



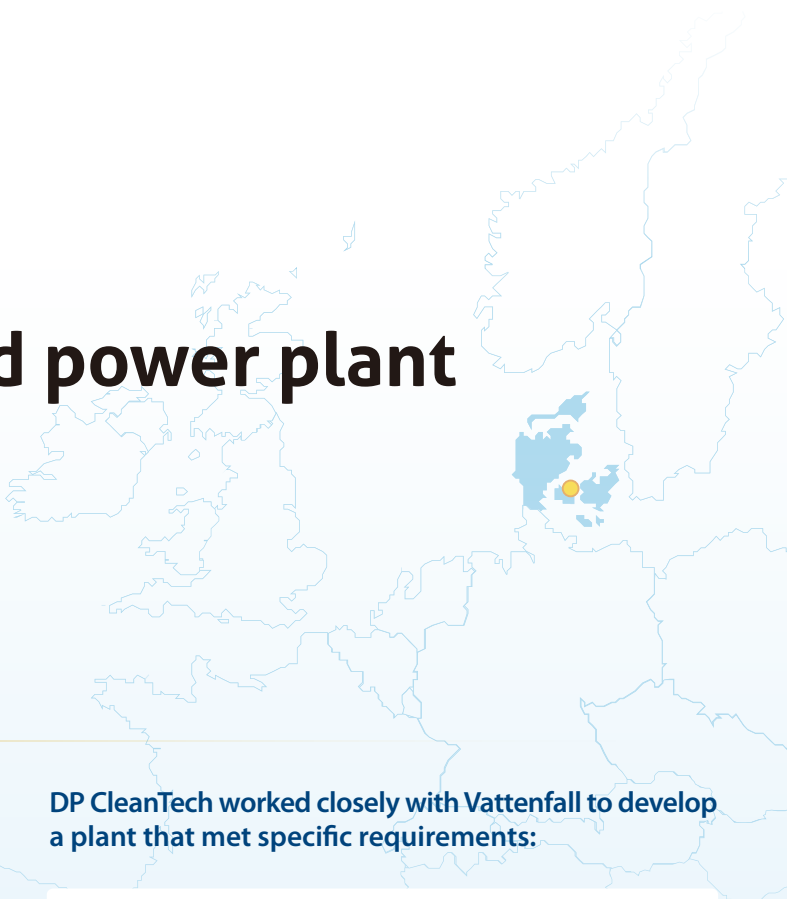
Advanced straw-fired power plant

Fynsværket Odense, Denmark



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Introduction

In 2009, DP CleanTech commissioned one of the world's largest and most advanced straw-fired power plants for Vattenfall. Vattenfall is a leading generator of heat and electricity in Europe, and a frontrunner in sustainable energy generation. Work on the project was begun by Bioener in 2006. After acquiring Bioener and taking on the project, it took DP CleanTech only 6 further months to commission the project. The complete project included boiler, feedwater system, soot blowers, straw feeding lines and flue gas system. The 35 MWe plant consumes straw from local farmers and delivers clean heat and electricity to the grid. It is considered to be one of the finest examples of Vattenfall's increasingly diversified and sustainable energy portfolio.

DP CleanTech worked closely with Vattenfall to develop a plant that met specific requirements:

- ✓ Fully automated
- ✓ The fastest regulating plant within Vattenfall's fleet of thermal units
- ✓ Provisioned for future co-firing of wood chips, pellets or other granulated fuels
- ✓ Maximize the total efficiency of the plant

