ТЕМПЕРИЛОДЖИСТИКСЕООД
TEMPERI LOGISTICS LTD

Charcoal

Part 1

2024

Part 1

General information

Charcoal is a product of burning different types of wood in the absence of oxygen. As a result of this process, the structure of the wood changes — it retains the maximum carbon content, while other chemical components burn out. Finished charcoal contains 84% non-volatile carbon — depending on the production technology and type of wood. Modern charcoal kilns for the production of charcoal are highly environmentally friendly and efficient. The resulting charcoal has a wide range of applications.

Compared to firewood, charcoal has a number of undeniable advantages. It is not only an environmentally friendly type of fuel, which does not produce harmful substances and carcinogens when burned, but it has high heat output, does not produce flames or smoke, provides even heat for a long time, is economical, compact, lightweight, easy to use and transport. There are several different turns in the development of charcoal production. The oldest technologies for the production of charcoal are batch kilns, they are associated with lower costs and are widely used in the world, mainly in developing countries.

A more recent introduction to charcoal production is the continuous retort process, where biomass is transported through the various process stages, heating and drying, carbonization and cooling. This technology requires a large capital investment, but can achieve a high level of automation. In addition to these technologies, charcoal can also be produced as a by-product in the production of liquid and gaseous fuels through the pyrolysis and gasification of biomass. Each of the production methods can produce charcoal of varying quality with properties that distinguish the various applications of charcoal. The uses of charcoal range from a high-capacity fuel to a sustainable soil conditioner, an adsorbent, a carbon source in chemical reactions and much more.

Charcoal has the following operational properties

- high combustion temperature and duration;
- low ash content, amounting to only 2.5 to 3%;
- homogeneity, ensuring uniform combustion with heat release;
- density, directly dependent on the porosity of the material and ensuring easy ignition;
- high calorific value of about 7500–8170 kcal/kg at a combustion temperature of 380–500 °C.

Like coal, charcoal is formed from wood, while coal is formed over millions of years as a result of the long-term decomposition of wood, and charcoal is obtained by the method of thermal decomposition of wood - pyrolysis.

Pre-dried wood is placed in a retort - a closed steel container into which no air enters. Then the container is installed in a special furnace, where the heating process takes place.

Under the influence of high temperatures, the material decomposes in an oxygen-free environment, turning into charcoal.

After pyrolysis, the material must be calcined. This process is also carried out in a furnace: its essence lies in the separation of excess gases and resins from the resulting coal.

At the final stage, the retort is removed from the furnace, and the coal is sifted from small fractions and dust.

Depending on the choice of "source material", different types of charcoal are produced.

They also differ from each other in the different levels of non-volatile carbon content.

Black charcoal is obtained from soft wood species, such as poplar, linden, and aspen.

It is considered the highest grade of charcoal: the material contains at least 90% non-volatile carbon and no more than 2.5% ash.

So-called white charcoal is formed from birch, oak, ash, and other hardwoods, and coniferous species (pine, spruce, or larch) produce red charcoal.

Charcoal *is a microporous high-carbon product formed during the pyrolysis of wood without air access. Charcoal is used in the production of crystalline silicon, carbon disulfide, ferrous and non-ferrous metals, activated carbon, etc., and also as a household fuel (specific heat of combustion 31.5 - 34 MJ/kg).*

Types of Charcoal

- *Regular charcoal is made from peat, coal, wood, coconut shells, or petroleum.*
- *Sugar charcoal is formed by carbonizing cane sugar, which is repeatedly recrystallized to remove any organic impurities. It is also made by dehydrating sugar in the presence of concentrated sulfuric acid, which absorbs the water from the sugar and leaves a black carbon residue. It is the purest form of amorphous carbon, and is used to make synthetic diamonds.*
- *Activated carbon is a form of carbon commonly used to filter pollutants from water and air, and in medicine and other applications. It is processed (activated) to have small, low-volume pores that greatly increase the area available for adsorption or chemical reactions, which can be thought of as a microscopic "sponge" structure. Activation is similar to popping popcorn from dried corn kernels: the popcorn is light, fluffy, and has a high surface area to volume ratio. Because it is so porous on a microscopic scale, one gram of activated carbon has a surface area of over 3,000 square meters (32,000 square feet).*
- *Lump charcoal is a traditional charcoal that is made directly from hardwood. It typically produces much less ash than briquettes.*
- *Japanese charcoal has the pyrolytic acid removed during the charcoal production; therefore, it produces almost no odor or smoke when burned. Traditional Japanese charcoal is divided into three types*:

1. White coal (binchotan) is hard and produces a metallic sound when struck
2. Black coal
3. Ogatan is a more modern type made from hardened sawdust.

- *Pillow-shaped briquettes are made by pressing charcoal, usually made from sawdust and other wood by-products, with a binder and other additives. The binder is usually starch. Briquettes may also include lignite (heat source), mineral carbon (heat source), borax, sodium nitrate (igniter), limestone (ash whitening agent), raw sawdust (igniter), and other additives.*
- *Sawdust briquette charcoal is made by pressing sawdust without binders or additives. It is the preferred charcoal in Taiwan, Korea, Greece, and the Middle East. It has a round hole in the center with a hexagonal intersection. It is used primarily for barbecues as it is odorless, smokeless, produces little ash, produces a lot of heat, and has a long burn time (more than 4 hours). • Extruded charcoal is made by extruding raw wood chips or carbonized wood into logs without the use of a binder. The heat and pressure of the extrusion process holds the charcoal together. If the extrusion is made from raw wood, the extruded logs are subsequently carbonized*.


Japanese Binchotan (Japanese high-quality charcoal obtained from Ubame oak).

Calorific value of charcoal

As a result of wood pyrolysis, coal is obtained with a large number of microscopic cavities, due to which it acquires high absorption capacity. Thanks to the oxygen that gets into the pores, the fuel burns easily and releases a lot of heat. Even a small amount of biofuel gives a long-lasting heat, and when burned, almost no smoke is released. In addition, charcoal is not prone to spontaneous combustion. The resulting charcoal consists of carbon, hydrogen and oxygen. Their proportion in the material depends on the charring temperature: the higher it is, the higher the carbon content and the lower the oxygen and hydrogen. On average, charcoal contains about 80% carbon, both volatile and non-volatile. The proportion of other substances is as follows: oxygen - from 5 to 15%, hydrogen - about 4.5%. The proportion of volatile substances in the product is no more than 20%, ash - no more than 3%, moisture - from 2-4% to 7-15% (if the material is stored in closed warehouses).

Calorific value (specific heat of combustion, calorific value) is the main fuel indicator that characterizes the amount of heat released during complete combustion of fuel weighing 1 kg or with a volume of 1 m³ (1 l). In general, this is the total energy released in the form of heat during complete combustion of a substance with oxygen under standard conditions, which is one of the most significant characteristics of fuel.

In fuel analysis and heat engineering calculations, the concepts:

- *Higher Calorific Value (Higher Calorific Value = Gross Calorific Value = GCV) - the amount of heat released during complete combustion of fuel, cooling of combustion products to fuel temperature and condensation of water vapor formed during oxidation of hydrogen included in the fuel;*
- *Lower Calorific Value (Lower Calorific Value = Net Calorific Value = NCV) - the amount of heat released during complete combustion of fuel without condensation of water vapor*.

