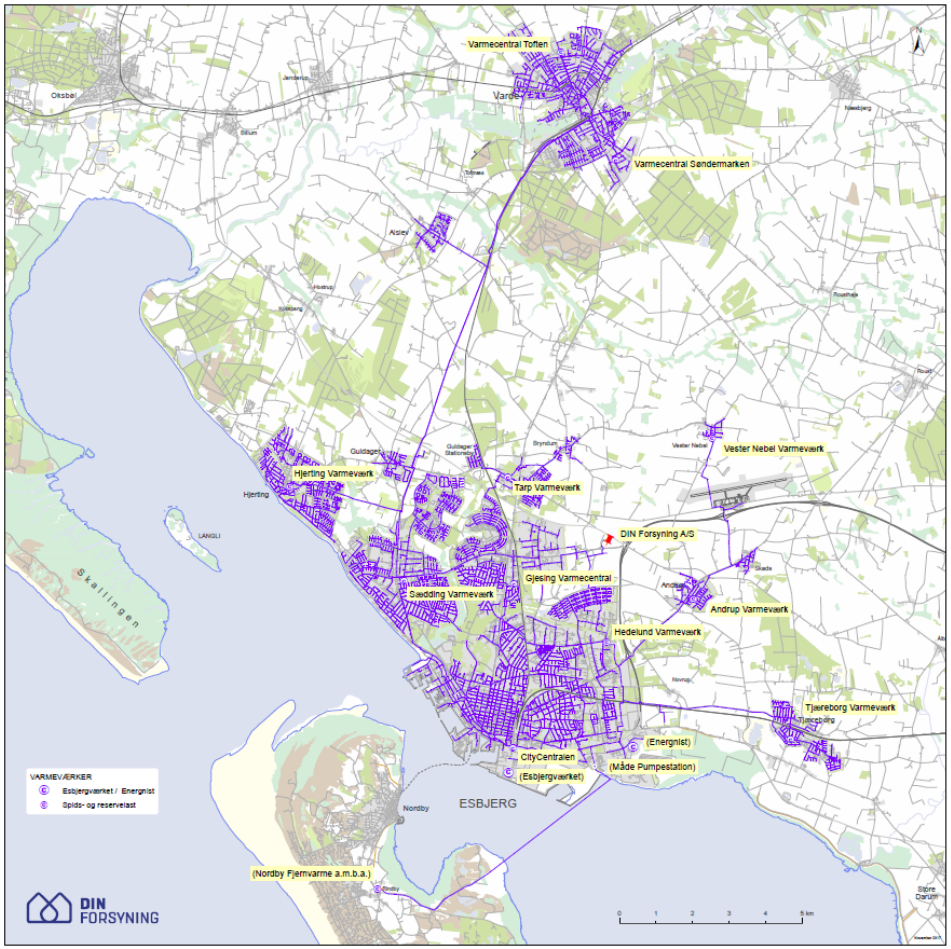
Fremtidens Fjernvarme
District Heating for the Future

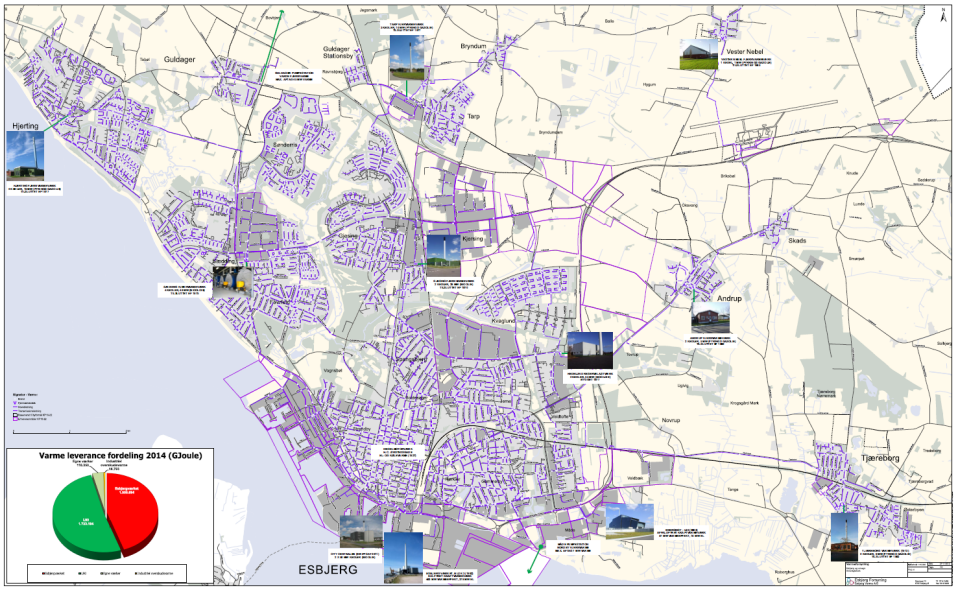
Project Director Kenneth Jørgensen

Fremtidens Fjernvarme
– en fleksibel og bæredygtig løsning

DINForsyning Varme A/S

District Heating for Esbjerg and Varde City – 25.000 customers
1,100GWh/year distribution
Coldest day ever 397MW average
Main heat supplier is Energnisten (71MW) and ESV3 (350MW) (Ørsted)
DINF has peak and reserve plants





Objectives

- Fossil free district heating production
- Zero waste – reduce heat loss in the production
- Facility use of waste heat in district heating from e.g. data centers, PtX facilities, etc.
- Robustness against fuel prices – smaller units on different technologies
- Use electrical energy for heat generation and provide balancing of the electrical grid
- Build production and heating plant competences in DINF
- Operational by 1 April 2023

