SMART ENERGY SYSTEMS

COST EFFECTIVE DEVELOPMENT OF A LOW CARBON ENERGY SYSTEM IN CITIES

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4th Generation District Heating 13-14 November 2018

CONTENT

- Energy is an important part of the smart city concept
- The smart energy system – what is smart and for whom ?
- How to establish smart energy in cities ?

- Case 1: Greater Copenhagen DH system – integrating electricity, DH, waste and biomass

- Case 2: Carlsberg City - sustainable urban development in the city

- Case 3: Gram consumer owned DH - integrating electricity, DH and gas – the virtual battery

- Case 4: Tårnby Municipal DH– integrating electricity, DH, DC and waste water in symbiosis

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THE ENERGY IS AN IMPORTANT ELEMENT IN THE SMART SUSTAINABLE CITY, BUT WHAT IS SMART ENERGY ?

- The most **cost effective** long-term solution for the residents and land owners of the city
- **Integrating** district heating and cooling, gas, electricity and buildings
- Integrating and **storing all** cost effective available energy resources
- **Flexible and resilient**
- A **low environmental impact**, low carbon, good air quality, low noise, low visual impact
- A smart city has a **smart "back yard"**
- **Maximal efficiency**: technical, institutional and not least financial

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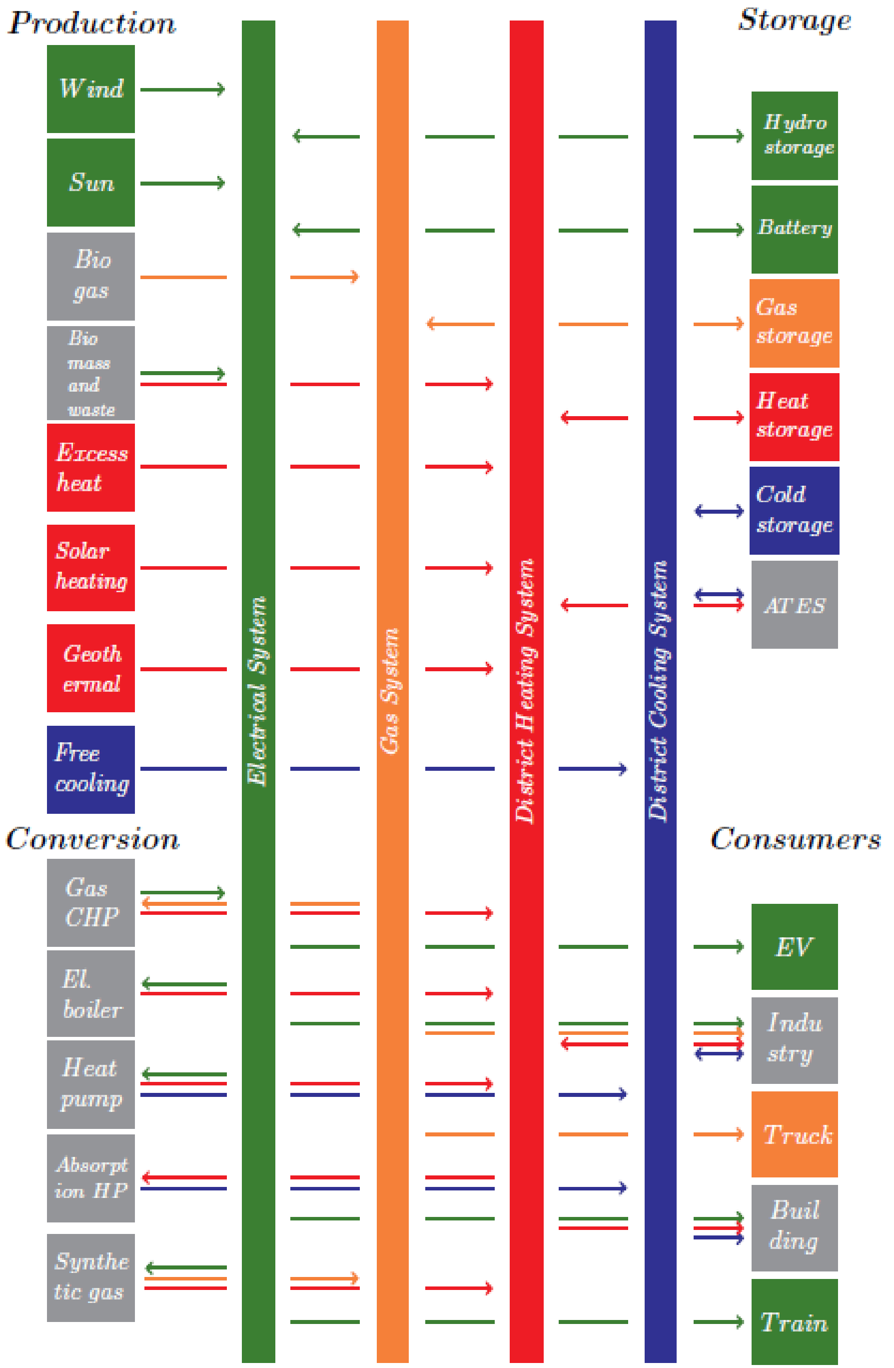
THE SMART ENERGY SYSTEM

