

Article

Analytical Study for the Determination of the Energy Use Potential of Forest Dendromass in the Czech Republic

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Abstract: The European Union's current pressure on the Member States to adopt both the Green Deal and the Fit for 55 package is leading to an accelerated drive to put in place measures to meet the 2030 climate targets. At the same time, many discussions at the international bilateral meetings of EU country representatives raise the question of the realism of setting climate targets, and therefore, the ability to meet these commitments. The results elaborated in this analytical study offer a realistic picture of the possibilities of meeting strategic climate targets using the example of the use of forest dendromass. The data assess the possibility of achieving a 22% share of renewable energy sources (RES) in gross final energy consumption by 2030 in the Czech Republic. The study points out that at present, the use of forest dendromass from primary production is at its maximum and meeting the climate targets for increasing the share of RES in the energy mix represents a major problem in the long term. The findings published in this study also point to the objective threat of the increased use of dendromass in the energy sector to the maintenance of sustainable forest management and the preservation of forest quality.

Keywords: dendromass; energy potential; logging residues; growing stock; national climate targets



Citation: Březina, D.; Michal, J.; Hlaváčková, P. Analytical Study for the Determination of the Energy Use Potential of Forest Dendromass in the Czech Republic. *Forests* **2023**, *14*, 1744. <https://doi.org/10.3390/f14091744>

Academic Editor: Pankaj Lal

Received: 27 July 2023

Revised: 21 August 2023

Accepted: 24 August 2023

Published: 28 August 2023



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1. Introduction

Climate change has become one of the most globally discussed environmental issues in recent years [1,2]. It is now indisputable that the climate is changing [3–5] and will continue to do so in the future. But the extent and the spatial and temporal impacts of these changes on the environment have yet to be seen [6]. In this context, the possibilities of further research and solutions to the adverse effects of these changes are debated worldwide. The ongoing global climate change poses a challenge for all sectors, forestry included [7]. Forests are believed to play a crucial role in mitigating climate change [8–10]. They are essential for global carbon sequestration and storage and are largely responsible for the consistency of the global carbon sink [11]. The impacts of climate change will affect the conditions for the forestry sector [9,12]. The forestry sector can help mitigate climate change significantly by increasing carbon stocks in the forest soil, either via changed forestry management practices or the use of harvested timber [13–15]. Kirilenko and Sedjo [16] argue that climate change will affect all types of forests and forest management. Forests will face profound long-term changes, such as changes in species communities on a scale that is still difficult to predict [17–21]. The issue of climate change is therefore taken seriously in the forestry sector. The Paris Agreement adopted by the Parties to the United Nations Framework Convention on Climate Change [22] also acknowledged the role of forests in mitigating climate change. Scientists and multi-faceted research projects are trying to develop a range of readily available adaptation options [6,20,21,23]. The adaptation of forests to climate change involves forestry measures such as using different tree species and promoting mixed stands [24]. However, the adaptive capacity of forests to overcome the adverse effects of climate change remains highly uncertain despite intensive research efforts [25].

From the perspective of possible solutions to climate change, searching for new energy sources and optimising the existing ones are currently the priority themes in environmental protection. Limiting the use of fossil fuels and massively expanding the use of renewable energy sources (RES) in its individual Member States, the European Union (EU) is considered the world's pioneer in the transition to cleaner energy [26,27], with renewable energy being one of the fundamental pillars of the European Union's strategy for energy and climate protection until 2030 and beyond [28]. Renewable energy sources have significant potential to contribute to economic, social, and environmental energy sustainability [29]. The above stems primarily from the obligations of the EU Member States, which are declared in binding documents such as the European Green Deal [30] and subsequent documents [31–35]. The results of various studies show [2,29,36] that renewable energy consumption is a significant factor in reducing carbon emissions.

The EU framework for climate and energy policies was adopted by the Conclusions of the European Council of October 2014 [31]. The adopted goals in renewable sources and energy efficiency were subsequently increased in 2018 via the amendment of the Renewable Energy Directive [32], which sets the target for the share of renewable resources in overall gross final energy consumption to 32% by 2030. The amendment of the Renewable Energy Directive of 2021 [34] further increased the target for the share of renewable resources in overall gross final energy consumption by 2030 to 40%. The latest increase to 45% was carried out in 2022 under the so-called REPowerEU Plan [37]. The need to increase the share of renewable energy sources is also included in the Communication from the Commission to the European Parliament entitled 'A Clean Planet For All' [33]. The Czech Republic (CR) has set a target of a 22% share of renewable energy sources in gross final consumption [38].

