PREFACE

This handbook has been developed for public use in order to promote the utilisation of wood pellets. This handbook also exists in Danish, English, Italian, French and Polish languages. The handbook contains general and technical information with respect to production, transport, storage, utilisation of pellets as well as market and legislation aspects. Thus, it is mainly targeted at pellet producers, distributors and large pellet consumers.

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The editor does not guarantee the correctness and/or the completeness of the information and the data included or described in this report.

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Acknowledgements
This handbook is based on translation of the existing book in Danish language (Træpillehandbogen, 2002), which is a publicly available document published by FORCE Technology. It has been a great success in Denmark and contributed largely to the development of the pellets market in Denmark.

Disclaimer
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# English Handbook for Wood Pellet Combustion

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1. Introduction

The Pellets are a modern form of densified biomass offering interesting opportunities for development of Renewable Energy in Europe. The market exists for domestic pellet heating but also boilers at commercial and industrial levels and finally for large scale plants, using pellets for electricity and/or heat production. The actual European technology is leading this sector.

This solid fuel is actually mainly produced by wood residues but should also be produced by mixed biomass residues through a quite simple process of milling, drying and compacting. The main advantage of compactation is the high density of the product in comparison with the other unprocessed biomass and therefore containing a high energy content. It also enables the production of a standardised fuel and reduction in the cost of handling, storage and transport.

The cheap process technologies already exist and are highly competitive in comparison with the fossil fuels. Actually, around 1,4 tons oil equivalent per dwelling is used in Europe for households (EEA, 2008). The development of pellets seems very important in order to improve the energy security and emission saving in Europe.

The scope of the Handbook for wood pellet combustion is to be key to the Danish/English/Italian/Polish market for pellet fuels. The handbook aims at supporting and increasing the use of wood pellets by presenting information on several aspects of the sector ranging from pellet production, quality and distribution, and small to large scale plants. Also safety and environmental issues are covered in detail.

The primary target group is professionals on all levels such as producers and distributors of pellets, plant manufactures, energy consultants’ etc. Moreover the handbook gives the consumers an easy to use guide to the pellet market. All together this will increase the transparency of the pellet market and create increase the competition on quality, plants and services for the benefits of producers and consumers on all levels.
2. The Pellet Market in the UK

2.1 UK Biomass Policy
The Biomass Task Force (http://www.defra.gov.uk/farm/crops/industrial/energy/biomass-taskforce/pdf/btf-finalreport.pdf) was launched in 2005 to aid the Government and the biomass industry in optimising the contribution of biomass energy to renewable energy targets as well as sustainable farming and rural objectives. The Task Force was led by Sir Ben Gill and produced a report which set out 42 recommendations, such as a call for the introduction of capital grants to fund more biomass heating boilers.

The UK Biomass Strategy 2007 (http://www.defra.gov.uk/environment/climatechange/uk/energy/renewablefuel/pdf/ukbio massstrategy-0507.pdf) was developed jointly by BERR (formerly DTI) and DEFRA with the aim of achieving optimal carbon savings from biomass, while complying with EU policies and the EU Biomass Action Plan of 2005 (http://www.euractiv.com/en/energy/biomass-action-plan/article-155362). It is also intended that the strategy should support existing renewable energy and climate change targets, and should facilitate the development of a competitive and sustainable market and supply chain for biomass. The Biomass Strategy was published alongside the Energy White Paper in May 2007.

The UK Government is currently undertaking a review on whether to establish a renewable heat obligation to go alongside the target of producing 10% of the UK’s electricity from renewable sources by 2010 (with the aim of producing 20% by 2020), which policy is supported by the Renewables Obligation. At present the amount of heating from renewable sources in the UK is low at (0.6%) of heat demand and with the UK’s obligation under the EU’s Renewable Energy Directive being to source 15% of its energy from renewables by 2020 action to increase the proportion of heat from renewable sources such as pellets is required very soon. For further information go to http://www.berr.gov.uk/whatwedo/energy/sources/renewables/policy/renewable-heat/page15963.html

2.2 Pellet Market Overview
In the UK it is estimated that the majority of pellets manufactured and imported are co-fired for the production of electricity. However, data on this is very hard to come by, as it is of a commercially sensitive nature. What we do know is that there are increasing numbers of individuals and organisations who are using pellets as their main source of space heating. For those wanting a low carbon heating solution with a heat demand of less than 40 to 50kW pellet heating is an obvious solution, particularly for an existing property. Over 40 to 50kW one might look at a woodchip heating system, although pellets might still be the preferred option due to the higher calorific value of pellets (meaning fewer deliveries and/less storage space) and reduce maintenance requirements (e.g. because pellets produce far less ash).

A list of UK wood pellet producers and suppliers can be found on NEF’s LogPile website at http://www.nef.org.uk/logpile/fuelsuppliers/pelletsuppliers.asp. Of the 79 companies listed, 12 are UK based wood pellet producers. The largest of these is Balcas Ltd which is based at Enniskillen in Northern Ireland with a production capacity of 55,000 tonnes.
Although there were some market failures during 2008, overall pellet production capacity in the UK increased to an approximate 200,000 tonnes p.a. The largest of the new plants to go into production during 2008 was that owned by Clifford Jones Timber who started producing in the autumn at Ruthin, North Wales with a total production capacity of 30,000.

This upward trend in pellet production capacity is set to continue during 2009. Balcas are due to start manufacturing pellets at Invergordon in Scotland during 2009 (capacity 100,000 tonnes) and Land Energy also have plans to start manufacturing up to 50,000 from a plant in North Yorkshire. If these and plans for smaller pellet plants in the UK come to fruition in 2009 the UK’s pellet manufacturing pellet capacity is set almost to double. What the actual utilisation of this capacity might be is harder to ascertain and will depend on (amongst others) the supply of raw material and the overall demand for pellets.

In terms of geographical spread it is notable that little of this production capacity exists in the South East or the Midlands regions of England. Only one small producer exists in the South East, Harvest Wood Fuels, despite the South East incorporating some of the most wooded counties in England (i.e. Surrey and West Sussex).

It is notable that since the start of the Pellets@las there has been a substantial increase in the number of companies supplying pellets across the UK and Ireland, with a number of companies (such as Forever Fuels) investing in specialist lorries to facilitate bulk deliveries of blown pellets, the cheapest way for consumers to buy pellets. With this growth in the fuel supply infrastructure the pellet market in the UK is gradually maturing to the point that pellets can be sourced with confidence no matter where one is located in the country.

### 2.3 Pellet Prices

As part of Pellets@las weighted UK price data NEF has collected quarterly price data in Euros since July 2007, with the last data collection being undertaken in December 2008 (see the graph below). It is notable from the graph (which is based on a delivery of 5 tonnes including the cost of delivery up to a 50km radius and VAT at the domestic rate of 5%) that the price of loose pellets over the last year has fluctuated between £146 and £163 a tonne. This in part can be explained by variations in the companies who have participated in the project and partly (particularly in relation to December 08) to the fact that the price data is collected in Euros and the value of the Euro against the pound has increased substantially toward the end of 2008.

Although there will be regional variations in prices not shown by the weighted average, it is worth noting that the cost of pellets (particularly when bought loose) is cheaper than fossil fuels, such as oil or gas. At £150 a tonne the cost of heating with pellets is 3.13p/kWh (based on pellets at 4,800kWh/t) and at £200 a tonne 4.2p/kWh substantially cheaper than heating with oil or LPG. For further information on how the cost of heating with pellets compares with other domestic heating fuels go to the Biomass Energy Centre website at http://www.biomassenergycentre.org.uk/portal/page?_pageid=75,59188&_dad=portal&_schema=PORTAL
Prices for the cost of bagged pellets are shown in the graph below. These prices do not include the cost of delivery (although do include VAT at 5%) and are therefore not as different from the cost of loose pellets as one might at first expect.
3. Current Legislation and Regulations for Wood Pellet Appliances

This chapter provides an overview of the current legislation in place surrounding the installation and operation of wood pellet appliances. It is intended as a guide only. Please see the relevant sources referred to in this document for a complete view of the relevant legislation concerning wood pellet appliances.

3.1 Background

Heating Installations
Regulatory authorities are involved in controlling heating installations (whether biomass or otherwise) if the rated output of the plant is greater than 0.4MW. Between 0.4MW and 3MW the local authority (i.e. Local Government) is the regulatory authority. If the plant is over 3MW the Environment Agency is the regulatory authority under the Pollution Prevention and Control Act 1999. This is best illustrated by this very useful slide, from a presentation given by the Carbon Trust. MBP will fall into 2, Waste or Waste Derived Biomass. Part A1 of the Pollution Prevention and Control (PPC) Act relates to Energy Industry Combustion Activities. Emissions to all environmental media must be controlled from Part A1 and A2 installations and such installations are also required to account for energy efficiency and to control against Noise Pollution.

![Figure 2.1. Pollution Prevention and Control Legislation applicable to wood pellets [1]](image)

PPC the companies regulated are required to measure emissions from their chimney-stacks. This permission from either the Local Authority or Environment Agency usually comes in the form of a permit, which usually requires the monitoring of emissions. Businesses either monitor their emissions all the time, known as continuous monitoring, or at times defined in their permit, known as spot tests or periodic monitoring. In both cases they must meet our quality requirements.
Large Combustion Plant Directive
The revised Large Combustion Plant Directive (LCPD) is also important since this establishes emission limit values (ELVs) for new and existing plant, in addition to making further provisions for pollution inventory reporting in support of the European Pollutant Emission Register (EPER) requirements. Under this legislation, existing combustion plant must either observe lower emission limits, or achieve equivalent emission reductions via a national emissions reduction plan, by 2008, unless it is intended to close the plant after a further 20,000 operating hours between 2008 and the end of 2015. Plant that is upgraded to meet the Part A Emission Limit Values, defined in the Annexes of the Directive, is ‘opted in’. Plant that is designated for eventual closure is ‘opted out’. It is anticipated that many of the existing coal fired stations will opt out rather than invest in the technology that would enable them to meet the ELVs which will consequently have the effect of reducing the quantity of pellets co-fired in the UK.

Smoke Control Areas
As can be seen from the diagram above under 0.4MW (or 20MW in the case of Biomass Fuels) no regulatory authority is involved unless the plant is in a smokeless zone. It is an offence to emit smoke from a chimney of a building, from a furnace or from any fixed boiler if located in a designated smoke control area. It is also an offence to acquire an "unauthorised fuel" for use within a smoke control area unless it is used in an "exempt" appliance ("exempted" from the controls which generally apply in the smoke control area). Smoke control areas cover about 50% of the UK (mostly in urban areas which formally had a problem with smog formation as a result of burning coal).

Exempt Appliances
Exempt appliances are appliances (ovens, wood burners and stoves) which have been exempted by Statutory Instruments (Orders) under the Clean Air Act 1993 or Clean Air (Northern Ireland) Order 1981. These have passed tests to confirm that they are capable of burning an unauthorised or inherently smoky solid fuel without emitting smoke. For a list of exempt appliances please go to http://www.uksmokecontrolareas.co.uk/appliances.php.

A list of authorised fuels can be found at http://www.uksmokecontrolareas.co.uk/fuels.php.

Authorised fuels can be used in a non exempt appliance in smoke control zone, however pellets are not an authorised fuel – most of the authorised fuels are coke, briquettes for fire logs made by one of a number of manufacturers.
3.2 Building Regulations and Wood Pellet Appliances

The building regulations that control the installation of wood pellet appliances (and all solid fuel appliances) are as follows:

<table>
<thead>
<tr>
<th>Approved Documents</th>
<th>Subject Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part A</td>
<td>Structure</td>
</tr>
<tr>
<td>Part B</td>
<td>Fire Safety</td>
</tr>
<tr>
<td>Part C</td>
<td>Site Preparation and resistance to contaminants and moisture</td>
</tr>
<tr>
<td>Part E</td>
<td>Resistance to passage of sound</td>
</tr>
<tr>
<td>Part F</td>
<td>Ventilation</td>
</tr>
<tr>
<td>Part G</td>
<td>Hygiene</td>
</tr>
<tr>
<td>Part J</td>
<td>Heat Producing Appliances</td>
</tr>
<tr>
<td>Part L</td>
<td>Conservation of Energy</td>
</tr>
<tr>
<td>Part P</td>
<td>Electrical Safety</td>
</tr>
</tbody>
</table>

Each of these documents can be accessed at:

3.3 References

4. Production technique

This chapter describes the production techniques for wood pellet production from the point the raw material is received at the pelletising factory to the point the manufactured pellets are completed.

4.1 Raw material

The main raw material for the production of pellets in the UK is sawdust produced as a by-product, either from a sawmilling operation (e.g. Balcas and Clifford Jones Timber) or the manufacture of wooden structures (the Briquette and Pellet Company). The increased demand for raw material has caused wood pellet manufacturers to start drying and pulverising whole tree trunks, to ensure sufficient raw material.

Both wood from deciduous and coniferous trees can be used for the manufacturing of wood pellets. In a single production process wood from coniferous trees typically makes up 70 to 95% of the raw material and wood from deciduous trees the remainder.

Often the cleaned raw material is mixed from several kinds of wood to ensure a homogeneous lignin content. As lignin binds the pellets together and as the amount of lignin varies between different types of trees (hard wood normally has a lower content of lignin than soft wood) it is very important to ensure that the mix is as even and homogeneous as possible. The use of uneven material increases the risk of interruptions during the pressing process.

Other producers in the UK e.g. Wood Pellet Energy UK make use of clean recycled wood to produce wood pellets. Recycled wood often has a relatively low lignin content and therefore an additive is required to ensure that the pellets do not crumble into fines. Natural binders such as potato starch and maize or vegetable oil may be used. Pellets produced from recycled wood are more often used for co-firing or in large commercial boilers than in domestic stoves or boilers due to the high quality requirements of most pellet stove and boilers.

Two producers in the UK (Charles Jackson and Agripellets) produce pellets from straw for industrial use. In future other forms of biomass maybe pelletised for use as a fuel (primarily for co-firing), although energy crops like miscanthus are more likely to be formed into something slightly larger than a pellet (defined as less than 25mm in diameter).

4.2 The Pelletising Process

From the point the raw material is received at the pelletising factory to the point that the pellets are ready to deliver, the raw material goes through three processes - grinding, pelletising and cooling – see figure 5.1 for details.
**Figure 3.1. Flow diagram of the pelletising process [1]**

**Drying**
The content of water in the raw material must be about 10 % before the pelletising process begins. If the content of water in the raw material is too high, it has to be dried. The drying is of high importance for the final product, since raw material with a water content higher than 15 % is difficult to pelletise. The extent to which a material needs to be dried before pelleting makes a big difference to the energy required in the manufacture of wood pellets. It is worth ensuring that any steam used in the process is recycled and trying to ensure that the drying process is itself powered using a renewable source of energy such as wood, which the manufacturer may well have close at hand.

**Cleansing**
On delivery of the raw material to the pelletising factory unwanted material, for example metal, is removed with the help of magnets and a screen. This is particularly important when using recycled wood.

** Grinding**
After this the raw material is ground in a hammer mill – see figure 5.2. The resulting wood flour is then separated in a cyclone, alternatively in a filter. The grinding is necessary because the raw material, at delivery can be very heterogeneous in size (although it will typically be below 5 mm in diameter).
Figure 3.2. The hammer mill pulverises and homogenises shavings/chips and sawdust [1]

Pressing
Before the wood pellets are pressed, 1-2 % of water in the form of steam is supplied to the raw material, which is thereby heated to approximately 70 °C. The heating ensures that the content of lignin in the wood is released and this contributes to the increased binding of the particles together in the final product. The now softened lignin and wood dust is then transported to the pellet press.

The pelletising process is illustrated in figure 5.3 (a) and (b). The raw material lies in a layer in front of a rolling press, which presses the material down into the die block. When the rolling press is once again rolled over the hole, new material is pressed into the hole, thereby compressing the raw material into pellets.

