Gheorghe Zane Institute for Economic and Social Research

Economy and Contemporary Society

Journal homepage: ecs-journal.ro

Empirical Article

Utilizing Solar Energy to Build the Resilience of Energy Consumers in the Republic of Moldova: Development of the Regulatory Framework

Viorica POPA[1], **Sergiu ȚIRIGAN**[2]

ARTICLE INFO

Article history:
Received 16 October 2024
Revised 6 April 2025
Accepted 12 May 2025
First published online 30 October 2025

JEL classification:
Q4; Q5; Q42

Keywords:
Resilience
Renewable sources
Stability
Security
Energy

ABSTRACT

In accordance with its long-term strategic visions and based on cooperation with external partners, the Republic of Moldova is pursuing a strategy of diversifying energy supply both by developing energy transport networks, especially through cross-border interconnection projects, and by consolidating and diversifying domestic sources of supply. The exploitation of renewable energy sources is an important pillar for ensuring the energy autonomy of the Republic of Moldova, with the potential to bring significant benefits to the country's socio-economic development, including through possible synergies with sustainable development measures and the adoption of development models aimed at increasing economic competitiveness and reducing the carbon footprint. Voluntarily, under the Energy Strategy 2030, the Republic of Moldova has set a target of reaching a 20% share of renewable energy sources in the 2020 energy mix, and a 10% share of electricity production from renewable sources in total gross consumption. Under the Energy Community Treaty, the Republic of Moldova committed to achieving a 17% share of renewable sources in its 2020 energy mix.

[1] Corresponding author; PhD, National Institute for Economic Research, Academy of Economic Studies of Moldova, Kishinev, Republic of Moldova, violin_s@yahoo.com; ORCID: 0000-0001-6739-4399

[2] Researcher, PhD Student, National Institute for Economic Research, Academy of Economic Studies of Moldova, Kishinev, Republic of Moldova, sergiu.tirigan@gmail.com, ORCID: 0000-0002-3139-4634

DOI: 10.59277/ECS.2025.30.2

1. Introduction

For the valorization of renewable energy and for ensuring the diversification of the energy mix of the Republic of Moldova is a priority assumed by the Government through strategic programming policies, and an opportunity in the context of balancing production costs with those from conventional sources, the expansion capacity was limited by the needs of major investments, the pace of development and adjustment of the regulatory and support framework, the balancing capacities of the energy system as a limit for capitalizing on intermittent sources of renewable energy, slow adoption of models and technical options to allow their integration into the national energy system (Abayev & Esengeldin, 2024; Ceban, 2016). Thus, until 2022, the rate of development of new capacities to transform solar energy into electricity was lower than the trends of increasing the role of electricity in the energy mix, and continues to be lower than investment interest (MERM, 2024). The development of the field of electricity production through the utilization of solar energy is at an early stage in the case of the Republic of Moldova, with an important reserve for expansion (Arion et al., 2014).

The increased investment interest in the exploitation of solar energy, both from the business environment and the population, is based on the meeting of a mix of factors: the tendency to increase the price of electricity and to decrease the prices of photovoltaic panels; the improvement of the regulatory framework, the support schemes and the extension by the Government of the level of quotas, etc. The catalysis of these processes can be integrated into a wider framework of strategies that the country is going to implement to face development challenges (MIDR, 2022).

2. Literature Review

This literature review examines the role of solar energy in building the resilience of energy consumers in the Republic of Moldova, focusing on its potential to enhance energy security (Agupugo et al., 2024), reduce dependence on imported energy (Arcipowska et al., 2024; Kakoulaki et al., 2024), and contribute to environmental sustainability (Saad & Myat, 2025). Solar energy, as a renewable energy source, offers numerous benefits for energy resilience, but its widespread adoption faces several challenges, particularly in developing economies such as Moldova.

Energy resilience refers to the ability of energy systems to withstand and recover from disruptions such as natural disasters, economic crises, or geopolitical conflicts (Scott et al. 2017; Wolniak & Skotnicka-Zasadzień, 2022). A resilient energy system ensures that consumers have reliable access to energy, even in the face of

supply interruptions (Hachem Vermette et al., 2024). For Moldova, a country highly dependent on imported energy, energy resilience is crucial for national security, economic stability, and sustainable development (Popa et al., 2023). Several scholars have emphasized the importance of energy resilience in the context of energy security, highlighting how diversifying energy sources through renewable energy technologies like solar can mitigate vulnerabilities caused by external shocks, such as disruptions in gas or electricity supplies from neighboring countries (Sovacool & Brown, 2010). Moldova's reliance on imported energy exacerbates its energy vulnerability, which can be addressed through renewable energy solutions (IRENA, 2019).