District Heating for the Future

- Future production
  - production capacity to replace ESV3
  - two phase: phase 1 urgent requirement
    phase 2 residual based on actual equipment and development

- Future distribution
  - reduce distribution network losses by lowering and controlling forward temperature to the branches of the district heating network
  - reduce flow by better cooling at customer (on-going)

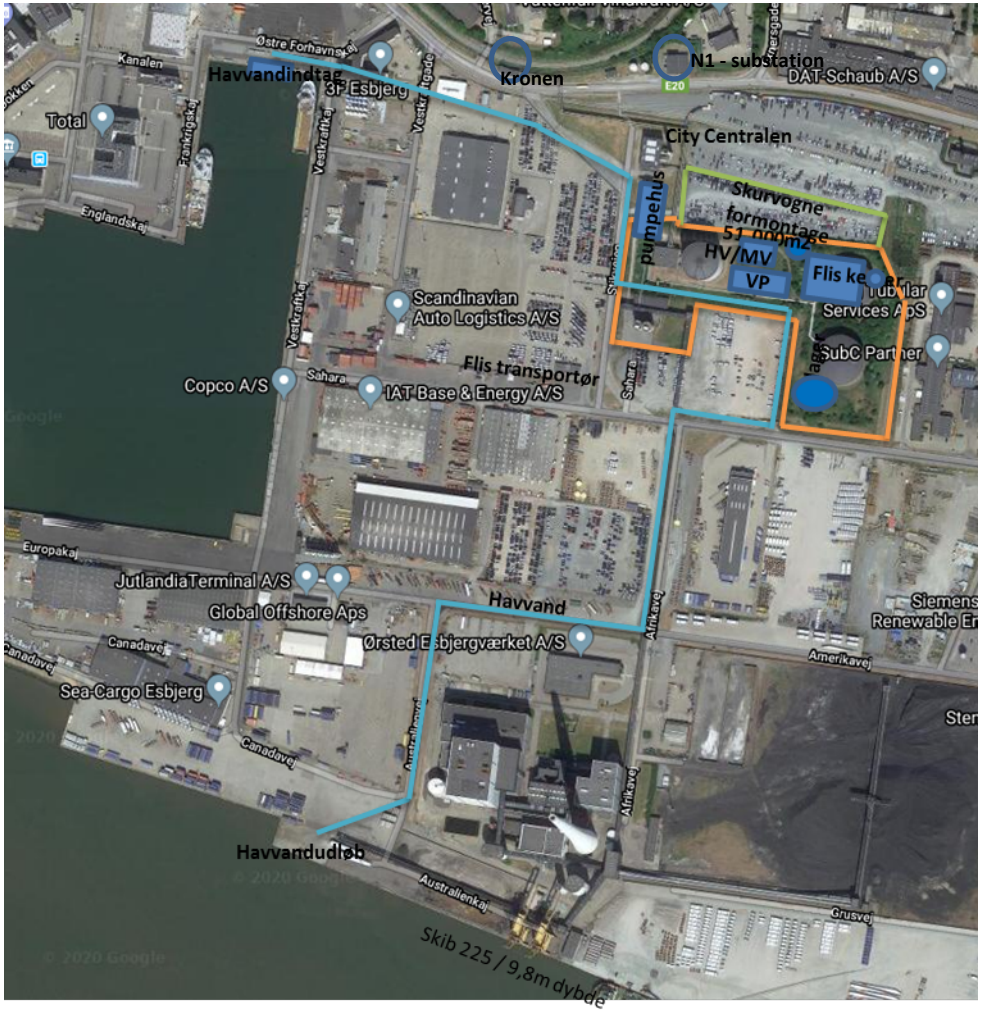
- Future consumer / heat supplier
  - reduce losses by a differentiated cost structure (morning and evening peak shaving)
  - optimize production by maximizing lowest marginal cost plants

Location

All district heat has been produced by Vestkraft and later ESV3 up until 2002. Energnist was added in 2002.

The district heating network is thus built with all distribution going out of “Kronen” in 4 main transmission Pipelines.

A large plant must be located at The same location to be able to deliver to the entire district heating network



Fremtidens Fjernvarme
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KEDELBYGNING
FLISLAGER
TRANSFORMER BYGNING
VARMEPUMPEBYGNING
EKSISTERENDE VARMEAKKUMULERINGSTANK
ADMINISTRATION (FREMTIDIG)
NY KRONE BYGNING
VIDENSSTI

VIDENSSTIEN "DINviden"

Vidensstien repræsentere en ide om at skabe et sammenhængenende informationsforløb, som kan kommunikere en basisviden om nogle af DIN forsynings grundlæggende kompetencer og funktioner. Det gøres ved selvsyn ved "view stations" og ved informationsinstallationer ved "uddannelsesstationer" langs den orange rute.

Buildings – Wave/sinus plate façade structure

Permits

Planning permit according to varmeforsyningsloven/projektbekendtgørelsen.
- CHP demand for units larger than 1MWt.
- Dispensation from CHP demand from Energistyrelsen / Ministry of Energy conditions on priority of waste heat

No hazardous operation according to Risikobekendtgørelsen (max 5 tons NH3)

Environmental Permits – to de-risk application process it was divided in two

1. Heat Pump
   - NH3, CO2 and R1234ze was approved refrigerants
   - refrigerant leakage detection
   - sediment issues
   - poisoning of the sea (NH3 issue)
   - cold spreading

2. wood chips boiler
   - Nox
   - wood smell, fungus,
   - noise issues in wood reception

