ETV Verification Statement

Technology type	Technology for combustion of biomass	
Application	Low emissions of particles, CO and NO_x	
Product name	Dall Energy Biomass Furnace	
Company (vendor)	Dall Energy	
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DANETV, The Danish Centre for Verification of Climate and Environmental Technologies, undertakes independent tests of environmental technologies and monitoring equipment.

DANETV is a co-operation between five technological service institutes, DHI, Danish Technological Institute, FORCE Technology, Delta and AgroTech. DANETV was established with financial support from the Danish Ministry of Science, Technology and Innovation. Information and DANETV documents are available at www.etv-denmark.com.

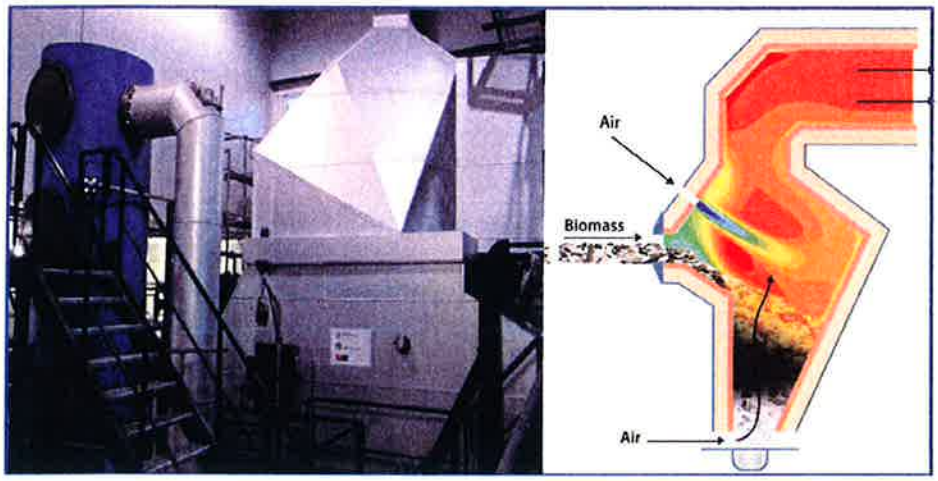
The verifications and tests are planned and conducted in accordance with the guidelines for the EU ETV Scheme.

This verification statement summarizes the results from the ETV test of the Biomass Furnace developed by Dall Energy applied for low emissions of particles, CO and NO_x.

Descriptions of technology

The Dall Energy multipurpose biomass furnace is a newly invented combustion design, which in one special designed unit combines the well known updraft gasification technology with a gas combustion section above the gasifier. The unit has no hot moving part inside the furnace. Figure 1shows the Dall Energy Biomass Furnace and a principle diagram.

Figure 1 Dall Energy Biomass Furnace and a principle diagram



The technology can only work as an integrated part of a biomass combustion plant, consisting of a fuel feeding system, a system to utilize heat and a chimney. To achieve the highest energy efficiency the heat utilizing system includes a wet condensation system. Several other units, e.g. blowers, instrumentation and a process control system are necessary to operate the plant.

In the bottom part, the solid fuel is converted into a burnable gas and fine ash. In the top layer, the fuel is dried and pyrolysed. The heat for the drying and pyrolysis process is a combination of convective heat from the gasification gases below and radiation heat from the gas combustion part above. The gas velocity in the bottom part is very low. Consequently, ash particles remain here and the dust emission of the furnace is very low. Due to the very efficient gas combustion the CO emission is very low. Moreover the emission of the fuel NOx is relatively low due to the gasification process. Gas from the bottom part is combusted in the upper section. The gas combustion can operate at low oxygen concentration and maintain very stable flow, temperatures, emissions etc. In combination with a flue gas condensation system and a fuel or combustion air moisturizing system, a very high thermal efficiency is achieved, and biomasses with up to 60 % moisture can be used for fuel.

Application of technology

The intended application of the Dall Energy Biomass Furnace is defined in terms of the matrix, the target and the effect of the product. The matrix is the type of material that the product is intended for. Targets are the measurable properties that are affected by the product and the effects describe how the targets are affected.