Figure 3.3. Pelletising principle (a) and compressing relation (b) – the compressing conditions = $d/(L+2l)$. [2]
Six conditions are important for successful pressing – and thus the quality of the pellets [3]:

- The correlation between the qualities of the raw material, the compressing capacity of the machine and the compressing process;
- The friction capacity of the die block;
- The surface and the material of the die block and the rolling press
- The length and diameter of the holes in the die block – figure 5.3 (b);
- The thickness of the layer of raw material above the die block and thereby the thickness of the material that is pressed into the block; and
- The frequency of the compression – i.e. the speed of rotation.

The distance between the die block and the rolling press has an influence on the quality of the pellets, the wear on the machine and the consumption of energy in the process. Tests have shown that an increase in the distance from 0 to 1 mm causes a 20 % higher consumption of energy, but at the same time reduces the volume of dust by 30 % [4].

Figure 3.4. Pelletising machine with ring die block. The raw material is led into the drum, where one or more rolling presses press the material through cylindrical holes in the die block. On the outside of the die block the pellets are cut into suitable lengths [4].

Die blocks
Pelletising is done using a machine either with a die block in the shape of a ring (figure 5.4) or with a plane type die block (figure 5.5). The raw material is led into the drum, where one or more rolling presses press the raw material into pellets through cylindrical holes in the die block. When the pellets have passed through the block they are cut or broken into suitable lengths.
The raw material is led into the drum, where one or more roller presses press the material into pellets through cylindrical holes in the die block. On the outside of the block the pellets are cut in to suitable lengths [4].

Die blocks can be changed, so that the diameter of the cylindrical holes can be altered, and in this way pellets of different lengths can be produced. Each production unit will however always have the same diameter. In the UK the diameter is typically 6 mm.

The pressing process increases the temperature of the raw material even more. The necessary pressure level in the die block depends amongst other things on the type of raw material. In general, increasing the content of hard wood in the raw material will increase the demand for pressure in the pelletising process. Material that requires a higher pressure than the one actually used, may block the holes in the die block and thereby interrupting the pelletising process.

Cooling
The still warm and elastic pellets are transported to a cooling device to be cooled to just above room temperature. The cooling increases the durability of the pellets, and this decreases the formation of dust during the following transportation and handling.

During counter-current cooling pellets and cooling air are moved towards each another so that warm air is used to cool the warmest pellets and vice versa – see figure 5.6. The counter-current cooling gives a gradual cooling of the pellets, which reduces the amount of heat stress that the pellets are exposed to (which may decrease the quality of the product).

Dust removal
After cooling the pellets are screened in order to remove dust and fine particles formed during the production process. The pellets are then stored loose or packed in bags and the residue is recycled back into the production process.
4.3 References

[1] Illustration from Sprout-Matador, Glentevej 5-7, 6705 Esbjerg


5. Fuel Quality

The quality of fuel pellets may vary considerably. Factors that have an influence on pellet quality include the raw material, durability and water content. The quality of the wood pellets can be difficult to assess and therefore the consumer should make sure that the manufacturer delivers a product that meets a series of minimum standards. This chapter describes:

- Different types of fuel pellets
- The influence of the wood pellet quality on distribution, handling, combustion, environment and economy
- Demands on the quality of wood pellets
- Tools for the consumer to evaluate the quality of wood pellets
- Future developments in standardisation and certification

5.1 Types of fuel pellets

The dimensions of fuel pellets vary between 3 and 25 mm in diameter depending on the die block that is used in production. The length generally varies between 5 and 40 mm. If the product exceeds 25 mm in diameter it is called a briquette – see figure 6.1.

Figure 4.1. The dimensions of fuel pellets vary between 3 and 25 mm in diameter depending on the die block that is used in production. When the diameter is more than 25 mm the product is categorised as a briquette.

6mm typical
In the UK the most common product sold are 6 and 8 mm pellets. Pellets from the same lot will have the same diameter which gives a very homogenous product that is easy to handle.

Alternative raw material
In the main, pellets produced in the UK are manufactured both from native and foreign wood. With an increase in pellet consumption the production of fuel pellets from materials other than wood has become increasingly relevant e.g. straw.
5.2 The importance of the quality to the consumer

Heating with wood pellets is normally quite simple and the need for inspection and care of the burner and boiler is often limited. However, combustion problems can arise e.g. if the amount of ash increases causing the system to slag and the efficiency to decrease. These problems are often caused by wood pellets of low quality or by the wrong choice of plant or system settings.

*The quality of pellets may vary*

In periods where there is a lack of raw material available to the manufacturer of wood pellets, a variable fuel quality is often seen, since the manufacturers are forced to buy what they can get – see figure 6.2.

![Figure 4.2. Wood pellets of four different qualities. The wood pellets in the lower right corner are of a good quality without dust, produced from clean and dry wood. The pellets in the lower left corner are a mix of pellets produced from two different types of raw material. This mix has caused heavy, glass like slag formation in a small boiler because of the lower melting point of the ash. The dark pellets in the top left corner created porous cinders which caused the ash screw conveyor in a small boiler system to block up. The pellets in the top right corner had a very high content of dust and fine particles on delivery to the consumer. These pellets formed a bridge in the feeding system resulting in poor combustion. [1]](image)

If the pellets are dark it can be because they contain a dark type of wood or bark, but it may also be caused by blackened wood, caused by an intense drying of a wet/humid raw material.
Low quality pellets cause combustion problems

The varying quality of wood pellets has created problems for users with smaller boiler systems. Several have complained about combustion problems in systems which up till then had worked fine. Figure 6.3 sets out some examples of combustion problems and their possible fuel related reason.

<table>
<thead>
<tr>
<th>Problem</th>
<th>The reason might be that wood pellets:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A lot of ash in the boiler</td>
<td>- contains raw materials such as bark, seed residues or other biomass with a higher content of ash than clean wood</td>
</tr>
<tr>
<td></td>
<td>- contains additives like dirt or sand</td>
</tr>
<tr>
<td></td>
<td>- contains waste products</td>
</tr>
<tr>
<td>Slagging in the boiler</td>
<td>- contains raw material like bark, seed residues or other biomass with a low ash melting point</td>
</tr>
<tr>
<td></td>
<td>- contains additives or impurities like dirt or sand</td>
</tr>
<tr>
<td></td>
<td>- contains waste products</td>
</tr>
<tr>
<td>Deposits and corrosion</td>
<td>- contains biomass other than clean wood or other materials with a considerable level of volatile components such as sulphur and chlorine</td>
</tr>
<tr>
<td>Poor combustion</td>
<td>- have too high a content of dust</td>
</tr>
<tr>
<td></td>
<td>- have too high a moisture content</td>
</tr>
</tbody>
</table>

Figure 4.3. Examples of heating technical problems and their possible fuel related cause [1]

5.3 Quality demands

Legal requirements

A number of European Pellet Standards are in existence. A pan European standard CEN/TC 335 for biomass is also being developed and will replace the voluntary UK standard for premium pellets as developed by British Biogen before it merged with the Renewable Energy Association.

At present in the UK the categorisation for premium pellets are:

- Size between 4 & 20mm
- Ash content either <1% (Low), <3% (Standard) or <6% (High) to be clearly labelled
- Moisture content below 10% Calorific value > 4.7kWh/kg
- Bulk density > 600kg/m Sulphur content < 300ppm, Chlorine <800ppm
- Only additives lignin and trace amounts of vegetable oil as a die lubricant
Dust content requirements
An important factor for the quality of the fuel pellets is the content of dust in the product. Dust can arise during the production of the pellets, handling at the plant and during transportation. Dust that arises during production is normally removed by the manufacturer, but other sources of dust can cause problems. The dust hinders the pellets from moving, which can lead to bridge formation over the screw conveyor in the pellet silo. Dust and pellets are easily separated during handling and storage. This gives a heterogeneous material which causes an uneven fuel supply. Normally, the smaller the plant the more sensitive it is to pellet dust.

In all, the total amount of dust in the pellets should not exceed 8%, but because of the uneven deposition of the pellets and dust it is extremely difficult to stay under this level [3].

Durability requirements:
The durability of fuel pellets is of high importance to the consumer. Wood pellets with a low durability are particularly sensitive to mechanical stress during transportation and when handled by the consumer, which results in the formation of dust. The durability is amongst other things determined by the content of lignin and water and how hard the pellets were pressed. As moisture content has a great influence on durability pellets must be stored in a dry place.

Importance of water content
The content of water in the pellets is often between 5-10% of total weight. The water content of wood pellets is significant to the heating value, which in wood pellets often lies between 4.7 and 5.0 MWh/tonne wood pellets [4]. The large variation in water content which occurs in wood chips, does not occur in wood pellets. This is because it is not possible to pelletise material with a water content above 15%. Furthermore, the pellets will swell and fall apart if they are exposed to humidity after pressing.

5.4 Controlling and securing quality

Many conditions such as raw material, production process, distribution and storage conditions determine whether wood pellets reach the consumer in peak condition. Since no standards apply to wood pellets in Denmark at the moment the following recommendations are given to the consumer when buying wood pellets for usage in small heating systems [1]:

- Demand a guarantee that the wood pellets are made from clean wood;
- Demand a guarantee that the wood pellets meet UK standards;
- Demand a fuel specification for the wood pellets and a guarantee that the pellets delivered meet this specification;
- Demand a guarantee that the wood pellets can be returned and that the supplier covers all expenses, if the above mentioned guarantees are not respected.
A fuel specification should include information relating to diameter, effective heating value, specific weight and the content of water, ash and sulphur.

In addition to this the quality of wood pellets can be tested using some simple criteria:

- The smell when burning should be the same as when burning wood;
- The colour should be woody;
- The specific weight has to be approx. 0.65 kg per litre;
- The wood pellets have to be without additives;
- Content of water < 12 %;
- The wood pellets should not contain too much dust.

Each criterion is tested as follows:

**The Smell Test**
During burning the smoke should smell like burning firewood. If the smoke smells differently, the wood pellets should be given a closer examination.

**The Colour Test**
The pellets should have a homogenous woody colour. The colour can vary depending on the type of wood used or if the wood was mixed with ground bark. The outside of the pellet might be dark brown because of singeing during the production process. The pellets may not contain particles that obviously do not have a woody colour. This kind of particle might come from paint, laminate, plastic and so on.

**The Specific Weight Test**
The Specific Weight (SW) of wood pellets depends on how much the pellets have been pressed. Good pellets have a SW of between 0.6 and 0.7 kg per litre. The SW can be found in the following way:-

Place a container of approx. 1 litre on a kitchen scale and note the weight. Fill the container with water and weigh it again and note the weight. The difference between the two weights gives the weight of the water. Wipe the container carefully and fill it with a level measure of pellets. Weigh the container with the pellets and note the weight. The difference between the weight of the container and pellets and the unloaded weight of the container is the total pellet weight.

The SW can be calculated with the following formula:

\[
\text{SW (kg/litre)} = \frac{(\text{total weight of pellets} - \text{weight of container})}{(\text{total weight of water} - \text{weight of container})}
\]

**The Additive Test:**
Pellets with no additives fall apart when wet. Eventual content of additives can be revealed by placing some pellets in a glass of water. If the pellets fall apart within a few minutes, there is only a small risk that the pellets contain additives.

**The Water Content Test**
Since the pellets fall apart at a moisture content of above 12-15 %, it is easy for the consumer to evaluate the quality of a product when it comes to water content: if the
pellets are disintegrating the water content is too high or the production pressure has been too low.

If a drying oven is at hand, the user can choose to determine the exact percentage of moisture. However, as a general rule the water content will be low (between 5-10 %), so it is acceptable not to check the content of water of each delivery.

The percentage of moisture is defined as the mass of water in the sample, expressed as percentage of the mass of moist material [6] and can be determined in the following manner: Weigh out approx. 1 kg of pellets with 0.1 gram accuracy and note the weight. Dry the pellets in an oven to a constant weight of 105 °C ± 2°C, weigh the pellets and note the exact weight. A constant weight is achieved when the weight of a sample does not changed more than 0.1 % between two successive weighs with an interval of 1 hour.

The percentage of moisture is calculated using the following formula:

\[
\text{Percentage of moisture} = \frac{\text{moist sample (g)} - \text{dry sample (g)}}{\text{moist sample (g)}} \times 100
\]

Dust Test

The dust which causes the consumer a problem is that which arises during transportation and the handling of pellets at his premises. The dust content can be difficult to check because of the uneven distribution of dust throughout a delivery of pellets. One way round this is to demand a guarantee from the producer that the pellets delivered do not contain too high a content of dust.

If there is doubt about the quality of a product, a durability test should be considered. This will calculate the amount of dust. There are a number of instruments that can determine the durability of wood pellets, but since these instruments are expensive to acquire, the best option will often be to have the testing done at a laboratory which specialises in the quality control of wood pellets.

The durability test is performed by exposing a pellet sample, cleaned of dust, to a rough processing in a test instrument – see figure 6.4. The type of instrument and the marginal value of what can be accepted vary depending on what standard is used for the test. The content of dust is calculated as follows:

\[
\text{Dust} = 100 \times \frac{\text{weight of pellets (before the test)} - \text{weight of pellets (after the test)}}{\text{Weight of pellets (before the test)}}
\]

Figure 4.4. Instrument for the determination of the durability of wood pellets (Borregaard L T II). This instrument is used in the Austrian standard of wood pellets.
5.5 Analysis-parameter of wood pellets

In addition to the possibility of the consumer checking pellet quality, pellets can be analysed at an accredited laboratory.

In figure 6.5 the most important analysis-parameters of wood pellets are stated based on an economic and application-technical view. Figure 6.5 sets out the general parameters of clean, Danish wood pellets (with no binding material or other additives). It also sets out the importance of deviance from these typical levels – from the view of the user.

<table>
<thead>
<tr>
<th>Analysis parameter</th>
<th>Typical level</th>
<th>Significance of deviance from typical level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>5-10</td>
<td>- The higher the water content, the lower the energy content</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- With a very high water content (&gt; 15 %) there is a risk of biological decomposition</td>
</tr>
<tr>
<td>Ash, 550ºC</td>
<td>0.2-1.5</td>
<td>- A higher content indicates content of foreign material (additives, dirt, other waste-material and so on)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- A higher content leads to a risk of slagging</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- A higher content requires the disposal of larger amounts of ash</td>
</tr>
<tr>
<td>Sulphur</td>
<td>&lt;0.02-0.08</td>
<td>- Content &gt; 0.05 weight%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Content &gt; 0.1 weight% db indicates content of foreign material (for example a sulphurous binder) or other waste material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Content &gt; 0.1 weight% db gives rise to a risk of slagging (formation of gypsum)</td>
</tr>
<tr>
<td>Effective heating values MJ/kg ar</td>
<td>1.9 – 18.6</td>
<td>- Poor combustion quality (if outside the parameters of the plant design)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Poor economy (if below supplier-guarantee)</td>
</tr>
<tr>
<td>Effective heating values MJ/kg daf</td>
<td>18.8 – 19.8</td>
<td>- Deviant values can be an indicator combustible materials other than wood</td>
</tr>
<tr>
<td>Ash melting conditions</td>
<td></td>
<td>- At lower values for the three characteristic temperatures there is a potential risk of slagging and/or the formation of a coating (depending on the actual operating conditions and the design of the plant)</td>
</tr>
<tr>
<td>for example cf. ISO 540:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Softening temp.</td>
<td>1200 - 1400</td>
<td></td>
</tr>
<tr>
<td>Hemisphere temp.</td>
<td>1200 - &gt;1500</td>
<td></td>
</tr>
<tr>
<td>Floating temp.</td>
<td>1300 - &gt; 1500</td>
<td></td>
</tr>
<tr>
<td>Dust</td>
<td>&lt; 8</td>
<td>- At higher content there is a risk of handling-problems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- At higher content there is a risk of poor combustion</td>
</tr>
<tr>
<td>Specific weight</td>
<td>600-700</td>
<td>- Poor economy (at delivery on the basis of volume)</td>
</tr>
</tbody>
</table>

Figure 6.5. Description of the analysis-parameters for wood pellets [4]
ar: “as received” – the value is on existing wet fuel basis
db: “dry basis” – the value is converted to dry fuel basis
daf: “dry ash free” – the value is converted into a water and ash free basis
5.6 References

6. Distribution of wood pellets

In this chapter an evaluation of each of the different types of wood pellet delivery are presented with an evaluation of the advantages and disadvantages of each followed by a short description of the distribution circumstances in the UK.

