

# THE ESBJERG VÆRKET CHP PLANT



**DONG**  
energy

# DONG ENERGY

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Esbjergværket is one of DONG Energy's ten central CHP plants. Esbjergværket is situated at the waterfront in Esbjerg thus facilitating ship supplies of fuel to the plant.

Esbjergværket consists of unit 3 with a capacity of 378 MW. With unit 3's 250-metre stack – which is the highest stack in Denmark – Esbjergværket is a notable building at the waterfront and in the city of Esbjerg.

At its commissioning in 1992, Esbjergværket set a record with a power efficiency of 45% at 100% power production. On an annual basis the total efficiency is approximately 55% at combined heat and power production. At optimum output the plant can achieve a total efficiency of more than 90%.

DONG Energy places great emphasis on producing eco-friendly heat and power paying due attention to optimum utilisation of resources. Thus the production at the plant

ensures the highest possible degree of recycling of by-products from the heat and power production.

Equipped with a so-called deNO<sub>x</sub> plant to remove the nitrogen oxides from the flue gas, the plant is one of the world's most technically advanced coal-fired CHP plants.

### Technical key data

Commissioned	1992
Max power production (net)	378 MW
Max district heat production	460 MJ/s
Coal consumption at full load	120 t/h
Oil consumption at full load	73 t/h
Steam pressure	251 bar
Steam temperature	560 °C



# HOW HEAT AND POWER ARE PRODUCED AT ESBJERG VÆRKET CHP PLANT

The heat and power production at Esbjergværket is primarily based on coal with a strong focus on environment and cost effectiveness.

The combined heat and power production is an advantage in terms of savings in resources and protection of the environment, but it also ensures economic benefits for the consumers.

## Cogeneration of heat and power

Esbjergværket, unit 3, which was commissioned in 1992, is a world leader when it comes to efficiency.

This highly efficient production is among other things obtained through high steam temperatures and high steam pressure. At power production alone, the plant has an efficiency of 45%, and at cogeneration of heat and power the efficiency can range as high as 90%.

The heat energy from the combustion process is converted into steam in the boiler tubes.

At a high temperature (560 °C) and at a pressure of 251 bar the steam is fed into the steam turbine. The steam is fed into the turbine through one of the turbine's high-pressure parts, two medium-pressure parts and two low-pressure parts.

The steam makes the turbine blades turn, and this rotational kinetic energy enables the generator to produce a power output of 378 MW net.

Part of the steam is bled from the turbine's intermediate pressure part. This steam is led to the district heat exchangers which heat the district heating water for the cities of Esbjerg, Varde and Nordby on the island of Fanøe.

## Fireball combustion

The coal dust is blown into the incinerator from burners located at the four corners of the boiler. In this way, the coal dust is combusted in a large fireball.

The "fireball combustion" technique keeps the combustion temperature down thus reducing the development of nitrogen oxide (NO<sub>x</sub>).

The flue gas from the boiler is treated in a catalyst, which removes 80-90% of the nitrogen oxides.

## Fuel

Esbjergværket annually consumes 600,000-800,000 tonnes of coal and 3,000-5,000 tonnes of oil.

The coal is transported by ship to the plant. The water depth at the quay is 10.5 metres making it possible for Panmax ships (ships that are able to cross the Panama Canal) to call at the harbour with partial load. The 54-metre high coal cranes are capable of unloading up to 750 tonnes per hour. Oil is used to start the plant and as auxiliary fuel.

# FROM COAL TO HEAT AND POWER

## Power

The coal is transported from the storage to the coal hoppers. The coal is then extracted from the hoppers when required and transported to the coal mills where it is ground into a fine dust. From the coal mills the coal dust is transported with the combustion air to the burners.

The burners are distributed over six levels and placed in the corners of the boiler. From the burners, coal dust and combustion air are blown into the boiler in such a way that combustion takes place in a spin, a so-called fireball.