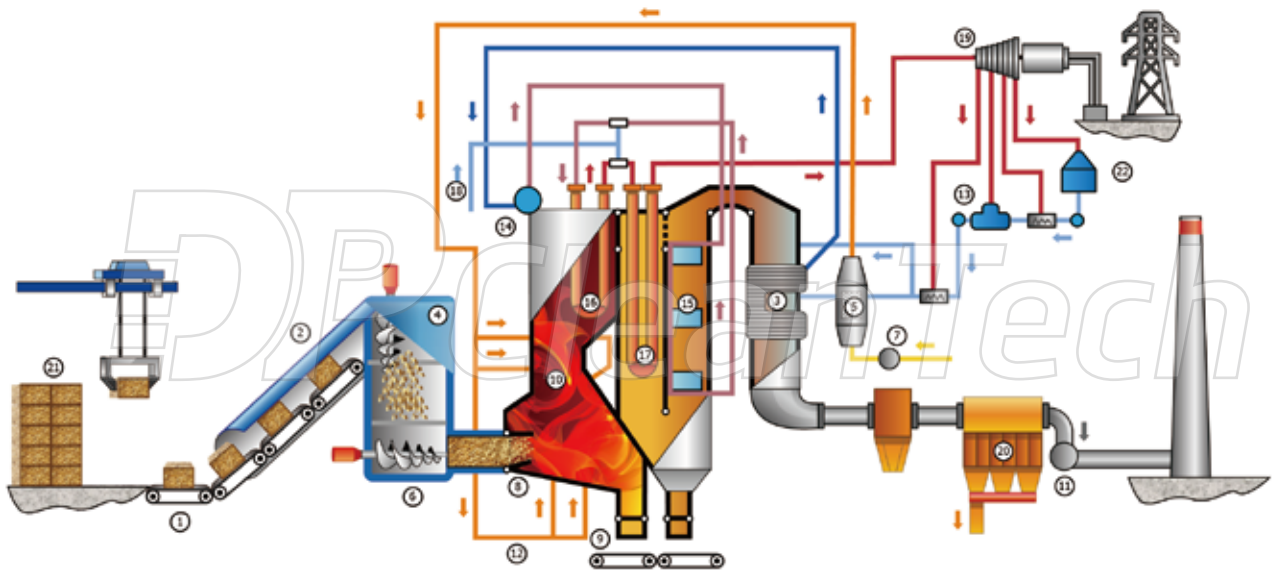
Plant Performance

Fynsvaerket biomass power plant is one of the best examples of fully automated straw firing technology anywhere in the world. The straw-fired steam boiler operates at high steam parameters 112 bar and 540 °C. The steam flow produced is 164.2 t/h and generates 35.2 MWe of electricity and 85.0 MWe for district heating. Due to heat recovery from flue gas cooling, flue gas condensation and additional residual heat, the plant is able to achieve 102.3% efficiency. The plant was designed to consume 170,000 tons of straw per year but in its first year of operation it achieved more than 180,000 tons.

Due to a low availability of straw in 2011, Vattenfall needed to utilize the boiler's capability to co-fire wood chips and has since implemented a wood chips reception and distribution to facilitate this. The re-commissioning of the boiler to co-fire both wood chips and straw was executed smoothly and efficiently.

Fuel	Straw and wood chips
Straw consumption	28.4 t/h
Power/heat output	35.2/85.0 MW
Steam flow	164.2 t/h
Steam pressure	112 bar
Steam temperature	540 °C
Boiler efficiency	92 %
Plant total efficiency	102.3% (on straw)
 108,3% (on straw/wood chips)
Availability	>8000 h/y

Straw-Fired Boiler



- | | | | |
|-------------------|------------------------------|----------------------------|--------------------------|
| 1. Chain conveyor | 7. FD fan | 13. Deaerator | 19. Turbine |
| 2. Seal gates | 8. Vibrating grate | 14. Steam drum | 20. Bag filter |
| 3. Economizer | 9. Slag conveyor | 15. Superheater 1 | 21. Straw barns |
| 4. Scarifier | 10. Combustion chamber | 16. Superheater 2 | 22. Air-cooled condenser |
| 5. Air preheater | 11. ID fan | 17. Superheater 3 | |
| 6. Stoker | 12. Preheated combustion air | 18. Water for atemperators | |

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Combustion

The straw is combusted on DP CleanTech’s water-cooled vibrating grate; the grate is specially designed to handle biomass fuels, its use in all DP CleanTech’s biomass plants has proved it to be one of the most reliable combustion grates in the world.