6.1 Types of delivery

The great advantage of fuel pellets over other types of biofuels is that they can be transported both loose and packed in bags, which makes them easy to distribute. Depending on the volume to be bought, one of the following methods of packaging and transportation can be used:

- Small bags with a maximum weight of 25 kg (most commonly 10 to 15 kg);
- Big bags of up to 1200 kg;
- Blower lorry;
- Tipped off;
- Personal collection.

6.1.1 Bags

Wood pellets can be delivered in small bags typically from 10 kg to 25 kg. Small bags are the most expensive way to buy pellets because of the costs of the bag itself, filling it up and distribution. Large quantities of pellets in bags are usually delivered on pallets weighing up to one tonne. Delivering on pallets means that no specialised equipment is needed to transport the pellets.

However, it should be noted that many companies in the UK will use third party hauliers to deliver pallet loads of small bags. These third party hauliers generally offer a kerbside service only and there is no guarantee that the haulier will take the pellet to the fuel store. This means that the customer might themselves have to break up the pallet and move the individual bags to the store. It should also be noted that some companies in the UK do not sell individual bags of pellets, but will sell only a minimum of one tonne at a time due to the additional costs involved in breaking down individual pallets both in terms of labour and transport costs.

Figure 5.1 Delivery of small bagged pellets by lorry on pallets
Advantages of bags
The advantages of the bags are that they are easy to handle and do not need specialised storage facilities as long as the storeroom is dry. In order to minimise delivery costs some consumers fetch bags of pellets from the supplier in their own car. However, some suppliers are unable to allow this for health and safety reasons. It is always sensible to check with an individual supplier whether personal collection is permitted.

6.1.2 Big bags
Delivery in big bags is a type of delivery that is fairly widespread within the agricultural sector, among others for the delivery of fertiliser and grain products. For delivery of wood pellets the use of big bags has not become widespread. This is due to the fact that only a few private consumers have the equipment necessary (such as a front-end loader or a fork-lift) for moving bags that weigh up to 1200 kg each – see figure 5.2.

Figure 5.2. Wood pellets in bags are primarily used by private consumers [1]

Figure 5.3. Big bags demand lifting equipment to handle [2]
Space Demand
At the same time it requires a large space and room height in the boiler room and the fuel store to be able to use a front-end loader or the fork-lift to empty the bags into the storage area. Delivery in big bags is a bit cheaper than delivery in small bags, but it is still more expensive than delivery by a blower lorry or in loose weight.

6.1.3 Blower lorry
Delivery by blower lorry is a fairly cheap type of delivery compared to delivery in bags. Even though it still makes some demands of the storage room, delivery by blower lorry is by far the most preferred type of delivery in the UK, although delivery by this method is not yet available across the whole of the UK. A blower lorry contains approx. 15 tonnes of wood pellets and normally the smallest quantity that can be delivered is 3 tonnes. It is worth noting that the delivery cost is often the same, whatever the volume being delivered so it makes sense for the customer to take larger deliveries if at all possible.

Storage Demand
This naturally means that the pellet silo must be able to hold a minimum of 3 tonnes of pellets. The fuel store must be fitted with an inlet and outlet with stortz 110A couplings for use by the blower lorry. The outlet enables the attachment of a dust bag so that the dust created by a delivery will on the most part be removed from the store. Customers should also bear in mind that periodically they will need to clear out the fuel store as there will be an accumulation of dust which builds up over a number of deliveries. Additionally the fuel store should have soft sides or some kind of impact matt to absorb the force of the pellets as they are blown in rather than allowing them to smash into a wall etc.

An important point to note when ordering pellets is that it is not possible to utilise all of the available space of the store as it is not possible to fill to the very top of the store and the bottom of the store will have to be angled (typically greater than 35% as this is the angle of repose of pellets) to enable the pellets to flow. Typically, a customer might be able to utilise around 75% of their available space, so that 10m³ would give storage for approximately 5.5 tonnes of pellets (assuming a typical bulk density of 650kg/m³). It should also be remembered that the store may not be completely empty by the time a new load of pellets is delivered.

Customers should be careful only to order what they can fit in their store as it is likely that they will have to pay for what they ordered in any event.

Carriage conditions
For the delivery by blower lorry the access road to the consumer needs to be designed in a way that enables the supplier to park without problems within 15 to 20 meters of the connection to the pellet silo. The actual maximum distance should be checked with the supplier prior to delivery if there is any concern about this. It should be noted that the further the pellets have to be blown, the harder it is to maintain their integrity. It is the customers responsibility to ensure that the store is ready to accept a delivery. Many boilers need to be switched off prior to a delivery and that is also the responsibility of the customer. The reason for this is that there are too many different boilers and systems for the delivery drivers to be trained up on all of them to enable him to switch off and on again.
Placement of the connection
The connection has to be placed at an appropriate working height, ideally not more than 150cm unless a secure platform is installed. In order to limit the wear on the pellets and thereby the amount of dust, the tubing system should have as few bends as possible, and where they do exist the pipe should have a radius of at least 500mm. The installation of vertical pipes should also be minimised due to the greater delivery pressure required which will cause more degradation of the pellets. To prevent dust being blown in to other parts of the building, the fuel store should be sealed and an outlet installed so that the only place for the dust to go is through the outlet.

Figure 5.4 Delivery by blower lorry is the preferred method of delivery for wood pellets [3]

Advantages of blower lorries
The advantage of delivery by blower lorry is that the wood pellets do not have to be handled manually at delivery. There is also no demand for the storage room to be readily accessible, since the blower lorry can easily blow the wood pellets into a remote storage site, for example an attic or a silo.

Disadvantages of blower lorries
When pellets are delivered by blower some safety considerations need be taken into account:
- The supplier checks whether the storage facility meets safety requirements before the pellets are blown in
- The supplier checks whether the boiler is out of action, since low pressure in the storage can cause burn back.

6.1.4 Loose weight by truck
A simpler type of transportation of fuel pellets is loose pellets carried on a tipper lorry. For this type of delivery it needs to be possible to tip the pellets directly into the consumer’s pellet storage facility. Opinions differ as to which method of delivering loose pellets (tipper or blower lorry) causes the least harm to the pellets. The tipper lorry can reduce the wear on the pellets and at the same time both the time it takes to unload the pellets and the noise nuisance are reduced. In order to avoid rain soaking the pellets the tipper truck has to be covered as does the delivery area which can be difficult to achieve.
Delivery price
The cheapest way to have the wood pellets delivered is by a normal tipper lorry. The price of delivery by tipper lorry is only approximately one third of the price of delivery by blower lorry. A fully loaded lorry with trailer contains approx. 30 tonnes of wood pellets and this type of delivery is therefore only used by large consumers that have the necessary fuel handling system for moving the wood pellets to the desired storage rooms at their disposal. The typical consumers are heating plants and combined heat and power plants, which have been designed to use biofuels.

![Figure 5.5 Loose Wood pellets [1]](image)

The condition of the consumer’s access road
The condition of the consumer’s access road is of very high importance. The tipper truck model is most suitable for larger plants, where normally there is no problem with the entrance to the pellet storage space. When the pellets are delivered by tipper truck some things should be considered:

- That delivery takes place at a time of the day when few residents will be disturbed – for example late in the morning
- That when planning the storage and the orientation of the opening the fact that dust-emissions will occur during delivery of fuel is considered.
- That fuel waste is removed after tipping, in order to maintain a good reputation and avoid eventual problems with residents or others.

6.1.5 Personal Collection
The final option is for the consumer to collect the pellets himself from the producer. This is possible for both bagged and loose pellets, but not from all suppliers due to health and safety concerns.

This type of transportation is simple and is suitable for smaller and middle-sized private plants. The consumer can fetch the pellets as needed, although he should be aware - as with transportation by lorry - that the pellets have to be covered to avoid soaking. There are some health problems with dust associated with working with pellets, and it is important to be aware of these.
6.2 References

[1] Illustration from Balcas, Enniskillen, Northern Ireland
[2] Illustration from EcoNordic, Islandsvej 8, 7480 Vildbjerg
[5] Illustration from Dansk Shell, Nærum Hovedgade 6, 2850 Nærum
[6] NEF would like to express thanks to Forever Fuels for their contribution to this Chapter (see http://www.forever-fuels.com/)
7. Combustion of wood pellets

This chapter describes the theory of wood pellet combustion.

7.1 The combustion phases

There are more or less four consecutive phases to burning pellets:

- Drying and evaporation of water
- Gasification (pyrolysis)
- Gas combustion
- Coke burnout

When combusting wood pellets, approximately 80% of the energy is released as gas, and approximately 20% is released from the remaining coke.

![Diagram of combustion process]

Figure 6.1. Combustion of a wood pellet. The fresh wood pellet goes through drying and gasification, whereby the flames are created. The pellet is burned out leaving ash behind. [1]

Drying

When a portion of wood pellets are being fed into a combustion chamber where combustion is already taking place, the heat from the combustion will make the water which is contained in the wood pellets evaporate. This evaporation demands heat. The heat is taken from the combustion already in progress. Since the water content of wood pellets is relatively low, this phase will quickly pass into the gasification phase.

Gasification (pyrolysis)

With further heating the wood pellets start to emit gases. At approximately 270 °C gasification will produce the heat necessary to continue the process. Carbon monoxide (CO), hydrogen (H₂) and methane (CH₄) are created along with other hydrocarbons.
Gas combustion
If there is sufficient oxygen present the gases will be ignited when they reach their ignition temperature. The hydrogen will react with oxygen and create water and the carbon of the hydrocarbons and the carbon monoxide will burn into carbon dioxide and water vapor. If the temperature is not high enough or there is not enough oxygen to feed the combustion, the gasses will be seen as smoke that will burst into flames, when the temperature or the inflow of oxygen is increased.

Burnout of coke?
When the wood has emitted all gases, the remaining carbon particles will burn out, helped by temperature, primary air and turbulence. There will be embers but almost no flames. The remaining ash residue consists primarily of incombustible minerals.

7.2 Heating value

The heating value is an indication of the amount of energy that a certain fuel contains. When calculating the heating value, one often assumes that the fuel is completely dry and that the ash is not included in the calculation. You are then talking about heating value on a dry and ash free basis (daf).

Heating value is usually described in megajoules per kilogram of fuel, shortened to MJ/kg or in gigajoules per ton (GJ/t). The fuel weight is stated inclusive of water content, which is why it is important to know the percentage of moisture that the stated heating value refers to. In practice it is the heating value and the water content of the fuel that is of most importance.

Wood has a heating value on a dry basis of 19.0 MJ/kg. If the water content is estimated at 7 % the heating value of wood pellets can roughly be calculated as

\[
19.0 - (0.2145 * 7) = 17.5 \text{ MJ/kg}
\]

7.3 The impact of the fuel on the plant technology

Water content
Dry wood has a high heating value and the heat from the combustion has to be diverted from the combustion chamber in order to prevent high temperatures damaging the plant. Wet wood has a lower heating value and the combustion chamber has to be insulated in order to keep the heat in and the combustion process going. This is typically done by insulating the combustion chamber with fireproof and heat insulating tiles.

Normally therefore the boiler will be designed to burn wood at a specific moisture content. Because of this wood pellets should only be used in a plant that has been designed to combust wood pellets. Likewise, other fuels should not be used in a plant that has been designed to burn wood pellets.

Ash
In wood pellets there are different impurities consisting of non-combustible components, namely ash. In itself, ash is undesirable, since it involves particle-purification of the flue gas and the disposal of ash and slag. The ash content in wood is caused by dirt and sand retained in the bark and from salts absorbed during the tree’s growth period.
Wood pellets have low ash content, often at around 0.5%. The ash consists partly of non-combustible minerals from the biomass and partly from mineral matter, sand and dirt that can be in the bark or be absorbed from the forest floor. Wood chips and firewood have an ash content of 0.5-3.0%, while straw can contain up to 8% ash. The ash content is important as it forms a part of the fuel that cannot be used for, since the ash does not give off heat, but on the contrary demands heat for its formation.

In the ash there are small amounts of heavy metals, which are a source of unwanted contamination, but the content of heavy metals are generally lower than in the ash from other solid fuels.

**Salts**

Wood pellets also contain salts that have an influence on the combustion process. The salts are mainly potassium and partly sodium. Potassium and sodium give a tacky ash, which are more likely to cover the surfaces of the boiler. The content of potassium and sodium in wood is normally so low that no problems occur when firing it through traditional heating technologies.

<table>
<thead>
<tr>
<th>% of dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
</tr>
<tr>
<td>Na</td>
</tr>
<tr>
<td>P</td>
</tr>
<tr>
<td>Ca</td>
</tr>
<tr>
<td>Mg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% of dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
</tr>
<tr>
<td>0.015</td>
</tr>
<tr>
<td>0.2</td>
</tr>
<tr>
<td>0.04</td>
</tr>
</tbody>
</table>

*Figure 6.2. Typical mineral fractions in wood chips stated in % of the dry matter of the wood. In comparison to straw the content of potassium in wood chips is approx. 10 times lower [2 and 3]*

When the ash is heated sufficiently the ash particles become soft and tacky. The temperature of softening varies between the different kinds of biofuel. For most wood fuels, including wood pellets, the softening temperature is approx. 1100 °C. If the ash particles in the flue gas are heated to more than 1100 °C, they will stick to the walls in the boiler unit and create an isolating layer which reduces the transfer of heat to the boiler water. This then demands frequent cleaning of the boiler piping and so on. On further heating the ash will melt completely and create slag, which is very difficult to remove.

**Volatile elements**

Wood pellets contain approximately 80% volatile elements (in % of dry matter). This means, that the component part of the wood during heating will release 80% of its weight as gasses, while the remaining part will be turned into charcoal. The high content of volatile elements means that combustion-air has to be added over the fuel bed (secondary air) where the actual combustion of gases takes place, and not under the fuel bed (primary air).
7.4 Combustion technique

An effective and complete combustion is a necessity for the effective utilisation of wood pellets as an environmentally friendly fuel. Besides ensuring a high energy efficiency the combustion process has to ensure, that there are no unwanted environmental components created.

Fundamentals for good combustion
In order to sustain combustion, certain fundamental conditions have to be met [4]:

- The effective mixing of fuel and oxygen (air) to ensure a certain ratio
- There has to be a radiation of heat from the fuel in the combustion chamber to the new fuel in order for the combustion process to proceed.

It is important to understand that gasses burn as flames and that solid particles smolder, and that during the combustion of wood 80 % of the energy is released as gas and the rest is released from the charcoal remains.

High mix of wood pellets and air during crushing
During the mixing of the fuel and the air it is important to achieve good contact between the oxygen in the air and the flammable components of the wood. The better the contact the quicker and better the combustion. If the fuel is a gas, as for example natural gas, the mixture is optimal because the two gaseous matters can be mixed in the exact proportions wanted. The combustion can proceed fast and it is easy to regulate as we can supply more or less fuel. In order to obtain approximately the same scenario with wood pellets it is necessary to grind the pellets into very small particle sizes (like flour). These fine particles will follow the movement of the air. A good mixture can thereby be obtained with combustion that resembles a gas or oil flame.

The combustion technology for wood pellets and other solid fuels is therefore more complex and more complicated than for example the combustion technology in a natural gas or oil-fired boiler.

