# 4th INTERNATIONAL CONFERENCE ON

# SMART ENERGY SYSTEMS AND 4TH GENERATION DISTRICT HEATING

## AALBORG, 13–14 NOVEMBER 2018

# REUSEHEAT SESSION

## AALBORG, 14 NOVEMBER 2018

REUSEHEAT SESSION

# URBAN WASTE HEAT RECOVERY POTENTIAL IN EU28
## MAPPING AND GEOGRAPHICAL VISUALISATION

PRESENTER: URBAN PERSSON

Europa-Universität
Flensburg

**4DH**
4th Generation District Heating
Technologies and Systems

**ReUseHeat**
**- Urban Waste Water Treatment Plants**
**- Germany (DE)**
**- R4: Available excess heat**
**- QL [PJ/a]**
**- All systems**

**QL_4_EHI_PJ_**
· < 0.05
● 0.05 - 0.1
● 0.1 - 0.5
● 0.5 - 1.0
● > 1.0
NUTS3 regions - EU28

Origin: Halmstad, Flensburg, and Aalborg Universities, 2018
Sources: Waterbase-UWWTD_v6 (EEA), SDHA 2005 to 2016,
SE UWWTP environmental reports 2013 to 2017,
UMZ 2006, HUDHC_v5.
NUTS data © EuroGeographics for the administrative boundaries

0    100    200    300    Kilometers

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4th International Conference on Smart Energy Systems and 4th Generation District Heating 2018/#SES4DH2018/14-11-2018

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**ReUseHeat**
- Metros (stations)
- Stockholm (SE)
- Accessible excess heat
- QH [PJ/a]
- Inside or within 2 km from DH area

**QH_COP3.0(PJ)**
- Above ground
- < 0.016
- 0.016 - 0.020
- > 0.020

Buffer_UMZ_HUDHC_2km
NUTS3 regions - EU28

Åkersberga

olm

**Stockholm**

0    2    4    6    Kilometers

N
W    E
S

Origin: Halmstad and Aalborg Universities, 2018
Sources: Official city transit maps 2018, Google maps,
climatemps.com, weatherbase.com,
UMZ 2006, HUDHC_v5.
NUTS data © EuroGeographics for the administrative boundaries

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**ReUseHeat**
- Data centres
- EU28
- Locations
- All systems

With P_tot data

Without P_tot data

NUTS3 regions - EU28

Origin: Halmstad and Aalborg Universities, 2018
Sources: Data Center Map,
UMZ 2006, HUDHC_v5.
NUTS data © EuroGeographics for the administrative boundaries

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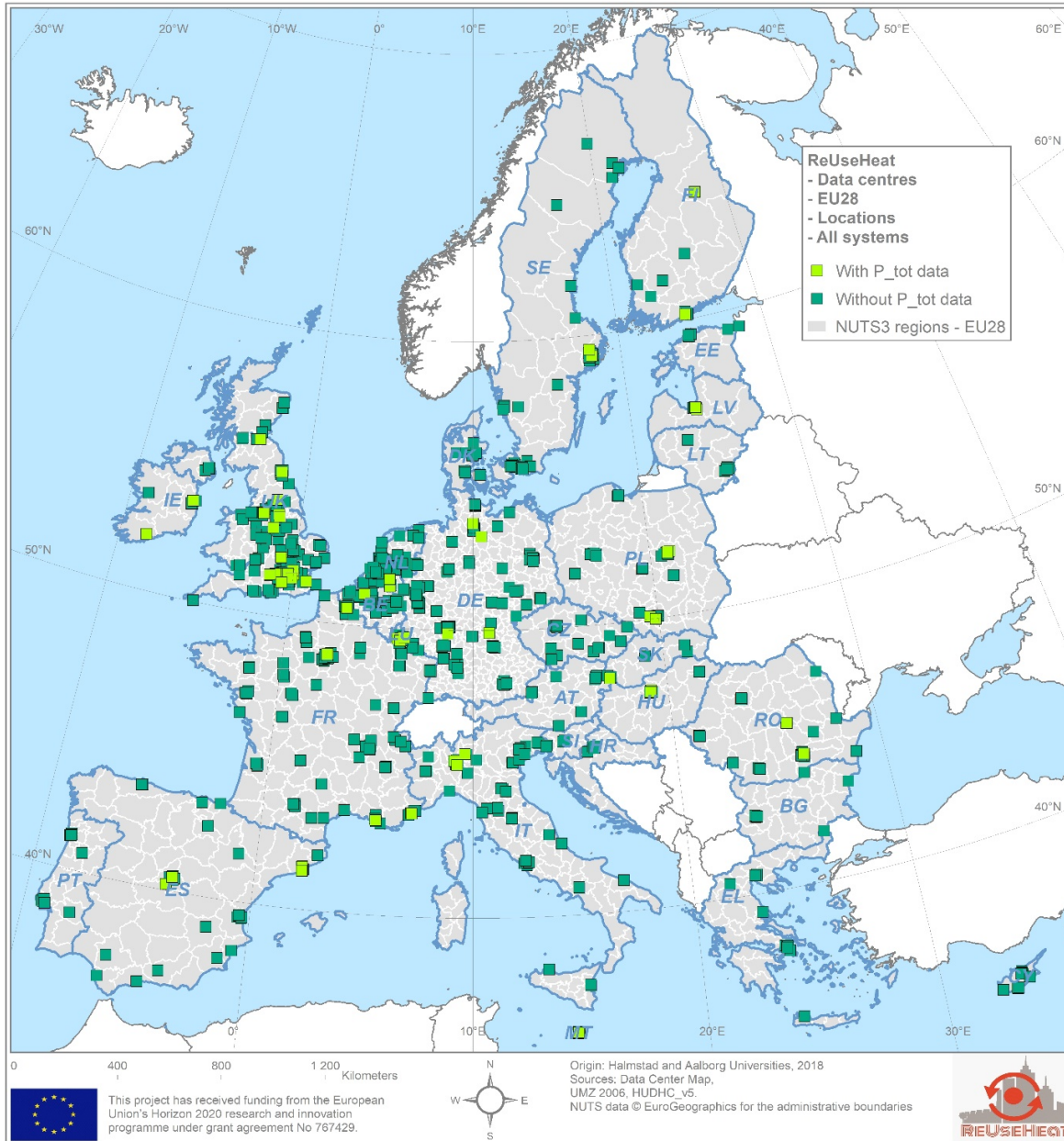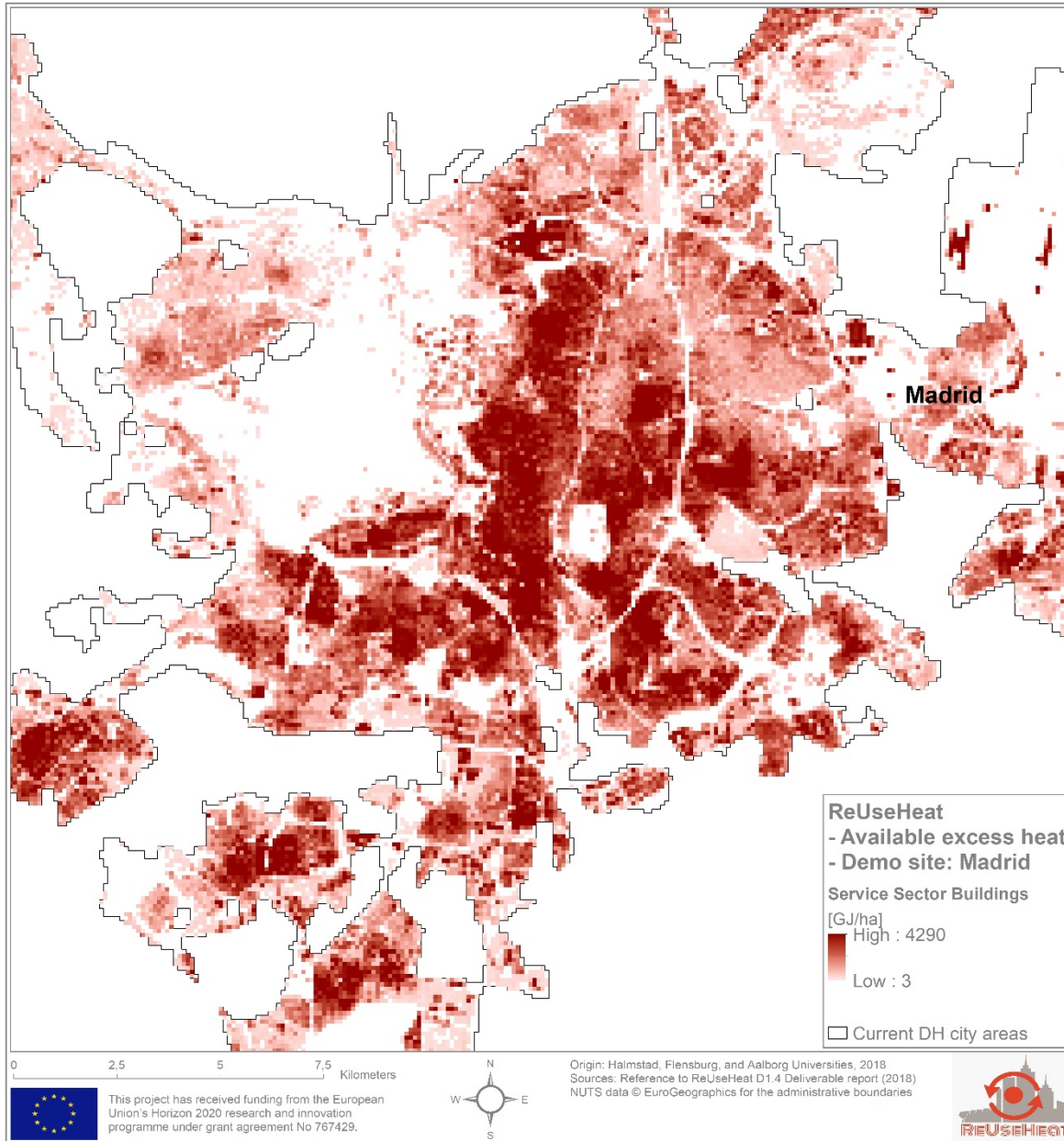
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Madrid

**ReUseHeat**
**- Available excess heat**
**- Demo site: Madrid**
**Service Sector Buildings**
[GJ/ha]
High : 4290
Low : 3

Current DH city areas

0    2,5    5    7,5    Kilometers

Origin: Halmstad, Flensburg, and Aalborg Universities, 2018
Sources: Reference to ReUseHeat D1.4 Deliverable report (2018)
NUTS data © EuroGeographics for the administrative boundaries

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# Overview

- **Introduction**
  - Four unconventional sources
  - Some concepts

- **Excess heat potentials**
  - Waste water treatment plants
  - Metro stations
  - Data centres
  - Service sector buildings

- **Demo sites**

- **Summary**

# Introduction

- # Four unconventional sources

  - ## Waste water treatment plants
    - Post-treatment heat in sewage water

  - ## Metro stations
    - Exhaust air heat in platform ventilation shafts

  - ## Data Centres
    - Rejected heat from cooling of IT equipment in server halls

  - ## Service sector buildings
    - Rejected heat from space cooling in sector buildings

Low-temperature < 50 °C... Utilisation by use of heat pumps

# Introduction

- ## Four unconventional sources
  - ### Waste water treatment plants
    - Anticipated potential (project description): **540 PJ/a**
  - ### Metro stations
    - Anticipated potential (project description): **36 PJ/a**
  - ### Data Centres
    - Anticipated potential (project description): **173 PJ/a**
  - ### Service sector buildings
    - Anticipated potential (project description): **40 PJ/a**
  - ### Total
    - Anticipated potential (project description): **789 PJ/a**

# Introduction

- **Some concepts**

- **Available** excess heat
  - Heat available at HP evaporator
  - Equivalent to "$Q_L$"
  - *Temporal dimension (Seasonality)*

- **Accessible** excess heat
  - Heat accessible at HP condenser
  - Equivalent to "$Q_H$"
  - *Spatial dimension (local conditions)*