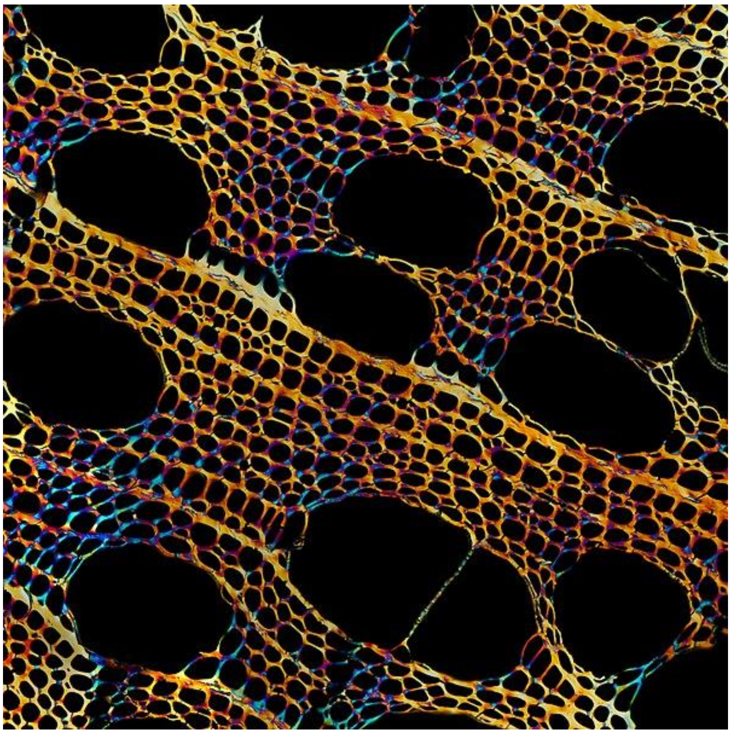
The calorific value determines the selectivity of the fuel.

For comparative calculations, the so-called Conventional Fuel (CF) is used.

The specific heat of combustion of CF is 29,308 kJ/kg (7,000 kcal/kg).

The calorific value of charcoal can be determined based on its elemental composition.*

**ISO 18125:2017 specifies a method for determining the gross calorific value of solid biofuels.*



Charcoal under a microscope. When burned without air, only a charred skeleton remains from the wood cells. The photo shows a piece of charcoal from the end, and it is clear that this area of the wood contains conducting vessels. Differential interference contrast, reflected light. Different colors correspond to different reliefs.

Different types of charcoal plant material have different elemental compositions, which in turn affects their calorific value, which is related to the carbon, hydrogen and oxygen content of the material.

The calorific value of charcoal can vary from 3274 to 8135 cal/g in dry condition. For comparison, Table 1 provides values that correspond to the highest calorific value for combustion of different types of fuel at a constant pressure of 1 bar and a temperature of 0^{o}C.

Table 1

Fuels, mass characteristics:	**Higher calorific value, kJ/kg**	**Higher calorific value, kcal/kg**	**Gross heating value, Btu/lb, Btu/lb**
Gasoline, Petrol	47 300	11 250	20 400
Hydrogen	141 800	33 800	61 000
Gas oil	38 000	9 050	16 400
Diesel	44 800	10 700	19 300
Wood (dry)	14 400 - 17 400	3 450 - 4 150	6 200 - 7 500
Kerosene	35,000	8,350	15 400
Coke	28 000 - 31 000	6 650-7 400	12 000 - 13 500
Heavy fuel oil	41 200	9 800	17 700
Propane	50 350	12 000	21 650
Oils vegetable	39 000 - 48,000	9 300 - 11 450	16 750 - 20 650
Petroleum	43 000	10 250	18 500
Peat	13 800 - 20 500	3 300 - 4 900	5 500 - 8 800
Anthracite	32 500 - 34 000	7 750-8 100	14 000 - 14 500
Bituminous coal	17 000 - 23 250	4 050-5 500	7 300 - 10 000
Charcoal	***29 600***	***7 050***	***12 800***
Coal	15 000 - 27 000	3 550-6 450	8 000 - 14 000
Lignite	16 300	3 900	7 000
Gases, volumetric characteristics:	**kJ/m3**	**kcal/m3**	**Btu/ft3, Btu/ft3**
Acetylene	56 000	13 350	728
Butane C_4H_{10}	133 000	31 750	1 700
Hydrogen	13 000	3 100	170
Methane CH_4	39 800	9 500	520
Natural gas	35 000- 43 000	8 350-10 250	455 - 560
Propane C_3H_8	101 000	24 100	1 310

Application areas

Charcoal is used in many areas, for example, in the food industry, medicine, agriculture.

It is also used to clean industrial wastewater and gas emissions from enterprises, to smelt valuable and rare metals, in the chemical industry and in everyday life as fuel.

For example, charcoal briquettes are produced from coal dust, which is produced during the pyrolysis process.

Charcoal is also used in furnaces and pottery kilns.

The material is mixed with some raw material (usually starch paste), after which it is sent to a mechanical press, where they are burned under high pressure and compressed into bars of a certain shape and size.

Charcoal briquettes burn evenly and completely, while they turn into ash. The calorific value of such fuel is over 8,000 kcal / kg.

Basically, charcoal, like briquettes, is used for heating private houses, and not thermal power plants. The fact is that biofuel costs almost twice as much as, for example, coal.

Technology of the process of production of charcoal

The technology for producing charcoal has remained virtually unchanged since the day it was first produced. It is based on pyrolysis, the combustion of raw materials in the absence of oxygen. In industrial production, about 90% of the process from growing and harvesting wood to distributing and selling the finished charcoal is still the same as with traditional methods. The novelty lies in the carbonization stage and the replacement of labor-intensive methods of processing materials with capital-intensive methods, but the technology itself has remained the same and includes several main stages.:

- *Growing fuel wood*
- *Harvesting wood*
- *Selecting raw materials*
- *Drying and preparing wood for carbonization*
- *Carbonization of wood into charcoal (pyrolysis)*
- *Calcination*
- *Screening, storage and transportation to the warehouse*

The performance characteristics of the final product directly depend on what the charcoal is made of. The optimal raw material is hardwood, and it is desirable that one batch of the product contains only one type of wood - this ensures uniform combustion of the coal with the release of heat. If different types of wood are used, the hard wood is placed in the kiln first, followed by the soft wood on top. The carbonization stage can be crucial in the production of charcoal, although it is not the most expensive.

Pyrolytic decomposition is the main stage of how charcoal is made. At this stage, dried wood is placed in a sealed container, or a flowing barrel is sealed with clay. Then the temperature is raised to 150-300 °C. When the temperature reaches 300 °C and above, exothermic pyrolysis of wood begins. The raw material changes its color, as a result of the processes taking place, its internal temperature rises and exceeds the temperature in the chamber. Then volatile substances begin to evaporate, and when the wood reaches a temperature of 400 °C, it finally acquires a black color, gets rid of volatile substances and already contains up to 65-70% carbon in its composition.

Wood is made up of three main components: cellulose, lignin, and water. Cellulose, lignin, and some other materials are tightly bound together to form the material we call wood. Water is adsorbed or held as water molecules on the cellulose/lignin structure. Air-dried or “seasoned” wood still contains 12–18% adsorbed water. Growing, freshly cut, or “unseasoned” wood also contains liquid water, giving a total water content of about 40–100%, expressed as a percentage of the dry weight of the wood.

All the water in the wood must be driven off as steam before carbonization can occur. It takes a lot of energy to evaporate the water, so using the sun to pre-dry the wood as best as possible before carbonization greatly increases efficiency. The water left in the wood for carbonization must be evaporated in a kiln or pit, and this energy must be obtained by burning some of the wood itself that would otherwise be converted into useful charcoal. Before charcoal is produced in a pyrolysis kiln, the raw material is pre-dried.