Construction permits etc. on-going

Environmentally friendly way to produce heat

Coefficient of Performance (Efficiency)

$$COP = \frac{Heat\ output}{Enery\ input\ (el)}$$

High COP requires low temperature lift

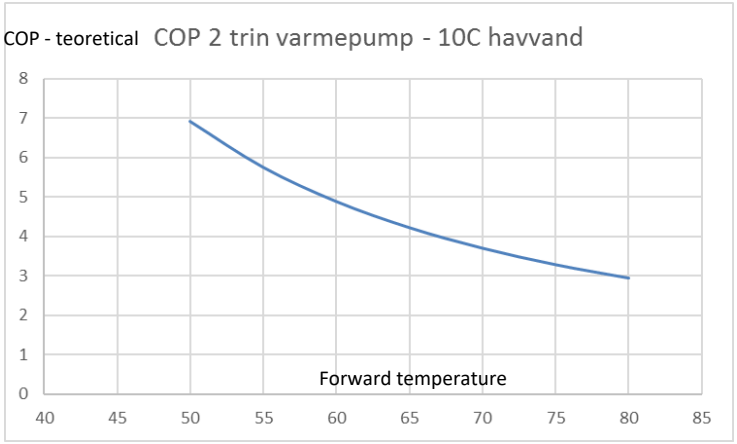
Marginal consideration for heat pump

$$\frac{El\ spot+tax+grid\ tarif}{Wood\ chips+tax+grid\ tarif+el\ spot} = \frac{430DKK}{200DKK} = 2{,}2 < \text{COP}$$

Electrical energy – use heat pump when the el spot is low

Lower district forward temperature / raise sea water temperature

- Heat pumps in series with thermal units
- Lower the forward temperature in the district hating network => more district heating flow flow to deliver energy



