Role of Agricultural Biomass in European Union Countries

Subjects: Business, Finance

Contributor: Dorota Janiszewska, Luiza Ossowska

The theoretical potential presenting the energy value of all existing agricultural biomass resources in EU countries and the technical potential taking into account agricultural biomass resources that are not used in agriculture. The research was based on Eurostat data for 2019. The conducted research shows that European Union countries are characterized by a significant potential of agricultural biomass.

Keywords: agriculture biomass ; energy potential ; EU countries

1. Introduction

As emphasized by the European Commission in “A new Circular Economy Action Plan for a cleaner and more competitive Europe”, there is only one planet Earth, but by 2050, global consumption will be as large as if there were three [1]. The 2018 OECD communication indicated that by 2060, the consumption of materials such as biomass, fossil fuels, metals and minerals will double, and the amount of waste will increase by 70% [2]. All of this negatively affects the quality of the environment and the size of natural resources, and requires action for a climate-neutral, resource-efficient and competitive economy. Moreover, according to some opinions, the ongoing war between Russia and Ukraine in the geopolitical sense may contribute to the acceleration of the energy transformation [3]. In the face of the crisis, it is crucial to focus on ensuring the continuity of fuels and energy as well as the economic and political security of domestic energy resources [4]. However, the current energy crisis has revealed that the transition to renewable energy is too slow and that serious efforts are needed to accelerate the transition from fossil fuels to renewable energy [5].

Renewable energy for the European Union has long been an important aspect of the functioning of the Community. Already in 1986, one of the first documents on energy in the European Union appeared, which was the Council Resolution on new community goals regarding energy and the divergence of the Member States, which contained a postulate to promote renewable energy sources [6]. Later successes in the use of renewable energy were influenced by a number of introduced reforms of a social and economic nature. One of the most important documents was Directive 2001/77/EC [7], which reflected the declarations and proposals contained in the White Paper “Energy for the future—renewable energy sources” [8]. In this directive, the Community made the promotion of renewable energy sources a priority, mainly due to its positive impact on environmental protection and sustainable development. In contrast, the 2005 Commission Communication [9] referred to the increased use of biomass as a renewable energy source in the energy sector. It was highlighted that biomass has many advantages over conventional energy sources as well as some types of renewable energy. The key document in the field of promoting the use of energy from renewable sources was also Directive 2009/28/EC [10], which considered it appropriate to set mandatory national targets, according to which, in 2020, 20% of energy and 10% of energy in the Community should come from renewable sources in the transport sector. Today, providing clean, affordable and secure energy is one of the key elements of the European Green Deal. In this respect, further decarbonization of the energy system by creating a sector based largely on renewable sources, while at the same time rapidly phasing out coal and reducing the emission of gas [11], was considered crucial for achieving the 2030 and 2050 climate goals. In order to face the emerging challenges (limiting dependence on non-renewable resources, sustainable management of natural resources, food security), the European Union is moving towards a bioeconomy. Bioeconomy should be understood as the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and bioenergy [12].

The share of energy from renewable sources in European Union countries is growing every year. Over the last 15 years, the share of energy from renewable sources has more than doubled and has amounted to 22.1% in 2020 (10.2% in 2005). The largest share of renewable energy is in Sweden (55.8%), Finland (42.7%) and Latvia (40.9%). Conversely, the lowest share of energy from renewable sources is in Luxembourg (7.0%), Malta (8.2%) and Netherlands (8.9%) [13].

Biomass dominates among renewable energy sources in European Union countries, which is one of the most popular and universal raw materials on earth [14][15]. Biomass in European Union countries currently accounts for 60% of all renewable energy sources and 10% of all energy sources [16]. The largest share of biomass in renewable energy is in Estonia (94%), Latvia (92.4%) and Lithuania (91.1%). A significantly lower share of biomass in renewable energy is found in Malta (9.3%), Cyprus (15.2%) and Ireland (23.5%) [13]. Conversely, the dominant source of biomass in the European Union is woody biomass, the share of which is over 60%. The largest share of forestry in the production of renewable energy is in Estonia, Latvia Lithuania, and the lowest in Malta, Cyprus and Ireland. Agricultural biomass (equally from agricultural crops and agricultural by-products) accounts for 27%. Countries such as the Netherlands, Germany and Belgium produce the most energy from agriculture in the European Union. The least amount of energy from this source is Estonia, Sweden and Bulgaria, while the remaining 12% originates from waste (municipal, industrial, etc.) [17][18].