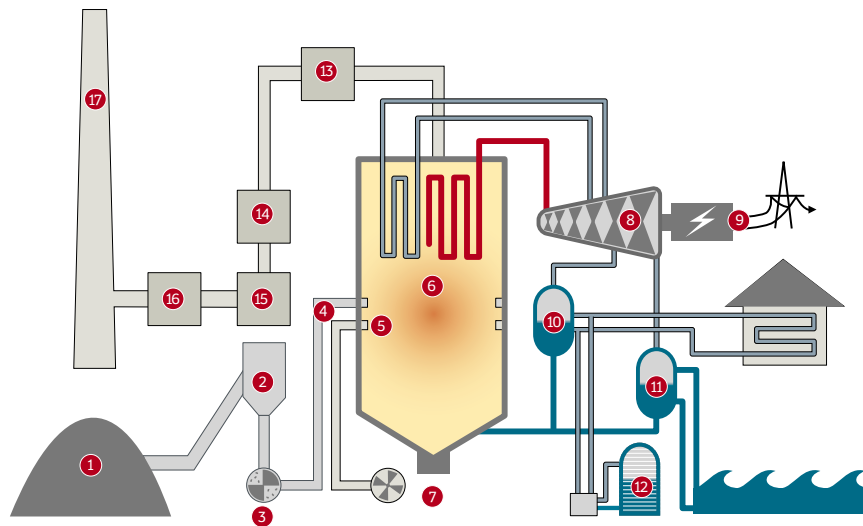
The boiler produces steam at a high pressure (251 bar) and at a high temperature (560 °C). The steam is led into the turbine where makes the turbine blades rotate.

The turbine is connected to the generator, and the rotating turbine causes a shaft to turn inside the generator, producing power.

## Power production

The total power production from Esbjergværket is sold on market terms. This means that production may vary from one year to the other.

The power production is solely determined by supply and demand on the Nordic power market and by the relation between fuel prices and power prices. When the power



## Workflow

1. Coal
2. Coal hoppers
3. Coal mill
4. Air and coal dust
5. Burners
6. Fireball
7. Bottom ash
8. Turbine
9. Generator
10. District heat exchanger
11. Condenser
12. Storage tank
13. DeNOx plant
14. Electrostatic precipitator
15. ID fan
16. Desulphurisation plant
17. Stack

price is low because of large domestic power production from wind turbines or large hydroelectric power production in Norway, then Esbjergværket reduces its production. The power produced at the plant is sold on a daily basis at the Nordic power exchange, Nord Pool in Norway, where the price is set by supply and demand.

## Extraction for district heating

From the intermediate-pressure part of the turbine it is possible to extract part of the steam to the plant's two district heat exchangers and use the steam to heat the district heating water. Hence the steam is cooled and condensed to water.

The remaining steam is utilised in the turbine's low-pressure parts before the steam is led to the condensers where the steam is cooled by seawater and condensed to water. In both cases water is circulated back to the boiler through the feedwater system to begin the process of producing power again and again.

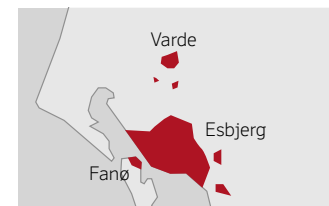
## District heating

The district heating produced at Esbjergværket is sold to the local district heating companies in the municipalities of Esbjerg and Varde. Furthermore, district heating is supplied through a submarine cable to Nordby Fjernvarme (district heating company) on the island of Fanø.

The district heating water is either circulated directly into the district heating system or stored in the storage tank. The tank makes it possible to produce heat and power at all times of the day, utilising the energy in the fuel to the optimum effect of the benefit to both the environment and the economy.

The storage tank at Esbjergværket is 41.7 metres high and has a diameter of 40 metres. The tank has a capacity of 47,000 m<sup>3</sup> of district heating water of a temperature of up to 98 °C.

The storage tank has a capacity of 9,200 GJ of heat at full load, corresponding to the quantity of heat supplied by Esbjergværket to the district heating system for 6-8 hours on a normal winter's day.



District heat supply area.

# ESBJERG VÆRKET

## FROM ABOVE

### **1. Boiler house/unit 3**

The boiler house contains boiler plant, fans, air pre-heaters, deNO<sub>x</sub> plant and bottom ash silo.

### **2. Coal silos**

The silo building contains coal silos, coal feeders and coal mills.

### **3. District heating building**

The district heating building contains forward, return and charging pumps.

### **4. Engine room**

The engine room contains turbine and generator plants and freshwater and deionate tanks. The auxiliary steam boiler is also placed in the engine room.

### **5. Control room**

Monitoring of the plant is carried out in the control room which is situated on the top floor of the building in which also switchgear and control system are located.

### **6. Storage tank**

The storage tank for district heating holds approximately 45,000 m<sup>3</sup> of district heating water.

### **7. Electrostatic precipitator**

The coal-fired plants are equipped with an electrostatic ash separation unit for the removal of solid particles from the flue gas – a dry powder called fly ash.