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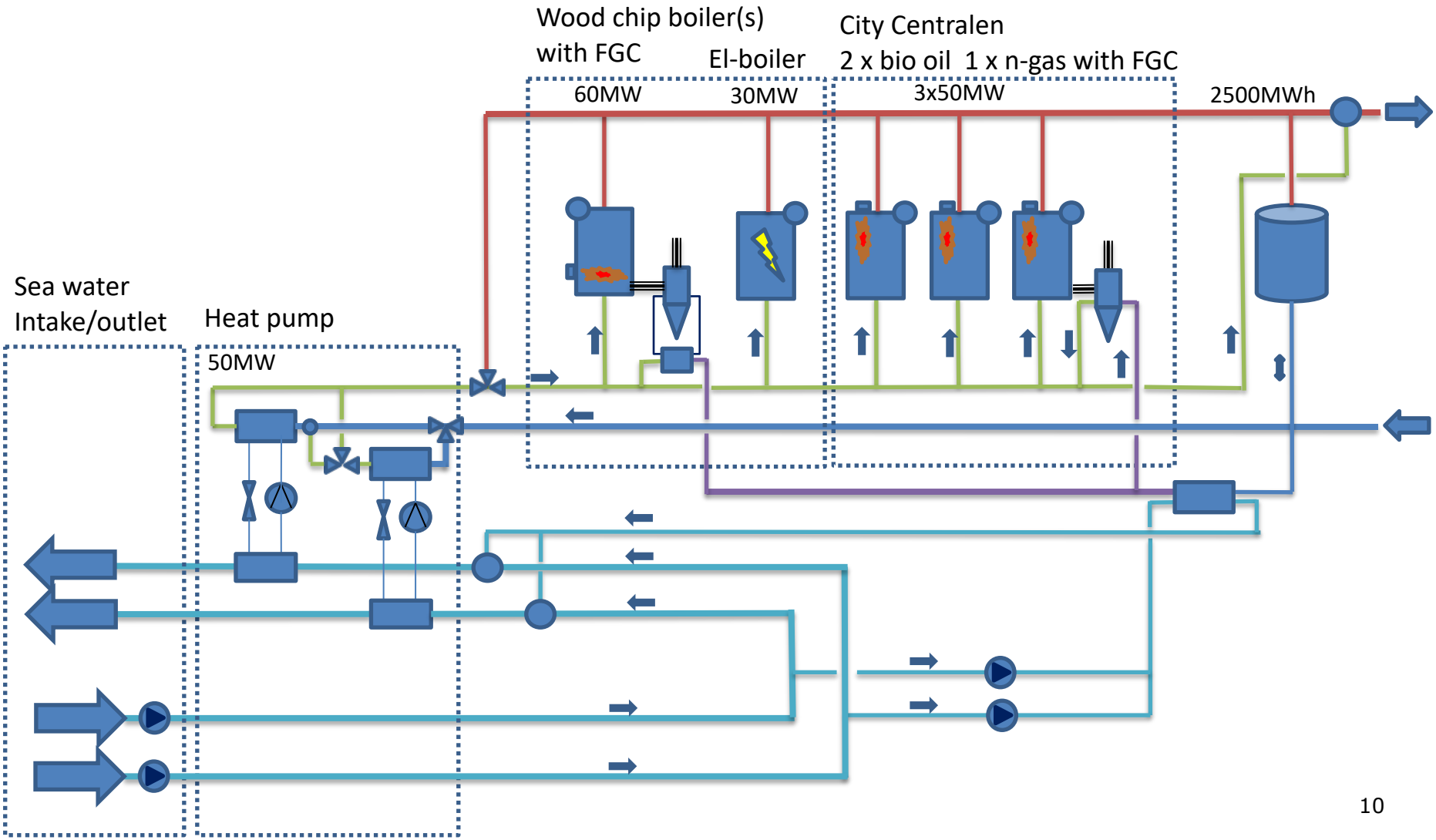
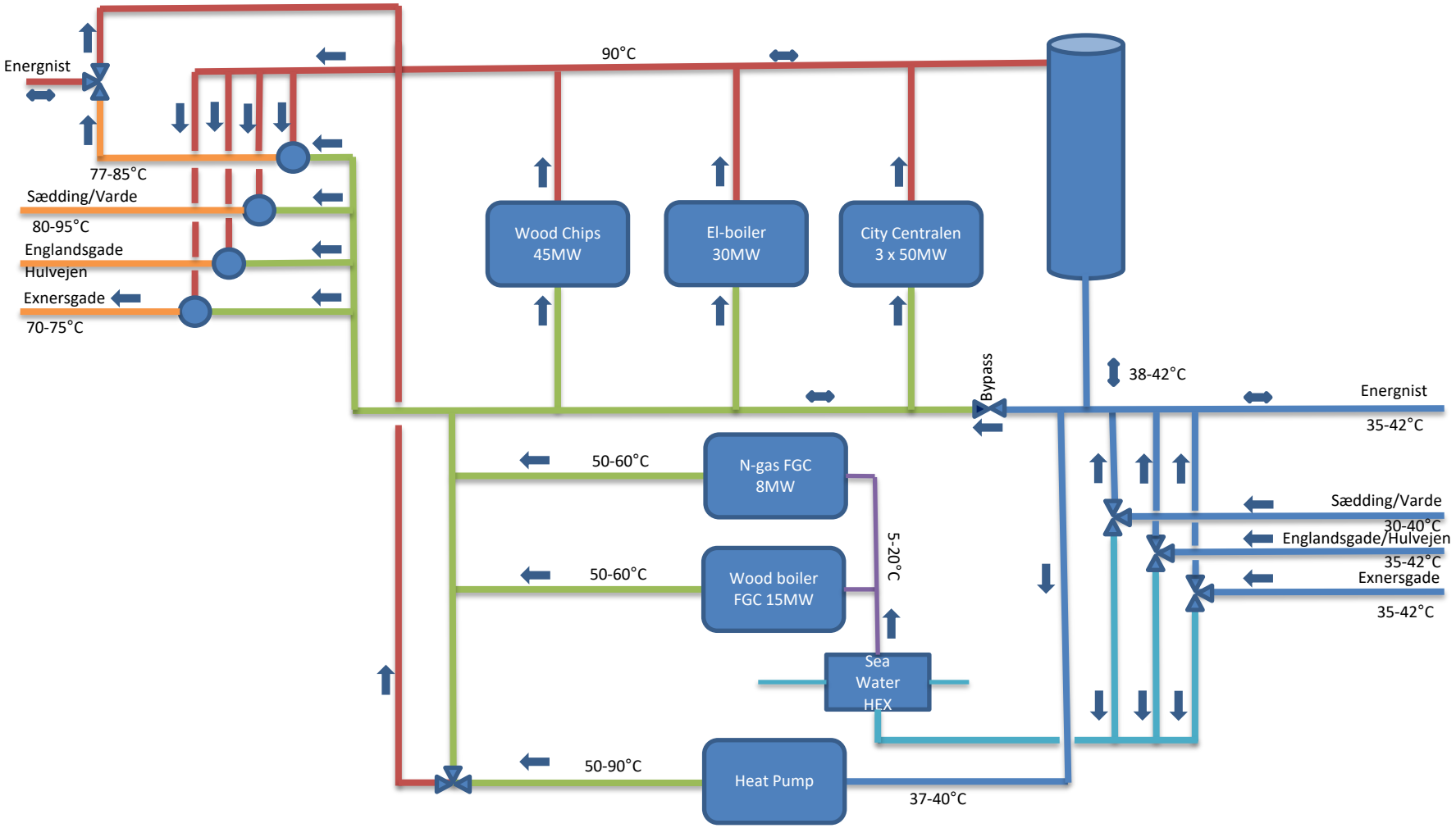
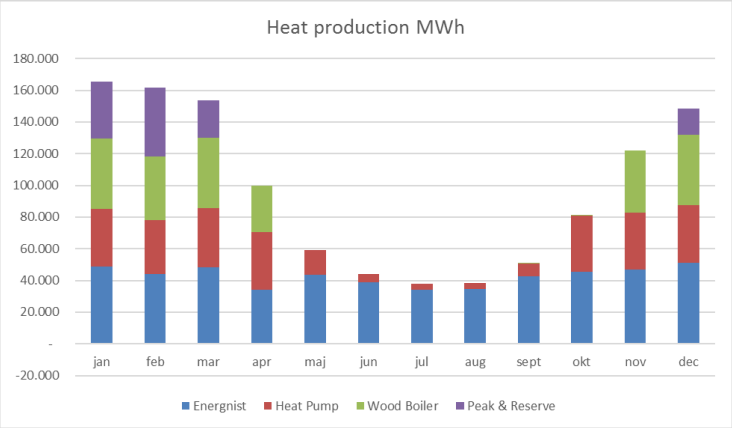
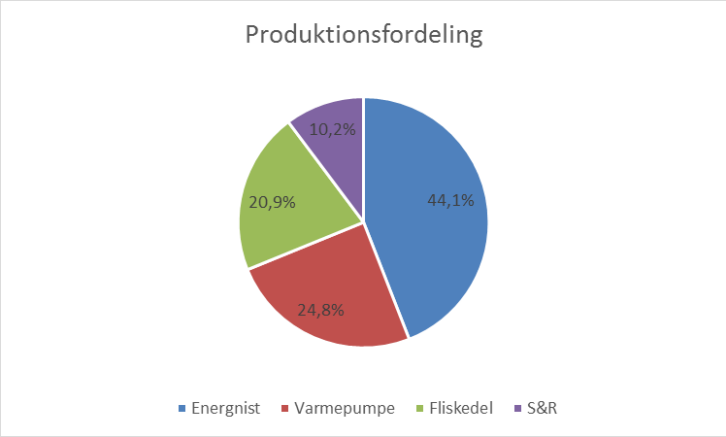


Districting Heating Distribution



Production projection 2024/25





Production for Phase 1

Peak and reserve of 10,2% is too high and Phase 2 plant shall reduce this to less than 2% of the production.

