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#SESAAU2019

Session 22:

Smart Energy infrastructure and storage options

Smart integration of district heating, district cooling, waste water and ground source cooling

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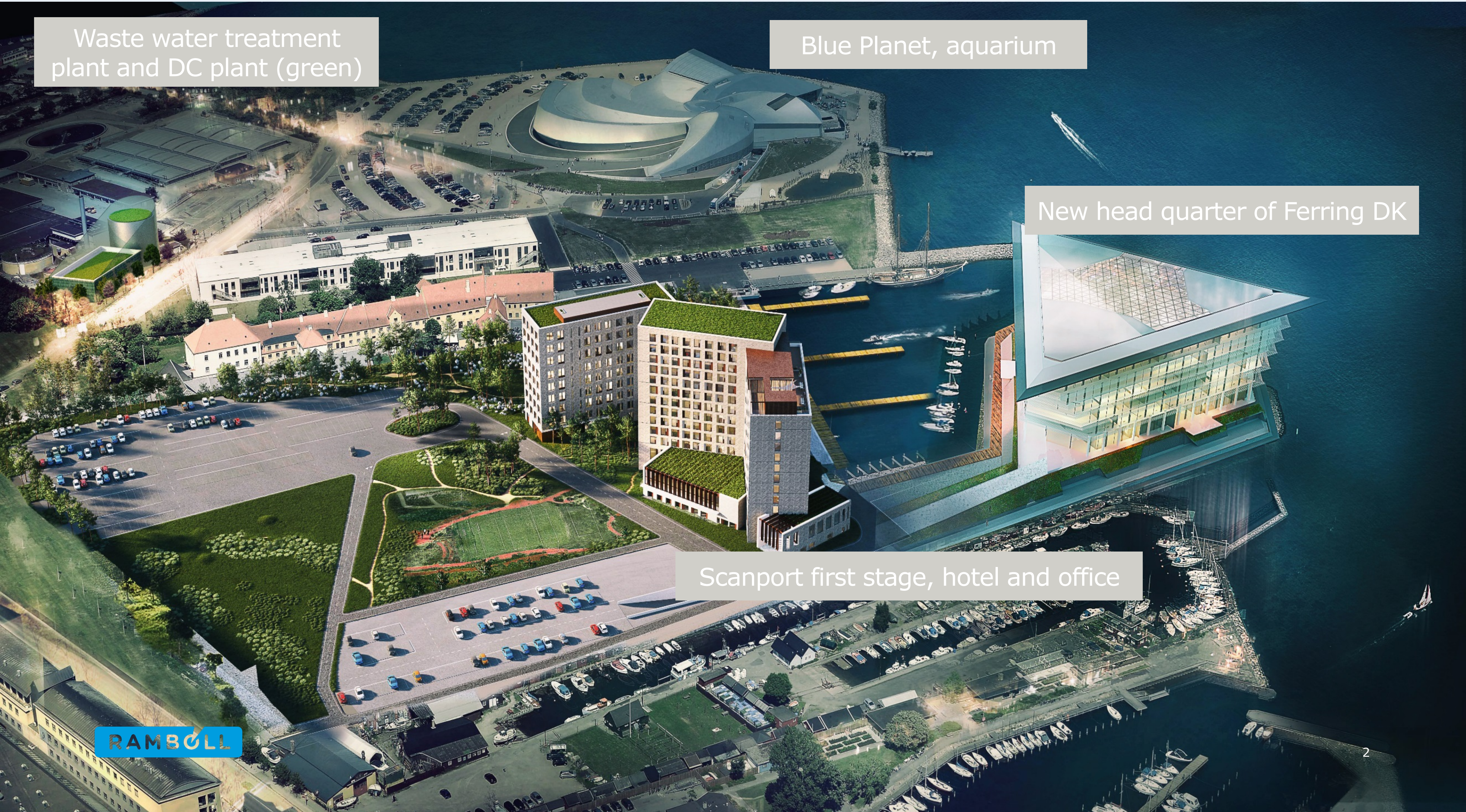
Waste water treatment plant and DC plant (green)
Blue Planet, aquarium
New head quarter of Ferring DK
Scanport first stage, hotel and office
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CONTENT