- National power grid
- National natural gas grid
  - storage, CHP and small houses
- City-wide district heating grid
  - Storage for CHP and RES
- City district cooling grid
  - Storage and optimal cooling
- Buildings and other end-users
  - Low-temperature heating
  - High-temperature cooling



HOW TO ESTABLISH SMART ENERGY IN CITIES – USE OF MARKET FORCES TO THE BENEFIT OF CONSUMERS

- Technical efficiency
  - Use relevant data and optimize system design at the national and city level, e.g.
  - Low temperature buildings, optimal design of the DH system, optimal operation etc.
- Institutional efficiency
  - All stakeholders co-operate to identify the best solution for all
  - Agree on how to share the benefit among all stakeholders
  - Able to implement the solution

Financial efficiency

  - Commitment from all stakeholders to take part and pay all costs
  - Lowest interest rate on the market to finance 100% of all investments

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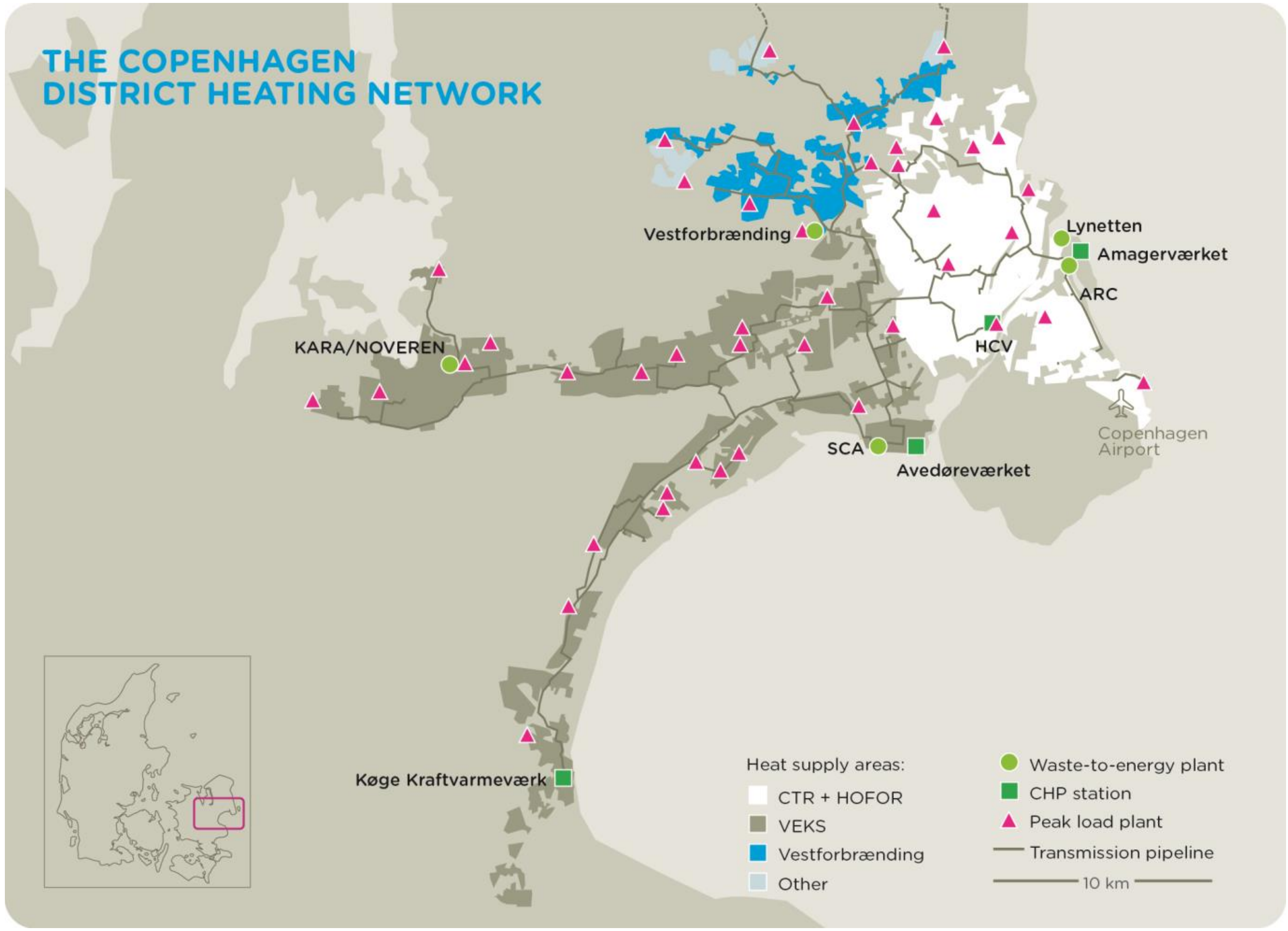
CASE 1: GREATER COPENHAGEN DISTRICT HEATING AND COOLING CTR, VEKS, HOFOR AND VESTFORBRÆNDING

