Изследване и анализ на устойчивостта на производството на биоенергия в България

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Research and Analysis of Sustainability of Bulgarian Bioenergy Production

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Key Words: *Bioenergy; sustainability index; Bulgarian bioenergy production; information system.*

Abstract. *The sustainable production of bioenergy (including bioelectricity and solid, liquid, and gaseous biofuels) is an important factor in reducing greenhouse gas (GHG) emissions. Bioenergy sustainability is determined by international and national standards and certification schemes. In addition, bioenergy sustainability assessment may consider other environmental, economic, and social indicators, such as the existence of circular production, wages, company profits, social benefits, etc. In the present work, research and analysis of the sustainability of Bulgarian bioenergy production are carried out. For this purpose, a research methodology is developed, including the formulation of an index of bioenergy production sustainability; collection of data on Bulgarian bioenergy-producing firms; and calculation and analysis of the sustainability index using a prototype information system and database for data storage and querying. Due to the relatively complete data available, the analysis was conducted for 148 firms in 2022. The firms are ranked according to their sustainability index values, and an analysis is provided based on their type of production and raw materials, availability of certificates, etc. Overall, the results of the analysis indicate insufficient sustainability of bioenergy production and the need to develop and implement national standards and certification schemes corresponding to European and international ones. It was found that accurate and reliable data are not available for a large number of firms in the bioenergy sector. One of the reasons is the high dynamics of this relatively new industrial sector, including the frequent opening, closing, and re-registration of firms; another is untimely reporting. The present research and analysis constitute a first attempt to investigate the sustainability of Bulgarian bioenergy production. As a next step, an extended analysis of bioenergy sustainability over a period of several years is planned, including a georeferenced digital map of Bulgarian bioenergy producers.*

Introduction

The sustainable production of bioenergy (including bioelectricity, solid, liquid and gaseous biofuels) is an important factor forr achieving reduction of greenhouse gas (GHG) emissions. In European Union (EU), the share of renewable energy source (RES) in energy consumption for 2024 is approximately 25.4%. About 60% of this share is of the bioenergy [12].

Bioenergy is a renewable energy produced directly from biomass or from biofuels derived from biomass. Unlike other renewable energy (from the sun, wind, water) which is inconstant and variable, the bioenergy is predictable and easier to balance and integrate into the national industry and households. The sources (raw materials), namely biomass, include: trees and wood waste; energy crops and residues; organic waste from industry, agriculture and households, as well as biogas from manure, landfill, etc.

The sustainable production and consumption of bioenergy is related to compliance with a number of requirements and regulations, regarding the origin and treatment of biomass, research of risks and benefits, the market, necessary investments, etc.

The different aspects of bioenergy sustainability are subject to specific standards and certifications. For example, standard ISO 13065 [9] on bioenergy sustainability criteria published in 2015 and revised in 2021, specifies principles, criteria and indicators for the bioenergy supply chain to facilitate assessment of environmental, social and economic aspects of sustainability. Other important standard in the area is ISO 17225-1:2021 [8] determining the fuel quality classes and specifications for solid biofuels of raw and processed materials.

On the base of these standards, national and international certificates are developed. The most recognized international certificates for sustainability of biomass, bioelectricity, liquid and gaseous biofuels are [3]:

- ISCC (International Sustainability and Carbon Certification) – system of certificates designed to promote sustainability, traceability, and climate-friendly practices in supply chains for bio-

based, and renewable sources.
- REDcert – European Union (EU) certificate concerning sustainable development of biomass production.
- SBP – EU certificate about sustainability of woody biomass.
- RSB – worldwide certification ensuring sustainability of biofuels, biomass, biomaterials, etc.

Concerning wood pellets, there are some most commonly quality certification schemes [7]: European ENplus, PFI Standards Program (of American Pellet Fuels Institute), CANplus (Canada), the French NF system, Ö-Norm (Austria), DINplus (Germany), PEFC etc. For non-wood pellets (also called agro-pellets or bio-pellets), ENplus, DINplus and SBP certificates are applied too.

In addition to the availability of certificates, bioenergy sustainability assessment may also consider other environmental, economic and social indicators as: existence of circular production (sustainable manufacturing model that minimizes waste by keeping resources, materials, and products in use through reuse, repair, refurbishment, and recycling), average annual worker's salary, company profit, social benefits, etc. All these indicators can be combined into specific index of sustainability.