The Renewable Energy Directive 2009/28/EC (RED I) defines 'gross final energy consumption' as energy commodities supplied for energy purposes to industry, transport, households, services (including utilities), agriculture, forestry, and fishing, including electricity and heat consumption via the energy sector used for electricity and heat generation, and including electricity and heat losses during distribution and transmission.

In 2021, the share of gross final energy consumption from renewable sources at the EU level reached 21.8%. Compared to 2020, this was a decrease of 0.3 percentage points (p.p.) and the first recorded decrease ever. In the Czech Republic, the share of renewable sources in gross final energy consumption accounted for 17.7% in 2021. Compared to the preceding year, it represented an increase of 0.4 p.p. [39].

One of the renewable sources of energy is biomass. Biomass is a competitive fuel that can be successfully used for energy production. With a share of more than 60%, biomass for energy production (bioenergy) is the primary source of renewable energy in the EU [40]. The volume of biomass for energy production depends on the origin of the resource, its alternative use, and the limitation of its use [41].

Forests are an important potential source of biomass. Forest tree biomass (dendromass) mainly comprises forest residues, which are divided into primary, secondary, and tertiary residues in the published literature [42]. The Intergovernmental Panel on Climate Change (IPCC) identified forest biomass as an essential source of renewable energy [43]. Efficient use of resources such as forest biomass (e.g., logging residues) expands the overall availability of biomass for both industrial and energy purposes. One of the main products of forestry, wood, is a renewable and sustainable raw material that is currently widely used in all sectors of the national economy, including the energy sector [44–46]. As Europe is moving towards a bioeconomy by reducing their dependence on fossil fuels, forest products are increasingly used to secure energy supplies [10,25]. Forest biomass for energy purposes is one of the most important sources of energy thanks to the raw material potential and the possibility of its renewal [47]. Moiseyev et al. [48] estimate that 24% of the European Union's renewable energy goal was met through forests and the forest industry. Therefore, the consumption and production of wood biomass and other forms of renewable energy have been increasing significantly. One of the factors influencing the overall balance of

forest biomass is the form and quality of wood mass that cannot be further mechanically processed [49].

From a biophysical point of view, wood biomass resources are large enough to cover a substantial part of the world's primary energy consumption in 2050. However, these resources have alternative uses, and their availability is limited, making them less competitive with other forms of energy [50]. In order to solve some of the problems related to climate change and the search for alternative raw materials for energy use, the energy sector pays more and more attention to low-cost waste and biomass residues [51,52]. The focus is on improving the flow of waste in a circular economy and enabling better management [53].

The article concentrates on the use of forest logging residues for energy purposes. A cheap and available raw material, forest residues can replace current fossil energy sources, thereby contributing to reducing greenhouse gas emissions and increasing energy security [52–55]. However, it has been argued that besides its positive impacts, logging forest residues could also have negative impacts on the carbon and nutrient balance and subsequently on climate change, as well as other bioenergy impacts depending on the forest management methods [56,57]. The problem of determining the potential of biomass for energy purposes has also been addressed by foreign authors in Switzerland, Sweden, Pakistan, Africa, and Nigeria [58–62]. The topicality of this issue is underlined by the fact that since 2000 (44), the number of traceable publications on the subject has increased on Scopus up to 884 (2021) as reported by [63]. The authors [58,60–62] agree that the fulfilment of the global identified potential of biomass is severely limited by regional conditions, state regulation, resource disposition (agroforestry/agriculture), and potential impacts on food security, the market regulation of selected sectors, climate targets, and national environmental interests. Among domestic authors, the issue was also addressed by [28], who points to a significant decline in the potential of biomass from forest stands at the level of 60%–70% in the next decade, which is also confirmed by the results presented in this analytical study. Therefore, it is vital to analyse the consequences of the increased use of forest logging residues on the environment and the economy with respect to all processes in the supply chain and the regional perspective [64–66]. Czech forestry produces approx. 2 million m³ (approx. 0.77 million tons) of wood chips, 1.5 million tons of cellulose leach, and nearly 5 million tons of fuelwood for energy purposes [38]. As stated in the document of the Ministry of Industry of the Czech Republic [38], predicting the availability of forest biomass for energy purposes is currently extremely complex due to the ongoing bark beetle calamity. The article aims to analyse the base of forest raw material for energy use and predict the volumes of available forest biomass (primarily forest logging residues) in the Czech Republic with regard to the next possible occurrence of calamities caused by abiotic or biotic factors. The outputs of the article will include a quantified estimate of whether the Czech Republic can meet the goals in the utilisation of renewable energy sources set via the binding documents of the European Union.

