

# Ørsted Vision and Experiences with Biomass

Presentation at Circular Convention  
14 March 2018  
Amer power plant, Geertruidenberg



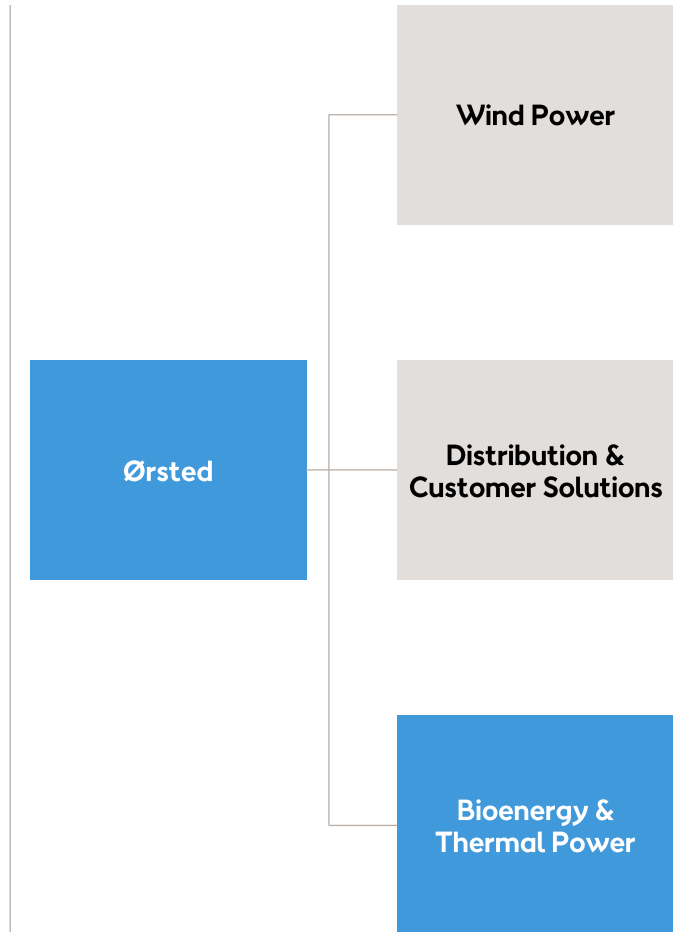
## Ivan C. Hundebøl

Senior Concept Manager

Technology Concepts

Ørsted Bioenergy & Thermal Power

- 1988 –** Ørsted (former DONG Energy)  
A long story of mergers / acquisitions / divestments / asset swap agreement / company name changes etc. in the danish energy sector
- 1987 – 88** IFV Energi
- 1986** M.Sc.M.Eng. Technical University of Denmark DTU



# Ørsted develops energy systems that are green, independent, and economically viable



- Revenue (2017): DKK 59,5bn<sup>1</sup>
- EBITDA (2017): DKK 22,5bn<sup>1</sup>
- ~5,600 employees
- Active in Scandinavia, United Kingdom, Germany, The Netherlands, USA, and Taiwan

## Wind Power



- EBITDA (2017): DKK 20,6 bn
- **Global leader in offshore wind with 3.6GW installed**
- Active in all parts of the value chain - develops, constructs, owns and operates offshore wind farms
- Robust and visible build-out plan of 3.8GW towards 2020
- Differentiated partnership model

## Distribution & Customer Solutions



- EBITDA (2017): DKK 2,1 bn<sup>2</sup>
- **Distributes power and sells energy solutions to our customers**
- Largest power distributor in Denmark with 1 million customers
- Largest utility with 900,000 residential and industrial customers in Denmark

## Bioenergy & Thermal Power



- EBITDA (2017): DKK 0.2 bn (+52% of 2016)
- **Generates heat and power at central heat and power stations**
- **#1 in Danish heat and power generation with a strong and increasing biomass position**

1. Continuing operations (1 € is appr. 7,5 DKK)  
2. One-offs from renegotiations of long-term gas contracts: DKK 4.3 bn  
3. Discontinued operations

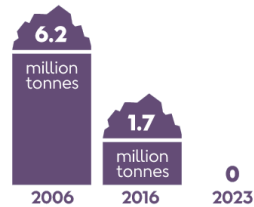
# Our vision is to create a world that runs entirely on green energy

Our **vision** is to create a world that runs entirely on green energy

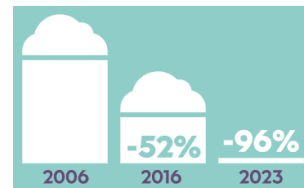
Our **mission** is to develop energy systems that are green, independent and economically viable

In that process we are..

..bidding farewell to coal in 2023..



..and saying goodbye to CO<sub>2</sub>



## Significant strategic and operational progress in 2017



- Upstream Oil & Gas divested



- Green share of generation increased to 64% and on track to reach 95% in 2023
- New name and visual identity



- Contracts awarded in the UK and Germany
- US and Taiwan developing as planned



- Coal-free in 2023: Commissioning of Skærbæk bioconversion and FID on Asnæs bioconversion
- Renesciende Northwich plant constructed but commissioning postponed



- All-time high EBITDA of DKK 22.5bn
- ROCE of 25%



- Positive free cash flow despite DKK 17.7 bn CAPEX
- Dividends increased by 50% to DKK 3.8bn

# By 2030 BTP will have transformed from a conventional Danish CHP business to a leader in bioenergy, smart waste recycling and storage

2016

CHP legacy business  
primarily based in DK

Denmark's leading  
provider of thermal  
heat and power

2030

Develop, build, own and operate green, competitive and innovative solutions within bioenergy, waste recycling and storage

## District heating and ancillary business

Denmark's  
leading provider  
of heating and  
ancillary services  
— green, smart  
and safe