- Basic heat pump concepts:

- $Q_H = Q_L + W$    [J]

- $COP_{HP,irev} = \dfrac{Q_H}{W}$    [-]

- $COP_{HP,rev} = \dfrac{T_H}{T_H - T_L}$    [-]

- $\eta_{Carnot} = \dfrac{COP_{HP,irev}}{COP_{HP,rev}}$    [-]
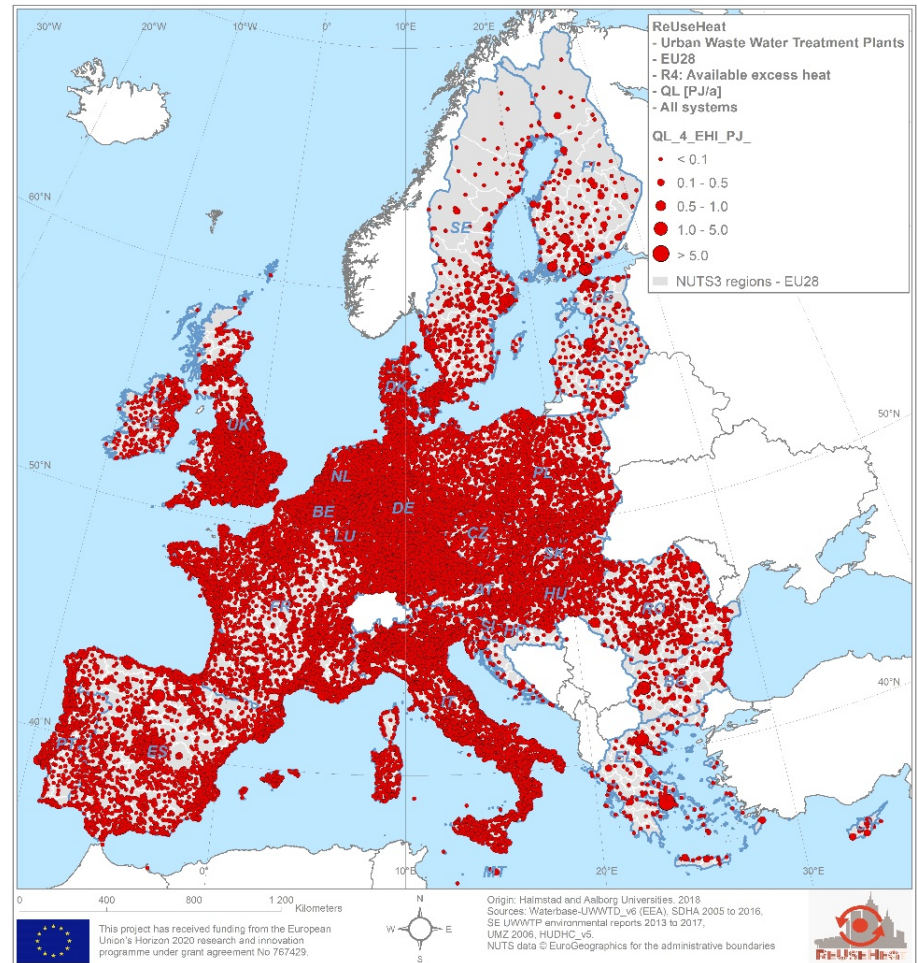
# Excess heat potentials – Waste-water plants

# Excess heat potentials – Waste-water plants

- ## Data and method
  - Excess heat potential estimated by
    - Applying best-fit linear regression function from the SE Model to the facilities recorded in the EEA database
    - Adjustment to seasonality of heat demands (EHI)
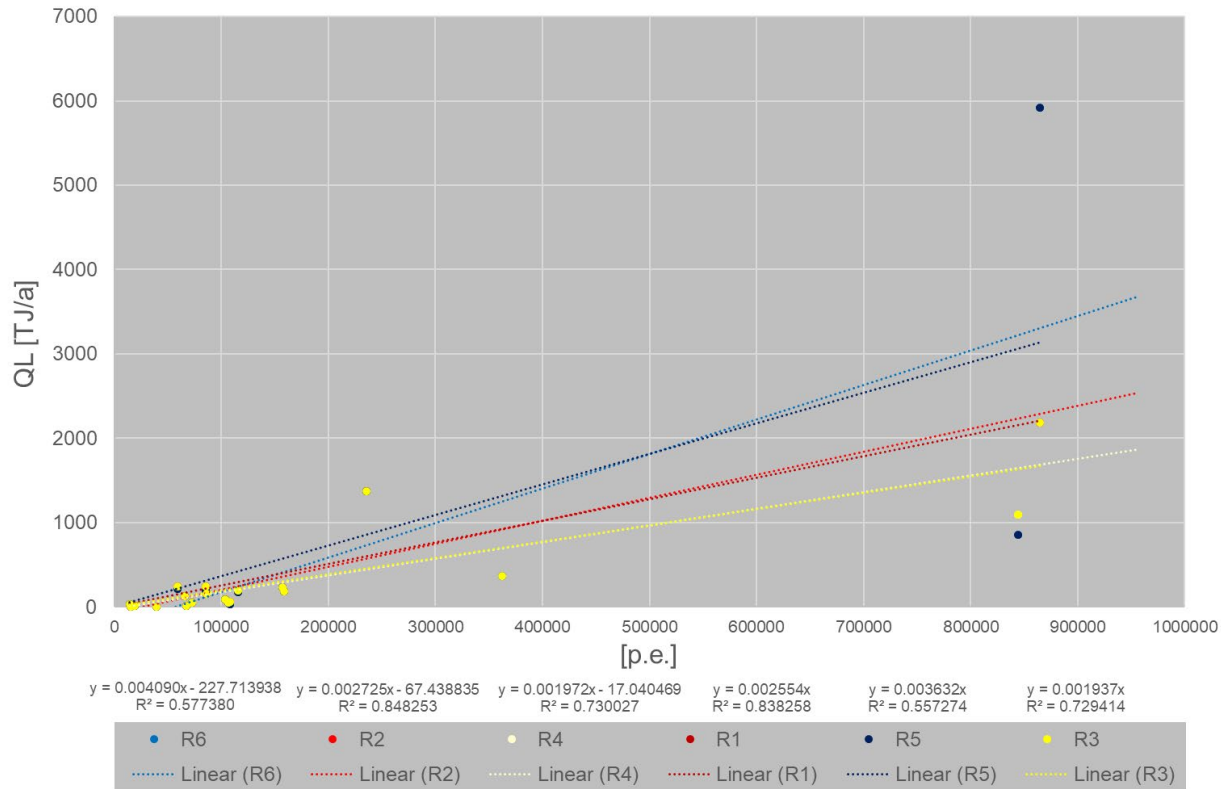    - Spatial correlation to current district heating areas

# Excess heat potentials – Waste-water plants

- Data and method
  - Waterbase-UWWTD_v6 dataset (EEA)
    - Plant capacities
    - Site coordinates
  - SE Model
    - Time-series data from 20 Swedish DH operators
    - Time–series data from 20 Swedish sewage facilities

# Excess heat potentials – Waste-water plants

- ## Data and method
  - ### SE Model



y = 0.004090x - 227.713938
R² = 0.577380

y = 0.002725x - 67.438835
R² = 0.848253

y = 0.001972x - 17.040469
R² = 0.730027

y = 0.002554x
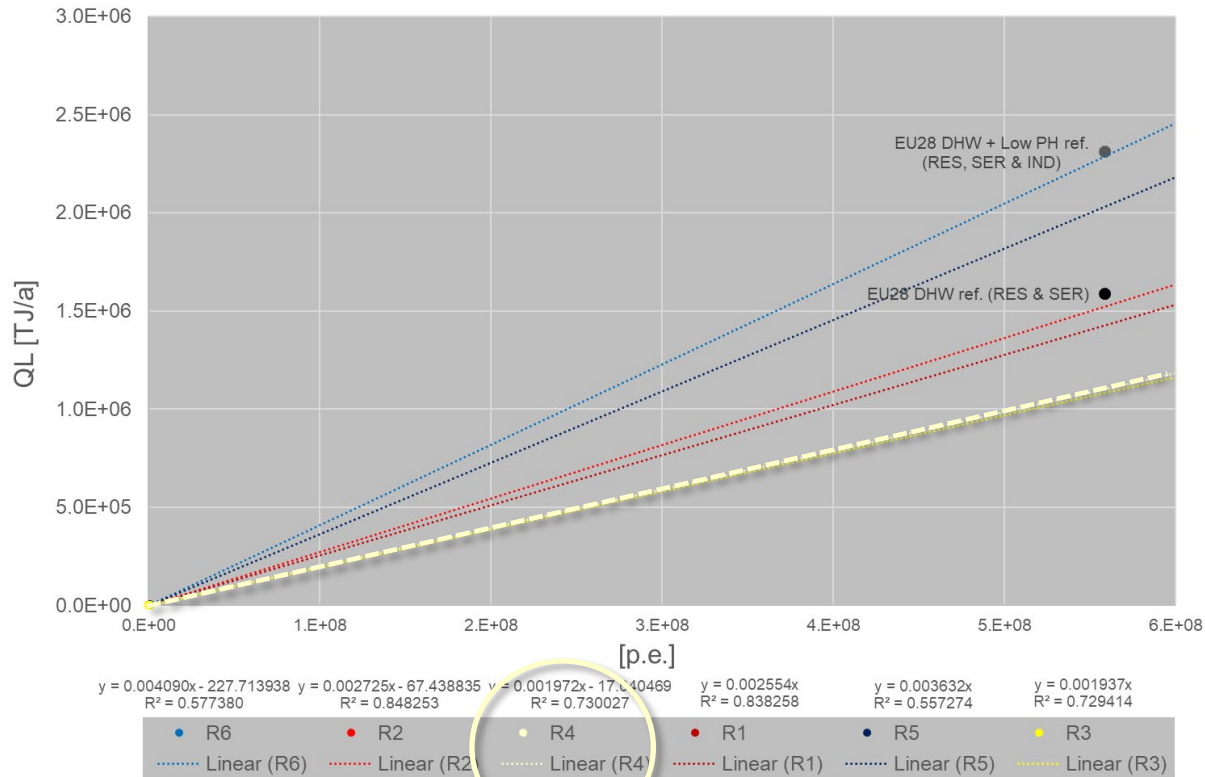R² = 0.838258

y = 0.003632x
R² = 0.557274

y = 0.001937x
R² = 0.729414

# Excess heat potentials – Waste-water plants
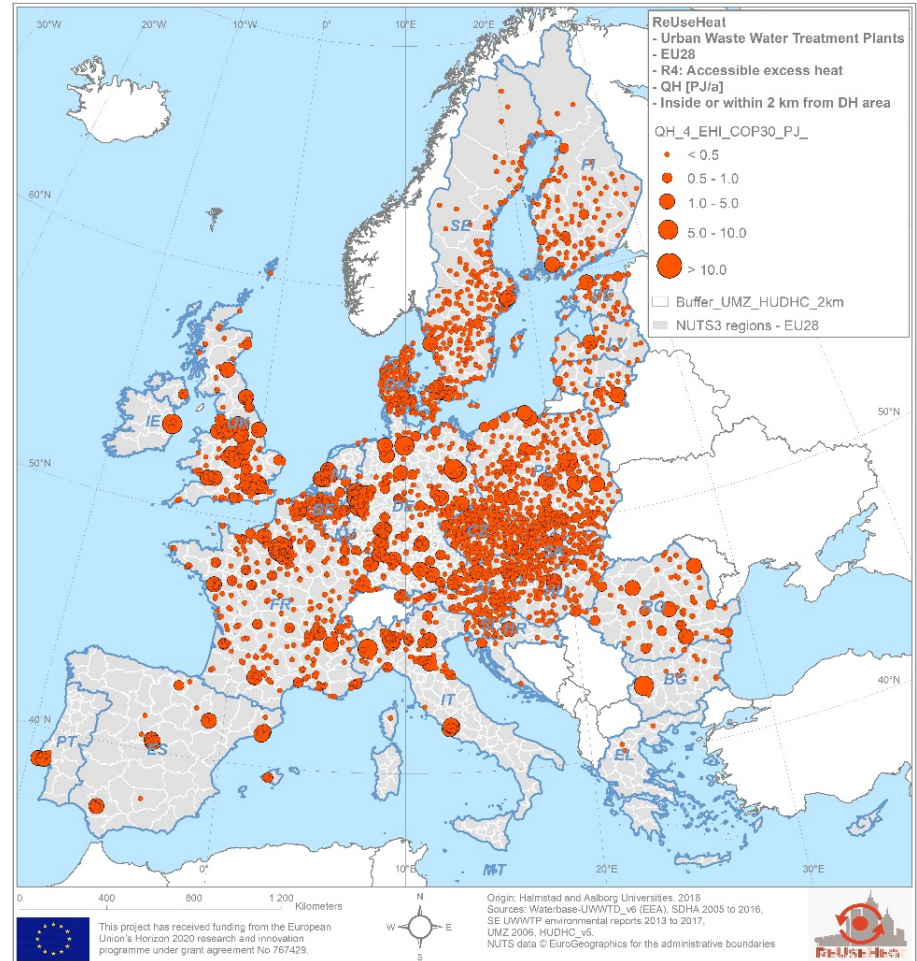
- ## Data and method
  - ### SE Model

