SOLAR ENERGY AS A DRIVER OF SUSTAINABLE DEVELOPMENT IN AGRICULTURE: POTENTIAL AND LEGAL FRAMEWORK FOR IMPLEMENTATION IN THE REPUBLIC OF SERBIA

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A R T I C L E I N F O

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A B S T R A C T

The authors analyze two very important topics, which are intertwined, and relate to the legal regulation and application of solar energy in agriculture in our country. Solar energy reduces the costs of agricultural production in the long term and increases sustainability and competitiveness. Therefore, when it comes to the application of solar energy in agriculture, an important factor that directly affects market positioning is the greater competitiveness of food produced using clean energy. In addition, legal frameworks significant for the use of solar energy in agriculture at the European level and within the borders of the Republic of Serbia were considered as the subject of the paper. The Republic of Serbia has real potential for the production and application of solar energy, but these potentials are not sufficiently used, and the experiences of EU countries can be significant when adopting measures from the sphere of energy policy, especially if one takes into account the context of European integration in accordance with environmental protection.

Introduction

Food, energy and water are the three most important resources on our planet that life depends on (Sarr et al., 2023, Barron-Gafford et al., 2019). These three resources are also of limited availability, increased global demand and limited sustainability (Carmona-Moreno et al., 2021; Acosta-Silva et al., 2019). Due to the rapid growth of

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the population and the satisfaction of their basic needs, the demand for these three basic resources is expected to increase in the future (OCDE/FAO., 2019; Iheanetu, 2022; Mughal, 2022). According to United Nations (UN) projections, the world population will increase from 8.5 billion, which is expected in 2030, to 9.7 billion in 2050 (Nations Unis. 2022). Accordingly, food production should be increased to meet the needs of the growing population. (Rao et al., 2023)

Agriculture, as a very important factor in sustainable development, is however facing the need for greater, but limited, access to energy. The agricultural sector consumes about 40% of energy worldwide. (Nazim et al., 2021)

Many energy policies in developing countries are designed for the needs of industry, transport and urban infrastructure. (FAO, 2000) The energy requirements of agriculture are often neglected, and although agriculture contributes significantly to economic and social development, often accounting for around 30% of the GDP of developing countries, the energy supply in agriculture has not received the attention that this sector deserves. (Benedek et al., 2023)

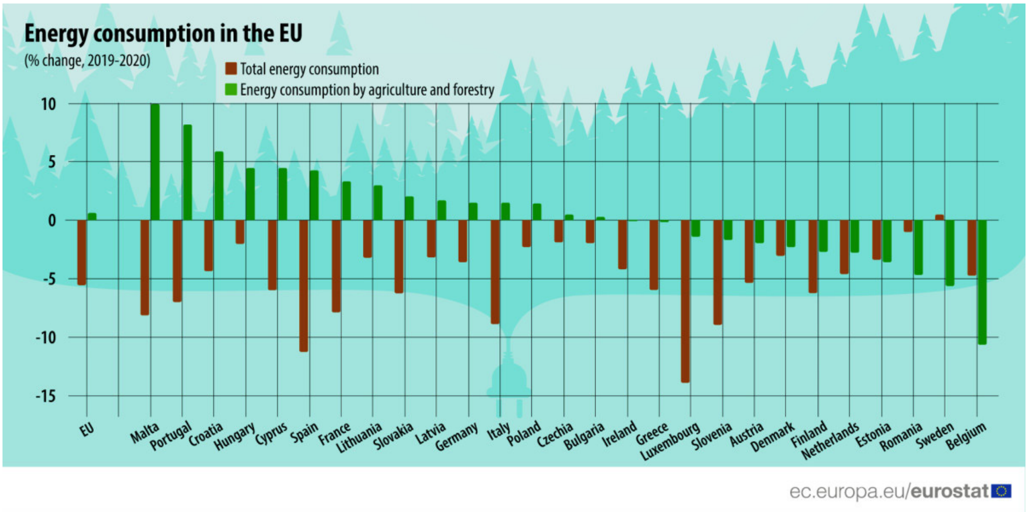
Ensuring a sufficient amount of available energy for agriculture should have a higher priority when evaluating the rural policy of the Republic of Serbia. Therefore, there is a need for urgent actions, due to the slow economic development in many rural regions and the migration of the rural population to urban areas. Modern agricultural production plays a key role in rural development.

Energy-sustainable agricultural production

Agriculture in itself represents the process of energy conversion, i.e. the conversion of solar energy through photosynthesis into food energy for humans and animal feed. (Zaman et al., 2012) Modern agriculture requires energy input in all phases of agricultural production, such as direct energy use in agricultural machinery, irrigation, cultivation, water management, and harvesting, but also after harvesting it involves energy for food processing, storage and transport to the market. In addition, there are many indirect or separated energy inputs used in agriculture in the form of mineral fertilizers and chemical pesticides, insecticides and herbicides. (Subić et al., 2017) Energy consumption in agriculture increased with the introduction of high-yielding plant varieties and mechanized crop production. (Acosta-Silva et al., 2019) According to Eurostat, between 2019 and 2020, an increase in the rate of energy consumption in agriculture and forestry was recorded, of which the highest growth was achieved by Malta at 10%, Portugal at 8% and Croatia at 6%. However, the decline of consumption in these sectors was recorded in Belgium by 11%, Sweden by 6% and Romania by 5%. (Figure 1.)

