15%	23%	19%	23%	20%
PT	23	10	20	10	0	64	36%	17%	32%	15%	0%
RO	63	34	28	54	4	183	34%	18%	16%	30%	2%
SE	32	41	50	51	120	294	11%	14%	17%	17%	41%
SI	8	6	6	9	7	35	22%	17%	16%	25%	20%
SK	11	22	21	31	11	96	11%	23%	22%	33%	12%
UK	58	94	725	331	154	1363	4%	7%	53%	24%	11%
EU28	**968**	**1399**	**3205**	**3002**	**2201**	**10776**	**9%**	**13%**	**30%**	**28%**	**20%**

EU28: **78%** of the total heat demand originate in density class 3-5 areas

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Results

- Physical suitability

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MS	1	2	3	4	5	Total	1	2	3	4	5
AT	25	39	59	41	69	232	11%	17%	25%	17%	30%
BE	16	50	122	59	77	324	5%	15%	38%	18%	24%
BG	18	12	17	19	2	68	27%	17%	25%	29%	2%
CY	3	4	1	0	0	8	41%	48%	11%	0%	0%
CZ	22	39	45	74	56	237	9%	17%	19%	31%	24%
DE	106	222	736	766	583	2413	4%	9%	31%	32%	24%
DK	16	27	42	37	42	164	10%	16%	25%	22%	26%
EE	5	4	5	8	11	34	16%	13%	16%	24%	31%
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FI	31	29	48	33	86	226	14%	13%	21%	15%	38%
FR	179	263	496	403	221	1562	11%	17%	32%	26%	14%
HR	14	21	20	12	1	68	20%	31%	29%	17%	1%
HU	20	71	48	29	41	210	10%	34%	23%	14%	19%
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LT	12	6	7	15	6	46	25%	14%	15%	34%	12%
LU	1	2	7	7	10	26	4%	7%	26%	26%	37%
LV	6	2	5	9	23	46	14%	5%	11%	21%	50%
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EU28: **48%** of the total heat demand originate in density class 4-5 areas

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Results

- Physical suitability

Heat demand by heat demand density class [PJ]					
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BG	18	12	17	19	2
CY	3	4	1	0	0
CZ	22	39	45	74	56
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DK	16	27	42	37	42
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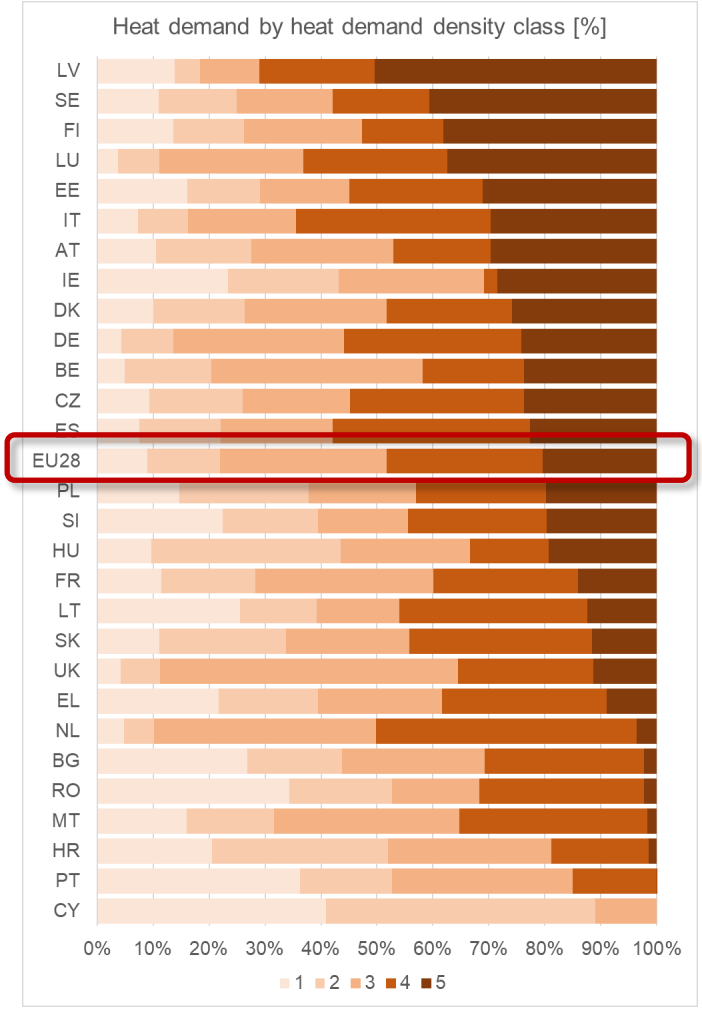