Solar energy is increasingly being recognized as an essential component of energy resilience (Chatzipanagi & Jäger-Waldau, 2023). It offers several advantages that make it particularly suitable for Moldova, including:

- decentralization: Solar power allows for decentralized energy production, enabling households and businesses to generate their own electricity, reducing reliance on the national grid. This decentralized energy generation is critical for building resilience, especially in rural or remote areas where grid infrastructure is often unreliable (Petelcă et al., 2024);
- environmental sustainability: Solar energy is a renewable, low-carbon source of electricity that helps reduce greenhouse gas emissions, aligning with global sustainability goals (REN21, 2021). Given Moldova's commitment to reducing its environmental footprint, solar energy offers a pathway to meet its climate targets;
- energy access and security: By integrating solar energy into the national grid and off-grid systems, Moldova can enhance energy access and security, particularly in areas with limited grid connectivity (Popa et. al., 2024). Solar energy reduces Moldova's dependence on imported fossil fuels, providing an opportunity for energy independence.

3. Methodology

In this research, the authors analyze support mechanisms and measures for the field of renewable energy in the Republic of Moldova. The choice of studying the field of renewable energy in the present research is argued by the lack of analytical studies in the given field (Ogunsola et al., 2021). In that field, research was carried out within Subprogram 030101 “Strengthening the resilience, competitiveness and sustainability of the economy of the Republic of Moldova in the context of the process of accession to the European Union”, through institutional funding. As

information support, the authors used the legislative and normative acts in the field of renewable energy, the reports and publications of the Ministry of Energy, the National Energy Regulatory Agency, the Energy Efficiency Agency (AEE, 2023), Termoelectrica and CET Nord. On an international level, important methodological studies have been developed within the UN, the European Commission (EC), the EBRD, the EIB, the European Agency for Sustainable Development (ADD), which were taken into account in this research.

To achieve the objectives proposed in the work, the following scientific research methods and tools were used (Rugină et al., 2017): the documentary method, based on accessing and studying the general and specialized bibliography; the synthesis method, applied to establish the connections between the researched phenomena; the method of systemic analysis, the method of quantitative and qualitative analysis.

4. Results and Discussion

The electric power sector and the exploitation of renewable energy sources in the context of the national energy system. According to the data of the International Energy Agency, in 2020 regarding the states and regions on the European continent (Baldursson et al., 2024), the Republic of Moldova records the lowest rate of electricity consumption per inhabitant (2.6 MWh), and the lowest level of production (0.03 EJ). The share of 6% in 2020 of renewable energy in total electricity production places the Republic of Moldova among the states and regions with the lowest performance in this regard, lower values being recorded only in the case of Kosovo (4%) and Belarus (6%)). In the case of the Republic of Moldova, this indicator has a correlation with the share of use of fossil fuels in the production of electricity, which is 94%, being surpassed in this chapter only by Belarus and Kosovo. Moldova's energy self-sufficiency is very low, among the lowest in the world. The Republic of Moldova is a net importer of energy resources, depending on imports of natural gas, petroleum products and electricity (including electricity supplies from the left side of the Dniester), a fact that accentuated the impact of the regional energy crisis during 2022, following energy supply difficulties and the increase in energy resource prices.

Table 1. Primary energy production, 2016-2021 (thousand tonnes of oil equivalent)

	2016	2017	2018	2019	2020	2021
Primary production	709	770	798	668	682	761
Biofuels and waste	698	760	787	653	668	742
Electricity	4	5	6	10	8	14
Gross domestic consumption	2,796	2,939	3,066	2,938	2,807	3,115

Source: Authors' elaboration based on data from National Bureau of Statistics

The domestic gross energy consumption has an upward trend, in 2021 registering an increase of 11.4% compared to 2016, reaching 3,115 thousand tons of oil equivalent. The most significant contributions were provided by petroleum products (1,064 thousand tons of oil equivalent, +18.8% compared to 2016), natural gas (997 thousand tons of oil equivalent, +19.1% compared to 2016) and imported electricity or production primary (324 thousand tons of oil equivalent, +11.1% compared to 2016). The final energy consumption in 2021 was 2,924 thousand tons of oil equivalent. During the last ten years, energy consumption experienced fluctuations largely determined by the thermal regime during the winter period and the dynamics of the national economy. In the long term, there is a tendency to decrease the consumption of coal determined by the expansion of the utilization of solid biofuel, and increases in the consumption of petroleum products, natural gas and electricity contributing to the average annual increase in energy consumption of about 1%, but which it has seen a boost over the last few years due to a moderate growth trend in the consumption of the industrial sector, trade and services and the agricultural sector. The distribution of consumption by sector experienced insignificant changes. The residential sector consumes the largest share of energy (48%). It ensures the recovery for energy purposes of 96.1% of biofuel and waste at the country level (43.6% of the total final energy consumption of the residential sector).

