Research into the Storage of Woody Biomass Fuel for Heating Equipment
Maurice Millar NIFES Consulting Group

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SUMMARY

This study has collected and reviewed information concerning the storage of solid, woody biomass fuel. This is focused on wood chips, wood pellets and chopped firewood. The use of wood fuel related to buildings has been divided between heating of dwellings and heating of non-domestic buildings. For dwellings, the study distinguishes between 100% wood fuelled central heating systems operating on wood chips or wood pellets; and secondary heating systems using wood fuels (wood pellets or chopped firewood) to provide 10% of annual heating demand.

A number of representative house types have been considered as the basis for assessing the possible annual consumptions of wood fuels and hence the suitable storage capacities required. Similarly, a range of sizes has been considered for each of a number of non-domestic premises. Annual fuel consumption figures have been calculated based on building services industry rules-of-thumb and the numbers and sizes of fuel deliveries have been estimated.

Matrices have been created to present indicative storage capacities and fuel delivery sizes for each of (i) 100% domestic heating; (ii) 10% secondary domestic heating; and (iii) non-domestic heating. For each application, the fuel consumptions, delivery sizes and storage have been based on wood chips and wood pellets for (i) and (iii); and wood pellets and chopped firewood for (ii).

The information presented in this report has been gleaned from sources in some other European countries where the use of wood fuels is well established; mature marketplaces exist with competitive pricing of fuel and equipment; secure supplies of fuel are available, as are multiple sources of heating and related equipment. In the UK, the use of wood fuels, as the principal energy source in automated central heating systems, remains a new technology. Capital grant schemes are available to encourage the development of this form of heating, but there is little wood fuel supply infrastructure and very few companies trying to develop the market by selling wood fuel heating systems to householders and operators of non-domestic buildings.

The industry in Scotland is underdeveloped by comparison with these other EU countries, in spite of the apparent large potential wood fuel resource in this country.

There is great interest in the forestry sector in wood fuel as a possible business diversification opportunity. Bespoke local wood chip supplies have been put in place in various locations to serve the initial wood chip boiler installations which currently number approximately 40 across Scotland. It follows from the current state of market development that there is, as yet, no common market price for wood chips for domestic heating.

Similarly, there is very little manufacturing capacity for wood pellets throughout the UK and none in Scotland. The initial supplies of wood pellets are mostly being imported from various other countries. Again, there is no secure supply infrastructure for wood pellets in Scotland.

Whilst the industry and infrastructure are yet to develop, the search for alternatives to reliance on fossil fuels is leading designers, specifiers, and property managers to investigate the use of woody biomass and a number of systems have already been installed in Scotland, many supported by government funding. This report has investigated a range of technical issues relating to a future wood fuel marketplace which has yet to develop. So it is possible to set out the technical issues relating to the storage of wood fuel, but the optimum size of wood fuel storage is also an economic decision to be based on the greater capital cost of larger storage capacity matched to the opportunity to make cost savings through discounts on bulk purchases; - i.e. from fewer, larger fuel deliveries per year. In parallel with this economic balance, there is also the constraint on the practical volume of storage capacity which can be accommodated at any typical dwelling.

This report presents an overview and preliminary assessment of the issues pertaining to the consumption and storage of wood fuels for heating buildings.
1.0 INTRODUCTION

This study has been commissioned by the Scottish Building Standards Agency in order to inform proposed revisions to the Scottish Building Standards and associated guidance.

The study investigates the issues relating to the storage of a range of solid wood fuel material at the energy end-users’ premises. The scope of the study includes –

- Wood chips from a range of sources, including energy crops
- Wood pellets
- Chopped firewood

The study has considered fully automated wood fuel or biomass central heating systems, operating on 100% wood chips or wood pellets. One of the possible revisions to the guidance on Energy standards concerns secondary forms of heating which may account for 10% of the annual heat demand. Therefore the study also considers the use of wood pellets and chopped firewoods for single-room heaters.

This report has the following structure:

Section 2 reviews the energy marketplace including renewable energies and biomass specifically and offers an explanation of some of the issues relating to solid wood fuels. A range of representative building types and sizes is considered and wood fuel consumption figures are generated to indicate the respective quantities of fuel required for differing applications.

Section 3 focuses on the practical arrangements which can be used to provide storage at the energy end-users’ premises, depending on the type of wood fuel being used. Storage matrices have been produced for domestic and non-domestic applications based on wood-chip and wood pellet fuels. Matrices for 10% secondary domestic heating indicate the possible delivery sizes and necessary storage required for secondary heating using logs and wood pellets.

Section 4 considers safety and environmental issues in the context of wood fuel heating.

A wide range of supporting information is provided in several appendices.
2.0 STATE of the MARKETPLACE

2.1 Overview
The international acceptance of Climate Change and the environmental policies put in place to mitigate its impacts are pushing the commercial introduction of renewable energy technologies to displace the use of fossil fuels and the related combustion emissions of greenhouse gases. In spite of this, the progress in increasing the use of renewable energy across Europe is slow. Figure 1 below shows how total energy consumption has increased since 1990. Figure 2 shows how the renewable energy contribution in 2002 remains small compared to fossil and nuclear sources. Renewable energy data for all 25 EU countries are included in Appendices 1 and 2.

Figure 1: trends in EU25 gross inland energy consumption
(source: EU Energy & Transport in Figures; 2004 edition; part 2 Energy)

Figure 2: gross inland energy consumption for EU25 for 2002
(source: EU Energy & Transport in Figures; 2004 edition; part 2 Energy)

2.1.1 Biomass
Biomass fuel is widely recognised as a source of renewable energy. Throughout the European Union, biomass is the most important source of renewable energy.
However, biomass is less important in the generation of electricity. Eurostat figures for 2002 indicate that biomass accounted for 1.6% of gross electricity consumption from renewable energy sources across the European Union of 25 countries and 1.8% across the European Union of 15 countries.

The inference is that biomass is a principal source of renewable energy for heating applications across the EU – principally in buildings.

In some EU countries, solid woody biomass is a major source of energy; principal amongst these are Sweden, Finland and Austria.

In the UK, we have a saturated heating market where a high proportion of properties with access to the mains natural gas grid are connected and use gas-fired space and hot water heating. Away from the mains gas grid, fuel oil and electric heating are the usual forms of heating. In Scotland, the mains gas grid extends to serve 75% of Scottish households, but consumers in large parts of the country have no access to mains gas.

Three decades of relatively low gas prices has driven the development of the gas central-heating to its current dominant market position. This, in turn, has frustrated the development of other forms of heating.

In Scotland, there is a slowly increasing awareness of renewable energies generally; and, as part of this, increasing interest in the use of carbon-neutral wood fuels. Wood fuel heating equipment, mostly manufactured in Austria and Finland, is available from three or four suppliers. The absence of any wood fuel supply infrastructure is frustrating the market development of the use of biomass for heating.

Some 30+ non-domestic, wood fuel boiler installations are operating across Scotland and further new installations are being completed on a regular basis. The availability of capital grants schemes¹⁻³ is supporting some new wood fuel boiler installations and the supply infrastructure for wood fuel.

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1 SCHRI – Scottish Community & Householder Renewables Initiative  http://www.est.org.uk/schri/
2 Highlands & Islands Wood fuel Development Programme
3 S11 Developing Farm Woodland Energy – Forestry Commission Scotland

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2.2 Wood fuels
The focus of this study is on the storage of woody biomass for heating buildings. Heating with wood fuels is established technology and, in those countries where wood fuels are widely used, there is extensive manufacturing of biomass heating equipment. It is to these countries that we must look for –

(a) good practice in the use of wood fuel heating; technical standards
(b) established marketplaces for wood fuels and related equipment
(c) diverse examples of wood fuel heating applications; domestic, commercial, industrial and public sector

2.2.1 Wood fuel Characteristics

2.2.1.1 Impact of Moisture on the Calorific Value of the Fuel
There is a straight-line relationship between Moisture Content and Net Calorific Value (NCV). Gross Calorific Value is the total energy content of the fuel. The hydrogen fixed in the wood material is released during combustion and converted to water. This, plus the free moisture content, turns to steam. This steam is lost with the flue gases. The energy to evaporate the water to steam is not recovered, so some of the theoretical energy content is lost. The total or gross energy minus the energy to evaporate moisture to steam is known as the Net Calorific Value\(^4\).

![Energy vs Moisture Content](image)

Figure 4 - graph of variation of NCV with Moisture Content (wet mass basis)

The Energy Density varies with Moisture Content in a different way. As one cubic metre of wood chips dries and reduces in Moisture Content and mass, the Net Calorific Value increases (expressed in terms of energy per tonne or GJ/te), but the volume changes little.

If the wood fuel supply contract is based on the delivered price per unit of energy (expressed as £/MWh or £/GJ), then, for a fixed volume (e.g. a truck load) the value increases, as the moisture content decreases.

Wood chips (at 40% MC) are less dense (about 275kg/m\(^3\)) than wood pellets (at 10% MC and about 600kg/m\(^3\)) and wood chips have lower Net Calorific Value (2.91MWh/m\(^3\), compared to wood pellet’s 4.7MWh/m\(^3\)), so larger quantities of wood chips are required for the same delivered energy value.