We will focus on

- The municipal ownership and commitment to establish DH and DC to the benefit of the local community
- The historical development from 1980 to 2020
- Taarnby - a part of the Greater Copenhagen DH
- A smart city energy solution integrating
    - DC with chilled water storage,
    - DH with heat storages,
    - Waste water treatment plant and
    - Ground source cooling
- The costs of the project and the benefits to the local community

Great moment for the mayor of Taarnby and the president of the utility to start the project

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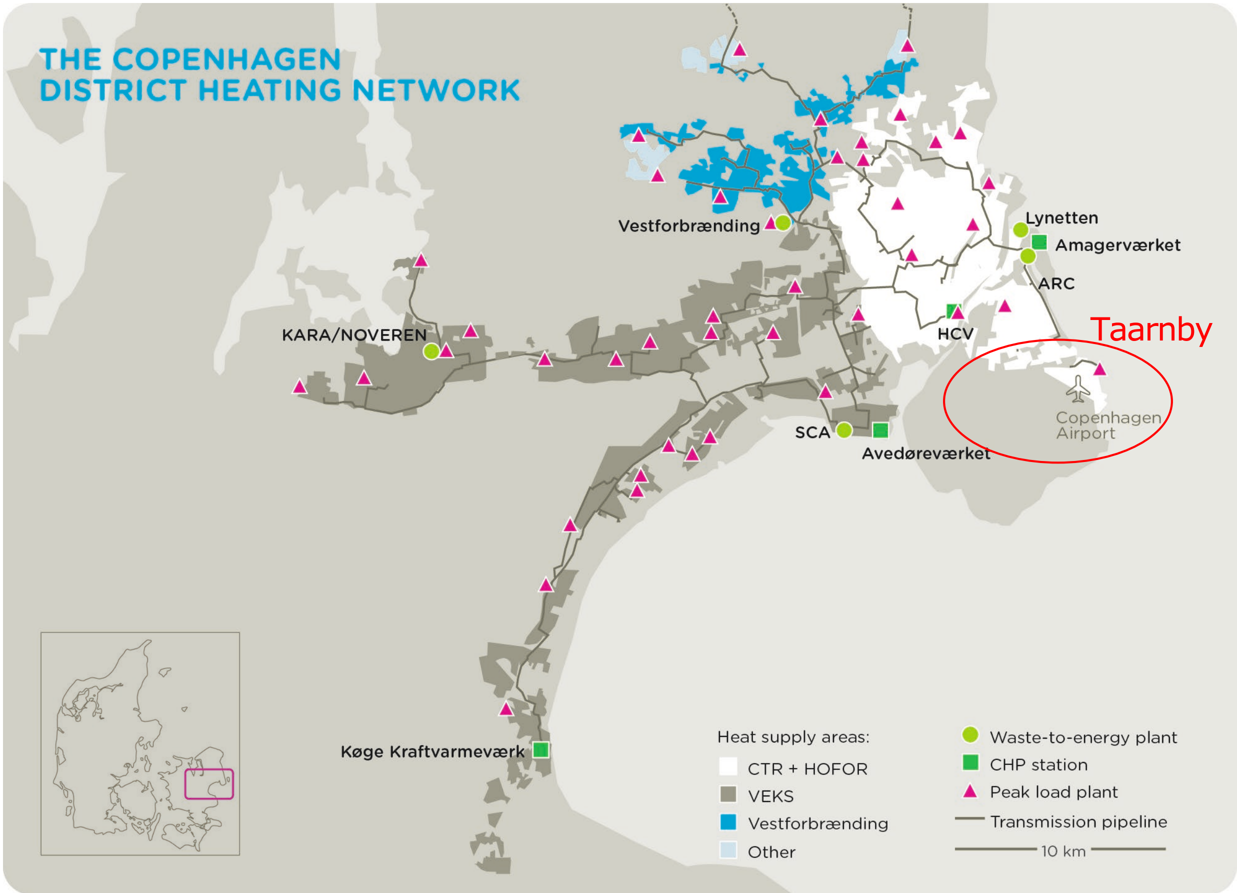
THE PUBLIC UTILITY IN TAARNBY MUNICIPALITY HISTORICAL MILESTONES, IN BRIEF