To do this, take a large container (barrel), fill it with wood, then heat it to a temperature of 140-160 °C. At this stage, it is very important to maintain the temperature regime:

- if the heating is insufficient, it will not be possible to dry the wood completely;
- if the heating is excessive, the smuts will crack, which will result in the production of fine-grained coal.

Drying is usually done by means of flue gases, and the container is installed at an angle to remove the moisture evaporated from the wood. The final moisture content of wood dried in this way is no more than 4-5%.

In industrial production, the first stage of carbonization in a kiln is drying the wood at a temperature of 100 °C or lower to zero moisture content. The temperature of the kiln-dried wood is then raised to about 280 °C. The energy for these stages comes from the partial combustion of some of the wood loaded into the kiln or pit, and this is an energy-absorbing or endothermic reaction.

When the wood is dry and heated to about 280 °C, it begins to spontaneously decompose, forming charcoal, water vapor, methanol, acetic acid and more complex chemicals, mainly in the form of resins and non-condensable gas consisting mainly of hydrogen, carbon monoxide and carbon dioxide. Air is introduced into the carbonization furnace or pit to allow some of the wood to burn, and the nitrogen from this air will also be present in the gas.

The oxygen from the air is used to burn some of the wood loaded. The spontaneous decomposition or charring of the wood at temperatures above 280°C releases energy, and is therefore called an exothermic reaction. This process of spontaneous decomposition or charring continues until only a carbonized residue remains, called charcoal.

If no additional external heat is supplied, the process stops and the temperature reaches a maximum of about 400°C. However, this charcoal will still contain a noticeable amount of resinous residue along with the ash of the original wood. The ash content of charcoal is about 3-5%; the resinous residue may be about 30% by weight, and the remainder is fixed carbon at about 65-70%. Further heating increases the fixed carbon content by removing and decomposing more of the resins. A temperature of 500°C gives a typical fixed carbon content of about 85% and a volatile content of about 10%. The yield of charcoal at this temperature is about 33% of the weight of the kiln-dried wood that has undergone carbonization, not counting the wood that has been burned to carbonize the residue.

Thus, the theoretical yield of charcoal varies with the carbonization temperature due to the change in the content of volatile resinous substances in it. Table 2 shows the effect of the final carbonization temperature on the yield and composition of charcoal.

Table 2. Effect of carbonization temperature on the yield and composition of charcoal

Carbonation temperature, °C:	Chemical analysis of charcoal, % of bound charcoal	Chemical analysis of charcoal, % volatile matter	Charcoal yield based on kiln dried wood (0% moisture)
300	68	31	42
500	86	13	33
700	92	7	30

Low carbonization temperatures produce a higher yield of charcoal, but this charcoal is low-grade, caustic due to the acidic resins it contains, and does not burn with a clean smokeless flame.

Good commercial charcoal should have a fixed carbon content of about 75%, which requires a final carbonization temperature of about 500°C.

If we consider how birch charcoal or a product based on any other wood is made in industrial conditions, then retort-type kilns are used for this purpose. The most expensive element of these kilns are pyrolysis units, the quality of which directly affects the stability and predictability of the process.

At the final stage, the charcoal is burned (calcined) by externally increasing the temperature to 500 °C. This process removes residual resins and eliminates the risk of spontaneous combustion of the wood. Then the heating is reduced to a temperature that eliminates the risk of spontaneous combustion, after which the finished charcoal is left to cool naturally.

Packaging, loading and transporting charcoal from the kiln to the distribution point or large-scale industrial use can account for up to 25% of the total production cost, as there are currently few locations where wood resources are close to the end user, and transport requires scarce and expensive liquid fuel. The cost of transporting charcoal in terms of thermal energy is much lower than transporting fuel wood, as the calorific value of charcoal is approximately twice that of dry fuel wood. Thus, charcoal can withstand relatively high transport costs, implying that charcoal should be produced as close as possible to the wood supply and then transported to market. Such transport logistics are of paramount importance when planning charcoal production systems. Production units in the transportation of charcoal: loading of charcoal on a vehicle, primary transportation, secondary transportation if used, with unloading/loading costs, unloading and storage operations at the main points of sale.
Important factors in the transportation of charcoal are:
- Low bulk density, requiring transportation and handling of large volumes.
- Fragility, resulting in the formation of "small waste" at each stage of processing and transportation.
- The tendency of fresh charcoal to spontaneously heat up and ignite due to the adsorption of oxygen from the air.
Experience has shown that there are fewer transportation problems when there is only one loading and unloading stage. This is easily achieved when using trucks. Costs per tonne/km are usually lowest when large unit loads are transported.

Twenty tone loads using a truck and trailer, both equipped with high sides, are practical. In this case, the charcoal is handled in bulk. Most of the fines are produced during loading and unloading operations. To reduce this problem, it is recommended to transport the charcoal in one operation from the charcoal kiln to the main distribution/storage point. Traditional producers often do not find bulk handling and transport practical, so it is necessary to bag the charcoal. But where large volumes of charcoal are regularly transported between the production center and the distribution point, bulk transport without bags should be developed to reduce packaging, transport and handling costs.

Charcoal readily absorbs water, so tarpaulins or other coverings should be used during transport to prevent soaking. There is always a risk that the charcoal will become wet from rain over a period of several days while it is "drying" on the side of the kiln. Dried charcoal should be transported as quickly as possible to reduce this risk. Plastic covers or an open shed made of galvanized iron can be used where large quantities need to be stored before transport. Every effort should be made to avoid double processing in the kiln, which results in wasteful production of fines and unnecessary labor.

The transport of industrial quantities of charcoal from the carbonization point to the blast furnace has been highly developed in Brazil. About 70% of all charcoal produced in the state of Minas Gerais is transported by truck, minimizing the generation of charcoal fines since the number of loading and unloading operations is small. Most small ironworks have no rail connection. Trucks can reach isolated furnaces located near poor roads. A typical truck has the following characteristics: a diesel engine of 145 hp, two axles for normal road driving and a third for fast and safe driving on the highway, in order to comply with the state regulations for maximum axle loads. The load capacity is 48 m³, the coal is transported in jute bags (a bag is about 25 kg or 11 bags / m³ of coal). This practice allows the use of general-purpose trucks, which can carry other goods on the return journey. Bagged coal is more voluminous than loose coal, which "settles" during transportation with a volume loss of 2–5%. Unloading of burlap bags must be done manually, which is a disadvantage.

Some transport companies use trailers with a capacity of 60 m³, but they cannot operate on bad roads and have a tendency to tip over. The transport distance varies from a few to 1000 km. Trucks transporting lump or loose charcoal must have sides about four meters high with a mesh cover to ensure a reasonable volume corresponding to the load capacity of the truck. All medium and large metallurgical plants in Brazil have rail connections and make maximum use of rail transport, as it is much cheaper.

Some large companies transport about 40% of their charcoal by rail. Most rail cars have a capacity of 54 m^3, a few have 80 - 100 m^3. Some older cars with a capacity of 20 to 30 m^3 are used; they have a flat bottom and wide unloading doors, but they must be unloaded manually. However, they can also be used for other goods as return cargo. Newer and larger cars have a sloping bottom and self-unloading doors on both sides of the track, which allows rapid unloading directly into coal bunkers or into a storage area. Sometimes cars are loaded on the railway line directly from trucks, but mainly from the transfer and storage depot via manual gates or conveyors. One company has started transporting charcoal by rail over a distance of 700 km in large plastic containers in the form of a 3 m3 bag, which is cost-effective compared to truck transport.

