Appendix 8

Sustainable utilization of biomass for low emission energy purposes in Serbia

---

For the GCF-FAO Project "Enhancing the resilience of Serbian forests to ensure energy security of the most vulnerable while contributing to their livelihoods and carbon sequestration (FOREST Invest)"

INDEX

a) Abbreviations and Acronyms

EBRD = European Bank for Reconstruction and Development
EE = Energy Efficiency
EIB = European Investment Bank
EU = European Union
FAO = Food and Agricultural Organization of the United Nations
IFI = International Finance Institution
GCF = Green Climate Fund

GEF = Global Environmental Facility
GJ = gigajoule
HH = Households
kcal = kilocalories
KJ = kilojoule
kWh = kilowatt hour
MJ = megajoule
OGRS = Official Gazette of the Republic of Serbia
RE = Renewable Energy
RSD = Serbian Dinar
SDG = Sustainable Development Goals
SRP = Short-Rotation energy crops plantations
toe = tonne of oil equivalent
UNDP = United Nations Development Programme
USD = United States Dollar
WP = Working Paper

b) Definitions and Glossary

Definitions are taken from 1

Biomass is defined – from a scientific and technical point of view – as material of biological origin form (EN 14558:2010). Biomass is organic material that is plant or animal based, including but not limited to dedicated energy crops, agricultural crops and trees, food, feed and fibre crop residues, aquatic plants, alga, forestry and wood residues, agricultural waste, processing byproducts and other non-fossil organic matter (prENISO/DIS 16559:2013).

Biofuels are solid, liquid or gaseous fuel produced directly or indirectly from biomass.

Forest fuel (fuelwood) is produced directly from forest wood or plantation wood through mechanical process, the raw material has not previously had another use (prENISO/DIS 16559:2013).

Wood fuels are defined as all types of biofuels originating from woody biomass, where the original composition of the wood is preserved and unaltered from its original form (FAO unified bioenergy terminology (UBET)

Definitions taken from 33

Biomass District Heating (DH) systems. Modern biomass DH systems are equipped with process control systems supporting fully automatic system operation based on the system's head load.

Biomass CHP technologies. Cogeneration—also known as combined heat and power (CHP)—is the simultaneous generation of heat and power, both of which are used for better total efficiency than conventional energy systems, since better exploitation takes place and energy is used to produce heat as well.

Small-scale biomass heating appliances. Wood stoves and wood-log small boilers are widely used in all W-B countries, while wood-pellet and wood-chip appliances are less common. Use of agricultural biomass and dedicated energy crops in domestic appliances may cause technical problems from the formation of molten or partially fused deposits on grates and chimneys exposed to radiant heat.

c) Currency Equivalent

1 Serbian Dinar = 0.0094 United States Dollar

d) Weights and Measurements

1 kWh = 860 kcal = 3.600 kJ (3.6 MJ)
1 MJ = 239 kcal = 0.278 kWh
1 kcal = 4.19 kJ = 0.00116 kWh
1 toe = 41.87 GJ = 11.63 MWh

Standard metric system utilized

1 Introduction

This working paper represents an analysis of the possibilities for a sustainable development of the solid biomass sector for energy purposes in Serbia to support the elaboration of the project "Enhancing the resilience of Serbian forests to ensure energy security of the most vulnerable while contributing to their livelihoods and carbon sequestration". The project is intended to give a significant contribution to Serbian's Nationally Determined Contributions to the UNFCCC.

As the experience in many different countries like, e.g. Italy, Austria and Finland showed, the development of biomass value chains can have very positive effects on rural employment and to sustainable development in general, but only if careful participatory planning safeguards biodiversity and overexploitation of resources.

2 Country Context related to Energy

According to the International Energy Agency (IEA), Serbia generates most of its total energy supply (664,224 Tera Joule (TJ) in 2020) from coal (49.6%), followed by crude oil (22%) and natural gas (12.5%). Biofuels, including mainly solid fuelwood (10.8%)[1] and Hydropower (4.9%) are the most significant renewable energy sources (RES), while wind and solar were only contributing 0.6% to the share. Fuelwood extraction is largely uncontrolled and poorly regulated by the outdated forest management processes, which explains partly also why official statistics generally represent only a fraction of its consumption: In 2019 e.g., the energy balances bulletini indicated that households consumed 1.957 million m³ of fuelwood annually [53], an exponentially lower value than the consumption estimated by scientific studies of about 6.7 million m3 per year [11]. Climate change, rising energy prices and current geopolitical tensions threaten Serbia's energy security. Since the country obtains approximately 60% of its oil imports and 89% of natural gas imports[2] from the Russian Federation (2019), the current conflict in Ukraine is negatively impacting long term energy planning. It is also leading to higher energy costs for the state and ultimately for consumers. In addition, climate change is also expected to negatively impact hydropower production[3]. It will also likely further increase Serbia's dependency from imports of energy and fossil fuels. Electricity prices are expected to rise by 15%[4] to 30% for households and by 30% to 70% for industry by 2023. Also, wood pellet prices skyrocketed in 2022 (+60%) due to the changing costs of electricity and raw material from an average retail price of Euro 200 per ton (2021) to the current Euro 320/t.

These increases will particularly impact poor and vulnerable people. An electricity tariff increase of 16.3 percent will lead to an increase in the share of household income spent on electricity by 0.5 percentage points. At the same time, the overall poverty rate (already on the rise due to COVID-19 adverse impacts) can increase by 1% under these conditions [54]. Despite government intervention, energy costs are already a high burden for the country, as evidenced by the fact that households currently spend more than 10% of their average expenditure on energy (the threshold to be considered "energy poor") [33] and that Serbia ranks among the 10 European countries with the highest share of households reporting that they could not keep their home adequately warm [54]. These trends reduce households' purchasing power, especially for the poor and vulnerable, and slow poverty reduction. Given that fuelwood is still the cheapest and most easily available source

[1] Includes next to solid biofuels from forests among others also municipal waste since the Total Energy Supply balances of the IEA indicate for Serbia in 2020 the category "Biofuels and waste" with a share of 10.8%.

[2] Estimation from Al Jazeera based on OEC data (2022)

[3] Both this issues are currently addressed by the Republic of Serbia via investments in wind and solar power parks (investors will be able to participate in 1.5 GW auctions until 2025) and improving the efficiency of irrigation technologies / practices and mainstreaming climate change adaptation into its water policy framework. With regards to the latter, the Republic of Serbia is currently engaged in upgrading and climate proofing its Irrigation Program with the support of the EBRD and FAO.

4 World Bank, Commodity Markets Outlook. April 2022. https://openknowledge.worldbank.org/bitstream/handle/10986/37223/CMO-April-2022.pdf

for heating, rising energy prices suggest that its consumption will increase further. According to official statistics, the share of wood fuels in final energy consumption has increased from 11% in 2017 to 11.86% in 2020[5]. To meet growing demand, private and public forests face pressure to increase logging even though the exploitation of forest resources is already at unsustainable levels [18].

In the BAU scenario, fuelwood extraction continues therefore to be the main anthropogenic driver of forest degradation. Given that most of the GHG emissions are stemming from the energy sector, the expansion of renewable energy from biomass plays however also an important role for the country's efforts to mitigate its climate change impact and to achieve its development goals. As an EU candidate country, Serbia aligns its actions to EU-directives and policies and generally to the EU acquis, e.g. the 2030 Climate and Energy framework that sets as Renewable Energy Sources (RES) target a share of 32% of the final energy consumption. Serbia has declared to increase its share in the same time frame from the current 26.3% (2020) to 33.6%.[6] Biomass, mainly from forest resources (44%) and agricultural harvesting residues (48%), represents 63% of the total potential for RES in Serbia and is therefore essential to reach any RES targets. It has to be noted that 67% of the total calculated technically feasible energy potential of forest resources are already utilized. There is therefore an urgent need to organize the sector in a sustainable and integrated manner in order to allow an efficient use of resources and to utilize the potential of other biomass sources - like short rotation plantations (SRP) and agricultural harvest residues for energy purposes. If properly and sustainably addressed, biomass, including fuelwood, can act as a central element in fulfilling national energy, climate and development objectives and can also serve as a tool to alleviate poverty in rural areas. It is important that the energy sector is timely informed about the objectives of the country's forest strategy and policy, to see the real potential for wood biomass supply in relation to the strategic goals of the energy sector.

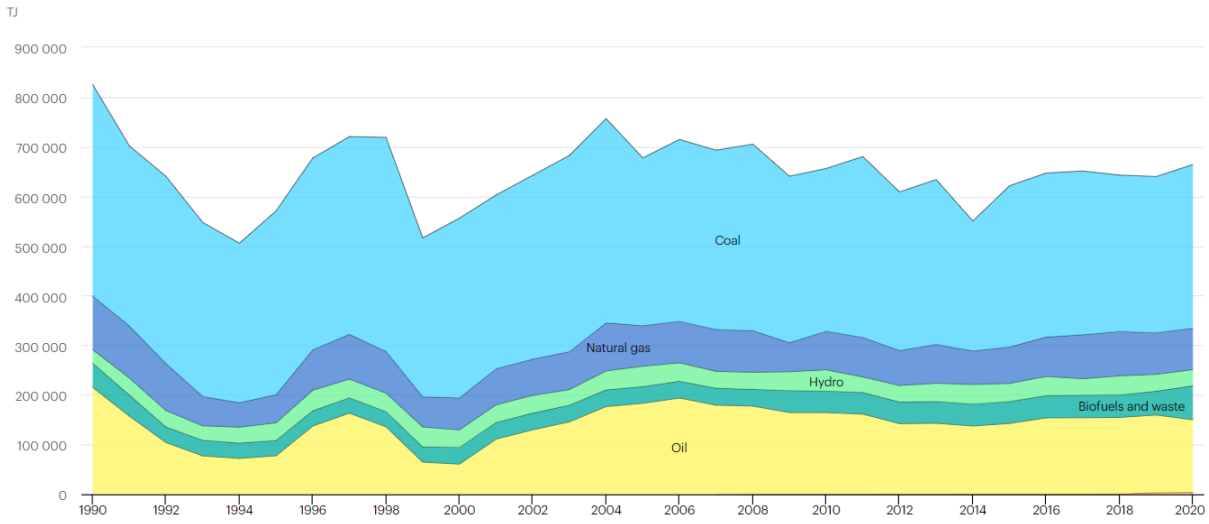


Figure 1 Total energy supply (TES) by source, Serbia (IEA)

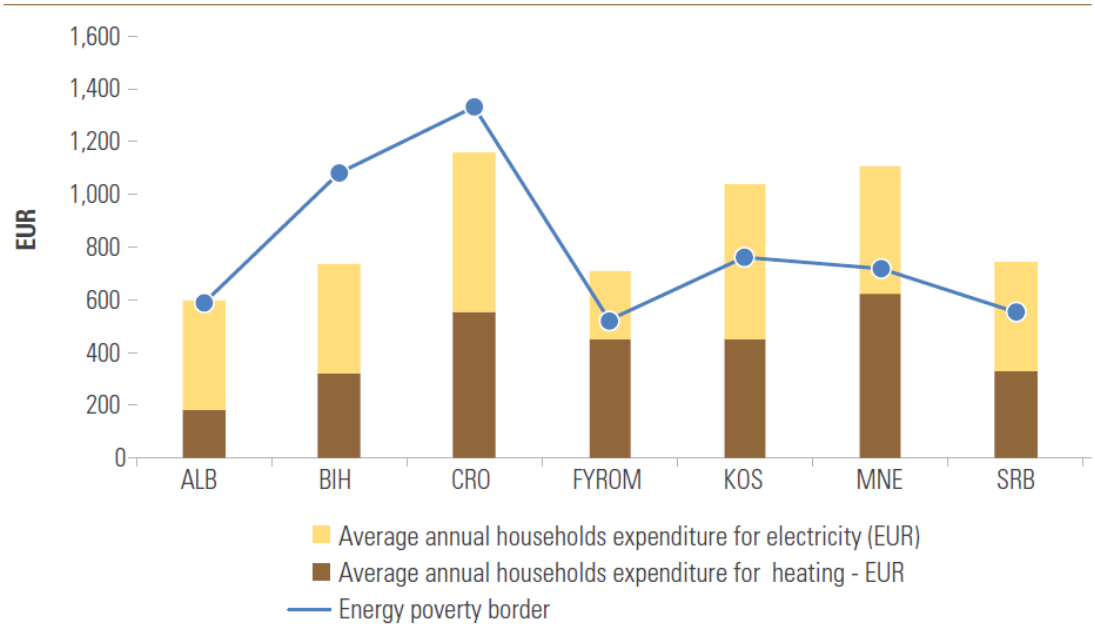
Final energy consumption corresponds to 9.2 Mtoe in 2018, an increase of 30% from 2000. The household sector has the highest consumption with 34%, followed by industry with 31%, transport 23%, services (10%) and agriculture (1.9%). Since 2000 almost all sectors have increased consumption significantly, only the household sector has decreased its share by 3%, in absolute

[5] Statistical Pocketbook of the Republic of Serbia, 2022 and 2018.
[6] Public consultation on Serbia's national energy and climate plan: Coal use to be cut 25% by 2030 (balkangreenenergynews.com)

numbers the reduction of energy consumption of the sector was 9.2% (44). Primary energy consumption corresponds to 24.6 MWh (2.12 toe) per capita per year, which is 30% lower than the average EU 27, but higher than other Western Balkan countries[7] (55).

Like in other Western Balkan countries, average energy expenditure in HH in Serbia is higher than the energy poverty border (=10% of total annual HH expenditure). Across the whole region these average costs correspond to Euro 829 (10.4% of average HH spending). In this regard, all measures that affect energy prices have a high social impact.

Figure 2 Average Annual Household Expenditures for Heating and Electricity (33)



Fuelwood represents the main source of energy for heating for over 49% of the total population and over 79% for rural communities. The extraction rate of fuelwood has already surpassed 6.7 mcm (2020) and imports increased by 80% (2017) in the past decades and demand is growing due to increasing prices of energy. Significant increases in fuelwood consumption over the last decade has been detected in studies[8] and official statistics[9], and is expected to grow further by an average of at least 0.5%[ii] per year in the coming years.