- 1980 Municipal owned utility owns water supply, waste water and waste water treatment
- 1980 Heating is 100% individual oil boilers, heat supply planning starts in Denmark
- 1981 Taarnby Municipality Co-owner of the new heat transmission company CTR
- 1981 Taarnby Municipality co-owner of the new regional gas company HMN
- 1983 Municipal heat plans for DH and gas, regional plan for heat from CTR
- 1985 Taarnby Public Utility establish a new DH business unit and a new DH system
- 2000 Taarnby Public Utility eliminate air pollution from waste water treatment (roof on top of bassins and air-cleaning filters) and opens for new urban development close to the plant
- 2018 Taarnby Public Utility establish a new DC business unit and district cooling
- 2020 District cooling first stage in operation, DC plant at the waste water treatment plant
- 2022-2030 Second stage of the DC project, expected to be in operation

DISTRICT HEATING IN TAARNBY IS A PART (2 %) OF THE GREATER COPENHAGEN DISTRICT HEATING SYSTEM

- Smart city land mark
- 70 million m2 - 1 mill. residents
- 12,000 GWh heat production
- 20 municipalities (CPH 50%)
- 3 heat transmission companies
- Optimal market share of DH
- 99 % connection to the DH grid
- 3 biomass CHP plants (65%)
- 3 waste to energy plants (30%)
- Heat pumps, Peak boilers.. (5%)
- 3 x 24,000 m3 heat storage tanks
- **8 District cooling** systems in operation, more in the pipe line



See also case 1 in this publication from EU: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC104437/study%20on%20efficient%20dhc%20systems%20in%20the%20eu%20-dec2016_final%20-%20public%20report6.pdf