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LT	12	6	7	15	6
LU	1	2	7	7	10
LV	6	2	5	9	23
MT	0	0	1	1	0
NL	20	23	169	198	16
PL	97	152	126	153	130
PT	23	10	20	10	0
RO	63	34	28	54	4
SE	32	41	50	51	120
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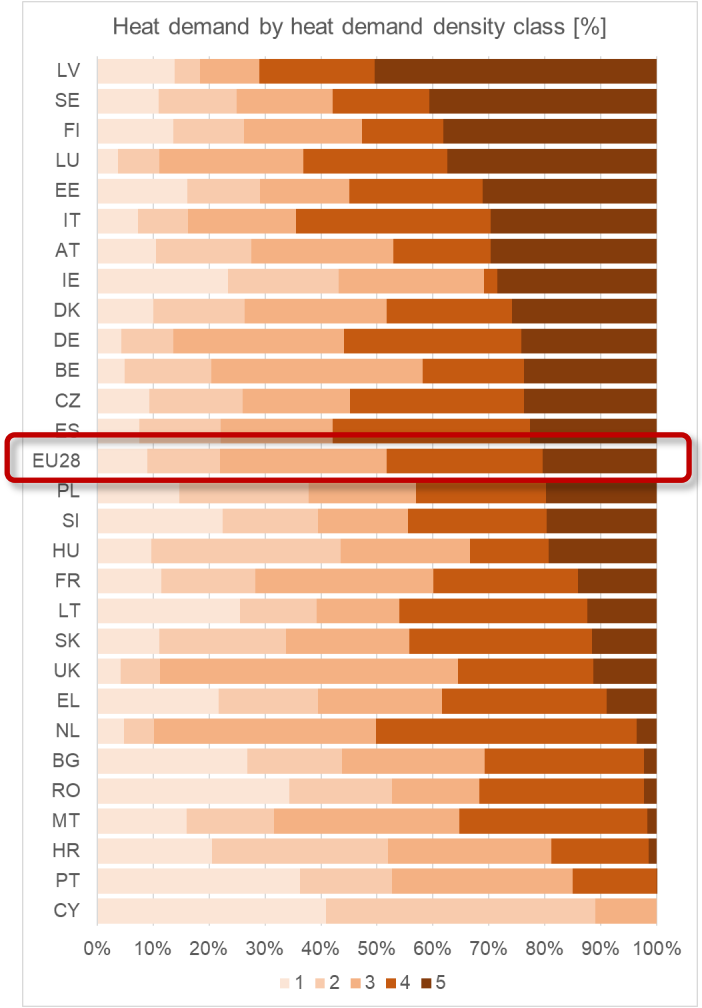

3-5: **78%** (Highest: the Netherlands at 90%), 4-5: **48%** (Highest: Latvia at 71%)

1-2: **22%** (Highest: Cyprus at 89%)

AALBORG UNIVERSITY DENMARK

HALMSTAD UNIVERSITY

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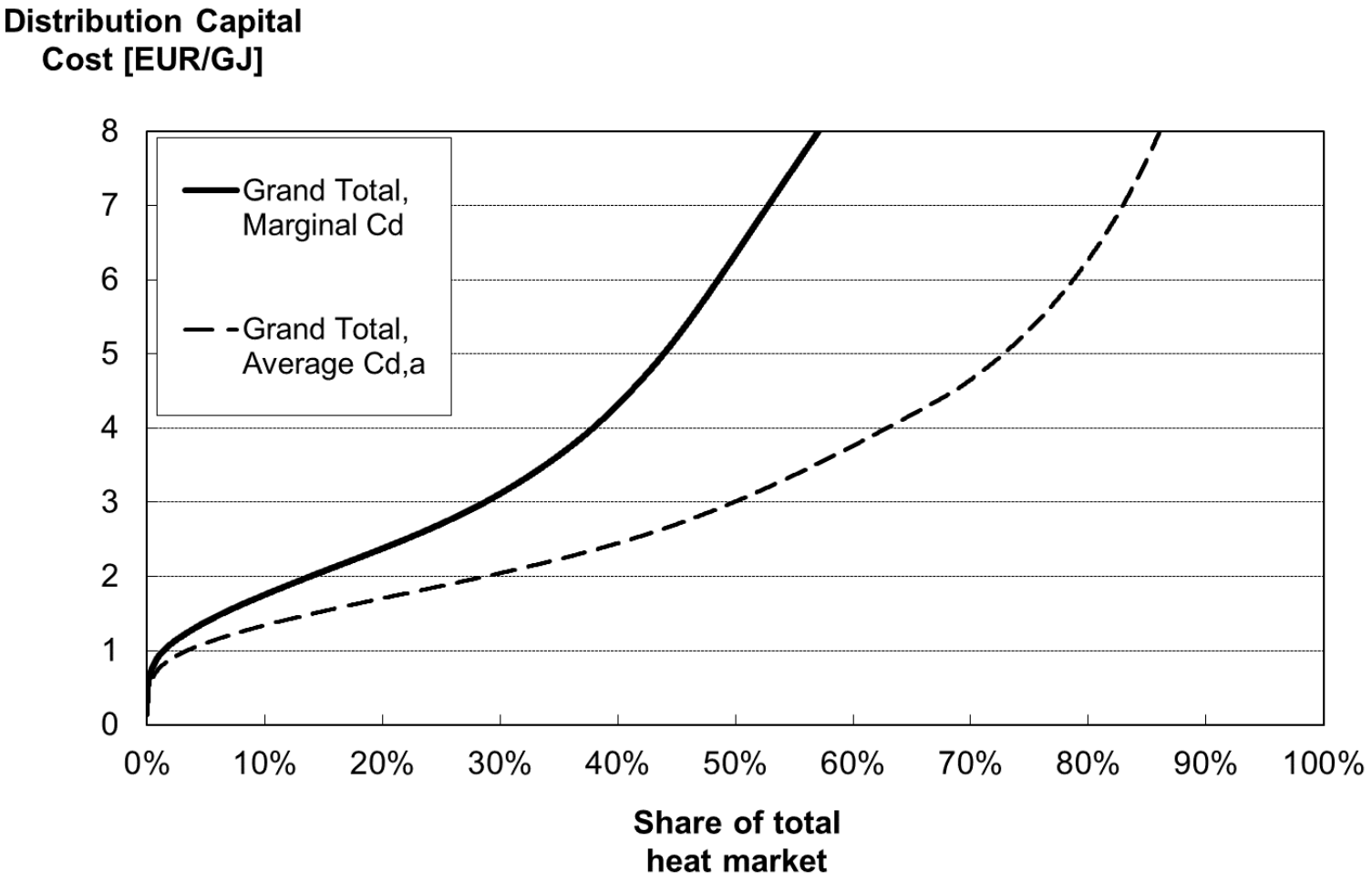