# Excess heat potentials – Waste-water plants

- Results
  - 3982 (of 23,189) plants inside or within 2 km of current DH areas
  - R4:
    - 417 PJ/a (Available)
    - 625 PJ/a (Accessible)
      - at $COP_{HP,irev} = 3.0$
      - W = 208 PJ/a
  - $Q_{t,EU28} \approx 10.7$ EJ/a
    - Accessible excess heat represents 5.8% of total heat demand
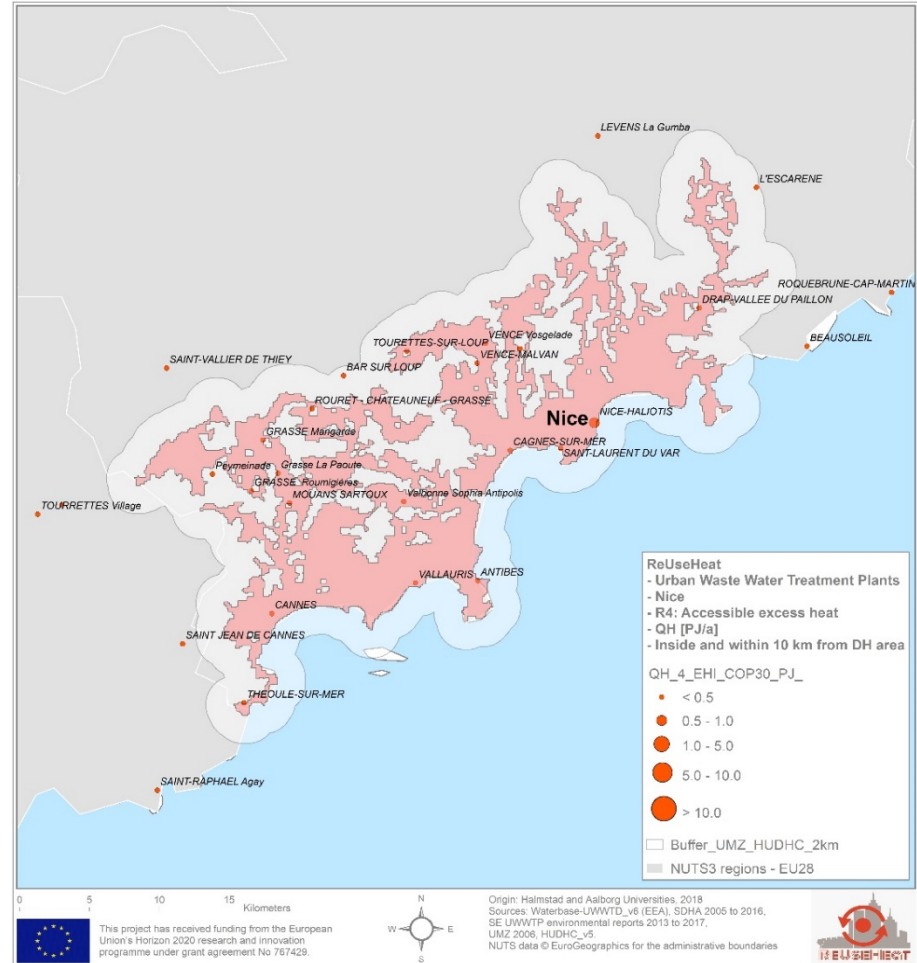
# Excess heat potentials – Waste-water plants

- Results
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  - $Q_{t,EU28} \approx 10.7$ EJ/a
    - Accessible excess heat represents 5.8% of total heat demand

# Excess heat potentials – Waste-water plants

- Results: R4 (2 km)

| MS | Count of uwwUWWTPSID | Sum of QL_4(PJ) | Sum of QH_4_COP3.0(PJ) | Sum of W_4_COP3.0(PJ) | Sum of QL_4_EHI(PJ) | Sum of QH_4_EHI_COP3.0(PJ) | Sum of W_4_EHI_COP3.0(PJ) |
|---|---|---|---|---|---|---|---|
| AT | 231 | 18 | 27 | 9 | 16 | 24 | 8 |
| BE | 218 | 11 | 17 | 6 | 10 | 14 | 5 |
| BG | 13 | 5 | 7 | 2 | 4 | 6 | 2 |
| CZ | 369 | 14 | 21 | 7 | 13 | 20 | 7 |
| DE | 418 | 89 | 133 | 44 | 81 | 121 | 40 |
| DK | 199 | 10 | 15 | 5 | 10 | 15 | 5 |
| EE | 45 | 2 | 3 | 1 | 2 | 3 | 1 |
| EL | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| ES | 57 | 24 | 36 | 12 | 15 | 22 | 7 |
| FI | 106 | 7 | 11 | 4 | 8 | 12 | 4 |
| FR | 597 | 71 | 106 | 35 | 57 | 86 | 29 |
| HR | 12 | 3 | 5 | 2 | 3 | 4 | 1 |
| HU | 113 | 12 | 19 | 6 | 11 | 16 | 5 |
| IE | 6 | 5 | 7 | 2 | 4 | 6 | 2 |
| IT | 194 | 35 | 53 | 18 | 27 | 40 | 13 |
| LT | 33 | 3 | 5 | 2 | 3 | 5 | 2 |
| LU | 5 | 0 | 1 | 0 | 0 | 1 | 0 |
| LV | 35 | 2 | 3 | 1 | 2 | 3 | 1 |
| NL | 64 | 12 | 18 | 6 | 10 | 15 | 5 |
| PL | 445 | 46 | 70 | 23 | 45 | 67 | 22 |
| PT | 14 | 5 | 7 | 2 | 3 | 4 | 1 |
| RO | 76 | 14 | 20 | 7 | 12 | 18 | 6 |
| SE | 232 | 13 | 20 | 7 | 14 | 20 | 7 |
| SI | 42 | 1 | 2 | 1 | 1 | 2 | 1 |
| SK | 153 | 5 | 8 | 3 | 5 | 7 | 2 |
| UK | 302 | 74 | 111 | 37 | 62 | 93 | 31 |
| **Grand Total** | **3982** | **483** | **724** | **241** | **417** | **625** | **208** |

# Excess heat potentials – Waste-water plants

- Results: R4 (all)

| MS | Count of uwwUWWTPSID | Sum of QL_4(PJ) | Sum of QH_4_COP3.0(PJ) | Sum of W_4_COP3.0(PJ) | Sum of QL_4_EHI(PJ) | Sum of QH_4_EHI_COP3.0(PJ) | Sum of W_4_EHI_COP3.0(PJ) |
|---|---|---|---|---|---|---|---|
| AT | 634 | 23 | 35 | 12 | 21 | 31 | 10 |
| BE | 402 | 14 | 20 | 7 | 12 | 17 | 6 |
| BG | 104 | 9 | 14 | 5 | 8 | 12 | 4 |
| CY | 15 | 1 | 2 | 1 | 1 | 2 | 1 |
| CZ | 600 | 15 | 22 | 7 | 14 | 21 | 7 |
| DE | 4244 | 182 | 273 | 91 | 166 | 249 | 83 |
| DK | 343 | 12 | 18 | 6 | 11 | 17 | 6 |
| EE | 57 | 2 | 3 | 1 | 2 | 3 | 1 |
| EL | 159 | 19 | 29 | 10 | 11 | 17 | 6 |
| ES | 2020 | 105 | 157 | 52 | 64 | 96 | 32 |
| FI | 163 | 11 | 16 | 5 | 12 | 18 | 6 |
| FR | 3610 | 115 | 172 | 57 | 90 | 136 | 45 |
| HR | 81 | 5 | 8 | 3 | 4 | 6 | 2 |
| HU | 747 | 16 | 23 | 8 | 13 | 20 | 7 |
| IE | 167 | 8 | 12 | 4 | 7 | 10 | 3 |
| IT | 3953 | 116 | 174 | 58 | 81 | 121 | 40 |
| LT | 75 | 4 | 7 | 2 | 4 | 7 | 2 |
| LU | 33 | 1 | 2 | 1 | 1 | 1 | 0 |
| LV | 89 | 2 | 3 | 1 | 2 | 3 | 1 |
| MT | 4 | 1 | 1 | 0 | 0 | 1 | 0 |
| NL | 337 | 31 | 46 | 15 | 27 | 40 | 13 |
| PL | 1665 | 57 | 85 | 28 | 54 | 82 | 27 |
| PT | 467 | 20 | 30 | 10 | 11 | 17 | 6 |
| RO | 556 | 19 | 29 | 10 | 18 | 26 | 9 |
| SE | 432 | 16 | 24 | 8 | 16 | 25 | 8 |
| SI | 91 | 3 | 4 | 1 | 2 | 3 | 1 |
| SK | 263 | 6 | 9 | 3 | 5 | 8 | 3 |
| UK | 1878 | 122 | 183 | 61 | 103 | 155 | 52 |
| **Grand Total** | **23189** | **935** | **1403** | **468** | **763** | **1144** | **381** |

# Excess heat potentials – Metro stations
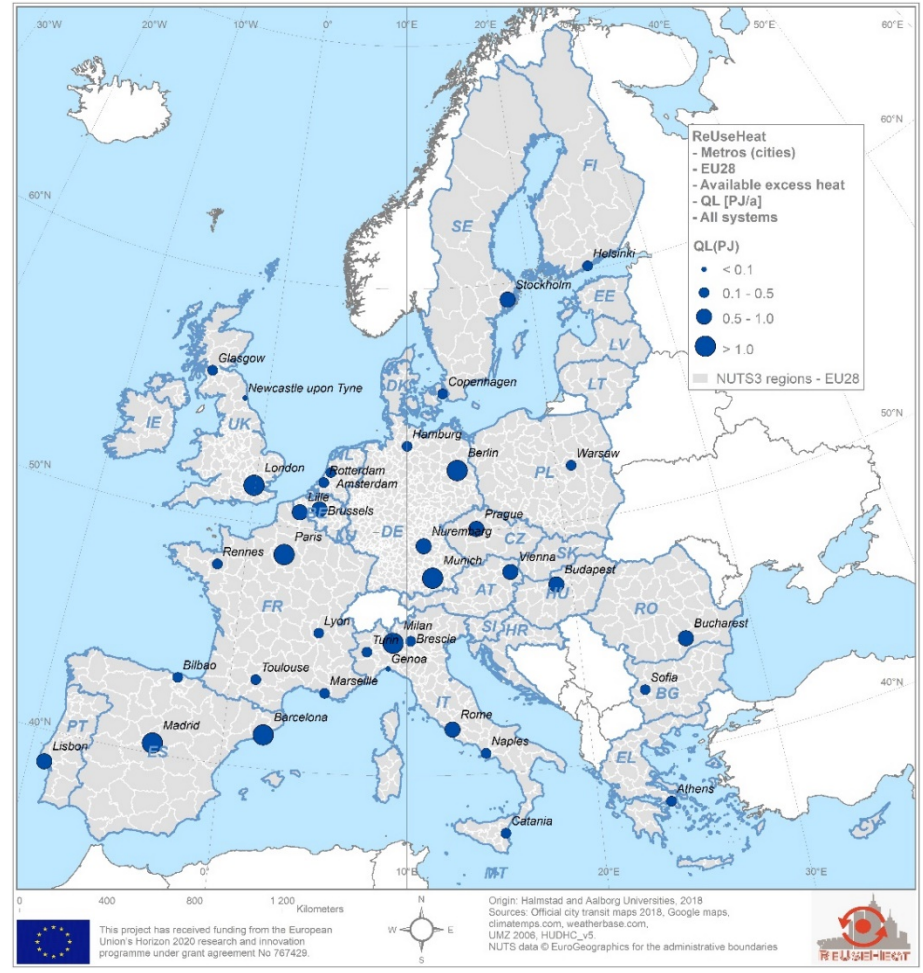
# Excess heat potentials – Metro stations

- ## Data and method
  - Excess heat potential estimated by
  - Georeferencing of station locations
  - **37 cities** operating heavy rail systems in EU28
  - Literature studies
    - Station average air flows, capacities, relations etc.
  - Meteorological data
    - Monthly averages of temperatures and humidity
    - Sensible heat (temperature drop limited to dew point temperatures)
  - Spatial correlation to current district heating areas

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 767429.