Approximately 60% of energy consumed for heating purposes in Households are currently coming from Non-fuelwood resources (see table 1). Assuming that due to higher energy costs, HH would consume 10% less of this resource and substitute them with fuelwood the following could result: To substitute 5,233 TJ of energy, approximately 654,000 tons[10] of wood has to be provided corresponding to 1.06 million m3[11]. Reportedly, Serbia is already using all of its yearly net forest increment. A significant increase in wood fuel consumption would therefore lead to a further degradation of the forest and consequently reduce its capacity to act as a carbon sink. The GHG emissions created would hence correspond to an estimated 49,732 tCO2eq. per year.

Table 2 Energy consumption by Serbian HH for heating (author estimation12)

Energy carrier	TJ

[7] Albania, Bosnia-Herzegovina, Croatia, Montenegro and Northern Macedonia
[8] From 2010 to 2020 total wood fuel consumption by HH has increase by 5.1%. Branko Glavonjić, 2023. Inventory of wood energy consumption and GHG emissions from wood fuels in Serbia
[9] According to official statistics, the share of wood fuels in final energy consumption has increased from 11% in 2017 to 11.86% in 2020. Statistical Pocketbook of the Republic of Serbia, 2022 and 2018
10 Based on the calorific value of wood at 50% moisture being 8GJ/tonne.
11 Based on the assumption that 1m3 weighs ca. 615 kg.
12 Data for Gas, Heat and Carbon for HH has been retrieved from Bulletin, Energy balances 2020 by Statistical Office of the Republic of Serbia

Gas	11,223
Heat	18,268
Carbon	5,342
Electricity[13]	17,500
Total Non-Fuelwood	**52,333**
Fuelwood[14]	34,672
Total	**87,005**

Policy framework: There exists a multitude of laws and regulations addressing renewable energy in general and biomass in particular that will be presented underneath. Generally speaking, while the utilization of biomass from forests are relatively regulated, there appears to be currently little corresponding legal text and hence also no legal impediment to collect and utilize agricultural harvesting residues for energy purposes.

Serbia is a candidate for membership in the European Union and joined the Energy Community (EnC) through the adoption of the law ratifying the corresponding treaty in the year 2006 (OGRS, No. 62/06). With this passage the country committed moreover to the implementation of the European directives in the energy sector (36).

Biomass action plan, 2010: This strategy aims at enhancing biomass utilization as a renewable energy source among other through (i) efficient use of local resources for energy production; (ii) mitigation of climate change; (iii) decrease dependence on energy imports; and (iv) job creation. The document estimates that 63% of the total potential for RE is from the biomass sector. It is worthwhile to mention in this regard that forests cover approximately 30% and agricultural land 55% of the country (17).

National Action Plan for Use of Renewable Energy Sources (OGRS, No. 53/2013). The policy is part of the efforts to harmonize legislation with the European Union and applies among others Directive 2009/28/EC on renewable energy sources. In this regard it set its aim is to increase renewable energy share in the gross final energy consumption (GFEC) from 21.2% in 2009 to 27% in 2020 (36). This ambitious goal became binding through the Ministerial Council of the Energy Community Decision of 18 October 2012 (D/2012/04/MC-EnC). (41).

National Energy Efficiency Action Plans (NEEAP): In line with the provisions of the different EU-Directives and of the Energy Community, Serbia is elaborating and continuously updating its NEEAP, for a time frame of 3 years. Currently, the country is elaborating the 4th NEEAP that will be the first one in line with the requirements of Directive 2012/27/EU. The increase in efficiency of household appliances, and hence also biomass combustion technology, has always been a priority for efficiency strategies. Other important aspects and opportunities have and will be, among others, the modernization of district heating in the country.

The **Energy law**, adopted in 2014: Provides an overall outline on safe, secure, and high-quality supply of energy and promotes renewable energy and energy efficiency. The law introduced several improvements with respect to the use of RES and opened new potential for investing in the free market. To be highlighted the system for the mandatory repurchase of electric energy from privileged producers. The law transposes Directive 2009/28/EC on the promotion of the use of RES and provides updates of Feed-in Tariffs (FiT, first introduced in 2009) to promote the sector.

13 The calculation for energy has been carried out based on the information retrieved from Engelmann et al, 2020 that electricity in Serbia has a share of 20.1% of total energy consumption for heating.

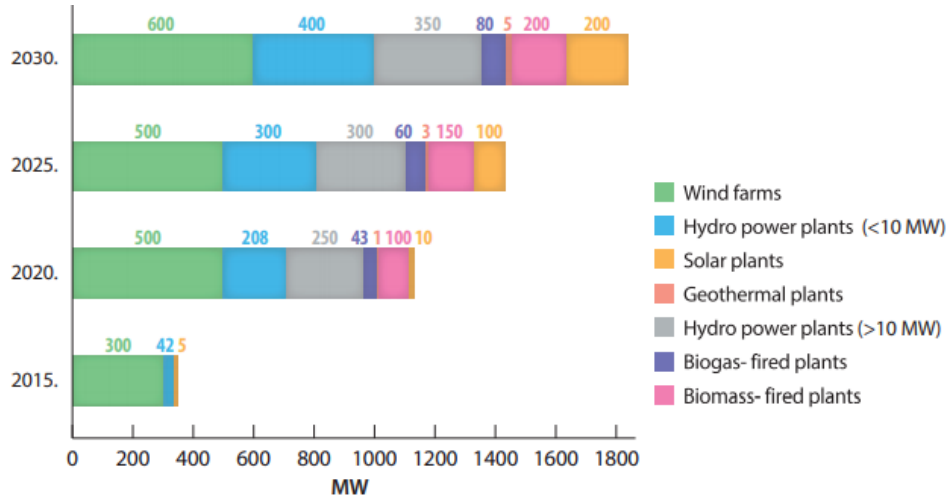
14 Energy for wood fuel has been estimated utilizing the following assumptions: (i) According to UNDP between 2010 – 2016 wood fuel consumption of HH in Serbia corresponded approximately to 7 million m3 per year. (ii) Per m3 a weight of 614 kg has been estimated. (iii) The calorific value of wood with a moisture content of 50% is 8MJ/kg.

Law on Rational Use of Energy (OGRS No. 25/13) addresses among others efficient energy production, transmission, distribution and consumption and aims also at an increased production through RES.

Law on Use of Renewable Energy Sources, (OGRS No. 40/21), proposes a new incentive system to promote electricity generation from RES. It includes market premiums and a limited feed-in-tariff, accessible through separate quotas and auction processes. The goal is to create a more favorable regulatory environment, encouraging investments in RES plants of various capacities. The scheme supports smaller projects with capacities under 3 MW for solar and wind, and under 0.5 MW for other RES power plants through the feed-in-tariff mechanism. By enabling investors to obtain both incentives through auctions, the law aims to attract more investment in renewable energy.

Energy Sector Development Strategy of the Republic of Serbia until 2025 with projections until 2030 (OGRS, No. 101/2015), based on the EU Energy Road Map, that focuses next to the modernization of energy facilities and energy efficiency also on the promotion of renewable energy and proposes a roadmap. The biomass sector plays in this regard an increasingly important role not only for heating but also in electricity production. As figure 4 shows, contribution from biomass should be continuously growing until 2030.

Figure 3 Projection of the construction of plants for RES (39)



Energy Security Plan: In 2022 the Ministry of Mining and Energy published a very ambitious plan including short- and long-term solutions to achieve energy transition and phase out of coal fired power plants by 2050. Among others the policy also the establishment of a company called "green energy of Serbia" tasked to with building new green power plants, achieving Climate neutrality by 2050 and a 49.6% of RES share in gross final energy consumption by 2040.

The **Strategy of Agriculture and Rural Development** of the Republic of Serbia for the period 2014-2024 („Official Gazette", No. 85/2014) and the new Law on Agricultural Land No. 112/2015 [12] have created the necessary initial conditions for state-owned land to be leased in order to establish Short Rotation Plantations. The provisions of this Law prescribe that *"state-owned agricultural land which has not been leased for the last three agro-economic years and was not subject to use, can be leased through public auction with the starting price RSD 0 to persons engaged in energy production from renewable."*

National Strategy of Sustainable Development (OGRS, No. 57/08) and the Action plan for the implementation of the national strategy of sustainable development for the period from 2011 to 2017 (OGRS, No. 62/11) both address the planning in implementation of measures and activities for local and national sustainable development and promote in this regard also an increased share of RES.

The utilization of biomass is also of main importance to fulfill the commitments of all mitigation scenarios ("with measures" and "with additional measures") of the **Second National Communication in the frame of the UNFCC** (SNC), as they foresee a significant increase in renewable energy by 2030 and 2050 when compared to the BAU case and that the country will be able to independently cover its electricity demand by 2050. Furthermore, the scenario "with measures" foresee that a further 564 MW RE based on the projected trend from 2020-2030 will be installed, leading to 1159 MW from Wind, Sun, and bioenergy sources by 2050 and an emission reduction of 3-4 million tCO2. Moreover, the SNC indicates also the possibility to utilize biomass waste as a fuel for industrial processes (4).

Serbia signed the Sofia Declaration on the Green Agenda for the Western Balkans committing to the work towards the 2050 target of a carbon neutral European continent.

The recent adoption (March 2021) of the **Law on climate change**, the first stand-alone law on this crucial topic, can pave the way to more efficient climate change adaptation, while at the same time reducing GHG emissions. This will also give the necessary push to reach the newly established goals of cutting GHG emission by 33% by 2030, significantly increased when compared to the 9.8% emission cut by 1990 communicated within the first NDCs. The law on climate change also harmonizes the legal framework with the regulations of the EU that foresee a special green agenda for the de-carbonization and sustainable development of the western Balkans in the frame of the Green Deal and plans to be fully adapted to the unavoidable Climate Change by 2050.

In the framework of its **Low Carbon Development Strategy**, aligned with the Climate Change Law approved in 2021, Serbia developed different 4 GHG mitigation scenarios[15]. The policy recommends following the M2 pathway until 2030 as the most cost effective and socially fair solution. This pathway foresees the implementation of all the EU *acquis*[16] and to shift to higher ambitions by introducing a mix of measures under M2, M3 and M4 scenarios with gradual levels of actions and emission reduction objectives [48 p.20]. In this regard, the strategy declares as its general objective to reduce GHG emissions by 33% by 2030 and by at least 65% by 2050 (compared to 2010 levels). In order to achieve this, one of the most crucial goals is to increase the carbon sink of the forests by 17% by 2030 and by 22% by 2050 (compared to 2010). The Low Carbon Development Strategy gives a particular importance to the forestry sector as it offers clear and significant mitigation potentials and important socio-economic benefits but also because it is vulnerable and in need for adaptation measures as reported in each of the three National Communications[17].

The Draft of the **third National Communication in the frame of the UNFCCC (TNC)**, 2020, developed 3 main categories of adaptation measures, based on Financial, Technological and Capacity building Needs, including: (1) Afforestation using location mapping and tree species adapted to climate change; (2) Introducing "Climate-Smart Forestry" approaches; and (3) Changing forest management practices following a Close-to-Nature-Forest- Management approach. Investment needs are estimated to be EUR 92 million per year up to 2030, mainly for reaching the proposed afforestation targets. In this regard and especially to reach the even more ambitious 2050 targets, it will also be essential to attract financing from the private sector, in particular through decarbonization initiatives: local companies could for instance invest in afforestation activities and obtain carbon credits for neutralizing emissions deriving from its own business practices. An important pre-requisite for such an approach is of course the implementation of a credible mechanism to monitor and verify investments, which the country has been lacking so far.

[15] Identified as the increasingly ambitious scenarios M1, M2, M3 and M4. The M1 scenario is the baseline scenario plus the implementation of the EU-Emission Trading Scheme (EU-ETS). Since it has shown not to be able to allow penetration of RES by 2030 it has not been considered for further analysis in the frame of the Low Carbon Strategy

[16] Applicant countries are required to accept the acquis before they can join the EU. The EU's 'acquis' is the body of common rights and obligations that are binding on all EU countries, as EU Members. It is constantly evolving and comprises: the content, principles and political objectives of the Treaties legislation adopted in application of the treaties and the case law of the Court of Justice of the EU; declarations and resolutions adopted by the EU; measures relating to the common foreign and security policy; measures relating to justice and home affairs; international agreements concluded by the EU and those concluded by the EU countries between themselves in the field of the EU's activities. See https://ec.europa.eu/environment/enlarg/candidates.htm and https://eur-lex.europa.eu/summary/glossary/acquis.html

[17] Hydrology and water resources, forestry, agriculture and health care are considered as the most vulnerable sectors (SNC, 2017) and adaptation measures were developed for each sector accordingly.

Based on the implementation of the described mitigation scenarios (M1, M2, M3 and M4) and in compliance with the requirements of the European Emission Trading Schemes (EU-ETS) requirements[18], Serbia is expected to achieve carbon neutrality according to the TNC by 2070, implying a significant increase in forest cover [49]. Nonetheless, institutional capacity and enabling conditions, in particular the establishment of national offsetting[19] / insetting[20] mechanisms as well as of a robust monitoring system, need to be strengthened. All envisaged scenarios imply the implementation of the EU ETS, as minimum requirement[21]. M2, M3, M4 also include additional measures with different target levels (including RES application for example), M4 being the highest level of mitigation expectations.

The above outlined emission reduction targets are also considered in the second/revised National Determined Contributions, approved in 2022, with which Serbia is expected to step up significantly its climate mitigation targets. In fact, while the first NDC aimed at reducing GHG emission by 9.8% by 2030 (ref. 2010), the revised version foresees an emission reduction of 33.3% for the same time period. For this purpose, the document includes 14 mitigation measures, two of which are directly related to the objective to reach a 17% increase in carbon sink by 2030 also through the annual conversion of 7,000 ha of coppice forest to high forests and the annual afforestation of 5,000 ha, while four of the other measures aim at increasing the Energy Efficiency (EE) and the share of Renewable Energy Sources (RES) in the tertiary sector, industry[22], households and district heating. Two further measures deal with EE measures in the residential and tertiary sectors, two with transport and two further measure address mitigation potentials in the agricultural sector. In addition, one measures aims at increasing the share of RES in energy production and one measure at the introduction of a CO_2 tax in the industry sector that shall gradually increase from 2022 onwards[23].