In electricity consumption, although the individual sector is the main consumer with a share of 44.5% (158 thousand tons of oil equivalent) of total consumption (355 thousand tons of oil equivalent), as a share of total consumption it has a more important role in the case of the sector of trade and services (41.7% of the total, 121 thousand tons of oil equivalent), and of the industrial sector (26.1% of the total, 64 thousand tons of oil equivalent).

According to the data from the National Bureau of Statistics' studies on energy consumption in households, completed for the years 2016 (reference period: April 2015-April 2016) and 2022 (reference period: 2021), the total annual electricity

consumption in households decreased insignificantly by 20 million kWh, constituting 1,648 million kWh. This decrease was determined by the calculation base regarding the number of households. The average annual level of consumption per household increased from 1,495.2 kWh to 1,651.7 kWh per year. At the same time, electricity consumption in the economic activities carried out by households also increases, from 9,184.9 to 30,456 thousand kWh. During this period, own electricity production capacities were established, which constituted 145.6 thousand kWh.

Table 2. Purchase of electricity, 2014-2021 million kWh

	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Amount of electricity purchased:	4,034.7	4,050.4	3,603.4	3,637.4	3,737.6	3,594.2	3,866.2	4,159.5
» from local producers	767.9	771.1	742.9	736.1	783.1	691.1	851.5	987.8
» from abroad and CTE Moldova	3,266.8	3,279.3	2,860.5	2,901.3	2,954.5	2,903.1	3,014.7	3,171.7
Share of local production in total (%)	19	19	20.6	20.2	21	19.2	22	23.7

Source: Authors' elaboration based on the data from National Agency for Energy Regulation

The volume of electricity purchased experiences significant fluctuations mainly correlated with the dynamics of the national economy. Own domestic production increased by 28.6% in 2021 compared to 2014, ensuring an increase in the level of coverage within total purchases by 4.7% (23.7% in 2021). The two largest suppliers procure and distribute 90% of the total. In 2021 U.C.S. Premier Energy S.R.L. purchased 2,728.4 million kWh (65.6% of the total) and S.A. FEE Nord 1,046.1 million kWh (20.3% of the total).

The internal sources of electricity production are represented by the urban heating power plants of S.A. Termoelectrica and S.A. CET Nord, which provides 81% (797.9 million kWh) of the total amount of domestically produced electricity, wind power plants, which provide 7.8% (76.3 million kWh), photovoltaic power plants, which provide 0.8% (7.8 million kWh), the biogas-based power plants, which provide 3.3% (32.2 million kWh), and the heating power plants of the sugar factories, which provided 0.3% of the amount of electricity produced locally. The Costești hydroelectric plant with a share of 6.9% of the domestic production, cumulatively with the other sources of renewable energy, provides about 4% of the electricity consumption.

Policy and regulatory framework for the promotion of renewable energy. The status of a net energy importer of the Republic of Moldova determines the

vulnerability of the national economy to the instability of the regional energy market, supply interruptions, price fluctuations, a fact that represents a risk for ensuring the sustainable economic development of the country (Dimitrov, 2018). The current geopolitical context, including the politicization of trade in energy resources, has exponentially increased supply risks leading to a rapid rise in energy prices. As part of the rapprochement process with the European Union, efforts were made to develop and liberalize the energy markets. An important part of the legislative framework was established by the transposition of the III Energy Package, but the process of its implementation is at an initial stage, the regulation of energy markets being largely maintained.

The policies in the field of developing the installed capacities of electricity generation based on intermittent renewable energy sources (solar, wind) are primarily based on a mix of factors such as climate objectives and their assumptions in the field of reducing greenhouse gas emissions, the level development of the capacity of networks and the distribution system, of storage for the exploitation of production from renewable energy sources (Ghai et al., 2024). The obligations assumed at the international level, including those derived from the European integration process, have a key role in dynamizing this process.

The aspirations of the Republic of Moldova to join the EU, as well as obtaining the status of a candidate country, impose the need to accelerate the process of carrying out reforms and aligning with EU norms and practices. In this sense, the Republic of Moldova is going to connect its long-term development objectives with those of the European Union. In the energy field, this includes the development of energy policy with consideration of the Clean Energy Package for all Europeans (Clean Energy Package), which provides for the transition from fossil fuels to cleaner energy. As a member of the Energy Community, the Republic of Moldova is going to strengthen the national legal framework by transposing five basic European acts in the field of renewable energy, governance, electricity and energy efficiency.