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# Excess heat potentials – Metro stations

- # Results
  - ## Available heat recovery
    - ### 37 cities
    - ### 1994 stations (UG)
    - ### Potential heat recovery $Q_L = 24.6$ PJ/a
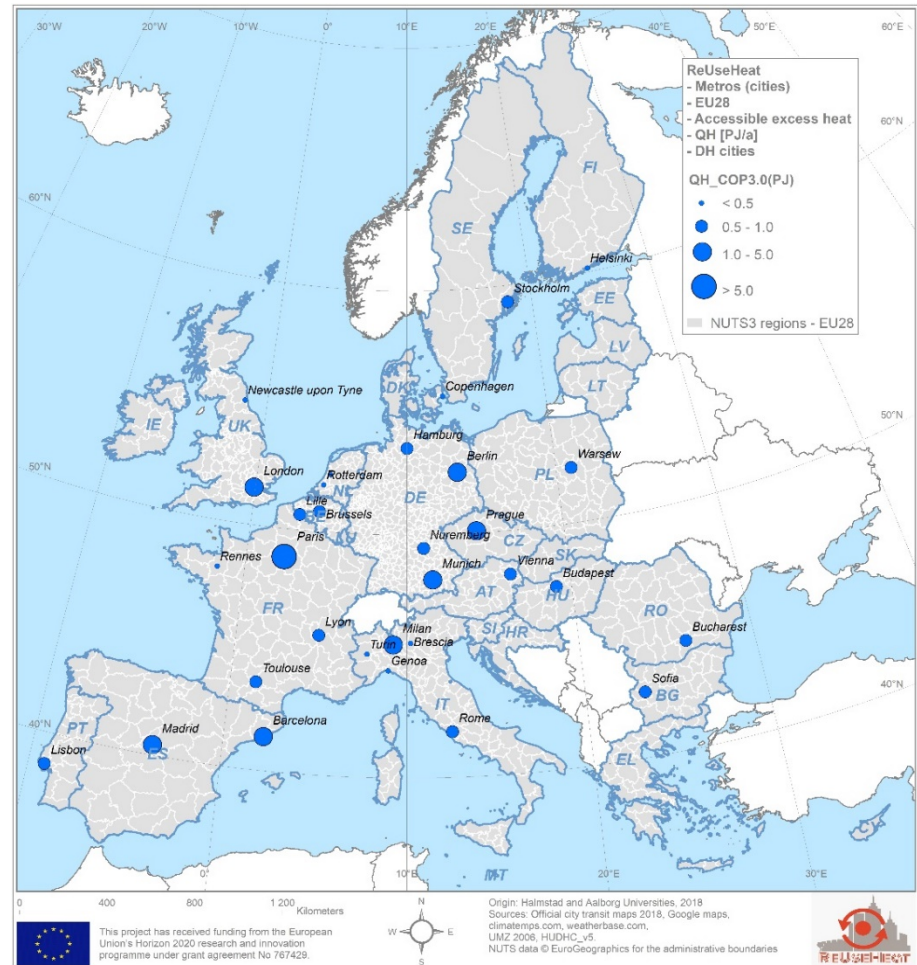
# Excess heat potentials – Metro stations

- # Results
  - ## Accessible heat recovery
    - **31 cities** with district heating systems
    - 1860 stations (UG)
    - Potential heat recovery
    - $Q_L = 23.0$ PJ/a
    - $Q_H = 34.5$ PJ/a
    - $W = 11.5$ PJ/a
    - $Q_H$ represents 0.33% of total heat demand

# Excess heat potentials – Metro stations

- Results: **DH cities**

| MS | Count of CityID | Sum of TotUniqUnStaName | Sum of QL(PJ) | Sum of QH_COP30(PJ) | Sum of W_COP30(PJ) |
|---|---|---|---|---|---|
| AT | 1 | 48 | 0.7 | 1.0 | 0.3 |
| BE | 1 | 47 | 0.5 | 0.8 | 0.3 |
| BG | 1 | 29 | 0.4 | 0.6 | 0.2 |
| CZ | 1 | 53 | 0.7 | 1.1 | 0.4 |
| DE | 4 | 318 | 3.9 | 5.9 | 2.0 |
| DK | 1 | 9 | 0.1 | 0.2 | 0.1 |
| ES | 2 | 376 | 4.8 | 7.3 | 2.4 |
| FI | 1 | 17 | 0.3 | 0.4 | 0.1 |
| FR | 5 | 419 | 4.9 | 7.4 | 2.5 |
| HU | 1 | 44 | 0.6 | 1.0 | 0.3 |
| IT | 5 | 185 | 2.2 | 3.3 | 1.1 |
| NL | 2 | 25 | 0.3 | 0.4 | 0.1 |
| PL | 1 | 27 | 0.4 | 0.5 | 0.2 |
| PT | 1 | 48 | 0.5 | 0.8 | 0.3 |
| RO | 1 | 45 | 0.7 | 1.0 | 0.3 |
| SE | 1 | 45 | 0.6 | 1.0 | 0.3 |
| UK | 2 | 125 | 1.4 | 2.1 | 0.7 |
| **Grand Total** | **31** | **1860** | **23.0** | **34.5** | **11.5** |

# Excess heat potentials – Metro stations

- Results: <span style="color:red">All</span>

| MS | Count of CityID | Sum of TotUniqUnStaName | Sum of QL(PJ) | Sum of QH_COP30(PJ) | Sum of W_COP30(PJ) |
|---|---|---|---|---|---|
| AT | 1 | 48 | 0.7 | 1.0 | 0.3 |
| BE | 1 | 47 | 0.5 | 0.8 | 0.3 |
| BG | 1 | 29 | 0.4 | 0.6 | 0.2 |
| CZ | 1 | 53 | 0.7 | 1.1 | 0.4 |
| DE | 4 | 318 | 3.9 | 5.9 | 2.0 |
| DK | 1 | 9 | 0.1 | 0.2 | 0.1 |
| EL | 1 | 37 | 0.5 | 0.7 | 0.2 |
| ES | 3 | 407 | 5.2 | 7.8 | 2.6 |
| FI | 1 | 17 | 0.3 | 0.4 | 0.1 |
| FR | 6 | 441 | 5.2 | 7.8 | 2.6 |
| HU | 1 | 44 | 0.6 | 1.0 | 0.3 |
| IT | 7 | 214 | 2.5 | 3.8 | 1.3 |
| NL | 2 | 25 | 0.3 | 0.4 | 0.1 |
| PL | 1 | 27 | 0.4 | 0.5 | 0.2 |
| PT | 1 | 48 | 0.5 | 0.8 | 0.3 |
| RO | 1 | 45 | 0.7 | 1.0 | 0.3 |
| SE | 1 | 45 | 0.6 | 1.0 | 0.3 |
| UK | 3 | 140 | 1.6 | 2.3 | 0.8 |
| **Grand Total** | **37** | **1994** | **24.6** | **36.9** | **12.3** |

# Excess heat potentials – Metro stations

- Results: All

| MS | Count of MetroID | Sum of QL(PJ) | Sum of QH_COP30(PJ) | Sum of W_COP30(PJ) | QL by station [TJ/St.] | QH by station COP3.0 [TJ/St.] | W by station COP3.0 [TJ/St.] |
|---|---|---|---|---|---|---|---|
| AT | 48 | 0.7 | 1.0 | 0.3 | 13.8 | 20.6 | 6.9 |
| BE | 47 | 0.5 | 0.8 | 0.3 | 10.9 | 16.4 | 5.5 |
| BG | 29 | 0.4 | 0.6 | 0.2 | 14.2 | 21.2 | 7.1 |
| CZ | 53 | 0.7 | 1.1 | 0.4 | 13.2 | 19.8 | 6.6 |
| DE | 318 | 3.9 | 5.9 | 2.0 | 12.3 | 18.4 | 6.1 |
| DK | 9 | 0.1 | 0.2 | 0.1 | 12.4 | 18.5 | 6.2 |
| EL | 37 | 0.5 | 0.7 | 0.2 | 12.4 | 18.5 | 6.2 |
| ES | 407 | 5.2 | 7.8 | 2.6 | 12.7 | 19.1 | 6.4 |
| FI | 17 | 0.3 | 0.4 | 0.1 | 14.8 | 22.1 | 7.4 |
| FR | 441 | 5.2 | 7.8 | 2.6 | 11.8 | 17.7 | 5.9 |
| HU | 44 | 0.6 | 1.0 | 0.3 | 14.5 | 21.8 | 7.3 |
| IT | 214 | 2.5 | 3.8 | 1.3 | 11.8 | 17.7 | 5.9 |
| NL | 25 | 0.3 | 0.4 | 0.1 | 10.8 | 16.3 | 5.4 |
| PL | 27 | 0.4 | 0.5 | 0.2 | 13.3 | 19.9 | 6.6 |
| PT | 48 | 0.5 | 0.8 | 0.3 | 10.9 | 16.3 | 5.4 |
| RO | 45 | 0.7 | 1.0 | 0.3 | 14.8 | 22.2 | 7.4 |
| SE | 45 | 0.6 | 1.0 | 0.3 | 14.2 | 21.3 | 7.1 |
| UK | 140 | 1.6 | 2.3 | 0.8 | 11.1 | 16.6 | 5.5 |
| **Grand Total** | **1994** | **24.6** | **36.9** | **12.3** | **12.3** | **18.5** | **6.2** |