2. Materials and Methods

The main method used in the paper is the method of modelling the overall overview of logging possibilities applied to the model data of forest stands and wood stocks in the Czech Republic. The goal of modelling the overall overview of logging possibilities in forests in the Czech Republic was to determine the theoretical outlook of ten-year logging possibilities in Czech forests for the period of 2021–2061. The outlook has been prepared for the entire Czech Republic using the following inputs:

- The data obtained during the preparation of forest management plans (FMP) and forest management outlines (FMO) that are stored in the Data Warehouse of the Information and Data Centre of the Institute for Forest Management Brandýs nad Labem Czech Republic (Institute for FM CR): available current FMP and FMO data (2012–2021).
- Other underlying data related to the restrictions on the felling volumes (categorisation of forests, NATURA 2000, etc.).

For the study, forests were divided into economically usable forests and forests with economic restrictions. The criteria for the division were the categories and subcategories as per the Forest Act (Act No. 289/1996 Coll., sections 6–9):

- Economically usable forests are production forests and special-use forests, with the exception of
 - The first zone of National Parks and Protected Landscape Areas, National Nature Reserves, National Natural Landmarks, and Nature Parks.
 - Forests with economic restrictions are protection forests and special-status forests of
 - The first zone of National Parks and Protected Landscape Areas, National Nature Reserves, National Natural Landmarks, and Nature Parks.

These exceptions are forests with economic restrictions.

The procedure for calculating the harvest outlook (based on Institute for FM CR methodology). The following steps are followed in each decennium:

- Determine the volume of regenerative harvesting according to the harvesting percentage.
- The harvesting percentage is used to determine the harvesting area.
- If the harvesting percentage is zero, the amount of clearing is calculated from the harvesting percentage.
- The age is increased by 10 years.
- The area is reduced via the harvesting area.
- The first age level of the harvest area is established and included in the restored parts of the stand.
- The stock is reduced via the volume of the regeneration harvest.
- The stock shall be increased via an increment coefficient.

The economically usable forests were used as the basis for processing the outlooks for the development of logging possibilities. The modelling and the prediction of logging were prepared by the Institute for Forest Management in Brandýs nad Labem CR as an expert consultant. The Institute for FM operates as an expert organisation of the Ministry of Agriculture of the Czech Republic for forestry and maintains a central database with information on the forests of the Czech Republic. Subsequently, the potential volume of forest logging residues from forests on the territory of the Czech Republic has been prepared in two variants:

Variant I:

- (Ad a) Theoretical outlook for forest logging residues in the period of 2021–2061 by individual decades. The outlook has been processed for individual regions and converted for the entire area of the Czech Republic.
- (Ad b) Theoretical outlook for forest logging residues in the period of 2014–2053 by individual decades. The output is calculated in aggregate for the Czech Republic.

Variant II:

- Theoretical outlook for forest logging residues in the period of 2021–2061 by individual decades. The outlook has been processed for individual regions and converted for the entire area of the Czech Republic.
- The theoretical outlook for forest logging residues in units of volume for Variants I (a, b) was prepared by the Institute for FM CR on the basis of the Agreement.

Variant I—(Ad a)

A derivation of the potential volume of forest logging residues in forests on the Czech territory for the period of 2021–2061 by individual decades. The outlook was prepared for individual regions and converted to the entire area of the Czech Republic. The volume of forest logging residues was determined using the Biomass Conversion and Expansion Factors (BCEF) derived by Assistant Prof. Cienciala for the purposes of the emission balance of the Czech Republic. Table 1 shows the used average proportions of forest

logging residues per 1 m³ of harvested wood, separately for regeneration and tending felling.

Table 1. Derivation of average shares of forest logging residues per 1 m³ of timber yield.

Species Category	Average Share of Forest Logging Residues/m ³	
	Regeneration Felling	Tending Felling
Spruce; Other coniferous species	0.138	0.224
Pine	0.082	0.115
Oak	0.222	0.313
Beech; Other deciduous species	0.123	0.186

Source: own processing based on the data from the Institute for FM CR.