The largest share in total energy consumption in 2020 was in the Netherlands at 9%, followed by Poland and Latvia, both with 6%. In the Netherlands, greenhouse production had the greatest impact on energy consumption in agriculture. (Eurostat, 2020)

Figure 1. Growth in energy consumption for agriculture and forestry from 2019 to 2020.



Source: (https://www.agroklub.rs/poljoprivredne-vesti/porasla-potrosnja-energije-u-sektoru-poljoprivrede-i-sumarstva-u-2020/80819/)

After labour costs, energy is usually the largest overhead cost in greenhouse crop production, even in temperate climates. Of the required total energy, about 75% is spent on heating, 15% on electricity, and 10% on transport. (Acosta -Silva et al., 2019) In order to ensure better conditions for the growth of crops such as adequate lighting, temperature, humidity, composition and gas concentration when growing plants in a greenhouse, the use of electricity is required. The decrease and increase in the price of available energy resources, climate change and the unstable price of fossil fuels have increased the need for more environmentally friendly energy sources, which represents a challenge for sustainable agricultural production. (Babatunde et al., 2019)

The application of RES can therefore be a solution to this challenge (Gajdobranski et al., 2021) and solar energy, as it is available everywhere, represents one of the most suitable renewable energy sources (RES) (Al-Saidi et al., 2019). Solar energy in agriculture brings several other advantages, such as greater competitiveness of food produced using clean energy. According to research the application of photovoltaic (PV) solar systems on agricultural farms can reduce electricity costs by 50 to 70%. (Acosta-Silva et al., 2019)

Materials and methods

The methodological approach to the research was determined following the previously defined goal of the research and consists of a theoretical and empirical segment. The theoretical part of the research includes a normative analysis of the provisions of the Law on Renewable Energy Sources (LURES) and a comparison of the legal framework important for the use of solar energy in agriculture at the European level and within the borders of the Republic of Serbia. First of all, the authors, through a normative analysis of LURES provisions, indicate the need for further harmonization of domestic legislation with world and European legislation in the field of solar energy, as well as with obligations from ratified international documents and European integration processes. The theoretical part of the research aims to show that solar energy, as clean energy, can be used to increase the competitiveness of agriculture in the Republic of Serbia, and that there is adequate regulation for its application. Because the Republic of Serbia is predominantly an agricultural country, it has real potential for the production of solar energy in agriculture. These potentials are not sufficiently used, and the experiences of European Union (EU) countries in this sphere can be significant when adopting measures from the sphere of energy policy, especially if the context of European integration is taken into account, which must not neglect the requirements of environmental protection, and which is particularly reflected in the advantage of using solar energy in agriculture. "There are the conditions (clearly defined laws, conditions, and incentives) for investments in solar energy plants". (Pavlović, 2017).

The empirical part of the research includes the analysis of relevant and available data on the application of solar energy in agriculture. The analysis aims to determine the relevant and available ways of applying solar energy in agriculture based on the experience of other countries.

The research is theoretical and empirical, in which the authors opted for the application of a descriptive, normative and comparative method. During the preparation, some current scientific and professional literature was used, through the research of foreign and domestic literature dealing with issues of solar energy in agriculture: books, collections of works, textbooks, and professional articles.

Bearing in mind the strategic importance of agriculture in the Republic of Serbia and the fact that solar energy in agriculture synergistically connects several components - economic, political, legal and environmental issues, the main hypothesis of this work is based on the assumption that solar energy can serve to increase competitiveness and sustainability in the long term, of agriculture in the Republic of Serbia, that is, the competitiveness of food produced using clean energy is greater. The sub-hypothesis is based on the assumption that there is an appropriate legislative framework in our country that ensures the use of solar energy in agriculture, to achieve sustainability and competitiveness, but it still needs to be harmonized with the legislation of EU countries, as well as with the obligations of harmonization with trends. European integrations and accepted international obligations.

In the end, a SWOT analysis was done, so that an important segment, in which all the mentioned components intertwine, was also processed. "Individual SWOTs can be examined in relation to one another according to estimates of their contribution to desired performance, along with approximations of the degree to which each factor is or is not within an organization's control". (Leigh, 2009)

Background

In the last fifteen years, the legislation regulating RES in the EU has been developing more and more. Massive, rapid deployment of renewable energy is at the heart of the REPowerEU PlanCOM/2022/230– the EU's initiative to end dependence on Russian fossil fuels. Solar energy is the main driver of these measures. A simple and abundant resource, such as solar energy, should contribute to reducing the EU's dependence on fossil fuels in all sectors of the EU economy, from heating residential spaces to agricultural use.