Given that most of the GHG emissions are stemming from the energy sector, the expansion of renewable energy plays an important role for the country's efforts to mitigate its climate change impact and to achieve its development goals. As an EU candidate country, Serbia aligns its actions to EU-directives and policies and generally to the EU *acquis*, e.g. the 2030 Climate and Energy framework that sets as RES target a share of 32% of the final energy consumption. So far, Serbia has reached a share of 21.5% (2019). Biomass, mainly from forest resources (44%) and agricultural harvesting residues (48%), represents 63% of the total potential for RES in Serbia. It has to be noted that 67% of the total calculated technically feasible energy potential of forest resources are already utilized. It is therefore of utmost importance to utilize the potential of other biomass sources - like short rotation energy plantations and agricultural harvest residues for energy purposes – and, at the same time, increase the efficiency of wood biomass consumption.

In support to the implementation of the above-mentioned policies, the Low Carbon Development Strategy outlines 5 Specific Objectives (SOs) to be reached for a climate resilient Serbian society. Two objectives deal with decreasing GHG emissions in EU-ETS sectors[24] (SO1: 15,0% GHG emissions decrease by 2030 and between 66,4% and 76,8% by 2050 compared to 2010) and non-EU-ETS

[18] The EU ETS is the major EU Carbon market instrument to reduce greenhouse gas emissions cost-effectively and is based on a "cap and trade" principle. As per the Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading (EU-ETS) Decision 406/2009/EC-Effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments, Serbia is expected to create the enabling conditions to implement the EU ETS system prior to its EU accession. See https://www.klimatskepromene.rs/en/euclimate/emissions-trading-system/

[19] A carbon offset is a reduction in emissions of carbon dioxide or other greenhouse gases made in order to compensate for ("offset") an emission made elsewhere [IPCC, 2018].

[20] In setting is defined by the International Carbon Reduction and Offset Alliance as: the development of a carbon offset project within a company's own supply chain and supply chain communities.

[21] Through the Law on climate change, adopted in March 2021, Serbia introduced MRV aspects of the ETS. However, trading aspects are not introduced, and it is expected to apply trading mechanism once Serbia becomes the EU member state. The same Law introduces main aspects of the Effort sharing decisions. Emissions and removals from land use, emission and removals from land use change and forestry (LULUCF), which are covered by the Kyoto Protocol and from 2021 by the LULUCF Regulation.

[22] The measure is foreseen to impact the manufacturing industry.

[23] The CO_2 tax addresses plants above a certain size (TBD) in the following industrial sectors: (i) power and heat generation; (ii) energy-intensive industry sectors including oil refineries, production of steel and iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals; and (iii) production of nitric, adipic and glyoxylic acids and glyoxalin.

[24] E.g. Electricity and heat generation, energy-intensive industry sectors including oil refineries, steel works, and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals.

sectors (SO2: 9,7% GHG emissions decrease by 2030 and between 33,5% and 54,5% by 2050 compared to 2010). SO3 addresses the aforementioned need to increase the forest sink by 17% by 2030 and by at least 22% by 2050. SO4 aims at enhancing the climate resilience of the priority sectors of agriculture, water and forestry. Specific Objective 5 is the promotion of a climate neutral and climate resilient economy and society. It is crucial to identify feasible mechanisms for the decarbonization of the industry, as a carbon intensive production could diminish the competitiveness of the Serbian economy in the long run. The Serbian industry is responsible for 69% of the country's GHG emissions, with the energy industry alone contributing to 52.6% followed by the IPPU with 9.5%[25] and the manufacturing and construction industries with 7.5% of GHG emissions. In the BAU scenario, industrial emissions are estimated to further increase by 9.8% until 2050 [49]. Therefore, the different sectoral policies set up emission reduction targets to be reached in the next decades (as reported in Table 9, and aligned with the mitigation target scenarios shown in Table 2), in particular through investments in EE and RES (48). Such decarbonization practices are also part of the EU Climate Action 2050 and the EU Green Deal. Nonetheless, the governance of the decarbonization process is still in its initial phase and requires support to enable the country to reach its targets and to align its actions to the EU strategy.

Institutional set-up energy sector

The Ministry of Energy and Mining is the reference governmental institution related to Energy. It has been founded in 1991, abolished in 2011 and reinstalled in 2014 and is built up of 7 sectors that are all responsible to prepare development strategies and action plans, draft laws and regulations and carry out harmonization with the European Union Regulations, all in the corresponding fields of action. Furthermore, other noteworthy activities are the following:

Electricity Sector: Monitoring of performance of the electricity network, including losses in transmission and distribution network; issuing energy permits for electricity generation facilities with a capacity of over 10 MW. Two internal units, Section for Legal and Economic Activities and Sector for Electricity and Technical Activities.

Green Energy Department: monitoring status of RES development and identification for the enhancement of the technologies in the power, heat and transport sector. Preparation of project finance by EU and other international institutions.

Sector for energy efficiency and heating plants: Analysis of infrastructural need and planning of local communal infrastructure programs. Cooperation with the financing institutions of local utility projects. Development of environmental protection strategies and plans in the field of energy for the purpose of sustainable development and for reducing the impact of the energy sector on climate change; Two internal units: (i) Division for Energy Efficiency Improvement, Sustainable Development and Climate Change in the Energy Industry; (ii) Group for preparation and implementation of communal infrastructure programs.

Oil and Gas Sector: preparation of proposals for Government measures in case of supply disruptions and threats to security of natural gas supply, operational oil reserves and oil derivatives. Monitoring the quality of petroleum products and pipeline transport of gaseous and liquid hydrocarbons. Issuing energy permits for energy facilities in the field of oil and gas. Internal Units: (i) Section for Legal and Economic Activities in Oil and gas Sector; (ii) Section for Technical and Process Activities in Oil and gas sector

Sector for Geology and Mining: geological research and exploitation of all types of mineral raw materials and geological resources; preparation of annual and medium-term programs of detailed research works in the field of natural resources and geological research in connection with the exploitation of mineral resources and providing material and other conditions for the

[25] the IPPU the metal industry is responsible for 63%, the mineral industry and the chemical industry for 9.6% of emissions and 4.5% of emissions are attributable to "product uses as substitutes for ozone depleting substances".

implementation of these programs. Two internal units: (i) Division for Geological Exploration and Mining; (ii) Section for Legal and Economic Activities in Geology and Mining Sector.

Sector for International Cooperation and European Integration: coordination and preparation of ratification, i.e. accession to international treaties; coordinating the implementation of multilateral agreements and cooperation with the secretariats of multilateral agreements for the purpose of their implementation;

Inspection supervision sector: the sector carries out supervision according to the different energy laws. Five internal units: (i) Group for legal and administrative affairs in the field of inspection affairs; (ii) Electrical Inspection Division; (iii) Pressure Equipment Inspection Division; (iv) Energy Inspection Group; (v) Division for Geological and Mining Inspection.

The **Ministry of Agriculture, Forestry and Water Management**, in particular the Directorate for Forestry, is a competent institution related to the extraction of woody biomass from forests that can be sold and utilized as fuelwood. Furthermore also the two Public Enterprises (PEs) Serbia Shume and Vojvodina Shume are the main responsible for forest management in Serbia and do also sell wood fuel. For more information on aforementioned institutions, please refer to the institutional set-up of the Forestry sector.

The **Ministry of Environmental Protection** (MEP) was established in 2017. It oversees the implementation of the Law on Nature Protection and of any policies related to environmental protection.

The **Ministry of Education, Science and Technological Development** is responsible for the scientific development of the sector.

The mission of the **National Biomass Association SERBIO,** founded in 2012 is to contribute to the sustainable development of bioenergy sector in Serbia. Among others it is actively involved in the development of markets and a favorable business environment for the sustainable bioenergy sector in Serbia and carries out public awareness and capacity development in the sector. In this regard the association participated also in various important projects, among others in the international project BioRES heating, financed by the European Union (see section about projects).

3 Sector Performance – Energy from Biomass

The expansion of renewable energy plays an important role in the country's challenge to obtain energy independence. Biomass represents 63% of total potential RES sources, and 44% of the biomass sources are from forest sources. Since Serbia is currently already using 66% of the total technical potential it is of utmost importance to increase energy efficiency and to exploit the potential of other sources like e.g. agricultural biomass (which represents 48% of biomass resources and is so far used to a very small degree) and short rotation energy crops in order for the country to be able to meet its RES targets in a sustainable way.

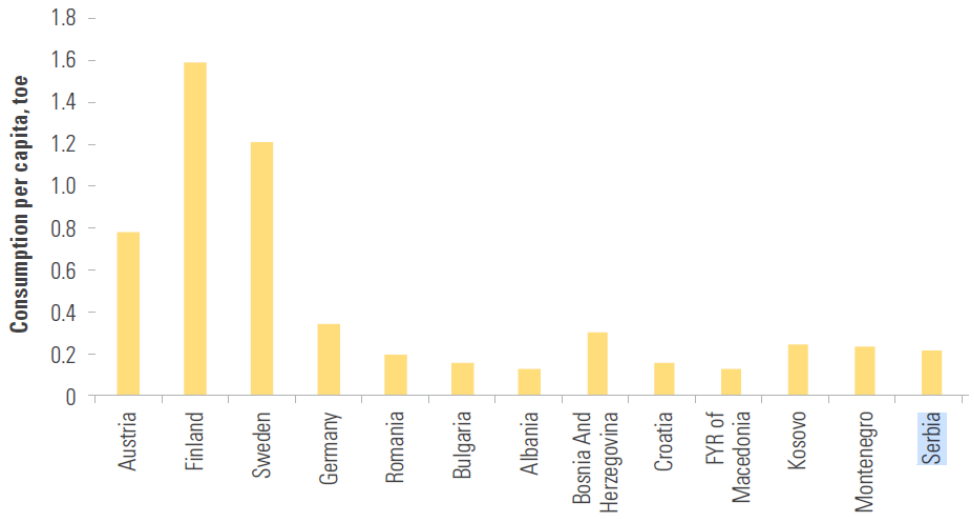
Figure 4 Overview of technical potential of biomass energy use (39)

RES type	Available technical potential in use (million toe/per year)	Unused available technical potential (million toe/per year)	Total available technical potential (million toe/ year)
BIOMASS	1,054	2,394	3,448
Agricultural biomass	0,033	1,637	1,67
Parts of agricultural species	0,033	0,99	1,023
Parts in fruit growing, wine growing and fruit processing	-	0,605	0,605
Liquid Manure	-	0,042	0,042
Wood (forest) iomass	1,021	0,509	1,53
Energy crops	-	-	not available
Biodegradable waste	0	0,248	0,248
Biodegradable municipal waste	0	0,205	0,205
Biodegradable waste (except municipal waste)	0	0,043	0,043

3.1 Biomass from wood energy:

Biomass use (almost exclusively wood fuel for heating) has a long tradition in the country and is utilized in 79% of rural and 49% urban Households. Nonetheless, biomass consumption per capita is lower than in neighboring countries and considerably lower than in countries like Austria and Finland.

Figure 5 Biomass Consumption per capita for Energy Purposes in Selected Countries

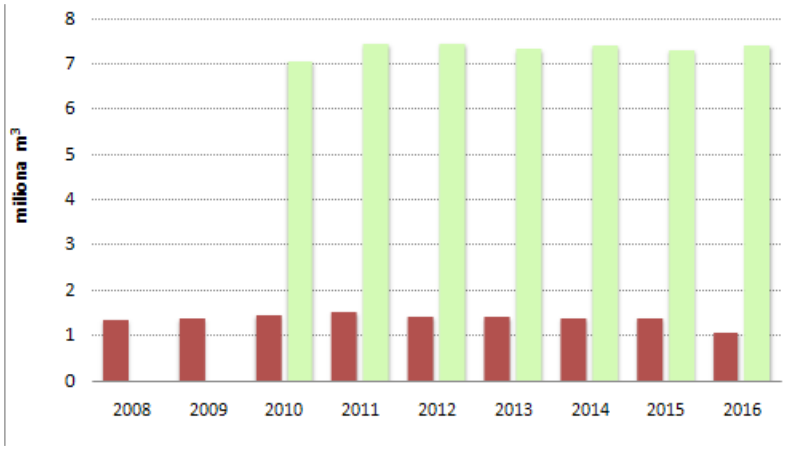


Average wood fuel consumption is estimated to be 9 m3 of stacked wood and ranging from 0,12 m3 /m2 in urban areas to 0,18 m3 /m2 in rural areas. Biomass is used to 81% in autonomous heating

systems like stoves and to a significant share also in central heating systems (18%). While 65% use the energy source next to heating also for cooking, only 2% use it for water heating (37).

Energy from wood fuel has a share of 3.4% of the gross final energy consumption and 25% among RES. According to the WISDOM study commissioned by the FAO, the contribution might however be significantly underestimated and could correspond to 11.6% of the total energy consumption. In the year 2010, e.g. official statistics showed only a consumption of 1.45 mln m3, while research estimations concluded that the real consumption was 7.05 mln m3 (from forest resources and outside forest resources). The difference in the numbers is mainly attributable to the fact the private forest owners often informally outsource wood cutting to contractors, with little or no state control over results. Most of the remaining RES in the final energy consumption come from Hydroelectricity (4) and to a lesser extend from wind, solar energy and geothermal energy.

Figure 6 Production of firewood in Serbia (18). Red color: Official statistics; green: actual production



While the total amount of wood fuel consumed is relatively stable, the amount of wood used for pellets production is continuously and significantly increasing over the last ten years (in 2016 5,16% of wood fuel). The surplus of the carriers is export. 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 the producers decided to construct wood pellet production facilities and to process wood chips further into pellets. Different types of fuels are used for different consumers: briquettes are used for commercial users and wood chips for large boilers (e.g. industries).