The acuteness of the need to diversify sources of supply and increase the level of self-supply with energy sources, the ways in which the exploitation of renewable energy sources can contribute to achieving the objectives of sustainable development, the options for developing competitive business models through the integration of measures is recognized energy efficiency and utilization of renewable energy sources. These objectives are integrated into the new strategic planning cycle (2023-2030), focused on the *National Development Strategy "European Moldova 2030"*, and developed within the sectoral strategies and programs, which are in the process of elaboration

and approval. The development of the electricity generation sector based on intermittent renewable sources is correlated with the capacity to reform the energy system, including through the development of feasible market mechanisms, the transformation and modernization of transmission and distribution networks, technical solutions and investments in energy storage, the implementation dispatchable consumption measures, digitization of the energy system, establishment of local energy communities, including by stimulating commercial exchanges of energy between consumers at the local level, etc.

The objectives of the state policy in the field of energy, in the medium and long term, as well as its priority development directions, are currently established in the Energy Strategy of the Republic of Moldova until 2030, approved by Government Decision 102/2013. Most of the specific objectives in the aforementioned Strategy have been established for the 2020 horizon. At the present time, the development of a new 2050 Strategy has been initiated, and the strategic policy will be updated and adjusted in accordance with the change in the situation based on recent developments.

The sectoral plans in the field of renewable energy and energy efficiency that included the 2020 horizon are to be reviewed, in accordance with the new priorities of the Strategy, being complemented at the moment with activity programming plans in the context of the energy crisis situation.

The unattractiveness of renewable energy during the previous decade was determined by the support mechanism introduced by the previous Renewable Energy Law applied until March 2018 (Law 160/2007) and the previous Methodology for the determination, approval and application of tariffs for electricity generated from renewable sources and biofuels (ANRE Decision 321/2009).

Even if the primary legislation stipulated that the principles of the policy were, among others, the adjustments of the national legal framework to European and international standards, the promotion of renewable energy through support schemes, the guarantees of the commercialization of renewable energy through non-discriminatory connection to networks, etc., the secondary legislation diminished the attractiveness of the sector. The law took into account the cost-plus principle. According to it, ANRE issued a tariff for 15 years, based on the current eligible costs charged, only after the investments were made. In addition, the regulator had the right to adjust the tariff to the regional reference values, if they were lower. This approach was not sufficient to attract investment in the sector and was therefore revised.

Law no. 10/2016 on the promotion of the use of energy from renewable sources, which entered into force in March 2018, provided for the necessary guarantees for investments, including: non-discriminatory connection to the grid, priority supply and an obligation on the part of the central electricity supplier to purchase electricity generated entirely from renewable sources for 15 years. In addition, the new market-based scheme promotes competition among investors, as it provides for the organization of tenders for projects with a capacity of more than 4 MW for wind power and 1 MW for other technologies. At the same time, the law supports the development of community-promoted, small-scale renewable energy projects.

The new Law on electricity (no. 107/2016) established the foundations of the favorable regulatory framework and the principles of promoting the use of renewable energy sources in the production of electricity, including by establishing guarantees of connection to the network, of the obligation to purchase energy from eligible producers, of the priority dispatch of eligible power plants, etc.

Law on energy efficiency no. 139/2018 establishes the objective of reducing energy consumption by increasing energy efficiency and the use of renewable energy sources by developing the institutional framework, supporting programs in the field, developing the energy services market, promoting the use by end consumers of efficient machinery and equipment from an energy point of view, as well as renewable energy sources.

In order to implement the new legal provisions, the National Agency for Energy Regulation (ANRE) developed the regulatory implementation framework. By ANRE Decision 375/2017 (in force since March 2018), the methodology for determining fixed tariffs and prices for electricity produced by eligible producers from renewable energy sources was developed. At the same time, the Regulation on the confirmation of the status of eligible producer (ANRE Decision 251/2019), the mandatory clauses of the contract for the purchase of electricity produced from renewable sources (ANRE Decision 252/2019) and the Regulation on guarantees of origin for energy were approved electricity produced from renewable energy sources (ANRE Decision 376/2017).

Popa, V., & Țirigan, S. (2025). Utilizing solar energy to build the resilience of energy consumers in the Republic of Moldova: Development of the regulatory framework. *Economy and Contemporary Society*, *30*, 92-109.
DOI: 10.59277/ECS.2025.30.2

Table 3. Institutional and administrative framework in the field of renewable energy

