Assessment of the market of wood fuels and solid fuel heating and cooking appliances in Serbia

GIZ DKTI Sustainable Bioenergy Market in Serbia

E4tech (UK) Ltd for GIZ

July 2017
Contents

1 Introduction and comments on data quality ................................................................. 1

2 Market for wood fuels in Serbia .................................................................................. 1
   2.1 An overview of the wood fuels supply chain ......................................................... 1
   2.2 Production and supply of wood fuels in Serbia ...................................................... 5
      2.2.1 Firewood production and supply ...................................................................... 7
      2.2.2 Wood pellet production and supply ................................................................. 9
      2.2.3 Wood briquette production and supply ............................................................ 10
      2.2.4 Charcoal production and supply ..................................................................... 11
      2.2.5 Wood chip production and supply .................................................................. 12
   2.3 Consumption of wood fuels on the national market .............................................. 13
      2.3.1 Firewood consumption .................................................................................... 14
      2.3.2 Wood pellet consumption ............................................................................... 16
      2.3.3 Wood briquette consumption ........................................................................ 19
      2.3.4 Charcoal consumption .................................................................................... 20
      2.3.5 Wood chip consumption ................................................................................ 20
   2.4 Prices of wood fuels ............................................................................................... 22
      2.4.1 Firewood .......................................................................................................... 22
      2.4.2 Wood pellets .................................................................................................... 22
      2.4.3 Wood briquettes .............................................................................................. 22
      2.4.4 Charcoal .......................................................................................................... 23
      2.4.5 Summary ......................................................................................................... 23
   2.5 Quality issues for wood fuels on the Serbian market ............................................. 24
   2.6 Regulatory framework ............................................................................................ 26
   2.7 Key issues and policy recommendations .............................................................. 28

3 Market for solid fuels heating & cooking appliances in Serbia .................................. 30
   3.1 Supply chain of wood fuel appliances .................................................................... 30
      3.1.1 Overview .......................................................................................................... 30
      3.1.2 Key actors in the supply chain ....................................................................... 31
      3.1.3 Role and interaction of supply chain actors .................................................... 32
   3.2 Quality and regulation of solid fuel appliances ..................................................... 33
      3.2.1 Lack of regulation of appliances in Serbia ....................................................... 33
      3.2.2 EU commercial policy .................................................................................... 33
      3.2.3 EU energy-related appliances policy: Ecodesign ............................................. 34
   3.3 Production of solid fuel heating appliances in Serbia .......................................... 35
      3.3.1 Structure & size of the supply side of the market ........................................... 35
      3.3.2 Product innovation ......................................................................................... 36
   3.4 Import and export ................................................................................................... 38
   3.5 Quality and performance aspects of Serbian produced solid fuel appliances ....... 41
      3.5.1 Nominal efficiency ......................................................................................... 41
      3.5.2 In-situ testing of efficiency .............................................................................. 43
      3.5.3 Testing of efficiency and emissions at foreign laboratory ............................... 43
      3.5.4 Implications of results of investigation ........................................................... 45
   3.6 Key issues and policy recommendations ............................................................... 46
Appendix A  Applicable EN standards for wood fuels ................................................................. 48
Appendix B  Case study of firewood supply system for households in Southern & Southwestern Serbia . 52
Appendix C  Quality requirements for firewood ........................................................................ 57
Appendix D  Quality requirements for wood pellets ................................................................... 59
Appendix E  Quality of wood pellets produced and sold in Serbia ............................................ 61
Appendix F  Quality requirements for wood chips ....................................................................... 71
Appendix G  Quality requirements for wood briquettes .............................................................. 75
Appendix H  Quality requirements for charcoal and charcoal briquettes ..................................... 77
Appendix I  Applicable EN standards for solid fuel heating & cooking appliances ...................... 79
4  References ................................................................................................................................ 81
1 Introduction and comments on data quality

This report was written to support the knowledge base relating to “Improving the efficiency of the use of fire wood in households”, which is a component of the GIZ DKTI Programme “Development of a Sustainable Bioenergy Market in Serbia”. It constitutes an update of the market report published in 2014.

It is divided into two main chapters: wood fuels and solid fuel heating appliances, and in each, endeavors to give the reader insight into production, consumption, international trade and quality issues. Its scope is limited to the household level, and focuses on the use of wood fuels for heating and cooking. The appendices are written to provide additional information about issues touched upon in the report.

This report synthesizes data obtained over the three year project duration, via direct interviews with industry players, official data requests to the Statistical Office of the Republic of Serbia, reports published by other initiatives and projects (as referenced), data bases of the University of Belgrade-Faculty of Forestry (Centre for timber trade), unpublished internal reports and on occasion, anonymised industry sources.

It was striking that in the case of solid fuel appliances only the large, medium and a few small-sized companies were willing to contribute data to the solid fuel appliances industry study in chapter 3. This made comprehensive analysis difficult for the authors and has likely biased the conclusions towards those applicable to the larger manufacturers.

Utmost effort has been placed on cross-checking and verifying data wherever possible, but given that these data are disperse, had to be assembled from a variety of sources and had to be grouped to provide confidence to producers that confidential figures would not become available in the public domain, readers of this report are advised to focus on general trends rather than the absolute numbers.

2 Market for wood fuels in Serbia

2.1 An overview of the wood fuels supply chain

In order for biomass to meet the demand of the consumer for clean and efficient heating, wood fuels need to comply with specific dimensions, moisture content and purity. However, woody biomass is prone to degradation which means that raw materials have to be processed expertly, kept in warehouses and logistics need to be well managed. The design, organization, functioning and management of the supply chain are of major consequence for all participants in the chain. The wood fuels supply chain in Serbia can be divided into the four main segments: production, transportation and processing, distribution and end use, as illustrated in Figure 1.
Production

The FAO project [15] identified that forests are the most significant source of woody biomass in Serbia, representing 58.2% of total woody biomass potential. The second most abundant source of woody biomass is trees and bushes from non-forested areas (32.4% of total potential). The remainder of the potential is prunings from urban trees, post-consumer wood and municipal wood waste.

Transportation and processing

A significant number of private haulers are engaged in transporting wood material to consumers, with industrial consumers sometimes collecting wood in their own vehicles. Trucks specially designed for this purpose are used in the transportation process and special containers are used to transport sawdust and wood chips. This segment of the supply chains is currently not experiencing significant limitations apart from slight increases in transport fuel prices.

Wood is processed by different actors, depending on the end product: for example, saw mills produce wood for individual use, as well as residues that enter further processing by other users.

---

2 According to the Serbian Forest Inventory non-forested area cover tree lined paths, urban parks, forest tree nurseries, and groups of forest trees in areas smaller than 5 ares
3 Municipal wood waste includes discarded furniture, parquets, window frames, doors etc.
pellet mills process wood into pellets, small local enterprises or individuals acting as wood traders transform virgin wood into firewood that can be sold to end consumers. Each of the following chapters dealing with different fuel types includes detailed information about processing. A rapid increase in demand for wood pellets has lead to an overenthusiastic increase in the number of pellet mills along with significant overcapacity. The wood processing sector is thus expected to further transform in the future.

**Distribution**

The wood fuel distribution segment of the supply chain is highly fragmented. Firewood is mostly distributed to the market through own production, direct sale to end-consumers, via wood yards of public enterprises and individual traders. A very small share of log wood is also distributed through other retailers such as petrol stations and DIY markets. Figure 2 shows the supply chain for firewood with all participants and their mutual connections.

![Figure 2 – Firewood supply chain in Serbia](image)

The most significant problems identified in the firewood distribution system are related to the system (or rather, lack thereof) of measuring the quantities at the point of sale (primarily on the doorstep of households) by small traders. Quantities sold are measured in “stacked m\(^3\)”. However, the most frequent length of the sold split logs is less than 1m, meaning that consumers receive less

---

4 do-it-yourself
wood than agreed and purchased. Often consumers do not check the length at the point of sale properly due to lack of information or not wanting to jeopardize their relationship with a long-term supplier of wood logs.

As Figure 3 illustrates, the distribution system of wood pellets and briquettes is simpler compared to firewood distribution because of fewer participants in the chain.

Solid fuel warehouses and small traders play the most significant role in the distribution system of wood pellets and briquettes to households. Smaller amounts are distributed through retailers or directly from producers to consumers.

**End use/consumption**

The stand-out characteristic of the market of wood fuels in Serbia in the last five years has been the steady increase in consumption, with wood pellets experiencing the fastest rate of growth. This demand for wood fuels, including pellets, can be fully satisfied through domestic production, with surplus being exported.

Wood fuels are used by a wide range of consumers with diverse needs. These include individual households, operators/managers of public and commercial/industrial buildings and facilities, and are generally used to produce heat. Given the different needs of consumers, each category tends to predominantly use one type of fuel, even if there are always exceptions and special cases. Households dominate the consumption of firewood for heat production (see also section 2.3.1),
While briquettes are used by commercial users such as bakeries and households (see section 2.3.3). Wood chips are most often used in large industrial boilers at company premises and for further processing into pellets (see section 2.3.5), with pellets mostly being exported, if not used to satisfy the rapidly growing demand from households in Serbia (see section 2.3.2). Charcoal, while being a more niche product, is used by households, the restaurant/food industry and exported (see section 2.3.4).

In this segment of the supply chain, the main issues relate to the quality of wood pellets and the quality of the combustion appliances. Almost all producers of wood pellets in Serbia have some form of quality certificate issued by national and occasionally international laboratories. However, some crucial elements of the testing procedures followed, e.g. sample collection, lend themselves to manipulation.

Wood chip distribution is characterized by direct deliveries to large commercial end users. Since this report focuses on domestic end users, detailed analysis was outside the scope of this report.

2.2 Production and supply of wood fuels in Serbia

In Serbia, firewood, wood chips, wood briquettes, wood pellets and charcoal production is mostly located in the South-West and West of the country, with some producers present in Southern, Eastern and Central Serbia. Production sites are indicated in Figure 4 below.

As of the beginning of 2017, woody biomass in general and firewood in particular is produced by PE Srbijašume and PE Vojvodinašume (two public enterprises responsible for management of state-owned forests), by five national parks and by numerous small private forest owners. Wood chips are produced by 14 companies and 37 companies produce wood briquettes. During the last five years, the expansion of production capacities and new market entries were largest in the wood pellet segment and currently 54 pellet production facilities are actively operating. Charcoal is mostly produced in rural areas with dense forest cover, spread over more than 1,500 charcoal kilns and one industrial plant.
 Suppliers producing wood fuels from wood raw materials delivered by PE Srbijašume and PE Vojvodinašume and national parks usually have annual contracts in which quantities, prices, delivery and payment terms, assortment structure and quality are set. Other consumers such as households, pensioners associations, schools and health centres supplied by the public enterprises and national parks are serviced through company-owned wood yards.

Currently the internal organisation of PE Srbijašume causes inefficiencies in delivery dynamics and fulfilment of wood orders. Functions along the internal supply chain are outsourced to private companies, whose technical capacity, equipment and staff capabilities are not always at a satisfactory level. This causes frequent delays in production and delivery for industrial purposes.

Wood from private forests is used by their owners to fulfil their own heat requirements or sold to traders or industrial companies. If wood is sold, this usually happens in the form of raw material as standing trees to entrepreneurs who do the logging, extraction, production of wood assortments and their distribution to the market. The main reason for this arrangement is the lack of adequate machinery, equipment, transportation vehicles and other elements significant for the production and distribution of firewood.

**Figure 4 – Map of wood fuel producers in Serbia[2]**

Legend
- Charcoal
- Wood pellets
- Wooden briquettes
- Wood chips

by Prof. dr Branko Glavonjić

*Under contract by GIZ DKTI “Development of a Sustainable Bioenergy Market in Serbia”*
The following sub-chapters provide an overview of the development of demand and supply in the past five years for different wood fuel types (firewood, chips, briquettes, pellets and charcoal) in Serbia.

2.2.1 Firewood production and supply

Firewood for the heating of buildings is found on the Serbian market most commonly in the form of long-meter log woods as round billets and/or cleft short logs (Image 1) and sold as “stacked m$^3$”.

With 47% of forests owned by approximately 500,000 private individuals/companies, many households supply themselves with firewood from their own forests. Not all owners are simultaneously firewood producers themselves: surveys show that a number of private forest owners living in cities make arrangements with local contractors by giving them authorisation to cut wood from their forests. In return for this service, the contractor is compensated with one stacked m$^3$ for every stacked m$^3$ for the owner. Often this ratio is 2:1 or even more in favour of contractors with owners lacking an effective control mechanism. In addition, these practices are part of the informal economy and thus do not appear in VAT statistics.

In most state-owned forest estates, services such as cutting and extraction of technical and fuel wood are outsourced to private companies; very rarely employees of state-owned forest estates perform these tasks. In 2012, according to data provided by PE Srbijašume, 343 private companies and entrepreneurs delivered the services of cutting, production of wood assortments and transport.

Firewood is also produced by traders who buy wood at the source or in the form of long-meter round wood. They then transport this raw material with their own vehicles to their production sites, where they split it to the length of 1 meter and then distribute the firewood in towns and cities. Image 2 shows the typical layout of such a work site in Central Serbia.
In addition to 1m log wood, during the heating season split wood assortments of 25 and 33 cm length packed on palettes or trucks are also supplied to the local market by traders (see Image 3).

The moisture content of firewood supplied to the market varies depending on the season in which it was produced. In some cases, firewood is air-dried for 2 to 3 months along the supply chain (being stored at wood yards). However, in the majority of the cases, firewood is produced and delivered to end-consumers right before the heating season resulting in moisture content significantly higher than the maximum recommended 25%.

In addition to high moisture content, consumers may also commonly reject deliveries that come up short of the 1m3 stack size.

Firewood production in Serbia has been steadily increasing due to growing consumer demand. As discussed above, the absence of a reliable and comprehensive system for monitoring production in private forests means that a significant amount of firewood production is not recorded statistically,
which is the main reason why the actual production of firewood is estimated to be almost five times higher than the officially recorded production (Figure 5).

This conclusion was reached based on the results of the FAO project [15] implemented in Serbia in the period 2009-2011, which showed that actual production of firewood in 2010 was 7.05 million m$^3$ while in the same year only 1.45 million m$^3$ were recorded in official statistics. A project carried out by the South East Europe Energy Community came to similar conclusions. As a result, since 2010, firewood production has been monitored in compliance with the methodology used in the FAO project. The results are shown in Figure 5.

![Firewood production in Serbia](image)

**Figure 5 – Firewood production in Serbia [15], [17], [20]**

### 2.2.2 Wood pellet production and supply

The number of wood pellet producers in Serbia increased from 2 in 2006 to 54 active producers in 2016 [4]. Expansion of the number of wood pellet producers in Serbia reached its peak in 2013 when 9 new plants were commissioned. During 2014, 2015 and 2016, the increase of the number of new producers was significantly lower. In 2016 seven producers ceased production and are currently undergoing liquidation, three out of which used to have large production capacities.

The growing number of producers was accompanied by the increase of installed capacity (i.e. there were new market entrants, rather than just existing producers increasing the size of their operations). However, there is now overcapacity. At the end of 2015, total installed capacity for the production of wood pellets in Serbia reached 550,000 tons, while 229,000 tons of pellets were produced, corresponding to a 41.6% utilization rate.

Several large producers increased their capacities in 2016 so that in combination with the closing of factories the total reduction of installed capacity in 2016 was 88,000 tons. The total installed capacity of all active producers at the end of 2016 was 463,000 tons, a 15.8% decrease over 2015. Given the closures of facilities, production saw a 2.4% increase in 2016 with a total output of 242,000 tons (see Figure 6), corresponding to a 52% utilization rate.
Wood fuels and solid fuel heating & cooking appliances in Serbia

Serbia is the leader in the Western Balkans in terms of installed capacity, but comes third in terms of output after Croatia and Bosnia and Herzegovina.

The steep increase in the number and capacity of pellet production plants in Serbia is based on the increase in demand for wood pellets on the national as well as the export market. However, due to issues such as climate or other natural influences, the technical potential of wood raw material is not realised in practice.

Wood pellets in Serbia are mostly produced from long-length roundwood, firewood and slabs, in contrast to pellets in EU countries, which are frequently produced from waste materials such as saw dust. Total consumption of biomass for the production of wood pellets in Serbia was 464,000 m$^3$ in 2016, and it is expected for 2017 that the consumption will exceed 0.5 million m$^3$.

### 2.2.3 Wood briquette production and supply

In Serbia, the predominant type of wood briquettes have a moisture content of 10-12 %, are 60-80mm diameter and 10cm or 30cm in length. Two producers are producing briquettes sized $5.5 \times 5.5 \times 32$ cm with a hole of 22mm in the middle$^7$. They are mostly produced from beech wood residues without any additives or impurities, even though some producers add corn starch during the production process to achieve better adherence and greater compactness of the briquette. Most commonly, briquettes are packaged into 15 kg boxes or are PVC shrink wrapped for distribution to consumers [3].

Serbia has 37 wood briquette producers, the majority of which process sawdust from sawmills throughout the year. The biggest producers have special lines and high-capacity technologies such as shown in Image 4.