However, the dominant wood biomass can only continue to play a significant role as a renewable energy source if it is produced and used in a sustainable and efficient manner, taking into account the cascading principle and the European Union's carbon sequestration and biodiversity objectives [19]. According to the EU Biodiversity Strategy for 2030, in order to mitigate the potential climatic and environmental threats related to the use of wood biomass, the use of whole trees for energy production should be minimized [20]. Thus, according to the cascading principle, biomass should be used in the following order: reuse, recycling, bioenergy and disposal. Therefore, the exploitation of biomass that does not violate the aforementioned principle is of interest. According to Alatzas et al. [21], waste, residues and surplus biomass generated in agriculture comply with these criteria, and further research into the possibilities of exploiting this resource raises high hopes. According to a 2009 report by the European Commission, biomass was expected to contribute to around two-thirds of the share of renewable energy [22]. Therefore, according to Scarlat et al. [23], the use of biomass for bioenergy production must take into account the use of all available resources in a sustainable manner without negative impacts. Therefore, only the technical potential of agricultural biomass should be used for energy purposes. As emphasized by Gavrilescu [24], from an ethical point of view, only biomass that does not compete with food production should be used for the production of fuels, energy and heat. Hence, only surplus biomass should be used for energy purposes.

2. Agricultural Biomass

Biomass provides people with food, fiber and fuel. In addition, it is an essential resource for all animals and microorganisms. The production of biomass replenishes the carbon in soil and vegetation, which is consumed by these animals and microorganisms and returned to the atmosphere [25]. Taking into account the political perspective, the use of energy from biomass can be an attractive option to reduce greenhouse gas emissions and improve energy security [26].

Biomass is derived from a wide range of feedstocks, such as biomass from agriculture (crop residues, bagasse, animal waste, energy crops, etc.), forestry (logging residues, wood processing by-products, black liquor from the pulp and paper industry, fuelwood, etc.), and other types of biological waste (food waste, food industry waste, the organic fraction of municipal solid waste, etc.) [17], whereas agricultural biomass is defined as a subset of biomass produced directly from agricultural activities, including cereal grains, sugar crops, oilseeds, other arable crops and crop by-products such as straw, vegetative grasses, farm forestry (e.g., willow and poplar), and livestock by-products, for example, manure and animal fats [27]. Agricultural biomass has many advantages as a source of renewable energy. The most important of them are the utilization of waste and residues from agricultural activities, reduction of agricultural emissions, the diversity of the use of agricultural biomass (production of heat, electricity, fuels in transport), widespread availability of raw materials and improvement of energy security at the regional level through decentralization of energy production. Moreover, it is possible to obtain additional income from the overproduction of agricultural raw materials and the creation of new jobs [28][29]. However, as emphasized by Daioglou et al. [26], the role of biomass and its benefits depend mainly on the supply chain, including factors such as land use dynamics, the amount and type of fossil fuels replaced, and potential feedbacks in the energy system. However, according to Nakicenovic et al. [30], the future of bioenergy development is influenced by many unpredictable factors, such as: population dynamics, economic development, food demand, feed, fiber and energy services, changes in agricultural and forestry production intensity, land protection decisions, and availability and costs advanced energy conversion technologies. Hence, it is important to analyze possible options for the development of the sector, taking into account the above-mentioned factors.

Biomass will become an increasingly important resource in the bio-fuel farm. However, this will require sustainable management, as biomass comes from many different sectors of the economy that are regulated by different policies [31]. In addition, Hamelin et al. [32] believe that the use of residual biomass is of crucial importance for the European bioeconomy. Similarly, Kluts et al. [33] and Haase et al. [34] consider that biomass residues from primary, secondary and tertiary economic activities play a key role in providing the raw materials needed to create sustainable bio-farm pathways. Additionally, as indicated by Tonini et al. [35] and Hamelin et al. [36], the use of biomass as the main bioeconomy feedstock

has a lower environmental impact than that produced on land. In addition, the residual biomass is an unused potential that can increase the resources of biomass that can be used for energy purposes [34][37].