Phase 2 is under preparation

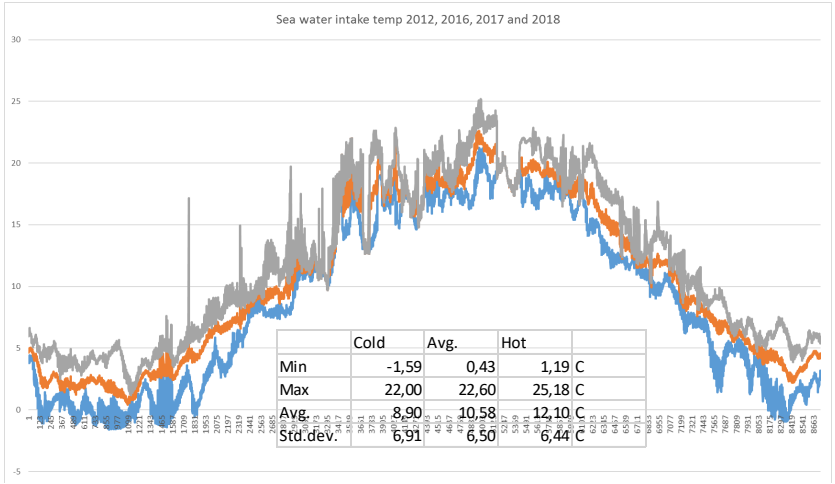
		Energnist	Heat Pump	Wood Boiler	Peak	Total
Heat	MWh	512.663	288.050	243.228	119.169	650.447
Fuel cost	DKK	-	41.881.046	43.237.565	53.250.013	138.368.624
Fuel cost	DKK/MWh		145	178	447	213
Wood	tons/year			83.941		83.941

Fuel cost is based on 2018 monthly average prices for electricity and natural gas and applicable taxes and fees. Wood chips is set at 53,57DKK/GJ.

Seawater as heat source

Vatten Sea

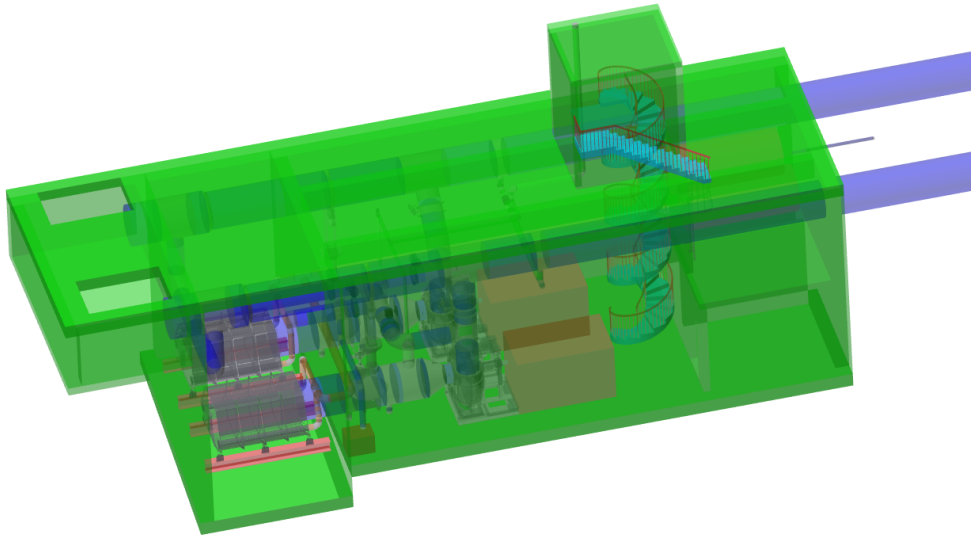
- Natura 2000 / Unesco area
- Low water dept (10 m in harbor)
  – no stratification
  - uniform temperature/salt profile
  - high biological activity: mussels, barnacles
  - slush ice
- High tidal variations in temperature and salt
- 2,3% salt – freezing at -1,59C



	Cold	Avg.	Hot	
Min	-1,59	0,43	1,19	C
Max	22,00	22,60	25,18	C
Avg.	8,90	10,58	12,10	C
Std.dev.	6,91	6,50	6,44	C

Sea water intake

- Protect fish, seals, otter,,
- Avoid taking material into the system
- Mussel larva will pass (20 micron big)
  - 48 hours to form shell
  - will attach to surface if velocity is low
- Pig launch system