# Excess heat potentials – Data centres

# Excess heat potentials – Data Centres

- ## Data and method
  - Excess heat potential estimated from data on
  - Average shares of electricity consumption (literature sources)
  - Combined with energy statistics
  - Geographical data on facility locations
  - Spatial correlation to current district heating areas
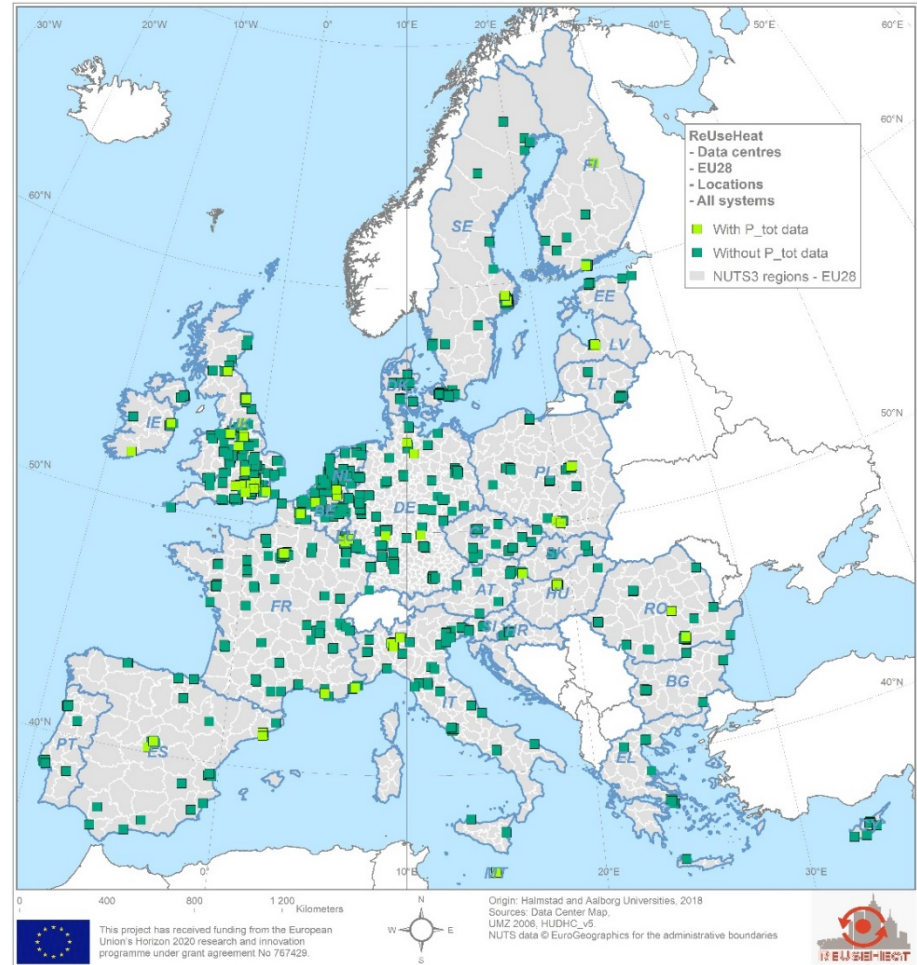
# Excess heat potentials – Data centres

- ## Data and method
  - Data base purchased
    - **World Data Center Map**
    - Approval for use
    - ~1300 EU28 facilities
  - Student assignment
- ## Main issues
  - Sector confidentiality
  - Lack of data at site level
- ## Assessment
  - Literature references
  - Energy statistics



266 with floor area data

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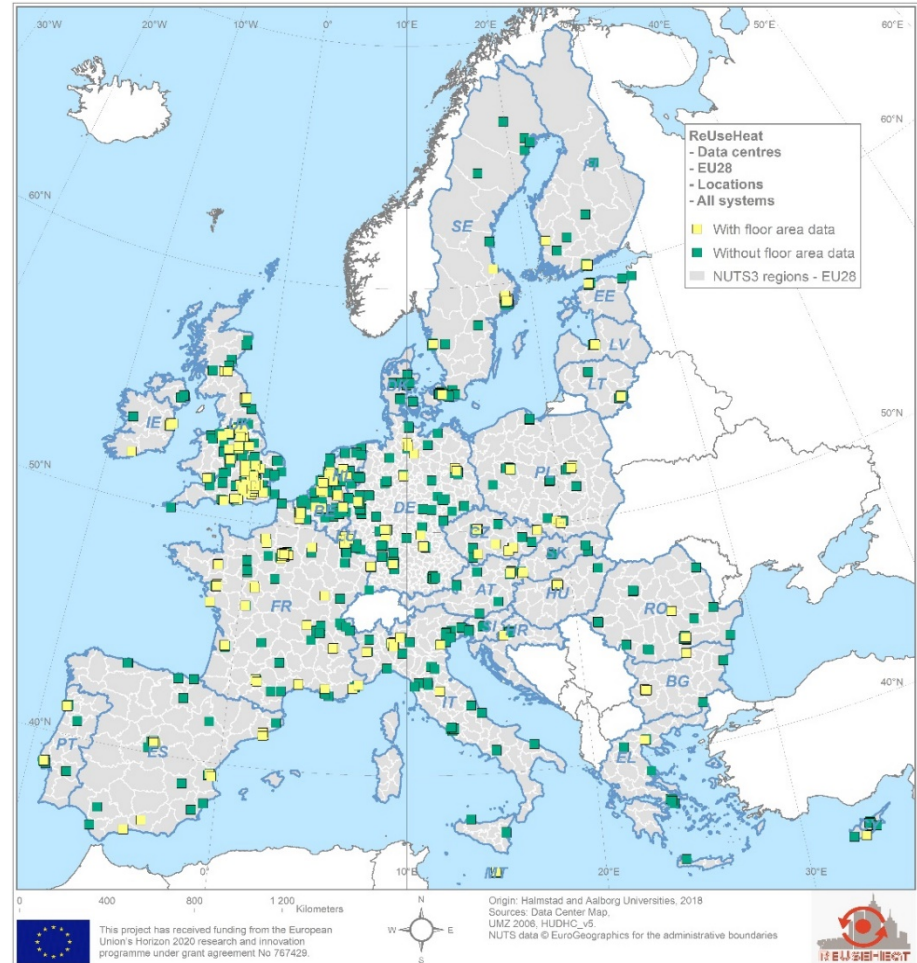
# Excess heat potentials – Data centres

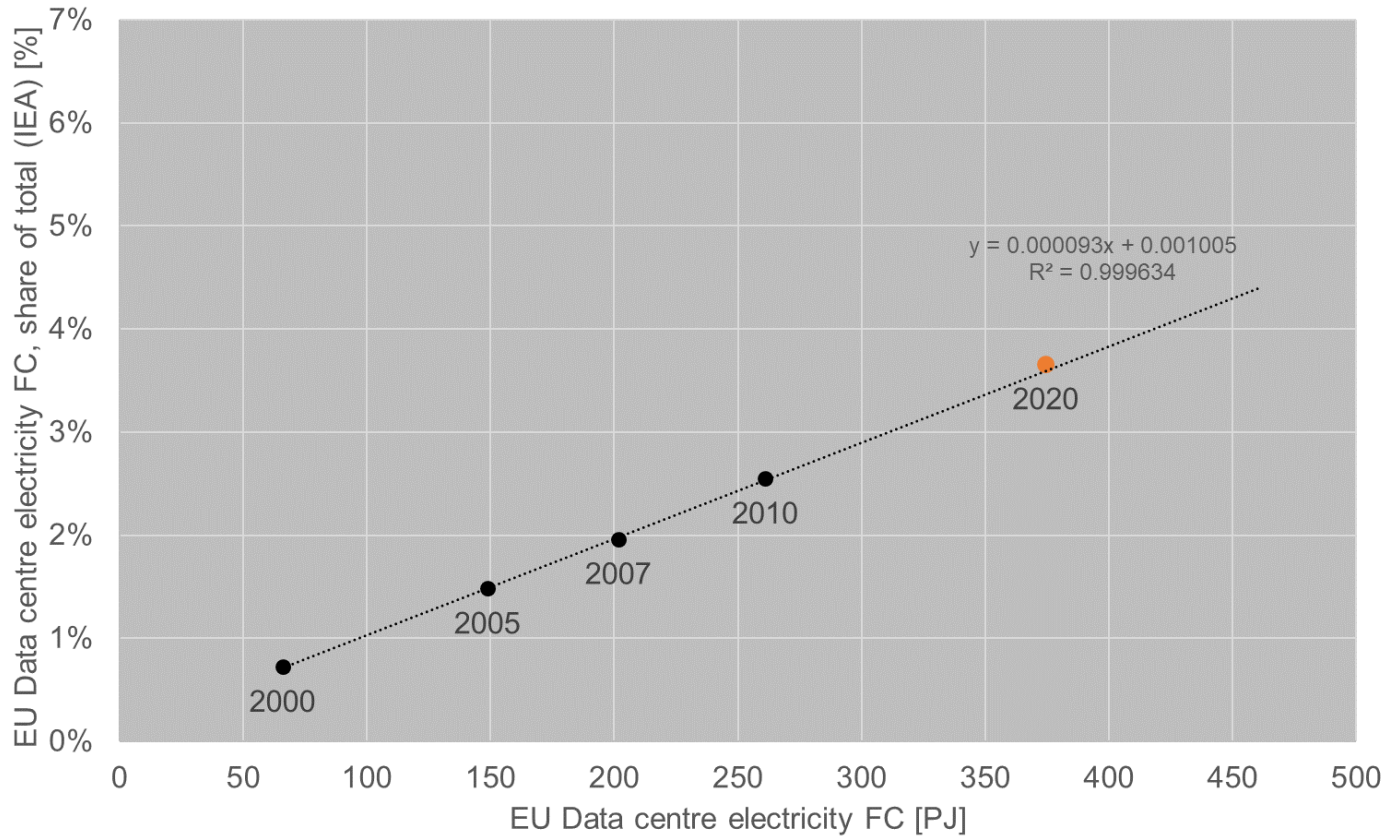- **Data and method**
  - Data base purchased
    - **World Data Center Map**
    - Approval for use
    - ~1300 EU28 facilities
  - Student assignment
- Main issues
  - Sector confidentiality
  - Lack of data at site level
- Assessment
  - Literature references
  - Energy statistics



63 with P total data

# Excess heat potentials – Data centres

- ## Data and method
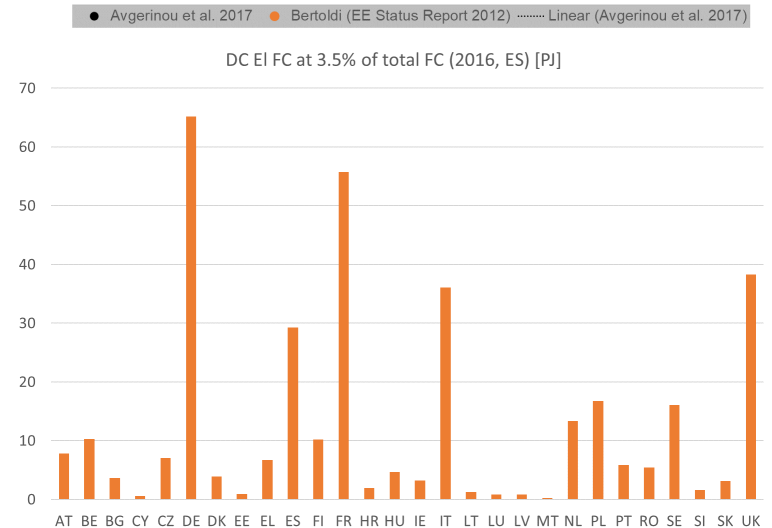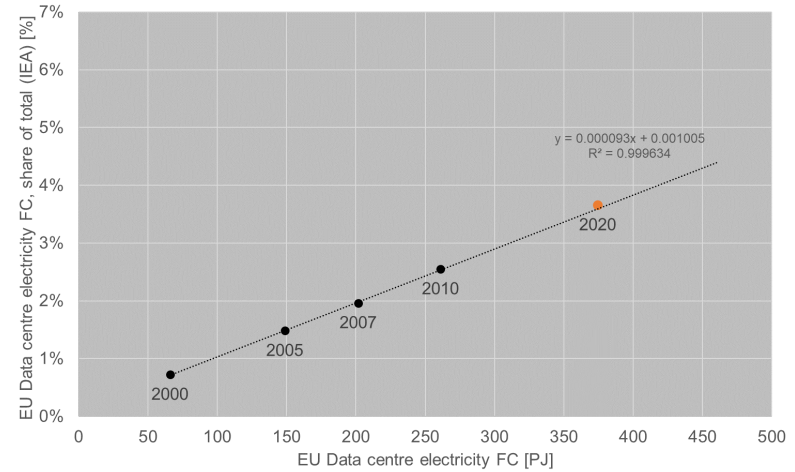
# Excess heat potentials – Data centres