## Renescience

World-class  
provider of smart  
solutions for  
municipal waste



## Industrial biogas solutions

Preferred  
partner for  
industrial  
organic waste  
solutions



## Energy Storage & Solar

Solar and storage solutions across and beyond current portfolio and footprint



Established position Proving the formula

# Ongoing transformation of the heat and power business model

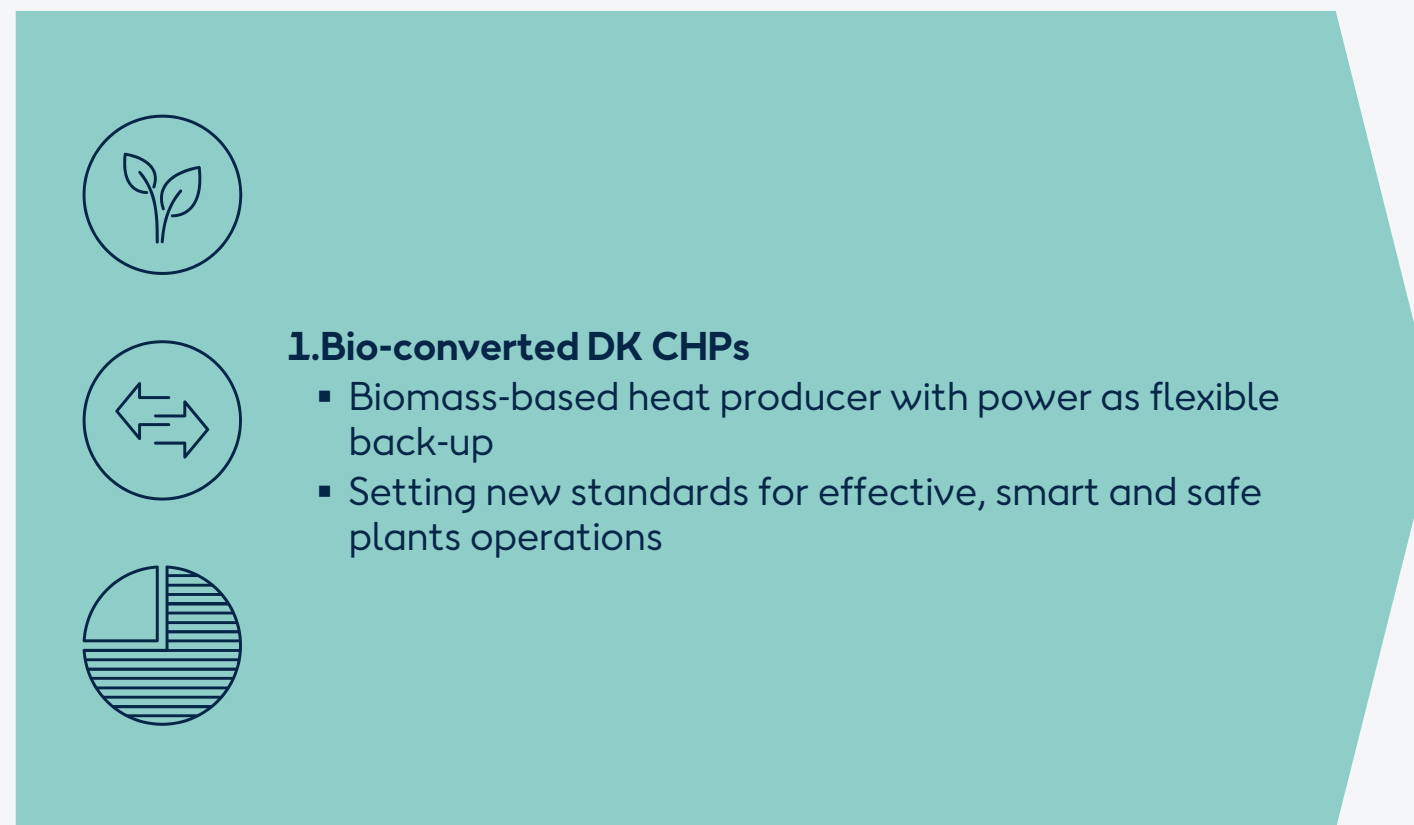
From



⊖ Regulated earnings

○ Commodity exposure

To

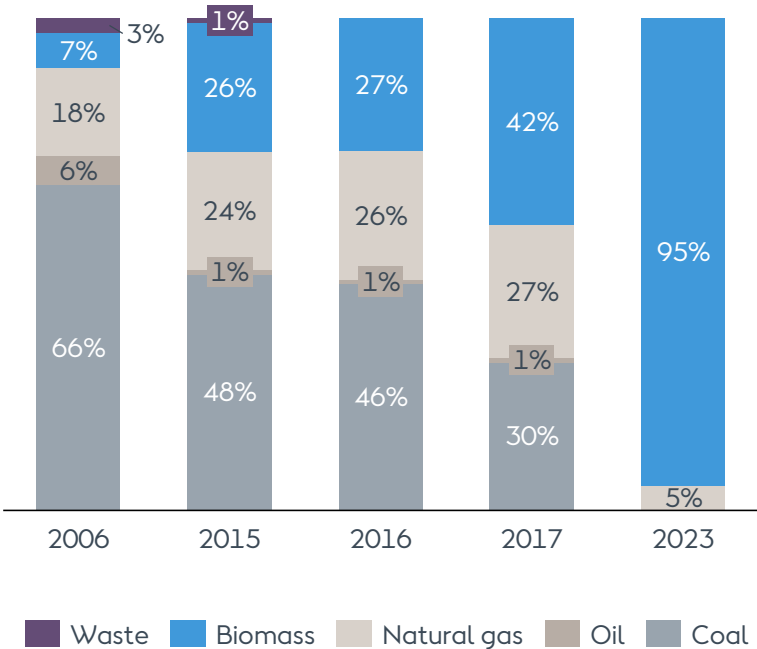




# Bioenergy & Thermal Power will exit coal by 2023

## Biomass conversions facilitate zero coal from 2023

Ørsted fuel consumption (PJ)



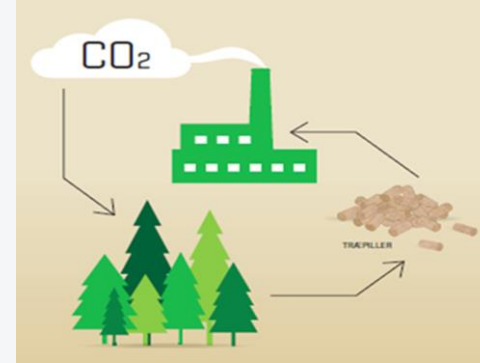
## First major utility to fully exit coal

- Putting further action behind Ørsted’s vision of leading the energy transformation
- Heat customers support early coal phase-out

Coal may be used in force majeure circumstances



## Combustion of biomass from sustainable forestry is CO<sub>2</sub>-neutral



**0g CO<sub>2</sub>/kWh**  
*Forest growth =  
CO<sub>2</sub> release from  
furnace*

### Under EU regulation, biomass is considered CO<sub>2</sub>-neutral

- 1 EU regulation assumes that carbon released when biomass is burned will be re-absorbed through tree growth
- 2 Biomass currently accounts for two thirds of renewable energy produced in the EU



# Ørsted only sources sustainable biomass

## Ensuring sustainable sourcing of biomass

Standard of Sustainable Biomass Partnership (SBP)



- Protection of key ecosystems or habitats
- Forest productivity and health is maintained
- Rights of indigenous peoples and local communities
- Protection of health and safety and basic labor rights
- Regional carbon stocks are maintained or increased over the medium- to long-term
- Genetically modified trees are not used
- End-to-end accounting for greenhouse gas emissions




SBP

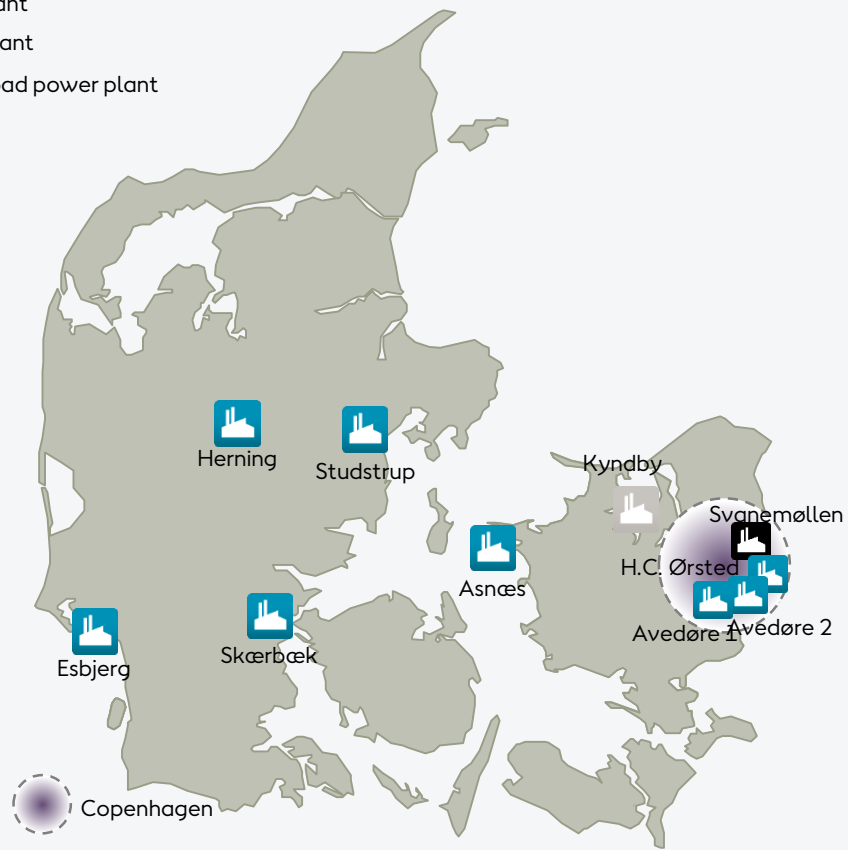
Independent 3<sup>rd</sup> party auditors certify suppliers through annual audits, recertification every 5 years and accounting from forest to furnace



# Ørsted BTP has a strong market position in Denmark

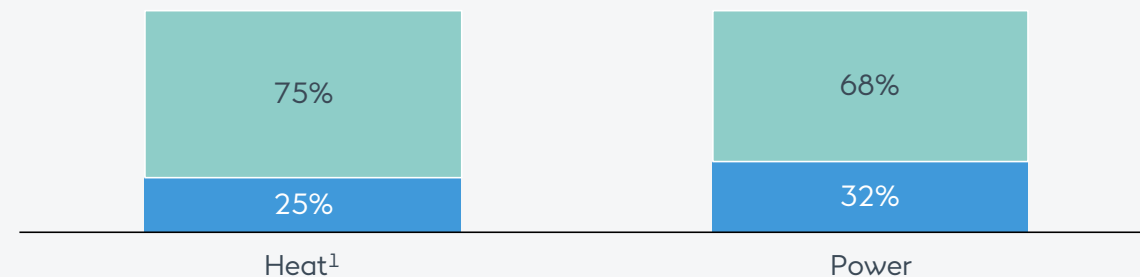
## Assets in Denmark

-  CHP plant
-  Heat plant
-  Peak-load power plant



## Approximate share of DK production (Heat 2016, power 2017)

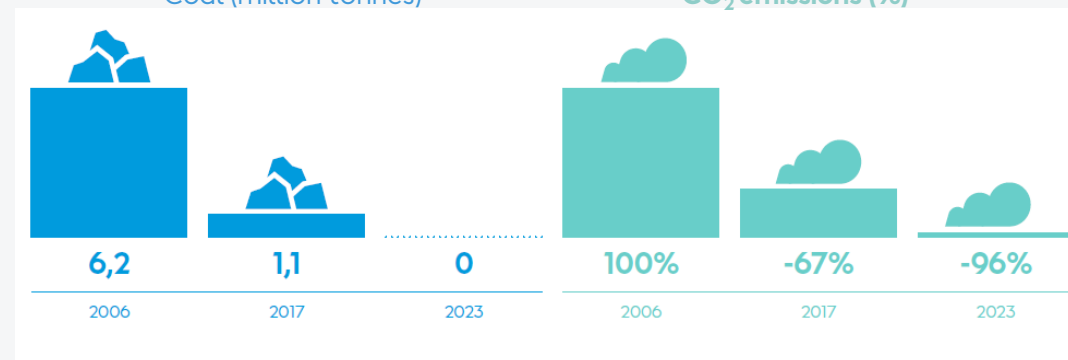
Other Ørsted



## Journey of conversion from fossil fuels to biomass

Coal (million tonnes)