The sources for wood fuel are mainly forests (58%), followed by trees and bushes from non-forested areas (32.2%). The remaining is coming from pruning from urban trees, post-consumer wood and municipal wood waste. As can be seen in figures 7 and 8 most of the wood fuel is consumed by households (84.6% in 2016).

Figure 7 Total consumption of firewood in Serbia

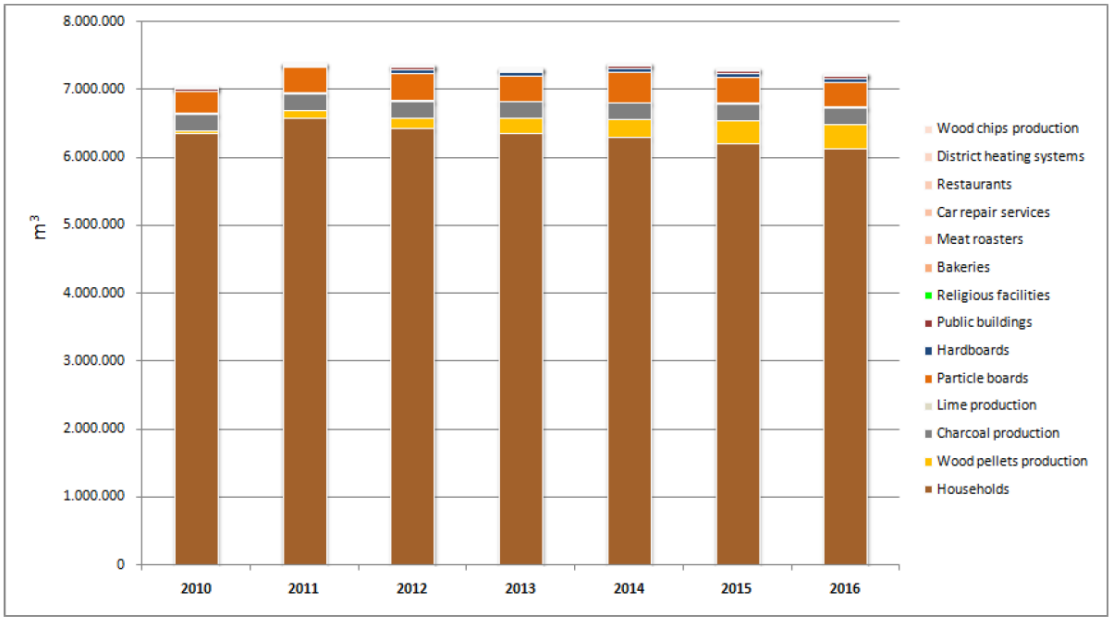


Figure 8 Consumption of firewood in Serbia (2016)

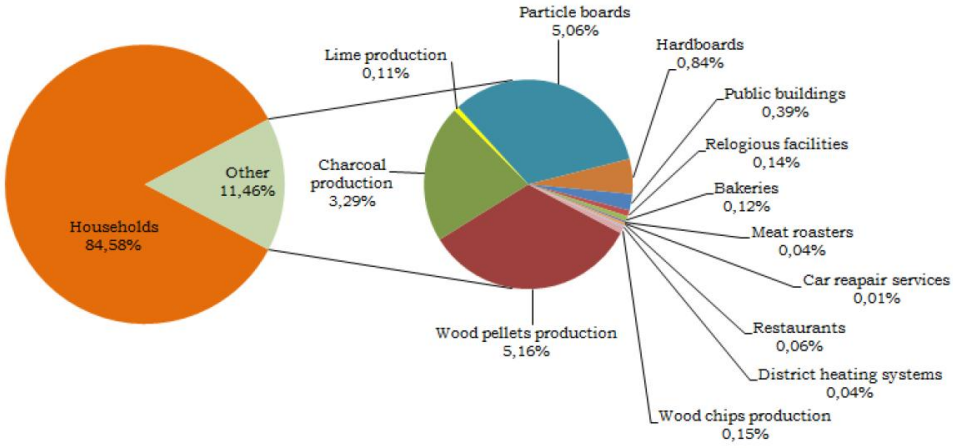
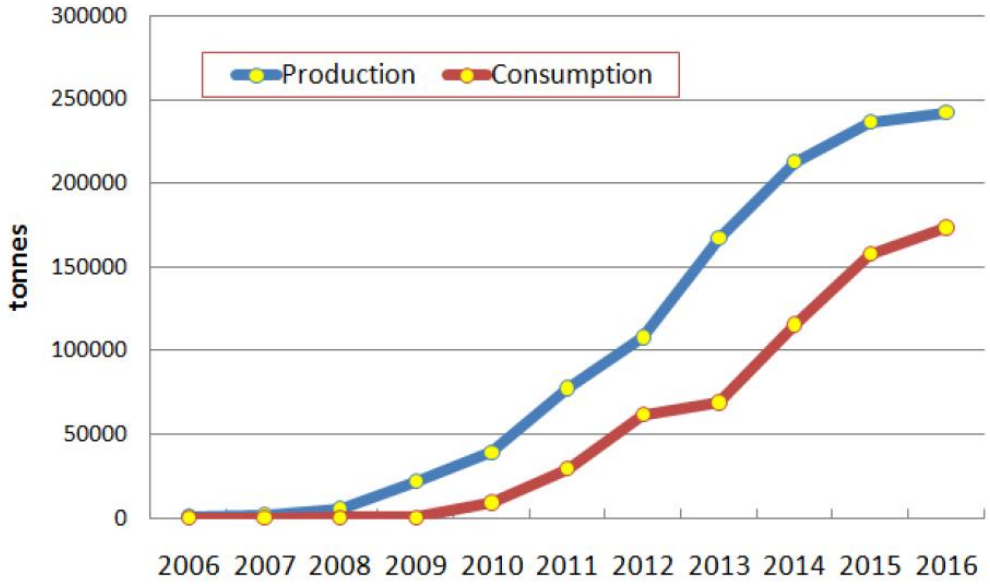


Figure 9 Consumption of wood pellets in Serbia



It is worthwhile to note that the remarkable increase in pellet production (figure 9) and consumption was mainly driven by promotional campaigns of local appliance producers, that committed also to supply the fuel to the consumers until it became widely available. Only since 2017, the government has reduced the VAT on the products from 20% to 10% (the lowest VAT in the region) to further boost the market. With the increasing local demand, the export of the energy carrier decreased from 60% in 2013 to 28.4% in 2016 With the export of Pellets, Serbia is exporting also cheap energy, while at the same time being dependent from much costlier energy imports: the average price (from 2006-2015) of heat produced e.g. by natural gas was in fact 2.1 time higher than the one from wood pellets. Serbia is hence exporting low carbon and cost effective resource to other countries that benefit from it, while importing fossil fuels at higher price (11).

The private sector is very much involved in the production of different types of wood fuels, an overview is given in table 2. The biggest growth in numbers has been by the Pellet producers that grew from 2 in 2006 to 64 in 2016. The biggest concern, as with the appliance producers, is the lack of control over the quality of the products.

Figure 10 Prices structure of biomass production

Description of costs	Costs (RSD/ton)	Structure (%)
Straw	4,374.94	29.13
Briquetting	8,923.24	59.42
Packing	540.00	3.60
Storing	1,178.57	7.85
Total	15,016.75	100.00

There appears to be no framework yet related to the testing of the quality of wood fuels, and only the public enterprises and the national parks classify into two different quality classes. The Serbian state forests are certified according to FSC, which is an essential requirement for the export of wood products to EU member states. Quality control and quality assurance standards are however for processed firewood are however only applied in case of export (50).

Since private forests have a higher share of (not well maintained) coppice origin, its wood is generally considered of lower quality (depending on location). Sawmills and furniture factories use residues either for own consumption or for the production of processed fuel (mainly wood pellets or briquettes) (50).

Wood pellets producers disposing of the high quality ENplus certification have the obligation to constantly monitor quality parameters of production, while others may have certifications from national laboratories. In February 2021, only 8 producers had an active ENplus certification (2016 it was 5 producers with ENplus certification.). The other wood fuel products are only rarely tested for quality.

An overview of the different wood fuel types of presents is given in table 3 below.

Table 3 Characteristics of the different wood fuel types produced and utilized in Serbia (information taken from 11)

	Firewood	Pellets	Briquettes	Woodchips	Carbon
Market development	Stable, dominates market	Fastest growth annual growth rate of 28,4% for the period 2012-2016 Covers local demand, surplus exported	Declining production and consumption, as consumers switch to Pellets	Volatile demand since 2012 Surplus in some years exported	Niche product
Main consumers	Mainly Households (2016 84%)	Households, residential sector	Households (80%) and increasingly bakeries	Consumers with big boilers (e.g. industries)	Restaurant, butchers etc.
Prevalent unit	stacked m3	tons	60-80mm diameter and 10cm or 30cm in length. Or 5,5 × 5,5 × 32 cm Often delivered in 15 kg boxes	tons	Sacks of 15-16 kg
Moisture content	< 25% after six months of drying Water content mostly higher when used	< 10%	10 - 12%	< 10%	
Producers (status 2017)	PE Serbia Shume PE Vojvodina Shume 5 national parks 343 companies (2012) Potentially ca. 500.000 forest owners for self-supply	Increased from 2 (2006) to 54 companies (2016)	37 companies	14 companies	1 industrial plant 1500 charcoal kilns in rural areas with dense forest
Amount produced	2010: 7.05 mln m3 (estimations) 1.45 mln m3 (o. statistics)	242,000 per year (2016) [26]		Production decrease from 114,000 tons in 2015 to 99,000 tons in 2016[27]	30,000-34,000 tons per year (2016)

[26] As several factories closed in the 2016 installed capacity (463.000 tons per year) was reduced by 88.000 tons compared to 2015 levels. At the same time, production increased by 2.4%
[27] Biggest producer of briquettes switched to pellets during 2015 and 2016.

In preparation of GCF project part of the previously mentioned WISDOM study has been updated for the regions Vojvodina and Eastern Serbia[28]. The outcome shows a further increase in wood consumption. In the last decade, the consumption of firewood grew in both regions: in Vojvodina by 14.7%, in Eastern Serbia by 6.3%;

Total consumption of wood fuels for energy purposes in the 2 regions in the heating season 2020/2021 was the following:

- firewood 1.6 million m3 in Vojvodina and 1.07 million m3 in Eastern Serbia.
- wood pellets 52,786 tonnes in Vojvodina and 34,419 tonnes in Eastern Serbia;
- wood chips 2,205 tonnes in Eastern Serbia;
- wood briquettes 5,004 tonnes in Vojvodina and 127 tonnes in Eastern Serbia;
- sawdust 37,972 tonnes in Vojvodina and 13,203 tonnes in Eastern Serbia.

Besides the consumption of wood fuels, the consumers from Vojvodina often combine agro biomass with wood fuels, mostly with firewood and wood briquettes and also LPG with wood fuels.

Sustainability of wood utilization for energy purposes: Reportedly [WB, 2017], the population is currently exploiting up to 99% of the annual forest growth increment, mainly for energy production and for industrial purposes (panel and sawmill industry). Woody biomass mainly deriving from forests[29] or a combination of wood and other solid fuels for heating, is used in 37.1% or 934.237 of all of the Serbian households [FAO, 201530], as alternatives like electricity and natural gas are not financially accessible for the most and especially for the poor (10,5% of the total population in rural areas)[31]. Therefore, fuelwood extraction remains the main anthropogenic driver of forest degradation and new biomass projects should increasingly consider investing in improving efficiency forest resource utilization for energy purposes and/or alternative fuels.

Energy content of fuel wood: The energy content of the wood depends, next to the tree species, in the first place on its moisture content. Due to lack of storage facilities and lack of knowledge/awareness across stakeholders, consumers often purchase fuelwood freshly cut (or air dried 2-3 months at most) from the producer right before or during the heating period having therefore a far below optimal moisture and energy content. Wood traders on the other hand do not have the capacity nor the incentive to change practices and to deliver high quality air-dried wood.

Recent surveys showed that due to delayed purchase of low-quality biomass, more than 60% of HH in Vojvodina and more than 40% of HH in Eastern Serbia utilize fuelwood with an inefficient moisture content (>30%). Firewood purchase by households in Vojvodina is unsatisfactory because only 40% of the urban and 36% of other households purchase firewood early enough before the heating season so that it can dry to an energy-efficient moisture content (below 30%). In Eastern Serbia only 47% of Urban households purchase firewood with energy-efficient moisture content. The situation is better outside urban areas in this region: 57% of the households' purchase firewood early enough for the wood to dry and to reduce the moisture content below 30% (47). In 2023, the study was extended to other regions: Overall firewood purchase by households was considered satisfactory in Belgrade region and Eastern Serbia only, because 59%

[28] Glavonjić, 2021. Inventory of wood energy consumption and GHG emissions from wood fuels in Vojvodina and East Serbia
[29] Forests (58%), non-forest areas (32%) and from industrial residues (9%).
[30] WISDOM SERBIA Spatial wood fuels production and consumption analysis, UN FAO, Rome
[31] The accredited entity will launch dedicated surveys and assessments to obtain data for developing wood energy consumption inventory, as well as for the estimation of GHG emissions from firewood at the household level. Results will be available with and included in the full funding proposal.

i.e. 52% respectively of the fuelwood users purchased wood on time to dry and to reduce the moisture content below 30%. The other regions: Vojvodina, Central, Western and Northern Serbia presented significantly lower numbers (56).