\(^4\) from “Quality Assurance Manual for Solid Wood Fuels in Finland”, FINBIO, 1998; section 5.3
Table 1 - Variation of properties for Spruce wood chips

<table>
<thead>
<tr>
<th>Moisture content</th>
<th>Density</th>
<th>Net calorific value</th>
<th>Energy density</th>
<th>Energy mass</th>
<th>$H_2O$ mass</th>
<th>fibre mass</th>
<th>total mass</th>
<th>energy MWh/m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>kg/m$^3$</td>
<td>MJ/kg</td>
<td>MJ/m$^3$</td>
<td>kg</td>
<td>kg</td>
<td>kg</td>
<td>MWh</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>165.00</td>
<td>19.06</td>
<td>3,145</td>
<td>0.874</td>
<td>0</td>
<td>500</td>
<td>500</td>
<td>2.65</td>
</tr>
<tr>
<td>10</td>
<td>183.33</td>
<td>16.91</td>
<td>3,100</td>
<td>0.861</td>
<td>56</td>
<td>500</td>
<td>556</td>
<td>2.61</td>
</tr>
<tr>
<td>20</td>
<td>206.25</td>
<td>14.76</td>
<td>3,044</td>
<td>0.846</td>
<td>125</td>
<td>500</td>
<td>625</td>
<td>2.56</td>
</tr>
<tr>
<td>30</td>
<td>235.71</td>
<td>12.61</td>
<td>2,972</td>
<td>0.826</td>
<td>214</td>
<td>500</td>
<td>714</td>
<td>2.50</td>
</tr>
<tr>
<td>40</td>
<td>275.00</td>
<td>10.46</td>
<td>2,877</td>
<td>0.799</td>
<td>333</td>
<td>500</td>
<td>833</td>
<td>2.42</td>
</tr>
<tr>
<td>50</td>
<td>330.00</td>
<td>8.31</td>
<td>2,742</td>
<td>0.762</td>
<td>500</td>
<td>500</td>
<td>1,000</td>
<td>2.31</td>
</tr>
<tr>
<td>60</td>
<td>412.50</td>
<td>6.16</td>
<td>2,541</td>
<td>0.706</td>
<td>750</td>
<td>500</td>
<td>1,250</td>
<td>2.14</td>
</tr>
</tbody>
</table>

A set of international standards for solid wood fuels is in preparation, see Appendix 3.

2.2.1.2 Wood chips

Wood chips are produced from a number of sources:

1. Short roundwood, produced as part of forestry harvesting, as the smallest diameter part of the recovered timber (from Ø5cm to Ø14cm)

2. Secondary processing in sawmills produces various supplies of timber materials which can be comminuted (i.e. chipped) to wood chips

3. Logging residues from primary forestry harvesting comprise the top and side branches of the trees; these are usually left in the forest and are not recovered for use

4. Short Rotation Coppicing of suitable species of energy crops

5. Recycled wood from packaging (pallets and packing crates)

6. Recycled wood from demolition waste

Wood chips from forestry or from sawmill processing vary in moisture content and this affects the available energy content or Net Calorific Value. Wood fuel boilers vary in their capacity for burning wetter wood fuels. Boilers for space and DHW heating applications tend to require partially dried fuel, whereas large industrial boiler plants can accept wet, freshly harvested fuel at 55% moisture content or greater.

2.2.1.3 Heating with Wood pellets

Heating with wood pellets is established practice in various other EU countries; particularly in Austria, Sweden, Denmark and Italy. Pellets are also referred to as ‘Refined Biomass’.

Pellets are manufactured from sawdust and the manufacture of wood pellets for fuel is a major international business in some countries. Pellets are traded between countries and used extensively at all scales; from the smallest single room heater to large industrial combined...
heat and power plants. Wood pellets are used in central heating systems in single- and multi-family homes.

The pellet manufacturing process provides a means of adding value to a co-product of the forest industries which would otherwise present a disposal problem at low value. Pellet manufacturing involves drying the wet sawdust from about 50% Moisture Content (defined on the wet mass basis => 50% of the sample mass is water) to approximately 10% Moisture Content. The dried sawdust is compressed, extruded and cut into regular sized particles, typically Ø6 or 8mm and 12mm long.

Wood pellets have various key characteristics:

- regular physical size
- consistent low Moisture Content (≤10%)
- higher energy density (2.82 MWh/m$^3$) compared to wood chips

Wood pellets are more expensive than wood chips (expressed as price per tonne [£/te] or as price per unit volume [£/m$^3$] or as price per unit of energy [£/GJ]), due to the higher energy content per unit. This is partly off-set by the lower capital cost of pellet boilers, compared to wood-chip boilers, and the need for a smaller fuel-store due to the higher energy density of the fuel.

Throughout Europe, there are various national quality standards relating to wood pellets and larger briquettes (collectively called ‘Refined Biomass’) – see Appendix 4.

### Table 2 - European standards relating to wood pellets

<table>
<thead>
<tr>
<th>Country</th>
<th>Standards</th>
<th>Scope:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>ÖNORM M 7135-1</td>
<td>Wood pellets, Briquettes and sticks</td>
</tr>
<tr>
<td></td>
<td>ÖNORM M 7135-2</td>
<td>Bark pellets, briquettes and pieces</td>
</tr>
<tr>
<td></td>
<td>ÖNORM M 7136</td>
<td>Wood Pellets, Quality Assurance, Transport Logistics and Storage Logistics</td>
</tr>
<tr>
<td>Germany</td>
<td>DIN 51731 - category HP 5</td>
<td>Wood briquettes (incl. pellets) length &lt;50mm; width 4 to 10mm</td>
</tr>
<tr>
<td>Sweden</td>
<td>SS 1871 20</td>
<td>Fuel pellets; three classes</td>
</tr>
<tr>
<td></td>
<td>SS 1871 23</td>
<td>Fuel briquettes; three classes</td>
</tr>
<tr>
<td>Europe</td>
<td>CEN/TS 14961</td>
<td>Solid Organic Fuels</td>
</tr>
</tbody>
</table>

Like wood pellets, briquettes are a manufactured form of biomass fuel made from dried and compressed sawdust. Different manufacturers have their own briquette shapes and sizes, but a typical briquette is 300 mm long and approximately Ø80mm in cross-section. Wood pellets are widely used in automated pellet boilers as part of domestic and non-domestic central heating systems. In contrast, briquettes can be used in a similar way to firewood logs and burned in stoves.

**2.2.1.4 Chopped Firewood**

The use of chopped firewood is, of course, traditional well-established practice in many areas. The Finnish Quality Assurance Manual (reference 3) sets out a quality classification for chopped firewood in three grades. The principal measures are -

- first class:
  - uniform sizes of single species, packaged in crates or on pallets
    - either hardwood only, or
– mainly softwood with some hardwood included
  moisture content of ≤20%
  incompletely chopped and/or de-barked pieces not to exceed 5%
– second class:
  standard sizes but with up to 15% of un-chopped or incompletely chopped wood
  - chopped hardwood can contain softwood without restriction
  - chopped softwood can include up to 5% of other species
  moisture content of ≤25%
  incompletely chopped and/or de-barked pieces not to exceed 15%
- third class:
  mixed irregular sizes
  - chopped hardwood can contain softwood without restriction
  - chopped softwood can include up to 10% of other species
  moisture content of ≤30%
  incompletely chopped and/or de-barked pieces not to exceed 25%

Like other forms of wood fuel, the available energy or Net Calorific Value (NCV) is related to moisture content. Chopped firewood from hardwoods have high NCV compared to coniferous species, see Table 3, below.

<table>
<thead>
<tr>
<th>Species</th>
<th>Moisture Content %</th>
<th>Heating value kWh/loose m$^3$</th>
<th>Heating value kWh/stacked m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birch</td>
<td>0</td>
<td>1,040</td>
<td>1,750</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>990</td>
<td>1,660</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>930</td>
<td>1,550</td>
</tr>
<tr>
<td>Mixed coniferous</td>
<td>0</td>
<td>830</td>
<td>1,380</td>
</tr>
<tr>
<td>(pine / spruce)</td>
<td>30</td>
<td>780</td>
<td>1,310</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>720</td>
<td>1,200</td>
</tr>
<tr>
<td>Mixed broad-leaves</td>
<td>0</td>
<td>790</td>
<td>1,330</td>
</tr>
<tr>
<td>(alder / poplar)</td>
<td>30</td>
<td>740</td>
<td>1,250</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>680</td>
<td>1,140</td>
</tr>
</tbody>
</table>

2.2.1.5 Miscanthus or ‘Elephant Grass’

Miscoanthus species are woody, perennial, rhizomatous grasses, originating from Asia. Once established, the crop can be harvested annually for at least 15 years. By the third year harvestable yields are between 10-13 tonnes per hectare. Peak harvestable yields of 20 tonnes per hectare have been recorded.5

Miscoanthus has a net calorific value, on a dry basis, of 17 GJ/te, with 2.7% ash content. For comparison, coal has a net calorific value of 28 GJ/te and softwoods (pine and spruce) have a similar value of 19 GJ/te (dry basis or oven-dried, i.e. 0% moisture content).

Large rectangular and round balers are capable of producing bales of miscoanthus with a dry matter density of between 120 and 160 kg/m$^3$ and weighing between 250 and 600kg.