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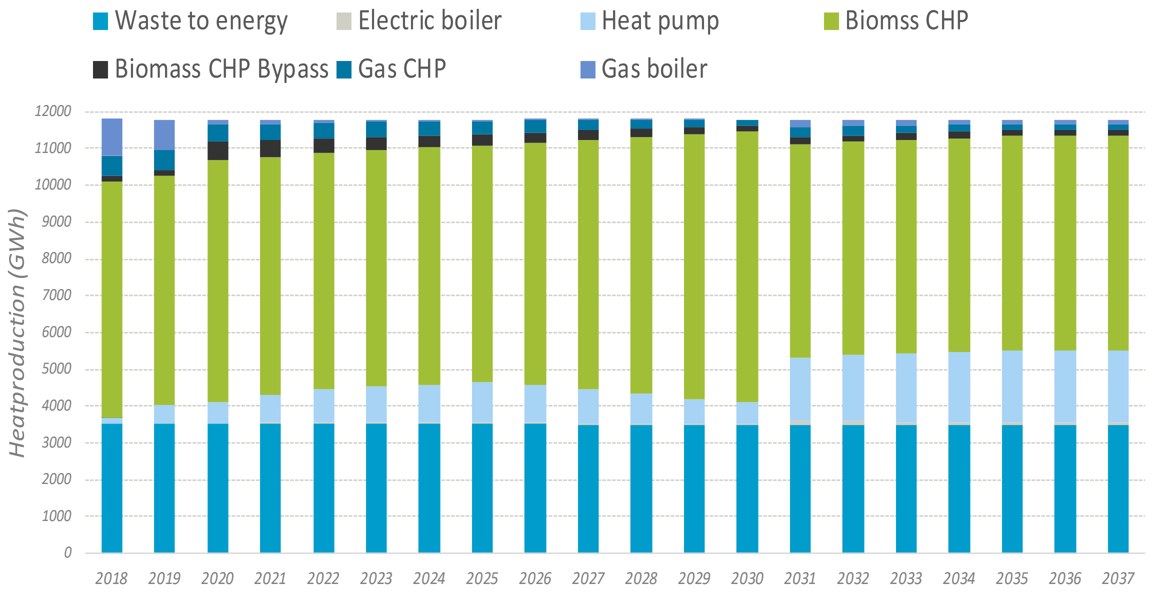
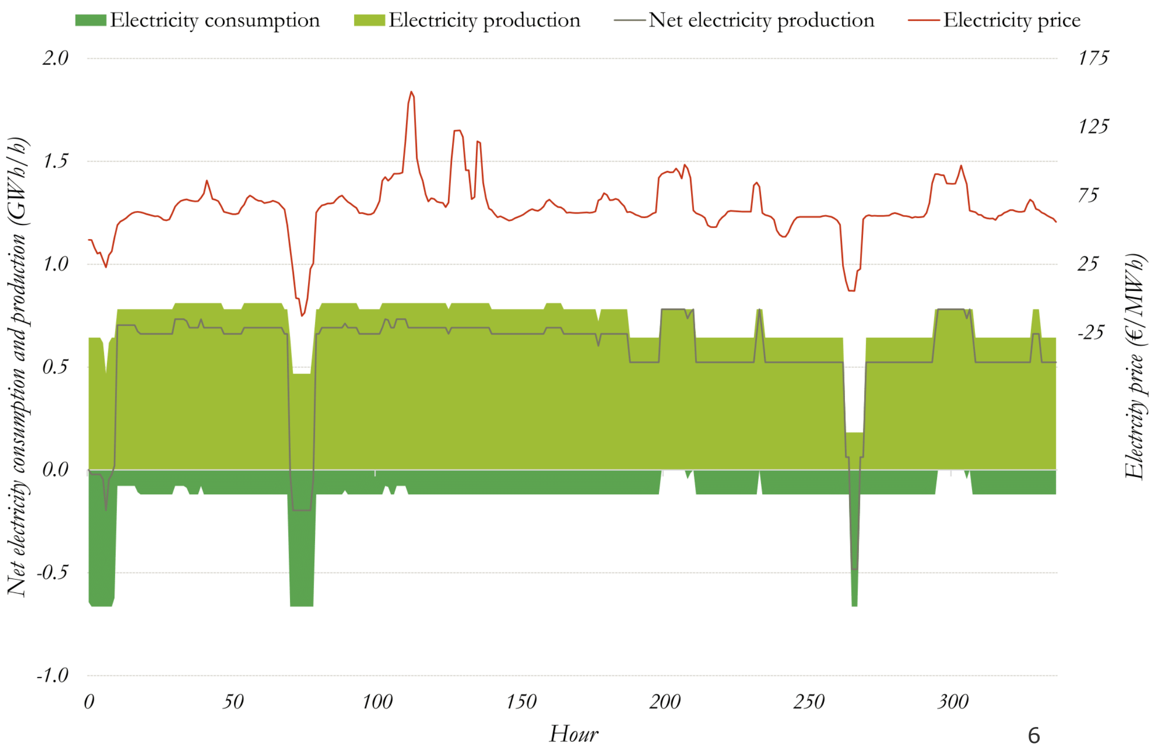
A TRANSITION FROM COAL-GAS-BIOMASS CHP TO A MIX OF BIOMASS CHP, HEAT PUMPS FOR DH&C AND ELECTRIC BOILERS

- Waste for energy is fully used
- CHP by-pass steam turbines + electric boilers
- Large heat pumps mainly for combined DH&C
- Large heat storages tanks and pits
- Large chilled water storage tanks