CO<sub>2</sub> emissions (%)



# Preconditions for Conversion of CHP plants from fossil fuels to biomass

## – District heating demand

- Regulations support district heating from biomass

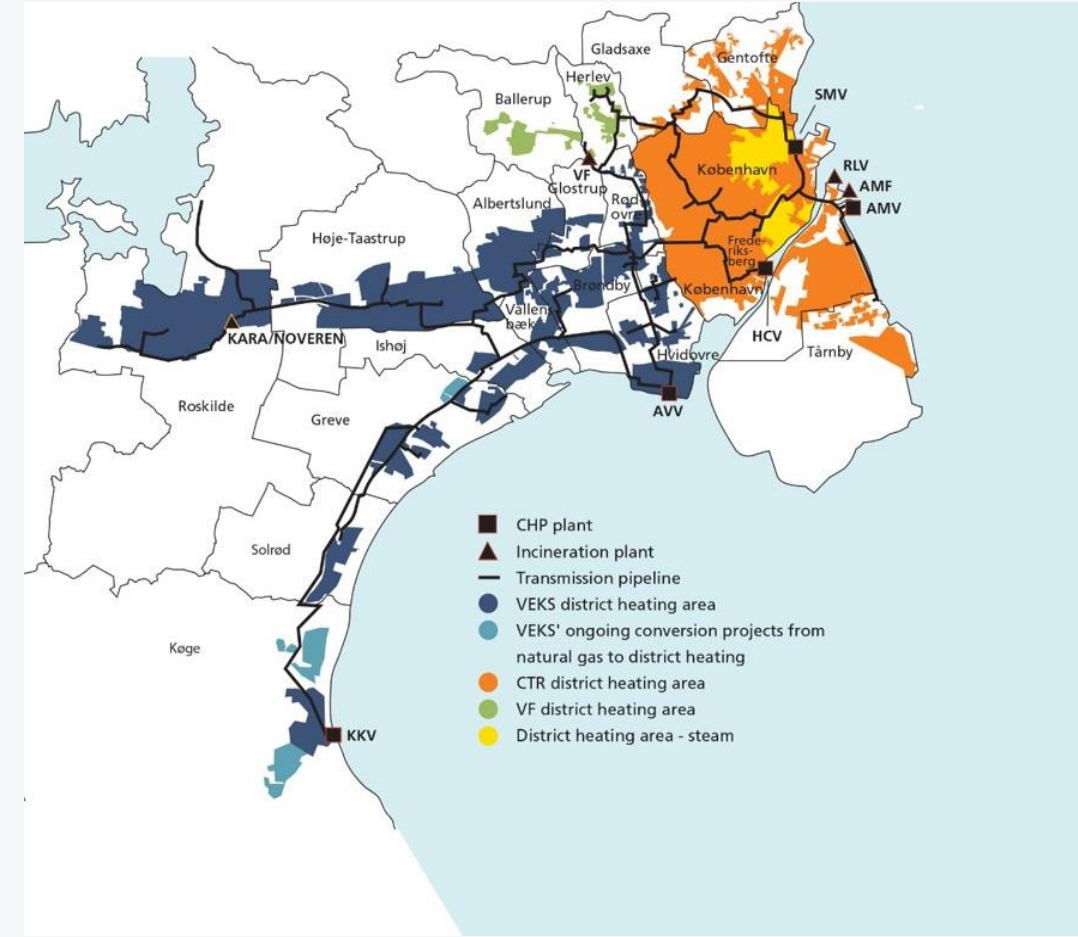
## – **Alternative district heating producers:**

- Waste to Energy plants (base load for district heating) ?
- Other present or future biomass CHP ?

## – **Characteristics of fossil fuelled plant** that may be converted:

- Unit size compared to realistic part of heat demand
- Unit and site characteristics; - i.e. existing firing system and flue gas cleaning system, harbour access, space for biomass storage etc.

## District heating system in greater Copenhagen:

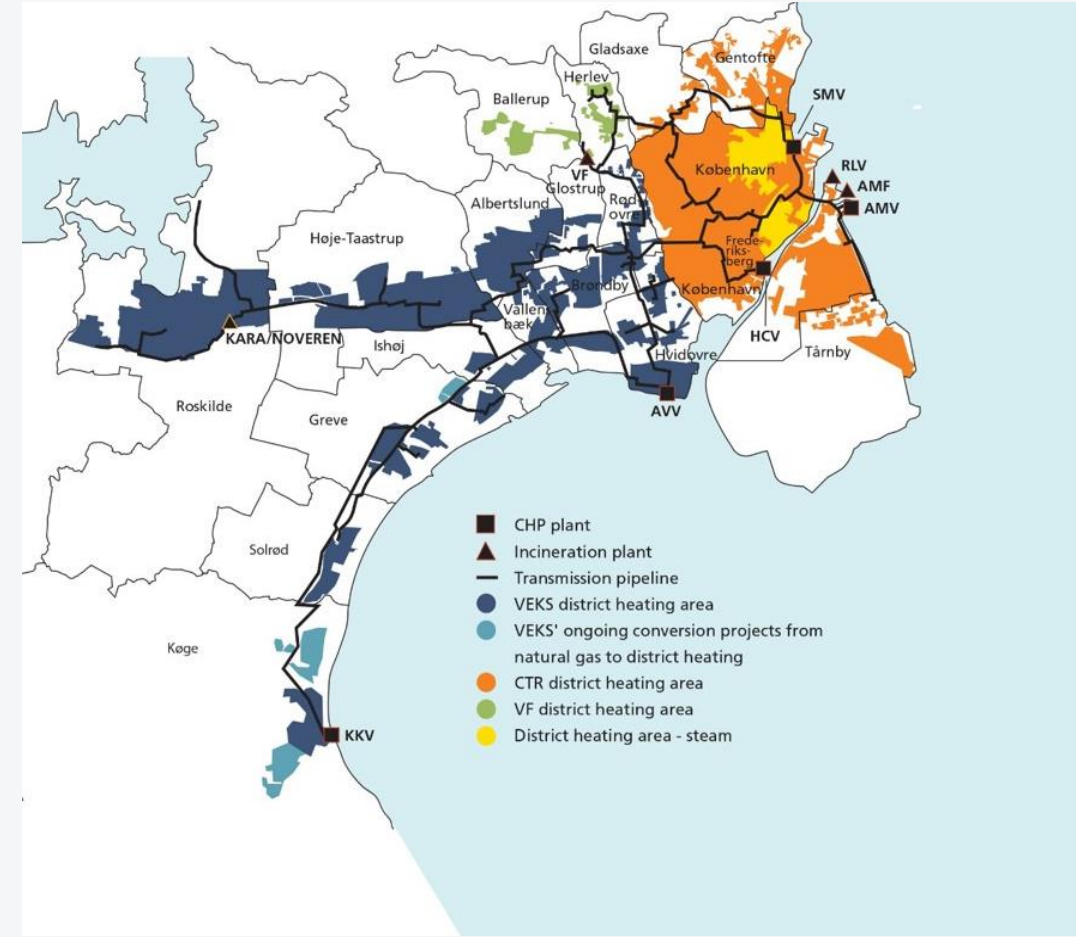


# Preconditions for Conversion of CHP plants from fossil fuels to biomass

- **District heating demand**
  - Regulations support district heating from biomass
- **Alternative district heating producers:**
  - Waste to Energy plants (base load for district heating) ?
  - Other present or future biomass CHP ?
- **Characteristics of fossil fuelled plant** that may be converted:
  - Unit size compared to realistic part of heat demand
  - Unit and site characteristics; - i.e. existing firing system and flue gas cleaning system, harbour access, space for biomass storage etc.

