COFORD working grant visit report

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The COFORD working grant was to aid in providing experience working in an established wood fuel testing centre, to learn the methods in which wood chips are tested, and also to establish connections with personnel within the testing centre. The grant also covered visits to chipping operations and heating instillations.
The trip to Denmark allowed the opportunity to investigate all stages of the wood chip operation from initial stand measurements to harvesting, drying, chipping operations, to final testing.

Plans have been made to move the Danish testing centre in the coming months so new contact details are unsure at present, details will be passed on when available. While carrying out the classification process there had also been a number of other testing equipment being used in the centre. Experience was gained of the methods and equipment used for the following methods:

- Wood Pellet Durability - This involved weighing the sample and screening to remove the dust particles. The sample was then placed in a sample shaker which is a rectangular box which makes 500 revolutions. The sample is then removed and screened. The amount of dust produced in the second screening is representative of the quality of the pellets.
- Incinerator – The incinerator reaches temperatures of over 1000°C. It is used to calculate the ash content in wood samples. It can also be used to find the amount unburned material in ash samples.
- Pellet sub divider – This is used to sub divide pellets in to manageable sizes without effecting the randomness of the samples.
- Grinder – This is used to produce a fine substance for incineration or to be used in chemical samples.

Size Classification Testing Process

- When the 31 wood chip samples arrived in Denmark each sample was spread on the ground to allow air drying begin.

Fig 1. Wood Chip samples allowed to air dry.

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- This method was proving to be slow so the samples were transferred to containers through which air could be blown to increase the drying rate.

Fig2. Containers to allow air to be blown through the samples.

- These containers could hold up to seven samples which allowed a maximum of seven samples to be processed each day. To give all the samples a uniform treatment all were dried in the containers which slowed the process greatly.
- To ensure the wetter samples dried over night a heater was used to increase the temperature of the air passing through the samples.
- When the moisture was believed to be below twenty percent they were placed into a sub divider which produced four random samples. The sample was placed in the top with the opening closed. When the opening was opened the sample fell on a cone which spread the sample into the sub sample drawers. Each sub sample was bagged with one being kept as a reference sample.

Fig3. View from top of sub sampler with open drawers.

- Some samples were too large even when sub divided so two sub samples were placed back in the divider and the others where kept as reference samples.
- The samples were then taken to be size classified. Before this began the 6 trays of the rotating screen where cleaned and weighed. Each tray is positioned to collect samples from the different size meshes in

the drum. The sizes of the mesh were 3mm, 8mm, 16mm, 45mm, 63mm, and greater than 63mm passed into the last tray.

Fig4. Open trays of Rotating Sampler.

- Each sub sample bag was emptied onto the tray of the rotary particle size analyser. These samples were pushed at a constant rate into the rotating drum insuring all particles passed through the drum.

Fig5. Sub samples pushed from tray into rotating drum.

- When the rotating drum was empty and checked for particles which may have become lodged in the grid the trays were removed, weighed, recorded and emptied.

Fig6. Wood chip in rotating in particle size drum, showing particles passing over smaller with 3mm holes, 8mm, 16mm, 45mm, to mesh of 63mm.

- The each tray was also checked for over long particles, which were removed after the tray had been weighed. These particles were then reweighed in either of their categories larger than 100mm or larger than 200mm).
- This was carried out for each of the sub samples before beginning on the next.
- When all weights were gathered the figures were entered into spreadsheets. The spreadsheet removed the weights of the trays leaving the weight of the particles in each sub sample. The weights were presented as percentages of the total weight.
- Results

Table1. Shows the percentages of the particles in each sample and if it conforms to the European standards.