The derived potential volume of forest logging residues represents the total volume of forest logging residues (including bark) without any reductions.

Variant I—(Ad b)

A derivation of the potential annual volume of forest logging residues in forests on the Czech territory for the period of 2014–2053 by individual decades. The output is calculated in aggregate for the Czech Republic. For the first decade, a part of the logging volume is taken from the data obtained by the Czech Statistical Office (2014–2021); the rest is a qualified estimate (2022–2023), whereas the calamity period is taken into account. The volume of forest logging residues was derived using the Biomass Conversion and Expansion Factors (BCEF) derived by Assistant Prof. Cienciala for the purposes of the emission balance of the Czech Republic. Table 1 shows the used average proportions of forest logging residues per 1 m³ of harvested wood, separately for regeneration and tending logging.

Variant II:

The volume of logging residues can also be quantified using the Forest Resource Assessment based on the relationships shown in Table 2.

Table 2. Ratio of the mass of timber with a top diameter of 7 cm or more under the bark to the volume of forest logging residues.

Stock Component	Share in the Total of Shoot Biomass
Volume of timber with a top diameter of 7 cm or more under bark (<i>w/o</i> bark)	77%
Bark	9%
Volume of timber with a top diameter of up to 7 cm	12%
Stump	2%

Source: own processing based on the data from the Institute for FM CR.

If we want to expand the volume of timber with a top diameter of 7 cm or more without bark to the total shoot mass using the above values, we must multiply the value of timber with a top diameter of 7 cm and more under bark via a coefficient of 1.299. In other words, branches thinner than 7 cm, bark, and stumps amount to approx. 30% more than the recorded stock of timber with a top diameter of 7 cm or more without bark.

The theoretical conversions of the potential of forest logging residues from m³ to tons (t) for variants I (a; b) and variant II were carried out using a coefficient of 0.625 based on the bulk density of wood, its moisture content, and, for example, long-term contracts with the forests of the Czech Republic state enterprise (FCR, s.e.). Furthermore, attention must

be drawn to the other specifics of handling forest dendromass (forest wood chips) arising from transport, handovers, etc. It means that the basic unit of wood (m^3 , plm) must be converted to bulk space metre (prms) and then to tons (t). The empirically determined coefficient of woodchip production volume used in operation is approx. 0.7 prms per 1 m^3 of timber with a top diameter of 7 cm and more under bark; the weight of a loose cubic metre of wood chips varies depending on the type of wood and the moisture content of the wood chips. For instance, the bulk weight of coniferous wood chips with a moisture content of around 50%–60% is approx. 250–400 kg. For deciduous wood chips with a moisture content of around 50%–60%, the bulk weight of the wood chips is around 350–450 kg.

3. Results

The figures (Figures 1 and 2) below provide information about the development in standing volume and an outlook of felling possibilities depicted in the volumes of regeneration and tending felling, with ending felling increased by 15% (the average increase for the entire Czech Republic pursuant to section 8(10) of the Decree of the Ministry of Agriculture No. 84/1996 Coll., and the total felling volume (a sum of the regeneration felling volume and the volume of tending felling increased by 15%). Lastly, Figure 3 shows the assortment possibilities via the individual assortment types: roundwood, pulpwood, and fuelwood.

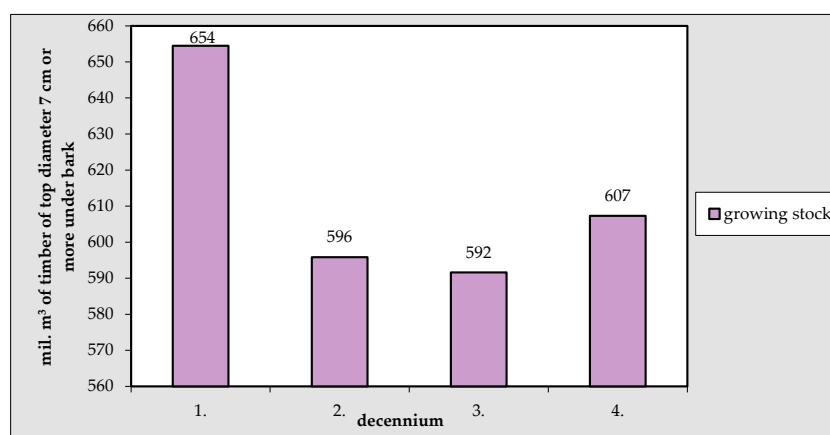


Figure 1. Outlook for the development of standing volume. Source: own processing based on data from Institute for FM CR.