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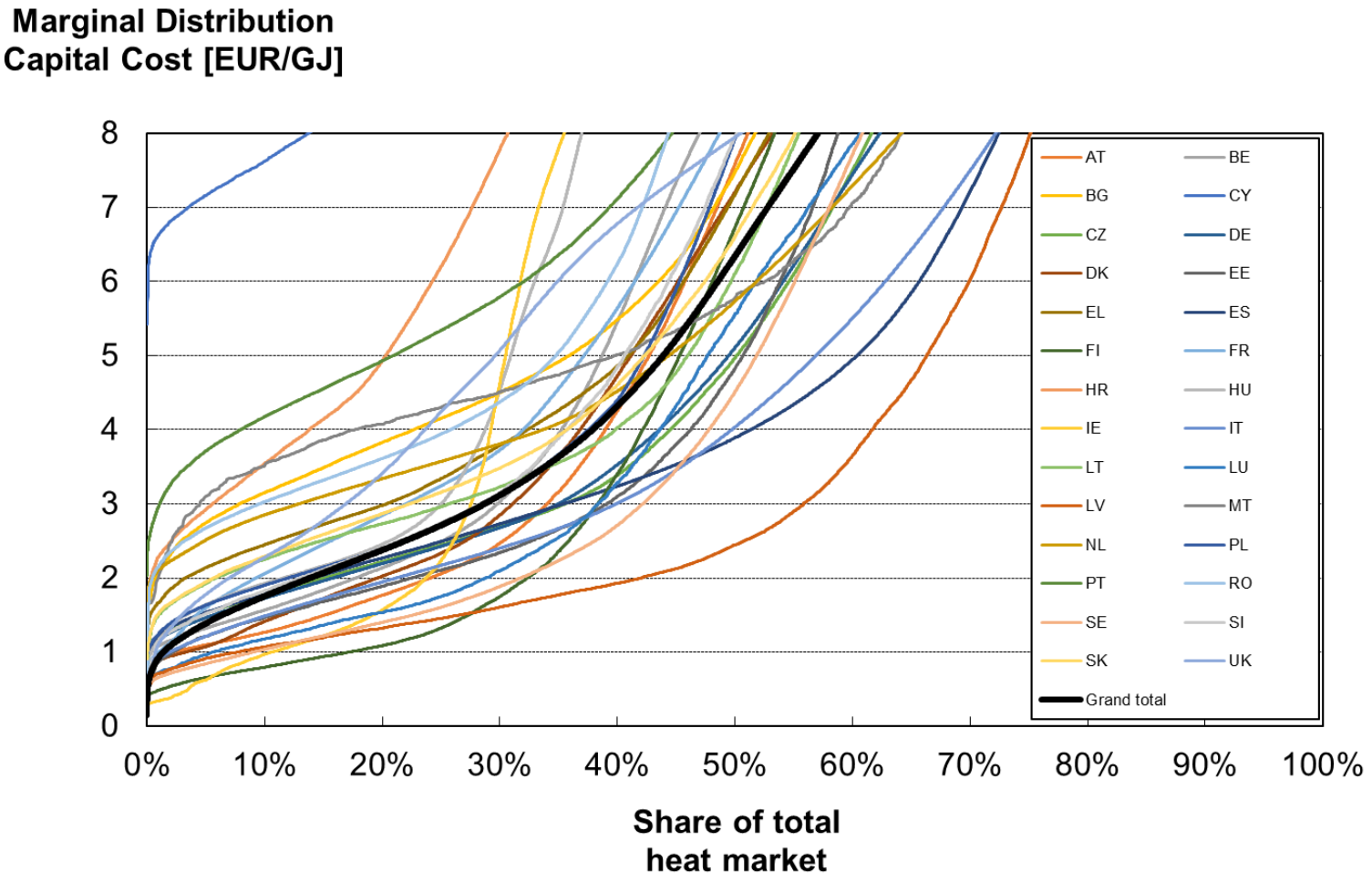