Locatioin	Species	Sample	Condition	Machine	Fines 3mm	Small 8mm	Medium 16mm	Large 45mm	Extra Large 63mm	Over large 63>	Over Long 100mm >	Over Long 200mm >	Total	P 16	P 45	P 63	P 100
Portlaw	ASH	TS	B	Truck	1.8	7.5	23.7	62.8	2.9	0.5	0.8	0	100	NO	NO	YES	YES
Portlaw	SYC	WT	B	TP	3.2	7.2	24.7	62.8	0.6	0.1	1.4	0	100	NO	NO	NO	YES
Portlaw	SYC	WT	B	SL	0.9	2	7.5	71.4	13	2.8	1.9	0.6	100.1	NO	NO	NO	YES
Portlaw	ASH	WT	B	TP	1.2	4.9	23.3	67.5	1.6	0	1.2	0.3	100	NO	NO	NO	YES
Portlaw	ASH	WT	B	SL	0.8	2.8	8.5	67.6	17.9	1.3	1	0.1	100	NO	NO	NO	YES
BNM	LP	WT	B	Truck	7.5	16.2	25.8	44.1	1.3	1.2	3.1	0.7	99.9	NO	NO	NO	NO
BNM	LP	WT	B	SL	3.7	8.9	12.9	57.7	9.1	3	3.4	1.2	99.9	NO	NO	NO	NO
BNM	SS-BI	WT	B	SL	3.4	5	13.6	68.4	5.1	2	2	0.5	100	NO	NO	NO	YES
BNM	BIN	WT	B	TP	3.8	7.4	29.5	57.9	0.7	0.1	0.5	0.1	100	NO	YES	YES	YES
BNM	BIP	WT	B	TP	2.6	8.8	28.1	54.8	2.9	0.1	1.8	0.8	99.9	NO	NO	NO	YES
KILB	SS	WT	B	TP	2.5	5.9	24.8	63.9	1.6	0.6	0.7	0	100	NO	NO	YES	YES
KILB	SS	WT	B	SL	2	3.1	10.4	71.2	11.4	0	1.8	0.1	100	NO	NO	NO	YES
KILB	SS	CHEM	B	SL	2.1	4.8	12.4	71.8	6.6	0.9	1.2	0.4	100.2	NO	NO	NO	YES
KILB	SS	TS	B	TRUCK	11.6	12.1	25.7	46.7	1.9	0	1.8	0.1	99.9	NO	NO	NO	NO
KILB	SS	WS	B	SL	1.3	3.8	10.3	66.8	10.2	4.1	1.8	1.6	99.9	NO	NO	NO	NO
FOIL	SS	RW	B	TRUCK	8.6	20.7	58.6	9.7	1.4	0.4	0.5	0.1	100	NO	NO	NO	NO
FOIL	SS	EW	B	TRUCK	3.2	8.1	30	56.4	1.4	0.1	0.6	0.2	100	NO	NO	YES	YES
SWAN	SS	WT	B	TP	3	5	23.2	54.5	7.8	2.1	4	0.6	100.2	NO	NO	NO	YES
SWAN	SS	WS	B	SL	1.1	2.9	7.2	63.9	18.8	5.3	0.5	0.3	100	NO	NO	YES	YES
SWAN	SS	TS	B	TRUCK	2.9	6.4	20.1	62	5.7	1.2	1.7	0	100	NO	NO	NO	YES
SWAN	SS	WT	B	SL	2.1	2.3	7.3	55.4	18	9.4	3.4	2.1	100	NO	NO	NO	NO
SWAN	SS	CHEM	B	SL	5.1	8.1	13.6	63.8	5.7	1.9	1.6	0.2	100	NO	NO	NO	NO
SWAN	SS	RW-BW	B	Truck	1.3	4.6	21.2	65.3	4.4	2.8	0.4	0	100	NO	NO	YES	YES
SWAN	SS	RW	B	Truck	5.1	8.1	13.6	63.8	5.7	1.9	1.6	0.2	100	NO	NO	NO	NO
SWAN	SS	EW	B	Truck	4.3	8.9	25.9	57.2	2.6	0	1.1	0	100	NO	NO	NO	YES
Fren	SS	WT	B	TP	4.4	9.2	29	51.5	2.6	1.3	1.4	0.6	100	NO	NO	NO	YES
Fren	SS	WT	B	SL	3.6	6.4	11.3	60.7	11.2	3.9	2.3	0.6	100	NO	NO	NO	YES
Fren	SS	WT	B	SL	2.7	4.1	8.1	61	15.3	5	3.7		99.9	NO	NO	NO	YES
Fren	SS	WT	B	Truck	5.8	7.9	27.6	55.4	1.9	0	1.5	0	100.1	NO	NO	NO	NO
BALLI	SS	TS	B	Truck	7.9	9.2	28.4	52.5	1.5	0	0.6	0	100.1	NO	NO	NO	NO
Fermoy	SS	CRL	B	Truck	25	15.5	24	31.1	2.3	0	2.1	0	100	NO	NO	NO	NO