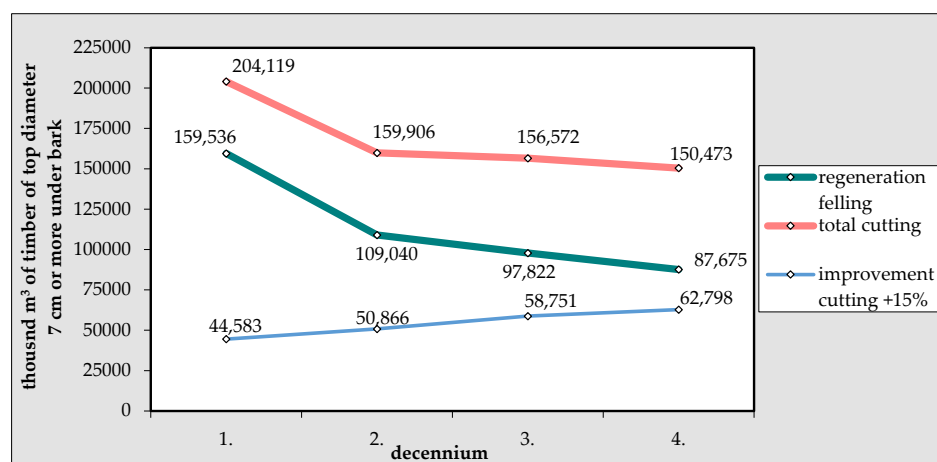


Figure 2. Theoretical outlook for ten-year logging possibilities (of logging percentages). Source: own processing based on data from Institute for FM CR.

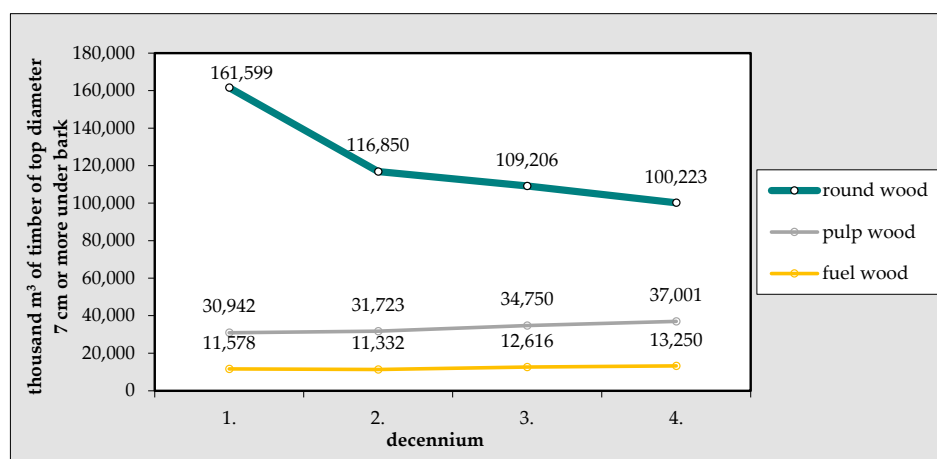


Figure 3. Theoretical outlook of assortment options. Source: own processing based on data from Institute for FM CR.

Based on the results of the felling possibilities analyses, a more significant decrease in felling possibilities can be predicted, derived from the current development of incidental felling in the past years (2015–2021), a decrease in increment, and the felling percentage. In the second decade (2031–2040), the total standing volume will drop below 600 million m^3 of timber with a top diameter of 7 cm or more under bark. Due to the course of the bark beetle calamity, there will be significant differences in the individual regions.

3.1. The Theoretical Potential of Forest Logging Residuals

Variant I (ad a) represents a derivation of the potential volume of forest logging residues in forests on the Czech territory for the period of 2021–2061 by individual decades. The outlook has been processed for individual regions and converted for the entire area of the Czech Republic. Table 3 shows an overview of forest logging residues by individual regions and for the Czech Republic in individual decades. Table 3 gives an overview of the annual potential of forest logging residues by individual regions and for the Czech Republic. The overview shows the distribution of the volume of forest logging residues in individual decades based on the annual available capacity.

Table 4 demonstrates the annual potential volume of forest logging residues in individual decades by individual regions and for the entire Czech Republic, calculated in tons.

Table 3. Overview of forest logging residues by individual regions and for the Czech Republic in individual decades.

