Heating with firewood, wood pellets, wood chips and wood briquettes
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Contents

Heating with wood – an eco-friendly alternative 4
Firewood and wood briquettes 5
Wood pellets 8
Wood chips 10
Biomass heating plants and local heat 12
Biomass Logistic and Trade Centers 13
Economics of heating devices 14

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Heating with wood – an eco-friendly alternative

Biomass is a renewable resource, which is **constantly** available in a system of sustainable cultivation. The **regional** availability favors shorter transport routes compared to those commonly used for fuel oil or natural gas.

The energy input for the processing and provision of solid biofuels in comparison to oil and natural gas is very low. The **added value remains in the region**. Energy from biomass establishes independence from crisis regions, conserves resources and has an important contribution to **climate protection**.

Biomass is **carbon neutral**, especially when cultivation and utilization are sustainable and regional, because during the combustion only as much CO$_2$ is released as was absorbed by the plant during growth. For a complete CO$_2$ balance, which includes the emissions from provision, processing and transport, need to be considered. Taking all these steps into account heating with wood only causes about 8% of emissions compared to heating with fuel oil!

Wood is a **traditional** fuel. Indeed it was the first energy source, which humans have used ever since. The finite nature of fossil resources and the man-made greenhouse effect let us return to more sustainable fuels.

Today the market offers modern heating units for firewood, wood pellets or wood chips, which are a **proven and tested technology**. Also flue gas cleaning technology, which is a reasonable investment, especially in large scale wood chip plants, is readily available. These developments have significantly improved the social acceptance for the utilization of wood fuels.
Firewood and wood briquettes

Firewood and wood briquettes are fuels, which are most commonly known for use in individual domestic stoves, while firewood can also be used for central heating.

Properties and quality

Firewood

Consumers receive their firewood as ready to use logs, bulk or sacked, sometimes also in containers or on palettes. Only uncontaminated, clean wood should be burned. If contaminated by paint, lacquer or similar agents, wood should not be burned in common domestic plants, because evaporated substances can be seriously harmful to health.

Furthermore, it is important that preferably dry wood is burned, as the calorific value is considerably higher and emissions are much lower. Wood dries out faster if cut into wood billets. Freshly harvested wood has a moisture content of 50%, appropriate firewood has 15-20%, which can be achieved after 1 year of proper air-drying.

Hardwood like beech and oak has a higher energy density than softwood like spruce or pine. This results in a longer combustion time and extends feeding intervals. Softwood does, however, ignite easily and reaches the operating temperature faster.

TIP: When storing wood, ensure good air ventilation, eg. by leaving space between the wood and the walls and floor.
quickly. This is essential for clean incineration. When buying wood per ton the calorific value is quite comparable: 1 kg of spruce has 4.02 kWh/kg, beech has 3.86 kWh/kg at a moisture content of 20 %. But it differs a lot when it is sold per solid cubic meter or stacked cubic meter. A solid m³ of spruce with 20 % has 1900 kWh, while beech has 2700 kWh. For stacked m³ with 20 % it is 1330 kWh for spruce and 1890 kWh for beech. Therefore it is very important to be aware of the kind of wood when buying firewood per volume and to pay attention to the moisture content when buying wood per weight.

The official international standard for the specification of “Graded firewood”, which can be referred to by producers and customers is “ISO 17225-5:2014”.

Wood briquettes

There are several kinds of wood briquettes with regards to shape and composition. All types of briquettes have a low moisture content of less than 10 % and therefore a high calorific value of 4.9 kWh/kg. The main components in wood briquette production are sawdust or planing chips from the wood-processing industry. Briquettes can be made from soft- or hardwood and have different burning properties. Softwood briquettes burn faster and under more heat development while hardwood briquettes last longer – similar as for firewood.