- In operation 30years, and still developing
- 1 million people
- 70 million m2 heated floor in one system
- >20 municipalities and DH companies
- 3 transmission companies
- Optimal market share of DH and gas
- 99 % connection to the DH grid
- 3 biomass CHP plants (70%)
- 3 waste-to-energy plants (25%)
- More than 40 peak boilers (5%)
- 3 x 24,000 m3 thermal storages
- 7 District cooling plants in operation, more in the pipe line



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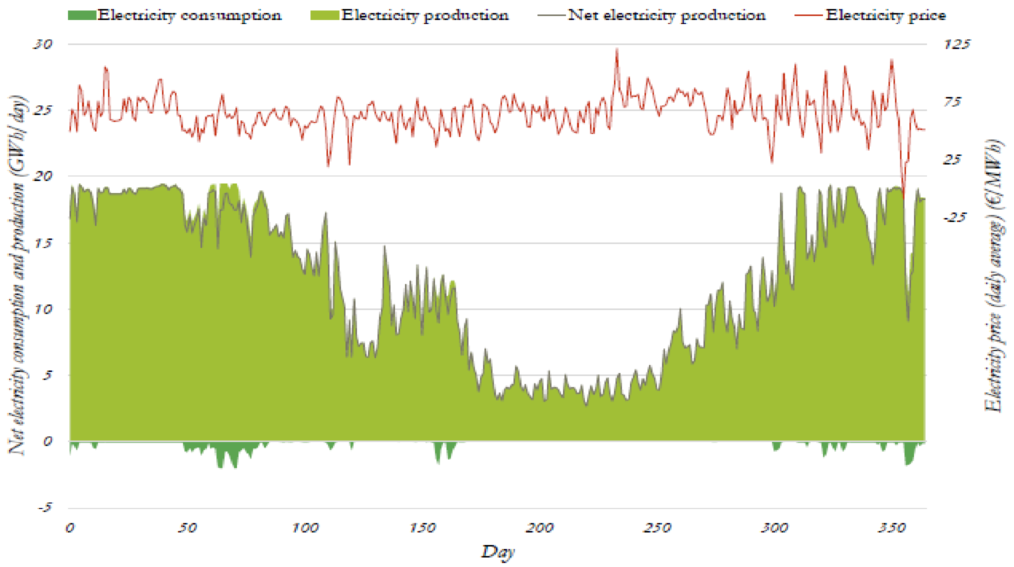
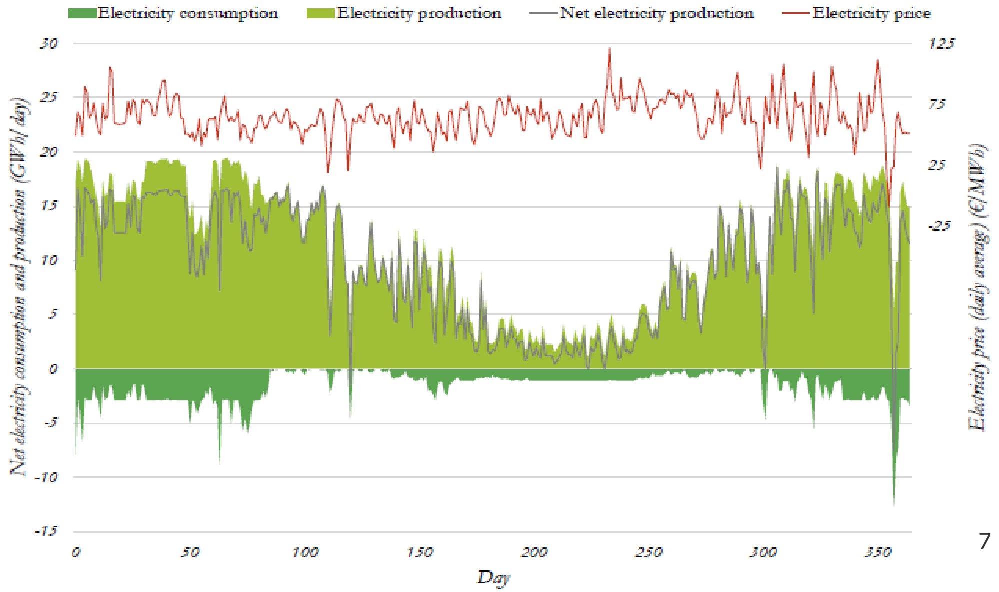
CASE 1: GREATER COPENHAGEN POWER MARKET RESPONSE