Individual Decades in m^3	1	2	3	4
South Bohemian Region	446,800	364,100	364,000	357,500
Plzeň Region	336,900	276,800	277,500	270,800
Karlovy Vary Region	157,600	130,100	128,500	127,900
Ústí nad Labem Region	108,700	100,800	106,900	101,800
Liberec Region	114,100	100,800	100,900	98,000
Hradec Králové Region	151,300	129,000	131,100	128,800
Pardubice Region	178,300	146,600	147,100	144,300
Vysočina Region	309,700	260,000	266,100	258,600
South Moravian Region	216,500	180,200	180,100	173,300
Olomouc Region	220,500	187,600	190,100	189,000
Zlín Region	227,400	186,700	187,300	181,800

Table 3. *Cont.*

Individual Decades in m ³	1	2	3	4
Moravian-Silesian Region	221,100	183,700	191,700	194,300
Central Bohemian Region; Prague	299,300	240,600	237,400	230,400
Czech Republic (total)	2,988,200	2,487,000	2,508,700	2,456,500

Source: own processing based on the data from the Institute for FM CR.

Table 4. Overview of the annual potential of forest logging residues by individual regions and for the Czech Republic converted to tonnes.

Individual Decades in (t)	1	2	3	4
South Bohemian Region	279,250	227,563	227,500	223,438
Plzeň Region	210,563	173,000	173,438	169,250
Karlovy Vary Region	98,500	81,313	80,313	79,938
Ústí nad Labem Region	67,938	63,000	66,813	63,625
Liberec Region	71,313	63,000	63,063	61,250
Hradec Králové Region	94,563	80,625	81,938	80,500
Pardubice Region	111,438	91,625	91,938	90,188
Vysočina Region	193,563	162,500	166,313	161,625
South Moravian Region	135,313	112,625	112,563	108,313
Olomouc Region	137,813	117,250	118,813	118,125
Zlín Region	142,125	116,688	117,063	113,625
Moravian-Silesian Region	138,188	114,813	119,813	121,438
Central Bohemian Region; Prague	187,063	150,375	148,375	144,000
Czech Republic (total)	1,867,625	1,554,375	1,567,938	1,535,313

Source: processed by the authors based on the data from the Institute for FM CR.

Variant I (ad b) represents a derivation of the potential volume of forest logging residues in forests on the Czech territory for the period of 2014–2053 by individual decades. The output has been calculated in aggregate for the Czech Republic. For the first decade, part of the logging volume is taken from the data obtained by the Czech Statistical Office (2014–2021); the rest is a qualified estimate (2022–2023), whereas the calamity period is taken into account. Table 5 shows an overview of the annual potential of forest logging residues by individual decades for the Czech Republic via the volume of the main tree species.

Table 5. Overview of the annual potential of forest logging residues for the Czech Republic by individual decades and main tree species.

Annual Potential in Individual Decades in (m ³)	1	2	3	4
Spruce	3,157,067	1,725,947	1,466,856	1,446,864
Pine	132,675	153,425	137,372	129,709
Other coniferous species	98,077	129,661	118,550	135,718
Oak	80,632	148,620	177,285	205,843
Beech	86,565	101,501	134,095	163,773
Other deciduous species	84,849	131,398	153,003	164,897
Total	3,639,865	2,390,550	2,187,161	2,246,803

Source: processed by the authors based on the data from the Institute for FM CR.

Table 6 shows the annual potential volume of forest logging residues by individual decades for the entire territory of the Czech Republic, calculated in tons.

Table 6. Overview of the annual potential of forest logging residues by individual decades for the Czech Republic converted to tonnes.

Annual Potential in Individual Decades in (t)	1	2	3	4
Total	2,274,916	1,494,094	1,366,976	1,404,252

Source: processed by the authors based on the data from the Institute for FM CR.

3.2. Derivation of the Potential Volume of Forest Logging Residues in Forests on the Czech Territory (Variant II)

Table 7 gives an overview of the annual potential of forest logging residues by individual regions and for the Czech Republic. The overview shows the distribution of the volume of forest logging residues in individual decades based on the annual available capacity.

Table 7. The overview shows the distribution of the volume of forest logging residues in individual decades based on the annual available capacity.