An advantage of briquettes compared to firewood is that storage is comparably uncomplicated. It is possible to store them in a very space-efficient manner in any closed

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Proportion of cubic measures

<table>
<thead>
<tr>
<th>Roundwood (scm)</th>
<th>Stacked one-metre firewood (stcm)</th>
<th>Bulk cubic metre woodchips (srm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 scm</td>
<td>1 stcm</td>
<td>2,5 bcm</td>
</tr>
<tr>
<td>0,7 scm</td>
<td>0,6 stcm</td>
<td>1,8 bcm</td>
</tr>
<tr>
<td>0,4 scm</td>
<td></td>
<td>1 bcm</td>
</tr>
</tbody>
</table>

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1 solid cubic metre (scm) = 1,4 stacked cubic metre (stcm) = 2,5 bulk cubic meter (bcm) woodchips
room e.g. in the basement or garage (preferably as packs stacked on palettes). **Bark briquettes** are produced from tree bark and are mainly used for **keeping embers**.

On the market for briquettes significant quality differences have to be faced. Before buying briquettes it is recommended to check whether they disintegrate easily and if they contain pulp or paper waste, which are the most obvious signs for poor quality.

Just as firewood “Graded wood briquettes” are also classified by an international standard, called “ISO 17225-3”. In several countries an ENplus certification is offered for wood briquettes.

### Combustion technology

Firewood and wood briquettes are most commonly known for their use in **domestic stoves**, like fireplaces, tiled or kitchen stoves. One should keep in mind such criteria as the efficiency of the combustion equipment and the reliability of the supply. Buying a very cheap stove can result in high emissions, incomplete incineration and short useful life of the facility. Not only is the quality of a stove crucial for efficiency – but the user’s behavior and the fuel quality also play a major role. An important aspect is the **correct ignition** of a fire, as this causes most emissions.

A further potential use of firewood is the operation of **central heating**. Modern log boilers are very efficient and represent an **economic** alternative. This boiler type is also called **firewood gasification boiler**, as the gasification of wood happens separately from the post-combustion. These facilities are also typically characterized by secondary air ducts, a non-cooled high temperature chamber and a blower. These systems can attain high efficiency and comparably low emissions.
Wood pellets

Wood pellets are formed of ground wood that is pelletized into cylindrical sticks. Usually they are produced from sawdust that accrues in saw mills. Wood pellets can be regarded as the wood fuel that ensures the maximum user comfort.

Properties and quality

Apparent quality features for wood pellets are a solid structure, low dust content and a smooth and shiny surface. Because of the high density and the low moisture content, pellets have a high calorific value of 4.9 kWh/kg.

The international standard for classification of wood pellets is the ISO 17225-2. Both ENplus and DINplus certification refer to the requirements of the standard. ENplus certification is especially popular in many European countries and is extensively used. In the domestic sector pellets of quality class A1 are most commonly used, which are also referred to as premium pellets. For a higher thermal output range wood pellets of lower quality can also be applicable, so called industrial pellets. These can mainly be found in the power station market, especially in the United Kingdom and Scandinavian countries.

In flood-prone regions, only prefabricated hoppers should be implemented. The design of the storage room should be coordinated with the pellet supplier. As odorless carbon monoxide can outgas from pellets, the storage room should be well-ventilated and should not

TIP: It is crucial to place firelighter and kindling wood close to the exhaust outlet (which is usually on top), so that the accruing gases pass the flame.
be entered without special safety measures.

Combustion technology

There are domestic stoves available as pellet stoves and heating elements. Those contain a small reservoir from which pellets are automatically transported to the combustion chamber. The thermal output can be adjusted individually or regulated via thermostat. Nominal heat output of pellet stoves, currently available on the market, range between 5 and 15 kW. The ratio of combustion air, pellets and temperature of the oven is controlled digitally. Thus an incineration process with low exhausts and high efficiency can be achieved.

Water-heating pellet stoves, in contrast to air heaters, possess a water pocket, which is connected to the heating circuit. This makes the pellet stove a central heating device. The stove will emit approximately 20% of the heat produced into the installation room, which makes it unsuitable for the heating of drinking water in summertime. Therefore the combination with a solar thermal energy system, which can provide the heat for this purpose, is a perfect fit. This kind of heating system is suitable for detached houses with a rather low heat demand.