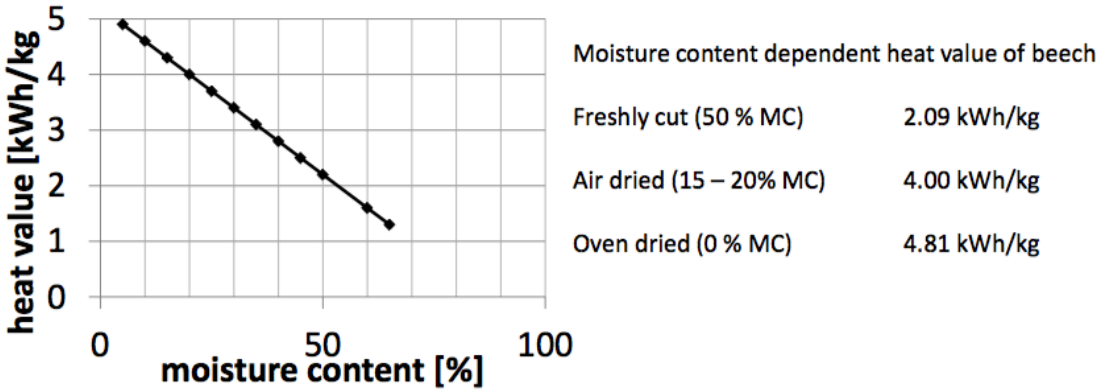


Figure 11 Correlation of moisture content and heat value of beech (source: 12)

From a climate change mitigation perspective fuelwood requires attention and precise strategies to reduce demand and increase quality. As demonstrated in other similar contexts (i.e. Austria, Finland) such reduction can be achieved through the following activities:

I. Increase **Fuel wood Quality (reducing moisture contents)** to increase energy content per kg wood. This objective can be achieved with specific activities aiming at behavioral change and sensitization of end users.

II. Utilize the best **Conversion Technology** and Increase efficiency of combustion. This activity requires minor/medium investments in technology transfer and capacity development of the private sector.

III. Decrease energy demand by applying **Thermal Insulation** to buildings. This activity requires medium/large investments and is often not accessible for the poor.

IV. **Optimizing Consumer Behavior** and technology transfer to practitioners and professionals in the architecture, building and administrative sectors.

Increase Fuel wood Quality and Alternative Biomass Fuels: The energy value of the wood utilized (calorific value) depends in the first place on its moisture content (which should be ideally below 20%). In many households this is not done appropriately, and wood is often burned right after cutting decreasing drastically the amount of energy that is transformed into space heating. The relation between moisture contents and energy content is well known in literature and there are studies in Serbia that show that energy obtained could be increased by more than 35% when utilizing wood with 23% instead of 45% humidity (14).Therefore, improvements in fuelwood handling are to be considered. Depending on the behavior of the user, energy consumption can be significantly different (5). With regards to wood fuel, the HH can improve its behavior in the first place related to the times and modalities of combustion and of heating. Awareness-raising campaigns are very important to improve these aspects. Also choosing the right wood fuel is important, since Serbian citizens often seem to prefer freshly cut wood with a high moisture content, as it looks “prettier” than well dried wood, which appears to be “rotten.

In order to increase the quality of the wood activities have to be carried out in support of the whole value chain of wood collection and distribution. There should be several moments allowing wood to dry in a proper manner (to less than 20%) from the first collection to the final user and to be stored without producing fungi and bacteria (1).

Increase efficiency of combustion/conversions technology: Effective combustion of wood is essential. Wood is burned in different phases demanding, among others, the effective air supply to avoid inefficient burning and the release of lost heat and unhealthy gases for the environment.

There are several producers of biomass appliances in the country that dispose of a high declared nominal efficiency, see table 3. As indicated however in some studies, when tested in German laboratories, some appliances could not fulfill the declared efficiency and were also deficient from some other perspectives.

Appliance category	declared efficiency
Solid fuels burning cookers for heating and cooking	60 - 89%
Solid fuels burning stoves for heating	55 - 89%
Solid fuel burning fireplaces for heating	70 - 83%
Solid fuels burning stoves for central heating	83 – 89%
Solid fuel burning cookers for central heating	86 - 89%
Pellet burning stoves	88%
Pellet burning boilers	90 - 92%
Solid fuels burning boilers for basements	78 - 92%

Table 4 Nominal efficient declarations for different types of heating and cooking appliances manufactured in Serbia: (11)

Decrease energy demand with thermal insulation: thermal insulation of buildings is an important tool to decrease the energy demand and hence fuelwood consumption.

As highlighted by the study of Glavonjić, average energy efficiency of existing buildings in Vojvodina and East Serbia is very low and ranges between 199 and 242 kWh/m2, which would classify the houses within the lowest class of the Serbian energy passport (G class > 188 kWh/m2)[32]. It can be assumed that the situation is similar in the other Serbian regions.

The production of wood fuel appliances has a long tradition in the country and in 2016 there were 18 manufacturers (size from micro to large). In the years from 2013 to 2015 the production of appliances was steadily growing and corresponded to approximately 250.000 units per year. Pellet appliances had the biggest relative growth with a 60% increase in 3 years, increasing their share of the total appliances from 5% to 7%.

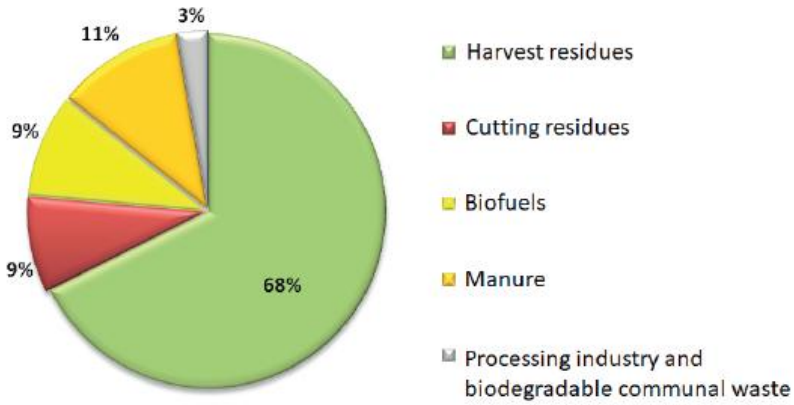
[32] Glavonjić, 2021. Inventory of wood energy consumption and GHG emissions from wood fuels in Vojvodina and East Serbia

Main issue is the low quality of the appliances, compared to EU standards. Furthermore, although the producers often declare a relatively high nominal efficiency of the appliances, these can often not be confirmed when tested in International laboratories, and dispose also of other worrisome features, like e.g. elevated CO (11).

3.2 Solid Biomass energy from agricultural residues:

Although its utilization for energy purposes is not as common as with wood fuels, agricultural residues have a very big and so far, largely unutilized potential in Serbia. According to the UNDP, Biomass from agriculture's real technical potential from agriculture corresponds to 1.532.636,32 toe per year, 68% of these come from harvesting residues (see figure 12). While the other sectors indicated in the graph have their limited exploitation potential, the utilization of manure for energy purposes is less feasible on a larger scale, due to the small size of the livestock entities in the country.

Figure 12 Potential agricultural biomass for energy purposes



The harvest residues of the crops generally considered as energy crops and their characteristics in Serbia are summed up in the following table 4.

Table 5 characteristics of agricultural harvesting residues for energy purposes

Crop		Water content [33]	Collection [months]	Heating value [kWh/kg]	Ash content %	Ash melting point Co	Product/ Residue Ratio	Surface [ha]	Yield of grain [t/ha]	Mass of grain [t/ha]	Yield of straw [t/ha]	Mass of straw [t/year]
Wheat straw		15-20%	06-07	4	5	900	1:1	262,900	3.7	972,730	3.7	972.730
Other cereals	**Oat straw**	15-20%	06-07	4	5	1:1	900	62,800	3.0	188,400	3,0	188,400
	Rye straw	15-20%	06-07	4	5	1:1.12	900					
	Barley straw	15-20%	06-07	4.1	5	1:1	900					
Corn stalk		15-30%	10-11	3.75	5	1,000	1:1	903,100	5.2	4,700,000	5.2	4,700,000
Corn Cobs		10-15%	Var.[34]	4.7	3	1,000	1:0.2	-	-	-	1.04	940,000
Sunflower		15-20%	09	4	10	800	1:2	153,000	2,0	306,000	4.0	612,000
Soya straw		15-20%	09	4.4	5	1,000	1:2	148,000	2.4	355,200	4.8	710,400
Rapeseed straw		20-30%	06	4	8	800	1:2	4,204	2.090	8,786	4.180	17,500

[33] Water content when collected.
[34] Depends on harvesting time.

Although the harvesting residues in the table 4 are generally considered as potential sources, utilization of the following sources is less recommendable and should be considered mainly in case of necessity of additional supply:

- Rapeseed, as losses in collection are up to 80%
- Corn, because harvesting occurs often during rainfall seasons
- Sunflower, have an exceedingly high ash content and low ash melting point

In particular the land structure, possibly flat and with large holdings, is crucial for an efficient collection of the resources, which is another factor indicating that the focus for agro-biomass exploitation should be on Vojvodina. In the region over 56% of all the land is in properties larger than 50ha. This is generally considered as the limit value of land for the production of big bales that can be utilized in District Heating and CHP. Other interesting valorizations could be for energy production in agricultural products processing industry.

A study conducted by the GIZ presented the agro biomass potential of the agricultural harvesting residues and analyzed for this purpose 10 cities and their surrounding regions distributed in the whole country (19). The study confirmed that most of the potential for biomass energy are in the Vojvodina region, as it appears to have the most favorable land and crop structure. There appear to be limited potentials for development in the central Sumadja region and for small to medium DH or small CHP development also in the Negotin area in Eastern Serbia. No potentials have been recorded in Western and Southern Serbia.

Total Mass of straw per year [t/year]	7,295,060
Realistic agro-biomass potential 30%-50% of total production [t/year]	2,200,000 – 3,600,000
Realistic agro – biomass potential [Gwh]	8,800 – 14,400
Potential share of contribution to heat and electricity production for total energy consumption	12%-19%
Sustainable potential for replacement of heating oil in toe/year	756,666-1,238,117

Table 6 Estimated energy potential from agricultural residues in the AP Vojvodina (28)

The utilization of agricultural residues for energy purposes is often in conflict with other purposes, like compost and animal bedding production. Furthermore, agricultural experts concur that it is more favorable for the residues to be retained in the field to maintain soil components and quality.

There are some other limitations when comparing the value chain to wood biomass, in particular: Harvesting usually has to be carried out in a short period of time, meaning there is the need to store the resources throughout the whole year. Furthermore combustion technologies are generally more expensive.

Pellets from agricultural sources are still relatively expensive and therefore not competitive yet. One of the reasons for it is that the VAT is still set at 20%, whereas Pellets from Wood are set at 10%. Other factors contribute to administrative burdens and costs, e.g. when exporting these kinds of fuels to Croatia, it is mandatory to execute a mandatory border control with costs of 240 Euro per truck. Nonetheless, in 2018 there were 8 plants producing pellets and four plants briquettes from agricultural sources, the biggest ones are in Zrenjanin and Indjija (Vojvodina) and produce 30,000 tons by the Victoria Group for own consumption and 12,500 tons by the Miva company for energy purposes and animal bedding (33).

Fuel	Thermal power	Unit price	Price €/kWh
Agricultural biomass- briquettes	4 kWh/kg	0.18 EURO/kg	0.045
Dark coal	3.5 kWh/kg	62.18 EURO/t	0.018
Fuel oil	12.6 kWh/kg	0.97 EURO/l	0.077
Natural gas	10 kWh/m³	0.41 EURO/ m³	0.041
Wood pellets	4.9 kWh/kg	160 EURO/t	0.033
Wood chips (humidity 35%)	3.1 kWh/kg	55 EURO/t	0.018
Baled straw	3.9 kWh/kg	45 EURO/t	0.012
Forest wood (humidity 40%)	3 kWh/kg	90 EURO/t	0..03

Figure 13 Prices of fuel sources in Serbia (17)

Short-Rotation energy crops plantations (SRP): There are so far only SRPs for research purposes in the country but no commercial plantations (status 2016) although fast growing wood like willow and poplar could provide significant energy sources: The new agricultural land law from 2015 sets the necessary conditions for state land to be leased out for SRP cultivation. State owned agricultural land is approximately 910,000 ha, after subtraction of all the land that is already leased or not suitable because e.g. marginalized, neglected or unresolved property issues, the land still available corresponds to 170,000 ha (exact area varies every year). 300,000 tons of wood would be necessary to substitute all district heating plants running on crude oil with biomass heating. To produce this amount of wood, only 20,000 ha, 12% of the total potential land, would need to be cultivated with SRPs. Examples for state subsidies for SRPs leading to take off of the market come from Hungary where the state provides 4,000 Euro per ha (for the establishment and the first year of production (18).

3.3 Potential large-scale consumers for biomass

District Heating (DH): Local Governments are responsible and have the full jurisdiction for DH systems as outlined in the law of local self-government, law on communal activities and the law on energy (38). Total installed capacity of DH was 6,587 GW of this 74% is running on natural gas, 15% on oil derivates, 11% on coal and biomass and less than 0.5% district heating use biomass (2019).

There is still a large unutilized potential for biomass in this sector, leading to an increased interest from the donor community. In fact Six Heating district plants with a total capacity of 30 MW received in 2017 project financing in the amount of 27 mln Euro (Euro 20 mln loan from KfW plus grants from Switzerland) in Priboj and Mali Zvornik, Prijepolje, Nova Varoš, Novi Pazar and Majdanpek. The first plants Novi Pazar, Priboj and Mali Zvornik, with a capacity of 18 MW using wood chips are operational. Further municipalities are interested in carrying out these kind of projects and are continuously added to the project development.

So far there seem to be no projects in place in the region Vojvodina, although, as table 6 shows, there is significant potential and also interest from local decision makers to carry out substitute projects.