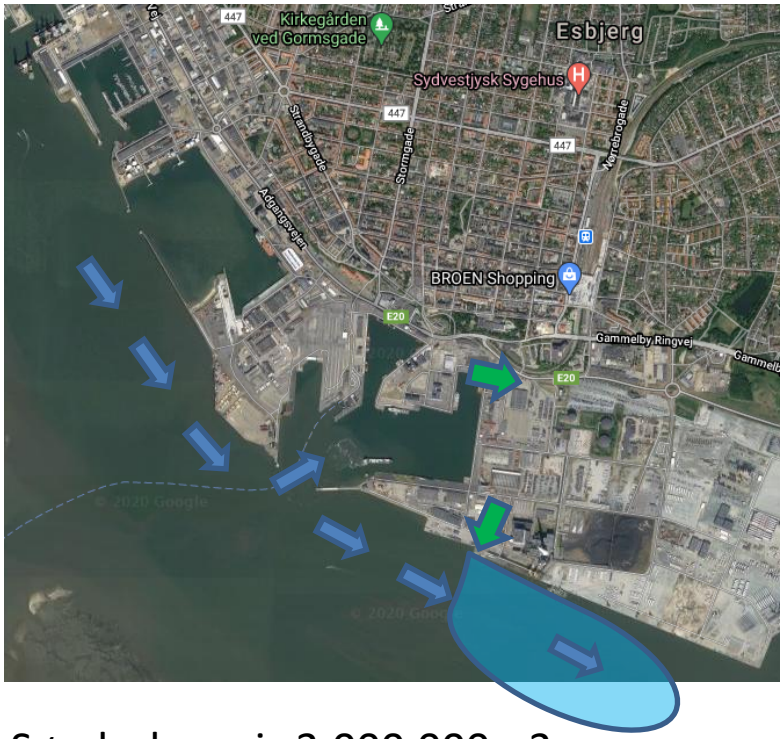


Sea water outlet (ESV3 present outlet canal)

- Avoid thermal short circuit
- Max cooling of 3C
- 4 m3/s of pumping (ESV3 is 16m3/s)
- Pig receiver

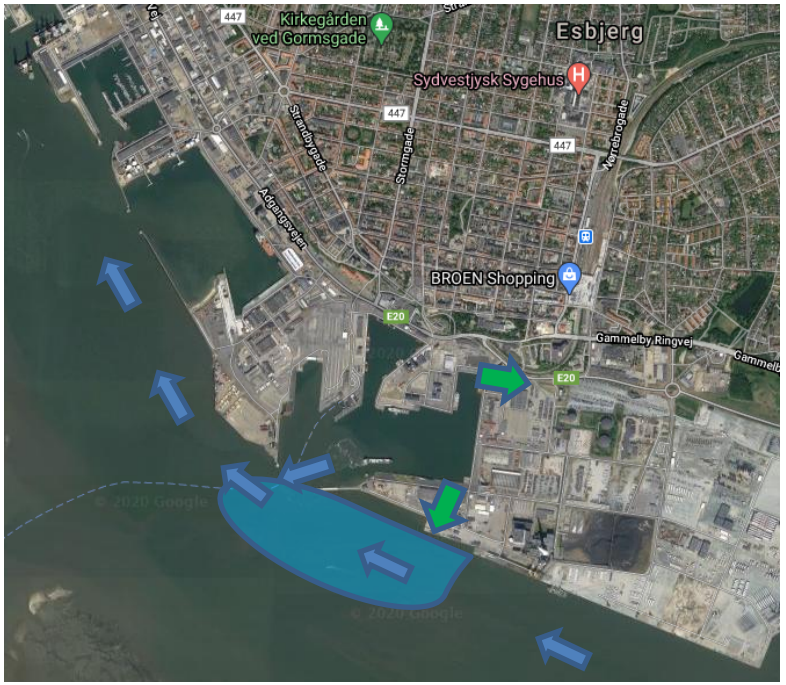
Seawater as heat source

Low to high tide



Sønderhavn is 3.000.000m3
Pumping is 4m3/s – 345.600 m3/day
Sønderhavn is a buffer/damper

High to low tide



Tide water change ~500.000m3 in Sønderhavn
Minimize short circuit – calculated to
Max. 0,1C with 3C cooling.

Sea water pipes

2.Pcs D1200mm GAP or PE. Smooth surface

1,6 km of pipe

Velocity always above 1,5m/s or mussels and barnacles will grow (all inclusive 24/7 buffet for mussels)

One heat pump per pipe / one sea water pump per pipe

Site is highest point (positive angle to site)

Outlet in ESV3 cooling water canal

Waterhammer has been extensively analyzed and preventive measures built in

Electrical Energy

Contract with N1 for deliver of 39MVA at 60kV at the Estrupvej transformer.
Cables under Estrupvej and railway.
Ørsted 150kV connection to Lykkegaard station will be removed together with ESV3.

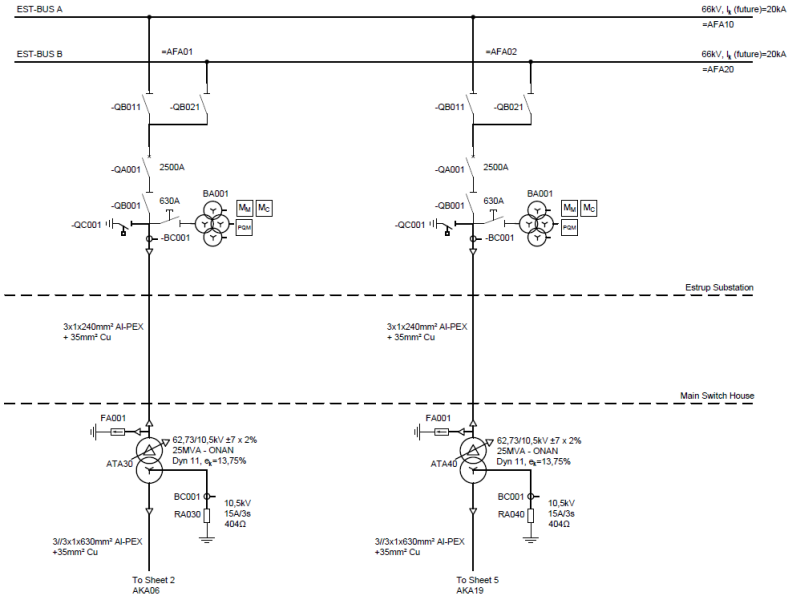
2 x 25MVA transformers for redundancy

2,5MWe n-gas engine for operation of pumping and n-gas and oil boilers at City Centralen

Due to slow start of n-gas engine, 1MWh battery back-up as well.