Institution	Key functions
Public authorities	
Ministry of Energy	Elaborates, promotes and coordinates the implementation of the state's policies and strategies in the energy field.
Ministry of the Environment	Develops policies in the field of environment and natural resource management, implementation of international treaties in the field of environment and climate change, land use management for renewable energy production facilities.
National Energy Regulatory Agency	Independent regulatory authority that ensures the regulation and monitoring of the electrical energy sector, the implementation of support schemes for the exploitation of energy from renewable sources.
Agency for Energy Efficiency	The national body promoting energy efficiency and renewable energy in Moldova. It implements national programs, supports investment projects, and monitors energy efficiency measures.
Competition Council	Ensuring the supremacy of competition principles on the energy market.
Companies from the energy sector	
SE Moldelectrica	State-owned enterprise that performs the functions of a Transmission System Operator (TSO) in the Republic of Moldova. Responsible for the operation, maintenance, and development of the national high-voltage electricity transmission network.
Energocom JSC	Sate-owned company that acts as Moldova's central supplier of electricity and gas on the wholesale market. It procures electricity, manages cross-border imports, and ensures energy supply security. Also supports the integration of renewable energy by contracting electricity from renewable producers and facilitating its entry into the national grid.
Distribution operators	Manage medium- and low-voltage networks to ensure reliable electricity delivery to consumers. There are three operators, two state-owned and one private. They are also responsible for connecting renewable energy producers to the grid, enabling the injection of surplus energy, facilitating net metering, and ensuring technical compliance for safe integration.

Source: Authors' elaboration

The solar energy market is expanding, with new potential and capabilities currently being installed in the Republic of Moldova. The country has a great potential for the use of renewable energy, including wind and solar resources. The availability of locations, from a technical point of view, throughout the country, offers significant possibilities for harnessing the wind. Moldova has a relatively high

number of hours of sunshine per year and therefore a significant potential for the use of solar energy, 279-296 sunny days per year are recorded, the duration of sunshine oscillating across the country between 1,950 and 2,210 hours (60-70% in summer and 30-40% in winter). According to the report of the International Agency for Renewable Energy, the photovoltaic capacity of the Republic of Moldova is 4.6 GW, which can ensure a production of 6 TWh annually. More than 20% of this (1 GW) was already considered cost-competitive as early as 2016. This meant that the technology had a normalized cost of electricity below EUR 90/MWh, but attractive financial terms were required.

Table 4. The potential of renewable energy sources in the Republic of Moldova

Source	Potential
Wind energy	20.9
Solar energy	4.6
Biomass	0.9
Hydroelectric power	0.8

Source: Authors' elaboration based on data from International Renewable Energy Agency (2019)

The amounts allocated by the Government based on HG 401/2021 within the maximum capacity quota of 410 MW, if all the installations will become functional, they would generate a quantity of electricity equal to 24.9% of the domestic electricity consumption. The total electricity generated by installations using renewable sources, the owners of which benefit from the support scheme (with the exception of Î.S. Nodul Hidroenergetic Costești and producers who sell electricity at negotiated prices), in 2021 was 116.6 million kWh, which represents an increase of about 43.3% compared to 2020. Of the total, for 58.9 mil. kWh of electricity was issued guarantees of origin by the central electricity supplier.

Table 5. Electricity production from renewable energy sources in the period 2016–2021

	2016	2017	2018	2019	2020	2021
Solar energy (photovoltaic)	1,311	1,509	1,457	1,437	3,275	7,764
Biogas	14,030	21,576	27,961	28,748	27,793	32,239
Wind energy	2,477	7,066	21,968	36,915	50,138	76,310
Hydroelectric energy (with the exception of Î.S. Nodul Hidroenergetic Costești)		38	279	330	147	239
TOTAL	17,818	30,189	51,665	67,430	81,353	116,552

Source: National Agency for Energy Regulation

From the total amount of electricity generated from renewable sources, the largest share is electricity generated using wind potential (65.5%), followed by electricity produced from biogas (27.7%), electricity produced from solar energy (6.7%), the lowest share going to the energy produced by hydropower facilities, less than one percent.

According to the data from the National Agency for Energy Regulation, the total installed capacity of generating capacity from renewable energy sources in 2021 was 103.8 MW, which is an increase of approximately 49.1 MW or 89.7% more compared to 2020. Thus, in 2021, the installed power related to technologies using solar potential (from 4.3 to 9.9 MW) and wind (from 44.1 to 87.6 MW) doubled.

In 2021, the number of final consumers who benefited from the net metering mechanism provided for by art. 39 of Law 10/2016 on the promotion of the use of energy from renewable sources increased by 1.8 times, reaching 473 at the end of the year. At the same time, during 2021 the installed power increased by 2 times, at the end of the year being registered capacities of 9.9 MW, and the electric energy injected into the electric network from the final consumers, who had renewable energy sources (photovoltaics) for internal consumption, was 4,100.9 thousand kWh, an amount 2.8 times higher than in the year 2020.

The addition of capacities for sources at a fixed rate, led to an increase in the number of new registered eligible producers, in accordance with the calls launched by the National Agency for Energy Regulation, and constituted 20 producers in 2020 and 154 producers in 2022.

Installed capacities and the international equipment market. There are three technologies that ensure the harnessing of solar energy: photovoltaics through which solar energy is transformed into electricity, concentrating solar energy that harnesses thermal energy in electric turbines, and cooling and heating systems that collect thermal energy to provide hot water and air conditioning. In the case of the Republic of Moldova, photovoltaic technology and systems based on thermal energy collection are the most widespread. If the expansion of thermal energy collection systems is mainly based on investments related to public buildings, the utilization of photovoltaic technology enjoys increased interest in the private sector.