Figure 14 Location of the district Heating in the AP Vojvodina (status 2014, extracted from (30)

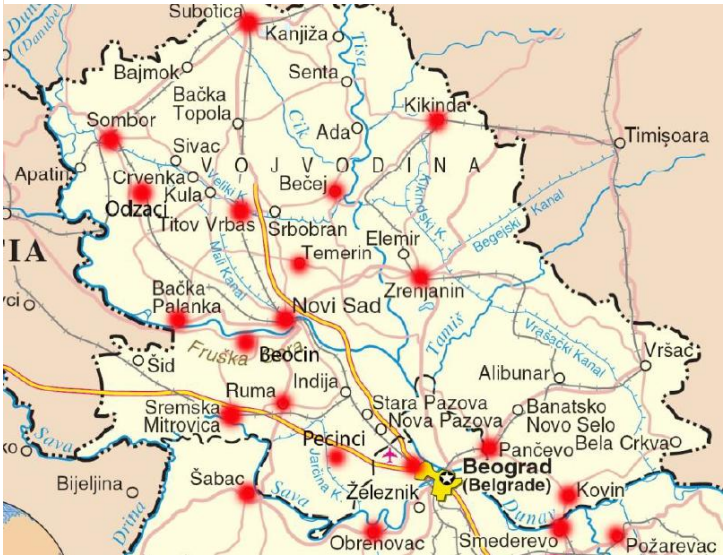
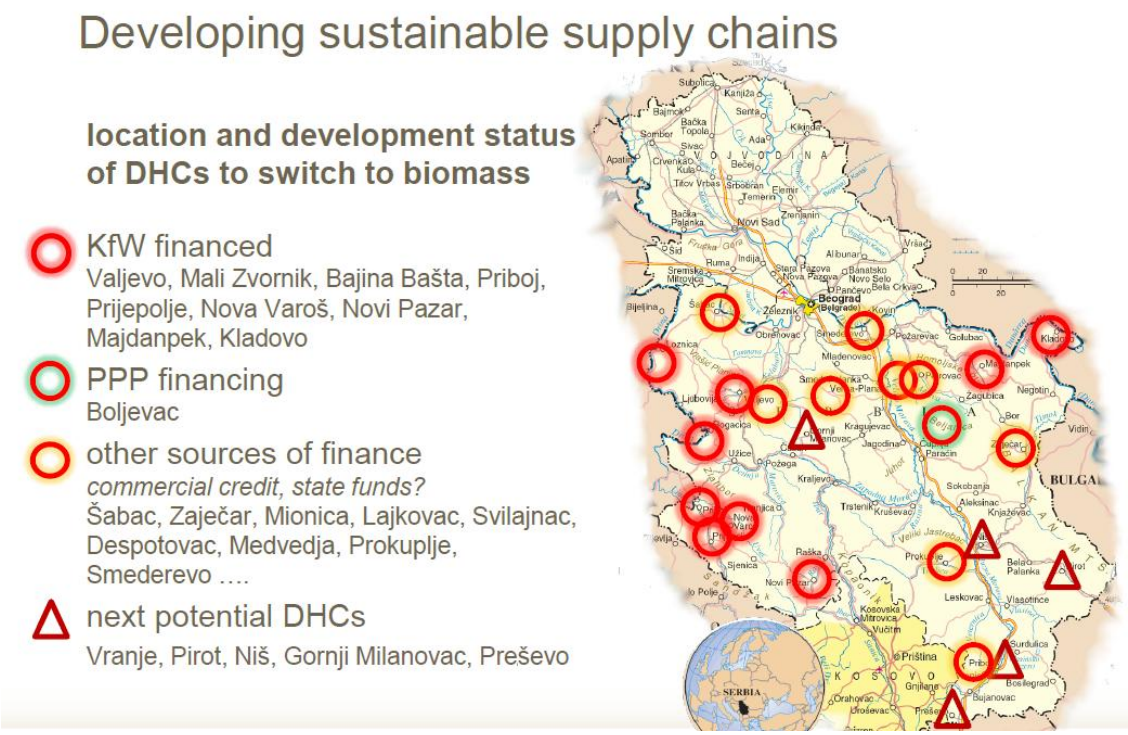


Table 7 Potential for fuel substitution in District heating in Vojvodina (30)

Location DH	Technical possibilities for using of biomass	Authorities interest for biomass as potential fuel
Bačka Palanka	No possibilities	No
Bečej	in existing boiler room but with new boiler(s)	Yes[35]
Beočin	in existing boiler room but with new boiler(s)	Yes
Kikinda	completely new boiler room on other location	Yes[36]
Kovin	completely new boiler room on other location	N/A
Novi Sad	in existing boiler room but with new boiler(s)	Yes
Odžaci	completely new boiler room on other location	No
Pančevo	completely reconstruction of boiler room	Yes
Pećinci	in existing boiler room but with new boiler(s)	Yes
Ruma	in existing boiler room but with new boiler(s)	Yes
Sombor	in existing boiler room but with new boiler(s)	Yes
Srbobran	No possibilities	No
Sremska Mitrovica	in existing boiler room but with new boiler(s)	Yes
Subotica	completely reconstruction of boiler room	Yes
Temerin	completely new boiler room on other location	N/A
Vrbas	completely new boiler room on other location	Yes
Žitište	No possibilities	No
Zrenjanin	completely new boiler room on other location	Yes[37]

[35] potential also in geothermal energy
[36] potential also in geothermal energy
[37] Interested only in CHP.

Figure 15 Implemented projects for District heating plants for switching from fossil fuel to biomass heating in 2018 (29)



4 Main Challenges and Climate Change impact

Serbian forests ecosystems have a variety of significant positive implications for the social, economic and environmental well-being of the Serbian society. In particular, it has a significant impact on the fuelwood industry and it related value chains:

Woody biomass extracted from forests is the main local renewable energy source and HH are depending on it, in particular the vulnerable and poorer segment of the population. As a result, total national consumption of fuel wood in Serbia corresponds to an estimated 7 million m³ per year [ec4tech, 2017]. Official statistics often underrepresent the consumption , in fact the energy balance bulletin in 2019 estimated the consumption to correspond to 1,957,028 tonnes. This shows that the governmental institutions are so far not capacitated to capture the extent and hence monitor the utilization of forest resources for energy purposes with obvious impacts on the sustainability of the management. [RoS, 2019]

The different types of woody biomass fuels are fuelwood, briquettes, wood chips and pellets. Pellets production had in the last decade the fastest growth in Serbia and corresponded in 2016 to approx. 5% of all fuelwoods. Briquette production is continuously declining as consumers switch to pellets and wood chips are mainly utilized by facilities with big boilers.

[1] P. 30, Energy Balances Bulletin 2019, Statistical Office of the Republic of Serbia. Total households in Serbia (2011 census): 2,487,886
https://publikacije.stat.gov.rs/G2021/PdfE/G20215670.pdf

The firewood market (ca 7 MCM with a value of about EUR 231 million, 2016[38]) is furthermore giving important opportunities for rural economic development and for the panel and sawmill industry to valorize its residues (total wood utilization of the sector ca. 1,350 MCM of wood [WB, 2017][39] per year). Due to lack of storage facilities and lack of knowledge/awareness across stakeholders, consumers purchase fuelwood mostly freshly cut from the producer right before the heating period having therefore a far below optimal moisture and energy content. Wood traders on the other hand do not have the capacity nor the incentive to change practices and to deliver high quality air-dried wood. Studies in Serbia utilizing different local burning appliances show that the efficiency value of fuelwood could increase between 27-54%, simply by reducing its moisture content from the prevalent 45% to 23% [e4tech, 2014]. In order to allow transparency of the market and awareness of the final consumer, sustainability and quality assurance schemes are paramount. Quality control and quality assurance standards for firewood are however only applied in case of export and there is no standard applied to locally consumed fuelwood (2016). Practices are more advanced related to wood pellets: Producers disposing of the high quality ENplus certification have the obligation to constantly monitor quality parameters of production, while others may have certifications from national laboratories. In February 2021, only 8 of a 54 producers (data from 2016) had an active ENplus certification (2016 it was 5 producers with ENplus certification.). Other wood fuel products are only rarely tested for quality.

A further degradation of the forests will decrease availability of wood biomass resulting inevitably to higher investment costs for the industry (because of e.g. higher transport costs, need to purchase special equipment, higher workload and risks in steep terrains). This will reduce the availability of woody biomass resulting in higher fuel costs and implying a higher share of overall spending towards energy for the poorer and vulnerable segments of the population.

Therefore, the overall resilience of rural population and the most vulnerable depends directly on the health and diversity of forests ecosystems. Any decrease in wood availability and diversity will have a direct and long-lasting impact also on the energy security of rural households and the poor. It must be highlighted in this regard that the average expenditure for energy accounts for about 16.7 % of the total household income and is hence higher than the threshold for energy poverty (= 10% of HH income to cover energy demand). Therefore, the need to satisfy the future fuel wood demand through a sustainable use of forest resources and to address at the same time forestry-decarbonization nexus[43] is evident. Without a strong and climate adaptive forestry sector the low carbon development and the renewable energy strategies of the country will remain incomplete and targets unmet.

5 SWOT Analysis of the Sector

The biomass sector in Serbia requires diverse set of actions to secure NDC and SDG targets. Weaknesses, strengths, opportunities and threats are reported below. Since the markets for biomass from agriculture and from wood are at a completely different stage of development and have furthermore significantly different characteristics, for each of the 2 sectors a different table is presented.

SWOT analysis woody biomass for energy use

Strength	**Weaknesses**
• Renewable and local energy source • Wood fuel utilization has long tradition	• Fuel often produced, delivered and utilized right before heating season with high moisture content

[38] Prices of firewood in cities brought directly to end consumers of 33 Euro per m3 Fuelwood (E4tech, 2017)
[39] World Bank, 2017

• Firewood is part of the national strategy for energy independence • Long tradition of appliance manufacturers and constant high selling of appliances • Pellet producers have certification (not all credible though, see threats) • Consumption of Pellet steadily growing and perceived as modern fuel • Different types of consumers (industries, commercial entities, HH) can access different types of wood fuels according to their needs. • Prices for firewood and wood chips are the most competitive among all sources. • Job creator (in 8 years 6-fold in wood pellets and 3.5-fold in wood chips) • Strong appliance market that carries out successful promotional activities • Different big projects in the sector to build upon (GIZ, UNDP)	• Lack of awareness of the population on how to choose the right fuel • Quality and safety standards for appliances and fuels vary greatly • lack of local expertise for engineering planning and installations • Lack of operational medium and large-scale applications of bioenergy production, such as district heating (although there is growing interest and projects in the sector, see opportunities) • Very few examples of complete wood energy value chain; • Limited access to funding sources; • Limited involvement of private sector and banks because of high risks. • little awareness on efficiency issues and possibilities for improvement • Low level of investments in research • Lack of interest of state forest managers to develop projects • Insufficient organizational setting of private forest associations;
Opportunities	**Threats**
• Serbia is an EU member candidate; all laws and regulation should therefore be aligned with the Union that disposes of the most advanced regulations. • VAT exemption for pellets • Growing interest and concrete projects for medium and large-scale applications of bioenergy production, such as district heating • Good international cooperation financed by European Union and other donors • Fuels can be produced in combination with locally available agricultural waste products • Job creations especially for the youth that could counteract rural depopulation • Need to substitute old obsolete fossil fuel boilers in district heating. Could open possibilities for fuel switch to biomass • creation of small business opportunities for local economic development • Enhanced cooperation among actors can complement project activities and synergies • Potential for utilization in public places high, but need for more efficient tender procedures	• Private owners outsource cutting to contractors -> little control over real amount cut and informal market (not subject to VAT) • Strong competition for woody biomass sources from the different sectors • Competent authorities resistant to change • Increased poverty increases wood fuel use • Declared standards of appliances and fuel is often not corresponding to reality • Some regions, in particular AP Vojvodina, have little forest resources, but high consumption, leading to potential forest degradation and unsustainable supply cycles in other regions

• Loans available for projects	

SWOT analysis agro biomass for energy use

Strength	**Weaknesses**
• Renewable and local energy source • High potential for utilization in the AP Vojvodina • Regional supply with positive impact on job creation and rural development	• Lack of standardization of agro-biomass • Lack of financial resources in public & private sector for project development and investment • Variations in quantity of agro-biomass (moisture content, deterioration, inadequate storage) • Appliances more expensive than for wood energy • Risk of insufficient quantities of agro-biomass supply (weather conditions, lack of professional farming) • Lack of knowledge for development of bankable projects in public and private sector • Little Research and development up to now • The market for agricultural biomass is in the early stages of development – few buyers and suppliers. • Biomass pellets are not price competitive yet (also due to higher VAT than Wood Pellets) • Short harvesting period => need for storage • Energy cooperatives having the role to collect biomass from small farms and joint processing are not developed. • Ash content is significantly higher than in wood fuel • Complicated and often insufficiently harmonized permitting and consent procedures by relevant authorities in the field of collecting, logistics, producing and using agricultural biomass.
Opportunities	**Threats**
• Serbia is an EU member candidate; all laws and regulation should therefore be aligned with the Union that disposes of the most advanced regulations. • Potential for utilization in public places high, but need for more efficient tender procedures • Job creation in rural areas • Employability for Women and youth	• Unsustainable past examples give negative visibility • change of legal framework especially for the feed-in tariff for biomass • Strong competition for biomass sources from the different sectors

• Land structure in Vojvodina favorable for the implementation of energy value chains • Increase of profitability and diversification of agricultural value chains. • Banks give loans for projects • Possible to substitute obsolete and inefficient fossil fuel boilers of district heating systems in the whole country	

6 Past and Ongoing Development Projects/Programmes

The following project have very strong links with the present initiative and their project partners will be contacted to develop synergies with ongoing activities and to obtain lessons learned.

Development of a sustainable bioenergy market in the Serbian republic, implemented by the GIZ from 2013 until 2020 and financed by the German Government. The initiative focused in its first phase on the promotion of wood fuels and wood-based technologies in pilot regions. In the second phase from 2017 onwards agro-biomass was included and aspects like policy advice, supply chains and modern heating systems were addressed. The initiative is supporting the conversion of district heating from fossil fuel to biomass. The first phase of these investments launched in 2017 amounted to Euro 27 mln, consisting of a loan from the kfW of Euro 20 mln in combination with a grand from Switzerland of Euro 5 mln and one grant of Euro 2 mln from kfW (see also previous chapters). The loan has an interest rate of 1.1%, a two-year grace period and a repayment period of 18 years.