Transition towards 2030 - Huge demand response on electricity prices

Smart integration of electricity from fluctuating wind and solar PV





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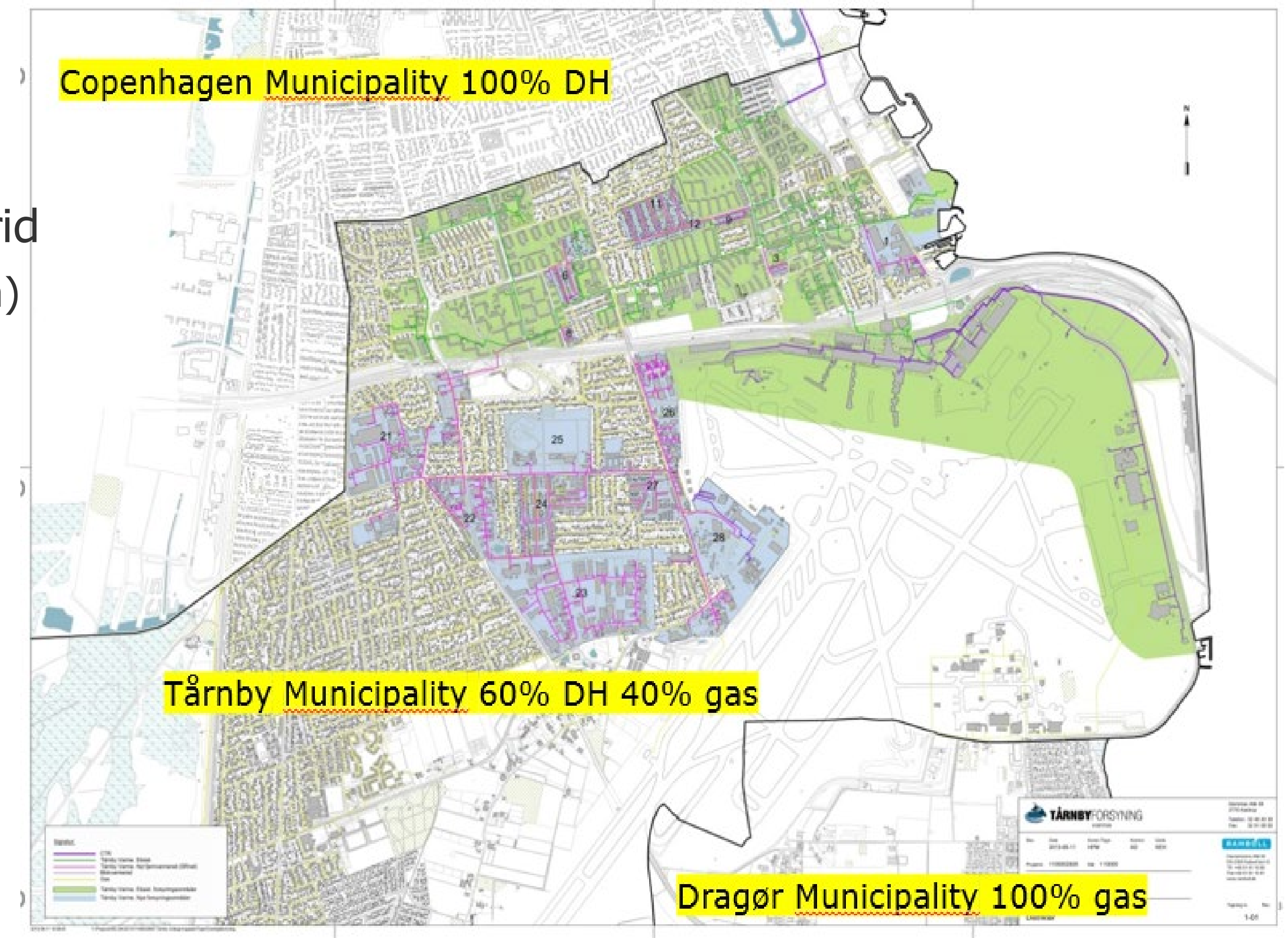
ENERGY PLANNING IN TAARNBY 1980-2020