The crushing of wood pellets and the production of wood dust is only used in to a limited extent. At Avedøre II, a Danish large CHP plant, the solution found has been to crush the wood pellets in coal mills with the resulting wood dust being used in dust-burners In order to burn pellets in this way it is necessary to have a power plant boiler which has a high rate of efficiency (and controllability) which can burn a large range of fuels.

7.4.1 Excess air

Excess air ($\lambda$)
For combustion to occur, fuel requires the presence of a given amount of air (oxygen). In the event of stoichiometric combustion (where all fuel is burned completely), the excess air figure $\lambda$ (lambda) equals 1.

If more air than is required is present, there will be oxygen in the flue gas and $\lambda$ is said to equal greater than 1 (e.g. when $\lambda$ equals 2, twice the amount of air required to combust the fuel is being supplied).
Typical excess air number
In practice combustion will always take place with an excess air figure higher than 1, since it is impossible to achieve complete combustion with a stoichiometric amount of air. In figure 6.3 the typical excess air figures are shown along with the corresponding oxygen content left in the flue gas.

<table>
<thead>
<tr>
<th></th>
<th>Air-surfus number, $\lambda$</th>
<th>O$_2$, dry (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fireplace, open</td>
<td>$&gt;$3</td>
<td>$&gt;$14</td>
</tr>
<tr>
<td>Wood stove</td>
<td>2.1-2.3 (should be 2.1 etc?)</td>
<td>11-12</td>
</tr>
<tr>
<td>District heating, wood chips</td>
<td>1.4-1.6</td>
<td>6-8</td>
</tr>
<tr>
<td>District heating, wood pellets</td>
<td>1.2-1.3</td>
<td>4-5</td>
</tr>
<tr>
<td>Power plant producing heat, wood dust</td>
<td>1.1-1.2</td>
<td>2-3</td>
</tr>
</tbody>
</table>

*Figure 6.3. Typical air-surfus numbers, $\lambda$, and the resulting air-content in the flue-gas [5]*

The excess air depends on combustion technology
The excess air figure is to a great extent dependent on the combustion technology and to some extent on the fuel. The amount of excess air when combusting wood pellets is typically lower than when combusting wood chips. The best combustion of wood fuels is attained at an excess air figure $\lambda$ of between 1.4 and 1.6. [6]

7.4.2 Combustion quality
The fuel influences the quality of combustion. At complete combustion only carbon dioxide and water are created. The wrong combination of fuel, plant type and supply of air can cause the bad utilisation of the fuel with consequential undesirable environmental effects.

Effective combustion requires:
- High temperature
- Surplus oxygen
- Retention time
- Mixing

In this way a low emission of carbon monoxide (CO), hydrocarbons and polyaromatic hydrocarbons (PAH) are ensured together with only a low content of unburned carbon in the ash. Unfortunately these very conditions (high temperature, high air surplus, long retention time) are the main reason for the creation of nitrous oxides (NO$_x$). Thus, the used technology should be so-called “low-NO$_x$”-i.e. technology which uses ways to reduce emissions of NO$_x$.

Apart from CO$_2$ and H$_2$O the flue gas will contain air (O$_2$, N$_2$ and Ar) and to a greater or lesser degree unwanted reaction-products such as CO, hydrocarbons, PAH, NO$_x$ and so on.

Because of the homogenous structure of wood pellets with a large surface area and a uniform water content it is easier to obtain a homogenous combustion than with firewood or wood chips.
7.5 Combustion of wood pellets in smaller plants

Wood pellets contain a high level of so-called volatile gases. In order to achieve an inflammable mixture these gases have to be mixed with oxygen. To ensure complete combustion and thereby the largest possible utilisation of the energy in the fuel, it is important that combustion air is supplied all the time, in the right amount and in the right place.

7.5.1 Combustion air
The correct supply of air is important
If sufficient air is not supplied some of the inflammable gasses will not get enough air to burn out and the flue gas will leave the chimney containing carbon monoxide (CO). If there is too much air the heating of the surplus air will require heat, and the flue gas will leave through the chimney with too high a temperature. A large surplus of air can also cause the flue gas to cool, so that the fuel does not burn out sufficiently.

Primary and secondary air
Besides a correct supply of air, a good mixing of air and gasses is necessary. This is achieved by supplying air partly early in the combustion zone (primary air) and partly later, where the air is mixed with the flue gas (secondary air). The mixing must happen before the gasses are cooled by passing the walls of the combustion chamber or by rarefaction with excess air.

Controlling the air supply
In wood stoves and small solid fuel boiler systems the air supply happens by natural draught produced by the warm flue gas going up through the chimney. By this means negative pressure is created in the combustion chamber and fresh air is drawn both as primary and secondary air.

In most heating plants for wood pellets the supply of combustion air happens artificially, either with an air-blower or with a flue-exhaust fan. Air supply and distribution between primary and secondary air is controlled either manually or by different kinds of automatic controls. The most advanced control of the combustion air happens with the help of a lambda probe in the flue gas duct. This probe registers the excess oxygen in the flue gas and regulates the air supply according to this.

To ensure the right air supply, the minimal vacuum in the flue gas duct given by the manufacturer - usually 10-20 pascal or 1-2 mm water column – must be respected. Because of the pressure difference over the tubing the vacuum in the combustion chamber of many boiler systems can be as low as 1-2 pascal.

7.5.2 Combustion temperature

Combustion temperature approx 900-1000 °C
The necessary combustion temperature, approximately 900-1000 °C, is sustained partly by the right design of the combustion chamber relative to the fired amount of wood pellets and partly by matching the amount of air to the amount of fuel that is used.
Too low combustion- temperature is unwanted
If the temperature in the combustion chamber is too low, there is a risk that some of the hydrocarbons (PAH) from the wood will go unburned through the chimney. Since PAHs are both harmful to health and can cause a smell-nuisance, it is important to avoid their emission. A consistently low smoke temperature smoke can also induce corrosion in boiler and flue gas ducting.

7.6 References

8. Combustion technology

Small combustion devices for wood pellets can be roughly divided into the following main types:

- Compact boiler systems where the fuel hopper, the combustion system and the boiler is in one integrated unit
- Pellet burner with an integrated hopper intended for installation on a boiler
- Pellet burner without a hopper
- Stoves with or without a back boiler

8.1 Compact boiler systems

Compact boilers, also called stoker boilers, are characterized by having a boiler, combustion system and fuel hopper built together into one compact unit. The whole unit is designed so that the single elements fit together. For example the hopper, combustion system and boiler are all designed to the same capacity, which is not always the case when installing a loose stoker on an existing boiler.

Figure 7.1. Typical compact boiler system where hopper, combustion system and boiler is built together into one unit [1]
Fuel types
Some compact boilers are designed to burn wood pellets, wood chips and grain. However, shifting between different fuel types normally requires an adaptation of the operating unit to the fuel it is intended to use.

As with other boilers systems that burn solid biofuel, the compact boiler system takes up more space - and costs more – than an oil fired boiler with the same output. If the compact boiler is chosen, it is a fairly comprehensive installation Compact boilers cost from £5,000 and up.

8.2 Loose stokers with integrated hopper

Another possibility for converting to wood pellets is to retrofit an existing boiler with a separate pellet burner. If the boiler is in good condition and the size and geometry of the combustion chamber makes it suitable for combustion of wood pellets, this can be a good solution, particularly where the existing boiler was used for burning coal (there are several UK schools in former coal mining areas which have had this conversion done).

An important condition to be fulfilled to make a retrofit system work satisfactorily is that the chosen pellet burner should be sized correctly so that it fits the capacity of the existing boiler.

Figure 7.2. A pellet burner with an integrated hopper for wood pellets-. The pellet burner (on the right) has been turned 45 deg. and is installed on a frame with a matching boiler (at left). [2]
Requirements
Attention must be paid to the fact that the installation and safety requirements for pellet burners are the same as for the installation of a new wood pellet boiler. Loose stokers can be type approved together with one or more boilers chosen by the stoker supplier.

Space demands and price
Burner and boiler have to be easy to separate as the combustion chamber of the boiler has to be emptied of ash and cleaned. Thus, this type of pellet burning system demands a lot of space in the boiler room. The price starts at around £2,500. There are a few UK suppliers of pellet burners, but more in Denmark and other parts of Scandinavia where this type of version is more common.

8.3 Pellet Burners without hoppers

In both Denmark and Sweden there are some manufacturers who produce very compact pellet burners which resemble oil burners both in size and appearance. These compact pellet burners, build upon differing principles of wood pellet firing of pellets than used in the traditional compact boiler.

Figure 7.3. An example of a pellet burner that amongst others can be used for the retrofitting of an existing boiler. [3]

A complete pellet burner normally consists of the following:
- A metal container for the wood pellets
- A screw conveyor that transports the pellets from the container to a drop tube
- A drop tube through which the pellets are fed to the burner
- The burner where combustion takes place

In addition, the pellet burner has a built in blower for the combustion air, automatic ignition and a device for preventing burn back.

Space demands and price
This type of pellet burner has the advantage that it can be retrofitted onto an existing boiler and that the installation is very simple and demands little space. However, there is a final demand which is that the stoker has to have a size and shape that makes it suitable for the combustion of wood pellets. The price for an approved wood pellet burner goes from £2,500 up. At the moment there are only a few UK suppliers on the market.
8.4 Pellet stoves

Based on the wood stove, pellet fired stoves designed for installation in the living room, have been developed and have become increasingly popular in recent years.

Minimal care requirement
In comparison to normal wood stoves, pellet stoves are designed for house owners that emphasize a need for simple operation and a minimal need for maintenance. Today most pellet stoves are equipped with a thermostat and electronic ignition and therefore they do not demand manual intervention such as stoking or the controlling of their output.

![Figure 7.4: Wood pellet stove designed for installation in the living room.](image)

The fuel is easy to handle and most stoves burn effectively even at a very low output of a few kW. A normal wood stove cannot perform this.

Fuel hopper
The fuel hopper, which is built into the stove, holds between 10 and 30 kilos of wood pellets, which corresponds to approx. 1-3 days of consumption at medium output. Wood pellets are often bought in plastic bags of between 10-25 kilos so that they are easy and clean to store. Loose wood pellets cannot be stored in the same room as the wood pellet stove, but wood pellets can be stored in closed bags. It is the dust from the wood pellets that is the problem.
Construction
The automatic heating system normally consists of a short screw auger that gets the wood pellets from the hopper through a drop tube to the burner, where combustion takes place. An example of the construction of a pellet stove is shown in figure 7.5.

![Diagram of a wood pellet stove](image)

**Figure 7.5. An example of the construction of a wood pellet stove [5]**

Distance from flue
The flue pipe must be at a safe distance from flammable material such as the floor and skirting, where a minimum of 30 cm is required. Some pellet stoves have the flue pipe exit at floor level. If this is the case it maybe necessary to place the stove on a plinth [6].

Disadvantages of pellet stoves
In general pellet stoves are more expensive than traditional wood stoves and one should pay attention to the fact that many of them are noisy because of the screw feed mechanism, the combustion air fan and integrated bower that distributes the hot air into the living room. Also existing are quieter models without motors that rely on natural chimney-draught for burning. When burning wood pellets dust cannot be avoided, but the inconvenience can be minimized by handling the wood pellets correctly – see chapter 11.

8.5 Pellet stoves with back boilers

Back Boiler
Some manufacturers have produced pellet stoves with an integrated back boiler. They produce 8–9 kW of heat, of which the water tank takes 35–45%. This heat is used to heat other rooms in the house via the central heating system. The remainder heats the room in which the stove is placed.
Connection
You should always check how your heating system is secured before connecting a pellet stove with back boiler. The installation and mounting of a pellet stove with a back boiler should always be carried out by a professional. Incorrect installation can be potentially fatal.

A pellet stove with a back boiler must never be connected to a system with a pressurized expansion tank.

If the water cooled heating surface in the wood stove is larger than 0.4 m², there has to be a separate safety flue that connects the top of the heating element to an open expansion tank. It must not be possible to block off the safety flue. It must also have a positive gradient. The safety flue must not exceed 20 meters in length.

If the water cooled heating surface is smaller than 0.4 m², it is possible for the connection to the open expansion tank to be made through the existing return flue provided it cannot be blocked off (i.e. no valves, pumps etc.) between the heating element and the expansion tank.

In comparison to wood stoves pellet stoves they are still relatively expensive, but in return they have some of the advantages of pellet fired central heating installations.

8.6 Combined heating installations

Many consumers supplement their wood pellet boiler with another type of heating source for spare capacity, peak capacity or summer time operation. Typically, an oil fired boiler, a wood stove, a solar heater or an electric heater is chosen.

8.6.1 Wood pellet boiler combined with an oil fired boiler
When installing a wood pellet boiler it can be desirable to keep any existing natural gas fired boiler, partly as a supplement to the wood pellet boiler in the coldest winter periods and partly as a spare boiler.

8.6.2 Wood pellet stove and wood stove
Wood stoves have become very popular. There have been great improvements in heating technology over the last few years. Wood stoves have become easier to operate and their efficiency has increased to a level between 60 and 70 %.

Economically the advantage of using a wood stove is not very large. This is partly because firewood is a relatively expensive fuel and partly because there will typically be a higher temperature in the room where the wood stove is located, which leads to a slightly larger heat loss through windows and walls. On the other hand, some will probably think that this gives a higher comfort level.
8.6.3 Wood pellet boiler combined with solar heating

The advantage of combining a wood pellet boiler with a solar heater is that in the summer period the solar heater can completely or partly cover the domestic hot water demand, so that the wood pellet boiler can be taken out of service.

The solar heater can either be implemented so that it only delivers domestic hot water or so that the solar panel delivers both hot water and space heating.

As opposed to wood pellet boilers a solar heater demands storage for the heat, which is produced by the solar panel during the day. The capacity of the storage tank has to correspond to the area of the solar panel and in many cases the hot water tank will have sufficient capacity.

An example of a combined system for wood pellets and solar heating is shown in figure 7.6.

![Combined wood pellet boiler and solar heating](image)

Figure 7.6. Combined wood pellet boiler and solar heating /7/

8.7 References

/1/ Illustration from BAXI A/S, Smedevej 6880 tarm
/2/ Illustration from TwinHeat, Nørrevangen 7, 9631 Gedsted
/3/ Illustration from Dansk Shell, Nærum Hovedgade 6, 2850 Nærum
/4/ Illustration from Dansk Shell, Nærum Hovedgade 6, 2850 Nærum
/5/ Illustration from Whitfield, USA
/6/ [www.skorstensfejer.dk](http://www.skorstensfejer.dk)
/7/ Illustration from Biosol
9. Determining boiler size

This chapter describes some methods for determining the appropriate boiler size for a given wood pellet boiler application. Accurate boiler sizing is one of the most important criteria for the insurance of both the efficiency and the cost-effectiveness of a heating system.

If a heating-system is oversized, its efficiency and operating life may be reduced due to short cycling (frequent on-off cycles) and the capital cost may be unnecessarily increased. If the system is undersized, the plant may not be capable of meeting the desired levels of thermal comfort in instances of cold weather.

The following should be taken into consideration when sizing a boiler:

- The building standard of the house (insulation, ventilation)
- The size of the house (area, number of floors, heated area)
- Previous energy consumption (oil, electricity, supplemental heating sources)
- Pattern of energy consumption (room temperature, hot water consumption)
- Plans for future expansions

9.1 The relationship of external temperature to heat demand

Sizing for heat load

Heating plants in the UK are generally sized to be capable of maintaining an internal temperature of 8 °C when the external temperature is -5 °C. The amount of heat required to satisfy this demand is known as the peak heat load of the house.

Since the outside temperature rarely reaches -5 °C in the majority of the UK, the peak demand will be seldom experienced each year, and heating plants are run at part load for the majority of the year.
A load duration curve presents the amount of time a given plant is run at a given load over the course of a year to maintain a set internal temperature (see Figure 8.3).

