Borregaard Case Study

Sarpsborg I & II

DP CleanTech
Creating value from waste

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Situation

Borregaard Industries is a major supplier of wood-based chemicals. The company owns and operates one of the world's most advanced bio-refineries in Sarpsborg, where it has demonstrated its commitment to sustainability by securing the supply of renewable heat for its operations. The plant has been constructed in 2 phases.

Sarpsborg 1 was originally contracted and operated by Østfold Energi from 2002 to 2012, after which Borregaard took over the facility. Since 2012, the plant has continued to be commercially successfully in supplying low cost renewable heat, producing 210 GWh per annum, displacing around 18,000 tonnes of fossil fuel. Borregaard identified that further energy cost savings and carbon reductions could be achieved with the addition of a second renewable energy plant.

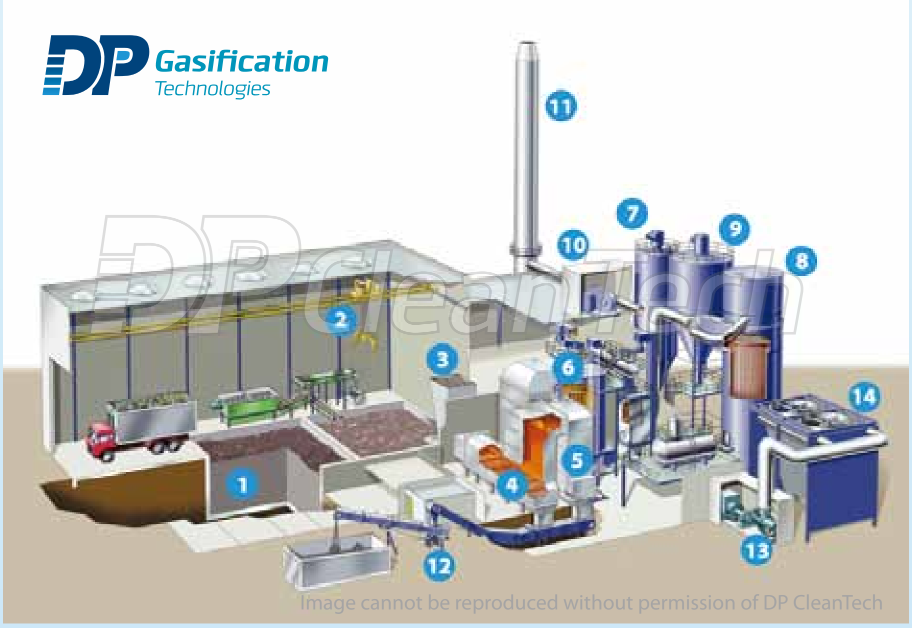
Solution

A second contract - Sarpsborg II - was awarded to Energos in February 2008. Working with one of Norway's leading power suppliers - Hafslund Heat and Power AS, Energos supplied, installed and commissioned the mechanical and electrical equipment.

The Sarpsborg II plant was officially handed over to Borregaard in July 2010, ahead of schedule and within budget. Sarpsborg 2 has since been producing 256 GWh per annum, displacing around 22,000 tonnes of fossil fuel annually.

Typical Plant Layout

1. Fuel bunker
2. Fuel crane
3. Hopper
4. Primary chamber (Gasification)
5. Secondary chamber (High temperature oxidation)
6. Heat Recovery Steam generator (HRSG)
7. Lime and carbon silo
8. Bag house filter
9. Filter residue silo
10. Flue gas fan
11. Chimney
12. Bottom ash extraction
13. Steam turbine
14. Air cooled condenser