Matrix	Combustion of wood chips
Targets	The composition of the flue gas where it leaves the furnace
Effects	• Low concentrations of particles, CO and NO_x • Stable concentrations by operation in the whole possible operation area from 20% to 100 % • Stable concentrations of particles, CO and NO_x during load changes

Description of test

The Dall Energy Biomass Furnace application system was tested at Andelsselskabet Bogense Fjernvarme in Denmark. The 8 MW furnace was operated by the local operators, supervised by Dall Energy. The test was carried out during two days at different loads.

In order to determine the Dall Energy Biomass Furnace ability to keep the emission of particles, CO and NO_X low, during stable operation at both high and low load, as well as during load changes, continuously measurement was made during the whole test period, while the manual measurements of particles and condensable was made during the two periods with stable operation.

The test was carried out according to the following program:

• Stable operation at 100% load • Changing load from 100% to 20% • Stable operation 20% load • Changing load again up to 60% • Stable operation 60% load • Changing load again up to 100%	The concentration of particles and condensable was measured at 100 % and 20 % load, by manually isokinetic sampling at the outlet from the furnace, at a flue gas temperature between 835 and 960 °C. Special equipment and adjusted sampling procedure was applied, to handle the high temperature. CO, O_2, NO_x and flue gas temperature was measured continuously in a measuring point after the boiler during the whole test period.

Also samples of the wood chips and the ash was analyzed for the content of water, ash, nitrogen and residual heat value.

Verification results

The main measurement results at the furnace flue gas outlet as average of three one hour samples are shown in Table 1.

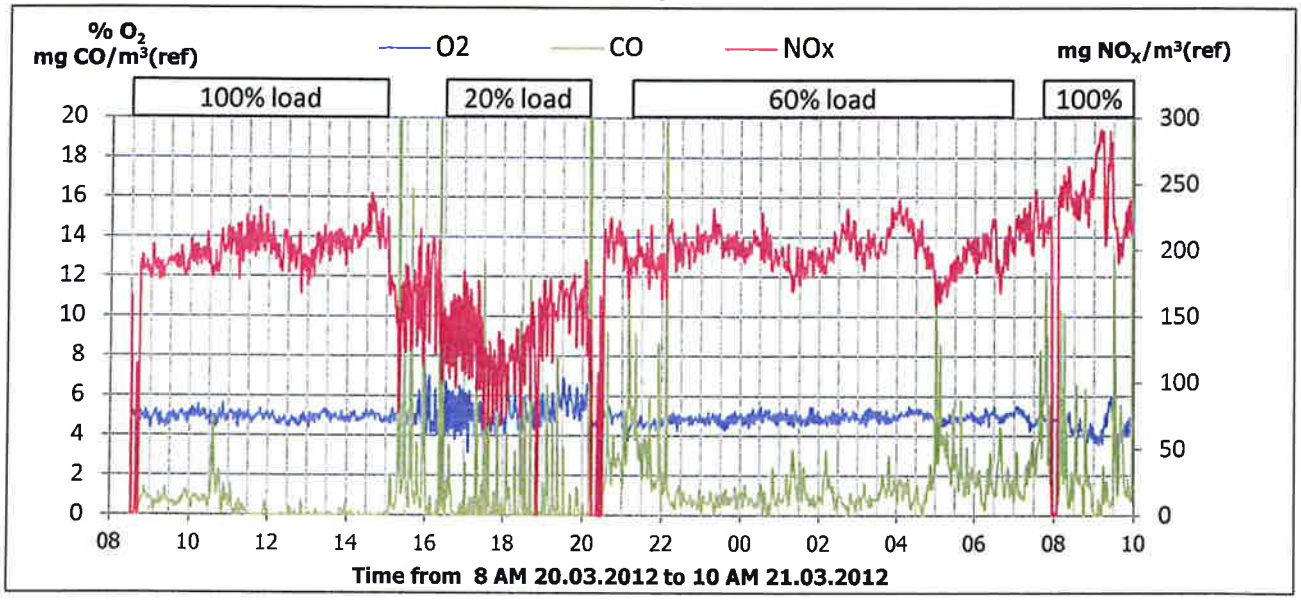
Table 1 Measurements at the furnace flue gas outlet – 20th March 2012 – Average values

Parameter	Unit	Full load		Load changes		
Load	%	100	20	100 → 20	20 → 60	60 → 100
Measuring period	hh:mm	11:12 - 14:22	16:44 - 20:00	-	-	-
Temperature	°C	958	845	-	-	-
O_2	Vol % (dry)	4.9	5.3	-	-	-
CO	mg/m³(ref)[1]	< 2	< 2	3.4	2,3	< 2
NO_X	mg/m³(ref)[1]	200	140	160	200	230
Particles	mg/m³(ref)[1]	69	64	-	-	-
Condensable in rinse and condensate	mg/m³(ref)[1]	50	68	-	-	-

The emission of CO was on average below the detection limit of 2 mg/m³ (ref). At load changes and at low load the concentration was intermittently above the detection limit - see Figure 2.