- 1980
  - 100% oil boilers in Taarnby

- 1985 optimal zoning of new DH and gas grid
  - 60% to hot water DH, large buildings (green)
  - 40% to gas, single family houses (no color)
- 2018
  - First DC system combined with DH
  - Integration of DH with airport campus grid

- 2020-2030
  - Second stage of the DC project
  - More DH to replace gas boilers (blue)
- 2030-2035
  - Remaining buildings to DH and heat pumps



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KEY FIGURES OF THE DH SYSTEM FOR INTEGRATING DC

DH demand 170 GWh (growing)

Heat losses in network 6%

60 MW Maximal capacity demand

7 MW minimum capacity summer

95% production from waste and biomass CHP 5% from boilers

60 MW back-up boiler at the airport

7 MW heat pump capacity extracting heat from cooling and waste water

In summer, all buildings can be sup-plied from heat pump, at 70 dgr.C

In winter temperature to consumers is boosted with heat from CTR

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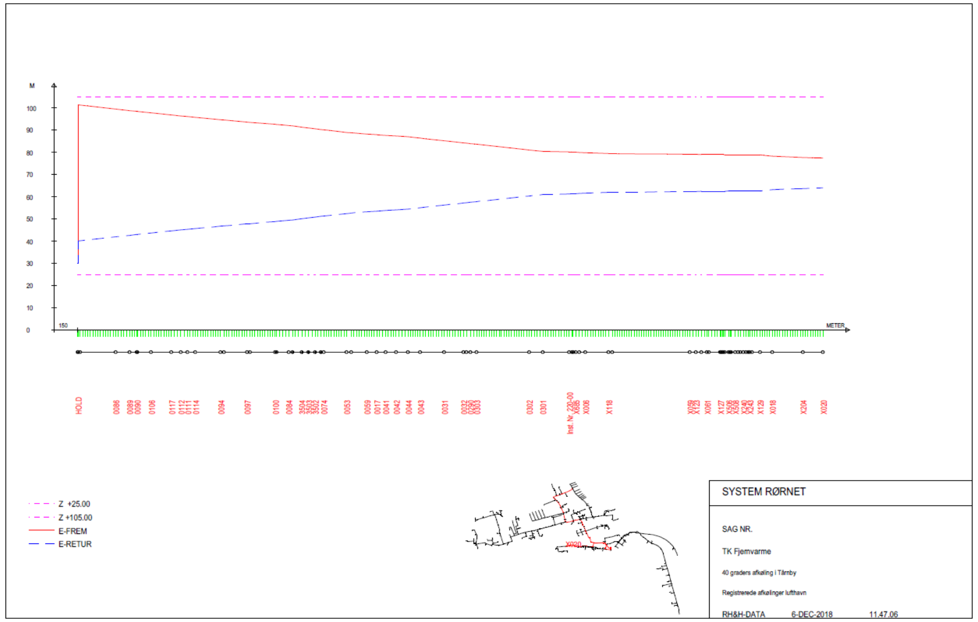
DESIGNING AN EFFICIENT NETWORK TO "LOW TEMPERATURE CONSUMERS"

- Hydraulic analysis to ensure optimal design and operation in all load cases
  - Coldest hour to supply at around 90 dgr.C
  - Maximal use of base load from the transmission system
  - Most buildings can be supplied in winter with 75 dgr.C
  - Heat pump to supply 70-75 dgr.C to the network

- Optimal preinsulated bonded system for DH and DC
  - Welded muffs
  - Survailence system
  - No expansion loops and -compensators