- Table2. Shows European Standard size classes
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- To compare these results to the European Standard more testing had to be carried out as the mesh on the rotating sampler did not meet the requirements. There were some sizes which were missing (less than 1mm size, and a screen for over 85mm) which had to be sorted by hand slowing the testing process.

- To insure the rotary size classifier was not biased the reference samples were passed through an oscillating partial size classifier.
- This required all reference samples to be passed through the sub divider, bagging all sub samples and keeping a reference sample. The samples were then taken to be classified.
- The trays of the oscillating sampler were cleaned and weighed before sampling began.
- Each sub sample bag was emptied into the top screen of the sampler and the machine switched on for fifteen minuets.

Fig7. Shows Oscillating Particle Size Classifier

- All particles begin in the large tray on top and pass through the trays till they can no longer fit through.

Fig8. Showing the drawers open on the Oscillating Classifier

- After this time each tray had to be removed from the machine and weighed.
- This machine had problems when removing the trays as the particles could cause the trays to become stuck. The particles could be sticking out into the tray beneath preventing it from being pulled out.
- The machine was time consuming and was quite noisy.
- There were a number of areas on the machine where particles or dust could fall past the trays.
- Results:

Table2. Shows the percentages of the particles in each sample and if it conforms to the European standards.

Locatioin	Species	Sample	Condition	Machine	Fines 3mm	Small 8mm	Medium 16mm	Large 45mm	Extra Large 63mm	Over large 63>	Over Long 100mm >	Over Long 200mm >	Total	P 16	P 45	P 63	P 100
BNM	LP	WT	B	SI	15.7	11.2	18.4	45.5	4.7	2.2	1.6	0.8	100.1	NO	NO	NO	NO
BNM	LP	WT	B	Truck	22.4	20	29.7	24.1	0.9	0	2.1	8	107.2	NO	NO	NO	NO
BNM	BIN	WT	B	TP	6.6	15	37.6	39.3	0.4	0	0.5	0.6	100	NO	NO	NO	NO
Port	Ash	TS	B	Truck	3.6	11.9	32.8	46.7	2.1	0.7	1.7	0.7	100.2	NO	NO	NO	YES
Port	Ash	WT	B	SI	2.5	5.9	17.8	62.7	9.1	0.3	0.7	0.9	99.9	NO	NO	NO	YES
Port	Ash	WT	B	TP	3.6	12.6	35.7	47	0	0	0.6	0.1	99.6	NO	YES	YES	YES
Port	Syc	WT	B	TP	5	11.1	32.3	50	0	0	1.1	0.6	100.1	NO	NO	NO	NO
Port	Syc	WT	B	SI	2.9	4.6	16.1	67.6	6.6	0.8	1.4	0.1	100.1	NO	NO	NO	YES
Swan	SS	WT	B	TP	6.5	14	31.4	40.8	3.3	1	2.1	0.9	100	NO	NO	NO	NO
Swan	SS	TS	B	Truck	8	13.2	32.2	43.7	1.9	0	0.9	0.2	100.1	NO	NO	NO	NO
Swan	SS	WS	B	SI	3.6	6.3	19.9	59.3	8.8	1.7	0.4	0	100	NO	NO	YES	YES
Swan	SS	RW	B	Truck	4.9	12.2	36.4	41.7	2.2	1.3	0.8	0.4	99.9	NO	NO	NO	YES
Kilb	SS	WT	B	SI	3.5	6.7	19.8	58.5	6.4	1	3.7	0.4	100	NO	NO	NO	YES
KIlb	SS	WT	B	TP	5.1	13.9	33.5	45.6	1.2	0	0.6	0	99.9	NO	NO	NO	NO
KIlb	SS	WT	B	SI	5.5	9.1	22.1	57.7	3.6	1	1	0	100	NO	NO	NO	NO
Kilb	SS	TS	B	Truck	14.1	16.3	36.1	31.4	0.2	0.2	1.6	0	99.9	NO	NO	NO	NO
Foil	SS	EW	B	Truck	7.4	19.2	43.4	29.5	0	0	0.3	0.1	99.9	NO	NO	NO	NO
Foil	SS	RW	B	Truck	9	20.8	39.7	30	0	0	0.6	0	100.1	NO	NO	NO	NO
Balli	SS	TS	B	Truck	12.3	15.5	35.5	34.3	0.3	0	2.1	0	100	NO	NO	NO	NO
Fren	SS	WT	B	TP	12.6	16.3	35.1	33.4	1.1	0.4	0.7	0.4	100	NO	NO	NO	NO
Fren	SS	WT	B	SI	9.5	7.6	19.2	50	9.4	1.5	2.1	0.7	100	NO	NO	NO	NO
Fren	SS	WS	B	SI	7	6.8	17.5	50.1	11.6	4.4	2.1	0.4	99.9	NO	NO	NO	NO
Fren	SS	RW-BW	B	TRuck	4.6	10.6	34.6	48	1.6	0	0.6	0	100	NO	NO	YES	YES
TP factory	Beech	WT		TP	5.5	46.5	41.5	6.5	0	0	0	0	100	NO	NO	NO	NO