Photovoltaic technology, benefiting from an average lifetime of over 20-25 years, ensures a high level of flexibility and modularity, regardless of the type of application in which it is integrated. The photovoltaic system comprises two key components: the photovoltaic panels (transforms the light energy from the sun's rays directly into electricity) and the inverter (transforms the energy produced by the

photovoltaic panels from direct current to alternating current). These technologies have become the cheapest source of new electricity generation in many parts of the world. The cost of electricity generated by PV plants fell by 77% between 2010 and 2018, while the cumulative installed capacity of PV systems increased 100 times between 2005 and 2018.

The global weighted average levelized cost of electricity for new utility-scale solar PV systems added in 2021 fell 13% year-over-year to $0.048/kWh. Between 2010 and 2021 there has been a dramatic increase in the competitiveness of renewable energy sources. The global weighted average levelized cost of electricity of newly commissioned utility-scale solar PV projects fell by 88% between 2010 and 2021, while that of onshore wind fell by 68%.

The life-cycle costs of new solar and wind capacity added in Europe in 2021 will average at least four to six times lower than the marginal cost of fossil fuel generation in 2022.

Globally, new renewable energy capacity added in 2021 could reduce electricity generation costs in 2022 by at least $55 billion. Between January and May 2022, in Europe, solar and wind generation alone avoided at least $50 billion worth of fossil fuel imports. As a result, photovoltaic technologies have quickly become a pillar of the sustainable, low-carbon energy system of carbon that favors access to affordable and reliable energy and helps achieve the goals of the 2030 Agenda for Sustainable Development.

At the heart of the rapid deployment of solar PV is the establishment of integrated solutions worldwide. Trade in solar photovoltaic components, which has grown rapidly, based on schemes where it contributes to the efficiency of costs and income offered to a wide group of beneficiaries from the individual sector, the public system and the entrepreneurial environment. The liberalization of tariffs, as well as the development of a quality system, constitute the basis of the process of internationalization of solar technologies.

According to the data of the International Agency for Renewable Energy, during the period 2010-2020, the utilization of solar energy for energy purposes had the most dynamic growth (25 times) compared to other technologies, the pace of introduction of new capacities being constantly increasing. The leader in this field is China, with an installed capacity of 254,345 MW, followed by the USA (75,571 MW), Japan (66,999 MW) and Germany (53,783 MW). China has consolidated its leading position as a producer of panels, cells and modules over the past ten years, while its share of global polysilicon production capacity has nearly tripled. Today, China's

share in all stages of production exceeds 80%, more than double its share of 36% in the deployment of photovoltaic panels worldwide, which positions the country as the main international supplier of technologies in this field.

The analysis developed by the analytical company Wood Mackenzie, ten companies ensured 82% of the deliveries of photovoltaic inverters in 2021, registering a trend of consolidating their position (+2% compared to 2020). Shipment volume increased by 22% due to significant growth in demand in Europe, Latin America and India, driven by decarbonisation efforts.

For the seventh consecutive year, Huawei (China) and Sungrow (China) continue to lead the pack by occupying the first and second positions respectively. Huawei's market share remained stable at 23% in 2021, while Sungrow came in a close second at around 21%, up from around 19% in 2020. Following a significant consolidation of market position, in 2021, the company Growatt (China) ranked third by the volume of deliveries, covering 7% of the market. Together, these three Chinese companies account for over 50% of global market shipments.

China also significantly dominates solar inverter production value chains. The list of top 10 companies includes 6 Chinese companies: Huawei (1st place), Sungrow (2nd place), Growatt (3rd place), Ginlong Solis (4th place), GoodWe (5th place), Sineng (8th place). In the case of other companies, a good number of them have production facilities in China or rely on the supply of components from China.

5. Conclusion

The structure of the international market is reflected in the structure of the imports of the Republic of Moldova, at least 83% of the imports of photovoltaic cells and 60% of the imports of inverters being ensured from China. The available offer, as well as the number of companies trained in the trade of components, services related to the design, installation and servicing of solar power plants, has a high degree of diversification in the case of the Republic of Moldova. Deficiencies are registered regarding the insufficient number of qualified installers, many of the projects implemented in the country requiring the invitation of specialists from outside. The establishment in 2022 of a laboratory within the Center of Excellence in Energy and Electronics will be able to ensure a consolidation of the supply of specialists.

Taking into account that the market has experienced a relative dynamism, especially in the recent period, only now are the conditions for the emergence of interest and the structuring of a market participation of large international equipment manufacturers, although there are some local companies that rely

primarily on partnerships with a manufacturer, including as an official distributor. The increase in demand and the number of projects implemented/served will contribute to an intensification of competition and decrease of costs based on the increase of volumes.