Sources:  
http://www.defra.gov.uk/erdp/schemes/energy/crops.htm and  

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2.2.2 Use of Wood fuels
There are three main applications for the use of wood fuels:

(i) space and domestic hot water (DHW) heating in buildings
(ii) industrial applications requiring process heating
(iii) power generation (including combined heat and power)

This study is focussed on (i) heating buildings.

2.2.2.1 Heating Buildings
In terms of heating buildings, we have a wide range of buildings in domestic, commercial and public sectors; from individual family homes to hotels, offices and hospitals.

Table 4, below, sets out ranges of heat demand for the various heating applications in domestic buildings, based on 100% heating from wood fuels.

For domestic heating of new, single family homes the heating demand varies with floor area and, consequently, the annual fuel consumption increases with house size. The figures given in Table 4, below, give an indication of the range of wood fuel requirements to satisfy small (typically 10 MWh/yr) to large (typically 20 MWh/yr) new houses.

Quantities of wood fuels required (see Table 4) vary with Moisture Content (MC). For wood chips, 40% MC is the worst case; 35% MC is the expected level. Wood pellet moisture content is less variable with 10% being the average level, as wood pellets are produced in a manufacturing process which delivers a consistent product. Logs are taken to be air-dried at 25% MC. For logs, there is some very small variation in NCV between species, but the main variation is in density. Similarly, in terms of storage requirement, there is a major variation in the volumes of stacked and loose chopped firewood.

CE marked boilers
CE marking is a declaration by the manufacturer that the product meets all the appropriate provisions of the relevant legislation implementing certain European Directives. The directives covering automatic wood fuelled boilers include:

- The Machinery Directive - 98/37/EC

Boiler efficiency
Wood fuel boiler efficiencies are typically between 80 and 90%. The manufacturer should have efficiency independently verified in accordance with EN303-5 or another recognised national standard.

Boiler emissions
Boiler emissions must comply with regulations; for boilers up to 300kW, emissions should conform to Euro Norm EN303-5 1999.

Details of the European Standard for Heating Boilers are set out in Appendix 5.
Table 4 - Types of houses with probable heat demand and requirements for wood fuel

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Annual heat demand MWh</th>
<th>Annual Fuel Demand MWh</th>
<th>Wood chips fuel need te/yr at 40%MC</th>
<th>Wood chips volume $m^3$/yr</th>
<th>Wood pellets fuel need te/yr at 10%MC</th>
<th>Wood pellets volume $m^3$/yr</th>
<th>Chopped firewood fuel need te/yr at 25% MC</th>
<th>Loose Volume $m^3$/yr</th>
<th>Stacked Volume $m^3$/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Low Energy House 80m²</td>
<td>6</td>
<td>7.8</td>
<td>2.7</td>
<td>9.8</td>
<td>1.65</td>
<td>2.8</td>
<td>1.9</td>
<td>7.7 - 10.5</td>
<td>4.6 – 6.3</td>
</tr>
<tr>
<td>Small House 80m²</td>
<td>10</td>
<td>13</td>
<td>4.6</td>
<td>16.7</td>
<td>2.8</td>
<td>4.7</td>
<td>3.2</td>
<td>12.9 – 17.6</td>
<td>7.6 – 10.6</td>
</tr>
<tr>
<td>Victorian Villa 120m²</td>
<td>25</td>
<td>32.5</td>
<td>11.2</td>
<td>40.6</td>
<td>6.9</td>
<td>11.5</td>
<td>7.9</td>
<td>32.1 – 43.9</td>
<td>19.1 – 26.4</td>
</tr>
<tr>
<td>Large House Low Energy 160m²</td>
<td>15</td>
<td>19.5</td>
<td>6.7</td>
<td>24.4</td>
<td>4.2</td>
<td>8.9</td>
<td>4.75</td>
<td>19.3 – 26.3</td>
<td>11.5 – 15.8</td>
</tr>
<tr>
<td>Large House Modern Construction 160m²</td>
<td>20</td>
<td>26</td>
<td>9</td>
<td>32.5</td>
<td>5.5</td>
<td>9.3</td>
<td>6.35</td>
<td>25.7 – 35.1</td>
<td>15.3 – 21.1</td>
</tr>
</tbody>
</table>

The variations in volumes of chopped firewood are due to the range of densities (e.g. Alder at 0.183te/m³ to Birch at 0.243te/m³ for loose volumes) and whether the storage is stacked or loose.

**Assumptions of annual heat demand**

The study includes tables that estimate the need for wood fuel on the basis of assumed annual heat demand. The following assumptions are made in the estimation of annual heat demand for different types of houses:

- Small low energy house 80m²: Designed to be 25% more energy efficient than the guidance given in the Technical Handbooks 2005
- Small house 80m²: Designed to the guidance given in the Technical Handbooks 2005
- Victorian villa 120m²: Masonry walls, timber floors, pitched roof, no added insulation.
- Large low energy house 160m²: Designed to be 25% more energy efficient than the guidance given in the Technical Handbooks 2005
- Large house 160m²: Designed to the guidance given in the Technical Handbooks 2005
In the commercial and public sectors, it is not so straight-forward to define typical buildings or to establish a range of typical energy consumptions. The figures included in Table 5 for Non-domestic Buildings are generated from industry rules-of-thumb.6

<table>
<thead>
<tr>
<th>Non-domestic Buildings</th>
<th>Annual heating demand MWh/yr</th>
<th>Annual fuel requirement - wood chips (at 40% MC) te/yr</th>
<th>Annual fuel requirement - wood pellets (at 10% MC) te/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>- educational 400 to 2,000m²</td>
<td>105 to 530</td>
<td>48 to 242</td>
<td>30 to 150</td>
</tr>
<tr>
<td>- industrial 100 to 2,000m²</td>
<td>21 to 421</td>
<td>10 to 193</td>
<td>6 to 120</td>
</tr>
<tr>
<td>- offices 100 to 2,000m²</td>
<td>24 to 492</td>
<td>8.5 to 169</td>
<td>5 to 105</td>
</tr>
</tbody>
</table>

2.2.2.2 Secondary Heating
Proposed revisions to the Energy guidance in the Scottish Building Standards Domestic Technical Handbook for new dwellings are to accommodate secondary forms of heating, which may account for 10% of the annual heat demand. It is quite feasible for this secondary heating to be provided from wood fuel in the forms of logs (chopped firewood) or as wood pellets.

Whereas chopped firewood and wood pellets can be used in individual room heaters and can be readily managed manually, a heating system based on wood chips would generally be a primary form of heating, as this would comprise an automated fuel-store, boiler and a 'wet' heat distribution system of radiators or under-floor heating.

Heating with chopped firewood
Chopped firewood is already widely used for heating. If chopped firewood is to meet 10% of the heating demand in a domestic dwelling, then the figures in Appendix 5, provide an indication of the volume of wood fuel required each year as chopped firewood, for various sizes of dwellings – both existing and new-build.

These calculations are based on Finnish wood fuel standards7 and data from the Finnish Bio-energy Network, BENET. The figures present data for several types of species (e.g. hardwood like Silver Birch and softwoods like Scots Pine and Norway Spruce). There is some small variation in the available energy content (Net Calorific Value – NCV) of the different species, but the major difference is in mass density.

This means that the volume of fuel required per year depends on the chosen species and whether it is carefully stacked or stored loose. For representative new-build dwellings and, for comparison purposes, an existing Victorian villa of 120m², the ranges of wood fuel consumption are presented in Table 5, below.

The annual required volume of logs varies with species; of the five example species shown in Appendix 6, Silver Birch is of approximately 33% higher density than Alder, consequently a comparable volume of Silver Birch logs contains 33% more energy than the same volume of Alder, given that the variations in Net Calorific Value are very small.

In addition to the variations in the physical characteristics of wood fuel, there is also a major difference in the method of storage.

6 BSRIA Rules-of-Thumb “Guidelines for Assessing Building Services (UK, 3rd edition)
Finnish sources use the following measures for comparing solid, stacked and loose logs –

\[ 1 \text{ m}^3 \text{ solid} = 1.5 \text{ m}^3 \text{ stacked} = 2.5 \text{ m}^3 \text{ loose} \]

- so it follows, of course, that there is a need for greater storage capacity for loose logs compared to carefully stacked logs.

The variations are quantified in Table 6 for loose and stacked logs over the range of species from Birch (higher density and therefore lower volumes) to Alder (lower density and therefore higher volumes).