The plastic containers also protect the coal from moisture. They are loaded using a mobile crane. The experiment can be expanded to fill the containers in charcoal kilns, which will avoid the movement of lump coal between the kilns and the railway sidings.
The railway transport of charcoal is calculated at 300 kg/m^3 of charcoal. All loading and unloading operations at the loading and unloading stations are carried out by the steel companies, which also supply all the necessary equipment and bear all the costs. However, the wagons belong to the railway company, which is state-owned.

The Manaus (Siderama) iron and steel works, located on the Amazon River, use barges to transport all of their iron ore and charcoal. Water transport is very cheap and should be considered if conditions are right.

Intermediate supply is necessary when large volumes of charcoal must await transportation due to irregular availability of transport, such as road or rail transport, or poor road conditions in remote areas. The following requirements should be observed when planning an intermediate storage station.

Precautions for storing charcoal

Charcoal demand is usually seasonal, necessitating the creation of significant stockpiles. Great care must be taken in storing fresh charcoal. It has a tendency to absorb oxygen from the air. Rapid absorption creates a significant amount of heat, which accumulates to the point where the stored charcoal will begin to burn.

Tightly packed masses of fine wood and charcoal with a high volatile content are more susceptible to spontaneous combustion than larger pieces of charcoal.

Spontaneous combustion can occur even if the charcoal has been sprayed with water to aid cooling.
It is therefore advisable to store freshly unloaded charcoal outdoors, separate from previously cooled and conditioned charcoal, for at least 24 hours. During this time, the charcoal should be exposed to air circulation and protected from rain and wind, preferably in an open shelter rather than under a tarpaulin. If after 25 hours there is no evidence of heat or active fire, the charcoal can be considered safe for storage in a specially equipped warehouse.

It should be large enough to accommodate the quantity of charcoal to be stored under abnormal conditions, such as during a long rainy season or a shortage of rail transport. The warehouse should be divided into sections of approximately 2,000 m^3 each, separated by walls. It should be covered and have sufficient facilities for easy and rapid handling of charcoal on arrival and departure. Unloading into the warehouse may be done from outside through wooden or metal chutes, and loading of rail cars and trucks through manually operated wooden or metal hatches. Trucks should not be allowed inside the warehouse because of the fire hazards of internal combustion engines and smoking by truck drivers.

Conveyor belts can also be used, but mechanization should be kept to a minimum as it is expensive. The height of the bulk charcoal should be less than six meters to avoid spontaneous combustion. The incoming charcoal should be dropped as little as possible (maximum two meters) to reduce the formation of fines.

The charcoal should be dumped on a naturally formed charcoal slope and handling should be kept to a minimum as every movement will create small particles. The building should be well ventilated and open on all sides to allow quick and easy access in case of fire. It should have no intermediate columns throughout the roof span.

The building structure may be brick, concrete or steel. The roof should be of galvanized sheet or asbestos.

The floor may be brick, stone, concrete or rammed earth.

Water pipes with hose connections should be available at various points, but in case of fire the best way to save the charcoal is to push the unburned charcoal out of the building with tractors fitted with spade blades.

The charcoal, after it has lain for two days, may be stored under cover indefinitely.

This allows stocks to be kept to balance seasonal demand. A wholesale distributor stock of about two months, a year's sales, stored at the wholesale distribution point would be a good practice.

Stocks should be built up before the rainy season starts and allowed to decline towards the end. In this way, retail prices can be stabilized, provided that stocks are sufficient to service most of the retail market system.

The type of packaging depends on the type of retail market and the number of links between the wholesaler and the end consumer.

The fewer links, the higher the cost-effectiveness of distribution, the number of retail outlets is crucial.

The price structure for retail sales of charcoal must adequately reflect the cost of increasing the distribution of the product. Otherwise, no worthwhile result will be achieved.

Charcoal ready for use by the consumer involves a specific sequence of steps in the production chain, all of which are important and all of which must be performed in the correct order. They have different impacts on the cost of production. Taking these differences into account allows us to assess the importance of each step or unit process so that we can focus on the most expensive links in the production chain.

Production costs of charcoal production

Manufacturing costs can be conveniently analyzed using costs that clearly demonstrate the benefits of different systems:

- Cost of fuel wood stored near the kiln, pit or retort, including financial costs.
- Cost of carbonization labor, including loading and unloading.
- Cost of transporting charcoal to major markets or distribution points.
- Cost of working capital.
- Fixed investment costs of pits, kilns or retorts.

All costs are expressed on the same unit basis, i.e. per ton of charcoal supplied, so that their relative importance is clear. An extract from the FAO studies gives the following general picture*.

**The Food and Agriculture Organization (FAO) is a specialized agency of the United Nations that leads international efforts to defeat hunger. / Food and Agriculture Organization of the United Nations*

(FAO) is a specialized agency of the United Nations that leads international efforts to fight hunger.

Using traditional clay brick kilns and savannah forest yielding about 40 m³ of wood per hectare, the following unit costs apply (expressed as a percentage of the cost of the charcoal supplied):

- Cost of wood in the kiln - 60%
- Cost of labor in the kiln - 9%
- Working capital costs - 3.5%
- Fixed investment costs -1.5%
- Transportation costs for charcoal - 26%
- In total – 100%

The importance of the expenses for wood procurement and transportation of charcoal is obvious. Together they account for 86% of the expenses. There are other auxiliary raw materials and supplies needed for charcoal production that should not be forgotten.

Kilns require clay for sealing and making slurry for cooling and bricks, which should be made as close as possible to the place of charcoal production. Earth pits and clamps require earth of suitable texture and a considerable amount of straw, leaves and branches. Metal kilns require sand and gas welding and cutting, as well as sheet steel for repair. All charcoal production processes require a certain amount of water for cooling, fire extinguishing and making clay slurry. Above all, the whole process currently requires a certain amount of liquid fuel for growing and collecting wood, transporting wood and charcoal and various transportation of personnel and maintenance of equipment, etc. All of the above are fundamental to the successful operation of charcoal production. If the charcoal is not processed in bulk, then packaging costs must be added.

Quality standards of charcoal

The European and Asian markets regulate the quality of charcoal based on standards for physical and chemical characteristics such as colour, sound, combustion speed and particle size. The EU markets use the DIN-Geprüft and DINplus quality certificates.

Barbecue charcoal and barbecue charcoal briquettes must comply with the requirements of the European standard DIN EN 1860-2*

*** DIN EN 1860-2: Barbecue appliances, solid fuels and fire starters - Part 2: Barbecue charcoal and barbecue charcoal briquettes - Requirements and test methods.**

The document is a revised version of the previous edition of 2005. The basic European standard was developed by CEN/TC 281 "Appliances, solid fuels and lighting devices for grilling" (Secretariat: AENOR, Spain) with significant contributions from German experts. The national mirror committee responsible for this document is NA 095-02-07 "Appliances, solid fuels and lighting devices for grilling" of the DIN Standards Committee on Safety Principles (NASG).

Quality criteria include:

- Safe to use with pre-treated BBQ charcoal and BBQ charcoal briquettes.
- No foreign matter
- such as wood preservatives, paints, resin, bitumen, glass, slag, rust, metal fragments.
- Consumer information and warnings on packaging

To obtain the DINplus quality mark for premium quality, demonstrating excellent combustion properties, very favourable ignition characteristics and low ash content, the following additional tests are carried out in accordance with the certification program:

- Particularly low ash content
  Barbecue charcoal: max. 4% (wt.)
  Barbecue charcoal briquettes: max.
- Particularly high carbon content
  Barbecue charcoal: min. 80% (wt.)