---

$^7$ The hole featuring in some types of briquettes is a result of the production process. It also has the advantage of aiding efficient combustion.
A smaller number of facilities process woody biomass as and when it becomes available in the wood processing industry, usually using small hydraulic presses [3] shown in Image 5.

Due to the rapid increase in popularity and price of wood pellets, some of the wood briquette producers installed additional lines for pellet production. This has led a redirection of raw material towards the production of pellets, and away from briquettes.

2.2.4 Charcoal production and supply

Annual production of charcoal in Serbia is 30,000-34,000 tons depending on the demand on the national market and the main export markets. It is produced in either earth cover kilns, brick kilns, portable steel kilns or industrial retorts (see Image 6).

---

8 Photo credit Glavonjić, 2013
9 Photo credit Glavonjić, 2013
Wood fuels and solid fuel heating & cooking appliances in Serbia

The predominant way to produce charcoal is in brick charcoal kilns, and even though portable steel kilns were introduced in 2009, they are not frequently used due to their low quality. An industrial facility using retorts started operation in 2010 and is producing high quality charcoal with Cfix of over 85% (for further details see Appendix H). All output from this facility is exported to Germany and distributed to silicon and gunpowder factories.

The majority of producers are located in the eastern, south-west and western parts of Serbia and can be roughly divided into two groups:

The first group comprises small producers in rural areas who produce charcoal as a side activity. Their production is seasonal, based on orders and is mostly executed during spring, summer and autumn. On average, these households produce around 1.5 tons of charcoal per year. Although the output from each household is small, this group of producers is significant due to their number. Producers in this group are officially registered as agricultural producers who pay tax to the state depending on the size of the household, class of agricultural land quality and other factors [2].

The second group of producers consists of medium and large producers. Production is conducted in brick charcoal kilns which are filled with firewood or large wood residues from sawmill wood production. This group of producers also includes producers located near forests who use split wood as a raw material for production of charcoal. Most medium-size producers use the so-called Swedish method, whose cycle of production lasts 7 days. Only 25% of mass of the original feedstock is converted into the final product.

Charcoal is packed by producers in sacks of 15-16 kg and delivered to big consumers such as restaurants and butchers. Other producers specialise in production and buying of charcoal to package it into bags of 3-5 kg which are then delivered to supermarkets and intended for retail.

2.2.5 Wood chip production and supply

In Serbia, the majority of wood chips are produced from conifers and soft broadleaves, and to a lesser extent from hard broadleaves such as beech. In 2016, wood chips production decreased by 12.5% from 114,000 tons in 2015 to 99,000 tons (Figure 7).

One of the main reasons for this decrease was the decision of the biggest wood chips producer to enlarge its production of wood pellets during 2015 and 2016. Consequently, the wood chips were mostly used in pellet production instead of being placed on the market.

---

10 Photo credit: Glavonjic, 2012
Wood fuels and solid fuel heating & cooking appliances in Serbia

In the period 2013-2016, wood chip demand on the national market was volatile, which led the largest producers to export stocks that could not be sold nationally. The first export contracts with international traders were signed towards the end of 2013, and currently wood chips are exported via the port of Bar to Italy and other countries (Image 7).

Because of stricter quality criteria imposed by foreign buyers, as well as the drop of prices on the foreign market during 2014, the export of wood chips became unprofitable for the biggest producers. Consequently, some of them decided to construct wood pellet production facilities and to process wood chips further into pellets.

2.3 Consumption of wood fuels on the national market

There are five types of wood fuel and biomass consumers in Serbia:

- Households
- Public facilities (schools, health centres, first aid centres, district heating systems)

---

11 Photo credit: Glavonjic, 2014
Wood fuels and solid fuel heating & cooking appliances in Serbia

- Commercial facilities (bakeries, meat roasters, restaurants, hotels, office buildings, selling facilities and other facilities)
- Religious facilities (church lodgings, residences, etc.)
- Industry (producers of other fuels, producers of wood based panels and other industries)

Not all wood fuel types are marketed to every segment of the market, for example, all types of wood fuels are consumed by households except for wood chips. Firewood and wood chips are most frequently consumed by industrial users, and so on.

Demand for wood fuels in Serbia is driven and influenced by:

- Tradition and habit
- Availability of different fuel types to end consumers
- Price of alternative fuels for heat generation
- Purchasing power of individual consumers
- Education of consumers and access to information
- Reputation of wood fuels as offering GHG benefits vis-à-vis fossil fuels
- Word of mouth (recommendations from neighbours, family, handymen)
- Availability of subsidies or other support mechanisms to encourage the purchase of modern appliances

The following sections of the study present detailed information on the demand for different types of wood fuel.

2.3.1 Firewood consumption

According to FAO project [15], firewood is the dominant source of energy for most households in rural areas and is also common in urban agglomerations. Both in terms of number of households dependent upon it and the absolute quantity used per heating season, firewood dominates the domestic market.

In rural areas, firewood is generally procured from forests owned by households (or family/close friends) themselves and is therefore typically a very low-cost fuel. The use of firewood in cities is determined by varying combinations of the following factors:

- Lack of infrastructure for other fuel types (gas, district heating)
- Relative price competitiveness of firewood compared to all other forms of heating fuels
- Ownership of forests by urban households
- Tradition and habit
- Ability of urban and suburban households to purchase more expensive alternatives such as pellets
- “New” forms in which firewood is produced and offered to consumers: short and ready to use log wood is more easily used and stored than one-meter log wood

Firewood consumption in Serbia in the last five years has been characterized by an increase in total consumption despite a simultaneous decrease of firewood use in households.

---

12 at the time of writing, no such mechanisms exist
Figure 8 shows actual consumption of firewood over the last seven years. As discussed in section 2.2.1, significant discrepancies between the statistically recorded and actual consumption exist.

As can be seen in Figure 8, total consumption of firewood in Serbia in 2016 was 7.24 million m³. The detailed break-down in Figure 9 and Figure 10 shows that households consumed almost 85% of total firewood in 2016, which is a decrease of 5.6% compared to 2010. The main reasons for the decrease of the household share in total firewood consumption are the increase of the participation of other consumers of firewood, notably the producers of wood pellets and wood based panels, and the transition of an increasing number of households to wood pellets.

Figure 8 – Total consumption of firewood in Serbia [20]

Figure 9 – Consumption of firewood in Serbia (2010) [15]
Besides households, the highest demand is by producers of wood-based panels (particleboard and hardboard) and charcoal, followed by energy generation for internal needs of wood industry companies, production of wood chips, wood briquettes and wood pellets, as well as heating of school facilities.

The amount of firewood consumed annually by households depends most critically on average monthly temperatures during winter months, altitude, quality of insulation of residential buildings, whether households have central heating and lifestyle.

The FAO project [15] showed that average consumption of firewood in Serbia was 7.3 m$^3$ in 2010, which was 12.3 % more than in Slovenia [1] and 32.7% more than Montenegro [18]. All three countries are largely in the same climate zone (the southern part of Montenegro has Mediterranean climate), and the comparison shows that the efficiency of firewood use in households in Serbia is alarmingly low.

An important characteristic of firewood consumption in rural areas is the continuous consumption throughout the year: uses are heating and food preparation in the winter months and food preparation, brandy distillation, meat drying and hot water during the rest of the year. Many rural households, especially in mountainous regions, require heating of living spaces even during summer months in evening hours. Use of electricity in rural households for food preparation is low because of extremely low disposable income of most rural households.

In urban households, wood fuels are only used during heating season, while electricity is used for food preparation and other purposes throughout the year.

### 2.3.2 Wood pellet consumption

In the last 20 years, wood pellets have seen high growth rates in consumption, production and trade globally, and Serbia is no exception. The main factors behind this growth are pellets’ relatively high energy density, the development of appliances that achieve high energy conversion efficiencies
during combustion, low ash content and ease of use for the consumer. Starting in 2017, pellets have also received government incentives through VAT reduction as part of the intent to shift the energy system towards renewable sources. Monitoring of the market development, trends and policy measures in this field has become necessary and significant for all participants in the value chain of wood pellets.

With an average annual growth rate of 28.4% for the period 2012-2016, wood pellet consumption in Serbia reached 170,000 tons in 2016 (Figure 11). A significant increase in consumption was mainly noted in the domestic sector, but also by commercial consumers such as restaurants, hotels and bakeries. Growth in consumption of pellets in public buildings like kindergartens, schools and medical facilities is somewhat slower, most likely due to slow tender procedures for procuring appliances and pellets.

![Graph showing consumption of wood pellets in Serbia](image)

*Figure 11 – Consumption of wood pellets in Serbia [20]*

It is notable that the increase in wood pellet consumption in Serbia took place in the absence of stimulating measures by the government for the purchase of new combustion appliances, as is the case in many countries in the European Union. One recent measure which should contribute to a further increase of wood pellet consumption in Serbia is the reduction of the VAT rate for wood pellets and briquettes from 20% to 10%, which is applicable since 1 January 2017. Compared to other countries in the region, Serbia now has the lowest VAT rate for wood pellets (Table 1).

<table>
<thead>
<tr>
<th>Country</th>
<th>VAT in %</th>
<th>Wood pellets</th>
<th>Natural gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serbia</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Bosnia and Herzegovina</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>TFYR Macedonia</td>
<td>18</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Montenegro</td>
<td>19</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Albania</td>
<td>20</td>
<td>...</td>
<td>20</td>
</tr>
<tr>
<td>Slovenia</td>
<td>22</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Croatia</td>
<td>25</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>

*Note: Countries are arranged according to the VAT rate, from the lowest to the highest*
Wood fuels and solid fuel heating & cooking appliances in Serbia

One explanation for the dramatic increase in pellet consumption is a promotional campaign by domestic producers of pellet furnaces and boilers which supplied customers with the required amount of wood pellets when purchasing their appliances. Later, when pellets became available at solid fuel yards and retail outlets of large distributors, appliance manufacturers were able to stop their pellet supply programmes. With a significant number of pellet appliances operating in households across the country, benefits of using pellets as a source of heat became ever more clear to consumers, leading to strong demand for appliances (see also section 3.3.2). There are sufficient quantities of wood pellets available to consumers in different parts of Serbia.

High consumption of wood pellets on the national market has also resulted in a dramatic drop in exports. In 2016, the share of export was 28.4% of the produced amount, while it stood at just over 60% in 2013.

The extent of the export of wood pellets should be viewed as critical since it is a low carbon fuel while Serbia imports large amounts of fossil fuels, primarily natural gas. It is instructive to analyse this situation in more detail.

In the decade 2006–2016, approximately 534,166 tons of wood pellets were exported from Serbia, which corresponds to 2.51 billion kWh of low carbon energy\(^{13}\). According to the author’s calculations, in the year 2016 alone the amount was 417.7 million kWh at an average price of USD 0.0313 per kWh (Figure 12).

![Figure 12 – Export of low carbon energy from Serbia through the export of wood pellets with average export price of 1 kWh](image)

\(^{13}\) calculation is based on the standard energy content of wood pellets (4,8 kWh/kg)  
\(^{14}\) Source: calculations by Glavonjic, 2014
The average price of 1 kWh of energy from wood pellets exported from Serbia was around USD 0.02-0.044 for the period 2006-2016\textsuperscript{15}, which is significantly lower than the cost of 1 kWh of energy from natural gas which was imported into Serbia in the same period.

Heat produced from natural gas in Serbia in the period 2006-2015 was 2.1 times as expensive as the estimated cost of heat from exported pellets in 2015 and as high as 3.2 times as expensive in 2007.

If the 2.51 billion kWh energy exported from Serbia in the form of wood pellets was used to replace 271.7 million m\textsuperscript{3} of imported natural gas, Serbia could realise a saving of USD 23.1 million.

Effectively, the practice of exporting low carbon energy and importing fossil fuel constitutes a “giving up” of CO\textsubscript{2} savings of approximately 350,000 tons of CO\textsubscript{2}e for the period 2006-2016 (cumulative), and that at a net cost to the Serbian economy. The CO\textsubscript{2}e savings are instead realised by the countries importing pellets.

2.3.3 Wood briquette consumption

With over 80\% of total consumption, households are the most significant consumer segment of wood briquettes in Serbia. Surveys show that households generally buy 3-4 tons of briquettes for the heating season, with a few purchasing significantly higher quantities (7-8 tons).

Demand for wood briquettes by households had a positive trend until 2012, when it started to decline slowly throughout the period 2012-2016 due to households switching to wood pellets.

Wood briquettes are increasingly used by bakeries for the production of bread. With their non-seasonal steady demand, they are the most favoured buyer for the briquette producers, especially for those producing 500-1,000 tons annually. The increase in demand from bakeries compensated the decline in demand for wood briquettes from households, and the continuity in demand means that they are being offered very competitive prices of up to 20\% lower than pellet prices.

One of the three large wood briquette producers supplies several heating stations in large buildings that are run by Belgrade’s district heating operator (Image 8), while other factories distribute briquettes via their retail outlets throughout Serbia and export a modest quantity as well.

\textsuperscript{15} calculations are based on data from the Statistical Office of the Republic of Serbia
Rapid increase of wood pellet consumption led to a fall of consumption of wood briquettes. In 2016 less than 15,000 tons of wood briquettes were consumed compared to 23,000 tons in 2012.

2.3.4 Charcoal consumption

The charcoal market in Serbia is growing due to both increased local consumption as well as export. Besides households, the biggest consumers of charcoal are grills and butchers, the latter offering the free and immediate grilling of meat purchases, which is a very popular service in a country that takes great pride in its barbecued food.

Statistics on the consumption of charcoal are not collected but estimated to be the range of 18,000 to 20,000 tons annually.

2.3.5 Wood chip consumption

Consumption of wood chips on the national market increased dramatically in the period 2009-2012, mainly triggered by demand from wood pellet production. The majority of wood chips during this period was used to satisfy raw material requirements of pellet mills. Particle board producers also ramped up their demand, leading to a rapid increase of wood chip prices.

In 2012, foreign traders entered the Serbian market, starting negotiations with domestic wood chip producers about exporting wood chips. This further strengthened chip producers’ negotiating position. At the end of 2012, wood chip producers demanded significantly higher prices from domestic pellet mills and particle board producers for shipments in 2013. Neither the largest wood pellet nor particle board producers accepted these terms and instead started procuring firewood and long-length round wood to satisfy their raw material demand. Their switch away from wood chips to firewood and long-length round wood continued into 2016 to the extent that pellet producers now rarely purchase wood chips on the market.

16 Photo credit Savic, 2011
With the difficulties in the export market discussed in section 2.2.5, wood chip producers struck new deals with particle board producers, who in 2016 constituted the most significant consumers of wood chips in Serbia.

Industrial companies outside the wood sector (for example juice factories, Image 9) are increasingly using wood chips for the production of thermal energy for industrial purposes and for heating, effectively switching from other fuels. Anecdotally, this has led some of them to reduce their energy costs 7 times, and further increase in demand by these types of consumers is to be expected in the future.

Image 9 – Example of using wood chips and fruit residues in a factory for juice production

Technical support by the GIZ DKTI programme’s project development component provided to municipalities across Serbia has contributed to movement in the wood fuels market. In March 2017, the first public private partnership contract for the delivery of heat was signed by the municipality of Pirot. The project is in the process of implementation, and delivery of heat from wood chips using boilers with an installed capacity of 2MW in off-grid public buildings is expected for the 2017/2018 heating season. It is expected that the innovative PPP-ESCO financing model of the project, once implemented in Pirot, will serve as show case to other municipalities and present practical solutions to common obstacles to such projects.

Additionally, the Municipality of Priboj used its own funds to invest in a new 0.9 MW wood chip boiler to heat 5 off-grid public buildings, which started operation in November 2016. Supported by the GIZ DKTI Programme, a second project in Priboj focuses on taking 7 public buildings off grid from their current heavy fuel oil fired central heat source and install two wood chip boilers of a total of 2 MW and a wood pellet boiler of 0.2 MW.

The implementation of these projects in Pirot and Priboj will create additional demand for wood chips and wood pellets with the associated creation of jobs in these municipalities.

Furthermore, about 15 municipalities and private investors are currently planning establish district heating systems based on wood chips, out of which four are planning a combined heat and power

17 Photo credit: Glavonjić, 2015
plant (CHP), the remaining heat only boilers (HoB). The expected rise in demand of wood chips for 2018 is 90,000 tons and for 2019 an additional 70,000 tons. The expected sources for these wood chips are forest residues, wood processing residues and roadside vegetation.

2.4 Prices of wood fuels

2.4.1 Firewood

The price of firewood varies depending on the type of seller and the format in which it is sold. The state enterprises managing public forest sell firewood of Class I beech for 35.5 – 44.1 EUR/stacked m³ (including VAT at 10%\(^1\)) at the forest road, depending on location. The price of firewood from state forests has increased 19.1-21.5% from 2014 to 2016.