Figure 8.3 clearly shows that the peak load is rarely experienced in the UK. In actuality, loads above 70% are generally experienced for less than 10% of the heating season.

**Dimensioning a wood pellet boiler**

Based on plant experience and economic key figures the economically and environmentally most optimal operation is achieved when the nominal rating of the wood pellet is 60-80% of the peak heat demand of the house. With this design, the boiler will cover around 90% of the heat demand of the house. This means, that in a relatively small number of hours in a cold period it will be necessary to supplement the wood pellet boiler with another heat source e.g. a gas fuelled boiler. The duration in which supplementary heating is required in the case of Figure 8.3, is that above the yellow line.

**9.2 Based on the previous consumption of energy**

Based on the previous consumption of energy it is possible to make a calculation estimation of the correct boiler size for a given property. The following is based on consumption of oil, however, the principle is the same for other types of fuel, for example electricity, heat pumps, firewood etc.

In this worked example we take a 3 bedroom house spending £1,000 per year on oil [2].

**Step 1 - Calculate your annual consumption in litres**

Assuming you pay 50p per litre of oil, this works out at £1000/yr + £0.50/l = 2,000 litres/yr.

**Step 2 – How much energy is in 2,000 litres of heating oil**
Heating oil or 28sec oil has an energy density of 37Mj (mega joules) per litre.  
37Mj x 2,000 litres = 74,000Mj or 74Gj (giga joules). 1Gj = 278 kWh.  
74 Gj x 278 kWh = 20,572kWh.  

So 2,000 litres of 28 sec heating oil contains approximately 20,572 kWh.  

**Step 3 – Calculating useful energy**  
Unfortunately you will not be able to use all 20,572kWh directly for heating and hot water, a proportion of the energy is lost when it is burned in the boiler. Boiler efficiency determines what proportion you are able to use. The efficiency of a 15 year old oil boiler will be about 60%.  

Therefore the useful energy used for heating and hot water is 20,572 x 60% = 12,343 kWh.  

**Step 4 – How many kilowatts (kW)?**  
Because we know the house needs 12,343 kWh, we want to remove the hours to leave us with kilowatts. A very approximate way of doing this is to divide our heating consumption in kWh by the number of full load hours the boiler will be running for. Because boiler use varies daily, weekly and seasonally we use a simplification called Full Load Heating Hours Equivalent or FLHE. For a domestic property we expect about 1,200 FLHE. 12,343 kWh ÷ 1,200hrs = 10.3 kW. About what you might expect for a large 3 bed property.  

*Further*  
In addition to the information contained within this chapter, the following websites contain more **Resources** accurate tools for biomass boiler sizing:  

http://www.asgard-biomass.co.uk/biomass_boilers_sizing.php  
http://www.swwf.info/images/boilersizewpdf.pdf  

**9.3 References**  

10. Small wood pellet systems

Modern wood pellet fired plants are designed for automatic operation, so that the supply of fuel and combustion control only requires the minimum of manual intervention. Because of this, wood pellet boilers have advantages in terms of comfort compared to other solid fuel boilers.

In full, a pellet fired boiler plant consists of:
- Fuel storage
- Fuel hopper
- Stoker or wood pellet burner
- Boiler
- Ash outlet and ash container
- Systems for controlling the supply of fuel and air
- Flue gas exit and chimney

10.1 Fuel storage

The design of the fuel storage system depends on the space the consumer has available for it and the wood pellet delivery method chosen.

Storage in bags
Some domestic boilers use wood pellets that are delivered in bags with a weight of 10-25 kg. Even though the bags are made out of a plastic, they have to be stored dry because the pellets are able to absorb moisture from the air. If wood pellets are exposed to moisture, for example in the form of rain, they will decompose and become useless as a fuel. The bags therefore have to be stored in a dry place, for example in an annex or in the basement. From the storage room the bags are carried to the boiler room, where they are manually emptied into the fuel hopper.

Storage in loose weight
Larger fuel stores where the wood pellets are delivered by lorry and blown into the storage room, can for example, be arranged in a room neighbouring the boiler room, in a silo or a room that is arranged in an attic above the boiler room. In such cases special fire protection measures for the storage room must be taken.

Wood pellets must never be stored loose in the boiler room. Wood pellets in closed plastic bags, may however on the other hand be stocked in the boiler room. It is the dust from the wood pellets that should be avoided.

Avoid dust
In order to reduce dust nuisance it is important that bags and wood pellets are handled in a way that does not cause the wood pellets to break. If the fuel storage room is established indoors, it is recommended that a cyclone is mounted in the injection-system in order to reduce the dust nuisance in the storage room. Low pressure in the fuel storage room during the injection of wood pellets furthermore ensures that the dust does not spread to other parts of the building.
Dust is not only annoying and harmful to the health, but can also constitute a fire risk and cause dust explosions. Thus, regular vacuum cleaning and removal of dust is important.

Avoid moisture
The maximum content of moisture in the raw material at 15 % is so low that dry rot and bacteria are not active. Because of this, wood pellets are in principle sufficiently dry to be stored for an indefinite amount of time without being decomposed by microorganisms.

![Diagram of a complete boiler plant with an outdoor silo for wood pellets](image)

**Figure 9.1. Drawing of a complete boiler plant with an outdoor silo for wood pellets [1]**

**Pellet silo**
Storage of loose wood pellets by the consumer will typically take place in a pellet silo - see the example in figure 9.1. A pellet silo will typically contain 5-6 m³ of pellets. This type of storage gives the least possible amount of work and only demands an agreement with the supplier for the regular delivery of new pellets as the old ones are being consumed. The silo has to have steep side walls towards the screw conveyor. If the sides are not sufficiently steep, the pellets will roll down, but the dust will remain in the silo. This means, that after a while the boiler will only be firing dust, which will increase the boiler temperature and reduce efficiency. The increased temperature also increases the risk of the ash clinkering.

**Storage**
The room in which the pellets are stored has to be dry and free from moisture, including the floor (loose storing of pellets on concrete requires that there is a moisture barrier in or beneath the floor).

**Minimise the creation of dust**
An important objective when handling wood pellets is that the pellets should be exposed to as little physical stress as possible, because it can cause the creation of dust and small particles. During mechanical handling of wood pellets small parts are loosened and thereby dust and small particles are created. Usually pellet manufacturers remove dust and small particles with a screen or exhaust equipment. However, it is difficult to
avoid the creation of dust during handling and storage. Especially at small plants dust can cause big operational problems:

- Uneven combustion caused by uneven induction of fuel
- Low efficiency
- High content of unburnt fuel in the ash
- Diffusion of dust

**Fuel transport**
Transportation of wood pellets from the storage area to the fuel hopper in these plants, usually takes place through a system consisting of screw conveyors. When choosing the conveyors it is important that they are suited for the transportation of wood pellets, which mainly means that they rotate slowly. Quickly rotating conveyors act as whisks and break the wood pellets.

**10.2 Fuel hopper**
The fuel hopper acts as a store from which the wood pellets are automatically transported with a screw conveyor into the combustion chamber. The fuel hopper has to be made of non-flammable material and has to be able to be closed with an air tight lid. The fuel hopper normally holds an amount of fuel that corresponds to approximately one day’s consumption at full load.

**10.3 Stoker or wood pellet burner**
From the fuel hopper the firing of the pellets happens via a stoker or screw conveyor (or a corresponding device) that conveys the wood pellets into the combustion chamber of the boiler.

The stoker is driven by a motor that is controlled so that it delivers the amount of fuel that corresponds to the heat consumption from the boiler or to the wanted boiler output.

Inside the stoker pipe a temperature sensor is placed that activates a sprinkler device if the temperature in the stoker pipe gets too high e.g. due to back firing. The sprinkler device is supplied with water from a water tank placed on the boiler or the stoker.

**10.4 The boiler**
The boiler consists of a combustion chamber with a water jacket around it. In the combustion chamber the wood pellets are combusted, with air supplied from one or more fans.

*Combustion chamber*
The combustion chamber may be designed in various ways. In smaller boilers it is fairly normal for the combustion to take place in a burner pipe on the stoker itself. The combustion air is supplied through a series of openings in the burner pipe. In larger boilers combustion normally takes place on a grate.

The combustion chamber may have a lining made of a fire resistant ceramic material or cast iron, which partly contributes to keeping a high temperature and is also more resistant to heat stress from the combustion.

To ensure good combustion the air supply is very important. When combusting wood pellets it is especially important that the air is supplied in such a way that the gasses
produced during combustion get sufficient oxygen to be combusted completely and before they leave the combustion zone.

Water from the radiator system of the house circulates in the water jacket around the combustion chamber. The heat that is generated during combustion is transferred to the boiler water through the heating surfaces in the boiler. A central heating pump pumps the heated boiler water to the radiators. In some cases the heat is transferred to the radiator water via a heat exchanger. Another heat exchanger ensures the heating of domestic hot water.

### Guidelines for the design of the combustion chamber

<table>
<thead>
<tr>
<th>The combustion chamber has to be large enough for the</th>
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<tbody>
<tr>
<td>- gas to have a sufficiently long retention time in the combustion zone</td>
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<td>- coke to have a sufficiently long retention time to burn out completely</td>
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<th>The combustion chamber has to be small enough for the</th>
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<tr>
<td>- air and gas to be mixed completely and not leave the combustion chamber unblended</td>
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<tr>
<td>- heat conduction in the grate not to cool down the coke too much</td>
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<tr>
<td>- burning gasses to ignite the fresh fuel</td>
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<td>- hot boiler surface or brickwork to ignite the fresh fuel</td>
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<td>- gas to “see” the embers</td>
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<th>The air has to be supplied so that</th>
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<tr>
<td>- the amount of excess air is correct, i.e. that the CO₂ content lies between 12 and 17 %</td>
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<tr>
<td>- the coke gets sufficient air to burn out completely</td>
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<tr>
<td>- the gasses get sufficient air to burn out</td>
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<tr>
<td>- the coke and ash are not blown out of the combustion chamber</td>
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<tr>
<td>- the largest possible turbulence of air is achieved in the combustion chamber</td>
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### 10.5 Ash container and ash outlet

**Ash amount**

When wood pellets are combusted the amount of ash generated is low. Only 0.5-1 % of a wood pellet is non-combustible. A larger amount of ash than that may be a sign that the pellets are of poor quality. For example they may contain an amount of impurities in the form of sand or other inorganic material.

**Slagging**

Good wood pellets leave only a little ash in the shape of a fine, grey powder, which is easy to remove. If the ash creates burnt cakes or slag it may either be because of impurities in the pellets or too high a combustion temperature.

**Ash**

The ash is collected in an ash dump or possibly in an ash container, which is emptied by hand.

**Container**

Larger boilers have an automatic ash outlet where the ash is transported to a container via a screw conveyor. To avoid the danger of fire, the ash has to be collected in a metal-container with a lid. It may never be put into a rubbish bag or the like before it is known for a fact that no embers are left.
10.6 Controlling air and fuel supply

**Pellet boilers vs. oil/natural gas boilers**

Wood pellet fired boilers are different from oil fired and gas fired boilers in one significant respect: fossil fuelled boilers operate in short heating intervals (on-off operation), as the supply of fuel and air is turned on and off momentarily. In oil fired and gas fired boilers the combustion in the combustion chamber of the boiler stops at the moment that the supply of fuel is discontinued.

In wood pellet fired boilers, on the other hand, the fuel is supplied in a steady flow. As long as fuel and air is supplied, the combustion of wood pellets will continue. If the supply is cut off, the combustion will continue until all of the fuel in the combustion chamber has been converted. Heating with wood pellets thus gives longer start-up and shut-down times than is usual in oil or gas firing.

**Control system**

The purpose of the boiler control system is to control the fuel and air supply, so that the boiler delivers the desired heat to the heat distribution system, i.e. the radiators and supply of domestic hot water. The more heat that is needed, the more fuel has to be supplied and the more air has to be added to ensure clean combustion.

**Oxygen control/lambda probe**

The control unit may be built upon a thermostatic control unit that registers the temperature of the boiler water at a suitable place in the system. When the temperature decreases beneath a certain level, a start up impulse is sent to the motor that conveys the pellets into the boiler. At the same time the control unit makes sure that the air supply corresponds to the amount of fuel that has to be combusted. Newer boilers are often fitted with an oxygen control unit based on a so-called lambda probe. This is a sensor that is placed in the flue gas duct and registers the oxygen content in the flue gas. The controlling system uses the signal from the lambda probe to ensure that a suitable amount of air is supplied into the combustion zone.

The control unit is very often equipped with pre-settings that are activated when the boiler starts up and at different output levels (modulating control), for example it can be preset for low, medium and high output, respectively.

The control unit is of high importance. Precise control is important in order to obtain the optimal fuel economy and clean combustion, which ensures that no non-combusted gasses e.g. carbon monoxide (CO) are emitted. Finally control is important for the sake of the easy operation of the boiler. Thus, the improvement of boiler control systems is an on-going process.

10.7 Flue gas outlet and chimneys

In order to obtain an efficient combustion it is important that the flue gas outlet and chimney are dimensioned to ensure the “breathing” of the boiler. If the chimney is blocked or wrongly dimensioned, it may lead not only to inefficient combustion but also in the worst-case scenario to the seepage of carbon monoxide.
Approval
The boiler must always be provided with flue gas ducts and chimney that comply with the requirements that the boiler manufacturer has stated and those of the relevant building regulations. These relate to both the diameter of the chimney pipe and the chimney height.

Chimney dimensions
When the wood pellet boiler is being installed as a replacement for a previous oil fired or gas fired boiler, or when a loose pellet burner is installed to an existing boiler, attention must be paid to the fact that a wood pellet boiler demands a chimney diameter of no less than 15 cm, corresponding to a cross section area of 175 cm². In order to obtain the right exhaust conditions it might be necessary to put up a new chimney, for example a steel chimney, or to rebuild the existing chimney for example by insertion of an insulated exhaust pipe.

Chimney cleaning
Both the flue gas outlet from the boiler to the chimney and the chimney itself has to be kept clear of carbon depositions.

Tarry soot
Problems can arise when house owners shift to a very efficient wood pellet boiler. Chimneys that have worked satisfactorily with old boilers, are corroded by tarry soot when a more efficient boiler is connected. New, effective wood pellet boilers have a low smoke temperature. Thus, these boilers set demands just as high on the chimney in relation to insulation and diameter as an efficient oil fired boiler.

Tarry soot in the chimney is destructive and foul-smelling and may cause a chimney fire if not stopped in time. Tarry soot is a result of condensation that develops, when the water vapour in the flue gas is cooled down below approx. 50 ºC. Condensation happens in the coldest places of the chimney – typically at the top of the chimney or in the part that passes a cold, poorly insulated attic. The condensation is absorbed by the joints and bricks of the chimney and dissolves the carbon it meets. The dissolved carbon then migrates through the walls of the chimney. After some time brown and black-brown discolorations will be visible on the outside of the chimney and in the attic at the horizontal divisions.

Reasons for tarry soot
The reason for the carbon layer is typically a combination of a poorly insulated chimney, low flue gas temperature and incomplete combustion.

When closing the air supply, the fuel lasts longer, but in return unburned flue gasses will settle in the plant and in the chimney as carbon deposits. When the air supply is shut off, the flue gas speed will decrease and the water vapours in the flue gas will stay in the chimney and mix with the unburned flue gasses. When this has happened, it is often seen in the chimney as a layer of carbon with a glossy surface (shining soot).

Risk of chimney fire
At worst a chimney fire may begin. A chimney fire normally begins during kindling or when fuel is added. Here lots of air is supplied and the temperatures thereby get so high that the shining soot is ignited.
Padding solves the problem
To prevent condensation the chimney can be insulated on the inside by lowering an insulating interior into the chimney or casting an insulating interior inside the old chimney. It is also possible to lower a steel-lining into the chimney. Installing a chimney liner results in a chimney with a smaller diameter.