Similarly, Table 6 also shows the quantities of wood pellets required to provide the same 10% secondary heating.
Table 6 – mass and volumes of logs and wood pellets for 10% secondary heating

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Annual Heat Demand MWh</th>
<th>Annual Fuel Demand MWh</th>
<th>10% fuel Demand MWh/yr</th>
<th>fuel need kg/yr</th>
<th>volume m$^3$</th>
<th>fuel need te/year</th>
<th>volume loose m$^3$</th>
<th>volume stacked m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Low Energy House 80m$^2$</td>
<td>6</td>
<td>7.8</td>
<td>0.78</td>
<td>165</td>
<td>0.3</td>
<td>0.2</td>
<td>0.8 – 1.5</td>
<td>0.5 – 0.6</td>
</tr>
<tr>
<td>Small House 80m$^2$</td>
<td>10</td>
<td>13</td>
<td>1.3</td>
<td>280</td>
<td>0.5</td>
<td>0.3</td>
<td>1.3 – 1.8</td>
<td>0.8 – 1.1</td>
</tr>
<tr>
<td>Victorian Villa 120m$^2$</td>
<td>25</td>
<td>32.5</td>
<td>3.25</td>
<td>691</td>
<td>1.15</td>
<td>0.8</td>
<td>3.2 – 4.4</td>
<td>1.9 – 2.6</td>
</tr>
<tr>
<td>Large House Low Energy 160m$^2$</td>
<td>15</td>
<td>19.5</td>
<td>1.95</td>
<td>415</td>
<td>0.9</td>
<td>0.5</td>
<td>1.9 – 2.6</td>
<td>1.2 – 1.6</td>
</tr>
<tr>
<td>Large House Modern Construction 160m$^2$</td>
<td>20</td>
<td>26</td>
<td>2.6</td>
<td>550</td>
<td>0.93</td>
<td>0.6</td>
<td>2.6 – 3.5</td>
<td>1.5 – 2.1</td>
</tr>
</tbody>
</table>
3.0 STORAGE ACCOMMODATION

3.1 Appropriate Storage
Solid wood fuels provide a form of energy storage; wood fuel is a naturally generated form of stored hydro-carbon. Suitable storage accommodation is needed at or within buildings, depending on the form (chips, pellets or logs); the quantities; and the nature of the handling system (manual or automatic feed).

The use of automated wood fuelled heating has developed differently across Europe. In Sweden and Austria, for example, domestic heating with wood fuel is based on wood pellets while wood chips are used in much larger applications. In Finland, the use of wood pellets is not so widespread, but there is an established marketplace for logs. Wood chips are used in large boilers supplying heat to district heating schemes, rather than individual houses.

The design and specification of the required wood fuel storage is also related to the economic volumes of available fuel and the manner in which the fuel is delivered. Similarly, the requirements of the heating equipment (boiler or stove) will determine the fuel specification.

In some countries, storage of wood chips and pellets is above ground in hoppers or silos.

![Figure 6 - basement store with indirect access](image)
![Figure 7 - basement store with direct access](image)

In Austria, below-ground storage for wood chips and wood pellets is popular, as in figures 6 and 7. The size of the fuel-store depends on many factors such as,

(a) expected fuel requirements,
(b) fuel-type,
(c) reliability of deliveries,
(d) space available, and
(e) the capacity of the delivery-vehicle.

In existing buildings, it is usually cheaper to adjust the fuel-delivery intervals to the available storage-space rather than building a new store outside the building.

New fuel stores should be at least 50 per cent larger than the size of a single delivery, to permit cost-effective fuel delivery.

The fuel can be transported from the store to the boiler in various ways:

- flat floor with horizontal hydraulic feed-bar – expensive, but the best possible use of the space. It can handle any type of fuel.
- rotating-arm feeder (as illustrated above) – cheaper and can be used for both pellets and chips.

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• inclined floor with a screw conveyor (suitable only for pellets) – as the gradient has to be at least 35°, the store should be long and narrow to keep the unused volume down to a minimum.
• inclined floor with a suction pipe – suitable only for pellets. The distance between the store and boiler-room may be up to 15 metres with a pneumatic feed-system.

The boiler-room should be separated from the fuel-store in order to prevent the spread of fire. When planning the boiler-room, sufficient space should be allowed for daily operation, maintenance and repair-work. Experience, in Austria, has shown that replacing the screw-conveyor for fuel-feeding requires the most space. Also ensure that there is enough room for cleaning the surface of the heat-exchanger (unless there is an automatic system). The average area required for a boiler heating a large commercial building is between 20 and 30 m².

3.1.1 Wood chips
Wood chips are delivered loose to the end-user or in large open bags. Alternatively, wood chips can be delivered in demountable containers, which are connected to the fuel transfer system to the boiler(s). These also provide the on-site fuel storage.

Loose wood chips can be delivered from tipping vehicles or from ‘walking-floor’ trucks into storage below ground level (see figures 6 and 7; and 8 and 9 below).

If wood fuels are stored below ground, then the following points should be noted:
• Precautions should be taken to ensure that nobody could fall into the store. For example, a steel grid could be fixed, but the mesh has to be wide enough to prevent it from becoming choked during unloading (at least 20 x 20 cm).
• The location of the openings in the fuel store should be designed to take account of the possible behaviour of the dust raised during unloading.
• Any fuel dropped during unloading should be removed.
• The lid of the store should be water-tight and the store should be constructed to ensure that the fuel remains dry.
• The construction of the store should allow for ventilation to prevent excessive condensation within the store.

Figure 8 – underground store adjacent to basement boiler-room (Austria)  Figure 9 – underground store with elevator to ground-level boiler (France)

Underground storage makes for ready access for unloading delivery vehicles, but may add to the capital cost due to any additional civil works.

An alternative to underground storage is to use above-ground hoppers with the implication that the fuel must be raised from the delivery vehicle to a higher elevation to fill the hopper (see Figure 10).
Any installations should be designed to take account of access and manoeuvring for delivery vehicles. The specific required arrangement of access roads for delivery vehicles will be related to the size of the vehicles; the size of the fuel deliveries and which of several methods of unloading is to be employed (tipping; walking-floor; bags; blowing, demountable containers).

3.1.2 Wood pellets
As 1 m$^3$ of pellets can have three or more times the calorific value of 1 m$^3$ of dry wood chips, a wood pellet installation would require either less frequent fuel deliveries or smaller fuel storage volume than for a wood chip installation of the same energy capacity. Because of this, wood pellet heating systems may offer a better solution in urban areas where traffic is an important aspect. Some domestic boilers are able to operate on wood chips or wood pellets.

Wood pellets are available packed in 15 or 20kg sacks; in multiples of these sacks delivered on pallets; in 1m$^3$ bags; or delivered loose (blown or tipped into on-site storage). In other EU markets, where pellet supplies are well established, pellets are usually delivered in road tankers and blown from the delivery vehicle into the pellet store.
The pellets can be damaged during delivery and the amount of fines or sawdust is a measure of the quality of the pellets and the way they have been handled during manufacture and delivery. If bulk deliveries are needed, the design of the installation must ensure that there is appropriate access and manoeuvring space for the delivery vehicle.

Once each year, the dust that has collected should be removed from the pellet store and the screw-conveyor’s bearings should be lubricated.

There is no pellet manufacturing capacity in Scotland at present. Pellets are manufactured in Northern Ireland from sawmill co-product; in County Durham from recycled wood; and in South Wales. However, the principal source at present is imports, mainly to supply the electricity industry’s co-firing operations in existing coal-fired power stations. The co-firing process allows biomass material from crushed pellets to be used in parallel with pulverised coal. A proportion of the total electricity produced is deemed to be eligible as higher value ‘green electricity’ in proportion to the relative inputs of primary energy from coal and biomass.

One company offers wood pellets in bags for quantities up to 3 tonnes that are available from retailers, but delivers bulk orders either bagged in 15kg bags on 1.2 tonne pallets, or loose, either as 25 tonne loads from a tipper, or loads up to 15 tonnes blown into storage.

Domestic pellet storage options include mini silos and pellet storage tanks, see Figures 14, 15, 16 and 17.
- pellet storage tank, 2.5 x 1.5 x 2m

- mini-silo 1.3 x 0.6 m

Figures 14, 15 – pellet storage options from Sweden (images: [http://www.statoilpellets.se/](http://www.statoilpellets.se/))

Various pellet storage options are available in other EU countries: internal bag silos and a basement pellet store.

Figure 16 - internal bag silo

Figure 17 - internal bag silo UV-Silo®
Figure 18 above shows the revolving spring arms which sweep fuel on to an Archimedes screw or auger, which transfers the fuel to the boiler.

For secondary heating using wood pellet heaters, each heater has built-in fuel storage (see Figure 19). The pellets are poured manually from the 15 or 20kg bags (or from some other container) into the fuel store which is integral to the design of the heater unit.

3.1.3 Chopped Firewood

Commercially prepared firewood will have been air-dried to less than 30% moisture content, ready for use. Like other wood fuels, it is important to keep it dry by providing suitable storage facilities. In some other European markets, such as Finland (Figure 20) and France, chopped firewood is supplied as split logs of uniform length, bound together with ties. This form of delivery makes it suitable for stacking under-cover and so reduces the required storage volume compared to loose storage.
Figure 22: stacked firewood – Perthshire
(photo: http://www.woodforwarmth.co.uk/)
3.2 **Storage Tables**
In order to present the many wood fuel storage options, separate tables are offered for domestic and non-domestic applications; and for domestic secondary heating.

3.2.1 **Domestic Heating**
The tables below (7 & 8) present proposals for suitable wood fuel storage capacity for domestic heating to meet 100% of the space and DHW heating demands, assuming (i) deliveries of wood fuel (pellets and chips) in whole bags of 1m\(^3\) each and (ii) storage capacity is 50% larger than the delivery size.