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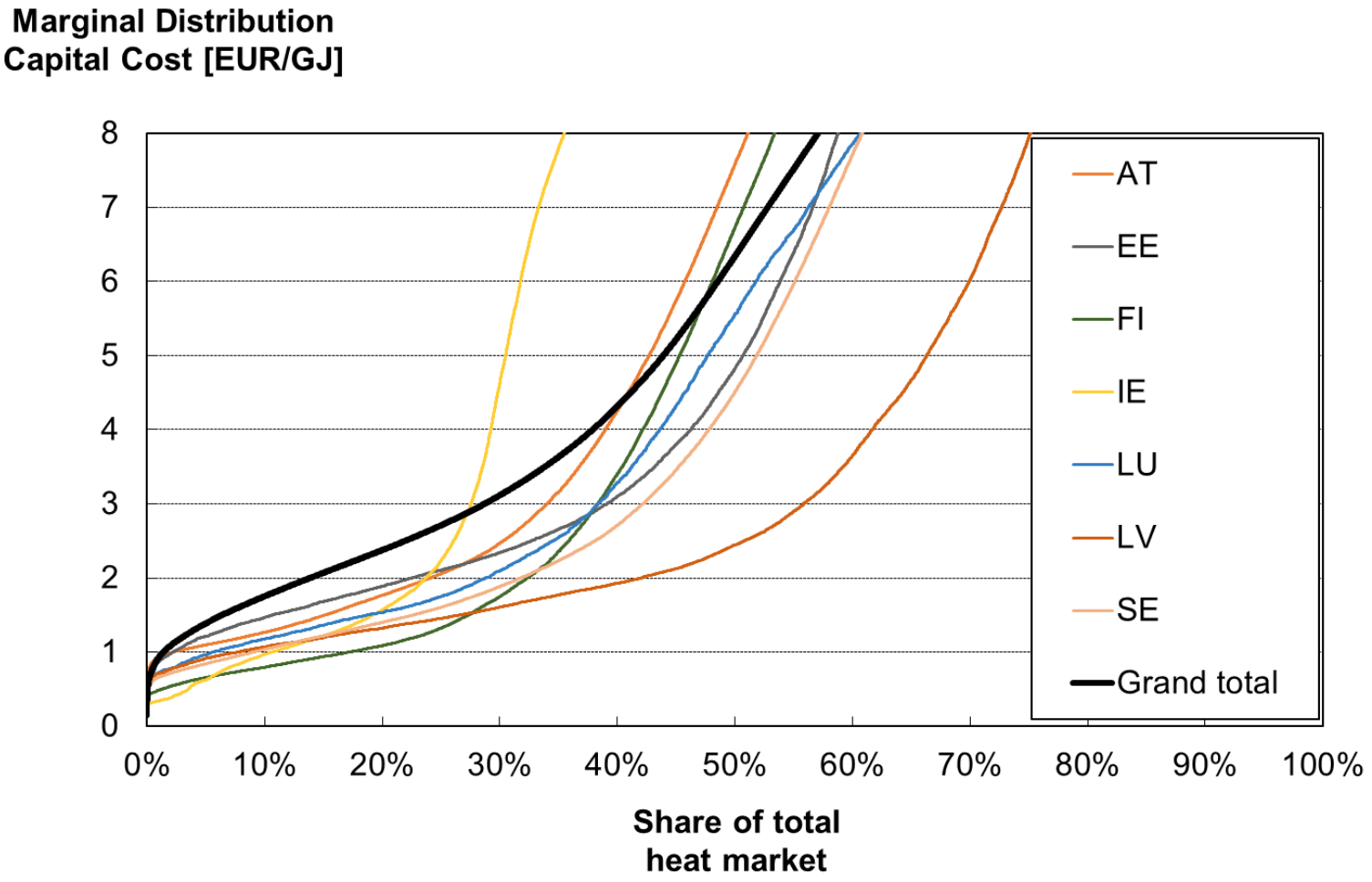

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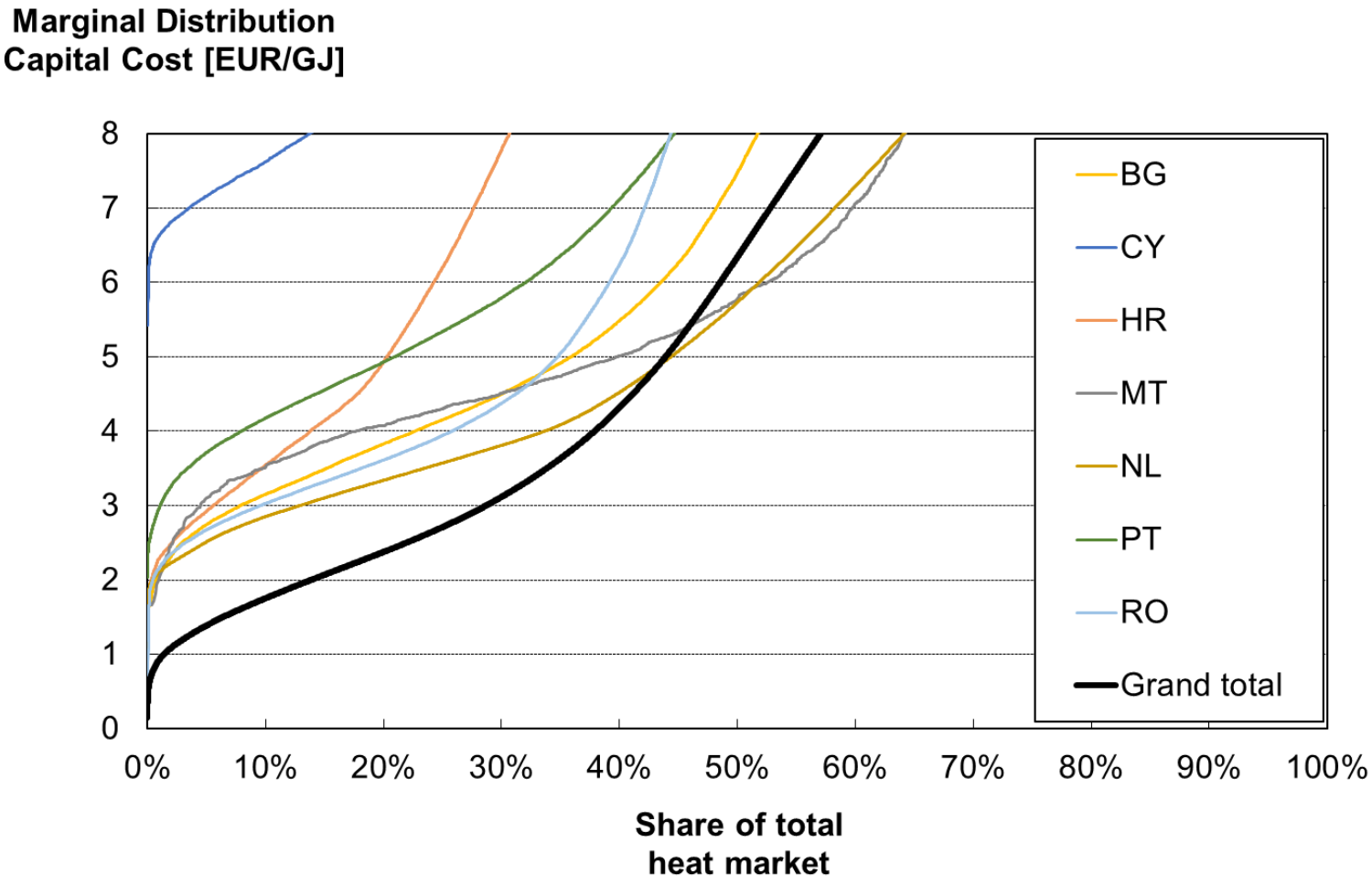

