SMART ENERGY SYSTEMS

COST EFFECTIVE DEVELOPMENT OF A LOW CARBON ENERGY SYSTEM IN CITIES

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

- In operation 30 years, 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 pipeline
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 m³ 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 m³ heat storage
CASE 2: CARLSBERG CITY DISTRICT IN COPENHAGEN - SUSTAINABLE URBAN DEVELOPMENT

- Mainly new buildings, preserving some old buildings
- 200% utilization
- 600,000 m² in total
- 350,000 m² 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 with cooling demand are to be connected to the district cooling
- This reduces costs for, improves the environment and guarantee safe investments
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%)
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 utilized due to lack of incentives from taxes and distribution tariffs
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 Greater 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
Efficient district heating and cooling systems in the EU
Case studies analysis, replicable key success factors and potential policy implications

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THANK YOU FOR YOUR ATTENTION
QUESTIONS & ANSWERS

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