- 2018 business as usual scenario
  - 2,000 MW_{th} biomass CHP in back pressure
  - 80 MW_{th} electric boilers
  - 10 MW_{th} large heat pumps
  - 72,000 m^3 heat storage
- 2038 forecast development scenario
  - 1,700 MW_{th} biomass CHP in back pressure with turbine by-pass (impact as an electric boiler)
  - 600 MW_{th} electric boilers
  - 400 MW_{th} large heat pumps, many in co-generation with cooling
  - 2,000,000 m^3 heat storage





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CASE 2: CARLSBERG CITY DISTRICT IN COPENHAGEN - SUSTAINABLE URBAN DEVELOPMENT

- Mainly new buildings, preserving some old buildings
- 200% utilization
- 600.000 m^2 in total
- 350.000 m^2 need cooling – may be also apartments
- Carlsbergbyen urban development company wanted
  - A sustainable city district
  - Sustainable energy
  - Being an integrated part of the community in Copenhagen
  - Maximal profit as an commercial entity
- Would there be any conflict between commercial interest and sustainability ??

CASE 2: CARLSBERG CITY DISTRICT IN COPENHAGEN - SUSTAINABLE URBAN DEVELOPMENT

- No conflict between sustainability and profit
- DH to all buildings from HOFOR was best for the society and the city
- Local DC to cover all cooling demand was the best for the society and the local community
- Off shore wind also much better than solar PV and local wind turbines
- Carlsbergbyen ensures via commercial contracts with developers, that all buildings are with cooling demand are to be connected to the district cooling
- This reduces costs for, improves the environment and guarantee safe investments

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CASE 3: GRAM CONSUMER OWNED DH
MAX FLEXIBILITY AND STORAGE - MANY SIMILAR CASES

- Heat production 30 GWh
- 120,000 m3 heat storage pit
- 44,000 m2 solar panels (61%)
- A 10 MW electric boiler (15%)
- A 900 kW heat pump (8%)
- Industrial surplus heat (8%) and
- A 5 MWe/6 MWth CHP gas engine (8%)
- Gas boilers for spare capacity (0%)