Barbecue charcoal briquettes: min. 65% (wt.)
- Packaging markings

Testing and certification are carried out in the following stages:

- Initial testing of your product
- Creation of a test report
- Submission of an application for certification (Application for certification, valid test report if applicable, proof of valid certification according to DIN EN ISO 9001) and documents according to the European legislation on hazards and safety regulations).
- Conformity assessment
- The certificate is issued if the assessment result is positive and is valid for two years.
- Annual self-monitoring of the certificate holder and transmission of the test report to DIN CERTCO (information on self-monitoring can be found in the certification program (PDF, 197 KB) under point 6)
- DIN CERTCO control test (carried out twice)

In the United States of America, the quality of charcoal is based on the fixed carbon also according to DIN EN 1860-2:2023, the size of the charcoal pieces, homogeneity, absence of sparks, amount of dust and impurities.

In China, the national standards GB/T 17664-1999 - Wood charcoal and test methods of wood charcoal, GB/T 28669-2012 regulates the certification of bamboo charcoal as fuel, GB/T 26913-2011 - Bamboo charcoal.

How to measure the quality of charcoal? *

The charcoal produced by the briquetting machine and carbonization furnace has different quality indicators for different purposes. Generally, the quality of charcoal is measured based on the moisture content, volatility, ash content, fixed carbon content and calorific value of charcoal.

1. Carbon content of charcoal

The carbon content of charcoal varies with the variety of raw materials and the carbonization temperature. Generally, the carbon content of hardwood is higher than that of cottonwood and Paulownia wood with lower density under the same carbonization temperature.

The carbon content of charcoal made by machine from the same raw materials is higher under high carbonization temperature. Taking pine as an example, when the carbonization temperature is 380 ℃, its carbon content is 76%; When the temperature reaches 500 ℃, the carbon content is 85%, and when the temperature reaches 600 ~ 700 ℃, the carbon content is 92%.

2. Moisture Content

The charcoal produced by briquetting machine and carbonization furnace has different quality indexes for different purposes. Generally, the quality of charcoal is measured based on the moisture content, volatility, ash content, fixed carbon content and calorific value of charcoal.

3. Calorific value

It refers to the energy released per kilogram of charcoal under certain conditions, and is expressed in kilocalories. The calorific value of charcoal is directly related to the heat preservation time of the carbonization temperature. Under the same carbonization temperature and heat preservation time, the calorific value of charcoal made from different raw materials is different. Generally speaking, high carbonization temperature and long heat preservation time will result in high carbon content and calorific value. When the carbonization temperature is below 450℃, the calorific value of charcoal made from wood and its residues is generally 6500~7000kcal/kg, and the calorific value of charcoal made from straw and rice husk is generally 6000kcal/kg. When the carbonization temperature is above 600℃, the calorific value of charcoal made from these materials can be improved by 500~1000kcal.

4. Ash content

Ash is the remaining white or pink substance after all the charcoal is burned. It directly affects the use and economic value of charcoal. For example, the ash content of straw, rice husk and other substances is large, and it is not easy to fall off when burning, resulting in a low combustion temperature, which is not suitable for making live and industrial charcoal. The ash content of charcoal varies with the carbonization process and temperature. But for wood or residual material, the difference in ash after carbonization is small. Generally, the ash content of charcoal obtained from broadleaf forest is higher than that of coniferous forest under the same conditions. The ash content of charcoal obtained from raw materials with a large proportion of bark is also higher. The normal ash content of charcoal is 1 ~ 4 percent.

5. Volatility (volatile matter content)

The volatile matter content depends on the carbonization temperature of the machine-made charcoal. According to different applications, low-temperature charcoal, medium-temperature charcoal, and high-temperature charcoal can be produced.

The content of CO, CO2, H2, CH4, gaseous carbohydrates and other volatile substances that the former releases during high-temperature calcination is generally 12~20%. The above volatility of high-temperature charcoal is lower, and its content is generally less than 5%.

*Source: KMEC Company, a Chinese biomass briquetting machine manufacturer

Web: https://www.woodbriquetteplant.com/products/

Generating electricity from wood

The energy content of each fuel is not the same. Charcoal has much less, so it is practically not suitable for maintaining and producing electricity.

However, in the world, and in particular on the European continent, research on this topic continues. Thus, in 2005, under the coordination of BTG BIOMAS TECHNOLOGY GROUP B.V. (Netherlands), and with EU financial support in the amount of € 427,458.00, research was conducted on "Charcoal for electricity generation" with a total cost of € 716,016.00.

The EU-funded project aimed to develop a new process for large-scale production of charcoal for use as a sustainable fuel in coal-fired power plants. The objective of the project “Large-Scale Production of Charcoal for Use in Coal-Fired Power Plants and Cogeneration Plants” (Power-Grade Charcoal) was to develop an innovative method of producing charcoal that would allow the carbonization process to achieve higher conversion yields and scale advantages. In order to compete with alternative biomass feedstocks, efforts had to be made to reduce the current costs of charcoal production. Power-Grade Charcoal designed a large-scale production plant that could produce 10,000 tons of charcoal per year, compared to the existing plant that could only produce 800 tons per year. The project, which also included a business plan, offered two different business opportunities for participating SMEs. The first allowed charcoal producers to scale up production, achieving a profit margin of 14%.

The research results of the project provided a comprehensive and realistic roadmap for large-scale, profitable charcoal production. Using charcoal as a co-firing fuel can overcome the challenges associated with raw biomass, and Power-Grade Charcoal provided a research platform to further explore the most efficient ways to produce fuel sustainably in coal-fired power plants.

The specific objective of the project was to reduce production costs by 30%, from 200 to 140 euros per ton, and the main project activities included:
1) definition of charcoal specifications;
2) laboratory and pilot scale carbonization experiments, including process modelling and conceptual design;
3) studies on feedstock drying and charcoal densification;
4) full-scale co-firing experiments; and
5) design of a large-scale retort and carbonization plant.
The project was organised into nine work packages (WP):

WP 1: Definition of minimum product specifications for charcoal suitable for co-firing in coal-fired power plants.
WP 2: Definition, design, construction, debugging and commissioning of a pilot laboratory test rig for charcoal production. Completion of an experimental program using this laboratory test rig aimed at obtaining optimal process conditions for large-scale wood carbonization and for numerical model validation.
WP 3: Development of a mathematical model predicting the yield and quality of carbonization products and by-products. Validation of the mathematical model using data from the laboratory test rig and a real production plant.
WP 4: Completion of an experimental program including in situ measurements in a real charcoal plant in Pärnu, Estonia.
WP 5: Determination of the (economically) optimal wood raw material drying method in a real charcoal plant in Pärnu, Estonia.
WP 6: Investigate the suitability of different low-cost binders that can be used for the production of briquettes from fine charcoal fraction. Determine the (economically) optimal drying method for briquettes produced from charcoal.
WP 7: Scale-up testing of co-firing of lump charcoal and coal briquettes in a coal-fired power plant in Poland.
WP 8: Develop a design (project) and associated cost estimate for a large-scale charcoal production plant with a capacity of 10,000 t/year.
WP 9: Develop an implementation plan and a bankable business plan for the first of such large-scale charcoal plants. Finalize the knowledge utilization and dissemination plan.
The four SME project partners jointly represented the entire charcoal production and supply chain, while the three RTD implementers were experts in individual bioenergy fields.

The energy company Electrabel was concluding a partnership. If the target price level were achieved, a large market would be created for the SME partners. The specific goal is to reduce production costs by 30%, from 200 to 140 euros per tonne.