Taking into account the above prerequisites, in the present work research and analysis of the sustainability of Bulgarian bioenergy production is proposed. The next section covers methodology and materials of research. In the third section, the results of analysis are exposed and discussed. The fourth section contains conclusions.

Methodology and Materials

The methodology of research includes methods and approaches for:
- formulation of index of bioenergy production sustainability;
- gathering data for Bulgarian firms producing bioenergy;
- data storage and sustainability index calculation using database (DB) of prototype information system (IS);
- DB querying and ranking firms.

Formulation of Sustainability Index of Bioenergy Production

There is no universal index for assessment of the bioenergy production sustainability. As whole, in [1] a common formula for calculation of such index (named Is) is proposed:

$$(1)\quad Is = \left(\sum_{i=1}^{n} w_i C_i\right) / n,$$

where i = 1,2,…,n is number of indicators; C_1, C_2, …, C_n are values of indicators and w_i – weight coefficient of the i-th indicator. Moreover, $w_1+w_2+\ldots+w_n=1$.

The calculated values of Is can be normalized in some interval (for example, [0, 1]) and in dimensionless units. The number of indicators and their weight coefficient values are dependent on specific conditions.

Obviously, the most important indicator is the availability of the abovementioned EU and international certificates – ISCC, FSC, PEFC, RSB, REDcert, SBP, ENplus, DINplus, etc. (depending on type of bioenergy). By the way, topical Bulgarian standard for solid biofuels is BDS EN ISO 17225:2021 [2] similar to abovementioned 17225-1:2021 [8]. No Bulgarian standards for other types of bioenergy could be identified. Furthermore, no Bulgarian certification schemes for bioenergy sustainability have been developed.

Additionally, other environmental, economic and social indicators are essential, such as the existence of circular production, employee wages, company profits, etc.

Data Gathering

For the current research, data about Bulgarian bioenergy producing firms for a period of five years (2019-2023) are gathered. The sources are Registry Agency of Republic of Bulgaria [13], National Statistical Institute [10, 11] and firm sites. It was found that there are no accurate and reliable data for the large number of these firms. One of the reasons is the great dynamics in this new industrial sector including frequent opening, closing and resealing firms, and another – the untimely reporting.

Relatively most complete are the data in 2022 used for the current research, processing and analysis. For this year were found 148 active firms. 98 of them produce pellets, 8 – biofuels (biogas, biodiesel and bioethanol), 37 – electrical bioenergy, 2 – heating bioenergy and other 3 – mixed electrical and heating bioenergy (*Figure 1*).

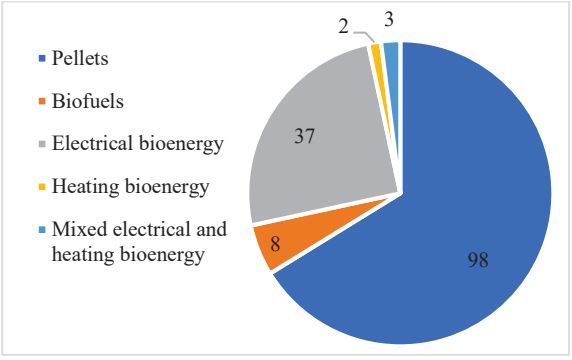


Figure 1. Number of Bulgarian firms producing different types of bioenergy in 2022

So, given the collected data, as indicators in the sustainability index are established:
- availability of EU or international certificates;
- availability of closed cycle of production;
- firm profit;
- average wage of employees;
- production export availability.

Data Storage and Sustainability Index Calculation

The collected data are entered into and organized in linked tables in the database (DB) of the prototype web-based information system (IS) presented in [1]. The main table covers basic, relatively constant firm data (name, address, production type, etc.). This table is linked to tables including main indicator values for the surveyed years. In the annual tables the formula calculating sustainability index is also embedded. All tables are linked to samples of Bulgarian and international code classifiers of:

- bioproducts and biomass – samples of combined
- EU classifier of Combined Nomenclature (CN) of stock and products [4] and Bulgarian classifier of Consumer Products by Economic Activities (CPID) [11], harmonizes with European Classification of Products by Activity (CPA) classifier [5];
- economic activities – sample of Bulgarian classifier of economic activities KID-2025 [10], harmonized with statistical classification of economic activities (NACE) of the (EU) [6] and International Standard Industrial Classification (ISIC) of United Nations (UN) [14];
- measure units;
- Bulgarian settlements and their geographical coordinates by Unified Classifier of Administrative-Territorial and Territorial Units (UCATTU) [15].