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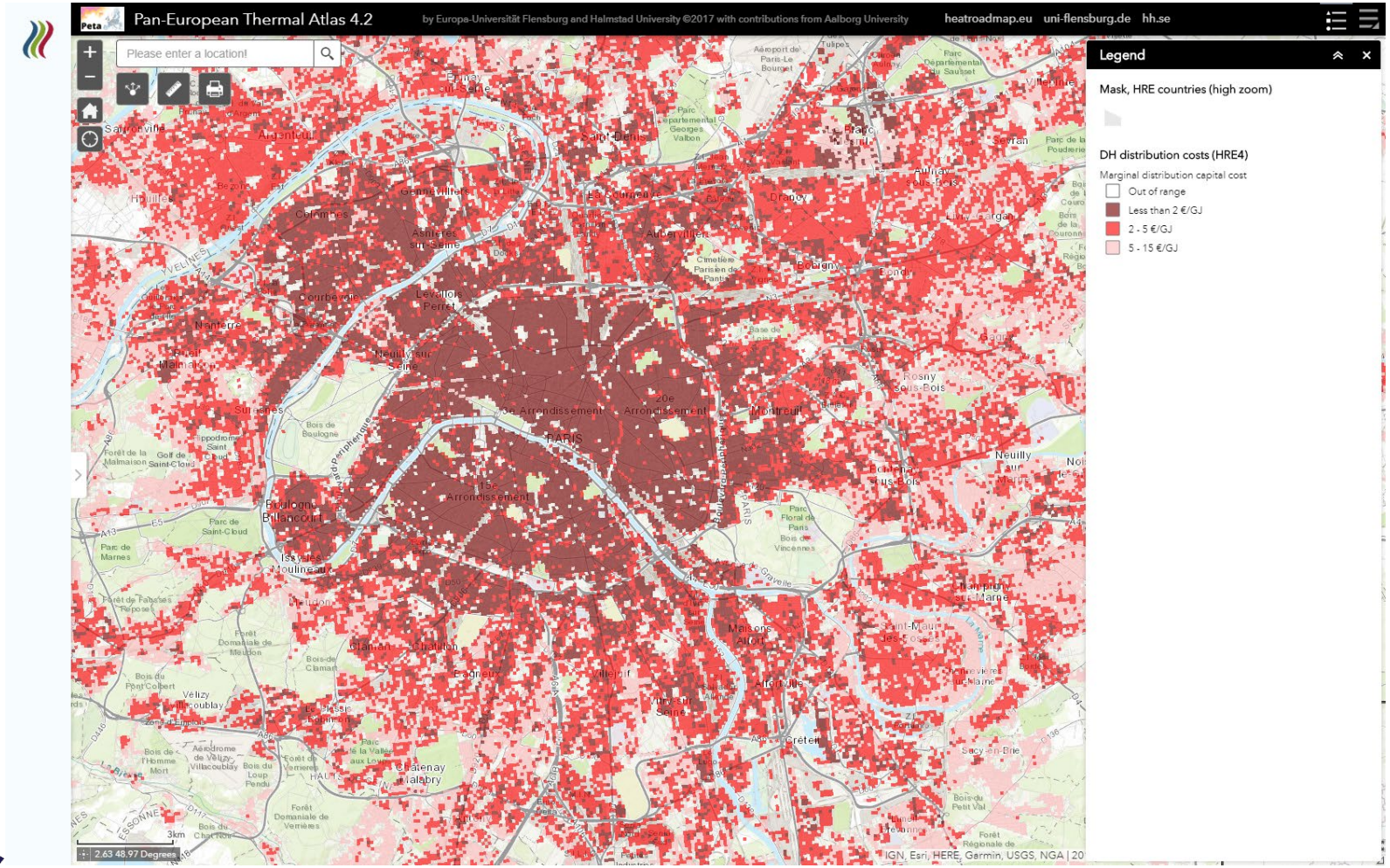