Detecting tarry soot
The consumer can detect for themselves if condensation is taking place inside the chimney by opening the cleanout door in the attic section of the chimney and rubbing a finger along the bricks and joints inside. The main rule is: If the finger gets wet and sticky there is condensation.

10.8 References

/1/ Illustration from TwinHeat, Nørrevangen 7, 9631 Gedsted
/2/ www.skorstensfejer.dk
/3/ Nielsen, Teddy. “Træpillefyre kan give fugt i skorstenen”, Vejle Amts Folkeblad
11. Large scale heating schemes

Large scale heating schemes provide heat for one or more large buildings. Examples include hotels, conference centres, service companies, industrial companies, schools, sports halls, terraced houses, day care centres and 24 hour care centres, administration buildings and blocks of flats.

Typically, the nominal thermal capacity of a large scale heating scheme lies between 50 kW and 1 MW.

Figure 10.1. Examples of buildings with a large scale heating scheme

11.1 Where and when is a wood pellet boiler an option?

Before deciding on using wood pellets for heating, some details have to be considered.

Positive mood
Modern wood pellet heating plants run just as well as oil or gas heating plants. The largest difference is that wood pellet plants are less common. In order to be able to accomplish a successful project and avoid scepticism towards a new technology, it is important that the relevant people receive information about the project and are well motivated toward the implementation of a wood pellet plant. Relevant people include the building owner, users of the building, neighbours and affected authorities.
Space
Heating plant for wood fuel demands somewhat more space for the boiler system and fuel storage than a plant using oil or natural gas. Furthermore, accessibility for fuel delivery is required. If there - for a given building – is only little space available, a wood fuel heating system might not be the appropriate choice.

Available fuel
In countries where the market for wood pellets has developed over many years, wood pellets can be attained widely from amongst others local heavy goods companies, oil companies, energy companies and directly from the manufacturers.

In some parts of the UK however, a fluctuation in supply and pellet quality may be seen (amongst other things) when the market develops intermittently. Thus, before building a plant it is a good idea to explore possible pellet suppliers and qualities and find a reliable supply of wood pellets with a high and constant quality.

Maintenance
The largest difference in running a modern boiler plant with wood pellets and an oil boiler is that the ash from the wood boiler has to be disposed of regularly. It is important, from the start, to designate a person responsible for handling the ash and for overseeing the stock of fuel. If a boiler plant where the flue pipes are not automatically cleaned for fly ash is chosen, some regular work cleaning the boiler will be necessary – see figure 10.2.

Economic evaluation
Evaluating the economics of a large scale wood pellet fuelled heating plant is often crucial to the decision on whether to change to wood pellets. It is necessary to know the fixed asset investment, the annual costs and the annual savings.

An experienced consulting company can help with both the initial considerations and the final project proposal. Help to evaluate these points can also be found in certain web based calculation tools where the user can enter a number of key figures and get an
estimate of the economics of a medium sized wood-fired heating plant – see the example at figure 10.3.

Figure 10.3. Free web based calculation tool evaluating the economic aspects of changing to wood fuel. The tool can be accessed at http://www.retscreen.net/ang/g_biomas.php

11.2 Tailoring the boiler capacity

It is vital to make an assessment of the heat demand of the building early in the planning process. The heat demand is used for designing the boiler plant. An appropriate design is crucial for the good economy and satisfactory technical operation of the plant. Methods for determining the plant size is described in more detail in chapter 10.

If the wood pellet boiler is replacing an existing heating plant in an existing building, figures from the previous fuel consumption are the best foundation to calculate the future demand for fuel and the nominal capacity for the new plant (which is rarely the same as the capacity of the existing plant).

If the pellet boiler is supplying a new building, the heat demand and peak load requirements can be calculated on the basis of data on the building area, the insulation standard and the demand for domestic hot water.

If the plant is supplying several buildings the necessary heat distribution system should be sketched and the subsequent heat loss estimated in order to include it in the total heat demand.

Throughout the heating season all types of heating plants are exposed to very different operational conditions as a result of large variations in heat demand which depend on the weather, user habits etc. The following duration curve (figure 10.4) shows a hypothesised annual heat demand (see chapter 10). As can be seen, a boiler sized to be capable of meeting the peak demand (where trendline intersects x axis) would run on part load for the majority of the year (e.g. less than 75% load for 95% of the year)
11.3 Heating plant

In the 50 kW and 1 MW range there are a number of different types of boiler. The three most common are compact boilers, detachable stokers and boilers with grate. There are different wood pellet plants and other heating plant combinations possible that will increase the flexibility of the boiler and the ability to adjust to different heat demands throughout the year.

Choosing the plant

Several factors are important when choosing boiler plant:

- High efficiency - above 85% nominal efficiency - proven by reliable tests;
- Low CO emissions and low dust emissions;
- Modulating operation – on/off operation is too simple and gives higher emissions and losses;
- High degree of automation to reduce operation and maintenance work;
- Option for the supplier to remote control the operational parameters of the plant;
- Case studies that show that the type of plant chosen has already been used successfully to heat larger buildings.

By choosing a boiler which is approved by an independent body the consumer gets a product that lives up to high demands on efficiency, safety and emissions amongst others.

Combination with oil or natural gas

The wood pellet fired plant can be supplemented with an ordinary oil or natural gas boiler plant to cover peak load and function as a spare in case of a breakdown. The capacity of the pellet boiler is set to 60-80% of the peak load demand on the coldest day, i.e. 60-80% of the value at which the duration curve crosses the y-axis (see figure graph).
10.4). In this way the wood pellets will be able to cover 90% of the annual heat demand. This is due to the fact that the peak load demand only occurs for very short periods each year. The oil fired or natural gas fired boiler should be able to cover the peak load demand on the coldest day. In this way a good security of supply is obtained in the cheapest possible way.

This solution is in particular an advantage when an existing oil fired or natural gas fired boiler plant can be used for peak and spare capacity in short periods. But since this type of boiler plant is relatively inexpensive it often pays to invest in a new one.

*Combination with a quick heat accumulation tank*

In this solution the pellet fired boiler plant is designed to cover the peak load demand on the coldest day, but it is supplemented by a heat accumulation tank. The tank helps with handling variations in heat demand and in addition ensures that the boiler plant can be operated in a reasonable way during periods of low demand. The accumulation tank can furthermore be used for storage of solar power in the summer period if a solar heating collector is installed.

This solution has the advantage of only needing one chimney. A spare oil fired boiler can be installed with a flue to the same chimney as the wood pellet boiler so long as it only operates when the wood pellet boiler is out of operation.

*Two wood pellet boilers that combined*

By combining two pellet fired boilers the security of supply is increased. A pre-requisite for this is the boilers have separate fuel transportation systems. This solution ensures that the wood pellet boilers can operate optimally in all demand-situations. It can be cheaper to install another pellet fired boiler than to install an oil fired or natural gas fired boiler with its own oil tank or natural gas supply and chimney.

If a supplementary energy source does not exist, the wood pellet boiler has to be designed to cover 100% of the peak heat load in the building. In this case the recommended choice would be for two wood pellet fired boilers. This allows for high operational efficiency at many loads. The recommended choice would be to have two boilers with different nominal capacities covering respectively:

- **Base load**: 2/3 of the dimensioning heat demand
- **Peak load and low load**: 1/3 of the dimensioning heat demand

In some cases an even higher security of supply might be wanted. If this is the case it would be possible to combine a large and a small biofuel boiler that together cover close to the peak load demand on the coldest day with an oil fired boiler that can cover the total peak load demand.

### 11.4 Fuel storage

*Storage types*

Wood pellets can either be stored in the existing building in a room close to the boiler plant or in a separate storage area outside the building. The outdoor storage area can be a silo that is placed above the ground or buried storage, from where the fuel is transported to the boiler plant.
All types of storage have to be secured against water ingress from the outside. This is especially important to focus on with the buried storage option, where rainwater and especially ground water pose a problem. When designing the storage room consideration should also be given as to how it might be emptied if there was a technical error with the equipment or the construction of the bottom of the storage room.

**Delivery of pellets**

When designing the storage room it is important to consider how the wood pellets will be delivered. Wood pellets are traditionally delivered by tanker lorry, that can blow the fuel into the storage room or by lorry that can tip the fuel into the storage room.

Among other things there should be sufficient space for the truck to manoeuvre. It can be a sensitive issue to use parking space or green areas as a turning place and for fuel storage. Figure 10.5 shows different possibilities for large scale heating plants.

![Figure 10.5. Wood pellets are delivered to large-scale heating plants with a blower lorry and tipping trailer respectively.](image)

**Storage size**

The size needed for fuel storage depends on the expected fuel requirements of the plant, the security of fuel supply, available storage space, the size of the lorry that delivers the fuel etc. For plants in existing buildings it often pays to adapt the fuel delivery system to the existing available storage space rather than build new storage.

Based on experience it can be difficult to fill up a pellet store to more than 70% of the available volume. Besides, it is important to have sufficient storage capacity to take a fully loaded lorry without having to completely empty the storage area first. If a new building is being built, the size of the storage is thus designed to be 50% larger than a full load of fuel or alternatively corresponding to at least two weeks of operation on full demand - whichever is the larger. If the plant is smaller it may be sufficient to settle for a storage area corresponding to 50% of a full tractor unit. Figure 10.6 shows weekly wood pellet consumption at full load relative to nominal boiler capacity.
Since wood pellets are often cheaper in the summer than in the winter - in the heating season, it makes economic sense for smaller boiler plants to be able to store an amount corresponding to the pellet consumption of a whole year. This should, however, be checked thoroughly in each case.

**Safety conditions**
The storage of wood pellets raises special safety demands such as avoiding damage in the storage room, dust explosions or the decomposition of the fuel. These points also partly apply to silo storage.

- The storage must be completely dry
- A protective rubber-mat must cover the wall that pellets hit during injection
- The door to the storage room must be fireproof and airtight and can if necessary be protected against the pressure with plates
- No electric installations in the stockroom
- The injection pipes are earth connected to prevent electrostatic discharging during the filling of the stockroom
- The walls must be strong enough to withstand the pressure from the pellets
- The walls must be fireproof

Once a year the accumulated dust must be removed and the bearings in the screw conveyor must be lubricated.

**Transportation to the boiler room**
Since wood pellets are homogenous and dry they are usually transported to the boiler plant by a screw conveyor as known from the feed stuff business. Figure 10.7 shows wood pellet silos and screw conveyors.
11.5 Tending of the plant

A precondition for optimal operation is the correct choice of boiler size and the correct construction and installation of the plant. The right design of the plant gives optimal operational conditions and reduces the need for handling ash and boiler cleaning etc.

Design of the boiler room
The boiler room and fuel storage must always be separated for the sake of fire safety. Subsequently it is important that sufficient space is left open for maintenance and possible repair work. Changing the stokers or the screw conveyors for pellet transportation may demand a lot of space.

There must be sufficient space for the day-to-day operation of the plant, including sufficient space for the regular cleaning of the flue pipes (if there is not an automatic system for this). For a biomass boiler of 200 kW it is typically necessary to have a boiler room with a minimum 20 m² of space.

Tending activities
The need for man power for operation and maintenance depends on a number of factors that should be considered during the planning phase. For example if the fuel delivery can take place without local personnel being present, if part of the supervision can be done via remote control etc.

Operation and maintenance activities include:

- Monitoring and checking the boiler twice a week
- Adjustments, maintenance and handling of smaller operational problems
- Procurement of fuel
- Handling and disposal of ash
Typically three hours a week
The time needed for the operation and maintenance of an existing wood fired block heating system has been estimated in a Danish study [1]. The time required is based on information from personnel operating the plant. The study showed that the work usually amounts to three hours a week for a wood pellet fired plant.

It is worth remembering that the operational crew will also spend time on the operation and maintenance of traditional oil fired or gas fired boiler plant. Thus, the above mentioned consumption of time is not an increase in net time consumption compared to traditional heating plants.

Time consumption depends on size
The time needed depends on the size and fuel consumption of the plant with lower amounts of time needed by smaller plants. On the basis of known fuel consumption and plant size, key figures have been calculated for the consumption of time needed for operation and maintenance relative to fuel consumption and plant size. For wood pellet fired plants the following is used [1]:

- 4 minutes per GJ injected fuel or
- 1 hour per 100 kW installed capacity

Reducing time consumption
The possibilities for reducing the need for man power are many, including:
- Outsourcing the operation and maintenance job to an energy services company
- Investing in automatic ash handling
- Investing in automatic flue pipe cleaning
- Letting the fuel supplier take over responsibility for the delivery of fuel based on actual, electronically transferred data of the heat production or the fuel level in the storage area
- Letting a chimney sweep take over the responsibility for the periodic cleaning of the plant

Training of the operational crew is essential
Many problems can be avoided if the responsible person receives good and accurate information about the plant from the manufacturer, the distributor, the installation contractor or the consultant when setting up the plant. The instructions should include:

- Daily routines
- Adjusting the combustion
- Typical errors
- Troubleshooting
- Contact persons, that can give further instruction
- Agreement on start-up of the plant

It should be an established standard that detailed instructions are given both orally and in writing.
11.6 Consultancy and acquisition of plant

As mentioned above the good and constant operation of a wood pellet plant requires a careful design of the plant, especially in relation to the nominal capacity of the boiler plant.

Make use of consultants

While the investment in small wood pellet plants can hardly justify the expense of hiring a consultant it makes sense to involve a consulting engineer when investing in large scale heating systems. The engineer should have particular expertise in wood pellet plants and heat supply.

Besides carrying out a detailed estimation of the heat demand and design of the plant according to this, a consultant can oversee competitive tendering, choose a supplier, carry out inspections and be in charge of the handing-over procedure.

The consulting engineer is liable for their advice as opposed to the situation where the boiler supplier is the contractor.

11.6.1 Purchasing the plant

Contact the suppliers early

The purchasing of the equipment can prepare be done at an early stage, as soon as there is certainty about the economics of the project. When the first outline of the physical and economic perspectives of the project have been completed and when the expected heat consumer has received the project positively, several potential suppliers should be contacted.

The more fundamental information you can give, the more clearly the supplier can recognise a possible deal. The supplier is thereby given a better opportunity to spend time on a project proposal including price estimation.

Information for the supplier

The minimum amount of information needed when first addressing a boiler supplier is the following:

- The heat demand
- Fuel, type and water content
- Area available for fuel storage inside or outside the existing building
- Space available in the building or outside for the boiler room and fuel silo/container
- Which emission standards apply for the plant

Demands for boiler supplier

From this information, the supplier can then return the following:

- Limits of the area of liability
- Rough layout sketches
- Preliminary price and delivery conditions
- References including name and phone number of clients with similar plants
Contact several suppliers
It is a good idea to contact around three suppliers at an early stage. It is important to keep possible suppliers objectively informed about the development of the project and to let them know that parallel contacts have been made to other suppliers.

Difference between boiler and boiler plant
Very often "boiler" and "boiler plant" are mentioned synonymously. This can lead to misunderstandings and, above all, difficulties in comparing various offers. Naturally the boiler is a very important component, but the phrase "boiler plant" includes a number of other components like fuel storage, systems for fuel handling and transportation, stoking into the boiler, circulation pump and pipe work, pressure system, flue gas fan, flue gas cleaning equipment, flue ducts and chimney, equipment for ash handling and storage, power supply, control unit, heat meter and boiler house.

Use a consultant to the owner
Thus, a large amount of components have to be unified to make up a whole plant. In order to make this possible it is important that the plant is well designed. In relation to this the first question to consider should be, in what size of packages should the plant be purchased and who is the ideal person to practically coordinate the purchase and take responsibility for the various deliveries. This role belongs naturally to a consultant. For smaller plants it is difficult to stretch the economics to pay for a building consultant, who from his point of view has low interest in getting involved in very small cases, unless it is part of a bigger job.