Prices of firewood in cities brought directly to end consumers (households) by traders with lorries are higher than the prices paid on the forest road and range from 33-43 EUR/stacked m³, including transport to the consumer’s place of residence. The service of cutting meter wood costs an additional 2 EUR per stacked m3. In smaller towns in South-western and Western Serbia, the prices of firewood range from 33-37 EUR/stacked m³ and in the larger cities (Beograd, Novi Sad, Kragujevac and Niš) the prices are up to 43 EUR/stacked m³. Beside meter firewood, consumers are also offered split wood of 33cm in length at prices of 38-49 EUR/stacked m³.

2.4.2 Wood pellets

Wood pellets are usually packaged in bags of 15kg. For commercial users, packaged units of 1.1 tonnes are common. Prices range between €190-€210/tonne in spring, with variations depending on producer and quality.

The price of wood pellets in Serbia can fluctuate significantly depending on the weather as illustrated by the extreme cold snap in the 2016-2017 winter. In October 2016, the wood pellet price ranged from 188-244 EUR/ton, with some lower quality pellets selling at 180 EUR/ton. However, due to extremely cold days in the period December 2016 - January 2017, many households exhausted the stocks they had prepared for the entire heating season, leading to a sharp increase in demand in the second half of January 2017. As a consequence, a temporary shortage of wood pellets occurred, which led to a rapid increase in price. In the second half of January 2017, retail prices leapt to 270-305 EUR/ton. Not even the emergency import of pellets from Romania could mitigate the hike in prices. However, demand decelerated with the increase of daily temperatures in the first half of February, and prices of wood pellets started to drop. By early April 2017, prices were in the range 190-205 EUR/ton.

2.4.3 Wood briquettes

Wood briquettes are predominantly packed in boxes of 15 kg and retail at 1.5 EUR/box or 0.1 EUR/kg ex works\(^1\). Some producers pack wood briquettes in sacks of 35 kg which are sold at price of 3.3

---

\(^1\) VAT for firewood in Serbia is 10%. Together with several other products (bread, milk, etc.), firewood falls into category of products which have social character and to which the lower VAT basis is calculated, while for all other products the VAT is 20%.

\(^1\) prices without VAT at the producer’s premises
EUR/sack or 0.09 EUR/kg ex works. Larger quantities can be bought at a price of 113-164 EUR/ton including VAT.

Wood briquettes are generally sold locally as transport costs would erode profit margins due to the relatively low energy density of the product (e.g. compared to pellets, for which transport can be economically feasible).

2.4.4 Charcoal

Charcoal prices are relatively low compared to the European market and range from 0.55-0.65 EUR/kg depending on the distributor.

2.4.5 Summary

An overview of the retail prices faced by private/household consumers for different types of fuel used in households in Serbia is provided in Table 2 below. Notably, prices for wood pellets are higher than those for pellets exported in bulk which have been used for the calculation in section 2.3.2.

<table>
<thead>
<tr>
<th>Type of fuel</th>
<th>Measurement unit</th>
<th>Price in €/measurement unit</th>
<th>Energy value in kWh/ measurement unit</th>
<th>Price in €/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuelwood in length of 1 m</td>
<td>€/stacked m$^3$ (M=30%)</td>
<td>33-37 (C. Serbia) 42-43(Vojvodina)</td>
<td>1,840</td>
<td>0,018-0,020 0,022-0,024</td>
</tr>
<tr>
<td>Split logs in length of 33 cm</td>
<td>€/stacked m$^3$ (M=30%)</td>
<td>38-49</td>
<td>1,840</td>
<td>0,021-0,027</td>
</tr>
<tr>
<td>Solid wood briquettes</td>
<td>€/ton</td>
<td>113-164</td>
<td>4,600</td>
<td>0,024-0,036</td>
</tr>
<tr>
<td>Wood pellets</td>
<td>€/ton</td>
<td>188-244</td>
<td>4,900</td>
<td>0,038-0,049</td>
</tr>
<tr>
<td>Charcoal</td>
<td>€/kg</td>
<td>0,55-0,65</td>
<td>7.2</td>
<td>0,076-0,090</td>
</tr>
<tr>
<td>Coal Banovići</td>
<td>€/ton</td>
<td>112-134</td>
<td>5,140</td>
<td>0,022-0,026</td>
</tr>
<tr>
<td>Coal Pljevlja</td>
<td>€/ton</td>
<td>101-112</td>
<td>3,750</td>
<td>0,027-0,030</td>
</tr>
<tr>
<td>Coal Kolubara (lignite dry)</td>
<td>€/ton</td>
<td>97-108</td>
<td>4,580</td>
<td>0,021-0,024</td>
</tr>
<tr>
<td>Gas</td>
<td>€/normal m$^3$</td>
<td>0,33-0,40</td>
<td>9.53</td>
<td>0,035-0,042</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>€/liter</td>
<td>1,35</td>
<td>9.79</td>
<td>0,14</td>
</tr>
<tr>
<td>Electric energy (average for blue and red zone)</td>
<td>€/kWh</td>
<td>0,08</td>
<td>1</td>
<td>0,08</td>
</tr>
</tbody>
</table>

Sources: Distributers of solid fuels in Belgrade, Novi Sad, Temerin, Pančevo, Ćuprija, Kruševac, Užice, Elektroprivreda Srbije, gas distributers, petrol stations. For the calculation of costs of electric energy, the average price of day and night was taken for households with two-tariff meters, assuming heating of thermal accumulation heaters overnight.

---

20 wood chips are not commonly used in private households
21 in Serbia, households receive a minimum amount of electricity at a lower price, with anything consumed above that threshold charged at a higher price per kWh

Under contract by GIZ DKTI “Development of a Sustainable Bioenergy Market in Serbia”
There was a slight increase of the prices of almost all wood fuel types between 2014 and 2016. Firewood remained the cheapest fuel for heating, apart from firewood from state forests, for which prices significantly increased due to its high consumption by pellet and panel producers.

2.5 Quality issues for wood fuels on the Serbian market

Variable wood fuel quality is a key issue that affects further development of the market. As such, this study has focused on identifying the most frequent problems relating to the quality of wood fuels. Also, given the rapid increase in their consumption in recent years, this study has also focused on exploring the quality of wood pellets through sampling and testing. Regrettably, the increase in production and export of wood pellets from Serbia is not accompanied by sufficient improvement of quality among all producers. Low quality pellets can cause serious problems to furnaces and boilers during combustion. As of November 2016, only 5 producers in Serbia had their pellets EN Plus certified, with all other producers evidencing quality aspects of their pellets through tests by national or international laboratories, but outside of voluntary standards. The main issue with this practice of obtaining quality characteristics without following one of the available European voluntary standards is that neither sampling nor test procedures are standardised and followed through, thus delivering results that are neither specific nor comparable. In addition to this, often these tests are not repeated for several years, which renders their validity nil.

The quality of firewood sold depends on four main factors:

- Moisture content
- Length/dimensions
- Wood species
- Health condition of wood (e.g. rot)

When purchasing firewood, most Serbian consumers pay the greatest attention to the physical appearance of cleft short logs and round billets as well as the wood species. Few consumers pay attention to the moisture content and size of the logs, even though these two parameters are the key quality aspects. The pervasive problem of high moisture content is discussed in this chapter, with the appendices to this report discussing in more detail other aspects of quality. The most frequent quality issue for firewood is an unsatisfactorily high moisture content which reduces its efficiency as a fuel. According to the standard SRPS EN ISO 17225-5:2015, quality classes of firewood exclusively depend on moisture content of the wood. The moisture content in the firewood offered on the market mostly depends on the characteristics of the supply chain and therefore the situation differs from town to town.

Since wood fuels need time to season between harvesting and combustion, it is pertinent to consider whether demand is being anticipated by vendors, in order that they sell fuels that have sufficiently seasoned with the required moisture content. The evidence suggests that this is not a consideration at all and that well-seasoned wood is rarely being sold.

The most intensive sales period for firewood has historically been August-October\textsuperscript{22}, and yard owners tend to increase stocks over this period to meet the additional demand. In recent years firewood has

\textsuperscript{22} For example, 80-85% of the total annual amount of firewood sold on one firewood yard was sold in the period August-October
been increasingly purchased in smaller amounts during the heating season. Thus yards tend to have firewood on offer during the heating season as well. In big consumer centres, yards selling wood fuels are typically well stocked and have them on offer all year round. Wood yard owners tend to have on site sufficient firewood for a typical month ahead. If demand spikes and the yard’s supplier cannot quickly meet that demand, occasional shortfalls occur. In such cases, yard owners record waiting lists of consumers with the required amounts and as soon the suppliers deliver firewood these consumers have the priority for delivery.

Given the modus operandi of wood yards and the common short notice procurement periods of firewood, most yards offer 2-4 months old green wood as firewood. This has been verified in the analyses during the visits to the yards. Such wood is 2-4 months old, and its moisture content is clearly too high to qualify as high quality firewood.

One of the additional reasons why yards tend to have on offer fresh logged wood is its appearance. Some yards explained that their customers preferred the “prettier” appearance of the green wood, than wood which left to air dry for one year because the air dried wood is much darker and buyers believed it had started rotting and therefore had a lower energy value, a completely incorrect conclusion. Image 10 shows a stack of recently logged wood and a stack of firewood about one year of age.

Due to such attitudes, yard owners typically do not sell properly seasoned, air-dried wood.

In the majority of smaller towns, households are supplied with firewood in several ways:

- From own forests if they have them,
- From firewood sellers who sell wood from their truck,
- From acquaintances or friends who have own forests,
- From smaller yards, if they exist.

Regardless of the supply channel, firewood is sold green with high moisture content in the majority of cases. Few households in the small towns obtain firewood in April and May and store it for air-drying until October. The most significant reasons being:

- habits of the households to obtain firewood a month or two prior to the beginning of the heating season,
- impossibility to store firewood for air-drying on public areas in front of the buildings in which they live,

---

23 Photo credit Glavonjić, 2015
Wood fuels and solid fuel heating & cooking appliances in Serbia

- lack of financial resources to buy the amounts of wood needed for the entire season,
- lack of wood on offer during April and May.

The extent to which this unsatisfactory situation persists can best be seen in the case study researched by the authors for Leskovac, Vlasotince, Užice and Bajina Bašta (see Appendix A). In these towns, support was provided through the component “Improving the efficiency of the use of firewood in households” as part of the GIZ DKTI Programme “Development of a Sustainable Bioenergy Market in Serbia”.

2.6 Regulatory framework

The development of the wood fuels market in Serbia depends to a certain extent on the legislative framework stimulating the use of woody biomass for energy purposes which will, in turn, increase the in-country demand for wood fuels and reduce the exports. This is particularly true for wood pellets. In addition, efficiency of wood-based technologies is also regulated by directives mandating the compliance with relevant EU standards. As such, whilst this study focuses on the markets for wood based heat and cooking in Serbia, it is impossible to avoid reflecting on the existing regulatory framework. A brief overview of existing regulations and key gaps are therefore presented here. A more detailed assessment of the legislative framework was conducted as a separate activity within the ‘Efficient Utilization of Fuelwood in Households’ project and a report is available via the GIZ DKTI programme website.

The use of biomass in Serbia, just as in the EU, is influenced by a multitude of regulations from the fields of agriculture, forestry, energy, environment, waste management and construction. The use of renewable energy sources in Serbia has been officially mentioned within the Serbian regulatory framework when the Energy Law was adopted in 2011. It provided an overall foundation for the development of renewable energy resources and addressed energy efficiency. In addition, in 2010, the Biomass Action Plan was adopted, defining the strategy for biomass utilization as a renewable energy resource. The overall objectives of biomass policy in Serbia can be summarised as follows:

- Efficient use of available resources for the production of energy;
- Reduction of GHG emissions;
- Decrease of import dependence;
- Jobs creation.

The most significant regulations in the field of energy related to energy from RES are the following:

- **Law on Energy adopted in 2011, amended in 2012** – main objectives are provision of a safe, qualitative and reliable supply of energy and energy sources, stimulation of market competition, provision of conditions for promoting energy efficiency in carrying out energy activities and energy consumptions, as well as stimulating the use of renewable energy sources and combined heat and power generation;

- **Energy Sector Development Strategy of the Republic of Serbia by 2015** – main objectives are the technological modernization of the existing energy facilities, the increase in the energy efficiency in the production and usage of energy, as well as the use of new renewable energy sources and construction of new energy infrastructure facilities;

http://www.bioenergy-serbia.rs/index.php/sr/giz-dkti-program
Wood fuels and solid fuel heating & cooking appliances in Serbia

- Implementation Programme of the Energy Sector Development Strategy by 2015 for the period 2007 - 2012 – identifies barriers to wider use of renewable energy, recommending regulatory, policy, institutional, organizational and technical measures to overcome these barriers;
- Law on Efficient Energy Use adopted in 2013 – main objectives are provision and stimulation of responsible, rational, efficient and long term sustainable use of energy. It is envisioned to contribute to increased security of energy supply, enhanced competitiveness of the economy as a whole and living standards or citizens and decreased negative impact of the Energy Sector on the environment;
- National Sustainable Development Strategy.

A regulatory framework for defining, testing and monitoring the quality of wood fuels does not exist in Serbia. In the practice of firewood sale, only public enterprises and national parks apply the criteria for classifying firewood into I and II quality class, pursuant to the provisions of the old JUS standard from 1984 which ceased to be valid with the adoption of the new European standards. Concerning firewood production and selling by private entrepreneurs, examples of firewood classification are rare; it is mostly sold as firewood pursuant to the principle “bought as seen”.

Production and quality of other wood fuels depend exclusively on the approach, equipment, wish and need of the producers to monitor the quality of the fuels they produce. The only exception are the producers of wood pellets who have certified their production pursuant to the provisions of the EN plus standard according to which they have the obligation to perform constant monitoring of certain quality parameters of the pellets they produce. Other producers who do not possess the EN plus certificate do not have this obligation. Some of these producers may have a certificate for pellet quality issued by a national laboratory which performs the testing of wood fuels. It is very rare for producers to test the quality of wood briquettes, wood chips and charcoal products.

Most producers of wood fuels are not familiar with the fact that 37 European standards on wood fuels, their testing methods and quality parameters were translated into Serbian in the period 2012-2016, as part of the GIZ DKTI programme, and adopted at the Institute for Standardization. The list of all translated standards is provided in Appendix A. This starting point is created to fully regulate the area of quality control of wood fuels offered on the Serbian market so that end consumers are sure that they are protected against the offer of low quality fuels.

Regulation of wood fuel quality is in the interest of all those producers who have already established systems for quality controlling the wood fuels they produce.

In addition to the need to regulate the system for the quality control of wood fuels, there is also a need to regulate the system for controlling dimensions or packaging in which certain types of wood fuels are delivered and sold.

In order to address the quality issues mentioned in this chapter, the GIZ DKTI programme produced a Draft Rulebook on Technical and Other Requirements for Wood Fuels. This defined the procedures for
testing quality and properly sizing wood. The draft Rulebook is harmonized with the Law on Technical Requirements for Products and Conformity Assessment (Official Gazette of RS, No. 36/09).

Forestry regulations need to be amended in a similar way in relation to the use of wood residue originating from logging and wood assortments production.

2.7 Key issues and policy recommendations

The pressure on forest resources in Serbia is strong and the competition among the participants on the woody biomass market is increasingly tough. This is reflected in the increasing prices of forestry biomass and wood residues from sawmills. To achieve a more dynamic wood fuel market in Serbia, measures are required to further stimulate the use heat generation from renewable sources. This would largely contribute to strengthening demand for wood fuels in Serbia and reducing exports, especially in case of wood pellets.

With rising demand for firewood expected from pellet producers (see also section 2.3.2), particle board producers and potential switch to firewood by households currently heating with other fuels, pressure on forest management is likely to increase over the coming years. It is essential that firewood is consumed as efficiently as possible by households and other consumers, and that forestry practices are implemented to allow for sustainable wood harvesting from Serbian Forests.

As described earlier, the average consumption of firewood in Serbia was 7.3 m$^3$ in 2010 (12.3 % more than in Slovenia [1] and 32.7% more than Montenegro[18]). This illustrates that the efficiency of firewood use in households in Serbia is alarmingly low. This problem should be dealt with in a serious and systematic manner and as soon as possible.

The table below summarises the key issues in the wood fuels markets and our recommendations for how policy can help address these market imperfections.