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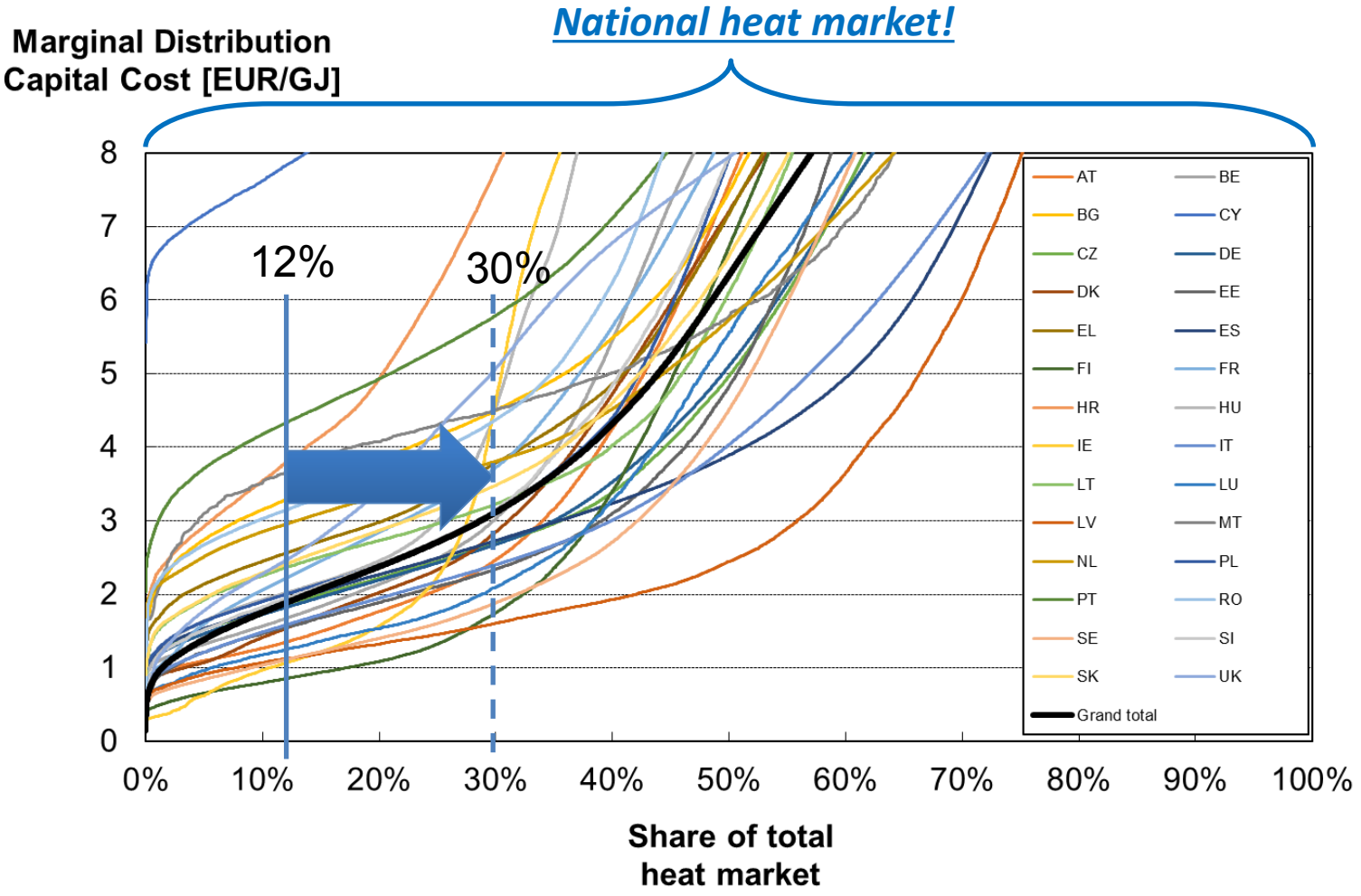

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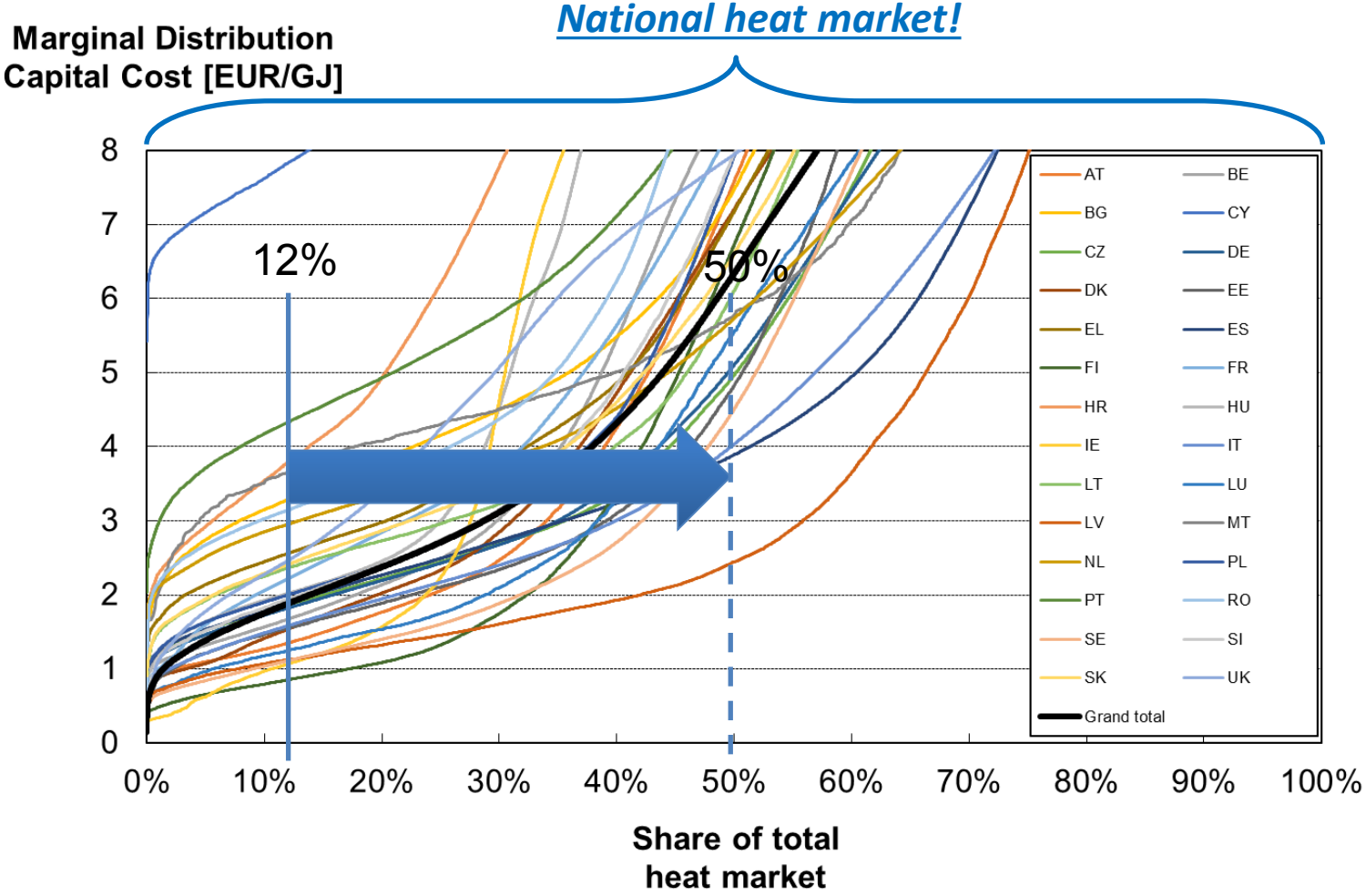
- Economic suitability