**Table 7 Wood chips: estimated storage capacities for 100% domestic heating**

<table>
<thead>
<tr>
<th>Building Type:</th>
<th>Assumed annual heat demand</th>
<th>Annual fuel demand</th>
<th>Annual fuel need at 40%MC</th>
<th>Assumed size of each delivery</th>
<th>Storage capacity</th>
<th>Delivery size related to annual need</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MWh</td>
<td>MWh</td>
<td>te/yr</td>
<td>m(^3)/yr</td>
<td>te</td>
<td>m(^3)</td>
</tr>
<tr>
<td>Small Low Energy House 80m(^2)</td>
<td>6</td>
<td>7.8</td>
<td>2.7</td>
<td>9.8</td>
<td>1.4</td>
<td>5</td>
</tr>
<tr>
<td>Small House 80m(^2)</td>
<td>10</td>
<td>13</td>
<td>4.6</td>
<td>16.7</td>
<td>2.2</td>
<td>8</td>
</tr>
<tr>
<td>Victorian Villa 120m(^2)</td>
<td>25</td>
<td>32.5</td>
<td>11.2</td>
<td>40.6</td>
<td>2.8</td>
<td>10</td>
</tr>
<tr>
<td>Large House Low Energy 160m(^2)</td>
<td>15</td>
<td>19.5</td>
<td>6.7</td>
<td>24.4</td>
<td>1.6</td>
<td>6</td>
</tr>
<tr>
<td>Large House Modern Construction 160m(^2)</td>
<td>20</td>
<td>26</td>
<td>9</td>
<td>32.5</td>
<td>2.2</td>
<td>8</td>
</tr>
</tbody>
</table>

**Table 8 Wood pellets: estimated storage capacities for 100% domestic heating**

<table>
<thead>
<tr>
<th>Building Type:</th>
<th>Assumed annual heat demand</th>
<th>Annual fuel demand</th>
<th>Annual fuel need at 10%MC</th>
<th>Assumed size of each delivery</th>
<th>Storage capacity</th>
<th>Delivery size related to annual need</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MWh</td>
<td>MWh</td>
<td>te/yr</td>
<td>m(^3)/yr</td>
<td>te</td>
<td>m(^3)</td>
</tr>
<tr>
<td>Small Low Energy House 80m(^2)</td>
<td>6</td>
<td>7.8</td>
<td>1.65</td>
<td>2.8</td>
<td>1.2</td>
<td>2</td>
</tr>
<tr>
<td>Small House 80m(^2)</td>
<td>10</td>
<td>13</td>
<td>2.8</td>
<td>4.7</td>
<td>1.8</td>
<td>3</td>
</tr>
<tr>
<td>Victorian Villa 120m(^2)</td>
<td>25</td>
<td>32.5</td>
<td>6.9</td>
<td>11.5</td>
<td>4.8</td>
<td>8</td>
</tr>
<tr>
<td>Large House Low Energy 160m(^2)</td>
<td>15</td>
<td>19.5</td>
<td>4.2</td>
<td>8.9</td>
<td>3.0</td>
<td>5</td>
</tr>
<tr>
<td>Large House Modern Construction 160m(^2)</td>
<td>20</td>
<td>26</td>
<td>5.5</td>
<td>9.3</td>
<td>3.6</td>
<td>6</td>
</tr>
</tbody>
</table>
The proposed sizes for storage are much larger for wood chips than for wood pellets. The proposed size of wood pellet storage (see Table 8) is intended to offer a large enough volume to secure volume discount on purchases of larger volumes of pellets, given the modest annual fuel requirements, particularly in the smaller dwellings. With wood chips (see Table 7), the volumes can be much larger and, if the same relative storage sizes were used as for wood pellets (e.g. about 65% of the annual fuel demand) then in the larger houses the fuel stores would be unreasonably large; for example, for the Victorian villa, the wood chip store would be \(27m^3\ (3m \times 3m \times 3m)\), based on 65% of 40.6\(m^3/yr\). Consequently, lower proportions are used, implying increased numbers of deliveries per annum compared to wood pellet heating.

### 3.2.2 Secondary Domestic Heating

Table 9 below offers examples of the weights and volumes of wood pellets, needed for secondary heating to provide 10% of the assumed annual heat demand. It is assumed that the pellets are delivered in small bags (20kg).

<table>
<thead>
<tr>
<th>Building Type:</th>
<th>Assumed annual heat demand</th>
<th>Annual fuel demand</th>
<th>10% annual fuel need at 10% MC</th>
<th>Assumed size of each delivery</th>
<th>Storage capacity</th>
<th>Delivery size related to 10% annual need % of 10% of annual fuel need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Low Energy House</td>
<td>6</td>
<td>7.8</td>
<td>0.16</td>
<td>0.28</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>Small House 80m²</td>
<td>10</td>
<td>13</td>
<td>0.28</td>
<td>0.47</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>Victorian Villa 120m²</td>
<td>25</td>
<td>32.5</td>
<td>0.69</td>
<td>1.15</td>
<td>10</td>
<td>1.0</td>
</tr>
<tr>
<td>Large House Low Energy</td>
<td>15</td>
<td>19.5</td>
<td>0.42</td>
<td>0.89</td>
<td>10</td>
<td>1.0</td>
</tr>
<tr>
<td>Large House Modern Construction 160m²</td>
<td>20</td>
<td>26</td>
<td>0.55</td>
<td>0.93</td>
<td>10</td>
<td>200</td>
</tr>
</tbody>
</table>
Table 10 below offers examples of the weights and volumes of chopped firewood needed for secondary heating to provide 10% of the assumed annual heat demand. It is assumed that the pellets are delivered in small bags (20kg).

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Assumed annual heat demand</th>
<th>Annual fuel demand</th>
<th>10% annual fuel demand</th>
<th>Fuel need for 10% annual fuel demand</th>
<th>Proposed delivery size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MWh</td>
<td>MWh</td>
<td>MWh</td>
<td>kg</td>
<td>1m³ bags</td>
</tr>
<tr>
<td>Small Low Energy House 80m²</td>
<td>6</td>
<td>7.8</td>
<td>0.78</td>
<td>200</td>
<td>0.8 – 1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.5 – 0.6</td>
</tr>
<tr>
<td>Small House 80m²</td>
<td>10</td>
<td>13</td>
<td>1.3</td>
<td>300</td>
<td>1.3 – 1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.8 – 1.1</td>
</tr>
<tr>
<td>Victorian Villa 120m²</td>
<td>25</td>
<td>32.5</td>
<td>3.25</td>
<td>800</td>
<td>3.2 – 4.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.9 – 2.6</td>
</tr>
<tr>
<td>Large House Low Energy 160m²</td>
<td>15</td>
<td>19.5</td>
<td>1.95</td>
<td>500</td>
<td>1.9 – 2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.2 – 1.6</td>
</tr>
<tr>
<td>Large House Modern Construction 160m²</td>
<td>20</td>
<td>26</td>
<td>2.6</td>
<td>600</td>
<td>2.6 – 3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.5 – 2.1</td>
</tr>
</tbody>
</table>

Wood fuel heating is widely used in other European countries in multi-family homes of several apartments connected to a single central heating system with a common boiler; in community heating schemes, where several blocks of apartments are connected together to a central boiler system; and in district heating schemes, where all types of properties, in large parts of a town or city, are all connected to a central heating system with wood fuelled boilers.

In each case, the size of the boiler(s); the associated wood fuel storage capacity; and the choice of fuel will be related to the number of separate properties to be heated and the occupancy; the profile of the aggregate demand for heating and the competing prices of available fuels. It follows that the wood fuel storage arrangements will be bespoke to each individual application.
3.2.3 Non-domestic Heating

The tables below (11 & 12) present proposals for suitable wood fuel storage capacity for non-domestic heating to meet 100% of the space and DHW heating demands.

Table 11 Wood chips: estimated storage capacities for 100% non-domestic heating

<table>
<thead>
<tr>
<th>Non-domestic Buildings</th>
<th>Annual heating demand</th>
<th>Annual fuel requirement</th>
<th>Deliveries per year at 25te/delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MWh</td>
<td>te</td>
<td>m³</td>
</tr>
<tr>
<td>- educational</td>
<td>105 to 530</td>
<td>48 to 242</td>
<td>176 to 879</td>
</tr>
<tr>
<td>- industrial</td>
<td>21 to 421</td>
<td>10 to 193</td>
<td>35 to 703</td>
</tr>
<tr>
<td>- offices</td>
<td>24 to 492</td>
<td>8.5 to 169</td>
<td>31 to 615</td>
</tr>
</tbody>
</table>

Table 12 Wood pellets: estimated storage capacities for 100% non-domestic heating

<table>
<thead>
<tr>
<th>Non-domestic Buildings</th>
<th>Annual heating demand</th>
<th>Annual fuel requirement</th>
<th>Deliveries per year at 25te/delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MWh</td>
<td>te</td>
<td>m³</td>
</tr>
<tr>
<td>- educational</td>
<td>105 to 530</td>
<td>30 to 150</td>
<td>50 to 250</td>
</tr>
<tr>
<td>- industrial</td>
<td>21 to 421</td>
<td>6 to 120</td>
<td>10 to 200</td>
</tr>
<tr>
<td>- offices</td>
<td>24 to 492</td>
<td>5 to 105</td>
<td>8 to 175</td>
</tr>
</tbody>
</table>

On the basis that bulk deliveries of wood pellets in loads of 25te become available and advice from Austria that the fuel store should be able to accommodate 50% more than the regular delivery size, then the minimum storage size for these non-domestic applications would be 36te or 60m³. From Tables 11 and 12 above, the largest non-domestic application considered would require six 25te deliveries of wood pellets or 10 deliveries of wood chips each year.