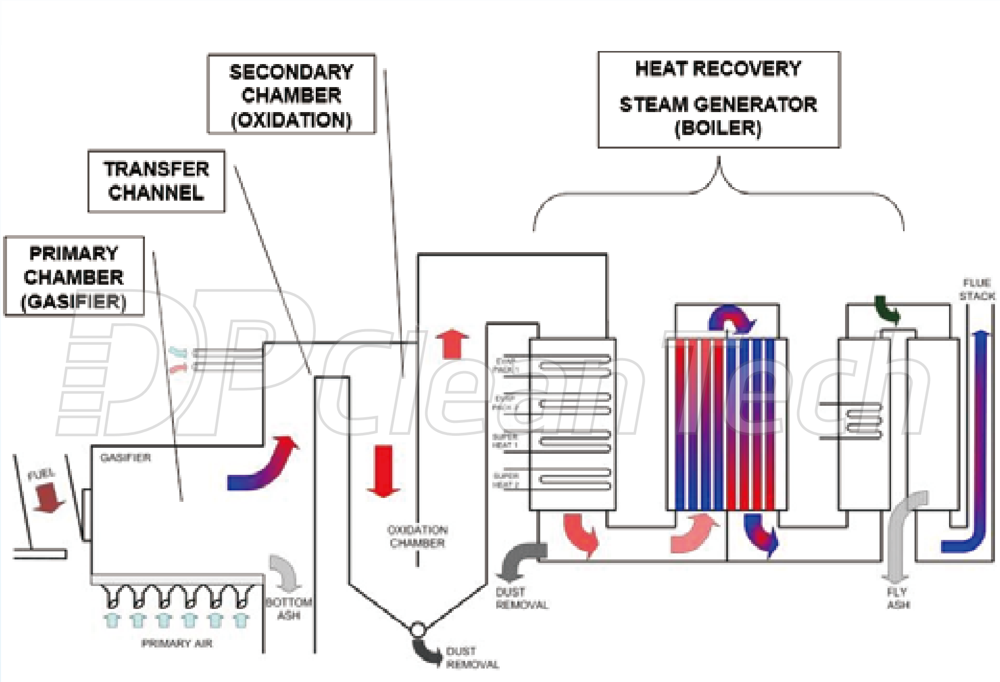


Technical Information

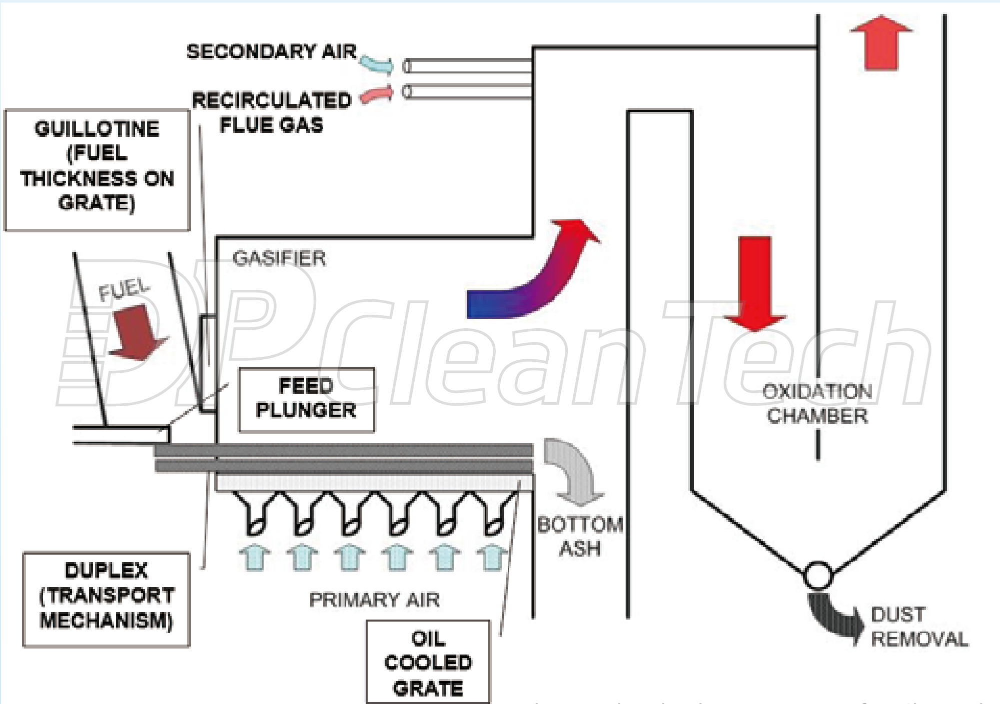
The Energos technology is an advanced two-stage thermal treatment process that converts residual, non-recyclable waste into a gas by using the heat of partial combustion to liberate the hydrogen and carbon within the waste. The waste is fed into a gasification chamber, where it is used to produce a syngas.

This syngas is transferred to a secondary high temperature oxidation chamber where it is fully combusted under tightly controlled conditions which results in very low emissions. The resulting heat energy is used to produce steam, which can be used to supply renewable heat and/or generate renewable electricity.