National heat market!



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Results

- Current levels and saturation

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- Current levels and saturation

	Current (2015)			Saturated (EU28 50% average)				Expansion		
MS	DH [PJ/a]	DH [%]	I [G€]	DH [PJ/a]	DH [%]	$C_{d,a}$ [€/GJ]	I [G€]	DH [PJ/a]	Factor [-]	I [G€]
AT	65	28%	1.88	109	47%	2.4	5.20	44	1.7	3.31
BE	5	2%	0.11	137	42%	2.6	7.06	132	26.9	6.95
BG	17	25%	1.11	31	45%	4.1	2.47	14	1.8	1.36
CY	0	0%	0	0.02	0.2%	6.1	0.002	0.02	-	0.002
CZ	68	29%	2.59	133	56%	2.9	7.61	65	2.0	5.02
DE	264	11%	7.60	1339	56%	2.9	76.93	1076	5.1	69.32
DK	95	58%	6.92	76	47%	2.7	4.01	-	0.8	-
EE	15	45%	0.61	19	55%	2.6	0.94	3	1.2	0.33
EL	2	1%	0.05	55	47%	3.5	3.72	53	31.5	3.66
ES	2	0.5%	0.04	328	67%	3.1	19.96	326	144.4	19.92
FI	107	47%	3.86	111	49%	2.0	4.27	3	1.0	0.41
FR	81	5%	1.98	669	43%	3.2	41.37	587	8.2	39.39
HR	7	10%	0.38	17	26%	4.0	1.35	11	2.5	0.96
HU	27	13%	0.88	71	34%	2.7	3.72	44	2.6	2.84
IE	1	1%	0.005	34	32%	1.7	1.14	33	41.3	1.14
IT	51	4%	0.98	828	65%	2.9	46.90	777	16.2	45.93
LT	24	52%	1.54	23	51%	3.2	1.46	-	1.0	-
LU	3	13%	0.07	14	53%	2.4	0.65	10	4.1	0.59
LV	23	50%	0.67	33	71%	2.2	1.41	10	1.4	0.75
MT	0.00003	0.001%	0.0002	2	55%	4.4	0.14	2	45543.6	0.14
NL	21	5%	0.95	230	54%	3.9	17.40	209	10.8	16.46
PL	206	31%	8.85	304	46%	2.9	17.29	98	1.5	8.43
PT	1	2%	0.07	22	35%	4.7	2.05	21	17.5	1.98
RO	42	23%	2.48	74	40%	3.8	5.47	32	1.8	2.98
SE	156	53%	6.27	165	56%	2.3	7.34	9	1.1	1.07
SI	4	13%	0.14	16	45%	2.9	0.91	11	3.5	0.77
SK	23	24%	1.06	47	49%	3.4	3.08	24	2.0	2.02
UK	21	2%	0.41	503	37%	3.4	33.95	482	23.8	33.54
EU28	**1343**	**12%**	**51.51**	**5398**	**50%**	**3.0**	**317.79**	**4076**	**4.0**	**269.27**

EU28: Heat market share of **~50%** at marginal distribution capital cost of **6.34 €/GJ**

Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

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4DH
4th Generation District Heating Technologies and Systems

Results

- Current levels and saturation
- **Selection**
  - Member states with largest expansion potentials in terms of annual heat demand volumes
  - Identify the most substantial expansion markets for district heating in EU28
- Eight member states: **BE, DE, ES, FR, IT, NL, PL & UK**
- Together these represent:
  - 89% of total expansion investment volume
  - 90% of total expansion heat demand volume
  - Average expansion factor of 29.6