---

25 A similar rulebook exists in Serbia for liquid fuels of oil origin and has been valid since December 2015.
Table 3 – Recommendations for realising a sustainable market for wood fuels in Serbia

<table>
<thead>
<tr>
<th>Issue</th>
<th>Causes</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Unregistered firewood harvesting in private forests</td>
<td>Rising demand for firewood from pellet producers, particle board producers and domestic users</td>
<td>▪ Improve the logging control system in Serbian forests</td>
</tr>
</tbody>
</table>
| 2 High levels of consumption of firewood by domestic users          | Use of wood with high moisture content.                                  | ▪ Development of technical regulations that set rules, control principles, inspection mechanisms and complaints procedures, which firewood producers and distributors would have to abide by. If the regulation set out the minimum quality requirements of fuel wood, market inspection could be initiated, and consumers would be able to hold suppliers to account.  
▪ Identification of possibilities to enable urban households to store firewood adequately for the time periods required for seasoning, e.g. creation of shared secure storage facilities.  
▪ Support of the formation of Biomass Logistics & Trade Centres that are able to sell seasoned wood                                        |
| 3 Variable quality of wood pellets                                  | Lack of technical regulations that align with EN standards             | ▪ Adoption of technical regulations in Serbia making application of adequate EN standards obligatory  
▪ Educate consumers                                                                                                                                                                                   |
| 5 Unrealised potential for the use of wood fuels                     | Causes vary in the different segments but generally fall in the categories of:  
▪ Inefficient & unsustainable supply chains of raw material  
▪ Processing & quality issues (both for fuels and appliances)  
▪ end user understanding and technical knowledge  
▪ lack of structured policy support | ▪ Technical regulations regulating quality of pellets and appliances  
▪ Adoption of standards for certification of stoves  
▪ Increase national administrative, technical and legal capacities for verification and certification  
▪ Facilitate co-operation between testing laboratories and between labs and industry  
▪ Promote utilisation of wood pellets  
▪ Eliminate implicit and explicit fossil fuel subsidies  
▪ Increase capacity building in biomass combustion in technical professionals  
▪ Support the formation of sustainable biomass supply chains  
▪ Educate domestic users of wood fuels about its correct use |

26 GIZ DKTI Programme has supported relevant ministries in the transposition of the Construction Product Regulation, which will introduce basic standards for household wood fired appliances  
27 In the period 2013-2017, 37 ISO EN standards were translated into Serbian within the GIZ DKTI Programme. Additionally, within the same programme, capacity was built in the biggest national laboratory for testing the quality of wood fuels. As such the groundwork is now in place for the preparation, adoption and implementation of the first technical regulation for wood fuels in Serbia.
3 Market for solid fuels heating & cooking appliances in Serbia

3.1 Supply chain of wood fuel appliances

3.1.1 Overview

Figure 13 illustrates the supply chain for wood fuel appliances in Serbia, divided into the five main segments of production, distribution, retail, customer service and consumption. The image does not convey the number of players in each part of the chain, but presents an overview of the ways in which end-consumers are serviced. Essentially, while manufacturers have some links to supply commercial and public users of solid fuel appliances directly, most products are sold through retail outlets which are stocked directly by manufacturers or a variety of distributors as intermediaries. Customer service (pre and after sale) is provided by Serbian manufacturers or distributors themselves, but most commonly by installers and maintenance providers, which are often SMEs.

The main characteristics of the wood fuel heating appliances supply chain in Serbia can be summarized as follows:

- Fragmented at consumer and retailer level, with more consolidation upstream at the distributor and manufacturer levels.
- Highly fragmented at the level of service providers with hundreds of small or micro businesses spread across the country offering installation and maintenance services. Some of them are certified by manufacturers and their contacts are available to end-consumers through manufacturers or retailers.
- Downstream vertical integration has occurred in Serbia in several different ways:
Wood fuels and solid fuel heating & cooking appliances in Serbia

- Manufacturers of heating and cooking appliances operate a small number of outlets and provide advisory, installation and maintenance services, as well as after-sale support;
- Distributors of appliances and spare parts operate retail networks;
- Distributors/importers of wood-based technologies establish and coordinate service networks for foreign based manufacturers not physically present in the country;
- Foreign manufacturers with subsidiaries or representative offices in Serbia develop their own networks of certified installers as a way to position themselves on the market;
- Foreign manufacturers without representative offices in Serbia work closely either with one of the big 6 distributors or directly with small distributors/importers offering advisory, installation and maintenance services.

The strong seasonality of the demand pattern makes the organization of appliance manufacture, transport and storage challenging. Also, efficiency can only be achieved through the necessary skills and capabilities along the supply chain – the current lack of skills has led to market imperfections. As a consequence, a large number of intermediaries are needed to provide e.g. financing of operating cash flow, consolidating inventories, and providing support services, from pre-sale advisory to after-sale support.

Sales are facilitated by proximity of manufacturers to the end-consumer. Based on the interviews conducted with distributors, retailers, manufacturers and services providers, it is evident that the decision-making process at the level of households is significantly influenced by independent installers and service providers. This often leads to sub-optimal solutions for end-consumers, since independent service providers do not always have information about the latest technologies and solutions available. Another important element for manufacturers’ brand building is swift reaction to consumer complaints, which ensures positive referrals. Therefore, manufacturers tend to organize their own networks of installers/maintenance teams, as well as networks of certified service providers (SMEs across the country providing the service of installation and maintenance) in order to ensure representation in geographically remote areas. This set-up not only allows manufacturers to keep better control, educate installers about new products and offer after-sale services through these networks, but also lets them collect feedback from end-consumers.

In the commercial or public segment customized solutions for larger buildings require project design based on the requirements of that specific customer and are thus likely to be handled more directly by manufacturers.

### 3.1.2 Key actors in the supply chain

The size and position of an actor in the solid biofuel appliance supply chain depends on several factors:

- Functional capabilities
- Access to retail network
- Access to service providers network
- Investment capability
- Differentiation of products for specific market segments (e.g. households, institutions)
Key stakeholders playing an active role and fulfilling either physical and/or market mediation functions of the supply chain can be grouped as follows:

- Appliance manufacturers
- Distributors/importers
- Retailers
- Installers
- Providers of maintenance services (usually provide advisory, installation and maintenance services to end-consumers)
- Accredited laboratories (as part of the supporting, quality infrastructure)
- Chimney sweeps
- Wood fuel producers
- Wood fuel suppliers
- Biomass traders and retailers
- Component/parts suppliers

It is common for actors in the supply chain to fulfil more than one function.

3.1.3 Role and interaction of supply chain actors

Many actors are integrated vertically along the supply chain, controlling processes that are part of several segments and thus capture more value.

Local manufacturers operate retail outlets in their home cities and in one or two large cities. They also have technical support departments where a combination of technicians and call centres provide not only installation but after-sales service and maintenance to consumers, or they have established networks of officially certified SME service providers across the country. However, manufacturers have not always fully identified the demands of the different market segments and developed efficient processes to ensure access to the market segments with highest potential for growth, leading to unfulfilled demand during peaks. Also, due to the seasonal character of demand and urgency in case of malfunction, service teams are often overwhelmed and struggle to react in a timely manner. Response time is critical, especially during the heating season, and a rapid response is seen as a key competitive advantage.

Distributors identified the demand for efficient service and distribution networks and have invested heavily in development of capabilities along the chain, in particular purchase, customer support, sales and HR development. The active inventory management of parts and components according to seasonal demand patterns allows distributors to flexibly service end-consumers.

Foreign manufacturers with representative offices in Serbia also tend to develop their networks of certified installers and service producers. End-users can choose from the list of certified SMEs offering the service of installation of heating systems as well as maintenance. Exclusive distributors of imported solid biofuel technologies organize and manage the service networks for foreign and, in some cases, local manufacturers.

When a stakeholder in this supply chain develops capabilities to play several roles within the chain, their profit margins improve and competitive advantages are created. However, often engaging in activities too far outside of the core business is seen to lead to inefficient and low-quality services due to a lack of required capabilities. An additional challenge in this market in Serbia is the lack of
readily available data and information flow along the supply chain, which leads to market imperfections such as flawed pricing mechanisms and informational asymmetries.

3.2 Quality and regulation of solid fuel appliances

3.2.1 Lack of regulation of appliances in Serbia

Currently, no regulation is in force that determines quality characteristics of solid fuel appliances for heating and cooking in Serbia. Consequently it is not possible to gather reliable data on the performance of appliances found on the local market in terms of emissions or efficiency and equally it is not possible to observe any trends in improvement of the quality of appliances sold. Some devices are alleged to have undergone type testing as defined by harmonised standards (see sections 3.2.2 and 3.5.1) that are part of EU commercial policy, while other appliances found on the local market do not obviously adhere to quality standards. Air quality and human health, protection of natural resources, and the competitive development of the Serbian market for solid fuel appliances urgently require policy that encourages the production and sale of safe and clean devices.

As part of the project’s activities, 5 randomly selected new wood-fired appliances typically used in Serbia were sent to the Technical University of Hamburg in Germany for testing according to the EN norms required under EU commercial policy for testing procedures and benchmarking against the values for airborne emissions (CO and PM) required by the Bundesimmissionsschutzverordnung, BImSchV in Germany.

None of the combustion devices tested fulfilled these demands, thus falling short of the state of technology available on the European market. The devices could be improved through better design and control devices, employing mature and widely available technical knowledge.

One important approach to bridging the technological discrepancy between available devices on the Serbian market and European state of the art technology is the introduction of regulation that sets clear requirements for test procedures as well as emissions limits for different pollutants from these devices, coupled with the necessary market surveillance.

As part of the GIZ DKTI programme, policy makers have been encouraged to consider policy that would put the Serbian market on par with the EU market. Key policies that were recommended for adoption are described in sections 3.2.2 and 3.2.3, and give an overview of the minimum quality requirements for solid fuel appliances.

It is also necessary to support the development of key infrastructure, such as accredited national laboratories and quality testing systems for appliances in accordance with EN standards.

In this respect, the GIZ DKTI programme has supported gap analyses of local laboratories and financed capacity building of their staff towards achieving the additional accreditation necessary to test according to the relevant EN standards.

3.2.2 EU commercial policy

To ensure the functioning of the EU common market, the EU defines testing standards for different types of products that any Member State has to adhere to. As a general principle, manufacturers or, if manufacturers do not have any direct activities in the EU, importers, need to certify their products’
conformity to European Norms (EN). Beyond the technical standards, additional requirements are set through EU Regulations for specific product groups.

Regulation (EU) No 305/2011 lays down harmonised conditions for the marketing of construction products. It lays out the principles regarding performance requirements of construction products and the conditions for CE markings and proofs of conformity. Space heating appliances are one of the 35 product areas named in Annex IV of this Regulation.

The regulation required that the following harmonised standards must be fulfilled for these products28:

- EN 13229 Inset appliances including open fires fired by solid fuels
- EN 13240 Room heaters fired by solid fuel
- EN 14785 Residential space heating appliances fired by wood pellets
- EN 12809 Residential independent boilers fired by solid fuel.
- EN 12815 Residential cookers fired by solid fuel

These standards lay out test methods for these types of devices and details can be found in Appendix I.

The Construction Product Regulation is currently being transposed by the Serbian government, a process that has been largely welcomed especially by large and medium-sized manufacturers during interviews for this report, but has shown very slow progress with long delays.

3.2.3 EU energy-related appliances policy: Ecodesign

The Ecodesign Directive (2009/125/EC) and the Energy Labelling Directive (2010/30/EC) set the framework for the requirement for energy related products to be put on the European market. These Directives have the double objective of helping to meet the EU’s 2020 Energy Efficiency Targets and to harmonise market conditions for energy related products in the EU, hence increasing competitiveness and removing market barriers.

The Ecodesign Directive, among other things has the following purpose:

- To regulate new products being placed on the market or put into service, i.e. no retroactivity
- To require manufacturers or importers to issue a declaration of conformity and affix a CE marking
- To require Member States to name a body responsible for implementation and market surveillance

The actual technical standards that products need to fulfil, however, are set in specific Regulations applicable to individual product categories. Given that Regulations, in contrast to Directives, have to be applied in their entirety in national legislation, this ensures that the technical standards are common to all Member States.

For wood-biomass devices, two product categories, or lots, are relevant: Lot 15, solid fuel boilers, and lot 20, solid fuel local space heaters. The Ecodesign directive sets limits for their emissions and efficiency.

Wood fuels and solid fuel heating & cooking appliances in Serbia

The Ecodesign directive for lots 15 and 20 will come into force in 2020 in EU Member States and its transposition process and timeline in Serbia is currently unclear. However, given its stringent requirements regarding efficiency and emissions, the export-oriented manufacturers in Serbia are planning steps to reach these standards and continue with the production of solid fuel heating appliances. It is highly recommended for Serbian ministries to engage with manufacturers to understand the needs of the industry in detail and to support them in this endeavour.

3.3 Production of solid fuel heating appliances in Serbia

The production of solid fuel heating and cooking appliances in Serbia has a long tradition, starting from the 1920s. Originally founded as craft workshops, some manufacturers are now large companies, parts of various national and international holdings in the field of production and distribution of heating and cooking appliances. Several large and medium sized domestic manufacturers have secured their position in this industry through strong brand management, increasing production capacity, certified quality of some products according to international standards and the adoption of quality management systems in compliance with international and national standards.

3.3.1 Structure & size of the supply side of the market

There are 18 manufacturers on the market that can be roughly divided into the following categories:

<table>
<thead>
<tr>
<th>Company size</th>
<th>Production (units/year)</th>
<th>Number of employees</th>
<th>Number of companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>&gt; 65,000</td>
<td>&gt; 350</td>
<td>2</td>
</tr>
<tr>
<td>Medium</td>
<td>11,000 – 65,000</td>
<td>100 – 350</td>
<td>2</td>
</tr>
<tr>
<td>Small</td>
<td>2,700 – 11,000</td>
<td>30 – 100</td>
<td>5</td>
</tr>
<tr>
<td>Micro</td>
<td>&lt; 2,700</td>
<td>&lt; 30</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 4 – Structure of supply side of solid fuel appliances market in Serbia

Over the three years of project activity, domestic production of appliances has shown a steady increase, coming to well above a quarter of a million units in 2015 (see Figure 14).

Figure 14 – 2013-2015 production of solid fuel appliances in Serbia

An important feature of the market is the pronounced dominance of the four large and medium-sized manufacturers who constitute 88% of the annual production in 2015 (the largest part
attributed to the two large producers), with the remaining 14 players producing the remainder 12% (see Figure 15)

![Figure 15 - Distribution of production among large & medium, small and micro producers in 2015](Image 15)

An insight gained from interviews with manufacturers is that many of them are increasingly focus on the export market (EU and RoW), higher quality appliances, technologically more advanced units such as pellet burners and boilers, and thus are improving their margins while in some cases the number of produced units remains relatively constant over the period examined.

These efforts require a focus on technological modernisation and R&D, supported by a modest increase in the number of skilled employees. This trend is largely driven by the efficiency and emissions standards that have to be met when exporting appliances to EU Member States, and a notable demand for related testing services in Serbia has been registered.

![Image 11 – Production plant of a medium-sized company](Image 11)

3.3.2 Product innovation

In 2005, the first wood pellet stove was produced in Serbia and initiated a growing interest in and development of different models of stoves, boilers and burners fueled by wood pellets have been continuously developed. Figure 16 shows the growing share of pellet fired units in the mix of solid

---

29 Note that due to the need to comply with confidentiality requests it was necessary to group large and medium sized enterprises for this graph

30 Photo credit: Glavonjić, 2014
fuel appliances produced in Serbia. Using the data obtained from five major manufacturers, the production of pellet fired appliances increased by just over 60% between 2013 and 2015. In interviews, manufacturers also confirmed a very strong and growing demand for pellet fired devices for the domestic market in 2016.

![Graph showing production of pellet fired appliances](image)

**Figure 16 – Share of pellet fired units in production of 5 of the largest producers in Serbia**

When conservatively comparing the production of pellet fired units of these five producers to total national production of solid fuel appliances, a rise in the share of production from 5% in 2013 to 7% in 2015 is observed.

This more recent development in production of pellet fired technology is testament to Serbian solid fuel appliances manufacturers’ investment in R&D to maintain relevance. Currently the wide range of products shown in Image 12 is manufactured and sold in Serbia by large and medium sized companies.

---

**Solid fuels burning cookers for heating and cooking**

**Solid fuels burning fireplaces for heating**

**Solid fuels burning cookers for central heating**

**Pellet burning stoves**

---

31 Note that data for pellet fired units was provided by 5 companies and are compared to the same companies’ total output, not total national production.
Wood fuels and solid fuel heating & cooking appliances in Serbia

Increasingly, medium-sized and the larger companies in the “small” category are focusing on pellet-based technologies and primarily target export markets. In some cases these companies have joint ventures for particular product lines with foreign companies, in other case R&D takes place entirely in-house, and business models are developed to a high level of sophistication.

Small and micro manufacturers focus on residential cookers fired by solid fuel. Those are the appliances whose primary function is to cook and whose secondary function is to provide heat into the space in which they are installed. These appliances may burn either solid mineral fuels, or natural or manufactured wood logs or be multi-fuel in accordance with the appliance manufacturer’s instructions.

3.4 Import and export

Data were provided by the Statistical Office of the Republic of Serbia according to the established import/export categories of products which are “Solid fuel cooking appliances” and “Other solid fuel household appliances” (i.e. space heating appliances). Unfortunately this lack of granularity does not allow for more in-depth analysis of for example burners vs. boilers, or the development of pellet technologies, but Figure 17 and Figure 19 do allow for important insights.

Given a domestic market with cash-strapped households, the export market was cited in all interviews with manufacturers as strategic priority. Even if the year on year time series for exported devices is relatively erratic, Figure 17 nevertheless shows that:

- both number of units and value of cooking devices constitutes about a quarter of the total exported appliances
- overall, exported solid fuel appliances have a positive growth trend over the time period 2009-2016, driven by heating appliances
- the growth trend for value of exported goods is roughly equal to that of units
- when comparing to total production figures for 2015, 54% were exported overall, evidencing the importance of the export market to Serbian manufacturers.