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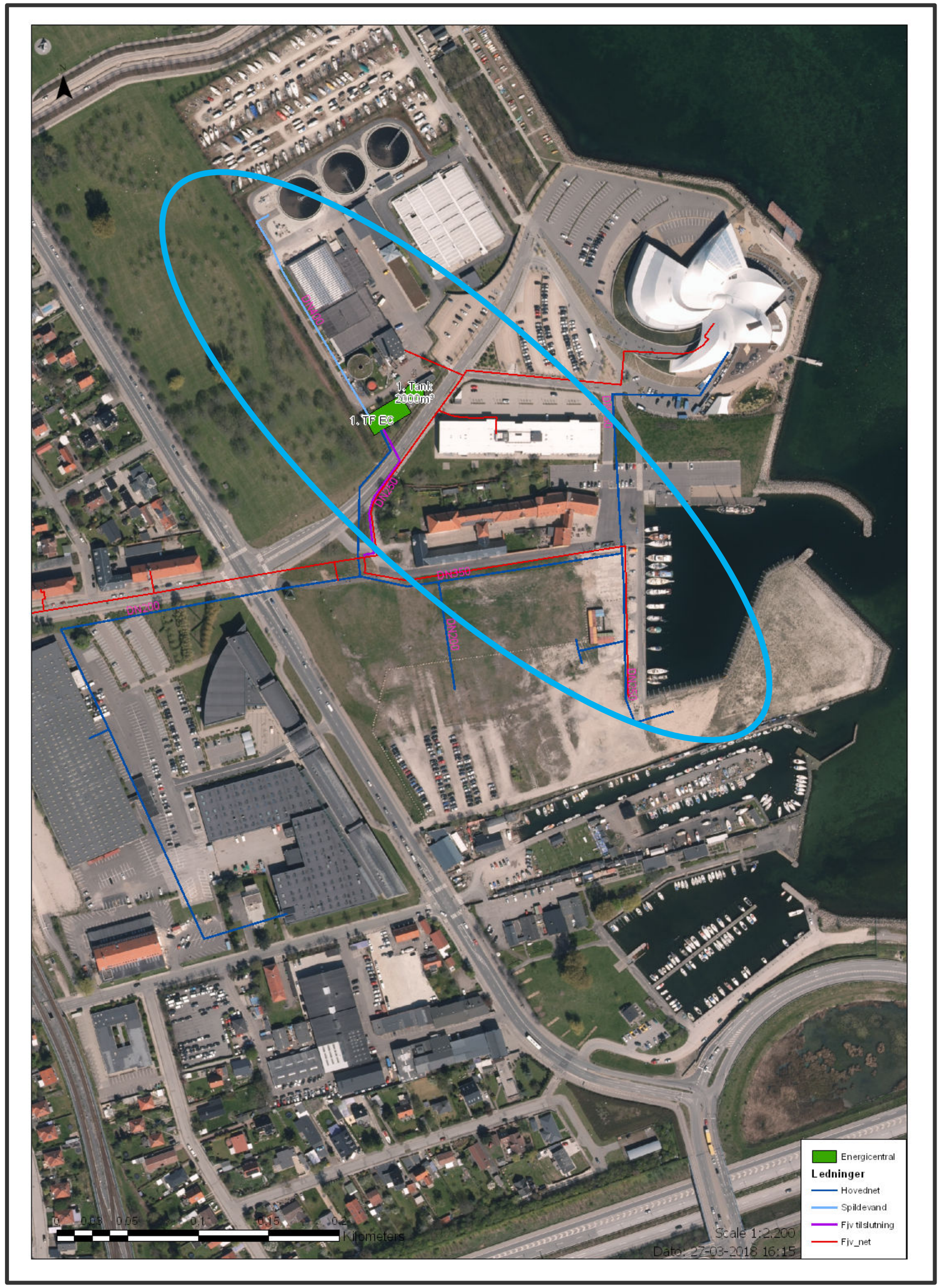
DISTRICT COOLING IN TAARNBY
STAGE 1 IN 2020

- Cooling demand in stage 1 — 4,3 MWc / 4.500 MWhc
- Capacity demand to network — 4,0 MWc ?