DB Querying and Ranking Firms

DB queries are executed in order to rank firms by:

- values of sustainability indices;
- availability of sustainability certificates;
- availability of closed cycle of production with waste assimilation;
- bioenergy production types;
- type of biomass, etc.

It should be noted that the diversity of products and differences in technology, limit the comparison of financial outcomes between firms. Moreover, due to incomplete data, ranking firms by dependence of their sustainability on production capacity and produced quantities of bioenergy is embarrassed.

Result Analysis

As mentioned above, due to the relatively most complete data, the analysis was conducted on bioenergy producing firms for year 2022. *Figure 2* shows a sample of calculated indices of sustainability for 148 firms, presented by their Unified Identity Code (UIC) identifiers [13]. Obviously, the values of these indices for the most firms are comparatively low (below 0.5). Besides, 25 of them have index 0. Only two firms (producing biodiesel) have the highest index (1). Others 5 (producing wood pellets, heating bioenergy and bioethanol) have index equal and greater than 0.9. The possible reason is that sustainability certificate for the small producers which prevail (see *Figure 3*) is not mandatory. According to RED III [16], "for solid biomass fuels in installations producing heating, electricity and cooling, the minimum threshold for the applicability of sustainability criteria should be lowered from the current 20 MW (in RED II) to 7.5 MW; for gaseous biomass fuels this threshold is equal to or exceeding 2 MW". Then, in 2022, 107 of Bulgarian bioenergy producers are small ones with production capacity below the specified threshold values and do not have any sustainability certificates.

On *Figure* 3 is also seen that the half of firms do not have closed production cycle.

On *Figure 4* the average index of sustainability depending on production type is given. Again, the greatest average values of the index are for producers of liquid and gaseous biofuels (bioethanol, biodiesel) and heating bioenergy, but their number is too small (*Figure 1*).