## Long Term Agreement with Heat Customer

District heating system in greater Copenhagen:



# Our journey of bio-conversions is progressing

## CHP conversion data (MWe/MWth)<sup>1, 2</sup>



**Herning (75E/200E)**

COD **2009 / 2019E<sup>3</sup>**

Primary fuel types Gas ▶ Wood chips / wood pellets



**Avedøre 2 (401/535)**

COD **2002 / 2014**

Primary fuel types Natural gas / Straw ▶ Wood pellets / Straw



**Studstrup 3 (362/513)**

COD **2016**

Primary fuel types Coal ▶ Wood pellets



**Avedøre 1 (258/370)**

COD **2016**

Primary fuel types Coal ▶ Wood pellets



**Skærbæk 3 (95/320)**

COD **2017**

Primary fuel types Natural gas ▶ Wood chips



**Asnæs 6 (25E/125E)**

COD **2019E**

Primary fuel types Coal ▶ Wood chips



**Esbjerg 4 (56E/214E)**

COD **2022E**

Primary fuel types Coal ▶ Wood chips

**Total:**  
**1.272 MWe**  
**2.277 MWth**

1. Biomass capacity after conversions. MWe refers to power production capacity after conversion. MWth refers to heat production capacity after conversion
  2. Max. capacities that can not necessarily be reached simultaneously
  3. Installation of flue gas condensation
- 13 E. Expected



# Bio-conversion concept: From coal to wood pellets<sup>1</sup>; - 3 cases

## CHP conversion data (MWe/MWth)



**Herning (75E/200E)**

COD **2009 / 2019E<sup>3</sup>**

Primary fuel types Gas ► Wood chips / wood pellets



**Skærbæk 3 (95/320)**

COD **2017**

Primary fuel types Natural gas ► Wood chips



**Avedøre 2 (401/535)**

COD **2002 / 2014** <sup>1</sup>

Primary fuel types Natural gas / Straw ► Wood pellets / Straw



**Asnæs 6 (25E/125E)**

COD **2019E**

Primary fuel types Coal ► Wood chips



**Studstrup 3 (752/513)**

COD **2016** <sup>\*)</sup>

Primary fuel types Coal ► Wood pellets



**Esbjerg 4 (56E/214E)**

COD **2022E**

Primary fuel types Coal ► Wood chips



**Avedøre 1 (258/570)**

COD **2016** <sup>\*)</sup>

Primary fuel types Coal ► Wood pellets

**Total:**  
**1.272 MWe**  
**2.277 MWth**

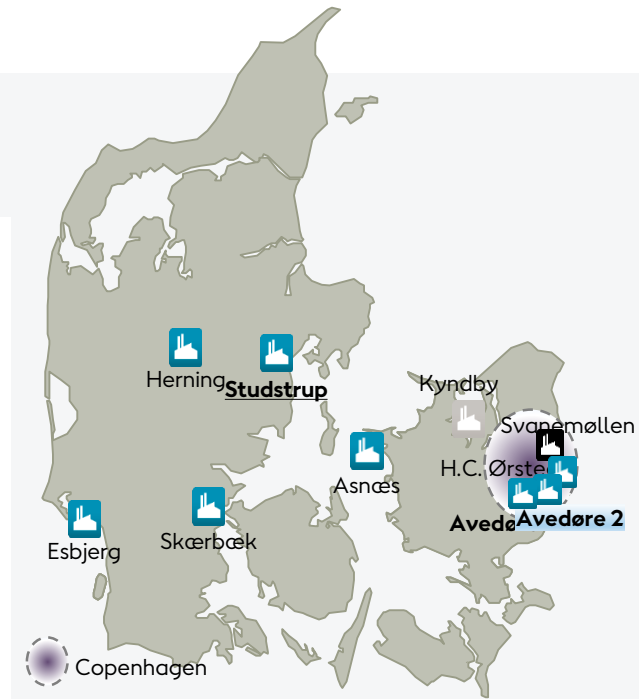
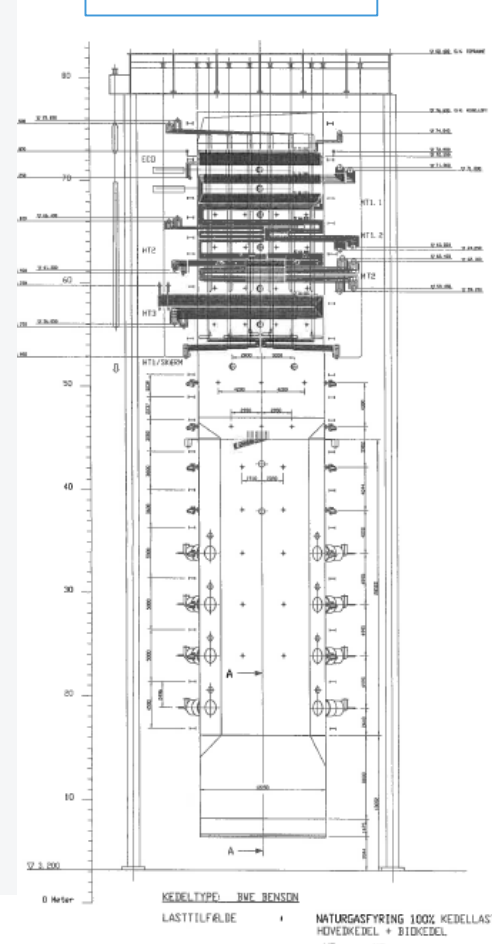


# Bio-conversion concept: From coal to wood pellets

## Case Avedøre unit 2

- **2002:** Commissioned as a gas fired power and district heating plant; - however built as a coal fired plant **incl. flue gas cleaning system and 3 coal mills;** - and prepared for a 4<sup>th</sup> mill
- 2003-2008: as a result of a **political agreement to reduce CO<sub>2</sub>** appr. 200.000-300.000 tonnes per year of wood pellets were used with pellets milled at the coal mills  
**Experiences with slagging/corrosion and degradation of catalysts.** Due to regulations there was **no incentive to increase wood pellets consumption;** - only to meet the annual target
- 2008: **change of regulations** made maximising wood pellets consumption attractive. A project of installing a 100.000 m<sup>3</sup> silo (65.000 tonnes), **Primary Air cooling** and **fly ash injection**<sup>1</sup> was developed: 80 % boiler load was expected achievable using all 3 mills at maximum load
- **2010:** 80% boiler load on wood pellets commissioned. A project of installing a 4<sup>th</sup> mill and 2<sup>nd</sup> unloading crane was developed; - to reach 100% boiler load
- **2013:** Siwertell unloading crane commissioned
- **2014:** 4<sup>th</sup> mill commissioned achieving 100 % boiler load on wood pellets

### AVV Unit2 Boiler



**Avedøre 2 (401/535)**

COD 2002 / 2014

Primary fuel types Natural gas / Straw Wood pellets / Straw

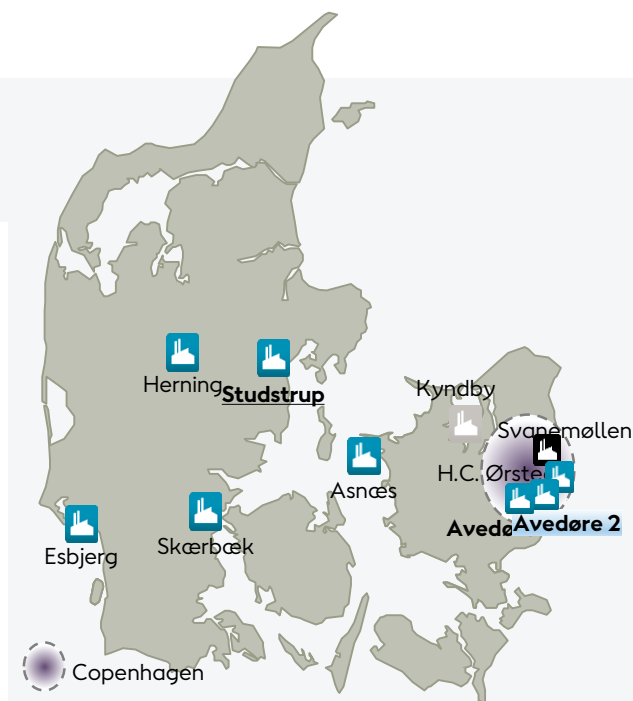
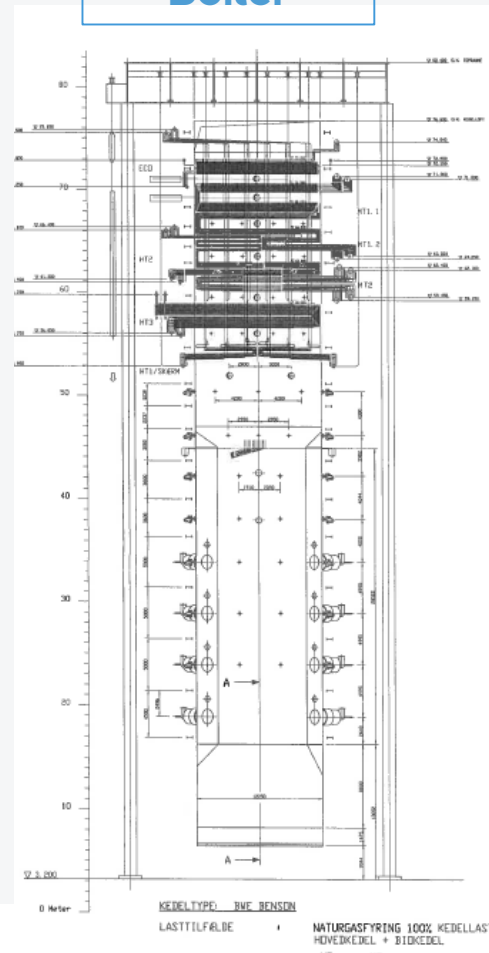
# Bio-conversion concept: From coal to wood pellets