Biomass co-firing is an efficient and cost-effective method for achieving these goals, but the use of raw biomass is technically challenging and not always viable. Using charcoal as a co-firing fuel could overcome these obstacles. The energy sector’s interest in the concept is demonstrated by the participation of end user Electrabel, which will conduct a full-scale trial (500 t charcoal) at its CG-13 coal-fired power plant. Electrabel planned to co-firing 240,000 t biomass (charcoal) per year by 2008. Other power producers have set similar goals.

The project ultimately resulted in a design for a scaled-up charcoal plant with a capacity of 10,000 tonnes per annum, which can produce charcoal for the energy sector at a 20-30% lower production cost compared to the existing 800 tonnes per annum plant. The figures below show the layout of a single carbonization kiln (capacity of 2,500 tonnes of charcoal per annum) and a carbonization plant based on 4 such kilns (total capacity of 2,500 tonnes of charcoal per annum).

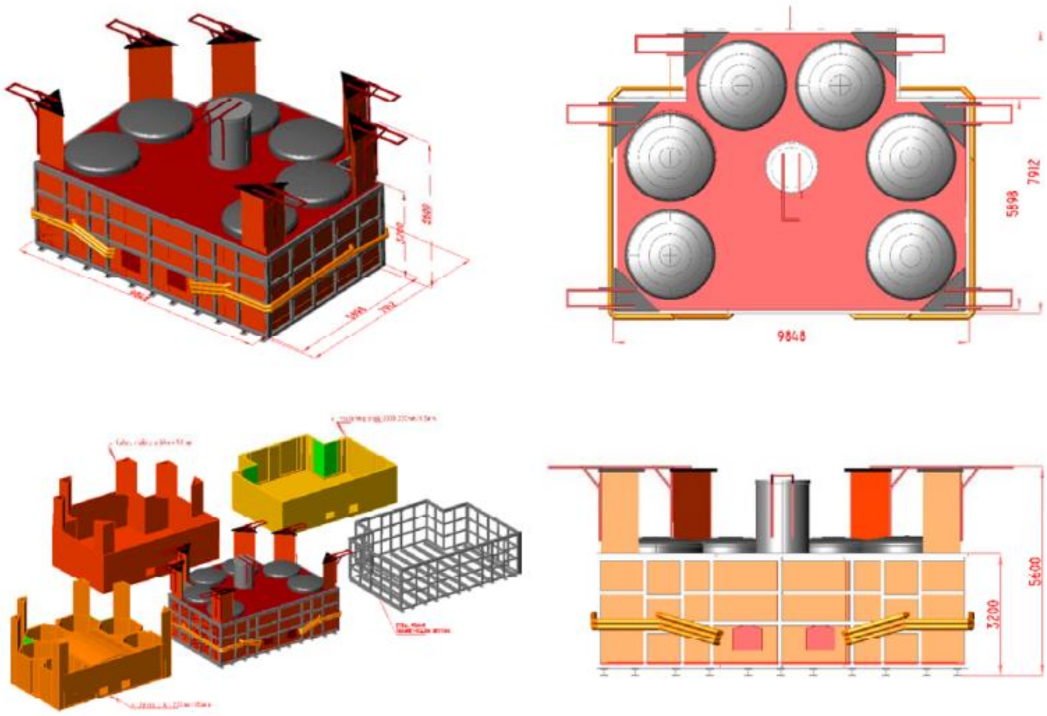


Figure 1 Various views and layout of layers of the scaled-up carbonisation oven

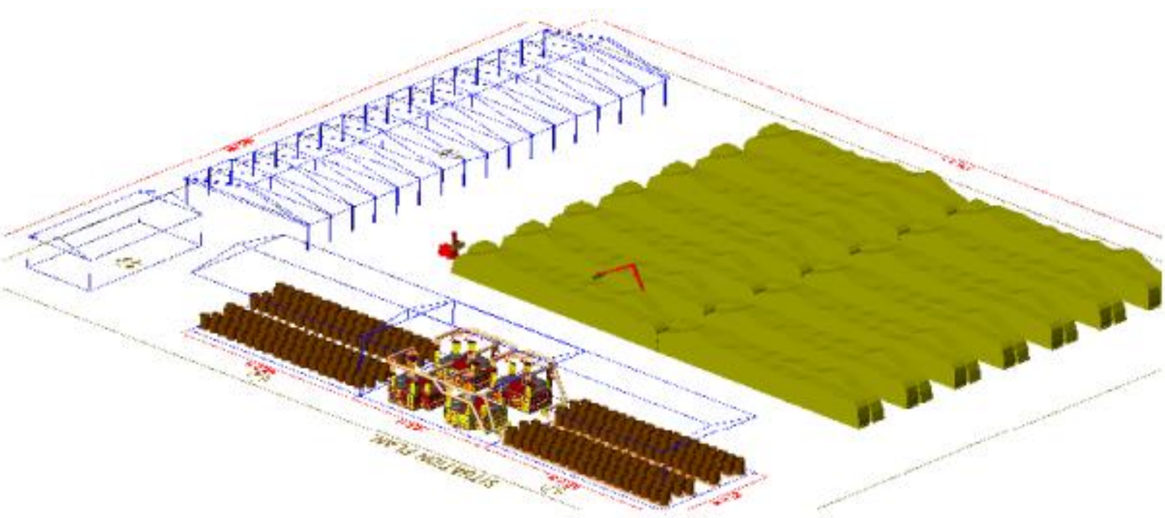


Figure 2 Top view (artist impression) of a scaled-up carbonisation plant (final design)

Looking at the specific targets, it can be concluded that most of them have been achieved, with the exception of the costs of charcoal compaction. Field studies in Poland show that these costs remain significantly higher than the target of 30 EUR/t charcoal. An important finding of the study was that the batch production of charcoal used by the SME partners does not allow adequate control over the degree of carbonization. Reducing this degree was the second of six key innovations that the projects aimed to achieve in order to achieve higher energy yields. Achieving this expected result will require a fundamentally different technology..

Project Summary: POWER-GRADE CHARCOAL has delivered the design, implementation and business plan for a large-scale charcoal production plant with a capacity of 10,000 tonnes per year. This result has enabled the participating SME partners to better serve their traditional market and offers them two distinct business opportunities.

Firstly, the charcoal producers ENER and Centropol now have the ability to scale up their charcoal production and can achieve a healthy internal rate of return of 14%.

Secondly, the joint venture of the partners ENER and Greencoal has the ability to sell the scaled-up charcoal production technology. It has been found that under current market conditions it is not possible to produce thermal coal at an attractive price for the power sector. It is unrealistic to envisage any major sales, except for research purposes, in this sector in the short to medium term.

Current market conditions for the traditional SME barbecue market are much better. In this market, contracts are concluded annually, and charcoal producers have been able to pass on recent increases in raw material and charcoal transportation costs to their customers (e.g. supermarket chains).

Since most of the results were confidential, communication outside the project consortium about the project's progress, results, outputs and outcomes was modest.

No project logo was developed, and the project website that was developed was simple.

The project was closed on December 31, 2007.

However, efforts to use alternative energy sources as heating fuels are currently ongoing.