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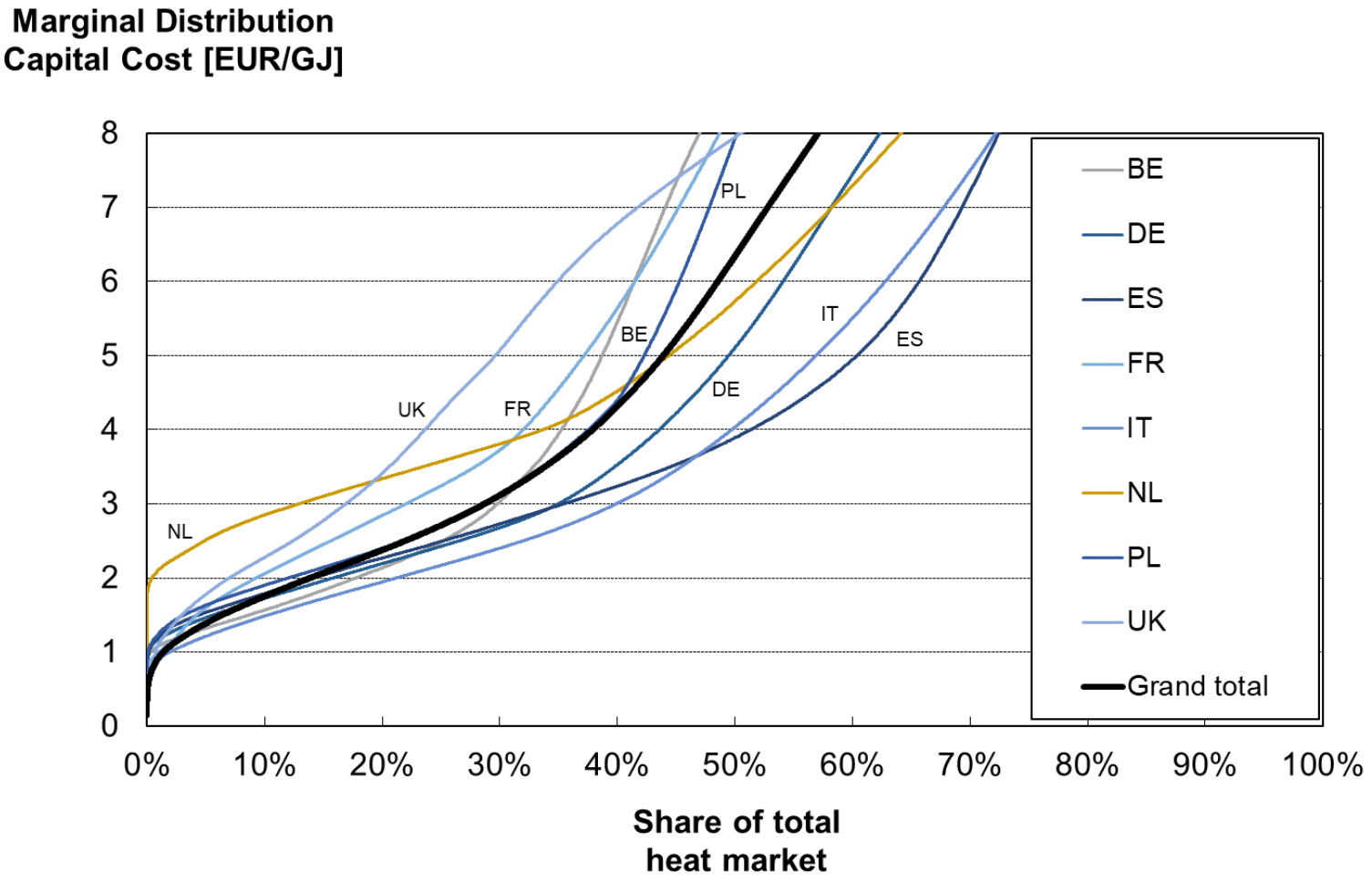
Results

- Current levels and saturation



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Results

- Current levels and saturation
- **Selection**

	Expansion			q_L classes 4 & 5		q_L classes 3, 4 & 5	
MS	DH [PJ/a]	Factor [-]	I [G€]	A_{Land} [kkm^2]	L [kkm]	A_{Land} [kkm^2]	L [kkm]
DE	1076	5.1	69.32	5.4	89.8	15.0	250.8
IT	777	16.2	45.93	3.2	53.6	6.3	104.5
FR	587	8.2	39.39	2.7	45.7	9.5	157.7
UK	482	23.8	33.54	2.2	37.3	11.3	187.8
ES	326	144.4	19.92	1.2	19.7	2.4	40.7
NL	209	10.8	16.46	1.2	20.4	3.2	52.8
BE	132	26.9	6.95	0.5	7.8	2.2	35.9
PL	98	1.5	8.43	1.1	18.5	2.9	49.0
Total	**3687**	**29.6**	**239.94**	**17.6**	**292.8**	**52.7**	**879.2**
EU28	**4076**	**4.0**	**269.27**	**21.1**	**352.4**	**62.9**	**1049.1**

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Conclusions

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Conclusions

- EU28 Res. & Serv. sector heat market: ~10.8 EJ (2015)
  - DH at ~12% heat market share
- *Physical suitability*
  - 48% of heat demand in dense and very dense areas
- *Economic suitability*
  - ~50% market share at ~6 €/GJ (average 3 €/GJ)
- *Expansion market (saturation)*
  - Annual heat demand ~4.1 EJ (total investment ~270 G€)
- ***Aggregated answer***
  - Why DH can be viable concerning physical suitability?
    - **MS with lower specific heat demands: Generally more dense!**
    - **MS with higher specific heat demands: Generally more sparse!**

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Conclusions

- Suitability concepts…
  - Physical – heat demand density
  - Economic – heat distribution capital cost
  - Others?
    - *Political suitability* – governmental, jurisdictional devotion and preparedness…
    - *Cultural suitability* - public awareness, traditional technology preferences…
    - *Environmental suitability* - efficiency and GHG reduction capacity of different technologies…

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THANK YOU!

QUESTIONS?