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- **2013:** Siwertell unloading crane commissioned
- **2014:** 4<sup>th</sup> mill commissioned achieving 100 % boiler load on wood pellets

## Experiences to be used for bio-conversion of SSV3 and AVV1

### AVV Unit2 Boiler



**Avedøre 2 (401/535)**

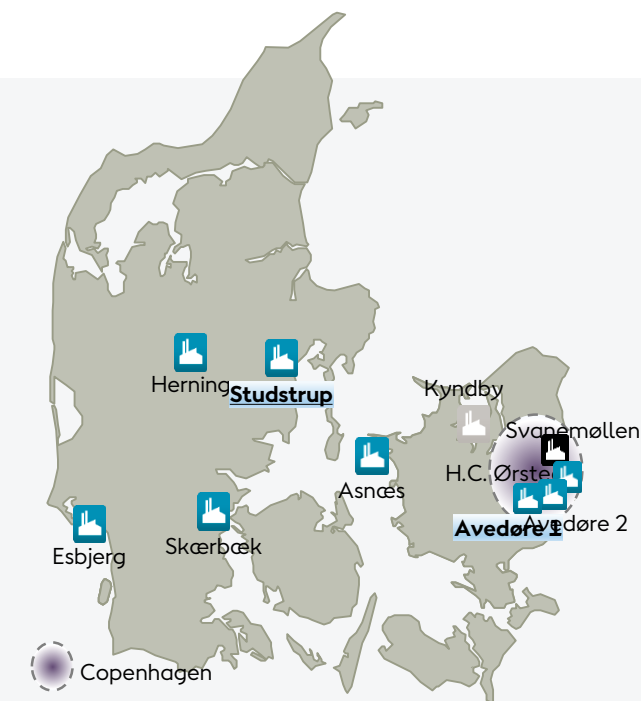
COD 2002 / 2014

Primary fuel types Natural gas / Straw Wood pellets / Straw

# Bio-conversion concept: From coal to wood pellets

## Case Studstrup unit 3 and Avedøre unit 1

Scope	Studstrup unit 3	Avedøre unit1
Wood pellets handling	New crane grabs and unloading hoppers for wood pellets	Use of existing cranes
	New separate wood pellets transport system	Upgrade of existing system (used for unit 2 since 2002)
	New storage silo for 65.000 tonnes	Use of existing storages
	2 new day siloes for wood pellets	4 day siloes modified to coal/wood pellets with "cross feed" system
Boiler	Modification of 4 existing coal mills	Same as SSV3
	Modification of 24 burners	Modification of 16 burners
	Install Primary Air (PA) coolers and rebuild PA duscts	Same as SSV3
	2 new PA fans	Upgrade of motor at existing PA fan
Coal ash injection <sup>1</sup>	New reception, storage, handling, transport and injection system from harbour to boiler	Same as SSV3



**Avedøre 1 (258/370)**

COD 2016

Primary fuel types Coal ► Wood pellets



**Studstrup 3 (362/513)**

COD 2016

Primary fuel types Coal ► Wood pellets



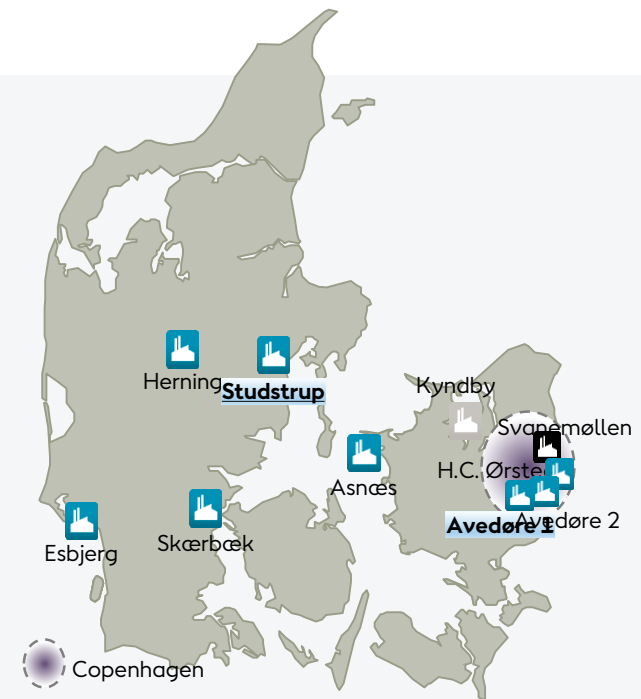
# Bio-conversion concept: From coal to wood pellets

## Case Studstrup unit 3 and Avedøre unit 1

### Studstrup: wood pellets unloading, transport and storage



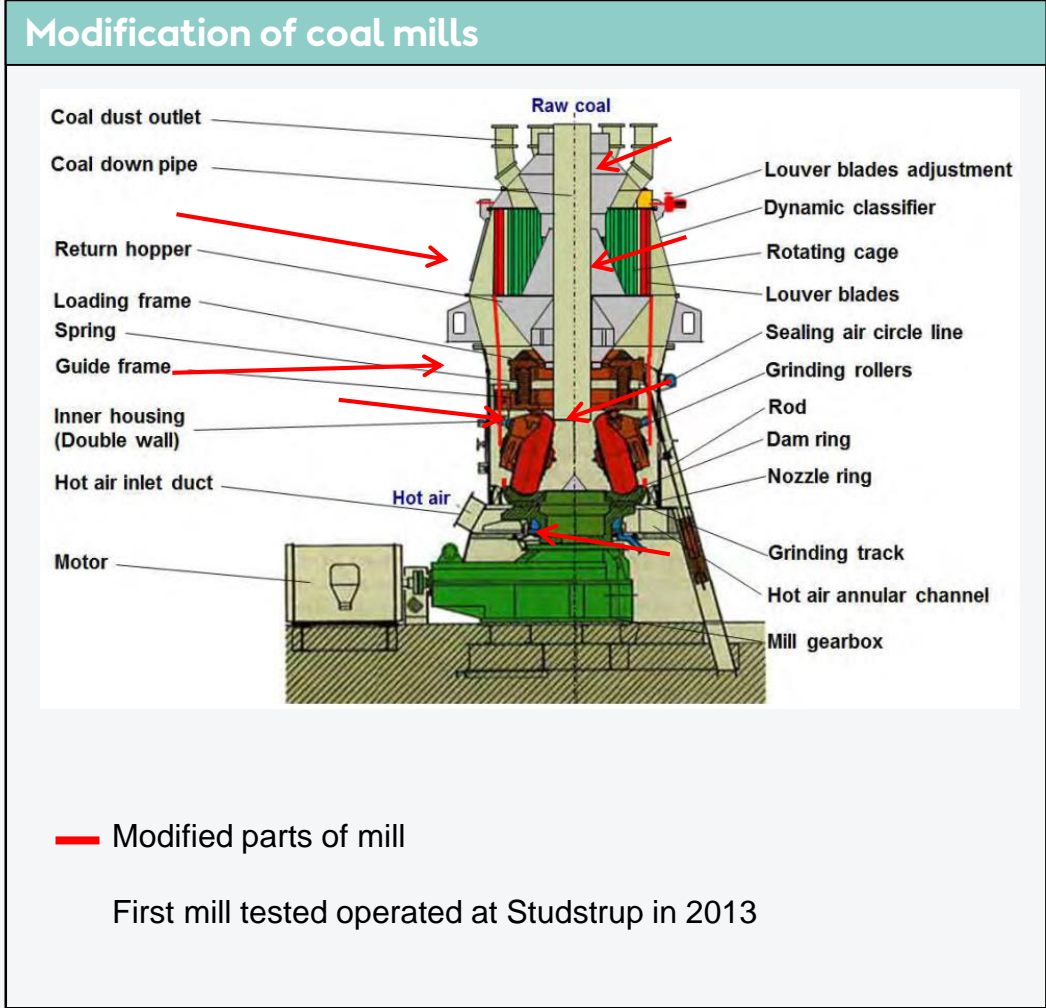
- New crane grabs and unloading hoppers for wood pellets
- New separate wood pellets transport system
- New storage silo for 65.000 tonnes
- 2 new day siloes for wood pellets



