

Case story

Multi-biofuel district heating plant parallels 2022 emission targets, and **delivers world-class 125% fuel utilisation performance**

The future is now

The world-class 30 MW multi-biofuel plant in Hjørring, northern Jutland, Denmark achieves exceptionally low emission levels, and at the same time is one of the most efficient plants of its kind in the world.

Its competitive status as one of the most internationally efficient biofuel

plants ever built is achieved by high demands placed on all equipment. These demands include maximal implementation of the newest IE4 synchronous reluctance (SynRM) motor technology, driving the numerous pumps and fans throughout the plant. Performance of each SynRM motor is enabled by Danfoss frequency converters.

The plant has the capacity to drive a future geothermic plant on the same site.

Despite heavy investment in new technologies, the plant has a payback period of only seven years. The result for the consumer is a planned reduction of heating rates by 5.5% for the coming financial year, 2014-2015.



2 years

payback on IE4 SynRM
motors by comparison
with traditional IE2
motors operating at
partial load.



I actually think it would be difficult to achieve higher efficiency by investing more.

Niels-Peter Heje
Operations Manager
Hjørring District Heating A.m.b.a.

Investment 16 M EUR

2 years payback on IE4 SynRM motors operating at partial load
7 years payback on entire new plant



Vertical biofuel boiler and flue gas shotblast cleaning.



Absorber in the foreground. Scrubbers in the background.

Visionary aims

The goals set by Operations Manager Niels-Peter Heje at tender phase in 2011 specified the newest technologies:

1. Flexible fuel utilisation

The primary fuel is wood chips, readily available in the local area. However the boiler must be able to burn many different non-explosive fuels such as straw, tree roots or tree trunks in the form of wood chips.

"It's a major economic advantage for us that the plant can use all types of biofuels", explains director Per Sorensen. "We have a surplus of

wood chips in the local area, so we also save on transportation costs because fuel is so close. Furthermore, it's an advantage in CO₂ accounting".

To achieve multi-fuel operation, the plant tolerates a range of 35 – 55% moisture in the fuel. The optimum is 45%. Therefore if the fuel is too wet, the combustion air is preheated. If it's too dry, the fuel is dampened by spraying with water. Water spraying is one of the several novel technologies used in this plant. The alternative is energy-costly flue gas recirculation.

For loading and blending purposes there are two wood chip loading areas, connected to a common conveyer feeder. Wood chip storage and blending is computer managed by creating multiple virtual stocks, keeping track of wood chips based on type, moisture, and a number of other properties.

2. Vertical boiler for optimal efficiency.

3. An electrostatic precipitator, instead of traditional multicyclones, removes particles from flue gas.

4. Synchronous reluctance (SynRM) motors and IE4 induction (IM) motors

All motors over 0.75 kW were specified as synchronous reluctance type (SynRM), 1500 RPM 4 pole motors, rated IE3 – or IE4 if available. Niels-Peter prefers SynRM over permanent magnet (PM) motors, due to PM being difficult and expensive to repair. The construction of the SynRM motor is very simple by comparison, and he therefore expects lower maintenance, and greater motor uptime.

SynRM motors have superior efficiency over IM motors. For ratings above 75 kW, IE4 SynRM

surpasses IE4 IM for partial speed and load efficiency performance. For ratings below 75 kW, IM motors only meet IE3. SynRM losses are substantially lower for partial load – this is where SynRM has a distinct advantage over IM motors.

At the time of ordering in April 2013, the project paid a 20% higher price to obtain IE4 motor rating, by comparison with IE3. This is no longer the case. Prices are decreasing, and in Denmark an IE4 SynRM motor is now available for the same price as IM motors rated IE3.

5. Radial flow pumps, no inline pumps.

6. High efficiency ventilation fans.

7. Transformer located closer to plant to minimise cable losses.

8. ABB 800 XA control system, set up for PROFIBUS communication to frequency converters, control valves and instrumentation. An OPC system for communication with the cranes, absorber and emergency generator. Operators control the plant using iPads, a new solution for district heating, although already well-known in other fields.

Outstanding performance parameters

The absorber enables optimum energy utilisation

- The absorber heat pump cools flue gas down to a record low 9.5°C, far exceeding the initial target of 12°C. The low temperature expresses the extremely high utilisation of energy transferred from the boiler output. The absorber consumes extra power compared to a traditional biofuel plant without absorber, around 1 kW electricity for 20 kW extra heat. However, due to the use of modern IE4 motors, energy consumption is still competitive with a traditional biofuel plant.
- The entire power consumption of the Hjørring plant, including district heating pumps, is 12 kW per 1 MW heat produced. Traditional power ratio for a boiler alone is 10 kW per 1 MW heat produced.

Flue gas emission levels are extraordinarily low

- Levels of gas and dust emission are a fraction of the current permissible limits, and parallel the planned compliance levels for the year 2022. See table below.



Loading crane for multiple fuel types.



IE4 SynRM motors equipped with VLT® AutomationDrive FC302 frequency converters.