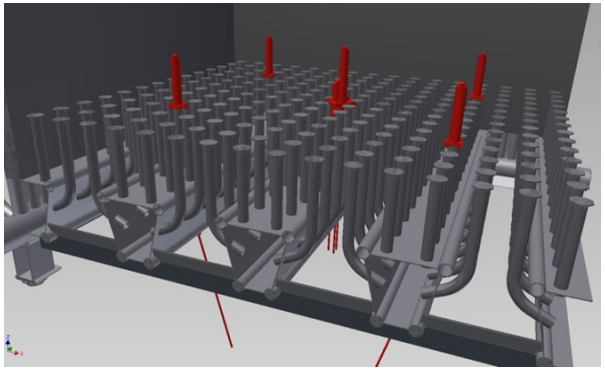
Heat pump motors VSD controlled at 10kV

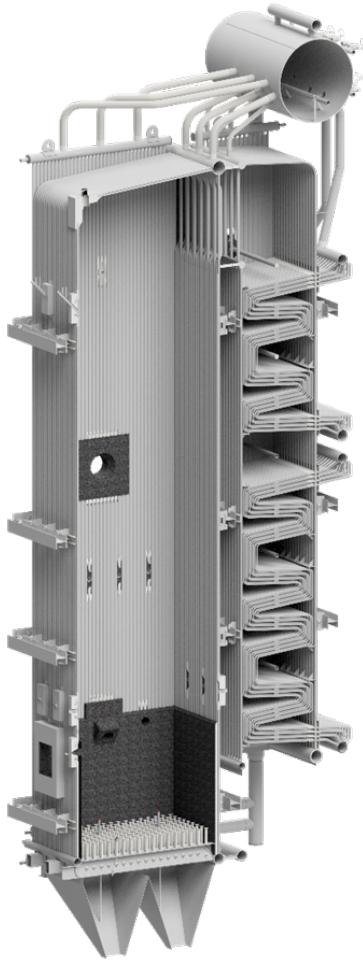
Expect signing of contract 4 February 2021.



Wood chip boiler

- 60MW including FGC at 37C district heating
- Large operation window
- Tender called for 1 to 3 boiler lines
- High ramping rate to balance heat pump
- 25 – 55% moisture content
- At 5C DH additional 6MW via heat pump
- Minimum load 35% with FGC
- 110% overload for
- Load change ramping time 7%/min (4,2MW/min)



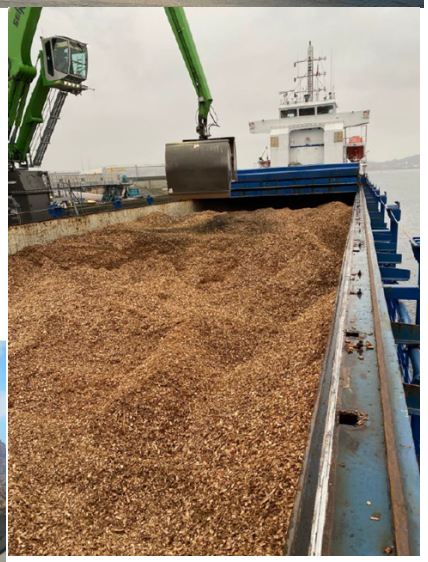


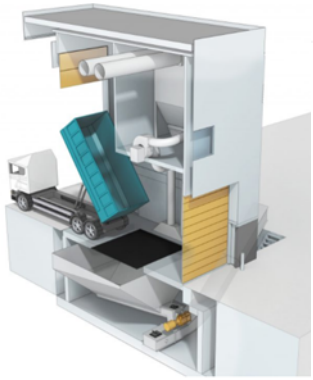
Unicon Renefluid

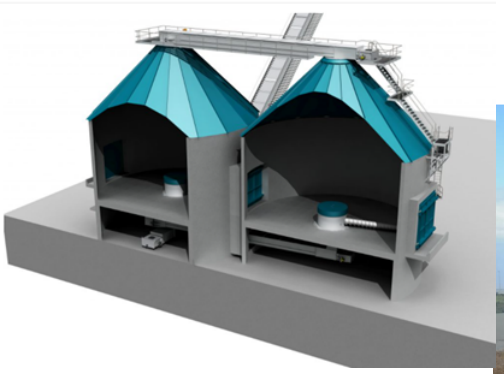
Wood chip reception

By ship or truck

Open mile at kay side secured with concrete "lego" blocks
Can be close at flooding to prevent wood chips sailing away
Reception, screening and metering at site
8000m3 of storage (4 days)
Wood tipping under roof and ventilated to chimney (no smell at neighbors)