Fig9. Shows the different particle sizes in piles

Conclusion:

Problems occur when the parts of the machines such as blades or anvils are damaged or of poor quality this has a large part to play on the quality of the wood chip produced. The quality requirements placed on the chippers to produce a uniform sized chip which would fit specifications required by boilers need to be understood by the producers and the consumers to prevent production problems and in feed problems. The end use of the chips should be the deciding factor when choosing the chipper to be used. There are great quality and size variations in the chip produced from each machine which could present substantial problems if delivered to boilers which require smaller chip. If the chip delivered for the boiler is small the price of the chip may increase as production would be lower increasing the time the chipper has to spend to produce the same amount of chip.

There are also a number of questions which have arisen as to how valid the European Standards are in relation to their requirements of chip particle size. These standards are unclear and difficult to understand which can cause problems when read incorrectly. The percentages of the particles sizes stated in the standards allow very little variations which may be found in wood chip samples.

There are also a number of problems when comparing the stated particle sizes required in the standards to the sizes of the trays required in the machines used to analysis the chips. The standards require 5% lower than 1mm, there is no tray or mesh for this size. There is also a requirement for an 85mm tray or mesh. The machines do have trays which are not mentioned in the standards such as the 63mm.

Gammel Ry Estate

This is a private residence of 3000m2. It is situated on a hill top with sparse protection from the surrounding tree cover from harsh winds. The house is over one hundred years old and has had problems with condensation and mildew. The house was fitted with oil fired central heating. The oil boiler has now become the back up when maintenance is needed or when problems occur with the wood chip boiler. Since the chip boiler had been installed the cost of heating the house has been cut to about thirty seven percent of the cost compared to when the house had been heated my oil.

The boiler uses about one thousand meter cubed of chip each year. The chip boiler was placed in a basement corner room to provide heat and hot water to the house. The room is enclosed with no ventilation causes the build up of heat in the boiler room. This room is remains warm as long as the boiler is in use. This heat used to condense on the walls. The heat is now extracted from the room and recycled to heat the water of the house which reduces the amount of waste heat which would otherwise condense on the walls creating future problems.

The boiler room is situated near the external wall. This allows the silo which fills the boiler using an auger of one meter length has and has an 8m2 capacity be filled from above ground with loader or trailer from a storage area 200m from the silo.

Around this storage area there is room to store round wood or other material to be chipped. The current species being chipped is Noble Fir *(Abies procera)* as the estate has its own supply however in previous years numerous species have been used as became available. The boiler can handle most size classes however if there are over long (> 100mm) they may create bridging in the silo.

Long green pieces have been found to wrap around the auger which in time can prevent the chip feed into the boiler or break the motor of the auger.

The wood chip is produced using Jenz 700 chipper once a year which blows the chip directly undercover into the storage area. The chipper is fed using the hydraulic arm of a timber truck with a 15m reach allowing minimal movements of the chipper. As the material being chipped is owned by the estate the greatest expense is the cost of hiring the chipper.