32 Images taken from manufacturers’ catalogues
The main destination countries for exports are other former Yugoslavian countries, notably Bosnia & Herzegovina, Croatia, Montenegro and the Republic of Macedonia (Figure 18). Other important export markets are Germany, Romania and increasingly Hungary, Italy and Poland.

Image 13 shows pellet stoves made in Serbia packed and waiting for export to Italy.

---

33 Source: Statistical office of the Republic of Serbia, Belgrade
34 Source: Statistical office of the Republic of Serbia, Belgrade
Shifting focus to imports, it is immediately evident that the number and value of exported goods are 14 and 15.6 times that of imports respectively. The 2009-2016 time series of imports is presented in Figure 19.

Points to note regarding imports are:

- The sharp drop in value of imported goods in 2013 is not mirrored to the same extent by the drop in units. It is not clear what may have caused this drop.
- The linear trend of the value of imported appliances shows a strong decline, while the value shows a slight increase, pointing to fewer but more expensive devices being imported.

The main origins of imported appliances are Bulgaria, China, Croatia, Republic of Macedonia and Turkey as can be seen in Figure 20.

---

35 Photo credit: Glavonjić, 2014
36 Source: Statistical office of the Republic of Serbia, Belgrade
Apart from some peaks in imports from Bulgaria and China, the different countries of origin’s contributions to imports into Serbia are relatively stable and evenly distributed.

3.5 Quality and performance aspects of Serbian produced solid fuel appliances

3.5.1 Nominal efficiency

Efficiency of appliances is a crucial characteristic as it expresses the amount of useful energy which the appliance transfers to the food to be cooked or emits into the room (or gives over to central heating system) compared to the amount of energy obtained from the combustion of fuel. It is expressed as percentage and ought to be an important factor influencing consumers’ decisions.

Almost all key manufacturers of heating and cooking appliances in Serbia highlight nominal38 efficiency values of their appliances in product catalogues, on their websites and in technical instructions/manuals. An overview of the range of efficiencies stated for products sold in Serbia was compiled in Table 5 based on publically available information. For some types of appliances, the ranges are large, highlighting the importance of educating consumers about the difference this makes for fuel consumption. Generally small and micro-sized manufacturers’ devices have lower stated ranges of efficiencies compared to their large and medium-sized competitors’ products.

Table 5 – Nominal efficiency declarations for different types of heating & cooking appliances manufactured in Serbia39

<table>
<thead>
<tr>
<th>Appliance category</th>
<th>Declared efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid fuels burning cookers for heating and cooking</td>
<td>60-89%</td>
</tr>
<tr>
<td>Solid fuels burning stoves for heating</td>
<td>55-89%</td>
</tr>
</tbody>
</table>

37 Source: Statistical office of the Republic of Serbia, Belgrade
38 Nominal efficiency is efficiency of the device stated by the producer for combusting certain test fuels under set appliance operation conditions.
39 Source: data from manufacturers
Wood fuels and solid fuel heating & cooking appliances in Serbia

As a general observed trend, newer wood pellet appliance generations do have the highest efficiency. An important driver for this development is the combination of regulation and incentive systems for consumers in some EU countries, where most of these appliances are exported to.

While some Serbian manufacturers have their own in-house laboratories to test appliances and support their R&D (see Image 14), most manufacturers rely on university-based or independent laboratories to issue examination reports.

![Image 14 – In-house laboratory](image)

In order to export appliances to the EU common market, it is necessary to obtain the CE marking from a so-called notified body laboratory. These laboratories are located in EU member states, and it is a substantial investment for Serbian manufacturers to have their appliances tested abroad as it involves temporary export processes as well as overnight stays for their engineering teams, etc.

A very important caveat is that nominal efficiency can be significantly higher than that achieved by the device operating in real-life conditions. This is not unique to products from Serbian manufacturers, but a common problem with type testing of appliances in laboratories. The issue was investigated by the project to understand the magnitude and implications in more detail (see

---

40 Photo credit: Glavonjić, 2014
41 indeed the “BeReal” project hosted by the Technology and Support Centre in the Centre of Excellence for Renewable Resources at Straubing in Germany is developing guidance for real-life performance testing http://www.bereal-project.eu/
section 3.5.2). In addition to this, the project randomly selected five popular devices and sent them to a foreign test institute for investigation (see section 3.5.3).

### 3.5.2 In-situ testing of efficiency

As part of the baseline survey in 2014 efficiency measurements of wood-based heating and cooking appliances was conducted in 12 households in the city of Leskovac. 12 different appliances were tested and can be divided into four groups:

- Residential cookers fired by solid fuels up to 10 kW power and years in use ranging between 1-5, 6-15 and over 15 - produced by Milan Blagojevic, Smederevo,
- Residential cookers fired by solid fuels up to 10 kW power and years in use ranging between 1-5, 6-15 and over 15 - produced by Alfa-Plam, Vranje
- Residential cookers fired by solid fuels up to 10 kW power and years in use ranging between 1-5, 6-15 and over 15 – produced by manufacturers other than MBS and Alfa-Plam
- Heating boilers for solid fuels up to 35 kW power and years in use ranging between 1-5 (produced by Sime, Italy), 6-15 (produced by Sukom, Knjazevac, Serbia) and over 15 years (produced by Megal AD, Bujanovac).

A total of 36 measurements were conducted, with each measurement repeated several times to obtain the most representative result. For each measurement the required amount of firewood with different moisture content was provided. This firewood was prepared in the same way for each data point, with moisture content measured beforehand.

Based on test results gathered through numerous measurements per device using firewood with different moisture content, it can be concluded that the level of efficiency of the cookers and the low-power boilers in real-life condition ranges between 20 to 40%.

Efficiency varies primarily with the quality of the firewood (moisture content) and the achieved efficiency values are significantly lower than the values declared by the manufacturer. The average efficiency for all tested cookers in combination with different fuel categories is 32.59%. In comparison, the standard SRPS EN 12815:2012 covering residential cookers fired by solid fuels specifies that the measured total efficiency from the mean of at least two test results at nominal heat output shall be greater than or equal to the manufacturer’s declared value and shall equal or exceed 60%.

### 3.5.3 Testing of efficiency and emissions at foreign laboratory

An additional attempt at understanding the quality of Serbian produced solid fuel heating & cooking appliances was made by selecting five typical appliances (details shown in Image 15, Image 16, Image 13) and sending them to the testing laboratory at TU Hamburg in Germany [21].
Wood fuels and solid fuel heating & cooking appliances in Serbia

<table>
<thead>
<tr>
<th>Device</th>
<th>F1</th>
<th>F2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal thermal capacity</strong></td>
<td>8 kW</td>
<td>21 kW</td>
</tr>
<tr>
<td><strong>Nominal efficiency</strong></td>
<td>86 %</td>
<td>86.1 %</td>
</tr>
<tr>
<td><strong>Max. fuel consumption</strong></td>
<td>1.9 kg/h</td>
<td>5.05 kg/h</td>
</tr>
<tr>
<td><strong>Fuel storage capacity</strong></td>
<td>19 kg</td>
<td>45 kg</td>
</tr>
<tr>
<td><strong>Capacity water tank</strong></td>
<td>-</td>
<td>32 l</td>
</tr>
<tr>
<td><strong>Fuel type</strong></td>
<td>wood pellets</td>
<td>wood pellets</td>
</tr>
<tr>
<td><strong>Boiler</strong></td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td><strong>Standard DIN EN</strong></td>
<td>14 785</td>
<td>14 785</td>
</tr>
</tbody>
</table>

Image 15 – Details of devices F1 and F2, image for illustration only [21]

<table>
<thead>
<tr>
<th>Device</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal thermal capacity</strong></td>
<td>7 kW</td>
<td>8.5 kW</td>
</tr>
<tr>
<td><strong>Nominal efficiency</strong></td>
<td>74 %</td>
<td>85 %</td>
</tr>
<tr>
<td><strong>Max. fuel consumption</strong></td>
<td>-</td>
<td>1.8 kg/h</td>
</tr>
<tr>
<td><strong>Fuel storage capacity</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Capacity water tank</strong></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fuel type</strong></td>
<td>wood logs</td>
<td>wood logs</td>
</tr>
<tr>
<td><strong>Boiler</strong></td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td><strong>Standard DIN EN</strong></td>
<td>12 815</td>
<td>12 815</td>
</tr>
</tbody>
</table>

Image 15 – Details of devices F3 and F4, image for illustration only [21]

<table>
<thead>
<tr>
<th>Device</th>
<th>F5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal thermal capacity</strong></td>
<td>25 kW</td>
</tr>
<tr>
<td><strong>Nominal efficiency</strong></td>
<td>&gt; 85 %</td>
</tr>
<tr>
<td><strong>Max. fuel consumption</strong></td>
<td>-</td>
</tr>
<tr>
<td><strong>Fuel storage capacity</strong></td>
<td>0.09 m³</td>
</tr>
<tr>
<td><strong>Capacity water tank</strong></td>
<td>72 l</td>
</tr>
<tr>
<td><strong>Fuel type</strong></td>
<td>wood logs</td>
</tr>
<tr>
<td><strong>Boiler</strong></td>
<td>yes</td>
</tr>
<tr>
<td><strong>Standard DIN EN</strong></td>
<td>12 809</td>
</tr>
</tbody>
</table>

Image 16 – Details of device F5, image for illustration only [21]

Under contract by GIZ DKT "Development of a Sustainable Bioenergy Market in Serbia"
The mandate was to test the devices according to the applicable EN standards under full and partial load for PM and CO emissions, as well as for energetic efficiency.

As reported by the team at TU Hamburg, key findings of the tests were as follows:

- For all devices, the basic instruction documents for device operation were insufficient and important control variables could not be adjusted by the operator.
- Two of the tested combustion devices did not show technically mature operation and did not reach the stable operating conditions necessary for the full testing procedure. Other devices showed various technical insufficiencies, which means that overall the investigated devices do not reflect the current state of technology available on the European market.
- None of the combustion devices tested fulfils the demands of the German BlmSchV (i.e. they cannot be operated legally in Germany); measured CO- and PM-emissions were too high and the energetic efficiency too low. Both of these parameters could be improved by better design and improved controllers – technical knowledge is readily available.

3.5.4 Implications of results of investigation

The two types of practical investigation of quality have led to a few insights that are relevant for the further development of the solid fuel heating market in Serbia.

- Regardless of the age of the appliance, its stated nominal efficiency or the efficiency it will reach in the laboratory, the key factor influencing efficiency of heat production is the quality of the firewood (or other wood fuel) used. As elaborated at length elsewhere in the report, the key quality factor of firewood is its moisture content – in other words, consumers must be educated about the importance of using wood that has been air dried for a minimum of six months.
- Even appliances that had apparently been type tested according to EN norms did not perform according to expectations in tests by a laboratory that was not involved in the original type testing. This opens up serious questions about the state of appliances produced in Serbia, the institutes responsible for type testing, and more generally the system of testing (which are well beyond the scope of this report).
- Even though the appliances tested in Germany did not perform well, relatively simple technical solutions could be implemented to significantly improve these devices.

Resolving these issues would require:

- policy makers to lay down a legal minimum quality baseline beyond the transposition of the Construction Product Regulation (EU) No 305/2011,
- consumer education about quality of appliances and the benefits of investing in a higher-quality appliance,
- various forms of public-private collaboration to support university engagement in R&D activities of manufacturers,
- subsidised stove/heater renewal schemes, and
- stringent market surveillance.
### 3.6 Key issues and policy recommendations

Table 6 presents the most critical issues impacting the fair competition of solid biofuel technologies’ manufacturers and provides recommendations.

**Table 6 – Ensuring the sustainable development of the market for wood-based technologies**

<table>
<thead>
<tr>
<th>Issue</th>
<th>Causes</th>
<th>Recommendations</th>
</tr>
</thead>
</table>
| 1 Low quality appliances | Manufacturers and importers are not required by law to take absolute responsibility for their products when they sell their products in Serbia. CE marking is not required for placement of products on the domestic market, i.e. products do not meet ‘harmonized’ Euro Norm (EN) standards. | • Urgent transposition of the Construction Product Regulation (EU) No 305/2011 which contains quality assurance processes applicable to space heating appliances verifiable by a set of EN standards  
• Implementation of regulation  
• Market inspection in accordance with regulation  
• consumer education about quality of appliances and the benefits of investing in a higher-quality appliance  
• various forms of public-private collaboration to support university engagement in R&D activities of manufacturers,  
• subsidised stove/heater renewal schemes |
| 2 Unaffordability of high quality devices | Inefficient, low cost devices are being offered at affordable prices. More efficient devices are not as affordable. | • Implementation of Construction Product Regulation to prevent sale of low quality appliances  
• Facilitation of direct incentives such as e.g. subsidies or subsidized loans |
| 4 Non-alignment of interests of different actors | Due to the lack of readily available information, households rely on service providers for gathering information regarding what type of the solid fuel equipment to purchase and install. Rarely, households decide to pay for technical documentation to help them design optimal and efficient solutions. Recommendations are mainly driven by providers’ profit margins and their own know-how, rather than optimization for households. | • Education of decision makers in households  
• Introduction of independent advisory services for households |
<p>| 5 Low investment in R&amp;D | R&amp;D requires relatively high investment and the time frame from product development to placement on the market is large. | • R&amp;D institutions and manufacturers to cooperate and jointly work on the improvement of products |</p>
<table>
<thead>
<tr>
<th>Issue</th>
<th>Causes</th>
<th>Recommendations</th>
</tr>
</thead>
</table>
| 6     | Lack of quality infrastructure | Laboratories not accredited to test based on all applicable EN standards related to solid fuels heating and cooking appliances. | • Accreditation of laboratories to test in accordance with applicable standards  
• Investment in equipment allowing the improved testing of wood-based heating and cooking appliances. |
## Appendix A Applicable EN standards for wood fuels

<table>
<thead>
<tr>
<th>Category</th>
<th>International standards (EN and ISO)</th>
<th>Serbian standards (SRPS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel quality assurance</td>
<td>ISO/NP 17588 - Solid biofuels -- Fuel quality assurance</td>
<td>Init</td>
</tr>
<tr>
<td>Fuel quality assurance</td>
<td>ISO/NP 17589</td>
<td>Solid biofuels -- Conformity assessment for fuel quality assurance</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------</td>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Sample and sample preparation</td>
<td>ISO/NP 18135</td>
<td>Solid biofuels -- Sampling</td>
</tr>
<tr>
<td>Sample and sample preparation</td>
<td>ISO/NP 14780</td>
<td>Solid biofuels -- Sample preparation</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>EN 16127:2012</td>
<td>Solid biofuels – Determination of length and diameter</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>ISO 18122</td>
<td>Solid biofuels -- Determination of ash content</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>ISO/NP 18125</td>
<td>Solid biofuels -- Determination of calorific value</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>ISO 17828</td>
<td>Solid biofuels -- Determination of bulk density</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>ISO/NP 18123</td>
<td>Solid biofuels -- Determination of the content of volatile matter</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>ISO/NP 17827-1</td>
<td>Solid biofuels -- Determination of particle size distribution for uncompressed fuels -- Part 1: Horizontally oscillating screen using sieve for classification of samples with a top aperture of 3.15 mm and above</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>ISO/NP 17831-2</td>
<td>Solid biofuels -- Methods for the determination of mechanical durability of pellets and briquettes -- Part 2: Briquettes</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>ISO/NP 17830</td>
<td>Solid biofuels -- Determination of particle size distribution of disintegrated pellets</td>
</tr>
<tr>
<td>Physical and mechanical properties</td>
<td>ISO/NP 17829</td>
<td>Solid biofuels -- Determination of length and diameter of pellets</td>
</tr>
</tbody>
</table>
### Chemical analysis

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
<th>Status</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO/NP 16948</td>
<td>Solid biofuels -- Determination of the total content of carbon, hydrogen and nitrogen</td>
<td>Publ</td>
<td>SRPS ISO EN 16948:2016</td>
<td>Solid biofuels -- Determination of the total content of carbon, hydrogen and nitrogen</td>
</tr>
<tr>
<td>ISO/NP 16994</td>
<td>Solid biofuels -- Determination of the total content of sulphur and chlorine</td>
<td>Publ</td>
<td>SRPS EN ISO 16994:2016</td>
<td>Solid biofuels -- Determination of the total content of sulphur and chlorine</td>
</tr>
<tr>
<td>ISO/NP 16967</td>
<td>Solid biofuels -- Determination of major elements</td>
<td>Publ</td>
<td>SRPS EN ISO 16967:2016</td>
<td>Solid biofuels -- Determination of major elements</td>
</tr>
<tr>
<td>ISO/NP 16993</td>
<td>Solid biofuels -- Conversion of analytical results from one basis to another</td>
<td>Publ</td>
<td>SRPS ISO EN 16993:2016</td>
<td>Solid biofuels -- Conversion of analytical results from one basis to another</td>
</tr>
</tbody>
</table>

### Sustainability

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
<th>Status</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FprEN 16214-4</td>
<td>Sustainability criteria for the production of biofuels and bioliquids for energy applications - Principles, criteria, indicators and verifiers - Part 4: Calculation methods of the greenhouse gas emission balance using a life cycle analysis approach</td>
<td>Under Approval</td>
<td>SRPS EN 16214-4:2013</td>
<td>Sustainability criteria for the production of biofuels and bioliquids for energy applications - Principles, criteria, indicators and verifiers - Part 4: Calculation methods of the greenhouse gas emission balance using a life cycle analysis approach</td>
</tr>
<tr>
<td>EN 16214-3:2012</td>
<td>Sustainability criteria for the production of biofuels and bioliquids for energy applications - Principles, criteria, indicators and verifiers - Part 3: Biodiversity and environmental aspects related to nature protection purposes</td>
<td>Publ</td>
<td>SRPS EN 16214-3:2014</td>
<td>Sustainability criteria for the production of biofuels and bioliquids for energy applications - Principles, criteria, indicators and verifiers - Part 3: Biodiversity and environmental aspects related to nature protection purposes</td>
</tr>
<tr>
<td>FprEN 16214-2</td>
<td>Sustainability criteria for the production of biofuels and bioliquids for energy applications - Principles, criteria, indicators and verifiers - Part 2: Conformity assessment including chain of custody and mass balance</td>
<td>Under Approval</td>
<td>SRPS CEN/TS 16214-2:2014</td>
<td>Sustainability criteria for the production of biofuels and bioliquids for energy applications - Principles, criteria, indicators and verifiers - Part 2: Conformity assessment including chain of custody and mass balance</td>
</tr>
</tbody>
</table>
Appendix B Case study of firewood supply system for households in Southern & Southwestern Serbia

Research into the characteristics of the firewood supply system for households in the pilot regions42 shows that these are largely informal and vary locally. The details presented here give an overview of the diversity of situations faced by households when procuring firewood, including the challenges.