Congress "Energy from Wood"

Thus, in Germany, the Federal Association for Renewable Energies Bundesverband Reneuerbare Energie eV (BEE), which unites as an umbrella organization specialized associations and state organizations, companies and clubs from all sectors and areas of application of renewable energy sources, holds annual specialized congresses on wood energy together with the Association for Wood Energy (FVH) in the BBE and the Agency for Renewable Resources (FNR).
Web: https://www.bee-ev.de/
https://www.fachverband-holzenergie.de/

At the 22nd Wood Energy Congress (Holzenergie), which took place in Bavaria in November 2022, Bernd Heinrich, Member of the Board of the Wood Energy Association (Fachverband Holzenergie – FVH), emphasized the importance of energy production from wood: "Wood is the largest renewable energy source and is indispensable, especially for heating independent of fossil fuel imports. Not only climate protection, but also German sovereignty requires that we urgently abandon fossil fuels and use all available alternative energy options, in particular wood biomass. Every ton of wood used for energy production, whether old wood, forest residues or waste from the wood industry, protects the climate and ensures energy independence." It was emphasized that there are all the prerequisites for a sustainable transition to the generation of electricity and heat from wood biomass from 16.5% in 2022 to 50% in 2030.

Germany today has a sufficient raw material base for energy wood. But many farm forests are underutilized, so the forest owner, being at the very beginning of the value chain, must be able to get a fair price for his raw material.

At the congress, many new, noteworthy technical solutions for the generation of electricity and heat from biomass were presented, for example the so-called hybrid concept - ORC with absorption heat pumps and the latest developments in gas generator units, which expands their scope of application, primarily for replacing natural gas. Dr. Volker Lenz from the German Biomass Research Center (DBFZ) in Leipzig presented a new project to replace liquid fuel boilers with biofuels – OBEN-Ölersatz Biomasse Heizung.

Over the next 20 years, more than 19 million boilers will have to be replaced. Such a large project will involve both classic technologies and innovations. The best examples are combinations with solar and thermal energy sources or heat pumps, and not only in individual buildings, but also in district and industrial boiler houses. This way, more systems can be created using renewable energy sources with less wood consumption. Mr. Lenz referred to hybrid biomass projects, one of which was presented by Harald Blazek from Steps Ahead Energiesysteme GmbH. This Austrian company plans to commission new and optimize existing biomass cogeneration power plants with a thermal capacity of more than 1 MW. It is supposed to use flue gas condensation in combination with absorption heat pumps. Steps Ahead supplies heat pumps from Chinese manufacturers to the European market; water is the coolant in them, and lithium bromide is the absorbent. According to Harald Blazek, the moisture content of the fuel used is usually 40-55%.

Many companies are currently experimenting with different types of fuel for gasification, for example, Ecoloop in Lauingen (Baden-Württemberg, Germany) is experimenting with gasification of plastic waste from PET bottles. Tests with tomato stems pressed into briquettes are being conducted at an Israeli research center. Burkhardt GmbH announced the release of a newly developed wood gasifier V5.90S with a cogeneration module, where wood chips serve as fuel.

Biomass fuel is mainly used in two directions: for heating and hot water supply and for electricity generation and cogeneration. Heating boilers that run on firewood, briquettes, pellets, chips and other wood waste (shavings, sawdust) have become widespread.

Generating electricity from biomass is accompanied by a number of technical difficulties, which are currently overcome mainly at combined heat and power plants (CHP) using high-power steam turbines. To increase the efficiency of a biofuel power plant, cogeneration technology is used in almost all implemented projects, using the generated heat for heating or for industrial needs (for example, steam generation). A cogeneration unit (CHP) is the same CHP (heat and power plant), only this term is usually used for medium and low-power plants. Steam turbines are common in the line of plants from 10 MW. In Europe, such biofuel plants are most often up to 25 MW, in Germany - up to 20 MW, since the legislation limits state subsidies for more powerful ones. And in the segment from 50 kW to several megawatts, gas generator cogeneration units are widely represented, they use generator or wood gas (German: Holzgas), which is often not quite correctly called synthesis gas. In gas generator units, thermal energy in the form of hot water or steam is produced during electricity generation. A special scheme allows increasing the efficiency of fuel use to 90% and higher.

The main disadvantage of gas generator units, primarily those of European manufacturers, is their very high cost. For example, a 25 kW (electricity) gas generator unit from Intrade, Germany, cost 125 thousand euros in 2015, while 30 kW gas generator mini power plants from another German company, Spanner Re² GmbH, cost 175 thousand euros. In terms of cost, this is approximately 5-6 thousand euros per 1 kW of installed electric capacity (in the case of CHP plants with megawatt steam turbines, it is more than two times cheaper). For low-power gas generator units, small-scale or individual piston steam mini-machines, Stirling engines, ORC modules, 8) are also used, mainly in Austria, Germany and Italy. But these technologies are still underdeveloped, and are also expensive and less efficient than classic steam turbines and even gas generator units.

For example, 10 years ago, in 2013, the company Otard, Germany, released the lionPOWER CGU with a two-cylinder opposite steam engine with an electric generator with a capacity of 2.25 kW. A pellet-fired version of such a plant was planned. But for the above reasons, the production of such CGUs was curtailed. Today, the most famous manufacturer of piston steam engines in Europe is the German company Spilling Energie Systeme GmbH.

The 23rd Wood Energy Congress took place from 26 to 27 September 2023 at the Congress Center in Würzburg. More than 250 participants took advantage of the two-day opportunity to exchange knowledge and network. 60 speakers shared their scientific and research insights as well as best practice examples in 12 cutting-edge sessions under the motto: “Decentralized, reliable, clean – modern wood energy”. The conference emphasized that the industry is going through promising, but also difficult times. Although it has been possible to secure the contribution of sustainable wood energy, for example through the revision of the EU Renewable Energy Directive (RED III) or the Building Energy Act, the turbulent past months have shown that the status of wood energy must be fought for. The policy of financing heating replacement and the construction of heating networks is being fought over, the federal government's plans to make half of the heat supply from renewable energy sources by 2030 are unachievable if solid biomass is at a disadvantage compared to other renewable energy sources.

In 2022, the share of renewable heat in Germany was only around 17 percent. The restrictions on the use of wood energy in federal funding for energy-efficient buildings must be abolished, as must the general restrictions on the use of biomass in district heating networks or the senseless and anti-economic regulations on technological heat production. With RED III, the EU has made it clear that wood energy is certainly a renewable form of energy in the context of sustainable development. This must also be reflected in national legislation. The FVH Council notes that private households in Germany account for only 46 percent of heat consumption and that there are still other large construction sites awaiting defossilization of industry, trade and services. In Germany, more wood is grown every year than is used. Wood is available regionally and forest areas are used to produce energy for which there are no other possible uses, be it for quality or logistical reasons. Wood makes a significant contribution to the secure energy supply and expansion of Germany's bioeconomy and climate protection by replacing fossil fuels, and saved around 34 million tonnes of CO_2 in electricity and heat production last year alone, while forests continue to absorb CO_2. Currently, only 7% (or around a fifth of Germany's total final energy consumption) of renewable heat is used for industrial processes such as steam generation, drying and high-temperature applications. Pellets and wood chips accounted for 31% of Germany's renewable energy used in 2023.

Combined with significantly lower financing rates for wood energy systems compared to other renewables, the transition to heat in the industry has virtually reached a standstill. The potential of sustainable waste and residual wood could contribute to the decarbonization of district heating networks, says Johannes Dornberger, energy industry and policy consultant at AGFW – the German Association for Energy Efficiency in Heating, Cooling and Cogeneration.

The 24th Wood Energy Congress will take place on 23 and 24 September at the Congress Centre in Würzburg and will bring together more than 250 participants, with 12 sessions on the topic of wood energy planned under the motto: Modern Wood Energy: Increasing Potential.

EUBCE Conferences

EUBCE – The European Biomass Conference, organized and established in 1980 in the UK, is characterized as a scientific event that addresses the balance between environmental sustainability and economic efficiency throughout the biomass value chain. This conference covers all aspects of biomass, from resources, research, innovation, implementation to policy. Particular emphasis is placed on the close partnership between academia, research institutes and industry.