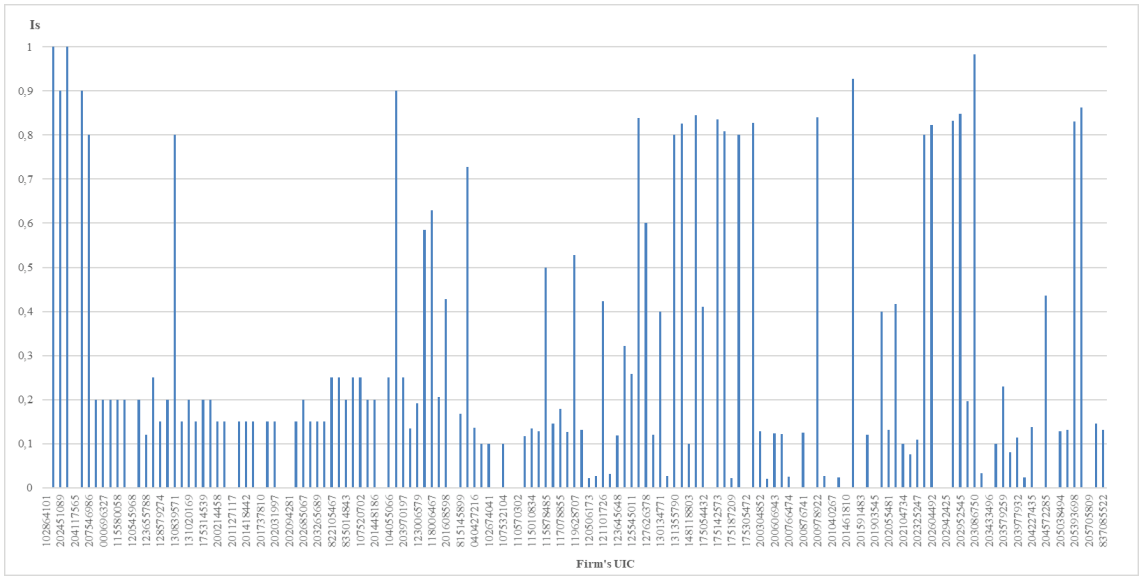


Figure 2. Indices of bioenergy production sustainability in 2022

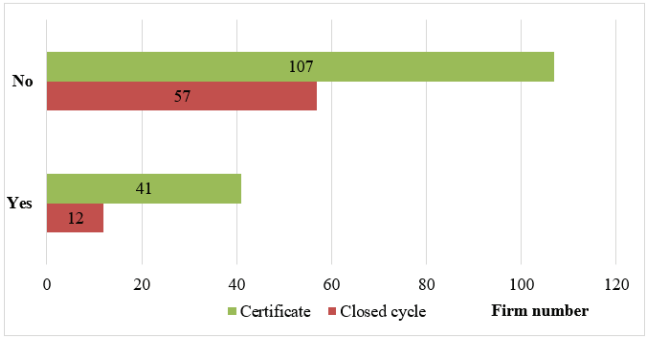


Figure 3. Availability of sustainability certificate and closed cycle of production

By type of sources, it is seen that most fi rms produce bioenergy from wood and agriculture biomass including wood shavings, hardwood and softwood fi rewood, wood and sunfl ower waste (*Figure 5*). Other sources for bioenergy production (about 33%) are peat, manure biogas, plant waste, landfi ll biogas etc.

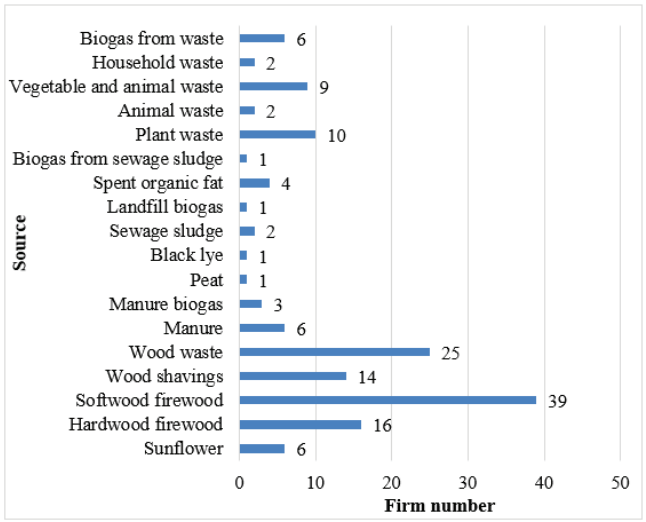


Figure 4. Average index of sustainability depending on type of production

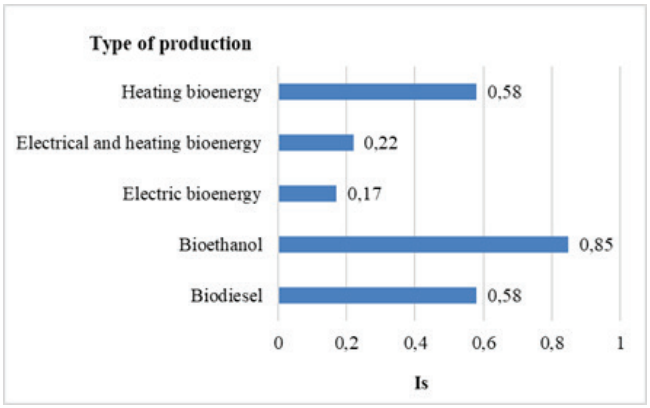


Figure 5. Number of firms by type of sources

Conclusion

The current research and analysis are a fi rst attempt for investigation the sustainability of the Bulgarian bioenergy production. A methodology of research is proposed including formulation of sustainability index Is; gathering data for firms producing bioenergy; data storage and sustainability index calculation using prototype information system; DB querying and ranking firms.

The analysis was conducted for the year 2022, when the firm data are most complete. When examining firms by production type, the highest average sustainability indices are observed among producers of liquid and gaseous biofuels, as well as heating bioenergy. However, the number of such producers remains relatively small.

Regarding sources, the majority of firms use wood and agricultural biomass, including wood shavings, hardwood and softwood firewood, and residues from wood processing and sunflower production.

As whole, the results indicate insufficient sustainability of the bioenergy production, as the most of firms have Is values below 0.5. Moreover, 25 firms have Is values equal to 0. Only two firms, both producing biodiesel, achieve the maximal Is value 1. These results are due to the fact that the prevailing number of Bulgarian bioenergy producers are small ones and do not have sustainability certificates.