**Studstrup 3 (362/513)**  
COD **2016**  
Primary fuel types Coal ► Wood pellets

# Bio-conversion concept: From coal to wood pellets

## Case Studstrup unit 3 and Avedøre unit 1



Studstrup unit 3:  
4 MPS mills

Avedøre unit 1:  
4 mills, same type  
at lower capacity



Avedøre 1 (258/370)  
COD 2016  
Primary fuel types Coal ▶ Wood pellets



Studstrup 3 (362/513)  
COD 2016  
Primary fuel types Coal ▶ Wood pellets



# Bio-conversion concept: From coal to wood pellets

## Case Studstrup unit 3 and Avedøre unit 1

### Modification of coal burners

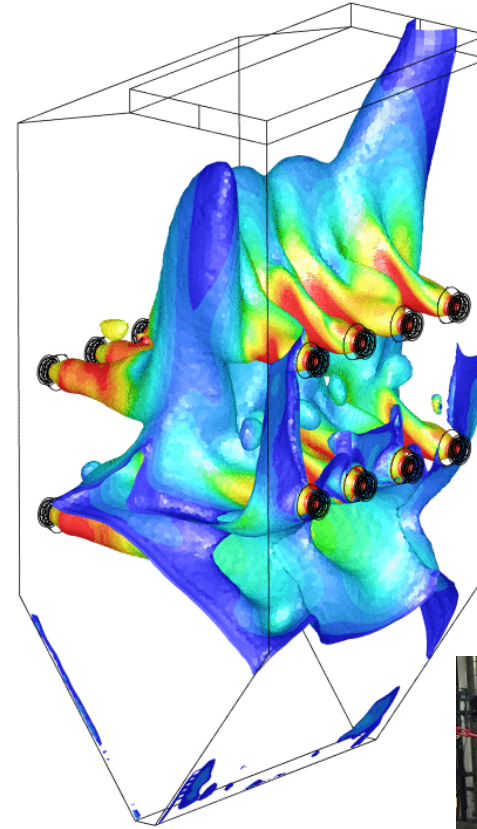
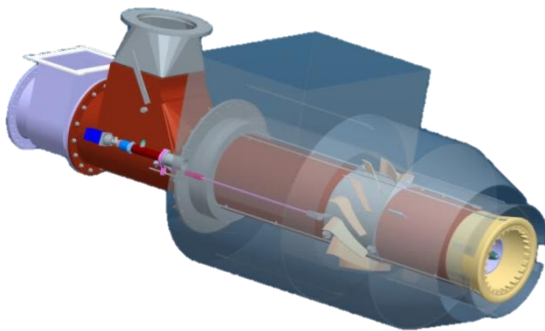


Modified SSV burner  
Test January 2013



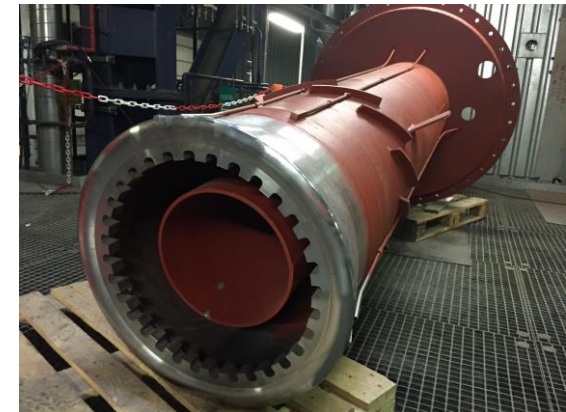
New SSV burner,  
oktober 2013

- New burners achieve stable flame both when operating on coal and wood pellets
- 6 of 24 burners changed in oktober 2013



Studstrup unit 3:  
4 x 6 burners

Avedøre unit 1:  
4 x 4 burners

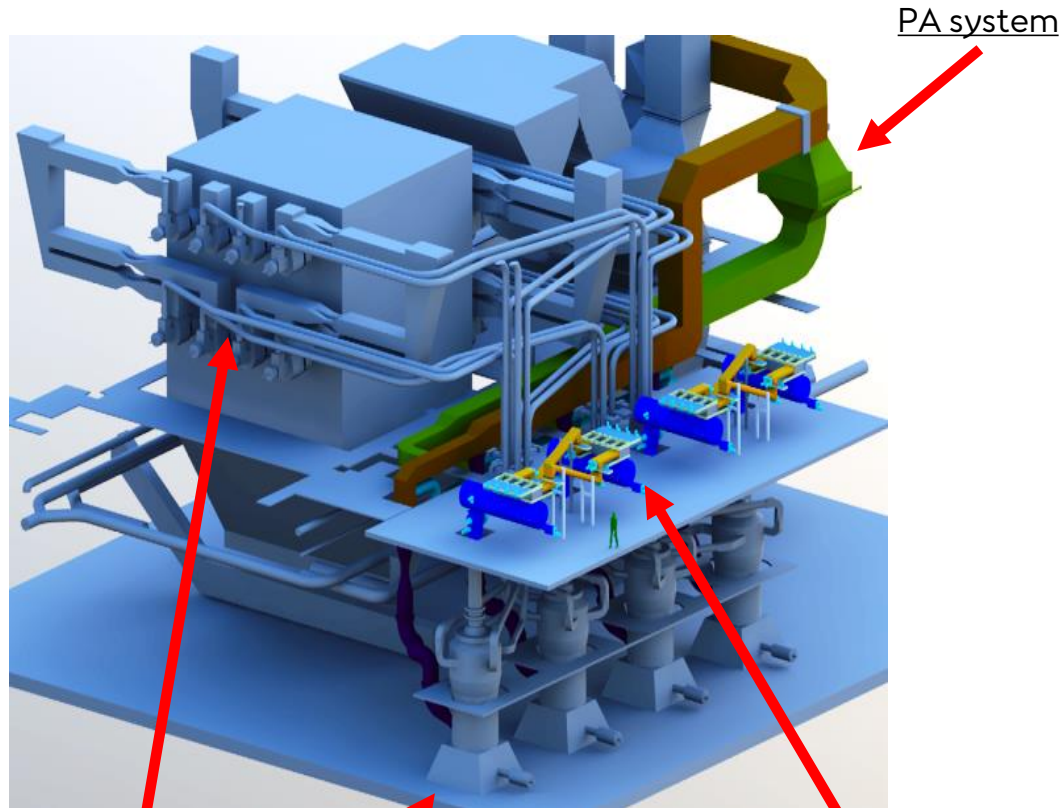




# Bio-conversion concept: From coal to wood pellets

## Case Avedøre unit 1

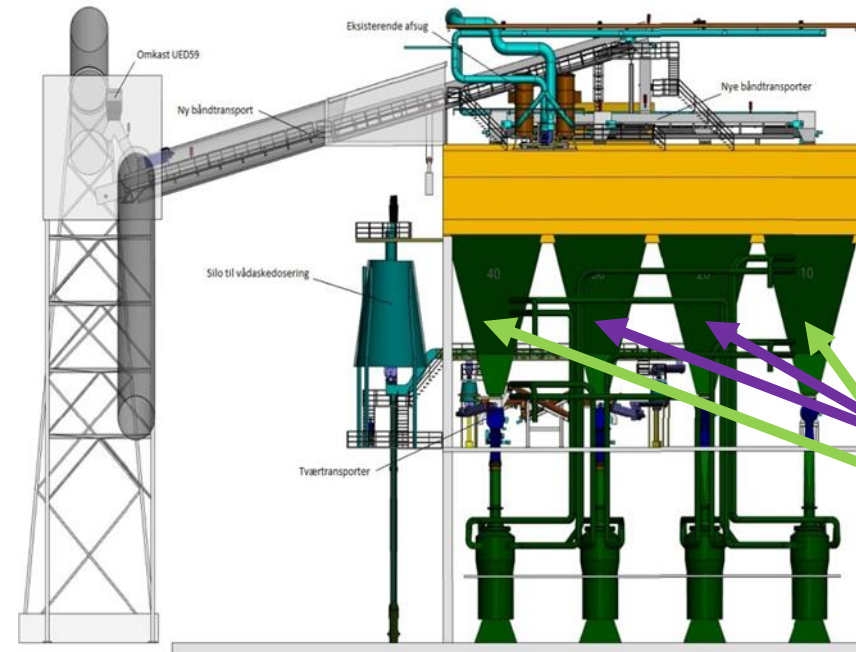
At Studstrup 3:  
Separat day silos  
for wood pellets



4 x 4 Burners

4 Mills

X-feed from day silos to mills.  
Each silo can feed to 2 mills  
(only AVV1)



**Avedøre 1:**  
4 coal day silos  
modified to wood  
pellets.  
X-feed for flexible  
switch between  
coal and wood  
pellets  
i.e.  
2 silos with coal  
2 silos with WP

4 day silos (i.e. 2 with coal and 2 with wood pellets)  
X-feed: each silo can feed to 2 mills below with  
either wood pellets or coal  
Wood pellets: attractive for heat and power  
**Coal: attractive for power only** (sea water cooling)  
outside heating season  
No coal from 2023!