### **8. Desulphurisation plant**

The unit is equipped with a wet desulphurisation plant that converts the sulphur in the flue gas into gypsum by means of limestone.

### **9. Stack**

The unit's stack is 250 metres high. Its diameters are 8 metres at the top and 32 metres at the bottom. The stack is equipped with a refractory core, which has a diameter of 4.9 metres.

### **10. Limestone silos**

Two limestone silos are installed – one with a capacity of 7,000 m<sup>3</sup> and one with a capacity of 1,000 m<sup>3</sup>.

### **11. Fly ash silos**

There are two fly ash silos at unit 3 and two fly ash silos at the district heating building. The fly ash is stored in the silos until it is removed from the site by lorries. The fly ash is used for concrete production.

### **12. Reception desk and service building**

Includes offices, workshop, storage and shower facilities.

### **13. Coal storage**

The coal yard covers an area of approximately 100,000 m<sup>2</sup> and holds approximately 1.2 million tonnes of coal.

### **14. Temporary ash storage**

### **15. Oil storage**

The fuel oil storage consists of two tanks, each with a capacity of 45,000 m<sup>3</sup>.

### **16. Cooling water inlet**

The amount of cooling water used is approximately 60,000 m<sup>3</sup>/h during the summer period and approximately 30,000 m<sup>3</sup>/h during the winter period .

### **17. Cooling water outlet**

### **18. Main gate**



# CONCERN FOR THE ENVIRONMENT

Esbjergværket is equipped with a number of flue gas cleaning plants that clean the flue gas before it is transported to the 250-metre stack. The cleaning process produces a number of mineral products which are subsequently used in the industry.

## Nitrogen oxides

Firstly the nitrogen oxides (NO<sub>x</sub>) are removed from the flue gas. This is done in a catalyst where ammonia is added to the flue gas. This will decompose and convert 80-90% of the nitrogen oxides into innocuous nitrogen and oxygen.

## Fly ash

Before being passed on to the desulphurisation plant the flue gas must be purged of fly ash. Therefore the flue gas is led to the ash separation unit where 99.9% of the fly ash is removed. The fly ash is used as an important raw material in the cement, concrete and asphalt industries.

## Sulphur

From the ash separation unit the flue gas is passed on to the desulphurisation plant where it is cooled. Then it is purged of 98% of the sulphur contents deriving from the fired coal. The desulphurisation process forms gypsum of good commercial quality. It is used as raw material for the production of gypsum boards, mostly used in the construction industry.



Control room.