Reducing Barriers to accelerate the Development of Biomass Markets in Serbia, implemented by UNDP from 2014 – 2018 with a total volume of USD30,475,000 (GEF: USD 2,845,000, the remaining funds from institutions of the RS and investors). The initiative concentrated on the following: (i) Improve capacity of governmental/ institutional bodies, municipalities and local entrepreneurs to identify, prioritize and develop bankable biomass energy projects in Serbia; (ii) Develop more effective secondary legislation related to biomass energy, developed, approved and adopted . operate Biomass Support Unit which leads to increased capability of municipalities and entrepreneurs in Serbia to develop, finance, construct and operate bankable biomass energy projects. (iv)Successfully finance and construct biomass projects.

"Rehabilitation Of Distance Heating System In Serbia", implementation since 2001 by the KfW, and the German Federal Ministry for Economic Cooperation and Development (BMZ). 4 Phases have already been realized with a total volume of Euro 123 mln, rehabilitating 21 DHS. The 5th phase commenced in 2020 comprising Euro 35 mln and the participation of 8 DHS (45).

BioRES - Sustainable Regional Supply Chains for Woody Bioenergy, funded by the European Union's Horizon 2020 research and innovation program for 1.86 mln Euro and implemented in 7 states, among which also Serbia, in the period from 2015 – 2017, aimed at supporting the dissemination of domestic woody bioenergy chains by introducing Biomass Logistic and Trade Centres (BLTC) as regional hubs increasing local supply and demand. In Serbia the project partner was SERBIO the national bioenergy association

The project Integrated biomass logistic centres for the agroindustry - AGROinLOG, funded by the European Union's Horizon 2020 research and innovation program from 2017 – 2020 is based on three agro-industries in the fodder (Spain), olive oil production (Greece) and cereal processing (Sweden) sectors that are willing to deploy new business lines in their facilities to open new markets, among others also for energy purposes. Partners from 7 countries participated in the

project, in Serbia it was the University of Belgrade that reviewed among others the state of some agro-industry sectors in Serbia (sugar, cereal drying, fruit processing, etc.).

6.1 Lessons Learned

General low quality of wood fuel: Despite it being a well-known fact that high moisture content leads to low efficiency in wood combustion, the utilization of freshly cut wood for heating purposes is still prevalent in HH in Serbia. Wood is mostly offered and purchased raw or at times air-dried for a maximum of 2-3 months. HH buy firewood mainly during the months of September/October, demand in other seasons is generally low. In particular in urban areas one of the main reasons for buying wood so late is the lack of space for air drying and the risk of fines for stacking wood on public areas in front of buildings outside of the heating season.

Wood traders have neither the capacity nor the interest to change practices and to deliver high-quality air-dried wood. There is therefore the high need to increase efforts for raising awareness on the selection of high-quality wood, while at the same time providing regulations and inspections procedures for wood trading/supply. There is currently no mechanism in place to denounce unethical suppliers.

Implementation of medium/large scale projects: Some of the initiatives in the past have carried out detailed feasibility studies for biomass projects that have however not resulted in bankable projects. There is the opportunity to involve all stakeholders in the sector, including banks and financing institutions, to provide clear legal framework and standardization, guidelines and regulations for feasible business plans and implementation of investments.

Elevated wood consumption is not always related to the local availability of forest resources. In fact some areas in the Vojvodina region have a high consumption of wood fuels. Voijvodina has, however, other biomass resources from agricultural harvesting which are exploited only to a minor extent. Activities are missing to promote sustainable local value chains in that region that have effect on the mitigation of forest degradation drivers in other regions.

There are different projects in the biomass sector active or have been recently concluded that all foresaw ad-hoc meetings of decision makers for the development of the sector. While this has been beneficial for strengthening the sector, it is highly recommended to hold regular coordination meetings on decision maker level to undertake strategic development for the whole biomass sector.

The perseverance and willingness to invest of the private sector has been crucial for the success of certain aspects of the biomass use (e.g. Pellets production). A major private involvement in projects is therefore highly recommended.

The development of Biomass Logistic and Trade Centers faces challenges in Serbia especially with regards to (i) the inability to mobilize capital for the investment, (ii) the inability to procure secure sale channels. The key to a sustainable biomass heat market is the customers' confidence in the entire supply chain from wood fuels to the installation of efficient appliances and ongoing maintenance. Important in this regard is also the implementation and widespread use of quality standards. It is crucial to work on the whole supply chain, improving therefore demand side measures in parallel with supply side measures.

A major factor for successful projects on a local level is leaders/s that are keen to change current situations and include in their considerations and awareness raising not only economic factors, but also social and environmental factors. The identification of these actors is a crucial success factor and in the communication of a project idea great care shall be taken to connect it with local development visions and strategies.

7 Rational and Description of Proposed Interventions;

The promotion of Bioenergy is an important aspect for the Serbian Government in order to become more independent from energy imports and to achieve its ambitious renewable energy goals.

Of the different biomass sources 2 are of crucial importance: wood fuel and agricultural harvesting residues. Further exploitation of forest resources is increasingly challenging. The potential for increasing efficiency is, however, large. Unsustainable use of forest for energy purposes is the main forest degradation driver. This is on one hand attributable to the high prices of alternative energy sources that cannot be sustained by large parts of the rural population. On the other hand strategies have so far not aimed at transforming wood fuel and solid bioenergy into a modern and dynamic sector.

In order to stimulate the envisaged paradigm shift, rural areas that are typically the most disadvantaged need capacity development actions and enabling investments to organize in an efficient manner. The GCF grant resources will constitute an effective source of funds to start the process towards the production of high-quality solid biomass by the private sector, including in the most disadvantaged rural areas typically less inclined to more expensive technologies, and will spark the shift and ensure self-funded scalability of proposed intervention.

7.1.1 Adherence with GCF investment Criteria

The activities proposed in this Working Paper will be defined in detail in exchange with the national stakeholders and are aligned with the six investment criteria of the GCF.

Investment Criteria 1- Impact potential:

The activities aim among others at decreasing the energy output of wood bioenergy and hence to reduce GHG emissions. This can above all be achieved by decreasing the moisture of the fuel. How significant the impact of moisture content in the GHG emissions is, is very well shown by the following examples: wood purchased a half month before the beginning of the heating season (as is often the case in Serbia) with the moisture content of approximately 50% emits in the process of combustion 43.2% more GHG compared to the wood purchased 6 months before the beginning of the heating season.

In the frame of the detailed design phase of the project, more precise estimations about the effect on GHG emissions from biomass energy will be carried out.

Investment criteria 2 - Paradigm Shift:

Wood fuel use is currently not effectively monitored, and the market lacks transparency related to quality of the biomass sources. This leads to wood fuel use being a driver for deforestation and to a low energy output of the energy consumed. Rural HH are highly dependent on the utilization of wood fuel with inefficient technology, which is at the same time burdening HH income.

The project will contribute to organizing the local wood fuel market in a modern and transparent way leading to healthier forests and to benefits for the final consumers that are mostly of the vulnerable share of the population. In addition a more efficient organized biomass sector can give a significant contribution to the government to reach its ambitious climate change and renewable energy objectives. Last but not least, a sustainable local value chain can also lead to significant local economic development and create jobs in rural environments.

Potential for expanding the scale and impact of the proposed programme or project (scalability): By aiming at key efficiency issues of the wood fuel use (i.e. related to humidity of the wood fuel, transparency of the market, value chains, lack of alternative bioenergy sources) the project will

be scalable without equally increasing its cost base since the measures are expected to be adopted by the general public thanks to its demonstrated saving opportunities

Potential for exporting key structural elements of the proposed programme or project elsewhere within the same sector as well as to other sectors, regions or countries (replicability): The proposed theory of change and intervention strategies are replicable in the region with particular scalability in all of the Western Balkans. In fact this project is designed with a blueprint approach and FAO will tailor it to local context and needs.

Investment Criteria 3- Sustainable development

The activities provide a series of benefits described more in detail in chapter 7. With regards to the SDGs, the following are the focus:

SDG 7: Affordable and Clean Energy

Target 7.2: Increase global percentage of renewable energy

Target 7.2: "By 2030, increase substantially the share of renewable energy in the global energy mix."

Indicator 7.2.1: "Renewable energy share in the total final energy consumption".

SDG 13 Climate Action

Target 13.2: Integrate climate change measures into national policies, strategies and planning.

Indicator 13.2.1 Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other).

Investment Criteria 4 - Needs of Recipient:

The project will address the vulnerability of the forestry sector by enhancing the sustainability of the biomass energy sector that is currently a driver for forest degradation. In this regard processes and practices will support the country in expanding/enhancing/establishing the needed policy and legal reforms to increase the efficiency of wood fuel utilization and to provide alternative affordable energy sources.

Investment Criteria 5 - Country Ownership:

The project will address the needs and priorities reported by the Republic of Serbia in its NDC(s) (2015 and draft 2020), National Communications, Low Carbon Development Strategy, EU-related commitments and other national policy framework. In addition, the project will contribute to implement the GCF Country Programme of Serbia, by supporting the priority areas: cluster 1 Energy efficiency and use of renewable energy sources

Investment Criteria 6 - Efficiency and Effectiveness:

The project will apply best biomass management best practices (e.g. wood biomass fuels standards for processing and use, creation of national biomass platforms) from Europe and other areas. In this regard the participation of the Province of Bolzano is of particular importance as it is considered one of the most advanced regions in the sector.

7.2 Contribution to the Outcome

This Working Paper will mainly contribute to the definition of the activities concerning the main drivers of forest degradation / sustainable use of agricultural residues ensuring transfer and application of modern energy carriers to the public and private sector and rural households to decrease pressure on natural ecosystems and strengthen natural regeneration and sustainability of forestry investments.

Component 1

Activity 1.1.3: Create national standard for biomass production / handling for energy purposes

The utilization of wood fuel in Serbia often results in wasted energy due to its high moisture content, which lowers its calorific value. This issue is mainly attributed to the lack of awareness among the population on how to select the best available fuelwood, and the absence of incentives for suppliers to promote high-quality fuels. As a result, suppliers offer mostly raw wood or air-dried wood for a short period, which further reduces its energy output. To address this challenge, the project aims to introduce technical regulations that will establish appropriate rules, inspection mechanisms, and complaints procedures that sellers and distributors of firewood must follow. The implementation will also evaluate the possibility on how to impact fuelwood quality provided from the informal sector. The primary objective of the regulation is to mandate sellers to provide the market with firewood with a maximum moisture content of 30%, thus increasing the energy output of purchased wood. This intervention will benefit urban households, which often purchase and utilize raw wood immediately due to the lack of storage facilities. Furthermore, the regulations will enable market inspections, which will hold suppliers accountable for unethical practices and provide consumers with the necessary information to make informed decisions. Together with the other activities of the project this will contribute to an increased monitoring of the utilization of forest resources and hence to better control. The aforementioned will be complemented by an evaluation of the impact of the biomass standards on a pilot area and by Renewable Energy Days organized in 10 different municipalities throughout the country that raise the awareness on the correct user information and utilization of biomass for heating in combination with other renewable energy and household energy efficiency measures. (GCF Financing: 155,500 USD; co financing: 0 USD)

Activity 1.1.4: Develop the national strategy, action plan and execution guidelines for Short Rotation Plantations

The Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014-2024 and the new Law on Agricultural Land No. 112/2015 [12] have created the necessary initial conditions for state-owned land to be leased in order to establish Short Rotation Plantations (SRP). These plantations could provide several benefits to the local population, including increased use of renewable energy, improved soil health, and increased employment and business opportunities in rural areas. Objective is to strengthen the capacities of local agricultural and energy actors related to the planting of bioenergy trees on abandoned agricultural lands and especially with regards to the preparation and adoption of the related regulations. Bearing in mind the prominent increase in demand for woody biomass in the last several years and announced investments in district heating systems, the demand for wood fuel is expected to increase in the coming years. Since the capacities of the Serbian forest fund for supplying the biomass for energy purposes have already reached their maximum, the energy plantations represent one of the future sustainable biomass supply channels.

The potential for SRPs in Serbia is significant, with decades of intensive farming compromising the quality of agricultural land and leading to 424,054 ha of unused agricultural land (5.5% of the total territory). This issue is particularly evident in the eastern and southern regions of Serbia, where farmers have increasingly abandoned cultivation. In these regions, the percentage of unused

agricultural land relative to the total agricultural land is between 20 and 50%, compared to 10% in the autonomous region of Vojvodina40.

Most bioenergy currently comes from natural or semi-natural forests or woodlands rather than from forest plantations. However, there is growing recognition that planted woody species are an important means for providing energy. Establishing plantations may also serve other purposes, such as land rehabilitation and erosion control, watershed protection and production of non-woody forest products. In addition, there is a wide variety of agroforestry, farm forestry or urban systems where trees are planted in non-forest conditions. The current level of production of wood fuel from plantations makes only a small contribution to the energy needs of Serbia, but plantations could be a very important source of wood energy in certain parts of the country. The project will, therefore, develop a National strategy, action plan and execution guidelines for sustainable wood energy plantations that can contribute to a diversified forestry sector. The guidelines will also analyze the potential of SRP for purposes competing with energy use, such as paper production. The activity will raise the capacities of experts in the field through workshops and training activities. (GCF Financing: 145,150 USD; Co-financing: 0 USD)

Component 3

Activity 3.1.4: Engage private actors in sustainable biomass value chains

Many businesses in the agrifood sector have biomass residues from their production that can be a valuable source for solid biofuels/and or biogas in particular if this "waste" is available during a period of the year, when the production plant is otherwise not operational. In many such cases equipment, e.g. for drying or to handle biomass, e.g. cranes, storage bays, belt conveyor stackers, hoppers or silos, are already available and can be utilized to support the production process of biomass. The activity will analyze the current potential for the valorization in Serbia in the frame of a technical report and use it as a baseline to train private sector actors on the possibilities for the valorization of biomass residues for energy purposes.