Imperial College London [38] in its report, *Sustainable biomass availability in the EU to 2050*, described three possible scenarios for the use of biomass for energy purposes. Scenario I provides for a low mobilization of biomass, assuming that agricultural practices will be at the level of 2020, approx. 25% of unused, abandoned and degraded land will be usable for biomass cultivation, and the main emphasis will be on the use of residues and waste in the bioenergy and non-energy sectors. Scenario II assumes improved mobilization of biomass in selected countries through improved agricultural practices (improving soil and biomass productivity), the use of approx. 50% of unused, abandoned and degraded land for biomass cultivation, and an emphasis on the use of waste residues in the bioenergy and non-energy sectors. Conversely, scenario III assumes increased availability due to R + I and improved mobilization through improved management practices in agriculture, the use of approx. 75% of unused, abandoned and degraded land for the cultivation of biomass; better research and innovation leading to higher yields, efficiency of harvesting equipment and emphasis on the use of residues and waste in the energy and non-energy biocomponents sectors.

As Tripathi [39] emphasizes, due to the intensification of agricultural and industrial activities caused by the growing population and its growing demand for food and other basic products, waste is a growing problem. Both the neutralization, utilization and methods of managing agricultural waste are inefficient and rarely used. Moreover, especially in developing countries, most of the biomass residues are left as organic matter in the field or are burned in the open, which has a negative impact on the environment. In addition, according to Vaish et al. [40], biomass sources are still underused, mainly due to the lack of standard national resource estimation policies. Therefore, there is a need to use alternative, sustainable energy sources and the supply of raw materials. According to Odavic et al. [41], the low level of utilization of the existing biomass potential from agricultural production may be caused by the low energy value of this resource per unit of transport volume and too large spatial dispersion. Waste from this source is underused, and thus far, there has not been much research focused on this issue. However, the available studies indicate a significant role of agricultural biomass in the production of energy from renewable sources in European Union countries.

Research by Ericsson and Nilsson [42] indicates that agricultural policy in the European Union will be a key factor for the future of bioenergy. According to the authors, the greatest potential in Europe is in the field of energy crops. Moreover, as the authors emphasize, due to the surplus of food production in European Union countries, this source of biomass may be an interesting alternative to food crops. Additionally, the analyses carried out also indicate that the potential biomass resources in European Union countries are unevenly distributed. Scarlat et al. [23] indicated that in European Union countries, there is a significant potential in terms of production and in the use of agricultural crop residues for energy purposes. According to the authors, this source of biomass may play an important role in sustainable energy production; however, when using it, certain limitations of this source should be taken into account, i.e., resources, logistics, technological, economical and social, which affect the security and continuity of biomass supplies. Moreover, the authors also emphasize that due to different geographic and climatic conditions and the status of agriculture activities, agricultural crop residues available for bioenergy in each European Union country show large spatial and temporal differences. Hamelin et al. [32] made a detailed analysis of the theoretical potential of biomass residues for energy purposes in the European Union. In their analysis, the authors took into account the biomass from: agriculture (straw, manure, residues from pruning permanent plantations); forestry (forestry residues); urban greenery management (residues from managing urban green areas and roadside vegetation); and food waste (agri-industrial food process waste and municipal biodegradable waste). The conducted research shows that straw from cereal cultivation is the main source of biomass that can be used in the European Union. This type of biomass accounts for about 8% of the marginal energy consumption in the European Union.

Agricultural biomass is also of interest to the authors who conducted research on its potential outside Europe. Research by Demirel et al. [43] in Sudan also indicates that the amount of biomass from agricultural waste is significant, which is the basis for energy production from this source. Due to this source, it is possible to reduce the energy shortage problems in the country. In addition, in these studies, biomass density varies depending on the crops and regions of Sudan. Vaish et al. reached similar conclusions in their research [40], as they conducted research on the potential of biomass remaining in crops in the agricultural provinces of India. According to the authors, the existing surplus of agricultural biomass has enormous potential to contribute to energy generation applications and to increase the total installed capacity of renewable sources in the country. Research by Mohammed et al. [44] in Ghana also indicates that the country has adequate bioenergy potential, giving high hopes for future energy supplies in the country. It is similar in other African countries, such as: Nigeria [45], Madagascar [46] or the countries of North Africa [47]. Researchers also point out that energy consumption from biomass lowers carbon emissions. Analyses of the potential of agricultural biomass were also carried out by Odavić et al. [41]. The authors' research carried out on the example of the Serbian region shows that this area also