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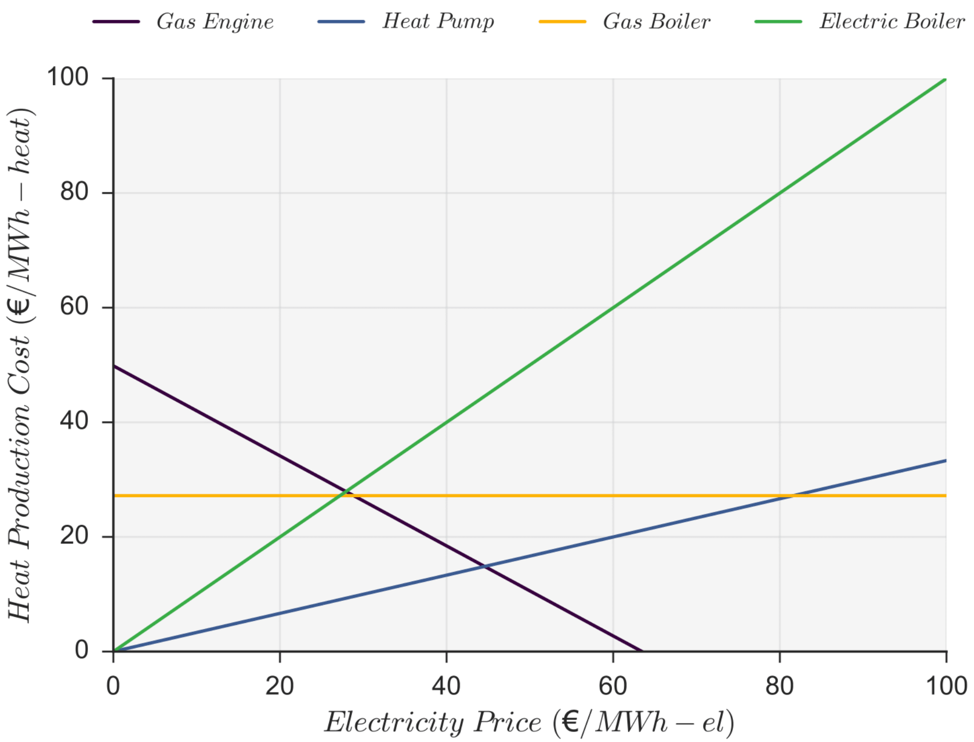
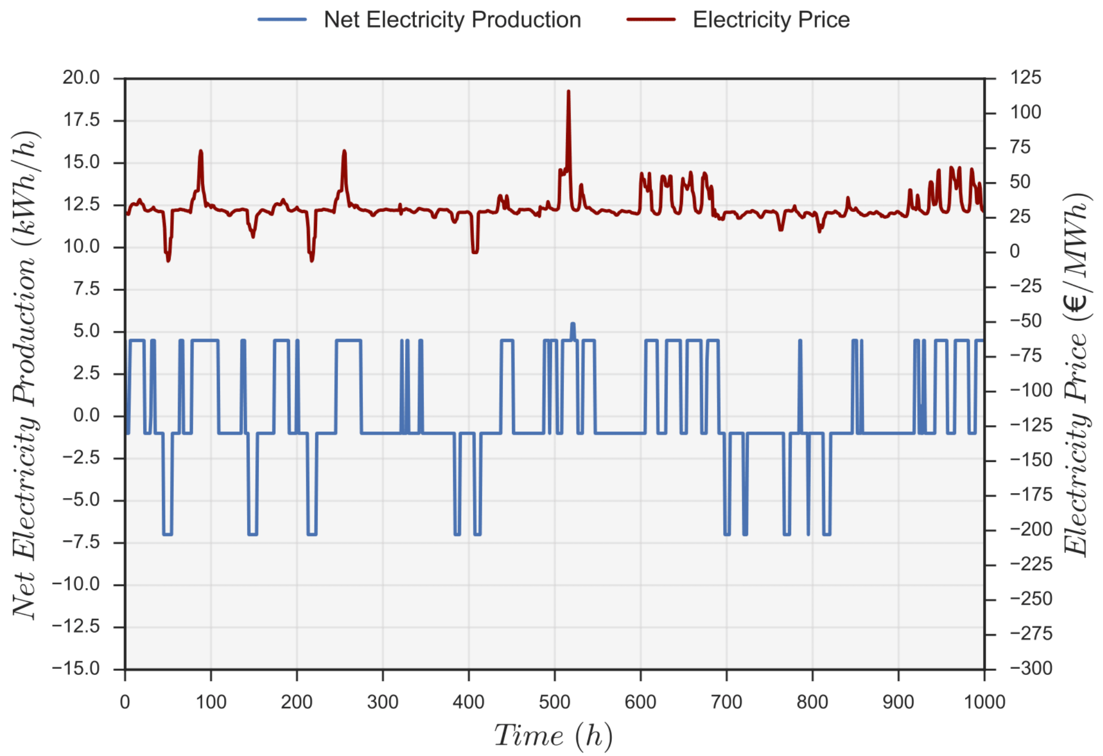
CASE 3: GRAM CONSUMER OWNED DH
SYSTEM RESPONSE ON FLUCTUATING ELECTRICITY PRICES