Solar energy holds significant potential to enhance the resilience of energy consumers in the Republic of Moldova. It offers a pathway to reduce energy dependency, mitigate climate change, and increase energy security. However, several challenges, including high costs, regulatory hurdles, and technical barriers, need to be addressed. A supportive policy and regulatory framework, along with public awareness campaigns and financial incentives, will be essential for driving the widespread adoption of solar energy in Moldova. Future research should focus on:

- evaluating the economic and environmental benefits of solar energy in the context of Moldova's specific needs;
- investigating the potential for integrating solar power into Moldova's existing energy grid and exploring innovative financing mechanisms to reduce costs;
- studying the effectiveness of existing policies and proposing new regulatory frameworks to overcome current barriers.

Planning the integration between the development of the renewable energy sector, including solar energy with other sectors denotes an acceleration based on the new strategic priorities. The contribution that technology can have to reducing costs and increasing competitiveness leads to an exponential increase in interest, the only limiting factor being access to cheap sources of financing. Development in the household sector may register a slower pace given the relatively high costs and lack of preferential financing opportunities for households in addition to support schemes.

Acknowledgements

This paper was developed within the framework of Subprogram 030101, “Strengthening the resilience, competitiveness, and sustainability of the economy of the Republic of Moldova in the context of the accession process to the European Union”, through institutional funding.

References

Abayev, A., & Esengeldin, B. (2024). Особенности внедрения солнечной энергии в условиях устойчивого развития [Features of the implementation of solar energy in the context of sustainable development]. *Государственное управление и государственная служба*, *3*(90), 114-123. https://doi.org/10.52123/1994-2370-2024-1309

AEE. (2023). Surse de energie regenerabilă [Renewable energy sources]. Kishinev: Agency for Energy Efficiency. https://old-aee.gov.md/ro/page/surse-de-energie-regenerabila

Agupugo, C. P., Ajayi, A. O., Nwanevu, C., & Oladipo, S. S. (2024). Policy and regulatory framework supporting renewable energy microgrids and energy storage systems. *Engineering Science and Technology Journal*, *5*(8), 2589-2615. https://fepbl.com/index.php/estj/article/view/1460

Arcipowska, A., Blanco Perez, S., Jakimów, M., Baldassarre, B., Polverini, D., & Cabrera, M. (2024). Role of solar PV in net-zero growth: An analysis of international manufacturers and policies. *Progress in Photovoltaics*, *32*(9), 607-622. https://doi.org/10.1002/pip.3797

Arion, V., Hlusov, V., Gherman, C., & Șveț, O. (2014). *Ghid privind evaluarea economică a proiectelor din domeniile eficienţei energetice şi energiilor regenerabile* [*Guide on the Economic Evaluation of Projects in the Fields of Energy Efficiency and Renewable Energy*]. Kishinev: Sirius Press. https://cned.gov.md/sites/default/files/document/attachments/ghid_privind_evaluarea_economica_a_proiectelor_din_domeniile_eficientei_energetice_si_energiilor_regenerabile_1.pdf

Baldursson, F. M., Banet, C., & Chyong, C. K. (2024). Regulation and standards for a resilient European energy system. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4724359

Ceban, V. (2016). Dezvoltarea energiei regenerabile în Republica Moldova. Realităţi, capacităţi, opţiuni, perspective [Development of renewable energy in the Republic of Moldova: Realities, capacities, options, perspectives]. Kishinev: Association for Foreign Policy. http://www.ape.md/wp-content/uploads/public/publications/2144156_md_aneza_nr_2_vad.pdf

Chatzipanagi, A., & Jäger-Waldau, A. (2023). The European solar communication—Will it pave the road to achieve 1 TW of photovoltaic system capacity in the European Union by 2030? *Sustainability*, *15*(8), 6531. https://doi.org/10.3390/su15086531

Ciucci, M. (2024, March 3). Energia din surse regenerabile [Energy from renewable sources]. European Parliament. https://www.europarl.europa.eu/factsheets/ro/sheet/70/energia-din-surse-regenerabile

Dimitrov, N. (2018). Renewable energy and solar business in the European Union. *European Journal of Economics and Business Studies*, *4*(1), 295-299. https://brucol.be/files/articles/ejes_v4_i1_18/Dimitrov.pdf

Ghai, M., Agnihotri, N., Agnihotri, R., & Kumar, R. (2024). Solar energy. In *Futuristic Trends in Renewable and Sustainable Energy* (Vol. 3, Book 3, pp. 213-231). Chikmagalur, Karnataka: Selfypage Developers. https://www.iipseries.org/viewpaper.php?pid=4423&pt=solar-energy