has a significant potential for biomass from agricultural production. For Serbia, the development of the domestic energy market is an important factor in achieving a competitive national economy and energy independence. It is an example of interest in energy from agricultural biomass in European but non-EU countries.

However, despite the significant role and significance of the analyzed renewable energy source indicated in various studies, the potential of biomass from agriculture cannot be perceived as a constant value over time, but rather as dynamic under the influence of changes in many factors and characteristics. These features include mainly: the amount of available agricultural land, the structure of crops, allocation of energy crops, the learning curve effect and the impact of climate change [48].

References

1. European Commision. A New Circural Economy Action Plan for a Cleaner and More Competitive Europe; COM (2020) 98 Final; European Commission: Brussels, Belgium, 2020; Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2020%3A98%3AFIN (accessed on 10 November 2021).
2. Global Material Resources Outlook to 2060, OECD, 2018. Available online: https://www.oecd.org/environment/waste/highlights-global-material-resources-outlook-to-2060.pdf (accessed on 10 November 2021).
3. Żuk, P.; Żuk, P. National energy security or acceleration of transition? Energy policy after the war in Ukraine. Joule 2022, 6, 703–712.
4. Agaton, C.B. Will a Geopolitical Conflict Accelerate Energy Transition in Oil-Importing Countries? A Case Study of the Philippines from a Real Options Perspective. Resources 2022, 11, 59.
5. Hosseini, S.E. Transition Away from Fossil Fuels Toward Renewables: Lessons from Russia-Ukraine Crisis. Future Energy 2022, 1, 2–5.
6. Council Resolution of 16 September 1986 Concerning New Community Energy Policy Objectives for 1995 and Convergence of the Policy of the Members States, OJ C 241. Available online: https://eur-lex.europa.eu/legal-content/SV/ALL/?uri=CELEX:31986Y0925(01) (accessed on 10 November 2021).
7. Directive 2001/77/EC of the European Parliamentn and of the Council of 27 September 2001 on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market; Council of the European Union: Brussels, Belgium, 2001; Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0077&from=ES (accessed on 10 November 2021).
8. Energy for the Future: Renewable Sources of Energy—White Paper for a Community Strategy and Action Plan; COM (97) 599 Final; European Commission: Brussels, Belgium, 1997; Available online: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A51997DC0599 (accessed on 10 November 2021).
9. Biomass Action Plan; COM (2005) 628 Final; European Commission: Brussels, Belgium, 2005; Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0628:FIN:EN:PDF (accessed on 10 November 2021).
10. Directive 2009/28/EC of 23 April 2009 on the Promotion of the Use of Energy from Renewable Sources and Amending and Subsequently Repealing Directives 2001/77/EC and 2003/30/EC; Council of the European Union: Brussels, Belgium, 2009; Available online: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:en:PDF (accessed on 10 November 2021).
11. European Commission. The European Green Deal; COM (2019) 640 Final; European Commission: Brussels, Belgium, 2019; Available online: https://eur-lex.europa.eu/legal-content/PL/TXT/?uri=CELEX%3A52019DC0640 (accessed on 10 November 2021).
12. Liebert, M.A. Innovating for sustainable growth: A Bioeconomy for Europe. Ind. Biotechnol. 2012, 8, 57.
13. European Comission. Energy, Transport and Environment Statistics, 2020th ed.; Publication Office of the European Union: Luxembourg, 2020; pp. 10–40. Available online: https://ec.europa.eu/eurostat/web/products-statistical-books/-/ks-dk-20-001 (accessed on 30 November 2021).
14. Țenchea, A.I.; Tokar, D.M.; Foris, D. The use of biomass as a renewable energy source in a fluidized bed combustion plant. Bull. Transilv. Univ. Braşov Ser. II For. Wood Ind. Agric. Food Eng. 2019, 12, 117–126.
15. Janiszewska, D.; Ossowska, L. Biomass as the Most Popular Renewable Energy Source in EU. Eur. Res. Stud. J. 2020, 23, 315–326.