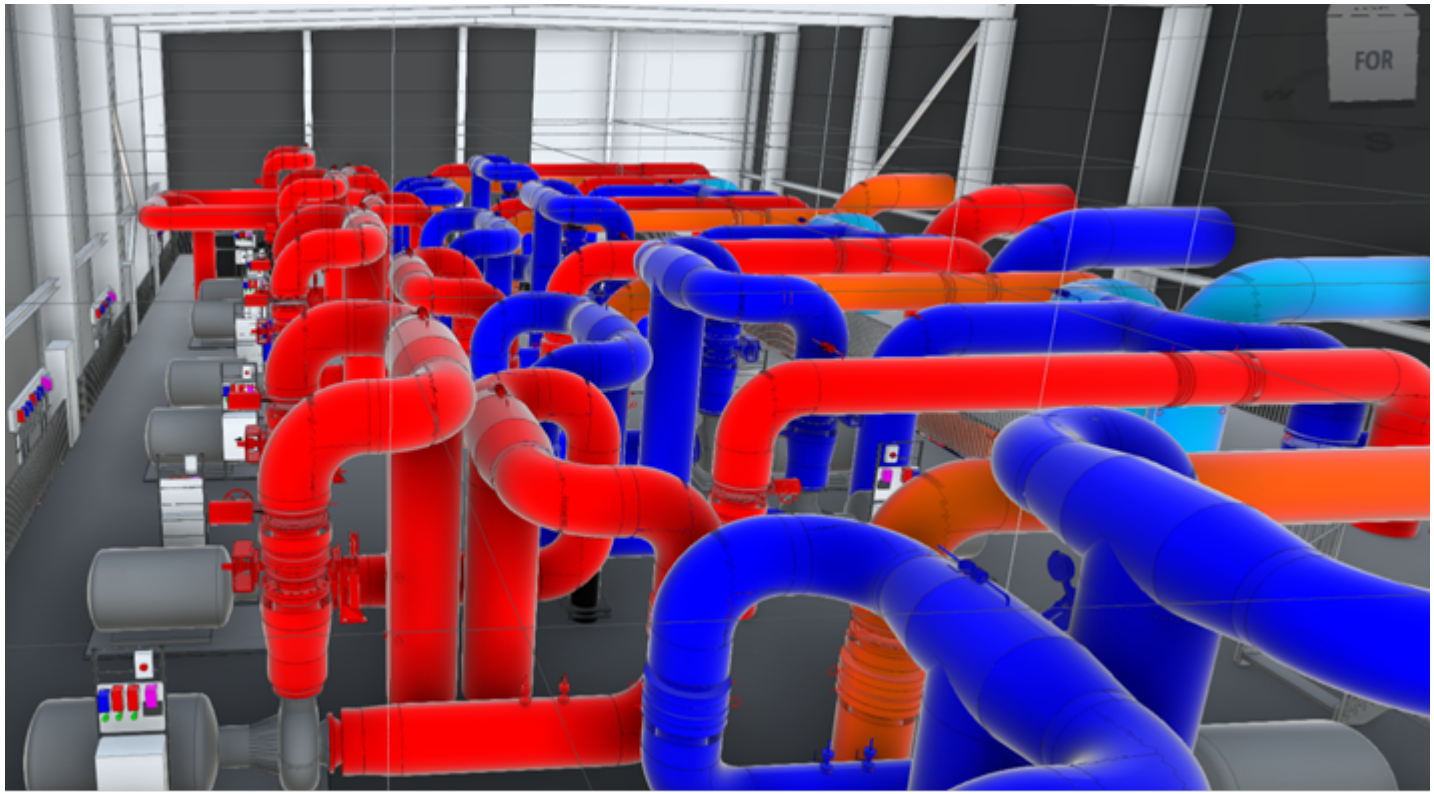
Ny Krone – the new hearth for DH

Individual forward and return lines

Four individual forward lines enabling lowest possible forward temperature per sub grid.

Four individual return lines – separate in two qualities allowing to waste heat to go return lines.

Ready May 2022.



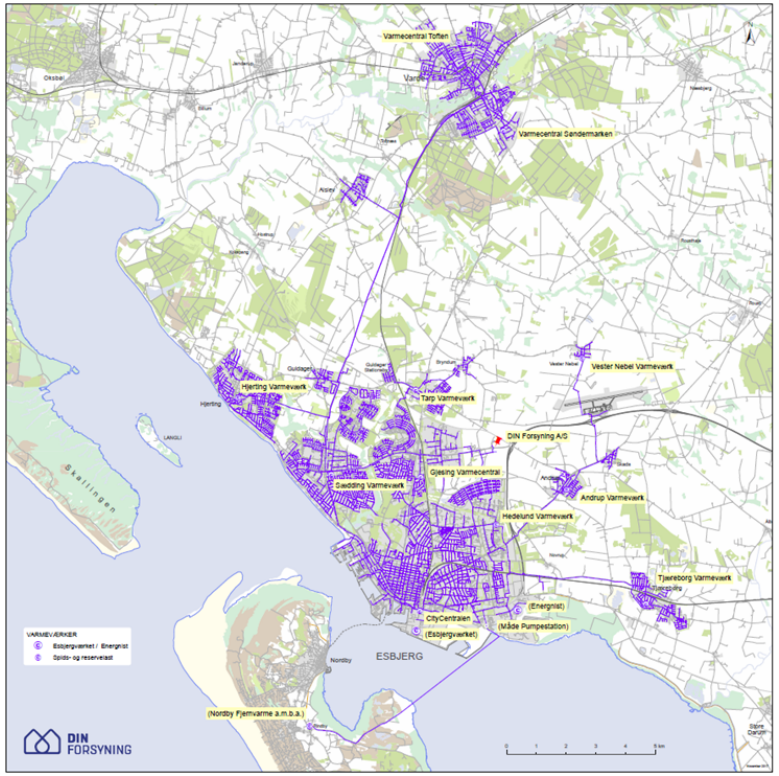
Future distribution

Operation of the District Heating network has been based on minimum 65C at customer installation.

Thermal units – heat production cost was nearly independent of forward temperature

High forward temperature ensures that energy can be pushes fast to costumer by increased pumping

Lowering and temperature increasing pumping to means that more energy is supplied by increasing forward temperature.
6 hours from plant to Varde!



Forecasting tools!
- **Heat consumption days ahead.**
- **Electrical prices ahead for production planning**

Questions