The Energos Process



The Gasifier and Thermal Oxidiser



Detailed Plant Description and Process

Waste Receipt and Fuel Preparation System

Waste is delivered by truck and unloaded in the waste bunker. An overhead crane system feeds the shredder and the hopper of the gasification chamber.

The plant is equipped with a pre-treatment system that includes shredder with belt conveyors, magnetic belt for metal separation and a pick-up crane.

The overhead crane loads the shredder. The magnetic metal is extracted from the shredded waste and transferred to containers. The pick up crane removes further unwanted waste and the remaining shredded waste is unloaded into the fuel bunker.

Fuel Bunker and Transport System

Fuel is transferred from the fuel bunker by an automatic overhead crane and unloaded into hoppers upstream of the feeding chamber of each gasification chamber. The fuel mixture is fed from the feeding chamber into the gasification chamber. Odour in the vicinity is avoided by using air from the bunker hall as process air for the gasification and high temperature oxidation process.

Thermal Conversion

Thermal conversion takes place in two steps. Drying, pyrolysis and gasification of the fuel is carried out in the gasification chamber. In the high temperature oxidation chamber a staged oxidation is facilitated by multiple injections of air and recycled flue-gas.

The gasification chamber is equipped with a fixed horizontal oil-cooled grate that is divided into several separate sections, each with a separate air supply. A hydraulically operated plunger feeds the fuel into the gasifier grate. A water-cooled guillotine is installed at the inlet of the gasification chamber to control the thickness of the fuel bed. A hydraulically operated water-cooled feeder (duplex feeder) ensures transportation of the fuel along the grate. The duplex feeder is designed in such a manner that in addition to the longitudinal transport, a good local mixing of the moving fuel bed is achieved to promote the local homogeneity. The main control system controls the fuel-feeding rate into the gasification chamber as well as transportation along the grate. The bottom ash is discharged from the gasification chamber at the end of the grate. The discharged bottom ash is cooled in a water-basin and transported to the outdoor bottom ash storage. The stored bottom ash is transported to a suitable landfill by truck at regular intervals.

The syngas produced in the gasification chamber is transferred via a channel to the high-temperature oxidation chamber. Injection of air and re-circulated flue gas through distributed nozzles in the high temperature oxidation chamber ensures temperature control and complete high-temperature oxidation of the syngas from the gasification chamber.

Flue gas exiting the high temperature oxidation chamber is passed to the heat recovery steam generator (HRSG).

Auxiliary burners are used during plant start-up, shutdown and one is used as a standby burner to ensure that the temperature in the high temperature oxidation chamber remains above 850°C while the plant is in operation.

Heat Recovery Steam Generator (HRSG)

Each HRSG that recovers the energy from the flue gas is connected downstream of each high temperature oxidation chamber. The HRSG is a combined water-tube and smoke-tube-boiler with an economiser. The water tube boiler section consists of evaporator water tube bundles that are easily removed for service and maintenance. The system is equipped with a feed-water tank, feed-water pumps, blow-down tank for blowing of the boiler and facilities for cleaning (shot cleaning) of the heat transfer surfaces (flue-gas side) during operation.

**The Design Data for
The Heat Recovery Steam Generator**

Steam pressure [bara]	22
Steam outlet temperature [°C]	220
Feed water inlet temperature [°C]	105
Nominal HRSG capacity [MW]	16.4

Flue Gas Cleaning System

The plant is supplied with a dry flue gas cleaning system located downstream of each HRSG. The flue gas cleaning system consists of an adsorbent silo, a bag-house filter and a storage silo for filter dust. The cleaning of the flue gas is based on injection of adsorbent (lime and carbon) into the flue gas for absorption of acid components, adsorption of heavy metals, mercury, TOC and dioxins. Fly ash and adsorbents are separated from the flue gas in a bag house filter.

Residue from the filter is collected at the bottom of the filter and pneumatically transported to the filter dust storage silo. The silo is emptied at regular intervals through a sealed system into designated trucks for transport to disposal in accordance with statutory regulations.

Flue Gas Fan and Stack

The flue gas fan is located downstream of each bag house filter. The flue gas fans maintain the required draft in the gasification and high temperature oxidation chambers, as well as discharging the flue gas to the atmosphere via a common flue gas stack. A portion of the flue gas is recycled to the high temperature oxidation chamber using a re-circulated flue gas fan.