After a three-year break, EUBCE 2023, the world's largest biomass conference and exhibition, was held again. Almost 1,500 participants from 79 countries took part in the event. Science and industry exchanged ideas, technologies, applications and solutions for biomass harvesting, production and use.

In 2024, the 32nd conference was held in Marseille from 24 to 27 June. The papers (about 200 oral papers and at least 500 posters) were selected from among the participants of the competition; in total, more than 750 papers were received.

Biochar Summit

The Biochar Summit took place in Helsingborg, Sweden, on 12-15 June 2023, with a visit to biochar plants with different technologies in southern Sweden. It was organised by the European Biochar Industry (EBI), Germany, an association of biochar producers, biochar plant manufacturers, wholesalers and processors.

The conference was a collaboration between EBI, the Nordic Biochar Network and the City of Helsingborg.

European Biochar Industry (EBI) website https://www.biochar-industry.com/

International Journals

Biomass & Bioenergy is an international journal publishing original research papers and short communications, review articles and case studies on biological resources, chemical and biological processes, and biomass products for new renewable energy sources and materials.

The scope of the journal extends to environmental, managerial and economic aspects of biomass and bioenergy.

Web: https://www.sciencedirect.com/journal/biomass-and-bioenergy

Energies is an electronic journal dedicated to research and development of energy technologies, from energy supply, conversion, distribution and end-use technologies to the physical and chemical processes that underlie such technologies. Published bimonthly by MDPI.

The European Biomass Industry Association (EUBIA), the Association of European Renewable Energy Research Centres (EUREC), the Institute for Energy and Fuel Processing Technologies (ITPE), the International Society for Porous Media (InterPore), CYTED are members of Energies.

Веб-сайт: https://www.mdpi.com/journal/energies

Sustainability is an international, peer-reviewed, open-access journal on the environmental, cultural, economic and social sustainability of humanity, published twice monthly on the MDPI network.

The Canadian Urban Transportation Research and Innovation Consortium (CUTRIC), the International Council for Construction Research and Innovation (CIB) and the Urban Land Institute (ULI) are members of Sustainability.

Web: https://www.mdpi.com/journal/sustainability

BioFPR (Biofuels, Bioproducts & Biorefining) is the leading journal on sustainable products, fuels and energy.

Published as a joint venture between Wiley and SCI (Society of Chemical Industry), BioFPR aims to promote the growth of the biorenewables sector and serve its growing interdisciplinary community by publishing unique systemic research and insights into technologies in these areas and their industrial development.

Web: https://scijournals.onlinelibrary.wiley.com/journal/19321031

Bioenergy International is an English-language trade publication with a subscription and an associated web platform that focuses on the value chains from biomass to energy; solid, liquid or gaseous. Founded in 2001, it is based in Stockholm, Sweden, and is owned by SBSAB, a subsidiary of the Swedish Bioenergy Association SVEBIO.

Web: https://bioenergyinternational.com/about-us/

Summary of Part 1

Charcoal is produced when wood is "charred" or "pyrolyzed" under controlled conditions in an enclosed space, such as a charcoal kiln. The result is a wood residue consisting of carbon, as well as small amounts of resinous residue, ash, combustible gases, resins, a number of chemicals, mainly acetic acid and methanol, and large amounts of water that is released as steam during the drying and pyrolytic decomposition of the wood. The vast majority of charcoal in the world is still produced by the simple process outlined above. It wastefully burns a portion of the wood feedstock to produce the initial heat, and does not recover any by-products or heat released during the pyrolysis process. Wood is the preferred and most widely available material for charcoal production. Many agricultural wastes can also produce charcoal through pyrolysis, but such charcoal is produced as a fine powder that usually must be briquetted at an additional cost for most charcoal uses.

In terms of availability, the properties of the finished charcoal, and sound environmental principles, wood remains the preferred and most widely used raw material, and there seems to be no reason why this should change in the future.

Approximately 3.2 billion cubic meters of wood are consumed annually worldwide, half of which is used as wood fuel.

Theoretically, the potential for wood fuel applications is enormous, but in practice, a number of technical, economic, and environmental factors limit the scale of its use even in countries with highly developed forestry and forest industry. Biomass for energy production (bioenergy) continues to be the main source of renewable energy in the EU and accounted for around 59% of renewable energy consumption in 2021, according to the Union's Bioenergy Sustainability Report 2023. The potential for the use of bioenergy from secondary wood fuels by European countries is around 22%.

The high energy dependence of some European countries on fossil fuel imports, the high consumption of these fuels worldwide, the high CO_2 emissions resulting from their combustion and the increasingly pronounced climate change are some of the main reasons that have initiated a more intensive use of renewable energy sources in recent years.

Bioenergy is a critical component of the EU energy system and economy, producing 85 percent of the EU's renewable heat, providing a third of jobs in the renewable energy sector.

Charcoal is a renewable energy source with a long history of use as a precursor to fossil fuels, now beginning to regain its place in the market as the world fights climate change. It is obtained from biomass through thermochemical processing. Charcoal can be used as a fuel, soil fertilizer, adsorbent, etc. on an industrial scale and in the home.

The production of charcoal involves the thermochemical conversion of biomass, resulting in the formation of charcoal, bio-oils and syngas, which are important components in the renewable energy sector.

Using charcoal as a sustainable energy option not only helps solve the energy crisis but also promotes waste management and environmental sustainability.

The world production of charcoal is estimated at 9 million tons per year, with the main production in Brazil - 7.5 million tons. Mainly hardwoods are used for production, although coniferous waste and bushes are also used, briquetting them.

In Europe and Asia, the production of coal using sawdust is becoming popular. Briquetted charcoal has a density of 1100-1200 kg / m3 and can be used as high-quality fuel.

The problem of recycling wood waste remains urgent for logging companies. About 25% of biomass remains in the forest after the removal of technological wood. But at the stage of wood processing there are also wastes: shavings, sawdust, knots, etc. There is a way to use this "waste" to obtain raw charcoal. The coal is small, but it can be crushed and used for stoves and fireplaces, as well as for boiler houses and thermal power plants. Bioenergy already offers a viable alternative to fossil fuels today, representing 85% of all renewable heat and a key player in carbon dioxide removal technology through bioenergy with carbon capture and storage (BECCS). Bioenergy is also a truly European asset, creating jobs and supporting the bioeconomy.

In Germany, renewable energies are the most important source of electricity. The share of renewable energies in electricity consumption is constantly growing: from around 6% in 2000 to 52% in 2023, and by 2030 this figure will reach 80%. In relation to the share of renewable energies as a whole in 2023, biomass accounted for around 18% in electricity production, 83% in the final energy consumption for heating and cooling and 81% in the final energy consumption in transport. In 2023, electricity production from renewable sources covered more than half of electricity consumption at 272.4 terawatt hours (TWh), exceeding the 2022 figure by 7%.

Globally, 15.7 EJ of heat was produced in 2020 from combined heat and power plants alone, mostly coal and natural gas-fired, accounting for more than 85% of global heat production. However, renewable energy technologies such as biomass, geothermal energy and solar thermal have doubled their contribution to global heat production over the past two decades, with 96% of renewable heat coming from biomass.

As of 2022, data shows that the world produced 46.4 million tons of wood pellets, 1.9 billion m3 of wood fuel and 54.9 million tons of charcoal. Europe is the leading producer of wood pellets, accounting for over 55% of global supply.

Meanwhile, Africa leads the way in wood fuel and charcoal production, accounting for 37% and 66% of global production, respectively.