Pellet central heating is suitable for small residential buildings and apartment buildings with only a small space for the fuel storage. The main components of pellet heating are the technology for heating, heat storage, pellet hopper and the equipment for transporting pellets from the storage to the boiler. The hopper should be designed for an annual filling interval, as it is done for heating oil tanks. Delivery is performed by a pellet tanker truck.

Control of pellet heating is fully automatic. Ignition is electrical. Combination of a pellet boiler with a heat storage tank is advisable in most cases.

For a retrofit or conversion of exis-

TIP: Storage of bulk pellets should be carried out mainly in tanks or rooms, which are protected against humidity and are constructed to be dust-tight.
ting boilers for being fueled with wood pellets several producers offer pellet burners. Also different combination solutions are offered: log boilers, which can burn pellets as well as firewood, and pellet boilers that can be run with wood chips.

Properties and quality

Wood chips can be produced from thinning waste or low quality wood. Also, wood chips from woodworking and wood processing, as well as wood originating from landscape conservation, are very common. Wood from short rotation coppice is another possibility to produce wood for energetic use. For this fuel as well as for all other kinds of wood fuels it is important to make sure only untreated wood is applied.

Wood chips

Wood chip heating systems as domestic facilities are mainly found in agriculture and forestry as well as for the heating of apartments. Apart from this wood chips are used in larger scale heating plants or cogeneration plants.
For residential heating systems high fuel quality is needed. **Dry** wood chips (usually with moisture content of 15-30 %) with homogeneous and small size variation should be used. For this reason wood from landscape conservation or short rotation coppice is not applicable. This mostly has high ash content and are suitable for plants with a higher thermal output range.

Depending on how wood chips are sold, per volume or weight, it is important to know about the kind of wood and the moisture content respectively. One m³ of spruce wood chips with a moisture content of 30 % has a **calorific value** of 745 kWh/m³ whereas beech has a calorific value of 1052 kWh/m³. Referring to weight, different kinds of wood with the same moisture content are very similar: spruce with 30 % moisture has 3.44 kWh/kg and beech 3.3 kWh/kg. For selling wood per weight the moisture content is crucial. With a moisture content of 50 % the calorific value of spruce is 2.26 kWh/kg, for beech it is 2.16 kWh/kg.

**Storage** of wood chips helps to balance seasonally alternating fuel supply with heat demand of consumers. For the operator of a plant security of supply is crucial.

For financial reasons it is recommended to keep the fuel storage as small as possible, but as large as necessary. This depends strongly on facility size. Wood chips with low moisture content can be stored much longer as those with higher moisture content (over 30 %). The demand for small and large scale plants differs hugely and so do the storage requirements.

The filling volume should match the capacity of delivery vehicles.

**Combustion technology**

Today wood chip furnaces are sophisticated. Mainly underfeed firing, overfeed firing and fuel bed firings are offered. These are **automatically fed** systems, which means that wood chips are carried into the ceramic-lined combustion chamber automatically by a screw stoker or a hydraulic thrust device.

A **burn back protection**, for
example a rotary feeder, prevents the fire from burning back into the wood chip storage. An appropriate fuel supply and an automatic air supply enable a consistently high level of efficiency of the furnace. The fuel quality needs to be adapted to the requirements of the plant. Depending on the fuel quality and size of the facility an appropriate flue gas cleaning system is to be implemented. Especially in large scale plants fired with wood chips of minor quality, an electrostatic filter should be considered, to minimize emissions.

For example it does not make sense to plan a project with local heat, if there is relatively low heat demand over long distances or a lack of potentially interested heat consumers. On the other hand local heat can be the most efficient way to provide heat, concerning performance ratio as well as heating costs.

Mostly wood chips are used for those solutions, because it is the cheapest fuel and usually these projects have good preconditions regarding space and manpower.

On the other hand, in some cases pellets can be the better choice, especially if time and simplicity for plant operation are the

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**TIP:** As for other wood-fired central heating systems, in order to ensure smooth operation, combination with a heat storage facility is strongly recommended.