Control and Monitoring System

The plant is equipped with an automatic process control and monitoring system. The plant operators interact with the control system via the human machine interface (HMI) in the control room. The HMI presents all important process data, including flue gas emissions. An independent emergency shutdown system (ESD) takes control during emergency situations and secures the plant into a safe state to avoid damage to humans, environment and equipment.

Emission monitoring of flue gas components is performed in accordance with Directive 2010/76/EU. A separate historical data logging system stores all process data in a database and is used for analysis purposes.

Utilities

The plant is supplied with the following process utility systems

- Electrical system excl. transformer and connection to the grid
- Emergency power generating unit
- Process air system
- Re-circulated flue gas system
- Compressed air system
- Hydraulic system
- Water cooling system
- Thermal oil system
- Recovered water system
- Fuel oil or gas system

Plant Performance

The second plant of 33 MW capacity generates up to 256 GWh of steam per year and this high quality process steam is delivered to several nearby chemical process plants. The gasification facility treats 78,000 tpa of locally sourced, non-recyclable, non-hazardous commercial and industrial waste, and recovers more than 80% of the latent energy.

The £ 45 million project reduces carbon dioxide emissions by approximately 47,000 tpa which is equivalent to the environmental benefit of over 4 million trees.

The new plant complements the existing Sarspborg I 27MW (thermal) Energos facility that has been generating 210GWh/a of steam, bringing the total 2 line capacity for residual waste treatment to 156,000 tpa.

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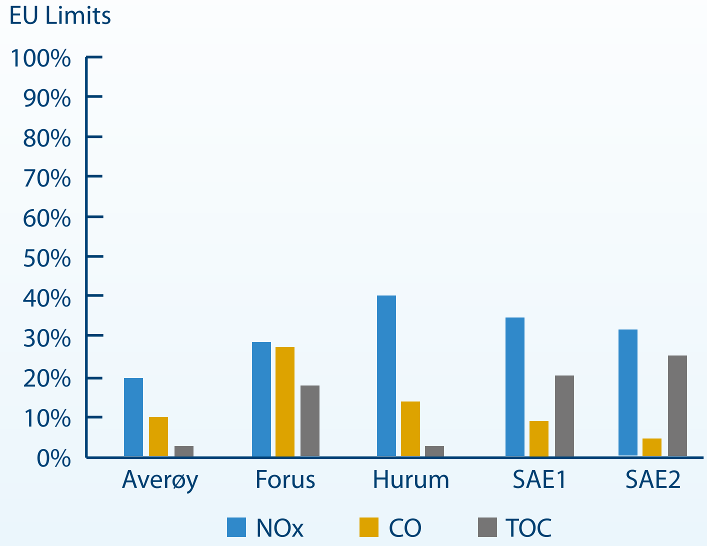
Energos Sarpsborg Avfallsenergi Plant Nov 2016

Component (mg/m^3, Dioxins ng/m^3)	EU Limits 24h average	ENERGOS average
Dust	10	<1
Hg	0.03	<0.01
Cd+Ti	0.05	<0.01
Metals	0.50	<0.1
CO	50	2
HF	1.0	<1
HCl	10	8
TOC	10	<2
NOx	200	55
NH3	10	1
SO2	50	9
Dioxins	0.10	<0.1

TÜV Emission Reports From Energos Plants



- Low carbon content in bottom ash (less than 3% TOC)
- Simultaneously low and stable Carbon Monoxide (CO) and Nitrogen Oxides (NOx) emissions

The Energos Design Philosophy

The key feature of Energos products are the flexibility of design to handle different fuel types; and the options for scaling up. The design can suitably treat wastes with calorific values between 8 and 18 MJ/kg. The design is modular in the range of 40,000 tpa to 200,000 tpa. A plant can be delivered to meet current residual volumes and additional capacity can be added as and when it is needed in the future, reducing the likelihood of expensive redundant capacity.

A typical 80,000 tpa facility can generate sufficient renewable electricity to power 10,000 homes, which is the equivalent to the output of 15 large wind turbines.

Most Energos designed plants are located next to major energy consumers where heat recovery can be optimised, or in locations where hot water can be supplied to a district heating network.

The energy recovered from the biodegradable fraction of waste allows limited exemption from CO_2 emissions under the EU Emissions Trading Scheme (EU ETS).