(GCF financing: 82,500 USD)

Activity 3.1.5: Support platforms involving stakeholders of the forestry sector for a modern and transparent biomass energy value chain

The activities will provide technical assistance and advice to the Serbian biomass association (SERBIO) that is currently planning to support the creation of a hub aggregating and involving stakeholders in the sector to produce and market solid biofuels at standardized high quality for the local population. The platform will have a production line for biomass and also have storage and logistic facilities. It will represent the intermediator to organize local bioenergy value chains between suppliers providing raw biomass resources and customers of different scales from private HH up to large heat and power plants. The model has been shown to be very successful in countries like Slovenia, Austria or Germany[41]. Most important factors for success of the hubs are (i) sufficient biomass supply covering the demands of current and future customers in the region; (ii) sufficient storage capacity for solid biofuels (e.g. fuelwood, wood chips and pellets), with option to install drying facilities; (iii) good access to transport infrastructure. The implementation of the activity, in line with successful experiences in other neighboring countries, will aim at involving the local administrations in the hub that can provide/lease public land to the private sector. Technical support will be provided to the SERBIO in all business activities, from feasibility studies, development of business and investments plans to marketing of products (GCF financing: 112,000 USD).

[40] Taken from **Radojevic** et al, 2015: "**Identification of marginal land suitable for biofuel production in Serbia"**
[41] Biores project, 2016

8 Expected Benefits

8.1 Mitigation

The activities of the WP are foreseen to have significant mitigation effect, in particular because it will make utilization of biomass more efficient and hence decrease needs for energy sources and emissions. Furthermore, there will be benefits through awareness raising activities and through the development of an enabling framework for renewable energies that can at the moment not be quantified yet.

8.2 Environment (i.e. biodiversity, ecosystem services)

Particularly important are the effects to the health of the population: Solid fuels, including wood and coal, are still used by 40% of the world population (22). Since the technology applied is often obsolete, energy carriers are an important source for indoor and outdoor pollution. Residential heating with solid fuels (wood and coal) and its outdoor PM2.5 pollution is hence responsible for an estimated 61.000 premature deaths in Europe per year (2010). The WHO considers this type of heating therefore to be the largest environmental risk (23).

Stove efficiency and emissions are generally inversely proportional to each other (33). The project promotes the distribution of efficient wood stoves and have therefore a positive effect on health and environmental pollution, such incentives is in line with governmental incentives in many countries (see figure 8) (23).

Country (scheme)	Incentive/subsidy	Notes on implementation
Denmark *(Incentive to scrap pre-1980 wood boilers)*	Grant of <€530 for households replacing old wood boilers with new boilers meeting an emissions limit (2008–2009)	3500 wood boilers have been replaced – about twice what would have been expected without the grant.
Germany *(Market incentive programme)*	Subsidy for installation of pellet boilers (over 150 kW) of >€2000 or €2500 when combined with solar panels	The programme is more than a decade old; designated funding has been adjusted downwards in some years.
Norway *(Ban on electrical and oil heating in new buildings; 40% of heat demand in new buildings must be supplied by non-grid electricity or non-fossil fuel energy)*	Subsidies of 20% for purchase of a new pellet stove (<€490) or new pellet boiler (<€1225)	The fund from which these subsidies come totalled €4.3 billion in 2013 and was managed in part by Enova SF, a state-run company.
United Kingdom *(2014 Domestic Renewable Heat Incentive)*	Household tariff from government of 12.2p (€0.15) per kW hour of energy generated when biomass boilers and pellet stoves used to heat home	As of August 2014 >1600 household biomass-fuelled home heating systems had been approved to participate in this programme.

Figure 16 Examples of government incentives and subsidies for residential heating with wood (source: 23)

.

8.3 Economic and Social

The project's activities around the fuelwood sector will help reduce poverty in Serbia in three ways: (i) increased access to fuelwood with improved quality (ii) greater transparency of the solid biofuel value chain, and (iii) enhanced economic opportunities through the sector's

modernization. First, the availability of higher quality fuelwood (drier with higher caloric potential) will increase energy efficiency at the household level. Households are expected to face a lower unit cost for energy produced by fuelwood. This lower unit cost of energy will enhance affordability of energy for the poorest segments of the population. In Serbia, households currently spend more than 10% of their average expenditure on energy. Coupled with environmental / energy efficiency awareness campaigns to avoid increase of consumption of fuel wood, lower fuel costs will also imply a lower share of overall spending going toward energy, freeing up resources for other household needs. Second, the project will enhance transparency around fuelwood availability and quality. Specifically, rural consumers will have greater knowledge around fuelwood types and heating appliances to make more informed consumption decisions. Third, the modernization of the biomass sector will create economic opportunities in rural areas, directly benefiting the population of these areas.

The project will not incentivize a shift of biomass use to other energy sources. It will on the contrary enhance the biomass sector and support its transformation into a modern sector providing opportunities for local economic development and enhancing energy security. In this regard , the project will support activities increasing the transparency of biomass market (through awareness campaigns and sustainable value chains) and ensure that the biomass used as fuel is green (from sustainable production) and of better quality (e.g. drier and with higher caloric potential). This will lead to a higher energy output per purchased biomass and therefore also to benefits for the poorer population.

Additionally the project thanks to its investments in forestry as well as in increasing local governance of forests and other natural resources will increase the number of job opportunities in rural areas transforming, once more, forests and other ecosystems from exploitable resource to investments of national relevance. The project aims at increasing access of the rural population to energy efficiency applications and to create in general a favorable market environment with impact on green job creation and reduction of energy poverty.

9 Monitoring and Evaluation

The following tables present an overview of indicators adhering to the GCF performance framework related to the current foreseen activities of the whole project and not specifically only to the activities described in this document. More details and updates will be provided during the detailed design mission.

9.1 Means of Verification

The project will apply FAO's standard M&E and Knowledge Management (KM) procedures and will focus on georeferencing and remote sensing activities. These procedures will allow us not only to clearly understand the context of our intervention and therefore improve reporting but also to attribute a clear spatial dimension to investment and beneficiaries' distribution.

In line with other FAO projects the following is suggested: (i) each activity will be georeferenced, (ii) that GIS based maps will be provided for each investment, (iii) that remote sensing and ground truthing are the privileged tools of monitoring, and (iv) the competent authorities will be involved in the process.

Georeferencing activities will strengthen national engagement process and Country's ownership allowing stakeholders, as well as donors in Serbia and elsewhere, to have transparency and an enhanced participation and transparency in the project.

For this purpose, the project shall elaborate a shared spatial database, accessible via Google Earth, addressing identified indicators and other important analysis, in order to have a timely update about outcome of the project, utilizing satellite images. FAO has already developed a specific

application supporting the entire project cycle and also impact evaluation. Independent evaluators will furthermore deliver the basis for the continuous verification processes and for the midterm and final evaluations.

10 Risks and Mitigation

Selected Risk Factor 1		
Category	Probability	Impact
Technical and operational	Medium	Low
Description		
Resistance to Change: Communities and administration will require time and incentives to shift from the BAU scenario in the utilization of wood fuel with a higher quality and/or alternative bioenergy. In the past decades forests have been considered a mining resource by communities and the shift to a new governance will require transparency and clear engagement of all stakeholders including the civil society and the private sector.		
Mitigation Measure(s)		
- The project will invest in awareness and education, always approaching investments and beneficiaries with an evidence-based approach and replicating good practices from the Country, the Region and from similar contexts. Additionally the project will work in the framework of the newly issued laws and policies - Sensitizing the awareness of the private sector will also be of crucial importance as this can have a multiplied effect on the whole rural population and the sector can become a driver for further development. A good example for this is the development of the wood pellets sector that was in particular driven by private sector initiatives - Provide the enabling framework through the application of standards, rulebooks and strategies in the sector - Concerned state actors and other stakeholders will be involved in the whole project cycle process including monitoring and evaluation of executed activities.		
Selected Risk Factor 2		
Category	Probability	Impact
Technical and operational	Low	Low
Description		
Lack of cooperation between different competent institutions		
Mitigation Measure(s)		
Each of the described activities will be implemented with the involvement of the designated institutions. The assignment of clear responsibilities is crucial for a smooth implementation. It will be, however, necessary to build up a technical follow-up by creating a team of competent representatives from different institutions and state agencies.		
Selected Risk Factor 3		
Category	Probability	Impact
Technical and operational	Low	high
Description		
National government does not implement developed strategies.		
Mitigation Measure(s)		
FAO will involve all stakeholders in the elaboration process and establish a close relationship also with the competent Ministries responsible for standardization and quality control of fuels. The project will maintain this close relationship and ensure that all partners are informed in a transparent and timely way.		

11 References

#	References
1	Krajnc N, 2015. Wood fuels Handbook
2	RoS, 2017. Intended Nationally Determined Contribution of the Republic of Serbia
3	RoS, 2010. Initial Communication of the Republic of Serbia under the UNFCCC
4	RoS, 2017. Second National Communication of the Republic of Serbia under the United Nations Framework Convention on Climate Change
5	Steierer F and Helbig F. 2015. More Heat and Less Wood Workshop. Introduction (ppt)
6	Loibnegger T, 2010. Telling the story in Austria Sustainable wood energy supply
7	Raitila J, 2009. Telling the story – how wood heat has become real business in rural areas
8	UNECE/FAO Joint Wood Energy Enquiry (JWEE) 2015. Fact sheet of data and trends
9	USAID, 2017. Climate Risk Profile: Serbia
10	FAO, 2015. WISDOM SERBIA Spatial wood fuels production and consumption analysis
11	E4tech, 2017. Assessment of the market of wood fuels and solid fuel heating and cooking appliances in Serbia
12	UNECE/FAO, 2015. Wood Energy (Poster)
13	UNECE/FAO, 2015. More heat less wood workshop report
14	Branko Glavonjic, PhD Milica Vukadinovic. Efficiency of Firewood Utilization in Households in the Pilot Regions in Serbia
15	Karlsvik, E. and Oravainen, H. 2014, Guidebook Effective and environmentally friendly firing of firewood
16	RoS, 2016. FIRST BIENNIAL UPDATE REPORT OF THE REPUBLIC OF SERBIA under the united nations framework convention on climate change
17	UNDP, 2018. Status of Using Agricultural Biomass for Energy Purposes in Serbia
18	UNDP, 2017. Status of Using Wood Biomass for Energy Purposes in Serbia
19	GIZ, 2017. Availability of Agro-Biomass in Serbia
20	Erkilä A. and Alakangas E, 2008. Manual for Firewood production
21	Ivezić,D., Đukanović, D, Bacanović, V., Božović V.,Mirić, M. 2015 Mapping of the Municipal Spatial, Infrastructural, Resource Related and Logistic Prerequisites for Electricity and/or Heat Generation from Biomass in the Srem District
22	Carvalho R, Jensen, O.M., Tarelho L.A.C. 2016 Mapping the performance of wood-burning stoves by installations worldwide
23	WHO, 2015. Residential heating with wood and coal: health impacts and policy options in Europe and North America
24	GIZ, 2019. AGRO-BIOMASS POTENTIAL AND LOGISTICS STUDY FOR SUPPLYING THE PUBLIC UTILITY COMPANY “GREJANJE-PANČEVO”
25	Malidzan, M. and Vitorovic, S, 2016. Agro -BIOMASS AND WOODY BIOMASS POTENTIAL AND LOGISTICS STUDY FOR THE CITY OF ŠABAC
26	Branko Glavonjic, PhD Milica Vukadinovic. Efficiency of Firewood Utilization in Households in the Pilot Regions in Serbia - Annex 2 Efficiency Measurements
27	Nadel, S. 2012. White Paper: The Rebound Effect: Large or Small
28	Wieser, H. 2014. Assessment of potentials for agro-biomass plants (straw combustion) in public & private sector in the Autonomous Province of Vojvodina
29	Vukadinovic, M. 2018. Sustainable business models for bioenergy projects
30	Savić, R. 2014.Survey and Assessment of the Actual Usage of Fuel of all District Heating Companies in Serbia and Existing Plans for Short and Mid-Term Investments, including those for Fuel Switch
31	Möllersten, K. 2017. The Power Africa Beyond the Grid Fund for Zambia: Methodology to measure, report and verify on annually avoided greenhouse gas emissions
32	Breisinger, M. 2012. Greenhouse Gas Assessment Emissions Methodology
33	World Bank, 2017. Biomass-Based Heating in the Western Balkans – A Roadmap for Sustainable Development
34	Ranson, M., Morris, L. and Kats-Rubin, A. 2014. Climate Change and Space Heating Energy Demand: A Review of the Literature
35	RoS, 2020. The second/revised Serbia's nationally determined contribution – CCM component1 - draft
36	ESCWA, 2018. Case Study on Policy Reforms to Promote Renewable Energy in Serbia
37	H3A\R,ZN \
38	Banjac M., 2019. Renewable Energy in Heating – projects in Serbia

39	RoS, 2016. Energy Sector Development Strategy of the Republic of Serbia for the period by 2025 with projections by 2030
40	UNECE, 2019. PROGRESS IN THE AREAS OF ENERGY EFFICIENCY AND RENEWABLE ENERGY IN SELECTED COUNTRIES OF THE UNECE REGION
41	RoS, 2020. Report on the Implementation of the National Renewable Energy Action Plan of the Republic of Serbia for 2018 and 2019
42	GIZ, EU harmonized standards related to solid biofuels
43	RoS, 2013. Report on the Implementation of the National Renewable Energy Action Plan of the Republic of Serbia for 2018 and 2019
44	Odyesee-Mure, 2021. Serbia- Energy efficiency trends and policies
45	RoS, 2020. Fourth Annual Report under the Energy Efficiency Directive
46	World Bank, 2021. State and Trends of Carbon Pricing 2021
47	Glavonjić, 2021. Inventory of wood energy consumption and GHG emissions from wood fuels in Vojvodina and East Serbia
48	GFA consulting, 2019 - Draft Low carbon development strategy with action plan - Serbia
49	Government of Serbia, 2020. Third National Communication to the UNFCCC – final draft version
50	BioRES project, 2016. Fact sheet (2016): Woody energy market in Serbia
51	UNDP, 2016. Short rotation energy crops of fast-growing tree species in Serbia: biomass production, legislation, market, and environmental impacts – potentials and constraints
52	World Bank, 2022. ESTERN BALKANS REGULAR ECONOMIC REPORT. Steering through the crisis.

[i] P. 30, Energy Balances Bulletin 2019, Statistical Office of the Republic of Serbia.
[ii] Assuming a similar average increase then from 2010 to 2020. See footnote 40