Both the furnace conditions and the nitrogen content in the fuel have influence on the NO_X emission, which is reflected as significant lower NO_X emission at 20 % load compared to 100 % load. The NO_X concentration fluctuates within a very constant value, depending on the actual load.

Figure 2 Emissions of O_2, CO and NO_x including load changes



The residual heat value in the ash sample was 0.27 MJ/kg, which calculated in relation to the heat value of dry wood, and the ash content in the wood chips equals app. 0.015 % of the input heat value.

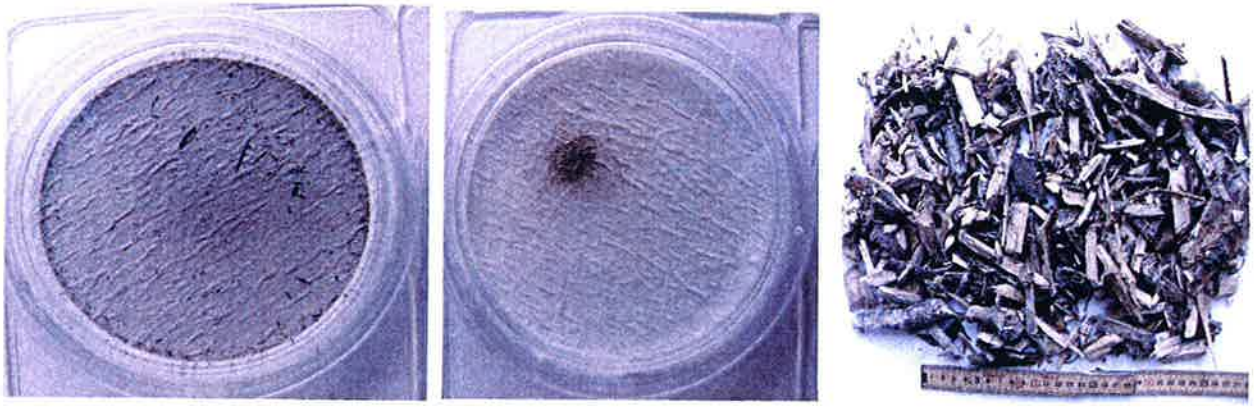
The following Figure 3 shows different photos: Samples of particles on filters at 100 % and 20 % load (photo 3a and 3b) and a sample of wood chips (photo 3c) used as fuel during the verification test.

Photos 3a and 3b indicates a significant difference in the combustion conditions and behaviour, as the particle size, colour and distribution on the filters are very different. The considerable lower temperature in

[1] (ref) indicates dry gas at standard conditions (0°C, 101,3 kPa) at 10 % O_2

the furnace at 20 % load (100 to 125 °C lower) could mean different combustion efficiency and consequently the light brownish colour could be some residual combustion by products.

Figure 3 Photos of particle filter and wood chip sample



a. 100 % load

b. 20 % load

c. wood chips sample with 34 % water content

EVALUATION OF PERFORMANCE PARAMETERS

On the basis of this verification test of Dall Energy Biomass Furnace it is verified that regardless the load the emissions of particles, CO and NO_x are simultaneously low.

The concentrations of particles at the furnace flue gas outlet are low at constant load and the concentration of CO is significantly low at constant load as well as during load changes. The NO_x concentration is also considered low especially at low loads, as it is in the low end of the normal range for similar wood combustion plants.

Quality assurance

The test and verification have been performed according to the DANETV Quality Manual. As a part of the quality assurance an internal technical expert provided review of the planning, conducting and reporting of the verification and tests.

	19/6-12		19.06.12
Signed by Marianne Kyed Ørbæk Test Centre Management representative	Date	Signed by Ole Schleicher Test responsible, FORCE Technology	Date