- ## Data and method

| MS | Sum of Data centres [n] | Sum of Total El FC (2016, ES) [PJ] | Sum of DC El FC at 3.5% of total FC (2016, ES) [PJ] |
|---|---|---|---|
| AT | 17 | 223 | 7.8 |
| BE | 32 | 295 | 10.3 |
| BG | 20 | 104 | 3.6 |
| CY | 13 | 16 | 0.6 |
| CZ | 24 | 202 | 7.1 |
| DE | 203 | 1863 | 65.2 |
| DK | 29 | 112 | 3.9 |
| EE | 10 | 26 | 0.9 |
| EL | 14 | 192 | 6.7 |
| ES | 59 | 837 | 29.3 |
| FI | 18 | 291 | 10.2 |
| FR | 147 | 1593 | 55.7 |
| HR | 5 | 55 | 1.9 |
| HU | 8 | 134 | 4.7 |
| IE | 22 | 92 | 3.2 |
| IT | 67 | 1030 | 36.0 |
| LT | 11 | 35 | 1.2 |
| LU | 15 | 23 | 0.8 |
| LV | 17 | 23 | 0.8 |
| MT | 8 | 8 | 0.3 |
| NL | 97 | 380 | 13.3 |
| PL | 31 | 478 | 16.7 |
| PT | 26 | 167 | 5.8 |
| RO | 48 | 156 | 5.5 |
| SE | 53 | 459 | 16.1 |
| SI | 7 | 47 | 1.6 |
| SK | 14 | 90 | 3.1 |
| UK | 254 | 1094 | 38.3 |
| **EU28** | **1269** | **10023** | **350.8** |



$y = 0.000093x + 0.001005$
$R^2 = 0.999634$

DC El FC at 3.5% of total FC (2016, ES) [PJ]

# Excess heat potentials – Data centres

- ## Results
  - – Indicative...
  - – Assumptions:
    - Air cooling (all)
    - **65%** of DC FC electricity for IT-equipment ($\approx Q_L$)
    - For facility averages: MS facilities all of same size (unrealistic)

| MS | Sum of QL (65%) [PJ] | Sum of QH COP3.0 [PJ] | Sum of W COP3.0 [PJ] | Average of QL by facility (65%) [TJ/DC] | Average of QH by facility COP3.0 [TJ/DC] | Average of W by facility COP3.0 [TJ/DC] |
|---|---|---|---|---|---|---|
| AT | 5.1 | 7.6 | 2.5 | 298 | 447 | 149 |
| BE | 6.7 | 10.1 | 3.4 | 209 | 314 | 105 |
| BG | 2.4 | 3.6 | 1.2 | 118 | 178 | 59 |
| CY | 0.4 | 0.5 | 0.2 | 28 | 42 | 14 |
| CZ | 4.6 | 6.9 | 2.3 | 191 | 287 | 96 |
| DE | 42.4 | 63.6 | 21.2 | 209 | 313 | 104 |
| DK | 2.6 | 3.8 | 1.3 | 88 | 132 | 44 |
| EE | 0.6 | 0.9 | 0.3 | 60 | 90 | 30 |
| EL | 4.4 | 6.6 | 2.2 | 313 | 469 | 156 |
| ES | 19.0 | 28.6 | 9.5 | 323 | 484 | 161 |
| FI | 6.6 | 9.9 | 3.3 | 368 | 552 | 184 |
| FR | 36.2 | 54.3 | 18.1 | 246 | 370 | 123 |
| HR | 1.3 | 1.9 | 0.6 | 251 | 376 | 125 |
| HU | 3.0 | 4.6 | 1.5 | 380 | 570 | 190 |
| IE | 2.1 | 3.1 | 1.0 | 95 | 143 | 48 |
| IT | 23.4 | 35.1 | 11.7 | 350 | 524 | 175 |
| LT | 0.8 | 1.2 | 0.4 | 73 | 109 | 36 |
| LU | 0.5 | 0.8 | 0.3 | 35 | 52 | 17 |
| LV | 0.5 | 0.8 | 0.3 | 31 | 47 | 16 |
| MT | 0.2 | 0.3 | 0.1 | 22 | 32 | 11 |
| NL | 8.7 | 13.0 | 4.3 | 89 | 134 | 45 |
| PL | 10.9 | 16.3 | 5.4 | 351 | 526 | 175 |
| PT | 3.8 | 5.7 | 1.9 | 146 | 219 | 73 |
| RO | 3.5 | 5.3 | 1.8 | 74 | 111 | 37 |
| SE | 10.4 | 15.7 | 5.2 | 197 | 296 | 99 |
| SI | 1.1 | 1.6 | 0.5 | 152 | 229 | 76 |
| SK | 2.0 | 3.1 | 1.0 | 146 | 219 | 73 |
| UK | 24.9 | 37.3 | 12.4 | 98 | 147 | 49 |
| **EU28** | **228.0** | **342.0** | **114.0** | **176** | **265** | **88** |

$Q_H$ represents ~3% of the total heat demand

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 767429.

Europa-Universität Flensburg

4DH
4th Generation District Heating Technologies and Systems

# Excess heat potentials – Data centres

- ## Results
  - ## Indicative…
  - ## Assumptions:
    - ### Air cooling (all)
    - ### **65%** of DC FC electricity for IT-equipment ($\approx Q_L$)
    - ### For facility averages: MS facilities all of same size (unrealistic)

| MS | Sum of Data centres (2k) [n] | Sum of DC El FC at 3.5% of total FC (2016, ES) [PJ] | Sum of QL (65%) [PJ] | Sum of QH COP3.0 [PJ] | Sum of W COP3.0 [PJ] |
|---|---|---|---|---|---|
| AT | 16 | 7.3 | 4.8 | 7.2 | 2.4 |
| BE | 29 | 9.3 | 6.1 | 9.1 | 3.0 |
| BG | 19 | 3.5 | 2.2 | 3.4 | 1.1 |
| CY | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| CZ | 22 | 6.5 | 4.2 | 6.3 | 2.1 |
| DE | 187 | 60.1 | 39.0 | 58.6 | 19.5 |
| DK | 28 | 3.8 | 2.5 | 3.7 | 1.2 |
| EE | 10 | 0.9 | 0.6 | 0.9 | 0.3 |
| EL | 1 | 0.5 | 0.3 | 0.5 | 0.2 |
| ES | 36 | 17.9 | 11.6 | 17.4 | 5.8 |
| FI | 17 | 9.6 | 6.3 | 9.4 | 3.1 |
| FR | 124 | 47.0 | 30.6 | 45.8 | 15.3 |
| HR | 4 | 1.5 | 1.0 | 1.5 | 0.5 |
| HU | 8 | 4.7 | 3.0 | 4.6 | 1.5 |
| IE | 21 | 3.1 | 2.0 | 3.0 | 1.0 |
| IT | 39 | 21.0 | 13.6 | 20.5 | 6.8 |
| LT | 9 | 1.0 | 0.7 | 1.0 | 0.3 |
| LU | 7 | 0.4 | 0.2 | 0.4 | 0.1 |
| LV | 17 | 0.8 | 0.5 | 0.8 | 0.3 |
| MT | 0 | 0.0 | 0.0 | 0.0 | 0.0 |
| NL | 62 | 8.5 | 5.5 | 8.3 | 2.8 |
| PL | 29 | 15.7 | 10.2 | 15.3 | 5.1 |
| PT | 13 | 2.9 | 1.9 | 2.8 | 0.9 |
| RO | 47 | 5.3 | 3.5 | 5.2 | 1.7 |
| SE | 45 | 13.6 | 8.9 | 13.3 | 4.4 |
| SI | 7 | 1.6 | 1.1 | 1.6 | 0.5 |
| SK | 11 | 2.5 | 1.6 | 2.4 | 0.8 |
| UK | 189 | 28.5 | 18.5 | 27.8 | 9.3 |
| **EU28** | **997** | **277.5** | **180.4** | **270.6** | **90.2** |

Within 2 km of current DH areas…

# Excess heat potentials – Service sector buildings

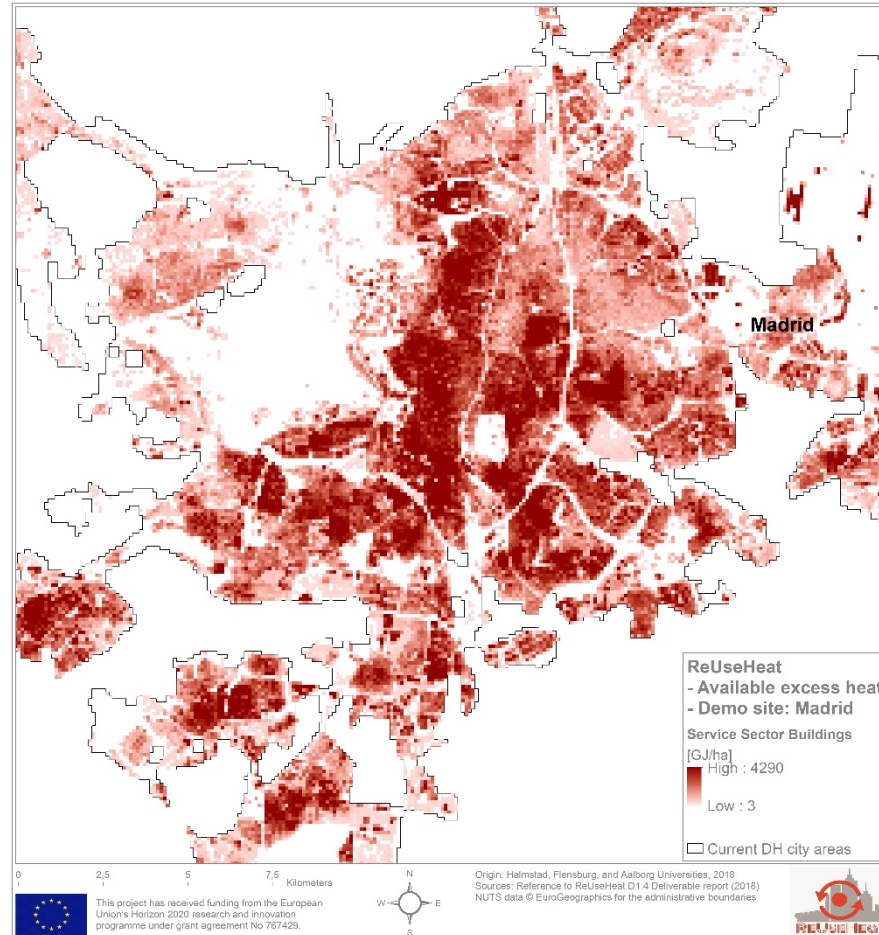# Excess heat potentials – Service sector buildings

- ## Data and method

  - Excess heat potential estimated based on:

    - Data on Service sector floor areas by hectares (Hotmaps)

    - Specific cooling demand and shares of cooled areas by member state (HRE4, WP3)

    - Spatial correlation to current district heating areas

# Excess heat potentials – Service sector buildings

- ## Results
  - – Excess heat potential

# Excess heat potentials – Service sector buildings

- ## Results
  - ## Excess heat potential
  - ## All

| Row Labels | Sum of QL 2015 [PJ] | Sum of QH_COP3.0 (PJ) | Sum of W_COP3.0 (PJ) |
|---|---|---|---|
| AT | 2.6 | 3.9 | 1.3 |
| BE | 7.4 | 11.1 | 3.7 |
| BG | 5.7 | 8.6 | 2.9 |
| CY | 4.1 | 6.2 | 2.1 |
| CZ | 1.5 | 2.2 | 0.7 |
| DE | 38.7 | 58.1 | 19.4 |
| DK | 1.7 | 2.6 | 0.9 |
| EE | 1.4 | 2.1 | 0.7 |
| EL | 79.0 | 118.5 | 39.5 |
| ES | 116.8 | 175.1 | 58.4 |
| FI | 1.9 | 2.8 | 0.9 |
| FR | 51.0 | 76.6 | 25.5 |
| HR | 2.4 | 3.5 | 1.2 |
| HU | 3.3 | 4.9 | 1.6 |
| IE | 0.5 | 0.7 | 0.2 |
| IT | 146.4 | 219.6 | 73.2 |
| LT | 0.4 | 0.7 | 0.2 |
| LU | 0.2 | 0.3 | 0.1 |
| LV | 0.2 | 0.3 | 0.1 |
| MT | 2.9 | 4.4 | 1.5 |
| NL | 4.7 | 7.0 | 2.3 |
| PL | 7.7 | 11.5 | 3.8 |
| PT | 9.3 | 14.0 | 4.7 |
| RO | 6.9 | 10.3 | 3.4 |
| SE | 5.0 | 7.5 | 2.5 |
| SI | 2.1 | 3.1 | 1.0 |
| SK | 0.6 | 1.0 | 0.3 |
| UK | 31.8 | 47.8 | 15.9 |
| **Grand Total** | **536.2** | **804.3** | **268.1** |