Hachem Vermette, C., Yadav, S., Brozovsky, J., Croce, S., Desthieux, G., Formolli, M., Grewal, K. S., Kanters, J., Lobaccaro, G., Manni, M., & Wall, M. (2024). Towards the development of legislative framework for solar neighborhoods. *Frontiers in Built Environment*, *10*. https://doi.org/10.3389/fbuil.2024.1352844

IRENA. (2019, February). *Renewables readiness assessment: Republic of Moldova*. Abu Dhabi: International Renewable Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_RRA_Moldova_2019_EN.pdf

Kakoulaki, G., Szabo, S., Fahl F. F., Taylor, N., Gracia-Amillo, A., Kenny, R., Ulpiani, G., Chatzipanagi, A., Gkoumas, K., & Jäger-Waldau, A. (2024). European transport infrastructure as a solar photovoltaic energy hub. *Renewable and Sustainable Energy Reviews*, *196*, 114344. https://doi.org/10.1016/j.rser.2024.114344

MERM. (2024). Starea actuală a domeniului energiei regenerabile în Republica Moldova: Potențial, provocări și perspective [Current state of the renewable energy sector in the Republic of Moldova: Potential, challenges, and perspectives]. Kishinev: Ministry of Energy of the Republic of Moldova.

MIDR. (2022, November 11). *Raport privind monitorizarea securității aprovizionării cu energie electrică și gaze naturale a Republicii Moldova pentru perioada 2020-2021* [*Report on the Monitoring of the Security of Electricity and Natural Gas Supply in the Republic of Moldova for the Period 2020–2021*]. Kishinev: Ministry of Infrastructure and Regional Development. https://energie.gov.md/sites/default/files/raport_privind_monitorizarea_securitatii_aprovizionarii_cu_energie_electrica_si_gaze_naturale_a_republicii_moldova_pentru_perioada_2020-2021.pdf

Ogunsola, O. Y., Adebayo, Y. A., Dienagha, I. N., Ninduwezuor-Ehiobu, N., & Nwokediegwu, Z. S. (2021). A conceptual framework for optimizing solar power plant development and financing in emerging economies. *Open Access Research Journal of Multidisciplinary Studies*, *1*(2), 100-107. https://doi.org/10.53022/oarjms.2021.1.2.0029

Petelcă, O., Pătrăuceanu, C. C., Beșliu, I., & Garbuz, V. (2024). Digitalization of the energy sector in the Republic of Moldova: An essential step for resilience and sustainability. *Analele Universității din Oradea. Seria Științe Economice*, *33*(2), 14-25. https://anale.steconomiceuoradea.ro/en/wp-content/uploads/2025/01/AUOES.December.2024.1.pdf

Popa, V., Popa, N., & Filimon, O. (2023). Procesul de valorificare a surselor de energie regenerabilă în Republica Moldova [The process of harnessing renewable energy sources in the Republic of Moldova]. *Institutional Repository of National Institute for Economic Research*. https://rses.ince.md/server/api/core/bitstreams/83320e45-60d7-49c4-b837-6301b09ffa9a/content

Popa, V., Ungur, C., & Țirigan, S. (2024). Mecanisme și măsuri de sprijin pentru domeniul energiei regenerabile în Republica Moldova [Mechanisms and support measures for the renewable energy sector in the Republic of Moldova]. *Vector European*, *2*, 110-117.

REN21. (2021). *Renewables 2021 Global Status Report*. Paris: REN21 Secretariat. https://www.ren21.net/wp-content/uploads/2019/05/GSR2021_Full_Report.pdf

Rugină, V., Badea, A., & Stanculea, A. (2017). Indicatori de eficiență energetică şi calculul economiilor de energie utilizînd metode top-down [Energy efficiency indicators and calculation of energy savings using top-down methods]. *EMERG*, *5*, 139-174. https://emerg.ro/cat/emerg-05

Saad, A. M. H., & Myat, A. (2025). Role of solar energy in achieving global net-zero targets: Policy and technological perspective. *American Journal of Energy and Natural Resources*, *4*(1), 1-8. https://doi.org/10.54536/ajenr.v4i1.3828

Scott, A., Worrall, L., Hörnberg, J., & To, L. S. (2017). *How solar household systems contribute to resilience* (Working Paper No. 528). London: Overseas Development Institute. https://hdl.handle.net/2134/28097

Sovacool, B. K., & Brown, M. A. (2010). Competing dimensions of energy security: An international perspective. *Annual Review of Environment and Resources*, *35*, 77–108. https://doi.org/10.1146/annurev-environ-042509-143035

Wolniak, R., & Skotnicka-Zasadzień, B. (2022). Development of photovoltaic energy in EU countries as an alternative to fossil fuels. *Energies*, *15*(2), 662. https://doi.org/10.3390/en15020662