# Bio-conversion concept: From fossil fuel to wood chips; - Case Herningværket (1 of 4 remaining cases)

## CHP conversion data (MWe/MWth)



**Herning (75E/200E)**

COD **2009 / 2019E<sup>3</sup>**

Primary fuel types Gas ▶ Wood chips / wood pellets



**Skærbæk 3 (95/320)**

COD **2017**

Primary fuel types Natural gas ▶ Wood chips



**Avedøre 2 (401/535)**

COD **2002 / 2014** ✓

Primary fuel types Natural gas / Straw ▶ Wood pellets / Straw



**Asnæs 6 (25E/125E)**

COD **2019E**

Primary fuel types Coal ▶ Wood chips



**Studstrup 3 (362/513)**

COD **2016** ✓

Primary fuel types Coal ▶ Wood pellets



**Esbjerg 4 (56E/214E)**

COD **2022E**

Primary fuel types Coal ▶ Wood chips



**Avedøre 1 (258/370)**

COD **2016** ✓

Primary fuel types Coal ▶ Wood pellets

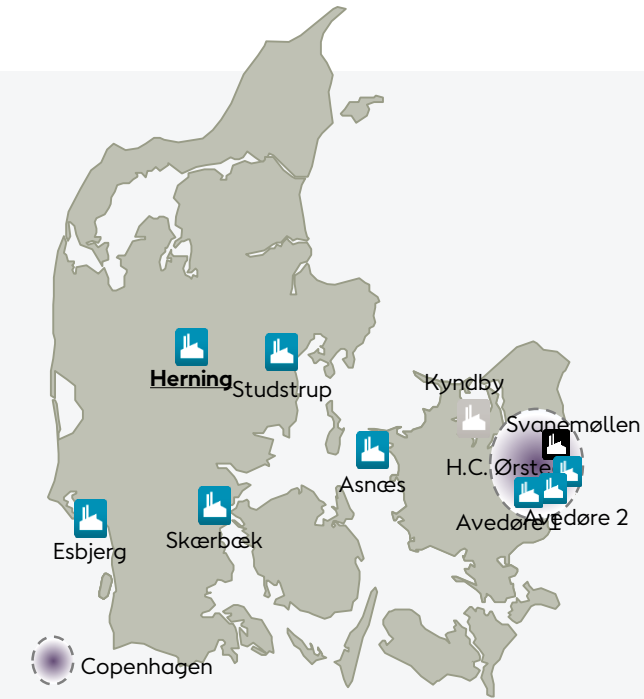
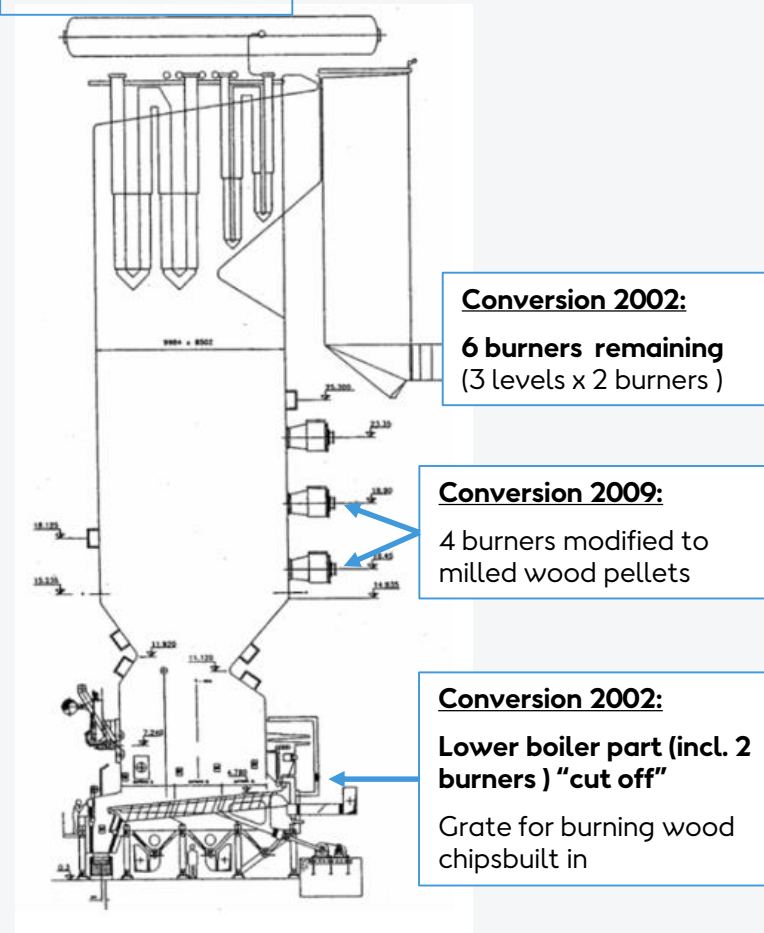
**Total:**  
**1.272 MWe**  
**2.277 MWth**

# Bio-conversion concept: From fossil fuel to wood chips

## Case Herning: Major boiler modification with built-in grate

- **1982:** Commissioned as a coal fired power and district heating plant. 8 coal dust burners - 300 MJ/s coal
- **2000:** 8 burners converted from coal to 100% **natural gas**
- **2002:** Converted to **44% wood chips** (base load) + 56% natural gas (major boiler conversion –see “Conversion 2001”) and reception, handling and storage facilities for wood chips
- **2009:** Conversion step 2: to 44% wood chips + **44% wood pellets** + 12% “top-up” gas, and reception, handling and storage facilities for wood pellets
- **Project in execution**  
**2019:** expansion with **flue gas condensation plant** to increase total efficiency from 85% to 103% by cooling flue gas from 160 °C to 40 °C

### HEV Boiler



**Herning (75E/200E)**

COD	<b>2009 / 2019E<sup>3</sup></b>	
Primary fuel types	Gas	▶ Wood chips / wood pellets