Individual Decades in (m ³)	1	2	3	4
South Bohemian Region	971,400	730,100	701,700	676,200
Plzeň Region	716,200	551,900	537,800	514,700
Karlovy Vary Region	320,300	251,200	240,200	233,300
Ústí nad Labem Region	220,600	197,400	204,800	187,500
Liberec Region	249,300	206,900	200,700	189,400
Hradec Králové Region	301,800	247,400	245,200	233,400
Pardubice Region	363,500	282,600	275,500	266,100
Vysočina Region	615,800	488,900	487,800	466,700
South Moravian Region	419,600	330,300	322,200	305,700
Olomouc Region	428,500	343,700	338,900	335,400
Zlín Region	452,300	351,400	341,900	325,700
Moravian-Silesian Region	430,600	338,300	346,100	349,700
Central Bohemian Region; Prague	633,700	477,200	454,500	430,400
Czech Republic (total)	6,123,600	4,797,300	4,697,300	4,514,200

Source: processed by the authors based on the data from the Institute for FM CR.

Table 8 demonstrates the annual potential volume of forest logging residues in individual decades by individual regions and for the entire Czech Republic, calculated in tons.

On the one hand, the industry's potential is limited by unperformed projects, logistics, and fossil fuel prices. On the other hand, it is constrained by the increasing requirements to keep biomass from primary forest production in forest stands. This potential reaches a maximum of 2.5 tonnes per year (4 million m³).

This includes farmed trees, where there is some room for an increase (estimated at max. 100,000 tons) and residual dendromass in the forests. This outlook is for the middle of the second decade, approximately until 2035.

Another factor that plays a significant role is the fact that forests with an increased interest in nature protection make up 44% of the forest land for which FCR, s.e. holds the management right. The collection of forest logging residues is excluded for the category of protective forests, national nature reserves, national natural landmarks, nature reserves, nature parks, first zones of National Parks, European areas of conservation, and water resource protection zones. Furthermore, the following locations are also not particularly

suitable for forest logging residues' collection: exposed sites, natural pine sites, natural regeneration areas, and locations in the 7th and 8th forest vegetation stage zones. It follows from the above that 657 thousand ha (i.e., 56% of timber land) of land for which FCR, s.e. holds the management rights meet the criteria for locations suitable for collecting forest logging residues for energy purposes.

Table 8. The overview shows the distribution of the volume of forest logging residues in individual decades based on the annual available capacity converted to tonnes.

Individual Decades in (t)	1	2	3	4
South Bohemian Region	607,125	456,313	438,563	422,625
Plzeň Region	447,625	344,938	336,125	321,688
Karlovy Vary Region	200,188	157,000	150,125	145,813
Ústí nad Labem Region	137,875	123,375	128,000	117,188
Liberec Region	155,813	129,313	125,438	118,375
Hradec Králové Region	188,625	154,625	153,250	145,875
Pardubice Region	227,188	176,625	172,188	166,313
Vysočina Region	384,875	305,563	304,875	291,688
South Moravian Region	262,250	206,438	201,375	191,063
Olomouc Region	267,813	214,813	211,813	209,625
Zlín Region	282,688	219,625	213,688	203,563
Moravian-Silesian Region	269,125	211,438	216,313	218,563
Central Bohemian Region; Prague	396,063	298,250	284,063	269,000
Czech Republic (total)	3,827,253	2,998,316	2,935,816	2,821,379

Source: processed by the authors based on the data from the Institute for FM CR.

Another important aspect is that for 2021–2030, FCR, s.e. anticipates the sale of forest logging residues amounting to approx. 2,700,000 m³ of concentrated felling and approx. 165,000 m³ of first thinning. For 2031–2040, this volume is expected to decrease by approximately 40%.

The overall energy mix does provide much room for improvement unless the following changes:

- (a) combustion technology and an increase in efficiency,
- (b) technology for the production of noble fuels (2nd generation).

4. Discussion

Climate change, pollution, and energy insecurity are among the biggest problems our society is facing [67]. With the ongoing energy crisis, renewable energy sources, if used correctly, contribute to reducing energy dependence on conventional energy sources. Thanks to low operating costs, renewable energy sources are little affected by fossil fuel price fluctuations [27].

The Green Deal for Europe [30], a very ambitious package of measures that should enable European citizens and businesses to enjoy the benefits of a sustainable ecological transition—has set the goal for the EU to become the world's first climate-neutral continent by 2050. Society's need to address issues related to global climate change has fuelled interest in the research and adoption of renewable energy sources such as the use of biomass [68].