Furthermore, the sustainability of the Bulgarian bioenergy production would rise by development and implementation of complete set of national standards and certificates corresponding to the European and/or international ones.

In the process of research and analysis some difficulties were encountered. One of them is the insufficient firm's data from the abovementioned governmental sources. Moreover, the analysis of the used classifiers indicates the necessity for maintenance and improvement of unified codes and names resolving inconsistencies between bioenergy production datasets.

As whole, there is insufficient harmonization of standards, certificates and classifiers between the different countries and organizations in the sector.

In the next step, authors provide an extended analysis of bioenergy sustainability for a period of several years adding georeferenced digital map of Bulgarian bioenergy producers.

Acknowledgments

This research has been conducted and presented with the kind support of Project SRS-B-1279/19.10.2023 (НИС-Б-1279/19.10.2023 in the Bulgarian version), "Information Modelling of the Sustainable Use of Renewable Energy Sources from Biological Resources", funded by the Scientific Research Sector (SRS) of the University of Forestry – Sofia, Bulgaria.

References

1. Deliyska, B., A. Ivanova, Nikolov, N., R. Popova-Terziyska. Information Modeling of Sustainable Bioenergy and Biofuel Production. – *Innovation in Woodworking Industry and Engineering Design*, XIII, 2024, No. 2, pp. 18-27.

2. Bulgarian Institute for Standardization. БДС EN ISO 17225-1:2021. 2021. https://bds-bg.org/en/project/show/bds:proj:111544.
3. Cucuzzella, C., A. Welfle, M. Röder. Harmonising GHG and Sustainability Criteria for Low Carbon Transport Fuels, Bioenergy, and Other Bio-Based Sectors. – *Supergen Bioenergy Hub Report*, No. 04, 2020. https://www.supergen-bioenergy.net/wp-content/uploads/2020/11/Harmonising-sustainability-standards-report.pdf.
4. Commission Implementing Regulation (EU). Combined Nomenclature (CN). – *Official Journal of the European Union*, 31.10.2025. https://eur-lex.europa.eu/legal- content/EN/TXT/PDF/?uri=OJ:L_202501926%20.
5. Eurostat. CPA Overview. 2025. https://ec.europa.eu/eurostat/web/cpa.
6. Eurostat. *NACE Rev. 2.1* – Statistical Classification of Economic Activities in the European Union. 2025. https://ec.europa.eu/eurostat/documents/3859598/21633320/KS-GQ-24-007-EN-N.pdf
7. Huang, J. Wood Pellets Quality Standards Review. 2014. https://www.biofuelmachines.com/wood-pellets-quality-standards-study.html.
8. ISO. ISO 17225-2:2021. 2021. https://www.iso.org/standard/76088.html.
9. ISO. ISO 13065:2015. Sustainability Criteria for Bioenergy. 2015. https://www.iso.org/standard/52528.html.
10. National Statistical Institute. Classification of Economic Activities (in Bulgarian). 2025. https://www.nsi.bg/sites/default/files/files/publications/KID-2025.pdf.
11. National Statistical Institute. Classification of Products by Economic Activities (CPEA-2015) (in Bulgarian). 2015. https://www.nsi.bg/pages/klasifikaciya-na-produktite-po-ikonomicheski-deinosti-809.
12. European Environment Agency. Share of Energy Consumption from Renewable Sources in Europe. 16 Jan. 2025. https://www.eea.europa.eu/en/analysis/indicators/share-of-energy-consumption-from?activeAccordion=ecdb3bcf-bbe9-4978-b5cf-0b136399d9f8.
13. Registry Agency of the Republic of Bulgaria. Commercial Register and Register of Non-Profit Legal Entities. 2025. https://portal.registryagency.bg/en/home-cr/.
14. United Nations Statistics Division. ISIC. 2025. https://unstats.un.org/unsd/classifications/Econ/isic.
15. Unified Classifier of Administrative-Territorial and Territorial Units (UCATTU). 2026 (in Bulgarian). http://www.ekatte.com.
16. EUR-Lex. Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 Amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as Regards the Promotion of Energy from Renewable Sources, and Repealing Council Directive (EU) 2015/652. Document 32023L2413. – *Official Journal of the European Union*, 31.10.2023. https://eur lex.europa.eu/eli/dir/2023/2413/oj/eng.

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