Emission type	Unit	Measured emission level at full load, April 2014	Maximum permissible emission limit, Denmark 2014	Probable maximum permissible emission limit, Denmark 2022
CO	mg/Nm ³	17	625	–*
NOx (NO ₂)	mg/Nm ³	230	300	220
Dust	mg/Nm ³	4.4	100	14
O _{2,dry}	%	7.37		6

*In 2022 focus will be on NOx emissions, and there will be no CO requirement

A total of 18 Danfoss VLT® AutomationDrive FC 302 frequency converters are installed at Hjørring District Heating plant. All frequency converters are installed with PROFIBUS and 24 V DC backup options:

Application	Size	No. of FC 302	Efficiency class and motor type
Boiler pumps	55 kW	3	IE4 SynRM motor
Absorber pump	45 kW	1	IE4 SynRM motor
Distribution network pump	37 kW	1	IE4 SynRM motor
	90 kW	2	IE4 IM motor
Primary combustion air	22 kW	1	IE4 SynRM motor
Secondary combustion air	55 kW	1	IE4 SynRM motor
Quench pump	11 kW	1	IE4 SynRM motor
Condensate pumps for scrubbers	75 kW	1	IE4 IM motor
	55 kW	1	IE4 SynRM motor
Flue gas fan	132 kW	1	IE4 IM motor
Fuel sorting	5.5 kW	2	IE3 IM motor
Fuel transport conveyor	5.5 kW	1	IE3 IM motor
Push feeder pump	7.5 kW	1	IE3 IM motor
Water injection boiler	1.1 kW	1	IE3 IM motor

Control parameters

- Efficiency (kW required for each MW produced)
- Fuel moisture content
- Volume of fuel

Target: 125% fuel utilisation
Design based on maximum 55% moisture content in fuel

SynRM motor compatibility now standard

As a dedicated frequency converter supplier, Danfoss is committed to manufacturing frequency converters compatible with all motor types.

Software development is always ongoing, to include algorithms to comply with the emerging motor types. In this case, the control algorithm was customized to the SynRM motors at Hjørring District Heating.

Danfoss makes some great products, and has been more cooperative and easier to work with than some of the alternative suppliers.

Niels-Peter Heje

Danfoss laboratories tested two motors, a 55 kW and a 22 kW, to prove SynRM compatibility and confirm IE4 efficiency levels.

Triggered by the development performed for this project, SynRM compatibility is now implemented as a standard feature. During commissioning, the electrician sets four motor parameters: current, RPM, frequency and torque, and enables the new automatic motor adaptation (AMA). The AMA for the SynRM motor takes 2.7 seconds, measuring the remaining required motor parameters for optimal performance and energy efficiency.

Danfoss solution

The project chose a Danfoss customised frequency converter development solution over an off-the-shelf drive-motor package from a competing supplier.

The customised solution providing SynRM compatibility is now available as standard for VLT® AutomationDrive, VLT® AQUA Drive and VLT® HVAC Drive.

Some of the reasons:

- Danfoss offered extensive application support.
- Danfoss frequency converters are compatible with all the different motor types installed in the plant.
- Hjørring District Heating already had long experience using Danfoss frequency converters.

The contractor Weiss is convinced this is the right solution and that the result is the ultimate multi-biofuel plant.

Gorm Gade Knudsen from Weiss explains, "We like Danfoss products and were not hesitant about committing to a development process. At the beginning of the project, it was quite difficult to find an IE4 motor. However nowadays, it's already realistic to specify IE4 motors."

Based on required performance, Danfoss dimensioned the frequency converters to match the specified motors. Each frequency converter was selected for the individual load and application – pump or fan.

Weiss A/S

WEISS A/S performs project management, design, and installation of combustion plants for biofuels.

The scale of plants ranges from 1000 kW to 30 MW, with a customer base throughout Europe.

Weiss supplies its biofuel combustion solutions primarily to process industries and district heating plants. In district heating, Weiss supplies turnkey automated solutions adapted for specific requirements and conditions.

www.weiss2energy.eu



Hjørring District Heating A.m.b.a.

Hjørring District Heating A.m.b.a. supplies electricity, heating and cooling to commercial industries and private homes in northern Jutland, Denmark. Hjørring District Heating aims for top reliability and low heating prices, and is amongst the 8% most inexpensive district heating suppliers nationwide.

Key figures 2013-2014:

- Turnover 146 M DKK
- Total energy production 287,000 MWh
- Heat supply to 10,000 private homes
- Power supply to 50,000 private homes

Operations:

- 30 MW multi-biofuel district heating plant
- Natural gas and wood-pellet-fired power and heating plant, supplying 59 MW electricity and 52 MW heat
- 1.5 MW district cooling plant
- 289 km pipeline network
- In assessment phase: Geothermal heating plant
- Co-owner with 66% stake in Energispareelskabet Vendsyssel A/S, which performs energy saving tasks for district heating companies in three local towns and a local electricity company.

<http://www.hjvarme.dk/>