**Characteristics of the firewood supply system of households in Užice**

According to the results of the household survey43, about 95% of households in Užice use one of the following three supply channels for firewood:

1. Wood traders
   - firewood yards (5%)
   - private forest owners in rural areas who traditionally have their buyers in towns (53%)
2. Household-owned forests (31%)
3. State forests (PE Srbijašume) (6%)

The town of Užice has two registered firewood yards, one of which is located in the municipality Sevojno and the other is near the old landfill site on the road Užice - Lunovo. The firewood and coal yard in Sevojno supplies about 3,000 households annually mostly with wood logs packed on pallets. Beside firewood, this yard also offers coal (Image 17).

![Image 17 – Firewood and coal yard in Sevojno](image-credit-Glavonjić, 2016)

Firewood can be purchased at the yard from the month of May, but according to the owner, sales peak during the month of September.

The firewood yard located on the road Užice – Lunovo (Image 18) operates on the basis of orders: Households order the desired amounts annually. The yard owner is both a private forest owner and purchases standing trees from other private forest owners and then organizes logging, extraction and transportation of wood from the forest to households directly or to his yard from where it is later delivered to the households. Receiving orders, wood logging and delivery to households are mostly performed in the period second half of August – October, sometimes even during November, depending on the weather conditions.

---

42 of the firewood component of the DKTI GIZ Bioenergy programme in 2014-17
44 Photo credit: Glavonjić, 2016
Both yards are characterized by relatively low turnover of firewood both in terms of amounts and value (around 6,000 m$^3$ firewood are delivered to 900 households or 5% of total households annually) since only those households which do not have “their personal supplier” are supplied from these yards. In both yards, 3 - 4 seasonal workers are engaged temporarily, with only the owners remaining at the end of the season at the end of October. Off-season, the owners are supported by family members to occasionally sell and deliver firewood to those households which did not purchase the required amount of firewood for the entire heating season in time.

_Private forest owners_ from rural areas who supply households in town are the most numerous in the category of wood traders. Around 53% of households procure their firewood through this channel. It is characteristic for Užice that most household have a firewood supplier from whom they have been purchasing firewood for many years and built relationships based on personal contacts and establishment of trust. Wood is ordered via telephone with amounts, price and delivery date agreed on that occasion. Private forest owners from rural areas are reliable suppliers to their buyers and it is very rare that a household faces problems with an established supply channel.

Private forest owners deliver wood between the second half of August until the end of October, i.e. after the end of main agricultural activities in rural areas (mowing of meadows, harvests).

About 31% of households in Užice are supplied from their own _household-owned forests_. Several log wood in March and April, but most during September and October. Despite the fact that they have their own forests and could thus change their practices, ingrained habits that are passed down through the generations mean that these households use raw wood for heating that was prepared only in September.

Supply of households from _state forests_ is characterized by the possibility to pay firewood in instalments (deferred payment), but only 6% of households are supplied via this channel. Pensioner Associations, trade unions of big companies and public institutions (schools, health-care centres, local administration) are the most frequent household consumers of firewood from state forests. Firewood from state forests is delivered from roadside landings directly to the buyer’s home address. Households have the option to receive firewood as early as April, which is significant from the aspect of the time required for air drying of wood. However, most households using this supply channel order wood in September, creating bottlenecks for deliveries by PE Srbijašume just before the start
of the heating season. The two main reasons for these households to choose wood delivery in autumn are cultural habits as well as a lack of available storage space. Storage is often an issue where wood has to be stored in front of the house both because of the risk of theft and fines imposed by communal inspectors. The storage of wood on the street in front of the house is not permitted but fines are only imposed outside of the heating season.

One of the important advantages of this firewood supply channel is the fact that trees on public forest estates are logged several months before delivery to households and thus the wood is air-dried at least to a certain extent.

**Characteristics of the firewood supply system of households in Bajina Bašta**

Household-owned forests are the main channel for firewood supply of 52% of the households in Bajina Bašta. This characteristic applies to rural and most urban households, which despite living in the town have their own forests from which they supply themselves with wood.

The second most significant channel are private forest owners with 22%, and the third is the National Park Tara from which about 14% of urban households receive their firewood. The other channels of supply are acquaintances/friends who have their own forests (10%) and firewood yards (2%).

With the exception of the National Park where it is possible to buy wood during summer months, all other supply channels make firewood available between the end of August and the end of October. The main reason is that private forest owners from rural areas first complete their agricultural activities and only log and prepare wood in August.

Private forest owners who live in town and supply themselves also often depend on other forest owners as they commonly use their equipment for logging, extraction and transportation of wood from the forest to the town. Since most forest owners work on their own estates during spring and throughout summer until August, households with own forests can only harvest wood from in September and October.

**Characteristics of the firewood supply system of households in Leskovac**

According to the household survey from 2014, only 0.1% of households are supplied with firewood from state forests, while forests in private ownership (both owner-traders and household for own supply) are the main firewood supply channel for households in Leskovac.

As in the Uzice/Bajina Basta pilot region, this channel is highly fragmented, with forest owners selling the highest volume off the back of their lorries (Image 19).
More than 50% of urban households in Leskovac are supplied by wood traders who sell wood from the back of their lorries. Their main characteristic is that these are entrepreneurs, some of whom have their own forests while others buy standing trees from private forest owners and organize logging, extraction and transportation of the wood to town. Activities related with logging and preparation of firewood are most often done during the summer months when they store the wood after logging on their yards in the villages or in the forest from where they transport it into town when the purchasing season starts. In most households in Leskovac, the firewood purchasing season starts at the beginning of September and lasts throughout September, October and November.

This system consisting mainly of these small forest owners/wood traders means that mostly raw or at best wood that was air-dried for 2-3 months can be found on the market. As in the other cities, the habit of households to demand wood only in autumn does not give a signal from the demand side to change these practices. This, combined with wood traders who are at the same time farmers cultivating their own land during the summer with wood sales their secondary source of income, constitute the primary obstacles to increasing the efficiency of using firewood in households in Leskovac.

As in the previous cases, households which have their own forests from which they are supplied with firewood are limited in terms of logging, extraction and transportation of wood from their forests to the town and rely on the availability of private forest owners and their machines. Thus, most of such households do not have the option to log wood before the end of August, i.e. after the period when private entrepreneurs finish logging and preparing their own wood for further selling.

**Characteristics of the firewood supply system of households in Vlasotince**

Vlasotince is the municipality where the situation concerning the functioning of firewood supply channels for households is the most difficult. About 23% of households are supplied from own forests and all other depend on private forest owner/wood traders. A small number of these forest owner/wood traders means that households are highly dependent on them and exposed to unethical practices. Research conducted during the household survey in 2014 and the ensuing years shows that households in Vlasotince are “hostage” to a few wood traders who have imposed their practices.
regarding wood delivery and quality. In particular, households often receive smaller amounts of wood than the amounts they paid for, without the ability to issue a complaint or reclamation. Given the scarcity of supply channels, households are often forced to take what is offered to them, even when they are aware of problems. Wood traders in this town frequently deliver wood during the night hours when deliveries cannot be controlled by households, and collect payments during the day. This can give rise to fraud regarding deliveries.

Conclusions and recommendations

General conclusions about firewood supply system for households in the selected pilot regions are as follows:

- In most supply channels, the offered wood is raw or air-dried for 2-3 months at most,
- Habits of most households to buy firewood during September and at the beginning of October are the main generators of wood demand in these months in particular, while their demand for wood in other months is very low,
- Private forest owners/wood traders as the most significant participants in firewood distribution channels do not have financial or organizational capacities, and in many cases no interest in changing existing practices,
- Lack of space for storing wood for air-drying (6 months) in urban households is one of the reasons why this category of households opts for buying wood very late,
- Policy of communal inspection in towns to write fines for stacks of wood on public areas in front of buildings in the months outside the heating season is also one of the limiting factors why households decide to purchase wood as late as September or October
- Firewood delivery in towns with limited supply options often unfairly disadvantages households as they cannot appeal or denounce unethical suppliers.

These limitations and problems which exist in firewood supply channels demand urgent solving in order to help the households to have a possibility to complain/appeal/denounce.

One of the ways in which many of the stated limitations and problems could be solved is the enactment of adequate technical regulation to set appropriate rules, control principles, inspection mechanisms and complaints procedures, which firewood producers and distributors would have to abide by. With regulation setting out minimum quality requirements of fuel wood, market inspection could be initiated, and consumers would be able to hold suppliers to account.
Appendix C Quality requirements for firewood

Firewood is the most frequent wood fuel for heating, food preparation and other needs in households in Serbia. Beside in households, firewood is also used in large amounts for heating public and commercial facilities as well as in industry.

For heating, firewood is most commonly supplied as one-meter log woods, as round billets and/or cleft short logs (Image 20) In addition to these assortments, firewood split into lengths (typically of 33 cm) has also be offered in recent years, packed in pallets.

Image 20 – Firewood assortments offered on the Serbian market (a: cleft short logs, b: round billets, c. wood logs)

Table 7 presents the limit values of maximum allowed moisture content of wood by firewood classes pursuant to the provisions of the standard SRPS EN ISO 17225:2015.

Table 7 – Characteristics of firewood according to moisture content

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Quality classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (M)</td>
<td>%mass as received wet basis</td>
<td>M20 ≤ 20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M25 ≤ 25</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M35 ≤ 35</td>
</tr>
</tbody>
</table>

A low moisture content of firewood is the best guarantor for efficient combustion and lower harmful emissions to the environment. It takes about 6 months after logging for wood to reach the level of moisture of about 25%. This means that wood needs to be logged latest in April, stacked properly and left to air dry naturally until the start of the heating season in mid-October.

It is recommended to measure moisture content of firewood at the moment of purchase, and according to the provisions of the standard SRPS EN 17225-5:2015 moisture content of cleft short logs and firewood pieces is ideally measured at three points as shown in Image 21.

---

46 Source: SRPS EN 17225-5:2015
47 for more details see http://www.bioenergy-serbia.rs/images/documents/info/Brosura_Kako-efikasno-koristiti-ogrevno-drvo.pdf
Image 21 – Points for measuring moisture content on cleft short logs and firewood pieces

The moisture content should also be measured on 5 pieces of cleft short logs/round billets/firewood pieces per each 2 prm or 2m$^3$ of the stack to produce a mean estimated value for the assessed stack.

The second major factor of firewood quality is the length in which cleft short logs/round billets and wood logs are produced. Table 8 shows the values of lengths of firewood i.e. wood logs pursuant to the provisions of the standard SRPS EN ISO 17225:5:2015.

Table 8 – Length as quality aspect of firewood

<table>
<thead>
<tr>
<th>Parameter (L)</th>
<th>Unit</th>
<th>Quality classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cm</td>
<td>A1</td>
</tr>
<tr>
<td>Length</td>
<td></td>
<td>L20 ≤ 20 (±2 cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L25 ≤ 25 (±2 cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L30 ≤ 30 (±2 cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L33 ≤ 33 (±2 cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L40 ≤ 40 (±2 cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L50 ≤ 50 (±4 cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L100 ≤ 100 (±5 cm)</td>
</tr>
</tbody>
</table>

Cleft short logs and round billets are the most frequent firewood assortments offered on the Serbian market. Length in which they are produced is most often 1 m and the standard allows the deviation of ±5 cm. Such provision was also contained in the JUS standards for firewood, and has been in use in Serbia for several decades, however the new standard SRPS EN ISO 17225-5:2015 goes further than that by limiting the amount of logs that can be shorter than required to 15%.

Neither the provision for moisture content nor length are adhered to in Serbian firewood trade practice, due to the lack of appropriate technical regulation that would obligate producers and traders.

---

48 Source: SRPS EN 17225-5:2015
49 Ex Yugoslav standards
Appendix D Quality requirements for wood pellets


Table 9 – The most significant characteristics of quality classes for wood pellets for use in commercial and residential buildings

<table>
<thead>
<tr>
<th>Property (Parameter)</th>
<th>Unit</th>
<th>Limit values for individual quality classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A1</td>
</tr>
<tr>
<td>Diameter (D)</td>
<td>mm</td>
<td>6 ± 1</td>
</tr>
<tr>
<td>Length (L)</td>
<td>mm</td>
<td></td>
</tr>
<tr>
<td>Moisture (M)</td>
<td>w-% as received, wet basis</td>
<td></td>
</tr>
<tr>
<td>Ash (A)</td>
<td>w-% dry</td>
<td>≤ 0.7</td>
</tr>
<tr>
<td>Mechanical durability (DU)</td>
<td>w-% as received</td>
<td>≥ 97.5</td>
</tr>
<tr>
<td>Fines (F)</td>
<td>w-% as received</td>
<td></td>
</tr>
<tr>
<td>Net calorific value (Q)</td>
<td>MJ/kg or kWh/kg as received</td>
<td>≥ 16.5 or ≥ 4.6</td>
</tr>
<tr>
<td>Bulk density (BD)</td>
<td>kg/m³</td>
<td>≥ 600</td>
</tr>
</tbody>
</table>

a Negligible levels of glue, grease and other timber production additives used in sawmills during the production of timber and timber products from virgin wood are acceptable if all chemical parameters of the pellets are clearly within the limits and/or concentrations are too small to be concerned with.

Wood pellets are measured and delivered according to weight (kilogram or ton). At delivery, in addition to weight, the most significant characteristics that are controlled are moisture content, ash content and net calorific value. Minimum net calorific value of wood pellets in all quality classes is equal or above 4.6 kWh/kg. Maximum moisture content of wood pellets shall not exceed 10 w-% as received (wet basis). Because of the characteristics of appliances burning wood pellets, the amount of ash remaining after their combustion in A1 quality class shall not exceed 0.7 w-% compared to dry basis. This is an extremely strict criterion because of which wood pellets of A1 quality class have to be produced from mostly debarked wood.

Some Serbian wood pellets producers have the EN plus standard certificate, the requirements for which are stricter than the standard SRPS EN ISO 17225-2:2015. For example:

- For EN plus A1, mechanical durability has to be ≥ 98.0 w-%;
- For EN plus B, mechanical durability has to be ≥ 97.5 w-%;
- Limit value for the amount of fines in small sacks and closed big sacks shall be 0.5 w-% at factory gate;
- Limit value for pellet temperature at loading for deliveries to end users: 40 °C.
- Mandatory requirements for ash melting behaviour. DT threshold (A1 class: >1200°C, A2 and B classes: >1100°C)
- Ash used for testing the melting behaviour occurs at 815°C.

**Wood pellets for industrial use** have slightly different quality criteria. According to the standard SRPS EN ISO 17225-2:2015, wood pellets for industrial use are divided into three classes: I1, I2 and I3.

The most significant differences regarding parameters for wood pellets for industrial use compared to the use in commercial and residential facilities refer to allowed dimensions, ash and share of small fractions:

- **I2** quality class wood pellets have a diameter 6-10 mm and in **I3** class 6mm-12 mm diameter is allowed
- Allowed amount of ash in **I1** class is up to 1 w-% dry and in **I3** class up to 3 w-%.
- The share of small fractions is up to 4 w-% as received in **I1** quality class and up to 6 w-% as received in **I3** quality class.

These are significantly higher values than for quality classes for use in commercial and residential facilities.