- Heat production optimization as it would be at the level of the society





- However, the response potential is not fully itilized due lack of incentives from taxes and distribution tariffs

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CASE 4: TÅRNBY MUNICIPAL DH COMPANY
DC, DH, ELECTRICITY, WASTE WATER AND GROUND WATER

Heat pump: 4,3 MW cold / 6,3 MW heat

- 4,3 MW cooling capacity to new DC system
- 9.000 MWh cooling to the DC system
- 2.000 m^3 chilled water tank
- 2 MW ground source cooling
- Up to 4,3 MW heat from treated waste water
- 45.000 MWh heat to the DH system in optimal load dispatch with other production and storage facilities in Grater Copenhagen:
  - 13.000 MWh heat from the cooling
  - 32.000 MWh from the waste water
  - 2 MW power to the heat pump can be interrupted in case of power shortage

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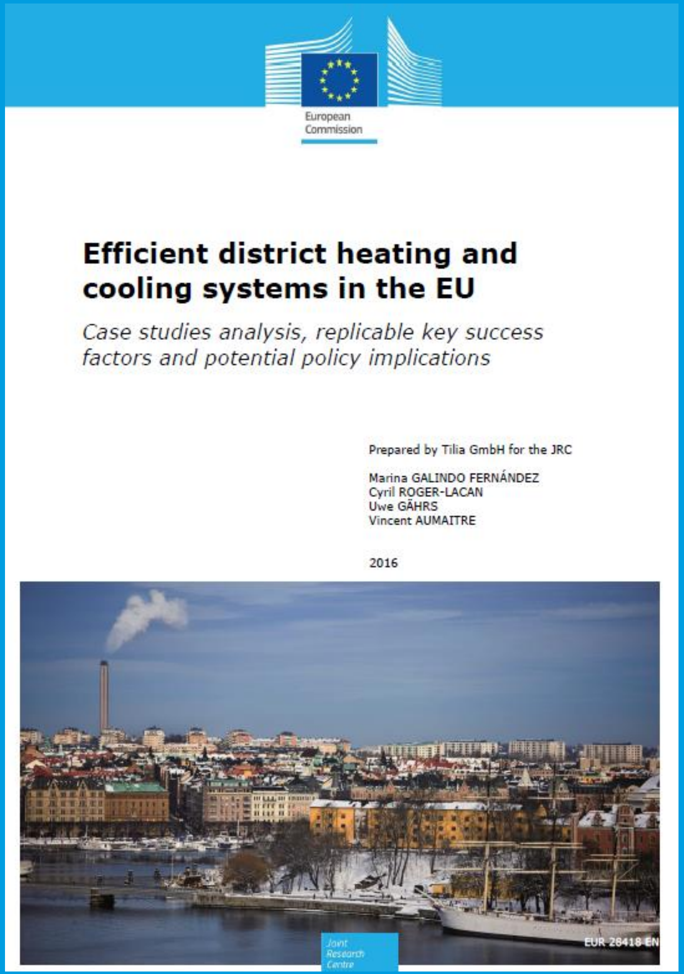
JRC STUDY REPORT ON EFFICIENT DH&C IN EU
CASE 1 GREATER COPENHAGEN DISTRICT HEATING
CASE 2 GRAM DISTRICT HEATING



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THANK YOU FOR YOUR ATTENTION
QUESTIONS & ANSWERS

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