16. Raport: Bioenergy Landscape. Brussels 2019. Available online: https://bioenergyeurope.org/article/275-bioenergy-landscape-2.html (accessed on 10 November 2021).
17. The European Commission's Knowledge Centre for Bioeconomy. European Union 2019. Available online: https://publications.jrc.ec.europa.eu/repository/handle/JRC109354 (accessed on 10 November 2021).
18. European Commission. Cap Context Indicators 2014–2020; Agriculture and Rural Development; European Commission: Brussels, Belgium, 2017; pp. 190–191.
19. European Commission. New EU Forest Strategy for 2030; COM (2021) 572 Final; European Commission: Brussels, Belgium, 2021; Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021DC0572&from=EN (accessed on 10 November 2021).
20. Europian Commision. EU Biodiversity Strategy for 2030; COM (2020) 380 Final; European Commission: Brussels, Belgium, 2020; Available online: https://www.eumonitor.eu/9353000/1/j4nvhdfcs8bljza_j9vvik7m1c3gyxp/vl8tqb8jwtyy (accessed on 10 November 2021).
21. Alatzas, S.; Moustakas, K.; Malamis, D.; Vakalis, S. Biomass potential from agricultural waste for energetic utilization in Greece. Energies 2019, 12, 1095.
22. The Renewable Energy Progress Report: Commission Report in Accordance with Article 3 of Directive 2001/77/EC, Article 4(2) of Directive 2003/30/EC and on the Implementation of the EU Biomass Action Plan; SEC (2009) 503 Final; European Commission: Brussels, Belgium, 2009; Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52009DC0192 (accessed on 10 November 2021).
23. Scarlat, N.; Martinov, M.; Dallemand, J.F. Assessment of the availability of agricultural crop residues in the European Union: Potential and limitations for bioenergy use. Waste Manag. 2010, 30, 1889–1897.
24. Gavrilescu, M. Biomass power for Energy and sustainable development. Environ. Eng. Manag. J. 2008, 7, 617–640.
25. Krausmann, F.; Erb, K.-H.; Gingrich, S.; Haberl, H.; Bondeau, A.; Gaube, V.; Lauk, C.; Plutzar, C.; Searchinger, T.D. Global human appropriation of net primary production doubled in the 20th century. Proc. Natl. Acad. Sci. USA 2013, 110, 10324–10329.
26. Daioglou, V.; Doelman, J.C.; Wicke, B.; Faaij, A.; van Vuuren, D.P. Integrated assessment of biomass supply and demand in climate change mitigation scenarios. Glob. Environ. Change 2019, 54, 88–101.
27. Biomass and Agriculture: Sustainability, Markets and Policies, OECD, Paris 2004. Available online: https://vdoc.pub/download/biomass-and-agriculture-sustainability-markets-and-policies-5etfsvelmih0 (accessed on 10 November 2021).
28. Janiszewska, D.; Ossowska, L. Diversification of European Union Member States due to the production of renewable energy from agriculture and forestry. Probl. World Agric. 2018, 18, 95–104.
29. Gokcol, C.; Dursun, B.; Alboyaci, B.; Sunan, E. Importance of biomass energy as alternative to other sources in Turkey. Energy Policy 2009, 37, 424–431.
30. Nakicenovic, N.; Alcamo, J.; Davis, G.; De Vries, B.; Fenham, J.; Gaffin, S.; Gregory, K.; Grübler, A.; Jung, T.Y.; Kram, T.; et al. Special Report on Emissions Scenarios. Intergovernmental Panel on Climate Change, Cambridge, UK. 2000. Available online: https://www.ipcc.ch/site/assets/uploads/2018/03/emissions_scenarios-1.pdf (accessed on 10 November 2021).
31. Muscat, A.; de Olde, E.M.; Kovacic, Z.; de Boer, I.J.M.; Ripoll-Bosch, R. Food, energy or biomaterials? Policy coherence across agro-food and bioeconomy policy domains in the EU. Environ. Sci. Policy 2021, 123, 21–30.
32. Hamelin, L.; Borzęcka, M.; Kozak, M.; Pudełko, R. A spatial approach to bioeconomy: Quantifying the residual biomass potential in the EU-27. Renew. Sustain. Energy Rev. 2019, 100, 127–142.
33. Kluts, I.; Wicke, B.; Leemans, R.; Faaij, A. Sustainability constraints in determining European bioenergy potential: A review of existing studies and steps forward. Renew. Sustain. Energy Rev. 2017, 69, 719–734.
34. Haase, M.; Rösch, C.; Ketzer, D. GIS-based assessment of sustainable crop residue potentials in European regions. Biomass Bioenergy 2016, 86, 156–171.
35. Tonini, D.; Hamelin, L.; Astrup, T.F. Environmental implications of the use of agroindustrial residues for biorefineries: Application of a deterministic model for indirect land-use changes. GCB Bioenergy 2016, 8, 698–706.
36. Hamelin, L.; Naroznova, I.; Wenzel, H. Environmental consequences of different carbon alternatives for increased manure-based biogas. Appl. Energy 2014, 114, 774–782.
37. Elbersen, B.; Startisky, I.; Hengeveld, G.; Schelhaas, M.-J.; Naeff, H.; Bottcher, H. Atlas of EU Biomass Potentials. 2012. Available online: http://ec.europa.eu/energy/intelligent/projects/sites/iee-