# Bio-conversion concept: From fossil fuel to wood chips; - Case Skærbæk (1 of 3 remaining cases)

## CHP conversion data (MWe/MWth)



**Herning (75E/200E)**



COD **2009 / 2019E<sup>3</sup>**

Primary fuel types Gas ▶ Wood chips / wood pellets



**Avedøre 2 (401/535)**



COD **2002 / 2014**

Primary fuel types Natural gas / Straw ▶ Wood pellets / Straw



**Studstrup 3 (362/513)**



COD **2016**

Primary fuel types Coal ▶ Wood pellets



**Avedøre 1 (258/370)**



COD **2016**

Primary fuel types Coal ▶ Wood pellets



**Skærbæk 3 (95/320)**

COD **2017**

Primary fuel types Natural gas ▶ Wood chips



**Asnæs 6 (25E/125E)**

COD **2019E**

Primary fuel types Coal ▶ Wood chips



**Esbjerg 4 (56E/214E)**

COD **2022E**

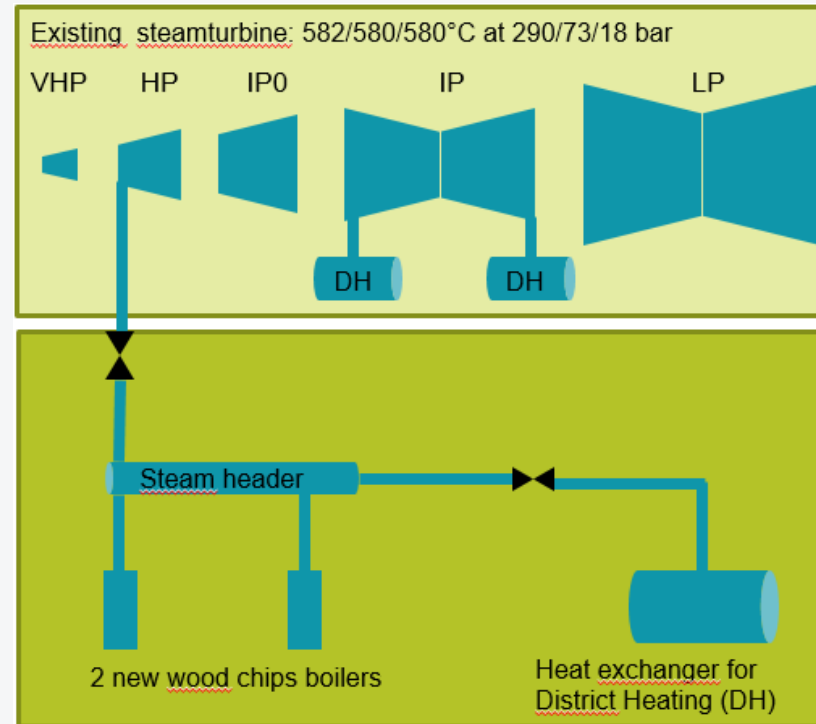
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**Total:**  
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# Bio-conversion concept: From fossil fuel to wood chips

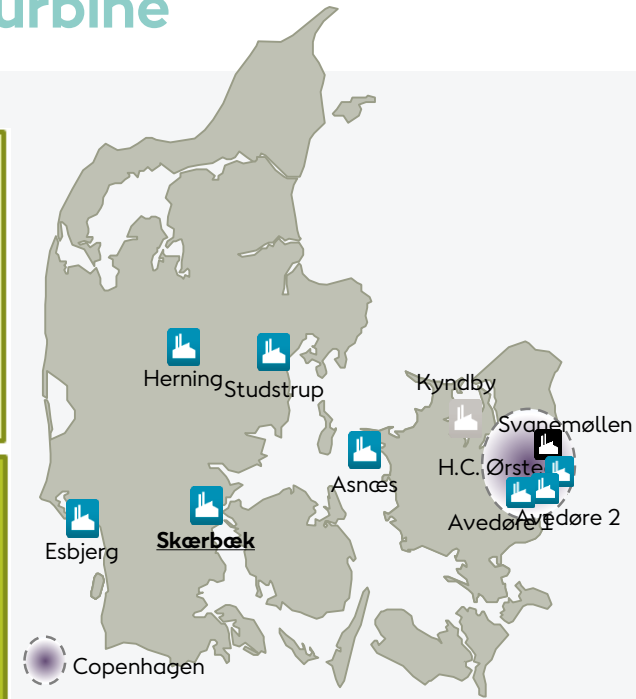
## Case Skærbæk: New wood chips boilers with steam to existing turbine

- **1997:** Unit 3 commissioned as a natural gas fired power and district heating plant with sea water cooling      No mills and no dust cleaning of flue gas
- Boiler size relatively big compared to heat demand
- A project was developed to build unloading, transport and storage facilities for wood chips + separate wood chips boiler with steam supply to existing turbine
- **2017:** Unloading, transport and storage facilities and new boilers commissioned



### Flexible operation:

- Steam from wood chips boilers directly to heat exchanger (heat only) or turbine (CHP)
- Unit 3 still available as peak load power producer based on natural gas



**Skærbæk 3 (95/320)**

COD      2017

Primary fuel types      Natural gas      Wood chips

# Bio-conversion concept: From fossil fuel to wood chips; - Case Asnæs and Esbjerg (2 remaining cases)

## CHP conversion data (MWe/MWth)



**Herning (75E/200E)**

COD **2009 / 2019E<sup>3</sup>**

Primary fuel types Gas ▶ Wood chips / wood pellets



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Primary fuel types Natural gas / Straw ▶ Wood pellets / Straw



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COD **2019E**

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**Studstrup 3 (362/513)**

COD **2016**

Primary fuel types Coal ▶ Wood pellets



**Esbjerg 4 (56E/214E)**

COD **2022E**

Primary fuel types Coal ▶ Wood chips



**Avedøre 1 (258/370)**

COD **2016**

Primary fuel types Coal ▶ Wood pellets

**Total:**  
**1.272 MWe**  
**2.277 MWth**



# Bio-conversion concept: From fossil fuel to wood chips

## Case Asnæs (in construction) and Esbjerg (under negotiation)

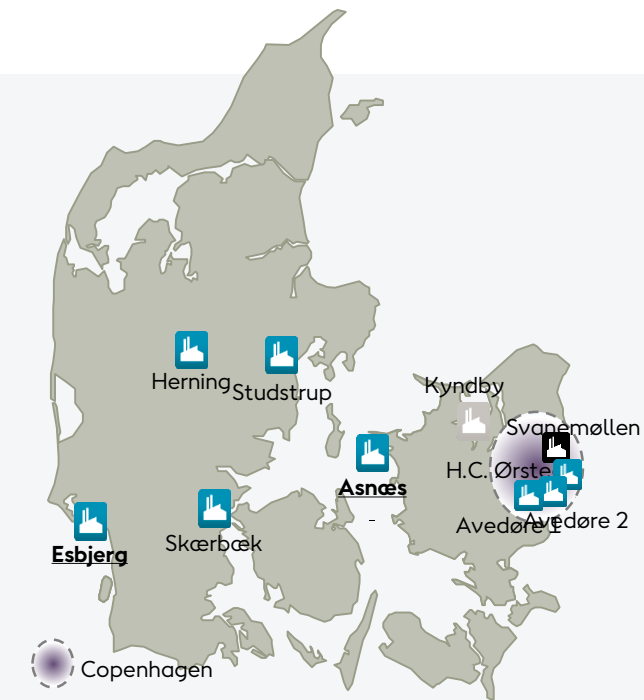
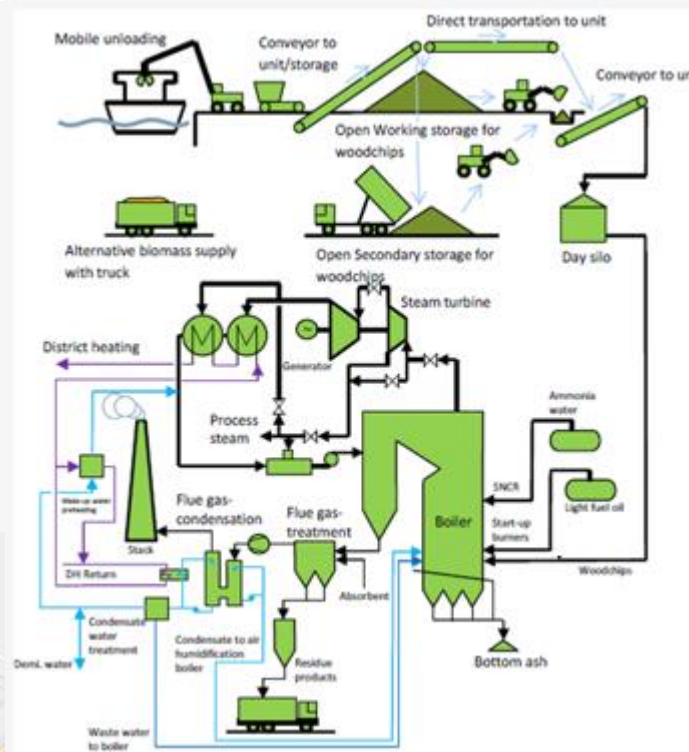
Conversion of existing coal fired units not attractive

New CHP designed according to for heat demand

**Asnæs:** Commissioning scheduled for 2019

District heating to city of Kalundborg and process steam to industry

**Esbjerg:** Negotiations are ongoing  
Commissioning is possible in 2022



Asnæs 6 (25E/125E)

COD 2019E

Primary fuel types Coal ► Wood chips



Esbjerg 4 (56E/214E)

COD 2022E

Primary fuel types Coal ► Wood chips

# Our vision is to create a world that runs entirely on green energy

## Power / Heat capacity (MW)

**HERNING (75 / 200E)**



✓ FGC  
Planned  
2019

**AVEDØRE 2 (401 / 535)**



✓

**STUDSTRUP 3 (362 / 513)**



✓

**AVEDØRE 1 (258 / 379)**



✓

**SKÆRBÆK 3 (95 / 320)**



✓

**ASNÆS 6 (25 E/ 125E)**



Planned  
2019

**ESBJERG 4 (56E / 214E)**



Expected  
2022 ?





Our vision is to create a world that runs entirely on green energy



Thank you for  
listening  
Any Questions ?