## Waste water

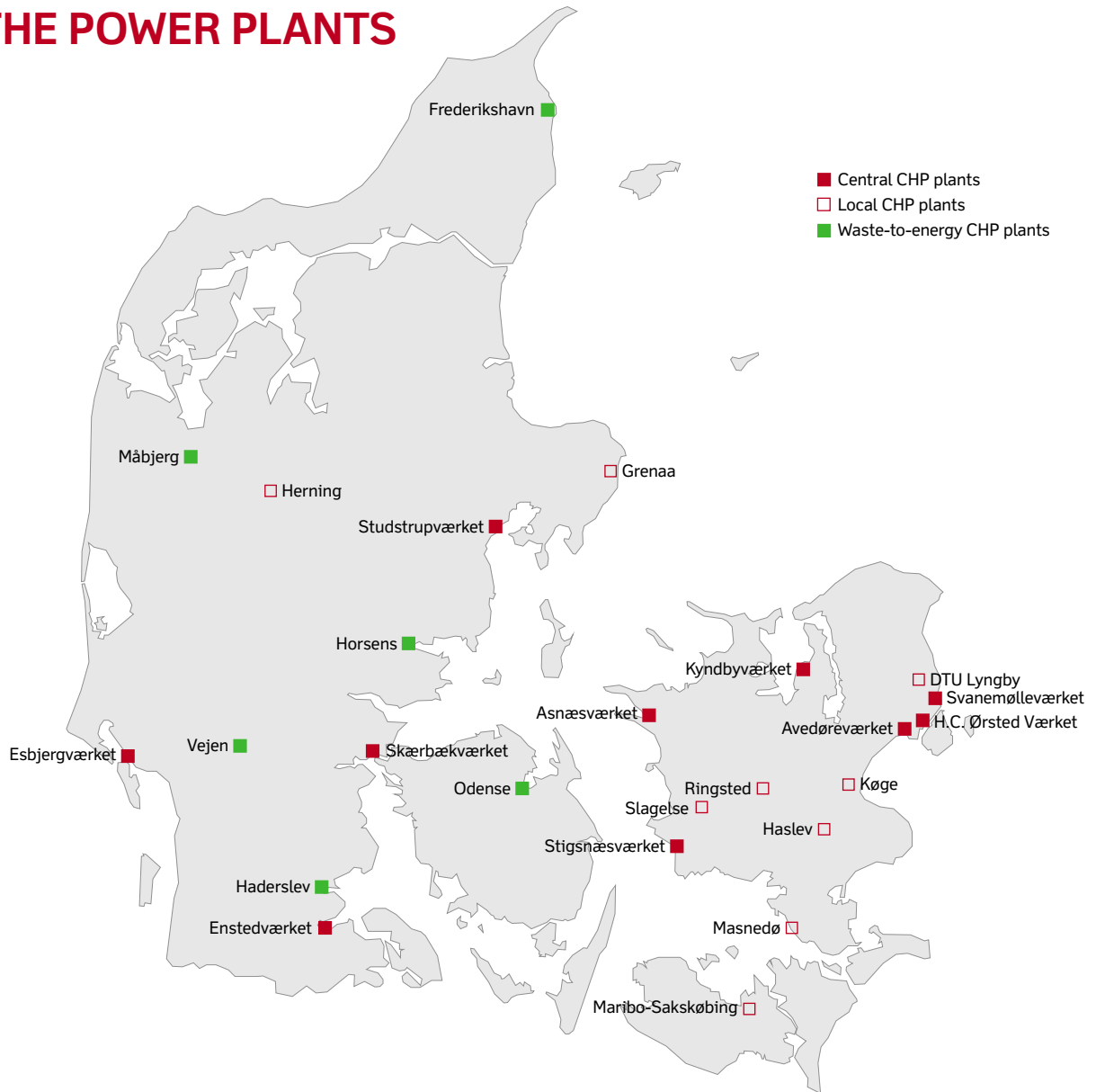
In Esbjergværket's wastewater treatment plant, the waste water from the desulphurisation process is purged of heavy metals before it is discharged into the municipal sewage system.

## Bottom ash

Approximately 1% of the fired coal ends up as bottom ash. The bottom ash is collected in a water bath under the boiler and used as raw material in the construction industry.

**Esbjergværket is QHSE-certified  
according to ISO 9001, ISO 14001  
and ISO/OHSAS 18001.**

# THE POWER PLANTS





## DENMARK'S NEW ENERGY COMPANY

DONG Energy is Denmark's new energy company established in 2006.

DONG Energy is active in all links of the energy supply chain from offshore oil rigs in the North Sea, power plants producing heat and power, and wind farms, to marketing the energy and transporting it all the way to our customers' doorsteps in Denmark and abroad.

This ensures a highly reliable supply of energy and gives us the necessary expertise for developing our company for the future.

DONG Energy has many years of experience. For more than a hundred years we have been supplying power to the Danish consumers and developed the special, Danish tradition of combining the production of heat and power.

Since the beginning of the 1980s, we have also supplied oil and natural gas to the Danish market.

Innovation is a natural part of how we work. We have been involved in the extraction of the North Sea's reserves of oil and natural gas for 25 years, and our power plants are some of the most efficient and eco-friendly in the world.

We are also at the cutting edge in the development of renewable energy, not least in the establishment of offshore wind farms.

DONG Energy has increased its international activities significantly and is now an international energy company focussing on the North European energy markets. On the liberalised market the customers are free to choose their energy suppliers and DONG Energy competes every day against other energy companies to be the customers preferred supplier.

Yet, still being a small player on international scale, DONG Energy is rapidly developing its activities in all aspects of energy supply to be well-positioned for future competition on the energy market.

[www.dongenergy.com](http://www.dongenergy.com)

## Pay a visit to Esbjergværket

Esbjergværket welcomes groups and schools and invites you to participate in a tour of our heat and power producing facilities.

If you would like to have more information about the visits, please contact Esbjergværket at tel. **+45 99 55 17 00** or send an e-mail to [esbjerg@dongenergy.dk](mailto:esbjerg@dongenergy.dk)

**DONG Energy A/S**  
**Esbjergværket**  
Amerikavej 7  
6700 Esbjerg  
Denmark

Tel. **+45 99 55 17 00**