Turnkey plant
When considering the purchase of plant it is important to be aware of the “turnkey” concept principle the concept means that you buy a plant, that is ready to start operation. This kind of plant is often more expensive than buying the various components separately. However, it has the clear advantage that you buy a service instead of a range of various technical components. A guarantee of the functionality of the plant from the supplier can more easily be negotiated for a turnkey plant.

The risks of several suppliers
If instead you choose to purchase the plant component by component, there is a risk of ending up in a situation where the different parts do not match and the responsibility for the functionality lies with the developer himself or his consultant. In this case the suppliers do not have the same responsibility for the unified function of the plant and can more easily evade responsibility. If choosing this option, it is therefore important that a big effort is put into ensuring that each of the individual components is compatible.

11.7 Economics
The economics of a wood pellet plant is determined by the cost of the investment which is generally higher, and the operational costs which are generally lower than for conventional heating systems. The installation of a wood pellet boiler tends to be more economical in new-build situations rather than in retrofitting, however this may not always be the case.

Wood pellet boilers with an installed capacity of greater than 50 kW can cost around £1,000-£1,200 per installed kW. However, the higher investment costs of wood fired plants can quickly be recovered on the low fuel price.
11.8 References


12. District heating plants

As there are presently no major CHP wood pellet plants in the UK, this chapter describes the large CHP plant in Avedøre close to Copenhagen, which uses wood pellets to generate power and heat for the greater Copenhagen District Heating (DH) network. The plant is owned by the Danish utility company DONG Energy.

At the end of 2001 the new block 2 at Avedøreværk in Copenhagen was put into operation – see figure 12.1. Avedøre 2 is a multi-fuel plant that combusts natural gas, fuel oil, orimulsion (a bitumen based fuel) coal and bio fuels in the form of straw and wood pellets.

Figure 12.1. Block 1 and 2 of the Avedøreværk. At block 2 (to the left/in the back) 300,000 tonnes of wood pellets are used annually. [1]

Electrical efficiency
The plant consists of a main boiler (Benson type) using natural gas, oil and wood pellets, a straw fired biomass boiler and two natural gas fired gas turbines, from where the heat in the exhaust gas is recycled as feed water preheating the steam circuit. This system has a total power efficiency that, at pure power production, can attain 51 %. See principle sketch of the plant in figure 12.2.
High steam data
The main boiler is an 80 metre high once-through tower boiler of the Benson type. The high efficiency is due (amongst other things) to the fact that it is an USC-plant - a plant with very advanced steam data which uses special steel alloys, a pressure of 305 bar and a temperature of 582 °C.

16 multi-fuel burners
The boiler is tangentially fired via 16 burners places on 4 floors. The burners can fire natural gas, oil and now also wood pellets that have been grinded to dust. However, each burner can only use one fuel at a time, but all three fuels can be used in the boiler at the same time in varying combinations.

Wood pellet dust firing
The main boiler was originally designed for natural gas and fuel-oil. In order to be able to incinerate more biomass it was decided to convert the main boiler to be able to incinerate wood pellets as well. The conversion to wood pellets was completed in the Autumn of 2002. On a yearly basis Avedøre 2 should be able to incinerate 300,000 tonnes of wood pellets. The wood pellets are to be pulverised in three mills and blown into the boiler through the burners in the same way as coal-dust firing.

Coal-mills used for grinding pellets
The same type of equipment is used for the wood pellet firing as for coal firing. Three coal-mills that can also grind wood pellets have been installed. During coal-firing each mill has a capacity which corresponds to 40 % of the boiler capacity. During 100 % wood pellet firing it can be expected that the boiler will run at 70 % load when all three mills are running. Compared with a pure coal-fired unit, there is a lot more equipment needed to ensure fire safety and control. The layout of a coal mill is shown in figure 12.3.
Storage room
Since 2003 the wood pellets have come in part from DONG Energy's own wood pellet plant situated by a wooden floor factory (Junckers Fabrikker) in Køge 35 kilometres south of the Avedøre plant. The pellets are transported to the plant by ship and are stored at the plant in roofed storage rooms. The total storage capacity is divided into two long term storage rooms that can each hold 18,000 tonnes and a fully automated working storage silo that can hold 15,000 tonnes. It is expected that the largest ships will transport 8,000 tonnes at a time. The transportation of the pellets from the stocking facilities to the plant happens with the same conveyer belts as is used for the transportation of coal to block 1. See the illustration of the wood pellet handling in figure 12.4. From 2006-2007 the wood pellet production at DONG Energy ceased.

Fuel Handling of Wood Pellets at AVV2

Dust minimization
In order to keep the wood pellets dry and to reduce the nuisance from dust all handling of the pellets happens in closed system with a vacuum. The existing coal conveyer belts have been roofed and exhaust systems remove dust.

Fire safety
In order to minimise the risk of fire 400 sprinkler nozzles at 3 meters intervals have been fitted above the 1.2 kilometres long conveyer belts. In addition, fire curtains have been put in place to prevent the spreading of possible flames. [3]

12.1 References

[1] Illustration from ENERGI E2, Lautruphøj 5, 2750 Ballerup
13. Environmental considerations

The environmental load from burning clean wood pellets is normally considered to be minimal. The most significant environmental load is related to the substances that are emitted via the flue gasses from the combustion process.

13.1 Energy consumption at procurement and use of wood pellets

In figure 13.1 the energy consumption in the transportation and manufacturing wood pellets is shown along with the loss on conversion to heat in the consumer’s wood pellet boiler.

The energy consumption figure is presented in three different ways:

- In MJ per ton of fuel
- In the percentage of the energy content of the fuel (lower heating value)
- As a percentage of the heat that can be generated by the consumer

The energy consumption stated for the transportation of the raw material is based on a distance of 50 km between the factory and the wood processing industry that delivers the raw material.

At the consumer end the pellets are presumed to be converted to heat with an annual efficiency of approx. 80%, which means that an average of 20% of the content of energy of the wood pellets is lost and thus cannot be used for heating purposes. The annual efficiency is the efficiency one in practice achieves when considering the heat loss via the flue gases and the periods during start up and shut down during which efficiency is significantly lower than nominal. A wood pellet boiler is normally characterised by the nominal efficiency that applies during nominal output. The nominal output is where the plant operates at its best and in this way the nominal efficiency will be higher than the annual efficiency.
If wood pellets are imported energy is consumed as illustrated in figure 13.1 as well as during transportation from the country in question to Europe. The energy consumption during transportation by ship is shown in figure 13.2 with examples of transportation from Canada.

### 13.2. Energy consumption at procurement of other fuels

Figure 13.3 shows the total energy consumption at procurement of wood pellets compared to a number of other fossil fuels.

It can be seen that it takes much less energy to procure wood pellets than natural gas, coal and especially oil.

<table>
<thead>
<tr>
<th></th>
<th>1..1..a.1 Energy consumption at procurement</th>
<th>[% of energy content]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native wood pellets</td>
<td>627 [MJ/tonne]</td>
<td>3.6</td>
</tr>
<tr>
<td>Imported wood pellets</td>
<td>787 [MJ/tonne]</td>
<td>4.5</td>
</tr>
<tr>
<td>Natural gas</td>
<td>2,840 [MJ/tonne]</td>
<td>5.8</td>
</tr>
<tr>
<td>Oil</td>
<td>4,617 [MJ/tonne]</td>
<td>11.4</td>
</tr>
<tr>
<td>Coal</td>
<td>1,764 [MJ/tonne]</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Note 1. The Values used for imported wood pellets are based on an average scenario, where around 60% of the imported pellets are expected to originate from countries around The Baltic Sea and 40% from overseas countries such as Canada.

**Figure 13.3. Total energy consumption at procurement of different fuels**

Even if the wood pellets are imported and thereby transported over long distances, the procurement of an average imported wood pellet demands less energy than the procurement of any fossil fuel.
13.3 Efficiency

13.3.1 Boiler efficiency

Fuel combustion generates heat which for the greatest part is transferred to the surrounding air (as with a wood stove) or via a heat carrying medium (water) to the radiators of the building. However, even the best boilers cannot fully utilise the energy content of the fuel. The boiler efficiency for high quality wood pellet fired boilers lies at around 85-91%. The remaining energy is lost as unburnt carbon in the ash and in the form of the heat disappearing within the flue gases and ash.

Boiler efficiency is an expression for the share of the fuel energy content that the boiler transforms into usable heat at the boiler’s nominal capacity.

The efficiency of the boiler is at its best when it works at or near its maxim output.

13.3.2 Annual efficiency

The boiler efficiency is an expression of the useful capacity of the boiler under certain, standardised testing conditions. However, the efficiency decreases at lower boiler loads, so that in periods with low heat demand e.g. in the summer when the boiler operates at less than 30% of its nominal output, the efficiency of the boiler decreases significantly. Since the boiler load varies during the year, the total annual efficiency, i.e. the exploited amount of heat in relation to the energy content in the used amount of fuel, will be lower than the boiler efficiency at nominal load. The annual efficiency varies from boiler to boiler, as parameters like the boiler capacity in relation to heat demand, control scheme, the use of other sources of heat, for example wood stoves and electric heaters, shut down during summertime and so on will have an impact.

The annual efficiency is an expression of the relation between the fuel consumption during the year and the heat production utilised from the boiler in the same period.

13.3.3 Network efficiency

In district heating systems and local heating systems the heat is distributed from the heating plant to the consumer through a network of insulated district heating pipes. Despite the insulation some energy is lost from the pipes to the surrounding soil. The network efficiency is the relation between the total amount of energy that is delivered to the consumer and the amount of energy that is delivered from the heating plant to the distribution network.
The network efficiency is among other things influenced by:
- The quality of the insulation of the district heating pipes
- The size of the pipes. The smaller the pipe, the larger the relative heat loss.
- The water temperature in the pipes in relation to the temperature in the surrounding soil. The higher the temperature of the flow and return, the higher the heat loss.
- The density of the energy, i.e. the length of the distribution network in relation to the amount of heat that is delivered to the connected consumer. The more consumers that exist on a given section, the higher the network efficiency.

For district heating networks the network efficiency is often around 70%, but especially in areas of low population it might be lower. Central heating installations that deliver solely heat to the building in which the boiler is placed only lose heat to the actual building, which means that it does not make up a significant loss. Only where the heat-pipes are led across for example unheated attics, should the loss be considered.

### 13.4 Flue gas emissions

When firing wood pellets the smallest environmental impact is achieved when all the components of the wood pellets are combusted entirely. At times the expression “pure combustion” is used. As described in chapter 6 many elements influence the quality of combustion, among other things the boiler design, the fuel and air supply and its operation.

#### 13.4.1 Visual combustion control

Measurement of emissions in the flue gas requires special measuring equipment and is normally conducted by companies that have specialised in this area. As a user of a smaller boiler plant you can however carry out some control of combustion quality by observing the smoke from the chimney.

<table>
<thead>
<tr>
<th>The appearance of the smoke</th>
<th>Combustion quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>None, or only quite thin, visible smoke, when the boiler is in operation</td>
<td>Good combustion with a suitable supply of air</td>
</tr>
<tr>
<td>Whitish smoke, that quickly disappears in open air</td>
<td>The smoke contains water vapour that is mainly caused by moisture in the fuel</td>
</tr>
<tr>
<td>Visible greyish or dark smoke. Visible carbon particles can occur.</td>
<td>The smoke contains ash particles. Can be controlled through the primary and secondary air supply. Possibly the air speed is too high through the boiler.</td>
</tr>
<tr>
<td>Thick, dark smoke with a smell of tar.</td>
<td>Bad combustion that emits large amounts of unburnt carbon into the atmosphere. Ensure that the air supply to the boiler fits the amount of fuel being burned.</td>
</tr>
</tbody>
</table>

*Figure 13.12. Table for visual control of flue gas from small boiler plants.*
13.4.2 Combustion air
The combustion air is supplied solely to provide oxygen for the combustion process. It is only the oxygen that is converted. The other parts of the combustion air pass on the whole unhindered through the combustion zone.

<table>
<thead>
<tr>
<th>Volume %</th>
<th>Enters into the combustion processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>O₂ Oxygen 21</td>
<td>Enters into the combustion processes</td>
</tr>
<tr>
<td>N₂ Nitrogen 78</td>
<td>Passes on the whole unhindered</td>
</tr>
<tr>
<td>Ar Argon 1</td>
<td>Passes unhindered</td>
</tr>
</tbody>
</table>

*Figure 13.4. Analysis of combustion air*

13.4.3 Flue gas
The amount of flue gas and the composition of the flue gasses that are created during complete combustion are determined by an element-analysis of the wood pellets. During the element-analysis the chemical composition of the wood pellets is determined. An element-analysis is carried out in a fuel laboratory.

<table>
<thead>
<tr>
<th>Matter</th>
<th>Share</th>
<th>Combustion product</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₂ Hydrogen 5.8</td>
<td>H₂O Water vapour in flue gas</td>
<td></td>
</tr>
<tr>
<td>C Carbon 46.5</td>
<td>CO₂ Carbon dioxide/carbonic acid gas</td>
<td></td>
</tr>
<tr>
<td>O₂ Oxygen 39.5</td>
<td>O₂ As surplus oxygen</td>
<td></td>
</tr>
<tr>
<td>A Ash 0.9</td>
<td>Ash Partly as dust in the flue gas</td>
<td></td>
</tr>
<tr>
<td>S Sulphur 0.05</td>
<td>SO₂ Sulphur dioxide</td>
<td></td>
</tr>
<tr>
<td>N₂ Nitrogen 0.28</td>
<td>N₂ Nitrogen in the flue gas</td>
<td></td>
</tr>
<tr>
<td>H₂O Water 7.0</td>
<td>H₂O Water vapour in the flue gas</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 13.5. Typical example of element-analysis of wood pellets and combustion-products*

In figure 13.5 the typical result of an analysis of wood pellets is shown along with the combustion products that each batch creates during complete combustion. The result of the elements-analysis of wood pellets is normally independent of whether the pellets are manufactured from coniferous wood or deciduous wood. The largest variations are found in the water content and the ash content.
13.4.4 Flue gas composition

If the element-analysis is known the amount of flue gasses and the flue gas composition can be calculated with the help of common combustion theory formulas. During the combustion of wood pellets with an element-analysis as in figure 13.5, with an air surplus of 1.5, one gets a flue gas composition as shown in figure 13.6.

<table>
<thead>
<tr>
<th>Gas component</th>
<th>Volume % - wet flue gas</th>
<th>Volume % - dry flue gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ Carbon dioxide</td>
<td>11.9</td>
<td>13.3</td>
</tr>
<tr>
<td>SO₂ Sulphur dioxide</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>N₂ Nitrogen</td>
<td>70.3</td>
<td>78.7</td>
</tr>
<tr>
<td>H₂O Water</td>
<td>10.6</td>
<td>0.0</td>
</tr>
<tr>
<td>O₂ Oxygen (air surplus)</td>
<td>6.3</td>
<td>7.1</td>
</tr>
<tr>
<td>Ar Argon</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>

*Figure 13.6. Flue gas composition when burning wood pellets with 7% moisture and an air surplus of 1.5

The combustion of wood also creates other gases and matter that from an environment and health related point of view are unwanted. These are primarily:
- CO;
- NOₓ;
- PAH;
- TOC; and
- Dust in the flue gas.