Given the increasing importance of pellets on the Serbian market and the potentially significant quality problems, the GIZ DKTI programme has tested sampled pellet quality across the country in order to get a realistic understanding of their quality. Results of this research are presented in the following appendix.
Appendix E Quality of wood pellets produced and sold in Serbia

Sample selection

For the needs of quality analysis of wood pellets produced and sold in Serbia, a methodology consisting of the following steps and activities was used:

- Selection of a reference laboratory in which the samples of wood pellets would be tested
- Defining of the criteria pursuant to which producer categories would be selected whose samples of wood pellets would be tested as well as their regional distribution
- Collection of samples
- Delivery of samples to the selected laboratory
- Testing of the samples
- Report on research results.

Analysis of the quality of the selected wood pellet samples was performed for the needs of the GIZ DKTI program with the purpose to:

- Get an adequate image of the situation regarding the quality of wood pellets offered on the Serbian market, having in mind that such research did not exist in previous years to such an extent in which they have been conducted within this programme
- Based on the obtained results, to observe the presence or absence of the justification for the dissatisfaction of end consumers regarding the problems they face during the combustion of wood pellets in their appliances.

Concerning the selection of the laboratory for testing the quality of wood pellets, it is done in view of the possibility of the selected laboratory to perform the testing of all 20 parameters required, pursuant to the standard for wood pellets SRPS EN ISO 17225-2:2015. Regarding this, data were collected about the current laboratories in Serbia that do the testing of fuels, including wood fuels, and visits and discussions were organized in order to get acquainted with their potentials to meet this criterion. Based on the results of the conducted activities, the decision was made to select the laboratory of the company Jugoinspekt from Belgrade for the stated testing of wood fuels quality.

Size of the producers and criterion of geographic distribution were selected to be the criteria for selecting producer categories whose samples will be tested. Accordingly, all producers are grouped into 3 categories:

- Big producers producing 30,000 tons and more of wood pellets annually
- Medium-sized producers producing 5,000-30,000 tons/year and
- Small producers producing below 5,000 tons of wood pellets annually.

For the purpose of collecting samples, the criterion was selected to have 4 producers from each group from different geographic regions, which gives a total of 12 producers sampled.

Concerning the geographic distribution of producers, territorial division into central and west Serbia as one region, south Serbia as another region and east Serbia as the third region was selected since

---

50 Jugoinspekt laboratory: Certificates of analysis of wood pellets, Internal reports, Belgrade 2016
then number of producers and size of their production in other regions of Serbia are negligible compared to these three regions.

After this, one producer from each of the selected regions was chosen from each of the producer size categories. This way, representative coverage was obtained regarding the categories and regional presence of the producers. Here, it should be mentioned that for conducting a more detailed analysis it is necessary to implement full coverage which would include all producers of wood pellets. However, from the aspect of purposes of this programme and its needs, the coverage of 12 different producers by categories and their regional distribution was sufficient.

In addition, a further objective was to include in the tested samples wood pellets produced from hardwood, coniferous and a combination of hardwood and coniferous species, since these are the most common pellet types offered on the Serbian market.

Samples were then collected by using random selection of one bag of wood pellets directly from the pallet. Collected samples were then delivered to the selected laboratory which performed their testing pursuant to the procedures specified in the relevant standards and the report on the performed testing with test results was submitted to the DKTI programme.

**Testing**

In the following section the test results are presented for all 12 samples for each parameter specified in the standard SRPS EN ISO 17225-2:2015.

**Length and diameter of wood pellets**

Table 10 shows the values of length and diameter of wood pellets individually for each of the selected samples.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Limit values</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>mm</td>
<td>3.15 &lt;L≤40</td>
<td>5-30</td>
<td>5-35</td>
<td>5-55</td>
<td>5-40</td>
<td>5-30</td>
<td>5-30</td>
</tr>
<tr>
<td>Diameter</td>
<td>mm</td>
<td>5-9</td>
<td>5.90-6.00-6.20</td>
<td>6.00-6.20</td>
<td>6.00-6.40</td>
<td>6.00-6.30</td>
<td>6.10-6.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S7</td>
<td>S8</td>
<td>S9</td>
<td>S10</td>
<td>S11</td>
<td>S12</td>
</tr>
<tr>
<td>Length</td>
<td>mm</td>
<td>3.15 &lt;L≤40</td>
<td>5-40</td>
<td>5-40</td>
<td>5-20</td>
<td>5-40</td>
<td>5-30</td>
<td>5-30</td>
</tr>
<tr>
<td>Diameter</td>
<td>mm</td>
<td>5-9</td>
<td>6.10-5.90-6.30</td>
<td>6.00-6.20</td>
<td>6.00-6.70</td>
<td>6.00-6.30</td>
<td>6.20-7.00</td>
<td></td>
</tr>
</tbody>
</table>

Values of diameter dimensions of the selected samples are within the limit values, thus pursuant to this criterion samples do not deviate from the values defined in the standard.

Analysis of pellet lengths of certain samples shows that in the sample S3 there were wood pellets with lengths exceeding the upper limit values, thus pursuant to this criterion this sample does not fulfil the provisions from the standard. Concerning other samples, in the total of 4 samples (S4, S7, S8
and S10) wood pellets with lengths on the upper limit value were found. Lengths of wood pellets in other samples were within the limits defined in the standard. The same can be stated concerning the minimum lengths of wood pellets, which were within the limits defined in the standard for all samples.

Since pellet length is very important for regular functioning of the combustion appliance, this was one of the reasons why the standard defined that only 1% of the total amount of pellets in a packaging can have length more than 40 mm.

**Moisture content**

Table 11 shows the measured values of moisture in all samples. Moisture content ranged from 5.4% to 8.94%.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Limit values</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>% m as received, wet basis</td>
<td>≤ 10</td>
<td>6.02</td>
<td>6.30</td>
<td>6.23</td>
<td>6.22</td>
<td>6.25</td>
<td>8.69</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>S7</td>
<td>S8</td>
<td>S9</td>
<td>S10</td>
<td>S11</td>
<td>S12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>5.40</td>
<td>4.98</td>
<td>8.94</td>
<td>7.23</td>
<td>5.94</td>
<td>7.26</td>
</tr>
</tbody>
</table>

Since the limit value defined by the standard is less or equal to 10%, all samples fulfilled this criterion. Since the content of energy obtained with the combustion of wood pellets largely depends on the amount of moisture, it is important for end consumers that wood pellets are within the limits defined in the standard concerning this criterion. The situation regarding the moisture content in the tested samples is generally estimated as satisfactory.

**Ash content**

Ash content in the selected samples is determined at the temperature of 550 °C and the received values of this parameter are shown on the Figure 21.
Figure 21 – Values of ash content of wood pellets individually by samples

Maximum limit values of ash content vary for different classes of wood pellets. The strictest criterion, and consequently the lowest allowed ash content is for A1 class of wood pellets amounting to ≤0.7%. According to this criterion, only one of the samples (S8) can be grouped into A1 class, while all other samples had bigger share than the percentage required for A1 quality class. Six samples (S2, S4, S5, S9, S10, S11) fulfilled the criteria of A2 class (A2≤1.2%) because their ash content was within the limit value ≤1.2%, and two samples, S3 and S12, were classified as B quality class because they had ash content in the range from 1.24-1.31% (allowed max. 2%). Three samples S1, S6 and S7 had ash content over 2% and according to this criterion they could not belong to any of the quality classes. Sample S6 had a particularly high ash content of as much as 7.08%, which is considered to be an extremely high value.

Since ash can cause numerous problems on the burners of appliances, the standard foresees that additional tests should be carried out regarding ash behaviour at high temperatures (above 1100°C).

In order to observe the ash behaviour and eliminate the problems caused by wood pellets of low quality, it is necessary to carry out the tests for shrinkage starting temperature, deformation temperature, hemisphere temperature and flow temperature in oxidizing atmosphere. Values of the stated temperatures are significant for making conclusions as to whether slag will appear and its agglomeration on the burners and grates of the appliances during the combustion of wood pellets in the appliances. This criterion is an increasingly expressed requirement of the market and end users in the European Union countries, thus producers pay special attention to it when testing the quality in accredited laboratories. Image 22 shows the example of wood pellet sample whose ash flow temperature is 1545 °C, which is significantly above 1100 °C, which is considered to be the threshold for this parameter.
Taking into consideration the number of samples which could not be categorized into any of the classes as well as the number of samples of B class, the situation can be estimated as unsatisfactory regarding this parameter because the number of samples of A1 and A2 classes does not exceed 2/3 of the total number of samples.

**Mechanical durability**

Mechanical durability as a parameter showing the capability of wood pellets to remain undamaged during transportation and handling, i.e. to keep their unity during manipulation is an important quality parameter of this fuel.

Values of this parameter for the tested samples are presented on the Figure 22
Out of the total of 12 samples, as much as 4 samples had the values of mechanical durability which could not be classified into any of the quality classes (S5, S6, S10, S12). One sample (S9) belonged to B class and 7 samples had the values meeting the criteria of A1 class. Bearing in mind the importance of this parameter as well as the number of samples of B class and the number of samples below its values, it can be concluded that the situation regarding this parameter is not satisfactory because only 58.3% of the total number of samples meet the criteria of the classes A1 and A2. Pellet samples with the values of this parameter below 96.5 crumble more easily and have an increased presence of fines.

**Net calorific value**

Net calorific value is the amount of usable energy expressed most often in J/g or kWh/kg of wood pellets and as such it is of particular interest for end consumers. The lower limit of this parameter for wood pellets for all quality classes is 16,500 J/g.

The obtained values of net calorific value for the tested samples are shown in Figure 23.

![Net calorific value of individual samples of wood pellets](image)

The minimum limit value of this parameter for wood pellets is 16,500 J/g or 4.58 kWh/kg pursuant to the standard. Concerning the samples that were tested, the values of two samples were below the minimum limit and one sample was slightly above the minimum. The net calorific value of sample 6 was 6.5% lower than the minimum limit value, the consequence of which is significantly higher consumption of pellets of this producer compared to the pellets of other producers. Excluding the samples S6 and S9, the net calorific value of the other samples is satisfactory.

**Bulk density**

Bulk density of pellets is important in terms of packaging and during the use in combustion appliances. Pursuant to the provisions of the standard, the lower limit of bulk density for wood
Wood fuels and solid fuel heating & cooking appliances in Serbia

pellets is 600 kg/m$^3$. If bulk density of pellets is below this limit value it means that the packaging of 15 kg will not weigh 15 kg. On the other hand, bulk density should not exceed 750 kg/m$^3$ if they are used for burners and furnaces in households which do not possess automatic control of air supply because of which they are extremely sensitive to bulk density variations.

Measured values of bulk density for the tested samples of wood pellets are shown on Figure 24

![Figure 24 – Bulk density of individual samples of wood pellets](image)

Obtained values for bulk density of individual samples show that only the sample S9 has values of below the lower limit defined in the standard (600 kg/m$^3$ for all classes). However, three samples S10, S11 and S12 have extremely high values of bulk density which can cause problems during combustion in burners and furnaces in households without automatic control of air supply. The overall conclusion for the tested samples for this parameter is that the situation is satisfactory.

**Fines**

Fines are particles in wood pellets whose dimensions are significantly smaller than the minimum size of particles specified in the standard, which is 3.15 mm. Due to such small dimensions, fines often look like wood powder. They are an inevitable element in the packages of wood pellets, thus the standard defines that their share should not exceed 1% of the total mass as received for all quality classes.

Share of fines in the tested samples of wood pellets is shown in Figure 25.
Nitrogen, sulphur and chlorine content

Nitrogen, sulphur and chlorine are elements which have direct impact on the level of emissions of harmful gases into the atmosphere during the combustion of all fuels, whereas the level of their emissions from fossil fuels is several dozen times higher than the level of emissions from wood fuels. Thus, for example, the level of sulphur emission during the combustion of certain coal types is up to 62 times higher than the level of sulphur emission during the combustion of wood, while for chlorine this difference goes up to 16 times. Nitrogen and chlorine generally have a small presence in wood and wood fuels compared to grains. Thus, nitrogen content in wheat straw is about 4 times higher than the nitrogen content in wood and during the combustion of wheat straw or fuel based on wheat straw significantly higher amounts of nitrogen oxides (NOx) are formed compared to wood combustion.

During combustion, wood emits about 3 times less chlorine than wheat straw.

Results of testing the selected wood pellet samples for nitrogen, sulphur and chlorine content are shown in Figure 26. Nitrogen content in all samples was below the level defined in the standard, and that in 10 samples, the level of nitrogen emission was within the limits specified for A1 class and in 2 samples, for the A2 class. With respect to chlorine, in 9 samples the chlorine content was below the level defined in the standard, with 3 samples meeting the class A1 and A2 requirements and 6 samples meeting the B class requirements. In 3 samples chlorine content was slightly higher than the
level specified in the standard. With respect to sulphur, all 12 samples had slightly higher values than the level defined in the standard.

![Graph showing nitrogen, sulphur, and chlorine content in wood pellets](image)

**Figure 26 – Nitrogen, sulphur and chlorine content in the tested samples of wood pellets**

With the exception of sulphur, the situation regarding nitrogen and chlorine content can be estimated as satisfactory.

**Content of heavy metals**

Woody biomass grows in various habitats that can more or less be contaminated with various heavy metals, and these heavy metals pass through the roots into the wood structure. As such, there can be large variation in the heavy metal content of wood grown in different places. The standard foresees the need to test the presence and concentration of the following heavy metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc. The standard defines maximum limit values for each of the stated heavy metals up to which their presence in wood fuels is considered as harmful. Figure 27 shows the average values of the presence of certain heavy metals collectively for all 12 tested samples of wood pellets. At the same time, limit values on control charts are given for each of the heavy metals individually ranging from 0 to the maximum amount expressed in ppm. Arrow on each individual control chart shows in which field the average measured values are for each of the analysed heavy metals.
Figure 27 – Average values of the presence of certain heavy metals in the tested samples of wood pellets

The general conclusion based on the measured values of the presence of certain heavy metals in the tested samples of wood pellets is that the obtained values are far below maximum defined values in the standard, and therefore the heavy metal content is deemed satisfactory for meeting the standard.
Appendix F Quality requirements for wood chips

Wood chips are a fuel which is increasingly used in Serbia for industrial energy and non-energy purposes. Use of wood chips in district heating systems is still at the very early stage, however it is expected that this energy generating product will have a significantly higher share than presently.

Concerning qualitative aspect of wood chips offered on the Serbian market, it is still in the domain of agreement between the producer and user regarding the specification of wood species, dimensions, moisture content and other quality parameters although there is a valid national standard SRPS EN ISO 17225-4:2015 regulating all most significant quality parameters for wood chips.

The most significant quality parameters for wood chips are the following:
- Dimensions of pieces
- Origin of woody biomass from which wood chips are produced
- Moisture content and
- Bulk density

Since during the production of wood chips pieces of various dimensions are created among which the smallest and the largest can cause problems during the operation of appliances burning wood chips, it was necessary to define the share of certain fractions of the pieces of wood chips in the total amount subject to delivery. Values of parameters referring to dimensions and share of certain fractions in the total delivered volume of wood chips pursuant to the standard SRPS EN ISO 17225-4:2015 are given in Table 12.

<table>
<thead>
<tr>
<th>Dimensions (mm)</th>
<th>Main fraction (^a) (minimum 60 w-%), mm</th>
<th>Fines fraction, w-% (≤3,15 mm)</th>
<th>Coarse fraction, w-%, (length of particle, mm)</th>
<th>Max. length of particles(^b), mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>P16S</td>
<td>3.15 mm &lt; P ≤ 16 mm</td>
<td>≤ 15 %</td>
<td>≤ 6 % (&gt;31.5 mm)</td>
<td>≤ 45 mm</td>
</tr>
<tr>
<td>P31S</td>
<td>3.15 mm &lt; P ≤ 31.5 mm</td>
<td>≤ 10 %</td>
<td>≤ 6 % (&gt;45 mm)</td>
<td>≤ 150 mm</td>
</tr>
<tr>
<td>P45S</td>
<td>3.15 mm &lt; P ≤ 45 mm</td>
<td>≤ 10 %</td>
<td>≤ 10 % (&gt;63 mm)</td>
<td>≤ 200 mm</td>
</tr>
</tbody>
</table>

\(^a\) The numerical values (P-class) for dimension refer to the particle sizes passing through the mentioned round hole sieve size (ISO 17827-1). The lowest possible class should be stated. Only one class shall be specified for wood chips.

\(^b\) Length and cross sectional area only have to be determined for those particles, which are to be found in the coarse fraction. Maximum 2 pieces of about 10 l sample may exceed the maximum length, if the cross sectional area is < 0.5 cm².

Quality parameters regarding the origin of woody biomass, moisture content and bulk density are also defined in the standard SRPS EN ISO 17225-4:2015 and their values depend on the quality class. Wood chips is categorized into four classes: A1, A2, B1 and B2 class.

\(^52\) Source: SRPS EN ISO 17225-4:2015
The most significant parameters of certain characteristics for individual quality classes of wood chips are given in Table 13.

