SES CONFERENCE 2019 SMART INTEGRATION OF FLUCTUATING RENEWABLE ENERGY INTO THE ENERGY SYSTEM

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RAMBOLL Bright ideas. Sustainable change

PRESENTATION

- The smart energy system
- Development in Denmark
- The renewable energy challenge
- Copenhagen district heating system
- SEMI (energy market incentives)
- Summary



THE SMART ENERGY SYSTEM

- International power grid
- International natural gas grid
 - Gas storage, CHP, P2G
- City-wide district heating grid
 - Storage for CHP and renewables
 - Demand response, virtual battery
 - Excess heat from industry
- City-wide district cooling grid
 - Storage and optimal cooling
 - Demand response, virtual battery
- Buildings and other end-users
 - Power demand response ?

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DISTRICT HEATING IN DENMARK CURRENT DEVELOPMENT

- 350 district heating systems with thermal storage
- Heat pumps and electric boilers are increasing
- Pit thermal energy storage (giga storage concept)
- Large scale solar thermal
- District cooling combined with district heating systems





Soruces: Annual Energy Statistics 2016 - Danish Energy Agency, PlansystemDK as of 01.08.2018 - Danish Business Authority, Danish Geodata Agency, Rambol/TSR

ELECTRICITY IN DENMARK CURRENT DEVELOPMENT

- Wind turbines and solar PV
- Conventional fossil fuelled CHP plants are decommissioned or converted to biomass
- HVDC interconnectors





Soruces: Annual Energy Statistics 2016 - Danish Energy Agency, PlansystemDK as of 01.08.2018 - Danish Business Authority, Danish Geodata Agency. Ramboll/TSR

THE RENEWABLE ENERGY CHALLENGE



Average electricity production distribution DK1 (2010 – 2017)



Electricity production distribution DK1 (week 1 in 2018)





DISTRICT HEATING IN COPENHAGEN

- District heating has a long tradition from 1920s in Copenhagen Municipality
- District heating supplying 99% of all buildings
- Growing district cooling. Now in 4 plants
- Copenhagen accounts for 50% of Greater Copenhagen district heating system
- Danish Heat-plan and mandatory connection part of the background





COPENHAGEN DISTRICT HEATING SYSTEM SIMULATION MODEL

- Large metropole
- Over 1,000,000 inhabitants
- Large district heating system (about 11,000 GWh)
- Two scenarios; business as usual and development
- Simulation were made towards 2037

Business as usual scenario

- About 2,000 MW-h CHP
- 80 MW-h electric boilers
- 10 MW-h heat pumps
- 72,000 m3 heat storage

Development scenario

- About 2,000 MW-h CHP
- 600 MW-h electric boilers in 2037
- 400 MW-h heat pumps in 2037
- 2,000,000 m3 heat storage in 2037



BUSINESS AS USUAL SCENARIO NET DAILY ELECTRICITY PRODUCTION 2035





DEVELOPMENT SCENARIO NET DAILY ELECTRICITY PRODUCTION 2035





BUSINESS AS USUAL SCENARIO NET HOURLY ELECTRICITY PRODUCTION (FIRST 14 DAYS IN 2035)





DEVELOPMENT SCENARIO NET HOURLY ELECTRICITY PRODUCTION (FIRST 14 DAYS IN 2035)







SUSTAINABLE ENERGY MARKET INTEGRATION ENERGY MARKET INCENTIVES

• Existing technologies can get us far

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- Flexible taxes and tariffs are urgently needed!
- Thermal infrastructure is the key for flexible operation
 - Flexible supply and demand side + storage \rightarrow virtual battery
 - It is not the power sector that integrates renewable energy, it is the district energy sector that makes the trick
- Natural gas system as energy buffer missing link is P2X
 - Two main path-ways: Power-to-gas (P2G) and Power-toliquid (P2L).
 - (P2L): Methanol, petrol, kerosene (jet fuel), diesel and gas oil. Requires CO₂.



Excess heat can be utilized as district heating

SUMMARY

- Any village, city or campus can be a virtual battery (district energy)
- Existing technologies can get us far in the renewable energy transition
- District energy (thermal energy infrastructure) is a key component
- P2X (and carbon capture) is the missing link (future potential)

We have to organize the society to establish the energy infrastructure, smart energy tariffs and taxation principles to enable the virtual battery and further strengthen the integration between the energy systems.



THANK YOU

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Soren Moller Thomsen: Smart integration of fluctuating renewable energy into the energy system

Ramboll has in a number of studies analysed the option to integrate renewable energy from wind, solar and waste heat into the energy system.

That includes a study for the Danish District Heating Association, Smart integration of renewable energy in the district heating system, a study financed by EUDP on Harmonized integration of electricity, gas and heat in association with Aalborg University and an ongoing EUDP financed study on Sustainable Energy Market Integration, in association with Syddansk University, Aalborg University and DGC.

The studies show how the energy system already today has the fully develop technology to transfer the heating and cooling sectors to renewable energy based on biomass, wind and solar an a minor part of natural gas. The only missing technology, P2G is still in the development stage.

The key components in the energy system for this integration is the water based system: namely hot water district heating at modest temperatures, district cooling, large heat pumps, electric boilers, gas CHP and thermal storages for heating and cooling.

The presentation will include an overall analysis, a proposal for market incentives and case studies

Søren Møller Thomsen is MSc. in Sustainable Energy with a special focus on electrical energy systems, system analysis, feasibility studies and energy markets. Søren has participated in a number of projects within sustainable development, smart energy systems and district heating and cooling.