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**Biomass heating plants and local heat**

Apart from consuming biomass directly it is also possible to consume or provide heat as a product from biomass. This is usually done either for large buildings with a high heat demand or for several proximate buildings, which can be connected by a heating network. These can be either small projects like a farmer supplying neighbors with heat but also large scale projects, like a municipality providing hundreds of citizens with district heating. Whether or not a heat selling concept is the best choice, strongly depends on the situation.
bottleneck. Projects can be initiated and/or operated e.g. by companies, agricultural enterprises, associations, cooperatives, municipalities or contracting services.

A BLTC offers convenient and regional purchase of biofuels with controlled quality and a crisis-proof all-season sale at steady and transparent prices. It can also be part of a BLTC’s concept to provide heat as a product. Quality control and quality assurance for woody biomass concerns harvest and transport, trade and delivery, production and supply as well as selling to customers. Quality control mainly refers to how products and services can be provided most efficiently according to their requirements. Quality assurance uses data from quality control to evaluate products and processes concerning reliability and developments to build trust, and being able to record improvements.

### Biomass Logistic and Trade Centres (BLTCs)

A BLTC is a regional station for solid biofuels of high quality. Centrality and extensive services like delivery and professional consulting complete the concept. Purchasing wood fuels in a BLTC ensures a long-term supply for a heating device. Therefore, private households and businesses can choose eco-friendly and cost-efficient wood heating without supply worries.

<table>
<thead>
<tr>
<th>Energy Carrier</th>
<th>Wood</th>
<th>Fuel Oil</th>
<th>Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition:</td>
<td>solid, firewood</td>
<td>solid, woodchips</td>
<td>solid, pellets</td>
</tr>
<tr>
<td>to obtain 10 kWh of energy these amounts of fuels are required</td>
<td>2,5 kg (air dry)</td>
<td>2 kg</td>
<td>0,860 kg</td>
</tr>
<tr>
<td>weight in kg</td>
<td>5 liter</td>
<td>12,5 liter</td>
<td>3,5 liter</td>
</tr>
<tr>
<td>volume in liter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Economics of heating devices

In order to evaluate the economics of a heating device it is advisable to compare several systems with the help of full cost pricing. Apart from the outcome, practical and non-material reasons should also be taken into account for the individual decision. Thus it can be cheaper to install a natural gas heating system than a pellet one, but this maintains dependence on an imported resource with higher variability in price. Furthermore, wood pellets have a considerably better CO$_2$-balance. Other important features are space and time demand that heating systems might require.

To receive those results it is necessary to calculate the average annual costs over the useful life span of the facility. This also contains, for example, costs for maintenance and auxiliary energy. Another crucial point is to choose a representative fuel price, which should, under no circumstances, be understood as a snap-shot, as the calculation is supposed to display a longer time span.

In times of historically low oil prices it is important to find a realistic average that could be representative for the next 20 years (e.g. average of the last 10 years). Another crucial factor is subsidy from support programs, which can be obtained for a new heating system – this needs to be taken into account as well. These differ from country to country.

**TIP:** When comparing different heating systems it is not sufficient to just compare current fuel prices or investment costs. The comparison needs to take full costs into account, meaning: capital, operating, consumption and other costs.

Further information
www.bioresproject.eu

Contacts
Croatia: www.regea.org
Serbia: www.serbio.rs
Bulgaria: www.bgbiom.org
BioRES aims at introducing an innovative concept of Biomass Logistic and Trade Centres (BLTCs) in Serbia, Croatia, and Bulgaria on the basis of cooperation with technology leaders from Austria, Slovenia, Germany, and Finland. This will help increasing the demand for woody bioenergy products (processed fire wood, wood chips, wood pellets, and wood briquettes) in these countries and contribute to the achievement of EU targets set out in the RES Directive (2009/28/EC). This publication has been produced with the assistance of the European Union. The contents of this publication are the sole responsibility of C.A.R.M.E.N. e.V. and can in no way be taken to reflect the views of the European Union.