# Excess heat potentials – Service sector buildings

- ## Results
  - Excess heat potential
  - Inside

| Row Labels | Sum of QL_UMZDH 2015 [PJ] | Sum of QH_UMZDH_COP3.0 (PJ) | Sum of W_UMZDH_COP3.0 (PJ) |
|---|---|---|---|
| AT | 1.9 | 2.8 | 0.9 |
| BE | 5.5 | 8.3 | 2.8 |
| BG | 3.9 | 5.9 | 2.0 |
| CY | 0.0 | 0.0 | 0.0 |
| CZ | 1.2 | 1.7 | 0.6 |
| DE | 17.7 | 26.5 | 8.8 |
| DK | 1.3 | 1.9 | 0.6 |
| EE | 1.0 | 1.5 | 0.5 |
| EL | 0.0 | 0.0 | 0.0 |
| ES | 39.6 | 59.4 | 19.8 |
| FI | 1.4 | 2.2 | 0.7 |
| FR | 33.4 | 50.2 | 16.7 |
| HR | 1.7 | 2.6 | 0.9 |
| HU | 2.7 | 4.1 | 1.4 |
| IE | 0.3 | 0.4 | 0.1 |
| IT | 45.9 | 68.9 | 23.0 |
| LT | 0.3 | 0.4 | 0.1 |
| LU | 0.1 | 0.1 | 0.0 |
| LV | 0.2 | 0.3 | 0.1 |
| MT | 0.0 | 0.0 | 0.0 |
| NL | 1.6 | 2.4 | 0.8 |
| PL | 5.3 | 7.9 | 2.6 |
| PT | 3.2 | 4.8 | 1.6 |
| RO | 5.2 | 7.8 | 2.6 |
| SE | 3.6 | 5.4 | 1.8 |
| SI | 1.1 | 1.6 | 0.5 |
| SK | 0.5 | 0.7 | 0.2 |
| UK | 16.1 | 24.1 | 8.0 |
| **Grand Total** | **194.3** | **291.5** | **97.2** |

# Demo sites

- **Four demo sites**
  - Nice (FR): Waste-water plants
  - Bucharest (RO): Metro stations
  - Brunswick (DE): Data Centres
  - Madrid (ES): Service sector buildings (Hospital)

  + Conventional excess heat sources

    - Power plants

    - Industrial facilities (energy intensive)

    - Waste-to-Energy plants
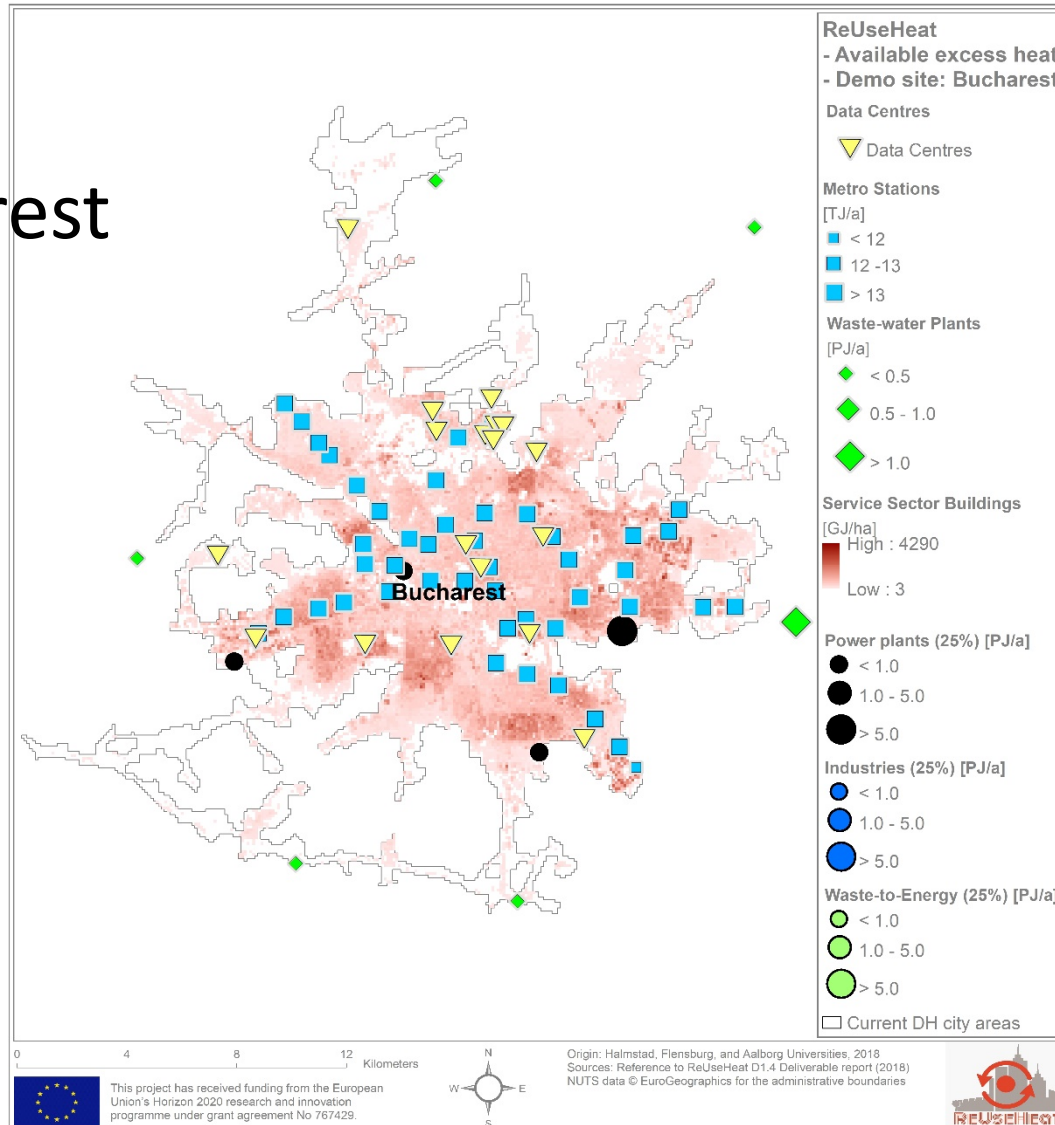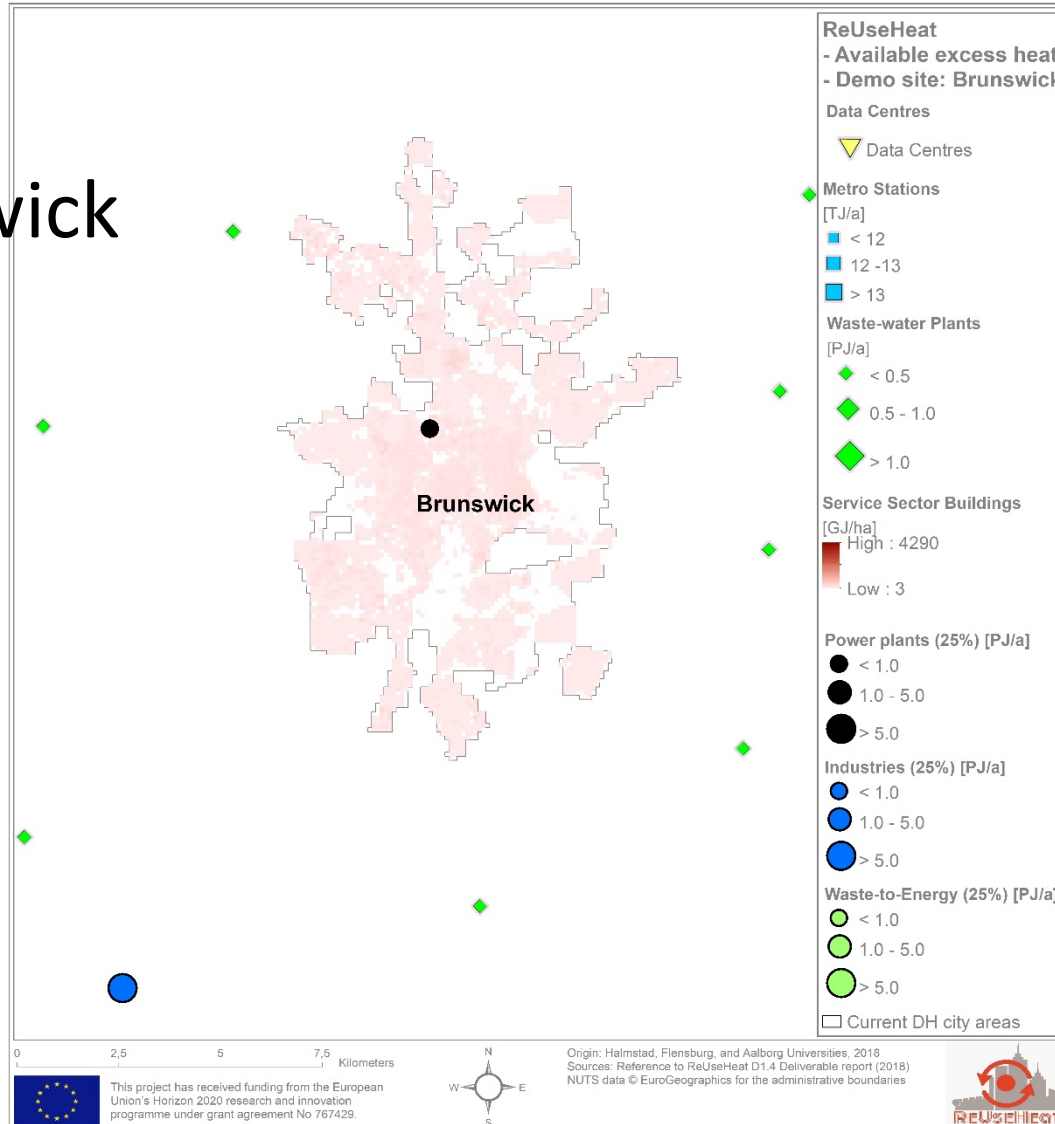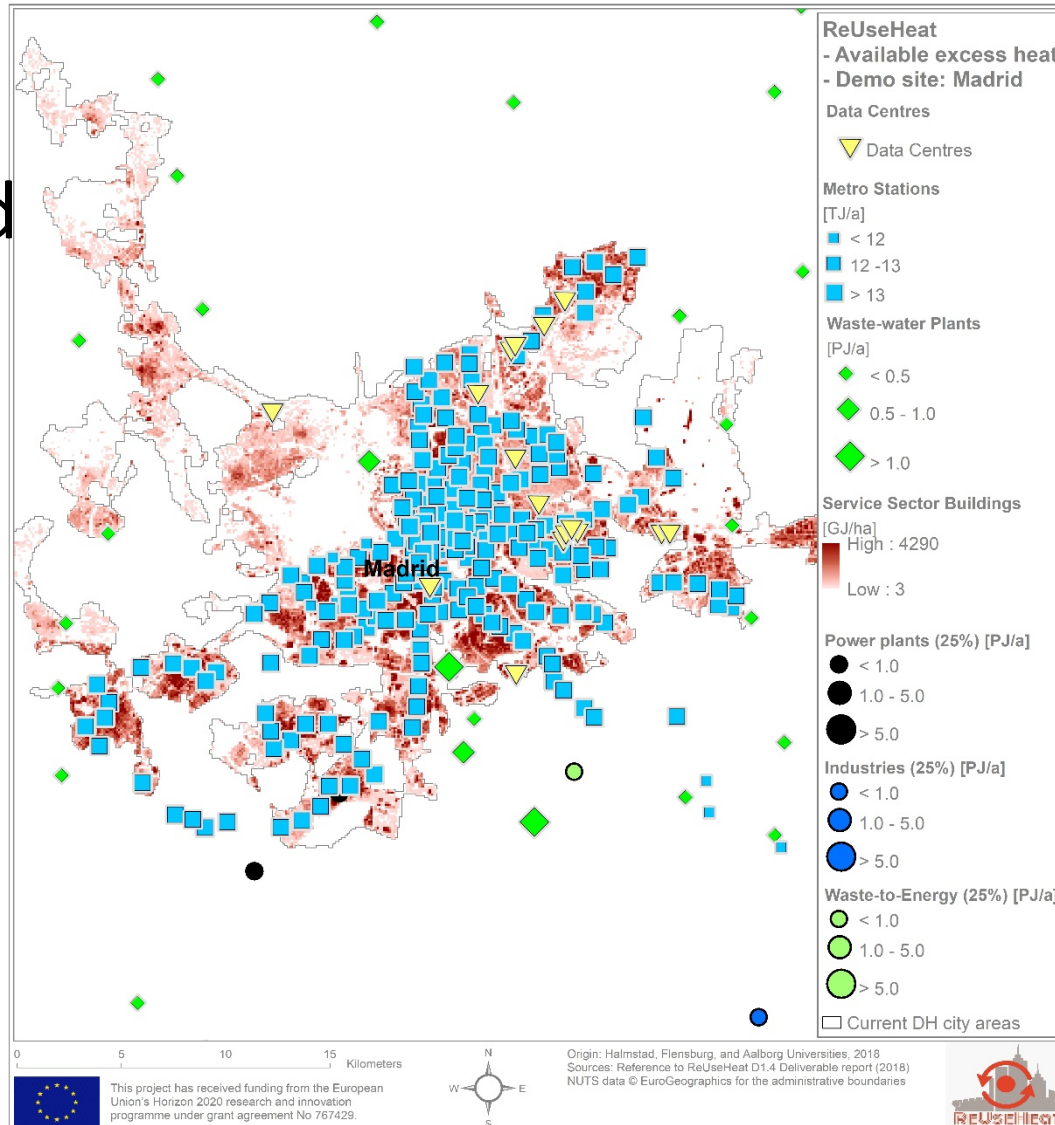
# Demo sites