The storage area which has over head cover but is without walls allows chipping from all sides directly undercover. This type of storage allows drying of the chip by the wind and prevents precipitation accessing the chips. The storage area has also one area to store fire wood which is used for open fires in the house.

Uldum Small District Heating Plant

This is situated near the town of Uldum and supplies heat to the town and imitate area. The plant buys chip of all qualities and stores them in an uncovered area near its silo. From the stack the chips are transported into the silo by wheeled loader which prevents the requirement for a large silo area. This allows different fuels to be stored and used as required or needed. The boiler can burn most materials after a couple of alterations.

The silo is emptied by an automatic crane which fills into a hopper feeding the boiler. The boiler of 2.5 MW heats the water using heat exchangers. This water is then pumped from the plant in a closed system to the customers. When it reaches the customer heat exchangers transfers the heat from the closed system to the heating system of the buildings.

The ash from the boiler is brought from the boiler by conveyer through a pressurised under water system and is placed in containers for transport.

This plant has also a diesel fuelled burner as a secondary boiler to be used when production need or high or when problems occur with the main boiler.

At present the plant is installing a larger boiler 4.5 MW which will be fed from the same silo but will require a larger crane. The heat which will be produced by the new boiler will be used to heat one customer who has come in the system requiring heat for a 65,000 m2 warehouse.

Babcock and Wilcox Vølund Assens Fjernvarme AmbA
Biomass Fired CHP Plant, Assens DEnmark

The site of the CHP plant is situated in an industrial estate on the outskirts of the city. It has been planned to provide adequate transport of chips from large trucks from forests and from the near by dock. All transport of fuel to the plant is carried out by contract allowing a wider selection of material to be sought.

The energy input of the plant is approximately 17.3 MW (mega watts) which is produced from burning biomass. The output of the plant is in a number of different means, such as 4.7 MW of electricity, thermal output including flue gas condenser 13.8 MW. On an annual basis the power generation of the plant varies between 26,000 to 28,000 MWh. The heat generated is about 226,000 GJ annually.

The plant originally was designed for a coal boiler. This boiler has now become a back up if the new boilers are unable to produce the required heat or needs repairs. This was the original boiler but has been replaced by the Vølund boiler.

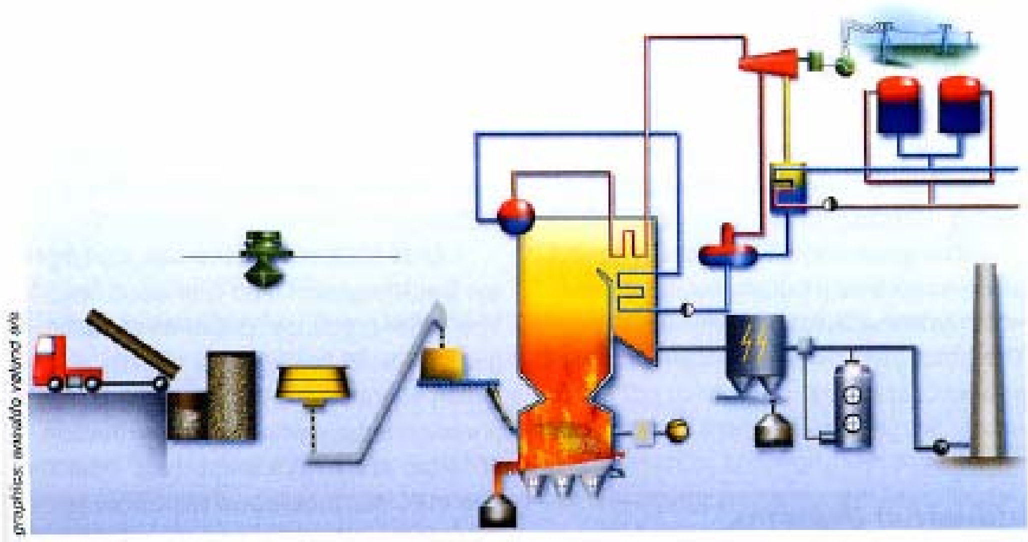

Fig 10. Shows the general layout of the Fjernvarme plant

At the entrance to the site is situated a weigh bridge which is operated by the truck driver who is given a sample bag and identification receipt. The driver then proceeds to the storage area at the rear of the plant. The storage area has four separate compartments which the trucks can tip into a separate hopper for each compartment. This material is later removed by automatic crane. There are problems with the method used to empty the hoppers as the cranes are unable to reach the corners of the hopper. This is because of the sloping side in the hoppers. It means that the hoppers must be cleaned manually which will slow the intake during busy seasons.