At 25te for a full truck-load, the volume would be 91m³ (for wood chips at 40%MC). The carrying capacities of trucks vary, depending on the truck configuration:

Table 13 – HGV haulage capacities

| Tipping trailers | 70 – 90 cu.yd | 53 – 69 m³ |
| Walking floor trailers | 120 – 130 cu.yd | 92 – 99 m³ |

From Table 1, the density of wood chips varies with moisture content. For a maximum load of 25te, the volume varies as in Table 14, below.

Table 14 - variation in volume with moisture content for a 25te load

<table>
<thead>
<tr>
<th>Moisture Content</th>
<th>Density</th>
<th>Volume of 25te load</th>
<th>Mass of max. load</th>
<th>Delivered energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>kg/m³</td>
<td>m³</td>
<td>te</td>
<td>MWh</td>
</tr>
<tr>
<td>20</td>
<td>206.25</td>
<td>121</td>
<td>20.42</td>
<td>83.8*</td>
</tr>
<tr>
<td>30</td>
<td>235.71</td>
<td>106</td>
<td>23.33</td>
<td>81.8</td>
</tr>
<tr>
<td>40</td>
<td>275.00</td>
<td>91</td>
<td>25.00</td>
<td>73†</td>
</tr>
<tr>
<td>50</td>
<td>330.00</td>
<td>76</td>
<td>25.00</td>
<td>58†</td>
</tr>
</tbody>
</table>

(* based on 99m³ walking floor truck; † based on maximum load of 25te)

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8 from http://www.stevensonbros.co.uk/fleet.htm
Table 14 shows how, at 20% and 30%, the maximum carrying volume of the walking floor truck (99m³) is filled without reaching the maximum load capacity (25t). At higher moisture content (40% and 50%), the maximum load capacity is reached before the available volume is filled.

On the basis that the maximum size of delivery (at 40% MC) would be 91m³ and 25t, and the fuel storage capacity should be 50% greater than the regular delivery size, then the maximum fuel storage capacity for wood chips would be about 140m³ and 38t.

It is acknowledged that 35% moisture content would be a more typical target for wood chips for relatively small heating applications. 40% MC is used as a worst case.
4.0 SAFETY

4.1 Fire Safety
With automated fuel feed systems, there is a risk of fire burning back from the boiler to the fuel store. To prevent this, there should be an interruption to the fuel-transport system (e.g. a star-feeder or chute for the fuel to fall into the boiler) and a sprinkler-system to flood the fuel-transport line in the event of back-burning. Any such sprinkler system should be supplied from an assured mains connection.

The relevant safety standards are described in EN 303-5. EN 303-5 is incorporated as British Standard BS EN 303-5(see Appendix 5). There is no harmonised European standard that is equivalent to the Austrian standard, ÖNORM M 7137, relates to wood pellet storage at the end-users’ premises.

4.1.1 Safety-features for a chip or pellet store

4.1.1.1 Wood pellets
Pellet-stores have to meet special safety-requirements to prevent problems such as damage to the store, dust-explosions and moisture-absorption. According to best practice in Austria, the ideal pellet-store would display the following features:

- solid walls that can withstand the pressure of the pellets, and which are fire-resistant for 90 minutes
- completely dry
- a protective rubber mat suspended opposite the inlet to the store such that the pellets hit the mat which absorbs some of the momentum of the pellets, so reducing the possibility of damage to the pellets hitting the wall of the store during unloading
- fireproof, properly-sealing door to the store with removable wooden boards which allow access when the store is partly full
- no electrical installations other than those required to operate the
- earthed pump-pipes that prevent electrostatic sparks from occurring during loading

Figure 24 - view of removable pellet retaining boards at access door to basement pellet store (photo: NIFES)
4.1.1.2 Wood chip hoppers
The storage of wood fuel may present dangers to children and others that can be limited by careful design and management. Children may be tempted to explore an above ground hopper and the designer should consider how easy it is to climb onto it. Suppliers of hoppers should make provision for the lids to be padlocked or locked. It would be prudent to lock away any ladder used to access above ground hoppers during deliveries.

4.2 Environmental Issues

4.2.1 Ash
Two types of ash are formed from wood fuel combustion: ‘bottom ash’ which collects in the combustion unit (the residue that is left in the combustion chamber) and ash collected from the flue gases in the larger industrial-scale plant.

Ash has the potential to form a valuable by-product as a low nitrate fertiliser for use in areas high in nitrogen.

4.2.2 Emissions
There are two forms of pollutants associated with wood fuel: leachates and atmospheric emissions.

Leachates can be produced during the timber harvesting and storage processes. When it rains on stored branchwood and residues, the rain can pick up contaminants, leachates, which can enter groundwater or watercourses. However, once the wood fuel has been air dried, prepared and delivered to the end user, there will be no risk of leachate if it is kept dry and under cover. Keeping the fuel dry also means that it will burn more efficiently.

Atmospheric emissions are released following burning. Emissions from modern wood fuel boilers and stoves are low compared to emissions from oil and gas boilers, but include sulphur dioxide, particulates (dust), carbon dioxide, carbon monoxide, organic compounds, nitrogen oxides and water vapour. Emissions should be considered over the life cycle of the fuel (see Figure 25).

For boilers up to 300kW emissions should conform to EN 303-5 1999. If the appliance is to be installed within a smoke control area, the Clean Air Act 1993 requires approval from Defra as an exempted appliance.
Figure 25 - Comparative annual combustion emissions from oil, gas and wood pellets (source: EVA [www.energyagency.at](http://www.energyagency.at))
References:

1. Forest Research – Wood fuel Information
   http://www.forestresearch.gov.uk/website/forestresearch.nsf/ByUnique/INFD-66SHAG


   (translated by VTT Energy)

4. 'Wood Fuels Basic Information Pack’, BENET, 2000

5. DIN 4102  (Fire behaviour of building materials) Classification B 2
## Gross Inland Consumption

### 2002, Renewables in 1000 toe

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Source: Eurostat
### Electricity from Renewable Sources

**Share in gross consumption of electricity**

**2002 (in %)**

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Sources: Eurostat and Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market.

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Appendix 3 - Standards for solid wood fuels and for automated wood fuelled boilers

CEN, the European Committee for Standardisation, established a Technical Committee to define standards for solid biofuels. The Technical Committee (TC335) comprises of five working groups (WG):

WG 1 - Terminology, definitions and description
WG 2 - Fuel specifications and classes, Fuel quality assurance
WG 3 - Sampling and sample reduction
WG 4 - Physical and Chemical test methods
WG 5 - Chemical testing methods

The scope of the mandate for TC335 for the production of Solid Biofuels includes:

- Products from agriculture and forestry,
- Vegetable waste from agriculture and forestry,
- Vegetable waste from the food processing industry,
- Wood waste, with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood preservatives or coating, and which includes in particular such wood waste originated from construction and demolition waste,
- Cork waste.

‘CEN-TS-14588 Solid Biofuels - Terminology, Definitions and Descriptions’ defines various terms such as biomass, densified biofuel and biofuel pellet.

**Moisture Content**

CEN-TS-14774-1, 14774-2, 14774-3 deal with methods for wood fuel moisture content determination.

**Ash Content**

CEN-TS-14775 deals with methods for the determination of ash content.

Solid biofuels are specified according to ‘CEN-TS-14961 Solid Biofuels, Fuel Specification and Classes’.

**Recommended Specification for Wood Pellets for Domestic Heating:**

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<td>≤ 8 mm ± 0.5 mm, and L ≤ 4 x Diameter</td>
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<td>Ash content:</td>
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<td>Additives:</td>
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<td>Energy density:</td>
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Only products from primarily agricultural and forest biomass that are not chemically modified are approved to be added as binding agents. Type and amount of additive has to be stated.
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| 00335003          | prCEN/TS 15234
                  | Solid biofuels - Fuel quality assurance                               | Under Approval       | 2005-11 |
| 00335013          | CEN/TS 15148:2005
                  | Solid biofuels - Method for the determination of the content of volatile matter | Approved             | 2005-12 |
| 00335015          | prCEN/TS 15370-1
| 00335016          | CEN/TS 15149-1:2006
                  | Solid biofuels - Methods for the determination of particle size distribution - Part 1: Oscillating screen method using sieve apertures of 3,15 mm and above | Approved             | 2006-01 |
| 00335017          | CEN/TS 15149-2:2006
                  | Solid biofuels - Methods for the determination of particle size distribution - Part 2: Vibrating screen method using sieve apertures of 3,15 mm and below | Approved             | 2006-01 |
| 00335018          | CEN/TS 15149-3:2006
                  | Solid biofuels - Methods for the determination of particle size distribution - Part 3: Rotary screen method | Approved             | 2006-01 |
| 00335022          | CEN/TS 15210-1:2005
                  | Solid biofuels - Methods for the determination of mechanical durability of pellets and briquettes - Part 1: Pellets | Approved             | 2005-12 |
| 00335023          | CEN/TS 15210-2:2005
                  | Solid biofuels - Methods for the determination of mechanical durability of pellets and briquettes - Part 2: Briquettes | Approved             | 2005-12 |
| 00335026          | prCEN/TS 15289
                  | Solid Biofuels - Determination of total content of sulphur and chlorine | Under Approval       | 2006-01 |
| 00335028          | prCEN/TS 15290
                  | Solid Biofuels - Determination of major elements                      | Under Approval       | 2006-01 |
| 00335029          | prCEN/TS 15297
                  | Solid Biofuels - Determination of minor elements                      | Under Approval       | 2006-01 |
| 00335030          | prCEN/TS 15296
                  | Solid Biofuels - Calculation of analyses to different bases            | Under Approval       | 2006-01 |
| 00335031          | prCEN/TS 15289
                  | Solid Biofuels - Guideline for development and implementation of Quality Assurance for solid biofuels | Under Development    | 2007-03 |
Appendix 4 – Wood Pellet Quality Standards