Demand for renewable energy sources (including biomass) is growing in many countries worldwide. The results of scientific research and the recent guidelines laid down by the Paris Agreement [69] call for radical changes in this area. Renewable energy sources play a crucial role in the transition to clean energy. The deployment of renewable energy

sources is one of the main factors in keeping the rise in average global temperature below 1.5 °C [10].

Yet, electricity generation from renewable sources must expand faster to reach the milestones set in the Net Zero Emissions scenario by 2050, which demands the share of electricity generation from renewable sources to increase from nearly 29% in 2021 to more than 60% by 2030. Annual generation must grow at an average rate of over 12% in 2022–2030, i.e., double the 2019–2021 average [10].

The EU needs to include as many renewable energy sources as possible in the comprehensive energy mix to meet its 2030 targets for the share of renewable energy in final gross energy consumption and the carbon neutrality of the energy sector by 2050. Looking at the EU goal, which is currently set at 32% for 2030 by Directive 2018/2001 of 11 December 2018 on the Promotion of the Use of Energy from Renewable Sources, the share of 21.8% recorded in 2021 is still significantly below this objective. Therefore, countries need to step up their efforts to stay above the baseline set in Regulation 2018/1999 on the Governance of the Energy Union and Climate Action and to follow the EU's required trajectory. That is all the more so since the Commission issued a proposal to amend the Renewable Energy Directive in 2021, seeking to increase this target to 40% and with the REPowerEU plan further increasing this target to 45% in 2022.

Currently, the share of renewable energy in the total consumption of the Czech Republic is more than 17%, while the vast majority of this energy comes from various forms of biomass [70].

According to the publication, *Development of Renewable Energy in the Czech Republic until 2030* [70], the Czech Republic should increase its share of renewable energy sources to 33%–35% by 2030. The report indicates that the use of sustainable biomass, such as wood waste, plays only a complementary role in the further development of renewable energy—simply because biomass is and will be a limited resource. According to this report, this type of renewable energy source should increase by 4 p.p. Despite its renewable nature, however, wood is a limited resource, and currently, a significant volume of processed raw material that ends up in secondary streams is used as fuel [45]. Wood biomass can be a sustainable source of energy, a valuable renewable alternative to the limited supply of available fossil fuels [44,46]. Regarding forest use, sustainability means that forests and the benefits they bring to current generations should not jeopardise the possibility for future generations to benefit from them similarly [47]. What our forests will look like for future generations and the resulting impact of climate change on forestry will be in the hands of forest managers [7]. This being said, more research is needed that takes into account the environmental, economic, and social constraints of logging residue disposal [66].

5. Conclusions

All sectors of the EU economy, including forestry, should contribute to achieving climate neutrality by all available means. Forestry could help to achieve the targets via the sustainable use of forest biomass for energy production. This would achieve energy efficiency, availability, and the security of energy supply across the European Union. The paper suggests whether and how this can be achieved.

If the set goal for the Czech Republic is the share of renewable energy sources in the total gross final energy consumption of 22% by 2030, the share of forest biomass from primary production in the energy mix is currently at its maximum available limit. A further increase in the share by 2030 while maintaining the principles of sustainable forest management is no longer possible; it could result in a threat to the security of supply in the longer term, including the risk of distortion of the wood raw material markets in technological processing assortments—saw logs, wood for the paper and pulp industry, and the production of wood-based agglomerated materials.

For these reasons, it is clear that if we want to preserve the quality of forests in the Czech Republic in the future, we need to focus on other resources that could be used to meet the goals set by our country as an EU Member State. A potential option can be found

in the waste generated at sawmills, paper mills, or the construction industry, i.e., wherever unprocessed wood waste remains.

Author Contributions: Conceptualization, J.M. and P.H.; methodology, D.B.; validation, P.H. and J.M.; investigation, D.B.; resources, D.B.; data curation, P.H. and J.M.; writing—original draft preparation, P.H.; writing—review and editing, P.H.; supervision, P.H. and D.B.; project administration, J.M.; funding acquisition, D.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded with support from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 952314.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: Thanks are also due to the contract research entitled: “Analysis and prediction of the development of raw timber stocks in forest areas of the Czech Republic and the development of the available raw material base of forest dendromass for technological and energy purposes in the Czech Republic”; prepared for the Forestry and Timber Chamber of the Czech Republic. The Institute for Forest Management in Brandýs nad Labem CR also participated in the study.

Conflicts of Interest: The authors declare no conflict of interest.

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