13.5 Emission data

The concentration of gases and dust in the flue gas depend on the choice of fuel and for some components also on the design of the combustion system. The emissions data for the most important gases and for dust, for firing with the following fuels, are stated below:
- Wood pellets
- Straw
- Fuel oil
- Natural gas

13.5.1 CO₂, carbon dioxide

Carbon dioxide plays a significant role in the greenhouse effect and the emission of CO₂ to the atmosphere is problematic. However, when combusting wood fuel there is no more carbon dioxide released than is bound up in the wood as carbon and that in any case would have been released during the decomposition process, which is the ultimate alternative to using wood for energy purposes. Thus, wood pellets and other bio fuels can be considered as being a very low fuel (only CO₂ attributable to pellets is due to
production and transport). In figure 13.7 the CO\textsubscript{2} emission from wood pellets and straw is therefore listed as zero.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Unit</th>
<th>CO\textsubscript{2} emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellets</td>
<td>g/MJ</td>
<td>0.108</td>
</tr>
<tr>
<td>Straw</td>
<td>g/MJ</td>
<td>0.108</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>g/MJ</td>
<td>0.972</td>
</tr>
<tr>
<td>Natural gas</td>
<td>g/MJ</td>
<td>0.72</td>
</tr>
</tbody>
</table>

*Figure 13.7. CO\textsubscript{2} emission key figures for delivered energy*

Since wood pellets and other bio fuels contain carbon, naturally CO\textsubscript{2} is also created during combustion. This released amount of CO\textsubscript{2} was however bound up during the period of growth of the bio fuel that for a tree is between 20-100 years.

The amount of carbon dioxide that is released when combusting fossil fuels, for example coal, oil or natural gas, was bound up in the subsoil millions of years ago. In the case of combusting fossil fuels in practise the total amount of carbon dioxide in the atmosphere is increased.

The carbon constitutes approx. 50% of completely dry wood. This corresponds to approx. 47% in wood pellets with a moisture content of 7% (see figure 13.5).

At complete combustion of 1 kg fuel 3.69 kg of CO\textsubscript{2} is created.

### 13.5.2 SO\textsubscript{2}, sulphur dioxide

Sulphur dioxide is normally not a problem when firing with wood pellets since the naturally occurring content of sulphur in wood is very low.

At the same time 40 to 60% of the sulphur dioxide that is created at combustion reacts with the alkaline components in the ash and the slag during combustion. In this way only the remaining 40 to 60% ends up as SO\textsubscript{2} in the flue gas.

In any case the emission of SO\textsubscript{2} from pellet firing is smaller than the emission of SO\textsubscript{2} from firing with fuel oil or natural gas which wood pellets often replace.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Unit</th>
<th>SO\textsubscript{2} emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellets</td>
<td>g/MJ</td>
<td>0</td>
</tr>
<tr>
<td>Straw</td>
<td>g/MJ</td>
<td>13</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>g/MJ</td>
<td>94</td>
</tr>
<tr>
<td>Natural gas</td>
<td>g/MJ</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*Figure 13.8. SO\textsubscript{2} emission key figures. [4]*
Special consideration needs to be given to wood pellets made with binding agents. The lignin based binders that are sometimes used in wood pellets are mostly either Wafolin or lignosulfonat, which both contain approx. 6 mass percentages of sulphur. The amount of binder is usually less than 1% of the finished wood pellet. With a binder content of 1% the content of sulphur in the pure wood pellet is quadrupled to approx. 0.08% compared to the content of sulphur in the pure wooden raw material at approx. 0.02%. This corresponds to a content of sulphur of 45 mg/MJ fuel which should be compared with the sulphur content in heating oil of less than 25 mg/MJ. [5]

13.5.3 N2, nitrogen
Nitrogen is an uncoloured gas that exists in the nature. Nitrogen is injected along with the combustion air, but is not part of the combustion processes. Thus, there are no environmental consequences from emitting nitrogen.

13.5.4 H2O, water
Water vapours in the flue gas come from:

- Combustion of hydrogen
- The moisture content of the fuel
- Water vapour in the combustion air

There are no environmental consequences from emitting water vapour in the flue gas. Water vapours in the flue gas may condense at low temperatures which may lead to corrosion or tarry soot in the chimney.

13.5.5 O2, oxygen
Oxygen in the flue gas originates from the extra air that is supplied to the combustion, the so called air surplus. There are of course no environmental consequences from oxygen emissions.

13.5.6 Ar, argon
Air contains approx. 1% argon, and argon is thus supplied into the combustion process as an inevitable gas. Argon is a so called noble gas that does not form part of the combustion process.

13.5.7 CO, carbon monoxide
Carbon monoxide is a toxic and combustible gas. In itself it is odourless and invisible. If one stays in a room with only 0.01% or 100 ppm carbon monoxide in the air, one will feel discomfort and get a headache after only a few minutes. Staying in a room with larger concentrations of carbon monoxide is outright life-threatening.

CO emission is unwanted, both because CO in the flue gas is an indicator that there is an incomplete combustion process and because CO is toxic and combustible (a health and safety risk) and finally because CO destroys the ozone layer.
A high CO emission is often an indicator that there are other unwanted and dangerous matters in the flue gas as for example unburned hydrocarbons and possibly dioxin. Conversely, a low CO emission is an indicator that these unwanted substances are not in the flue gas. In practise it is not possible to entirely avoid the creation of a little carbon monoxide during combustion.

Complete combustion requires the presence of the right amount of air at the right place and at the right time. If this is not the case, some of the hydrocarbon gasses that are created when the wood is heated (pyrolysis process) will pass up through the chimney without meeting sufficient oxygen to be converted to carbon dioxide and the creation of CO is inevitable.

Wood pellets are homogenous and have a very low moisture content, which means that in a well designed boiler very low CO emissions can be achieved.

CO can for example be created in larger amounts by combusting a fuel that the boiler is not designed for. CO problems may arise when firing wet material in a boiler that is not designed for it or when combusting wood in a coke boiler, where all the combustion air is injected below the grate. Typical CO emissions are found in figure 13.9.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Unit</th>
<th>CO-emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellet boiler</td>
<td>Mg/MJ</td>
<td>50-3000</td>
</tr>
<tr>
<td>Straw boiler</td>
<td>Mg/MJ</td>
<td>500-3000</td>
</tr>
<tr>
<td>Fuel oil boiler</td>
<td>Mg/MJ</td>
<td>15-30</td>
</tr>
<tr>
<td>Natural gas boiler</td>
<td>Mg/MJ</td>
<td>15-20</td>
</tr>
</tbody>
</table>

Figure 13.9. CO emissions - key figures at optimal setting of the boiler. The CO-emissions will be very dependent on the type of boiler and on the operational conditions.

13.5.8 NOx, Nitrogen oxides

NOx is a generic term for the sum of the gasses NO and NO2 converted to NO2. NOx gasses are unwanted because NOx is a greenhouse gas and at the same time NOx contributes to the acidification of precipitation.

Nitrogen oxides are created partly during the combustion of fuels with a natural nitrogen content including bio-fuels, and partly in the boiler room by the nitrogen that is injected during combustion with the combustion air. The design and size of the boiler combustion chamber is therefore of importance in the emission of nitrogen oxides.

It is not possible to give completely plain guidelines for the design of boilers with low NOx emission but the following tendencies are certain:

- A high content of N in the fuel gives increased NOx emission
- High combustion temperatures give high NOx emissions
Of the important combustion parameters the following can be mentioned: stepped combustion with low air surplus in the first part, low flame temperature possibly due to flue gas recirculation that lowers the content of oxygen in the combustion chamber and cools the combustion process.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Unit</th>
<th>NOx-emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellet</td>
<td>Mg/MJ</td>
<td>130-300</td>
</tr>
<tr>
<td>Straw</td>
<td>Mg/MJ</td>
<td>130-300</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>Mg/MJ</td>
<td>75</td>
</tr>
<tr>
<td>Natural gas</td>
<td>Mg/MJ</td>
<td>50-100</td>
</tr>
</tbody>
</table>

Figure 13.10. Typical key emission figures for NOx for smaller boiler plants. In larger boiler plants with NOx constraining equipment it is possible to obtain lower values.

### 13.5.9 TOC

TOC, which is short for “Total Organic Compounds” is an expression for the unburned hydrocarbon combinations in the flue gas. TOC are unwanted in the environment because many of the organic combinations are toxic and some of them are carcinogenic. The requisites for low TOC emission are the same as for CO-emissions.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Unit</th>
<th>TOC-emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellet</td>
<td>Mg/MJ</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Straw</td>
<td>Mg/MJ</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>Mg/MJ</td>
<td>0-2</td>
</tr>
<tr>
<td>Natural gas</td>
<td>Mg/MJ</td>
<td>0-2</td>
</tr>
</tbody>
</table>

Figure 13.11. Key emission figures for TOC. [4]

### 13.5.10 Dust

Dust in the flue gas occurs because light solid particles from the combustion process are carried along with the flue gas and are released through the chimney. The particles can be divided into two main groups:

- Unburned particles
- non-flammable cinder remains

The unburned particles consist of coke, also called soot. Soot is very fine-grained and is unwanted in the air since the particles are bothersome and usually harmful to inhale.

It is soot that gives the smoke the characteristic black or dark-brown colour at incomplete combustion.
The non flammable particles are the ash remaining when the flammable components in the fuel have been combusted. Like the soot particles, the unburned particles in the ash are unwanted in the air since the particles are bothersome and can be harmful to inhale.

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Unit</th>
<th>Dust emission</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood pellets</td>
<td>Mg/Nm3 flue gas</td>
<td>25-500</td>
</tr>
<tr>
<td>Straw</td>
<td>Mg/Nm3 flue gas</td>
<td>200-500</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>Mg/Nm3 flue gas</td>
<td>0</td>
</tr>
<tr>
<td>Natural gas</td>
<td>Mg/Nm3 flue gas</td>
<td>0</td>
</tr>
</tbody>
</table>

*Figure 13.12. Key figures for dust-emission. [4]*

Since natural gas and fuel oil do not contain ash, the dust emissions from these plants are not important, if the plant is adjusted correctly.

The dust emissions from smaller wood pellet plants are usually modest and it is not necessary to have flue gas cleaning technology at these plants.

In larger boilers, where the flue gas speed is higher, some dust particles are normally carried with the flue gas. Thus, it is necessary to design the plants with a flue gas cleaning system.

The cleaning methods might be cyclones, bag filters or electro filters. The choice of cleaning technology depends on the emission requirements and the operational conditions.

### 13.5.11 Noise

Noise emission is not a problem at heating plants for private houses.

At larger boiler plants noise can be emitted from the fuel handling equipment from rotating machinery in the boiler house or from the top of the chimney. The noise limit for the boiler plant will appear in the environmental approval for the plant.

### 13.6 References

2. Information centre for Straw and Chips burning, Videnblad nr. 106
3. Videnblad nr. 107.2 “Brændværdier”, Information centre for Straw and Chips burning, 26th of march 1999
14. Grants

This chapter describes the major grants that are currently available in the UK to assist with the capital expense of wood pellet installations.

14.1 Grants for Domestic & Installations

Low Carbon Building Programme
Low Carbon Building Programme Phase 1 - Householders can apply for grants of up to £1,500 per property towards the cost of installing a certified boiler by a certified installer or £600 towards the cost of installing a certified pellet stove. The grant programme is due to continue until June 2010, as long as funds are available. For further information see: http://www.lowcarbonbuildings.org.uk/home/

Scottish Community and Householder SCHRI provides grants to householders of up to 30% of the costs of renewable energy installations (including pellet stoves and boilers) to a maximum of £4,000. The installer and product must be accredited. For further information see http://www.energysavingtrust.org.uk/scotland/Scotland/Scottish-Community-(SCHRI)-Initiative-and-Householder-Renewables-Initiative-SCHRI

14.2 Grants for Non-Domestic Installations

Low Carbon Building Programme
Carbon Building Programme Phase 2 - Community groups, public and non-profit sector applicants can now apply to the Low Carbon Buildings Programme Phase 2 for grants toward up to 50% of the total cost of wood pellet installations until the end of June 2009. For further information see: http://www.lowcarbonbuildings.org.uk/home/

Bio-energy Scheme
The Bio-energy Capital Grants Scheme is aimed at businesses, organisations and Capital Grants charities in England in the commercial, industrial and community sectors that are considering investing in biomass-fuelled heat and/or combined heat and power projects, including anaerobic digestion. There is no minimum grant aid in any one application and the maximum is £500,000 per installation. Grant applications must be made before 30th April 2009. For further information see: http://www.bioenergycapitalgrants.org.uk/

Enhanced Capital Allowance Scheme
The Enhanced Capital Allowance (ECA) scheme provides businesses with enhanced tax relief for investments in equipment that meets published energy-saving criteria. 100 per cent first-year Enhanced Capital Allowances (ECA) allow the full cost of an investment in designated energy-saving plant and machinery to be written off against the taxable profits of the period in which the investment is made. The general rate of capital allowances for spending on plant and machinery is 20% a year on the reducing balance basis. For further information see: http://www.eca.gov.uk/etl/default.htm
Wood Energy Business Scheme

The Forestry Commission Wales are developing a successor to the Wood Energy Business Scheme (WEBS). Subject to funding being available, it is intended that this will include support for the installation of wood fuelled heating and CHP in Wales. For further information see: http://www.woodenergybusiness.co.uk/en/default.aspx

Scottish Community and Householder Initiative Renewables (SCHRI)
SCHRI also provides grants of up to £100,000 for communities and has a network of development officers who can provide support and advice to the communities throughout the installation process. http://www.energysavingtrust.org.uk/scotland/Scotland/Scottish-

Scottish Biomass Heat Scheme
The new Scottish Biomass Heat Scheme is Scotland-wide, with funding of £2million from April 2009 to March 2011. The Scheme will provide grants for installation of biomass heating systems in business premises and district heating demonstrators. The Scheme will prioritise support for small-medium sized enterprises, and is restricted to heat-only biomass applications. The Scottish Government would particularly welcome applications for district heating demonstrators from private developers. http://www.usewoodfuel.co.uk/ScottishBiomassHeatScheme.stm
**Project Description - PELLETS@LAS**

Development and promotion of a Transparent European Pellets Market – Creation of a European real-time Pellets Atlas

The project started in January 2007 and will continue for 3 years until January 2009. It is co-funded by the Intelligent Energy program. It aims to develop and promote transparency on the European fuel pellet market. This is done to facilitate pellet trade and to remove market barriers, mainly information gaps but also local supply bottlenecks, production surpluses and uncertainties in quality assurance management. Furthermore:

- Contribution to the implementation of future European legislation which is hindered by lack of market confidence and attitudes rather than costs.
- Provision of detailed pellet market data on wood and mixed biomass pellets (MBP), such as current prices, available quantities and qualities to all pellet actors in Europe.
- Support of market participation and increase of energetic utilisation of pellets by the permanent availability of market information within a real-time European Pellets Atlas.

**Work programme**

**Phase 1:** Development of a methodology

**Phase 2:** Data collections on European pellet markets and pre-feasibility studies on MBP utilisation

**Phase 3:** National and international pellet markets

**Phase 4:** Dissemination and communication activities

**Outcomes**

The core of PELLETS@LAS is data and information collection in all EU 27+2 (plus Switzerland, Norway) countries from wood and mixed biomass pellet producers, traders and consumers.

- A web-based information platform on important fuel pellet market data, such as produced and available quantities and qualities and regularly up-dated regional sales prices.
- Recording and evaluation of the acceptance and implementation of CEN quality standards.
- A database on logistic management from which a transportation chain model will be derived.
- Four pre-feasibility studies for mixed biomass pellet (MBP) utilisation in Poland, Slovakia, Greece and Germany
- A handbook in five European languages (English, French, Italian, Polish, Danish) on the general use of pellets
- Six workshops (in UK, France, The Netherlands, Poland, Greece and Hungary) in order to promote the energetic utilisation of pellets

**Project Website:** [www.pelletsatlas.info](http://www.pelletsatlas.info)

**Participants** WIP Renewable Energies (Germany), FORCE Technology (Denmark), Holzforschung (Austria), Utrecht University (The Netherlands), EUBIA (Belgium), ETA-Renewable Energies (Italy), Baltic Energy Conservation Agency (Poland), LETEK (Estonia), GEONARDO (Hungary), ADEME (France), Agricultural University of Athens (Greece), National Energy Foundation (UK).
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