

# Combustion of Miscanthus and other biofuels in a full scale CHP plant

Lars D. Fenger(lfd@e2.dk), Energi E2 A/S ([www.e2.dk](http://www.e2.dk))

## Test firing with alternative biofuels at Masnedø CHP plant

Masnedø CHP Plant has hosted a large number of tests with different biofuels in the period from January 1997 to May 2000. The tests are listed below. Phase 1 was the initial test where biofuels for phase 2 were selected. The tests in phase 1 were short and lasted only 4 to 6 hours. The tests in phase 2 were longer and lasted for 24 hours, in most of the tests. In phase 2 a mass balance was calculated for 24 hours. During a period of 8 hours fuel and ash was sampled, and selected fluegas components were measured.

- Reference (15<sup>th</sup> January 1997)
- Phase 1 (1998)
  - Straw and wood chips
  - Triticale
  - Straw and seed shells
  - Straw and Olive stones
  - Straw and garden- and park residues
- Phase 2 (1998-2000)
  - Straw
  - Straw and wood chips
  - Straw and Olive stones
  - Straw and Shea nuts
  - Seedgrass
  - Peastraw
  - Straw and Miscanthus
  - Rape
  - Straw
  - Wet straw
  - Straw and Wood chips
  - Miscanthus

During the tests a large number of different parameters were measured/analysed. Below is listed the measured parameters during phase 2.

- Stack (O<sub>2</sub>, CO, NO, water, temperature, dust, SO<sub>2</sub>, HCl, trace elements\*)
  - Fuel (water, ash, volatiles, LHV, Cl, S, C, H, N, O, Si\*, Al\*, Fe\*, Ca\*, Mg\*, Na, K, P, trace elements)
  - Bottom ash (water, ash, Cl, S, total-C, Si\*, Al\*, Fe\*, Ca\*, Mg\*, Na, K, P, trace elements)
  - Fly ash (water, ash, Cl, S, total-C, Si\*, Al\*, Fe\*, Ca\*, Mg\*, Na, K, P, trace elements)
- \* only December 1999

## Tests with Miscanthus

The 22<sup>th</sup> of April 1999 a test with Miscanthus in bulk form was conducted during 6.7 hours. By a mistake a wrong density was written in to the control system, otherwise there would have been a test for 24 hours. During the 6.7 hours 7% of Miscanthus was added to straw, calculated on energy basis. No severe problems were seen in the test.

The 22<sup>th</sup> of April 1999 a test was made with Miscanthus in hole bales. 25 bales were burnt in 1½ hour, corresponding to 13.5 tons. No problems were observed. It was not possible to measure bottom ash or fly ash.

The 9<sup>th</sup> of may 2000 the test lasted for about 3.5 hour. The amounts of ash were not measured because of the short period of time for the test. Without any problems, 28 tons was burnt corresponding to 51 bales.

### Selected results from the analyses

Miscanthus 1 is a sample from the bulkform i 1999, Miscanthus 2 is from the bales i 1999 and Miscanthus 3 is bales from 2000. The Straw analyze is from the test with Straw and Miscanthus in bulk form.

	unit	Straw	Miscanthus 1	Miscanthus 2	Miscanthus 3
<b>Fuel</b>					
Water	%	13.6	31.1	11.9	8.4
Ash	% d.b.	6.0	5.6	2.0	2.1
C	% d.b.	45	47	47	48.6
H	% d.b.	5.8	5.8	5.8	6.0
N	% d.b.	0.65	0.63	0.4	0.38
S	% d.b.	0.13	0.21	0.07	0.05
Cl	% d.b.	0.75	0.37	0.23	0.21
LHV	MJ/kg dry	17.13	17.33	17.73	17.28
Na	% d.b.	0.05	0.069	0.018	0.015
K	% d.b.	1.6	1.4	0.81	0.58h
<b>Bottom ash</b>					
Ash	% d.b.		97.7	91.0	92.3
Unburnt	% d.b.		2.3	9.0	7.7
S	% d.b.		1.2	1.6	1.06
Cl	% d.b.		1.3	1.8	4
Na	% d.b.		0.46	0.46	0.45
K	% d.b.		13	14	15
<b>Fly ash</b>					
Ash	% d.b.		93.1	90.3	87.1
Unburnt	% d.b.		6.9	9.7	12.9
S	% d.b.		3.8	3.1	3.0
Cl	% d.b.		26	28	20.8
Na	% d.b.		0.82	0.90	0.63
K	% d.b.		37	38	31

### Conclusion of the 3 tests with Miscanthus

- Bales must be in minimum length
- It is necessary to optimize on the air distribution
- Suction pipes in cleaning device can block
- Bulk can be handled, but with some problems.
- Low emissions of dust and SO<sub>2</sub>, compared to straw.
- Minimum 400 tons for a third test.

## Masnedø CHP Plant

### Electricity and heat production

Masnedø CHP Plant has a capacity of 9 MW electricity and 23 MJ/s heat. The annual electricity output is about 33 mio. kWh, corresponding to the consumption of about 7,000 households. Heat production is about 360 TJ/year, supplying 90% of the demand for heat in the town of Vordingborg. The other 10% is supplied by Vordingborg's own naturalgas fired district heating stations, which also act as back-up for the CHP plant.

### Fuel

Masnedø CHP Plant uses only the indigenous and CO<sub>2</sub>-neutral fuels straw and wood chips.

The straw is supplied by farmers in Lolland-Falster and South Zealand, who later purchase the residuals, bottom ash and fly ash, as fertiliser for their fields. In this way, the straw forms part of a natural cycle. The annual consumption of straw is about 40,000 tons. Some of the straw can be substituted by wood chips.

The plant's straw store has a capacity of 2,000 bales (1,000 ton). This corresponds to three days fuel consumption at full production.

### **Energy and environment**

Co-generation of heat and power in a CHP plant means that the energy in the fuel is exploited twice as well as in power plants producing only electricity.

The production plant at Masnedø CHP Plant utilises up to 88% of the energy in the input fuel. 25% is used for electricity production and 63% for heat production.

The efficient utilisation of the energy in the fuel saves resources and improves environmental performance. Co-generation results in considerably lower emissions of carbon dioxide (CO<sub>2</sub>), sulphur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>). In addition, firing with straw is in itself environmentally beneficial.