projects/files/projects/documents/biomass_futures_atlas_of_technical_and_economic_biomass_potential_en.pdf (accessed on 20 February 2022).

38. Sustainable Biomass Availability in the EU to 2050. Imperial College, London 2021. Available online: https://www.concawe.eu/publication/sustainable-biomass-availability-in-the-eu-to-2050/ (accessed on 20 February 2022).
39. Tripathi, N.; Hills, C.D.; Singh, R.S.; Atkinson, C.J. Biomass waste utilisation in low-carbon products: Harnessing a major potential resource. Clim. Atmos. Sci. 2019, 2, 35.
40. Vaish, S.; Kaur, G.; Sharma, N.K.; Gakkhar, N. Estimation for Potential of Agricultural Biomass Sources as Projections of Bio-Briquettes in Indian Context. Sustainability 2022, 14, 5077.
41. Odavić, P.; Milić, D.; Zekić, V.; Tica, N. Potential of agricultural biomass: Comparative review of selected EU regions and region of Vojvodina. Contemp. Agric. 2017, 66, 62–67.
42. Ericsson, K.; Nilsson, L.J. Assessment of the potential biomass supply in Europe using a resource focused approach. In Proceedings of the World Conference and Technology Exhibition on Biomass for Energy and Industry ETA Florence Renewable Energies, Rome, Italy, 10–14 May 2004.
43. Demirel, B.; Gurdil, G.A.K.; Gadalla, O. Biomass energy potential from agricultural production in Sudan. ETHABD 2019, 2, 35–38.
44. Mohammed, Y.S.; Mokhtar, A.S.; Bashi, N.; Saidur, C.R. An overview of agricultural biomass for decentralized rural energy in Ghana. Renew. Sustain. Energy Rev. 2013, 20, 15–22.
45. Jekayinfa, S.O.; Orisaleye, J.I.; Pecenka, R. An Assessment of Potential Resources for Biomass Energy in Nigeria. Resources 2020, 9, 92.
46. Tolessa, A.; Bélières, J.F.; Salgado, P.; Raharimalala, S.; Louw, T.M.; Goosen, N.J. Assessment of Agricultural Biomass Residues for Anaerobic Digestion in Rural Vakinankaratra Region of Madagascar. Bioenerg. Res. 2022, 15, 1251–1264.
47. Shahbaz, M.; Balsalobre-Lorente, D.; Sihna, A. Foreign direct Investment–CO2 emissions nexus in Middle East and North African countries: Importance of biomass energy consumption. J. Clean. Prod. 2019, 20, 603–614.
48. Knapek, J.; Kralík, K.; Vavrov, K.; Weger, J. Dynamic biomass potential from agricultural land. Renew. Sustain. Energy Rev. 2020, 134, 110319.