- Installed capacity — 7,3 MWc incl. back-up
    - *Heat pump cooling* — *4,8 MWc / 4.500 MWhc*
    - *2.000 m3 chilled water tank* — *2,5 MWc / 0 MWhc*
- Heat Pump heating — 7 MW-heat, 50,000 MWh
    - *Cogeneration heat/cold* — *6.500 MWh COP=6*
    - *From waste water* — *43.500 MWh COP=3*

- DH pipe connection to DH network
- PEH pipe connection to the treated waste waster



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DISTRICT COOLING IN TAARNBY
STAGE 2 FULLY DEVELOPED

- Cooling demand in stage 2 9,5 MWc / 9.000 MWhc
- Capacity demand to network 8 MWc ??
- Installed capacity 9,3 MWc incl. back-up
  - *Ground source cooling 2,0 MWc / 4.000 MWhc*
  - *Heat pump cooling* ***4,8 MWc*** */ 5.000 MWhc*
  - *2.000 m3 chilled water tank >2,5 MWc / 0 MWhc*

- Heat Pump heating 7 MW-heat, 50,000 MWh
  - *Cogeneration heat/cold 7.000 MWh COP=6*
  - *Ground source 5.000 MWh COP=6*
  - *From waste water 38.000 MWh COP=3*

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OPTIMAL OPERATION WITH RESPECT TO ELECTRICITY MARKET AND THE DH MARKET IN GREATER COPENHAGEN, STAGE 2

- DC chilled water tank regulates the pressure to ensure supply of cold water
- Ground source cooling has first priority in summer to reduce heat pump generation in summer
- 4 Heat pumps deliver peak cooling capacity in summer optimized with respect to electricity prices and heat prices (marginal COP = 6 for heat generation with cooling as baseline)
- 4 heat pumps cool ground water to 6 dgr.C in winter to ensure annual energy balance
- Available heat pump capacity generates heat from waste water optimized with respect to electricity prices and heat prices (COP = 3-4)
- Heat pumps close down in case of large electricity prices
- Heat pumps can be disrupted in case of capacity problems in the power grid
- This operation is important for cost effectiveness and for integration of the fluctuating wind energy (virtual battery)

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DC SAVES INVESTMENTS AND COSTS

- Investments cooling baseline 97 mill. DKK
- Investment in DC project 81 mill. DKK
  - DC plant incl. building 55 mill. DKK
  - DC storage tank 4 mill. DKK
  - DC network 19 mill. DKK
  - Connection to DH network 3 mill. DKK
  - Including transformer to 10 kV to save costs
- Stage 1 only (no stage 2 is worst case for financing)
  - NPV Benefit for the society 60 mill. DKK
  - NPV Benefit consumers and utility 23 mill. DKK
- Stage 1 and 2
  - NPV Benefit for the society 103 mill. DKK
  - NPV Benefit consumers and utility 60 mill. DKK

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WHY IS THIS PROJECT A GOOD CASE TO MAKE CITIES SMARTER AND MORE LIVEABLE

- Focus on energy solutions which reduce costs and improves environment and resilience in cities
- Focus on municipal commitment in order to implement the solutions to the benefit of the consumers and for integrating energy and environment in one utility
- Focus om municipal co-operation
- Focus on sector integration, which opens for smart city solutions across following sectors:
    - The energy sectors: Electricity, District heating, District cooling and gas
    - The environment sectors: Waste water and ground water resources
    - The building sector, Ferring and Scanport go for sustainability as being a part of the community
- The symbiosis between
    - heat pump for combined DH&C and
    - heat pump for generating heat from waste water
- is the key to cost effectiveness and bankability, in particular for the difficult stage 1.

PROGRESS OF THE DC ENERGY PLANT, SEPTEMBER 10 2019
FERRING IN THE BACK GROUND, TANK TO THE RIGHT

THANK YOU FOR YOUR ATTENTION

QUESTIONS

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