Austrian Quality Standards for Pellet Logistics
The Austrian standards for pellets deal with the whole supply chain from the production of the pellets right through to fuel storage at the customer site. They involve inspection of accredited institutions. In addition, special labels (or quality seals) were developed by the Austrian Pellet Association (including pellet and boiler manufacturers, retailers etc). The labels are a sign of high pellet and boiler quality, maintenance and delivery quality. It also contains a labelling system for pellets. For every production batch, encoding particles are added that make it possible to trace back to the producer. Thus, quality deficiencies can very easily be traced back and the overall quality management can be improved.

Austria

ÖNorm M7135, ÖNorm M7136 ÖNorm M7137

Germany

DIN 51731

Combines the Austrian ÖNorm M7135 and German DIN 51731 standards in a common, single, highest quality standard
EU Norm for Wood Pellets

The German standard DIN 51731 regulates similar parameters to the Austrian ÖNORM M 7135, and, since spring 2002, a new regulation, 'DIN plus', has been in force.

In addition, the industrial standard ÖNORM M 7136 aims to ensure quality control during transport, storage and distribution. Another standard (ÖNORM M 7137) lists quality criteria for wood pellet storage rooms at the customer's premises, and deals with the requirements of different wood pellet storage options in one-family houses or apartment blocks.

Fuel quality certification is the responsibility of the pellet manufacturer. These standards established two pellet fuel grades: premium and standard. The only difference between grades is in the inorganic ash content: premium should be less than 1%, and standard less than 3%. Premium is usually made of core wood (not bark).

Manufacturers are encouraged to label their product as meeting EU Standard or Premium Grade. They are also encouraged to disclose the type of material used, and to print a guaranteed analysis on the pellet fuel bag that includes the following information: grade, type of material, percentage of ash, percentage of fines, and concentration of sodium (in ppm). Manufacturers should have samples of their fuel tested at least twice a year by an independent testing laboratory set out by the EU testing and materials procedures.

Pellet stoves designed for low-ash (less than 0.5% or premium grade) tend to operate poorly when used with pellets of higher ash content. Also, some pellet fuel producers may have trouble obtaining high-quality, low-ash materials for making pellets. Many pellet appliance manufacturers have designed or are redesigning their products to burn pellets with varying ash contents.
Appendix 5  -  European Standard for Heating Boilers

The European Standard EN 303-5 is quoted widely by biomass boiler manufacturers across Europe. In the UK, this standard is incorporated as BS EN 303-5: 1999.

STANDARD

BS EN 303-5:1999

TITLE IDENTIFIER

Heating boilers. Heating boilers with forced draught burners. Heating boilers for solid fuels, hand and automatically fired, nominal heat output of up to 300 kW. Terminology, requirements, testing and marking

Status

CU

Publication Date

15/11/99

Committee

RHE/10

Approximate Price

£106.00

ISBN

0 580 32356 0

Pages

36

International Equivalent

EN 303-5:1999

DESCRIPTORS:


CROSS REFERENCES


- from
http://www.standardsdirect.org/standards/standards1/StandardsCatalogue24_view_13408.html

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Clear Skies was a recent grant scheme supporting the introduction of renewable energy technologies for households and community projects in England, Wales and Northern Ireland. An equivalent scheme exists in Scotland (SCHRI - Scottish Community & Householders Renewables Initiative). The following note sets out the product criteria relating to biomass boilers; particularly the role of the European standard EN 303-5.

SCHRI is based on the product criteria, eligible products and installer accreditation of the Clear Skies Programme.

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**Clear Skies Product Criteria for Wood fuelled Boilers**

Criteria for listing recognised products

1 **Scope of the criteria**

   - Wood fuelled boilers should comply with the essential requirements of the European Directives relevant to their class of equipment. See 2.
   - They should be certified as meeting the criteria given below concerning their emissions and efficiency. See 3.
   - Adequate instructions should be provided with each appliance, written in English. See 4.

2 **European Directives and labelling**

Boilers should be labelled with the CE mark to signal the manufacturer's declaration that the product meets the essential requirements of the applicable European Directives.

The Directives applying to a particular wood-fired boiler will depend upon its design. However, for information, the following Directives are those that are likely to be relevant:

<table>
<thead>
<tr>
<th>Directive</th>
<th>Applicable Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery Directive</td>
<td>E.g. boilers with automatic stoking</td>
</tr>
<tr>
<td>Construction Products Directive (CPD)</td>
<td>Boilers (with a rating of less than 50kW)</td>
</tr>
<tr>
<td>Pressure Equipment Directive (PED)</td>
<td>Boilers forming part of sealed systems (CE marking under this directive only applies above certain pressure and volume minima)</td>
</tr>
<tr>
<td>Low Voltage Directive (LVD) and Electromagnetic Compatibility Directive (EMC)</td>
<td>Boilers fitted with electrical equipment</td>
</tr>
</tbody>
</table>
3 Emissions and efficiency

An independent test body should certify that the wood fuelled boiler:
• achieves at least the Class 3 emission standard of EN 303-5 when tested with an appropriate fuel, with visible smoke not exceeding Ringelmann 2; and
• achieves at least the following measured efficiency:

<table>
<thead>
<tr>
<th>Heat output less than 50kW</th>
<th>Tested according to EN 12809 (or EN 303-5 for boilers operating on sealed systems). Achieve efficiency in accordance with Figure 1 of EN 12809 relative to its nominal heat output (from 65% at 5kW up to 70% at 50kW net efficiency) or 57 + 6 log Nominal Heat Output for boilers tested to EN 303-5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat output between 50kW and 300kW</td>
<td>Tested according to EN 303-5. Achieve a Class 2 rating or above (thermal efficiency at least 57 + 6 log Nominal Heat Output). The test fuel should be in accordance with Table 8 of EN 303-5.</td>
</tr>
<tr>
<td>Heat output more than 300kW</td>
<td>There are no standard tests for wood fuelled boilers of more than 300kW output. Achieve at least 72% net efficiency in ad hoc tests using an appropriate fuel.</td>
</tr>
</tbody>
</table>

It is recognised that many products have not been tested and certified to EN 303-5 or EN 12809 at present, although the aim is to encourage eventual compliance with these standards. In the interim:
• equivalent national standards can be considered provided it can be demonstrated that the boiler meets similar requirements for emissions and efficiency as those given above; or
• the appliance should be approved by HETAS Ltd (tel +44 (0)1242 673257) as “Safe and fit for purpose”.

4 Instructions to be provided

Manufacturers/suppliers should include the following English-language instructions with each boiler:

• Installation instructions
• A maintenance schedule
• Instructions for the user

Where these are obtained by translation, care should be taken to ensure that they are relevant to UK installers and consumers. Where specifications in the original document are only meaningful in the context of the original country of destination, they should be substituted by text suitable for the UK and not translated verbatim. In assessing an application for product listing, particular attention will be paid to the fluency of English in safety-critical instructions and to the fluency of instructions for the user.

BS EN 12809 and BS EN 303-5 describe the Technical information and/or instructions to be supplied with boilers.

The installation instructions should warn the reader that they will normally need to comply with the building regulations when installing a solid fuel boiler (see below).
Review of criteria

These criteria will be regularly reviewed in consultation with the industry and may be amended in line with the introduction or revision of relevant standards.

Other UK regulations

Clear Skies grants are paid on completion of installations. It follows that, if the characteristics of a boiler prevent an installation from being built in accordance with the regulations in force, a grant cannot be paid in that case.

The listing of a particular boiler on the Clear Skies product list means that it meets the criteria that would allow Clear Skies to pay a grant where it forms part of a legitimate installation. The criteria include meeting the requirements of European Directives for the appliance type. However, listing is not an endorsement of the appliance’s compatibility with all UK regulations affecting heating installations.

Manufacturers / suppliers should therefore satisfy themselves that the characteristics of their appliances are compatible with the regulations that will apply in the circumstances (type of installation, power rating, geographical location etc) for which they are being proposed and should not restrict an installer from themselves complying with those regulations that shall apply.

UK regulations affecting wet heating installations fired by solid fuel include:

Clean Air Act 1993

If the appliance is to be installed within a smoke control area, an approval from DEFRA as an exempted appliance must be attained. Note: the listing of a boiler on the Clear Skies product list does NOT confer exempt appliance status.