Fig11. Shows the build up of chip on the sides of the hoppers.

Once the truck is empty the driver takes a sample of the material which he deposits in a store at the weigh bridge. These samples are later collected and sampled by plant staff.
The plant has its own testing area where the moisture of the samples are recorded. The moisture content of the samples is used in conjunction with the weight of the trucks to provide a cost for the materials delivered by the trucks. In this testing centre there are facilities to measure the ash quality and to check the quality of the water passing through the plant.
The reason for the separate storage areas is to allow a mix of material to be used in the plant e.g. saw dust, pellets, wood chip. This has a number of advantages which increase the productivity of the plant. If material with high moisture content is deposited in the store it can be mixed with dry on a sorting grid before entering the boiler.
The store area is emptied using two automatic cranes which load into a sorting grid. This grid filters out large unwanted materials into separate bins to be used else where. The remaining material is transported by conveyer to a buffer silo.

Fig12. Automatic crane filling the sorting grid.

From the buffer silo two pneumatic throwers blow the fuel into the furnace. This material gets additional drying while the particles are suspended at this time gasification takes place. Combustion takes place on a water cooled vibrating grate.
Secondary combustion air and recycled flue gas are added to the furnace combustion area through a number of nozzles in rear walls of the boiler. The ash and unburned material is gathered and later transported to a deposit area. The flue gases pass through an electrostatic precipitator to clean the flue gas of fly ash with the facility to pass through a flue condenser if necessary.

The steam produced in the boiler is sent through a turbine with a velocity of 12,500 rpm. The turbine drives a generator with a velocity of 1,500 rpm. Steam which is not used by the turbine is converted to heat in two district heat exchangers.
During the warmer months in summer there is less requirement for the plant to operate at full capacity. This allows the plant to shut down for a number of days and restart when heat is required. It allows maintenance to be carried out and other works. While the plant is closed the heat for the surrounding area is stored in to large silos of water which work like batteries of heat.
The plant is automated which allow the plant to be run from an external source. If problems occur there are people on call who first check the problem from the external source and if deemed necessary will go to the plant.

Assens Trapiller Pellet Factory

The site of the factory is surrounded by timber yards and industries. It was established in 1982. The plant is not as efficient as modern establishments but can still produce 30,000 ton per year.
The plant uses mainly saw dust and debarked wood chip but can also use other materials such as straw or other biomass.

Fig 13. the different materials used in the pellet production.

The material is loaded by wheel loader into a hopper which feeds into a ten tone drum drier. The heat for the drier is produced using a lower grade wood chip, most wood chip qualities can be used. The drier lowers the moisture of the material to between 9% - 12%.

Fig 14. Shows the in feed system to the drier.

It is then passed through a hammer mill to make it into a powder material. This material is placed in a large storage area and as required for pellet production is loaded into hoppers in the store which conveys it to be pressed. This storage area is full of dust which can cause explosions because of the small particles in the air and also there is a high content of methane gas in the air. The sides of the stores are not fixed securely to all an explosion to go through the wall instead of causing damage the equipment in the rest of the plant.

Fig 15. Hopper filled with dust to be made into pellets. Also the walls are not secured

The fine power material is fed into a dye with two rollers inside which press the powder through to make pellets. The temperature of these pellets can be ninety degrees and if were stored at this temperature would absorb the moisture from the air and return them to powder form. To prevent this they are passed from the dye into a cooler and are then stored. The pellets are then ready for burning as a fuel. From the storage area the pellets can be bagged on site or sold in bulk by the tone.

Fig 16. Storage of the final product