- Nice
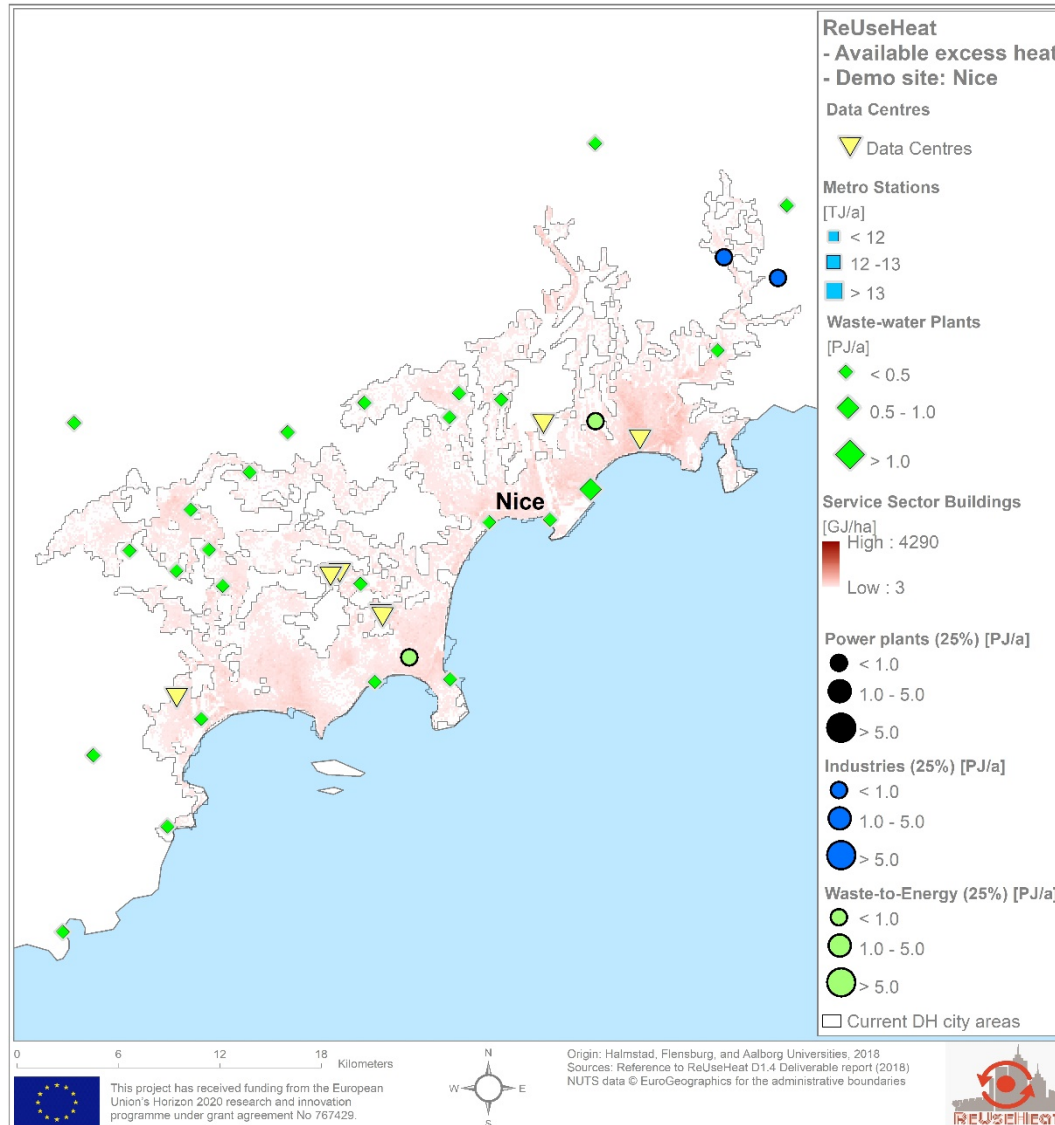
# Demo sites

- Bucharest

# Demo sites

- Brunswick

# Demo sites

- Madrid

# Demo sites

- Results – Available excess heat ($Q_L$)

| Demo Name | Data Centres (65%) [PJ/a] | Metro Stations [PJ/a] | Waste-water Plants [PJ/a] | Service Sector Buildings [PJ/a] | Conventional (25%) [PJ/a] | Total |
|---|---|---|---|---|---|---|
| Brunswick | - | - | 1.2 | 0.1 | 12.2 | **13.6** |
| Madrid | 6.1 | 3.2 | 7.6 | 21.4 | 1.4 | **39.7** |
| Nice | 1.7 | - | 1.9 | 1.0 | 1.3 | **5.9** |
| Bucharest | 1.8 | 0.7 | 2.2 | 3.2 | 2.8 | **10.7** |
| **Total** | **9.6** | **3.9** | **12.9** | **25.7** | **17.8** | **69.9** |

# Summary

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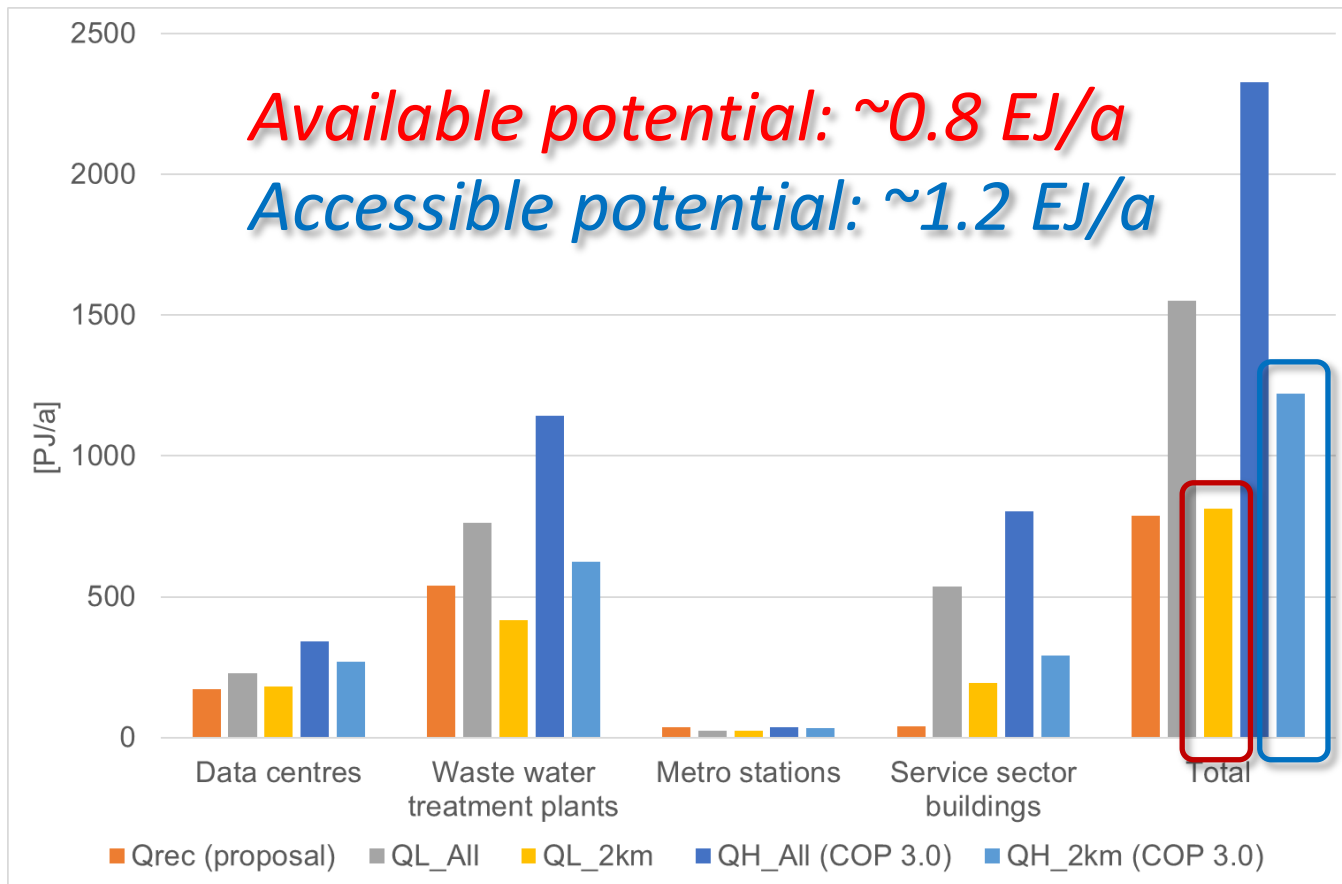
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Technologies and Systems

# Summary

## • Results – Urban excess heat

| EU28 potential (anticipated in proposal) | | | | T1.2 - Available excess heat | | | T1.2 - Accessible excess heat | | |
|---|---|---|---|---|---|---|---|---|---|
| No | Waste heat source | Qrec [TWh/a] | Qrec [PJ/a] | QL_All [PJ/a] | QL_2km [PJ/a] | Ratio [%] | QH_All (COP 3.0) [PJ/a] | QH_2km (COP 3.0) [PJ/a] | Ratio [%] |
| 1 | Data centres | 48 | 173 | 228 | 180 | (+) 4% | 342 | 271 | (+) 57% |
| 2 | Waste water treatment plants | 150 | 540 | 763 | 417 | (-) 23% | 1144 | 625 | (+) 16% |
| 3 | Metro stations | 10 | 36 | 25 | 23 | (-) 36% | 37 | 35 | (-) 3% |
| 4 | Service sector buildings | 11.2 | 40 | 536 | 194[*] | (+) 385% | 804 | 292[*] | (+) 630% |
| | **Total** | **219** | **789** | **1552** | **814** | **(+) 3%** | **2327** | **1223** | **(+) 55%** |

[*]Inside UMZDH areas

# Summary

- Results – Urban excess heat

# THANK YOU!

## QUESTIONS?