Date of Issue
6th September 2004
## Appendix 6  - Chopped Firewood Requirements for 10% Secondary Heating

- the table below presents data for several species of timber; carefully stacked or stored loose

<table>
<thead>
<tr>
<th>10% secondary heating</th>
<th>Logs</th>
<th>8-12-05; MNM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 m³ solid =</td>
<td>1.50 m³ stacked =</td>
<td>2.5 m³ loose</td>
</tr>
<tr>
<td>MC</td>
<td>NCV kWh/kg</td>
<td>NCV MWh/m³</td>
</tr>
<tr>
<td>wet mass basis</td>
<td>kWh/te</td>
<td>loose</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
<th>NCV</th>
<th>NCV</th>
<th>NCV</th>
<th>loose</th>
<th>stacked</th>
<th>density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver Birch</td>
<td>20%</td>
<td>4.15</td>
<td>0.74</td>
<td>13.00</td>
<td>0.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scots Pine</td>
<td>4.15</td>
<td>0.79</td>
<td>1.32</td>
<td>0.322</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norway Spruce</td>
<td>4.10</td>
<td>0.79</td>
<td>1.33</td>
<td>0.333</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspen</td>
<td>4.00</td>
<td>0.79</td>
<td>1.33</td>
<td>0.333</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alder</td>
<td>4.05</td>
<td>0.74</td>
<td>1.23</td>
<td>0.304</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Annual Heat Demand

<table>
<thead>
<tr>
<th>HOUSE TYPE</th>
<th>10% Secondary Heating</th>
<th>Chopped firewood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Alder</td>
<td>Alder</td>
</tr>
<tr>
<td></td>
<td>loose</td>
<td>stacked</td>
</tr>
<tr>
<td></td>
<td>m³/yr</td>
<td>m³/yr</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Small Low Energy House 80m²</th>
<th>6</th>
<th>1.05</th>
<th>0.77</th>
<th>0.19</th>
<th>0.46</th>
<th>0.19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small House 80m²</td>
<td>10</td>
<td>1.76</td>
<td>1.29</td>
<td>0.32</td>
<td>0.76</td>
<td>0.31</td>
</tr>
<tr>
<td>Victorian Villa 120m²</td>
<td>25</td>
<td>4.39</td>
<td>3.22</td>
<td>0.80</td>
<td>1.91</td>
<td>0.78</td>
</tr>
<tr>
<td>Large House Low Energy 160m²</td>
<td>15</td>
<td>2.64</td>
<td>1.93</td>
<td>0.48</td>
<td>1.15</td>
<td>0.47</td>
</tr>
<tr>
<td>Large House Modern Construction 160m²</td>
<td>20</td>
<td>3.51</td>
<td>2.57</td>
<td>0.64</td>
<td>1.53</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Appendix 7  - Schematics of Various Wood fuel Storage arrangements

- from “TDS Powerfire 150 kW Technology and Planning”
  KWB wood fuelled boilers (http://www.conness.at/ and www.kwb.at )
Ground plan

Implementation of the boiler and storage rooms according to TRVB H118 guidelines as described in the chapter "Constructional Conditions", or according to local building regulations!

- F90
- # 25/30 cm
- at least 15 cm free space from boiler must be kept for manoeuvring purposes

- wood chip storage room
- wall opening 60x65 cm (close again after assembly — channel uncoupled in terms of noise)
- ventilation 5 cm² per kW, but not less than 750 cm²
- min. 435
- min. 250
- min. 15
- min. 15
- 120 (+/-0)
- 200
- fire extinguisher
- emergency-off switch
- * in the case of assembly in dismantled state (surcharge)

Dimensions in cm

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View of Sloping Floor

- board thickness: 3 cm
  recommended: larch

- max. 50 cm

- max. 150 cm

- bracing thickness: 10 x 10 cm

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This text is based on Austrian directive TRVB H 118 and ÖKL Merkblatt No. 56 and No. 66.

Fuel storage room

The constructional on site requirements for the boiler room also apply to the fuel storage room. The stirrer is installed in the middle of the storage room and fastened to the concrete floor with anchor screws. A back-ventilated dead floor should be installed at the same level as the top edge of the fuel extractor duct. If a pumping car (road tanker) is used to fill the fuel storage room with wood chips or pellets, it is necessary to mount hose couplings and pipelines (to be earthed). These are available from KWB. If this filling method is chosen, dustproof sealing of the fuel storage room is required. The escaping air is removed through a second earthed pipeline and hose coupling or blown off into the open after having passed through a filtering section. The removal or filtration of the transport air is the responsibility of the fuel supplier. The walls, windows and doors must withstand the overpressure created during the filling process. Electrical installations in the fuel storage room should be avoided. If this is not possible, an explosion-proof design must be chosen. KWB biomass boilers are supplied with all the necessary fire-protection equipment included. Depending on the local installation situation, type of fuel and amount of storage, a manually triggered fire extinguisher and/or the built-in fire extinguisher may have to be connected to a pressurised water line. The fire extinguisher with manual release featuring a frost-proof connection (from the boiler room) is to be fitted out at least 3/4" or as DN 20 directly above the feed through of the fuel-extractor trough discharging into the fuel storage room as empty piping. The shut-off device which is to be installed in the boiler room must be marked with the following sign

“Fire extinguisher — fuel-storage room”

A fire extinguisher with manual release must be installed in storage systems containing 50 to 200 m³ of wood chips for systems up to and including 400 kW. If such a fuel-storage room is built onto fire-resistant parts without openings, it is not necessary to enclose it with F90 sheathing/design. In the case of wood-chip storage rooms in farm outhouses (multi-purpose rooms) with a fire wall facing the living quarters, an F90 design/sheathing of the fuel-storage room is not necessary so long as the fire section is smaller than 500 m². Fuel must be stored separately from other goods (e.g. by means of wooden planking).

A manual-release extinguisher and an integrated extinguisher must, however, be installed. In the case of storing up to (and including) 200 m³ of other wood materials (with dust) in systems up to and including 400 kW, an integrated extinguisher is basically necessary in addition to a manual-release extinguisher. In the case of systems larger than 400 kW or stored quantities greater than 200 m³, both (a manual-release extinguisher and an integrated extinguisher) are necessary.

Additional statutory safety and acceptance conditions apply to storage rooms and silos continuously suction-fed with shavings or grinding dust. If you have any questions, please contact your KWB works representative. Above-ground fuel stores must be accessible to the outside by means of a door of at least 1.80 m cross section, and be planked to prevent the fuel from trickling outside should the door be opened by mistake. The planking should be removable from outside. An inspection opening must be installed above the feed extractor channel, closing to F90. Observe installation examples.

Water connection

When using wood chips, the return flow inlet temperature into the boiler must be at least 55 °C, when using pellets at least 50 °C, otherwise there is an increased risk of corrosion, which also has the effect of voiding the warranty. To increase the temperature of the return flow, the boiler control unit can drive a mixing controller or a mixing pump. For systems up to 60 kW, the return flow temperature maintenance can also be achieved by means of a thermal control valve. Suitable fittings to increase the return flow temperature are available.

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from KWB. With the exception of cases where the return flow temperature is maintained by a
mixing pump, the heating system must feature a pressureless distribution system (switch,
distributor, load balancing accumulator, buffer) and a safety group that complies with the relevant
regulations (e.g. according to ÖNORM B 8130 or ÖNORM B 8131). A load balancing accumulator
or buffer tank is not required, but it is useful in some cases, for instance if a solar system or a split
log boiler is integrated or if there is a need to achieve a very low permanent heating output during
the summer months. Consult your fitter for specific details. Components of sound insulated water
connections must be impermeable to oxygen, otherwise there is an increased risk of corrosion,
which also has the effect of voiding the warranty. If plastic pipes for floor heaters or district
heating pipes are connected, it is necessary to integrate a limiting thermostat for the boiler circuit
pumps to provide additional protection against excessive temperatures. With respect to the
composition of the boiler water, VDI 2035 and ÖNORM H5195 T1 and T2 must be unconditionally
adhered to, otherwise there is a risk of corrosion, which may void the warranty.

Backfire protection:

A host of details testify to the conscientious
design of the overall system. The safety
systems are multi-stage, independent, easy to
control. It consists of a tested, backfire-proof
unit, a gas-tight flashbackproof fire shutter
(also available with cellular wheel sluice if
desired), an anti-backfire unit, a stand-alone
sprinkler, a temperature monitor, a hopper with
opto-electronic filling level control, a
mechanical overfill protection, a drop zone and
a safety temperature limiter. Fire shutter and
sprinkler continue to work fully even after
power failure. The sprinkler is supplied by a
level-controlled water tank integrated in the
system. Also, min./max. fuel restriction in the
burner and electronic and mechanical/
electronic monitoring of firing.

Electrical connection

Mains connection of the system is via the main boiler switch and must be executed as prescribed
(to EN 60204 1, Electrical Equipment of Machines — General Requirements). Mains connection:
three-phase current connection with neutral wire (400 VAC, fuse 13 A, cable min. 1.5 mm²).

Required connections at customer’s site: Euro socket 5-pin / 16 A, type “C” lightning arrester at
the distribution board of the house (recommended as lightning protection), rotating field detection
relay for backup power supply and escape switch “Emergency off”. Potential equalisation is
recommended.