**Table 13 – The most significant characteristics of quality classes for wood chips**

<table>
<thead>
<tr>
<th>Property class</th>
<th>Unit</th>
<th>A 1</th>
<th>2</th>
<th>B 1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Origin and Source</strong> ISO 17225-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.1 Whole trees without roots a</td>
<td>to be selected from previous table</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.3 Stemwood residues</td>
<td>to be selected from previous table</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2.1 Chemically untreated wood residues</td>
<td>Maximum value to be stated</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Particle size, (P)</strong></td>
<td>mm</td>
<td>to be selected from previous table</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Moisture, (M)</strong> c</td>
<td>w-%</td>
<td>M10 ≤ 10</td>
<td>M25 ≤ 25</td>
<td>M35 ≤ 35</td>
<td>Maximum value to be stated</td>
</tr>
<tr>
<td><strong>Bulk density, BD</strong> d</td>
<td>kg/loose m³ as received</td>
<td>BD150 ≥ 150</td>
<td>BD200 ≥ 200</td>
<td>BD250 ≥ 250</td>
<td>BD150 ≥ 150</td>
</tr>
</tbody>
</table>

- **a** Excluding class 1.1.1.3 Short rotation coppice, if reason to suspect contamination of land or if planting has been used for the sequestration of chemicals or growing trees have been fertilized by sewage sludge (issued from waste water treatment or chemical process).
- **b** Excluding classes 1.1.5 Stumps/roots and 1.1.6 Bark
- **c** Lowest possible property class to be stated. Certain boilers require minimum moisture content, which should to be stated. Moisture class M10 is for artificially dried wood chips.
- **d** The bulk density is lower for coniferous than for broadleaf wood, see informative Annex A in SRPS EN ISO 17225-4:2015.

**A1** and **A2** classes require virgin wood and chemically untreated wood residues. **A1** class requires wood chips with lower ash content, which indicates at the absence or presence of very small amount of bark, as well as the lower moisture content, while **A2** class allows for slightly higher ash content and moisture content. **B1** expands origin and source of **A** class and also covers other material such as short-rotation coppices, wood from gardens and plantations, etc. and chemically untreated by-products and residues from industry. **B2** class also includes chemically treated industrial by-products and residues and chemically untreated used wood.

Concerning moisture content in **A1** and **A2** classes, maximum allowed values are specified, while for **B** class, values are stated measured at the moment of delivery. Regarding this, **A** class contains two values for moisture content of wood chips – moisture content class M10 refers to artificially dried wood chips whose moisture content does not exceed 10%. Concerning the moisture content of chips which are air dried naturally, maximum allowed moisture content in **A1** class is 25% and in **A2** class it is maximum 35%. Wood chips with higher moisture content, regardless of meeting all other requirements in the standard for example to be categorized as **A1** class, has to be categorized as **B** class.
Moisture content of wood chips is measured with various devices of various precision, speed of moisture determination, and consequently the price. Thus the selection of moisture measurement devices for wood chips depends on the required precision and speed of its determination.

Since moisture content has the most significant impact on the price, it is necessary to measure it as precisely as possible. This statement refers in particular to the deliveries of producers and traders to big consumers (heating plants, industry and other) whose annual consumption is several hundred tons. In such deliveries, each percentage of moisture content can mean a significant loss or gain for the supplier or user.

Moisture content of delivered wood chips can be measured and expressed on wet and dry basis. In the first case, the ratio is between the amount of moisture and total weight of wood. For example, if the measured amount of moisture is 20 kg and dry matter is 80 kg of the total weight of 100 kg, moisture content is expressed as the ratio of water to the total weight of wood.

\[
\text{w} = \frac{20}{100} \times 100 = 20\%
\]

Equation 1 – Calculation and expression of moisture content in wood on wet basis

The second method is to relate the measured amount of moisture to the amount of dry matter and in that case moisture content is expressed on dry basis.

\[
\text{u} = \frac{20}{80} \times 100 = 25\%
\]

Equation 2 – Calculation and expression of moisture content in wood on dry basis

Difference in the magnitude of moisture content between these two procedures is evident.

In practice, moisture content is most often calculated and expressed on wet basis.

In order to reduce misunderstandings between the seller and the buyer, the most frequent delivery system used today in practice is by weight in atro tons.

Atro ton is the weight of oven dry wood (moisture content 0%). At this moisture content, wood has the maximum energy value. This means that in this case the buyer pays for energy through the price of wood chips, not for water. A practical approach for calculating the delivery and payment of wood chips is given in the following example:

**Example 1.** Net weight of the delivered beech wood chips is 6,800 kg and its measured moisture content is 35% (meaning that 65% is pure wood mass). Energy value of 1 kg of beech with moisture content of 0% is 5.0 kWh/kg. In this particular example, the buyer purchased the following amount of energy:

\[
6,800 \text{ kg} \times 0.65 = 4,420 \text{ atro kg} \times 5.0 \text{ kWh/kg} = 22,100 \text{ kWh}
\]
Bearing in mind the approach to calculating atro weight and energy of wood chips, resulting prices are significantly higher than the prices calculated for wood chips delivered with a certain percentage of moisture.

Bulk density as a parameter of wood chip quality depends on wood species and share of certain fractions of wood chips pieces. For classes A1 and A2, the standard specifies minimum values of bulk density which wood chips must meet so that they could be classified into one of these two classes pursuant to this parameter. For B classes, there are no specified values for bulk density, only the lowest values at delivery are stated.

In addition to the above stated quality parameters, ash content is also an important quality characteristic of wood chips. Amount of ash originating after the combustion process depends to the greatest extent on the presence of bark and small fractions in the delivered amount of wood chips. Regarding this, SRPS EN ISO 17225-4:2015 defines three levels of ash content:

- In A1 class, maximum allowed amount of ash shall not exceed 1 w-% dry;
- In A2 class, maximum allowed amount of ash shall not exceed 1.5 w-% dry and
- In B1 and B2 classes, maximum allowed amount of ash shall not exceed 3 w-% dry.
Appendix G Quality requirements for wood briquettes

Although wood briquettes are produced in different shapes and dimensions, requirements for their quality are the same for all shapes. Wood briquettes are measured and delivered to the consumers by weight (kilogram or ton). At delivery, in addition to weight, the most significant characteristics that are controlled are moisture content, ash content and net calorific value.

Pursuant to the standard SRPS EN ISO 17225-3:2015, wood briquettes are categorized into three classes: A1, A2 and B and the most significant parameters of certain characteristics in the stated classes are presented in Table 14.

Table 14 – The most significant characteristics of quality classes for wood briquettes

<table>
<thead>
<tr>
<th>Property (Parameter)</th>
<th>Unit</th>
<th>Limit values for individual quality classes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A1</td>
</tr>
<tr>
<td><strong>Origin and source</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1.1 Whole trees without roots</td>
<td>1.1.3 Stemwood</td>
<td>1.1.4 Logging residues</td>
</tr>
<tr>
<td>1.1.2 Chemically untreated wood residues</td>
<td>1.1.3 Stemwood</td>
<td>1.1.4 Logging residues</td>
</tr>
<tr>
<td><strong>Moisture (M)</strong></td>
<td>w-% as received, wet basis</td>
<td>≤ 12</td>
</tr>
<tr>
<td><strong>Ash (A)</strong></td>
<td>w-% dry</td>
<td>≤ 1.0</td>
</tr>
<tr>
<td><strong>Particle density (DE)</strong></td>
<td>g/cm³ as received</td>
<td>≥ 1.0</td>
</tr>
<tr>
<td><strong>Net calorific value (Q)</strong></td>
<td>MJ/kg kWh/kg as received</td>
<td>≥ 15.5</td>
</tr>
<tr>
<td><strong>Nitrogen (N)</strong></td>
<td>w-% dry</td>
<td>≤ 0.3</td>
</tr>
<tr>
<td><strong>Sulfur (S)</strong></td>
<td>w-%²</td>
<td>≤ 0.04</td>
</tr>
<tr>
<td><strong>Chlorine (Cl)</strong></td>
<td>w-%²</td>
<td>≤ 0.02</td>
</tr>
</tbody>
</table>

Concerning moisture content, in the best A1 class it shall not exceed 12%, while the maximum share of ash is 1 w-% dry. Net calorific value in A1 quality class has to be equal or higher than 4.3 kWh/kg as received. Concerning the emission of nitrogen, sulphur and chlorine during the combustion process, their values for A1 quality class are maximum 0.3 w-% dry for nitrogen, maximum 0.04 w-% dry for sulphur and 0.02 w-% for chlorine.

In A2 class, slightly higher contents of ash and nitrogen are allowed, while in B class wood briquettes are allowed to be produced from chemically treated biomass of industrial by-products, wood residues and chemically untreated used wood.
The shape of wood briquettes is extremely important from the aspect of their proper use. Various shapes have various dimensions (Figure 28) as well as behaviour during combustion in heating appliances.

Thus, for example, briquettes produced in excenter presses shall bear the note: “Briquettes may expand during combustion”. This note is important for consumers in terms of the amount of wood briquettes they put in the heating appliances.

Briquettes with the shape 1, 2, 3 and 5 in Figure 28 should bear the note: “Not to be used for open space heaters. Briquettes may roll off the grate”. This note is also important from the aspect of safe use of these wood briquette shapes.

Figure 28 – Shapes and labels of certain dimensions of wood briquettes
Appendix H Quality requirements for charcoal and charcoal briquettes

Charcoal is produced in Serbia in two ways: traditionally in charcoal kilns and industrially in retorts, and charcoal briquettes are produced from coal dust and small residues. The most significant elements of charcoal quality are the following:

- dimensions of the pieces and the related share of certain fractions in charcoal packaging delivered to the consumers
- content of fixed carbon
- moisture content and
- bulk density.

The quality of charcoal produced in Serbia varies depending on the type of charcoal kiln in which the process of carbonizing wood is executed. During the visits to charcoal kilns, it was concluded that the quality is uneven due to differences in production processes, different level of expertise and skills, as well as the need to produce and sell in the shortest possible time, especially during peaks.

Big oscillations in the values of the stated elements can significantly lead to very poor quality of charcoal. Because of this, as far back as in 1977 a standard for charcoal was adopted bearing the mark JUS D.B9.020 which is still valid. However, a new European standard SRPS EN 1860-2 is in the process of adoption, thus this field in Serbia will be fully harmonized with Europe. Values of the most significant charcoal parameters pursuant to the standard SRPS EN 1860-2 are presented in Table 15.

Table 15 – The most significant parameters of charcoal quality\textsuperscript{53}

<table>
<thead>
<tr>
<th>Property (Parameter)</th>
<th>Unit</th>
<th>Parameter values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin and source</td>
<td></td>
<td>According to chapter 6.1. and table 1 (woody biomass 1.1. and 1.2.1, fruit biomass) of the standard SRPS EN ISO 17225-1</td>
</tr>
<tr>
<td>Dimensions</td>
<td>mm</td>
<td>Main fraction, % w, 20 mm&lt;P \leq 80 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>minimum 80 %</td>
</tr>
<tr>
<td>Moisture (M)</td>
<td>w-% as received</td>
<td>M8 \leq 8 %</td>
</tr>
<tr>
<td>Ash (A)</td>
<td>w-% of dry basis</td>
<td>A8.0 \leq 8.0 %</td>
</tr>
<tr>
<td>Fixed carbon, C</td>
<td>w-% of dry basis</td>
<td>C75 \geq 75 %</td>
</tr>
<tr>
<td>Bulk density (BD)</td>
<td>kg/m\textsuperscript{3} as received</td>
<td>BD130 \geq 130 kg/m\textsuperscript{3}</td>
</tr>
</tbody>
</table>

\textsuperscript{53} Source: SRPS EN 1860-2
Unlike other wood fuels, charcoal is not entirely grouped into quality classes in line with European standards. Some aspects align, for example, the minimum amount of fixed carbon required by the European standard is 75%, while in the JUS standard the share of fixed carbon for the production of black powder is 70-80% with the share of fixed carbon being 72% in the second quality class. The greatest difference between JUS and European standard relates to the amount of ash. In the European standard 1860-2, the share of ash is max 8% dry, whereas in the JUS standard for class I it is 3% for retort coal and 5% for forest charcoal, while for class II as much as 18% is allowed. Bulk density is not specified in the JUS standard while the European standard limits its minimum value at 130 kg/m3.

Concerning the dimensions of pieces and the related share of certain fractions in the total amount delivered to the consumers, the JUS standard does not contain any requirements. The European standard however defines the minimum presence of each of the 3 fractions which occur in charcoal production, with particularly high requirement that the share of small fractions (pieces with dimensions of 0-10 mm) shall not exceed 7%. Specifying the presence of certain fractions in the overall amount of charcoal to be delivered is significant for end consumers.

Charcoal briquettes have become increasingly popular in Serbia in recent years. In Europe the briquettes have been popular for years, which explains why a standard already exists to define the most significant parameters and their values. Table 16 shows values of the most significant quality parameters for charcoal briquettes.

<table>
<thead>
<tr>
<th>Property (Parameter)</th>
<th>Unit</th>
<th>Parameter values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Origin and source</td>
<td></td>
<td>According to chapter 6.1. and table 1 (woody biomass 1.1. and 1.2.1, fruit biomass) of the standard SRPS EN ISO 17225-1</td>
</tr>
<tr>
<td>Dimensions</td>
<td>mm</td>
<td>Shape and size of charcoal briquettes should be suitable for use in barbeque appliances pursuant to EN 1860-1. The share of briquettes with dimensions below 20 mm shall not exceed 10%.</td>
</tr>
<tr>
<td>Moisture (M)</td>
<td>w-% as received</td>
<td>M8 ≤ 8 %</td>
</tr>
<tr>
<td>Ash (A)</td>
<td>w-% of dry basis</td>
<td>A18.0 ≤ 18.0 %</td>
</tr>
<tr>
<td>Fixed carbon, C</td>
<td>w-% of dry basis</td>
<td>C60 ≥60 %</td>
</tr>
</tbody>
</table>

The most significant parameters of the quality of charcoal briquettes in the European standard are fixed carbon, ash and moisture. For charcoal briquettes, the minimum value of fixed carbon is 60%. Maximum moisture content is 8% as well as for charcoal and ash content is 18%.

The JUS standard for charcoal does not have provisions referring to charcoal briquettes.

54 Source: SRPS EN 1860-2
Appendix I  Applicable EN standards for solid fuel heating & cooking appliances

The most significant European standards used for testing the parameters of residential cookers fired by solid fuel, room heaters fired by solid fuel and heating boilers for solid fuels are the following:

- EN 12815 - Residential cookers fired by solid fuels;
- EN 13240 – Room heaters fired by solid fuels;
- EN 12809 - Residential independent boilers fired by solid fuel, nominal heat output up to 50 kW;
- EN 14785 - Residential space heating appliances fired by wood pellets;
- EN 303-5 - Heating boilers for solid fuels, manually or automatically stoked, nominal heat output of up to 500 kW.

The standard EN 12815 sets requirements for designing, production, manufacture, safety and performances (utilization degree and emission), instructions and marking, together with accompanying testing procedures and test fuels for testing residential cookers fired by solid fuels. Among other provisions this Europe-wide EN standard lays down that a cooker must demonstrate an efficiency of over 60% and a capability of burning for at least 1 hour between refuels on wood, or 2 hours (3 if automatically controlled) on other fuels.

The standard EN 13240 sets requirements and test methods for room heaters fired by solid fuels. This is the main European Standard for room-heating solid fuel stoves, with or without boilers, including those which can be operated with the door open. It covers freestanding appliances and inset (built into the wall) ones only where they can be installed without special modification of their setting. Other types of inset heater are covered by EN 13229. It is not applicable to appliances with fan assisted combustion air. Among other provisions it lays down that stoves must be soundly constructed, have an efficiency of at least 50% and CO emissions of less than 1% when operated according to manufacturer’s instructions, need refueling no more than every 45 minutes when burning on wood etc.

The standard EN 303-5 contains requirements and test methods for safety, combustion quality, operating characteristics, marking and maintenance of heating boilers. It also covers all external equipment that influences the safety systems (e.g. back burning safety device, integral fuel hopper). The standard EN 12809 contains requirements and test methods for residential independent boilers fired by solid fuel, with nominal heat output up to 50 kW. This European Standard specifies requirements relating to the design, manufacture, construction, performance (efficiency and emission), safety, instructions and marking together with associated test methods and test fuels for type testing residential independent boilers fired by solid fuel. This standard is applicable to hand and automatically fired appliances having nominal heat outputs up to 50 kW, the primary function of which is to provide hot water for central heating and/or domestic use.

The European Standard EN 14785 specifies requirements relating to the design, manufacture, construction, safety and performance (efficiency and emissions), instructions and marking together with associated test methods and test fuels for type-testing residential space heaters fired by wood.
pellets, and mechanically fed up to 50 kW nominal heat output. According to this standard, the measured total efficiency from the mean of at least two test results at nominal heat output and at reduced heat output shall be at least 75% and 70% respectively.
4 References

6. Internal business reports of the companies for wood fuels production in Serbia
19. Vukadinović M. Internal supply chain assessment reports prepared by for different clients, including IFC, the World Bank, private sector
20. University of Belgrade-Faculty of Forestry, Centre for timber trade: data bases, Belgrade.