The vibrating movements regulate the stages of combustion; part of the combustion air is fed to the furnace from beneath the grate and further combustion air is led to the furnace through nozzles situated above the grate. The ignition zone of the grate is stabilized by a patented ignition air supply system. The vibrating motion occurs in cycles which alternate between 1.5-3 minutes for a period of 5-10 seconds at a time. The fuel ash and slag are transported down the grate to the slag fall along with the final burn out of the fuel.



Water-Cooled Vibrating Grate

DP CleanTech’s water-cooled vibrating grate was designed and developed specifically for the combustion of biomass fuels. The vibrating grate is one of few grates able to effectively accommodate mixtures of woody and herbaceous biomass fuel. The water-cooled vibrating grate is one of the most reliable combustion grates in the world. The vibration inhibits the formation of large slag particles, which are common in straw and waste wood fuels. This makes the grate suitable for burning fuels with high slagging and sintering propensities. In addition, a vibrating grate requires less maintenance than a moving grate because it has fewer moving parts.

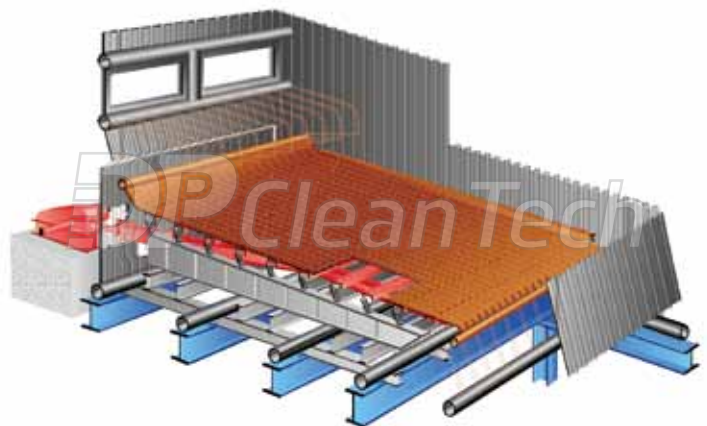


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Fuel Handling

The plant is designed to consume approximately 170,000 tons of straw per year for both power and district heating, but is capable of consuming 230,000 tons per year. The fuel handling system uses Heston straw bales sourced from local farmers on a combination of short and long term contracts. The plant's 'Just-In-Time' storage facility is designed to hold 2300 bales; this is enough fuel to run the plant for 45 hours.

The straw bales are delivered to the storage facility by trucks. Thereafter, everything is fully automated; cranes are used to lift the bales and simultaneously check the weight and moisture content of the straw. The fully automated unloading is the first of its kind. The bales are then either stored or lifted directly on to the automatic conveyors which transport the fuel to the feeding system. An automatic knife cuts the twines, and scarifiers are used to loosen the fuel before it is fed into the boiler.



Straw feeding system

DP CleanTech's specially designed straw bale feeding system handles Heston bales.



High Pressure, High Temperature Boiler

The steam boiler operates at high steam parameters (112 bar and 540 °C) which is made possible by DP CleanTech's unique and well proven design. The design, together with the right material selection and advanced temperature control counteracts the fouling and corrosive effects of the straw fuel. Furthermore, soot blowing with water in the furnace reduces slagging and corrosion and improves performance.

Flue Gas Cleaning

Gaseous emissions are low due to DP CleanTech's advanced combustion techniques. The steam boiler is provided with a fabric filter for removal of particulate matters. All plant emissions are well below EU regulatory standards.

The flue gas condensing plant located after the fabric filter not only improves the efficiency of the plant, but also reduces SO₂ and HCl emissions by 95%.