Key legislation in the area of renewable energy includes Directive 2009/28/EC on the promotion of the use of energy from RES (Renewable Energy Directive (RED)).[4] The European Green Deal was published at the end of 2019 and represents EU's biggest action to reach climate neutrality.(Kougias, 2021) The European Green Deal and the more ambitious EU climate goals enshrined in the European Climate Law (at less than 55 % greenhouse emissions by 2030 and climate neutrality by 2050) required further changes to achieve a higher share of RES in EU. The Fit for 55 (2021), which included another proposed revision of the Directive (EU) 2023/2413 (RED III) seeking to increase the share of RES in final energy consumption to 40 % by 2030. (EPRS, 2022)

The European Parliament adopted RED III, which is crucial for accelerating the introduction of RES, and is in line with the European Green Deal and the REPowerEU PlanCOM/2022/230). In RED III, the binding share of RES for 2030 is raised from 32 to 42.5%, with the directive calling on member states to reach 45%. RED III is also part of the Fit for 55 legislative and regulatory package. RED III has not been implemented in our legislation.

Changes from 2023

- The EU has updated its rules on energy in the framework European Green Plan and the Fit for 55 package, which aims to bring those rules into line with the EU's goal of climate neutrality by 2050, as well as the goal of reducing net greenhouse gas emissions by 2030 by at least 55% compared to 1990 levels.[5]
- Those rules have also been amended to include plan REPowerEU Plan COM/2022/230) which aims to reduce the EU's dependence on Russian oil and gas.
- Directive (EU) 2018/2001 was amended by Directive (EU) 2023/2413. (Most of the rules introduced by Directive (EU) 2023/2413 are to be transposed into

4 Originally adopted in 2009, it set the target of a 20 % share of RES in final energy consumption by 2020. The recast RED of 2018 (Directive (EU) 2018/2001) (RED II) increased this objective to 32 % of RES in final energy consumption by 2030 (it was supposed to be transposed into national law by 30 June 2021). (European Parliamentary Research Service (EPRS), 2022)

5 It is predicted that 25% of the required electricity will come from solar FN energy by 2050, with a reduction of 4.9 Gt CO_2, which corresponds to a 21% reduction in emissions in the energy sector (IRENA, 2021).

national law by 2025, while most of those rules relating to licensing procedures are to be transposed by 1 July 2024).

Solar energy plays a crucial role in the global transition to clean energy and zero net emissions. (Pulselli et al., 2022) For the EU to achieve the 2030 RES target proposed by the Commission and the objectives of the REPowerEU Plan COM/2022/230), it must accelerate the process of introducing solar energy. To achieve this, the EU will have to install an average of 45 GW per year.[6] (EU Solar Energy Strategy (Com (2022) 221)) According to Solar Power Europe, the EU's solar energy production capacity continues to grow and reach an estimated 259.99 GW in 2023.

The potential of solar energy in the Republic of Serbia

Solar PV energy is everywhere available, a more environmentally friendly and economically viable alternative to conventional energy sources (Sass, 2020, Dos Santos et al., 2019, Belaud et al., 2019, Kibar, 2003). In 71 minutes, our planet receives as much solar energy as is sufficient for the energy needs of humanity for an entire year.

Serbia shows excellent potential for using solar energy. (Licastro, 2022) The potential of solar energy represents 16.7% of the usable potential of RES in the Republic of Serbia. The energy potential of solar radiation is about 30% higher in the Republic of Serbia than in Central Europe and the intensity of solar radiation is among the highest in Europe. (Lambić, 2011; Prvulović et al., 2018) Even so, the use of solar energy in the Republic of Serbia is still at the beginning. (Jakovljević et al., 2022)

The average daily energy of global radiation for a flat surface in the Republic of Serbia during the winter period ranges between 1.1 kWh/m2 in the north and 1.7 kWh/m2 in the south, and during the summer period between 5.4 kWh/m2 in the north and 6.9 kWh /m2 in the south. (Lambić, 2011) The most favourable areas in the Republic of Serbia record a large number of sunny hours, and the annual ratio of actual irradiance to total possible irradiance is approximately 50%. (Stamenić, 2009)

Application of solar energy in agriculture

Application of solar energy can be achieved in two ways: by converting solar energy into heat and electricity. (Stamenić, 2009) Solar systems for heat production are used in households, agricultural facilities and in the processing of agricultural products, where

6 EU Solar Energy Strategy (Com (2022) 221) it foresees that most of the funding will be private, but partly supported by public funding, among other EU funds. Within the "Recovery and Resilience Mechanism" at least EUR 19 billion has already been allocated to accelerate the introduction of RES. These measures will be financed from other instruments such as: cohesion policy funds, InvestEU, Innovation Fund, Modernization Fund, Horizon Europe and LIFE programs. The horizon of Europe framework program (from 2021 to 2027)," is the EU's main instrument for stimulating research in the field of energy with a budget of EUR 95.5 billion, including EUR 5.4 billion from the Next Generation EU program". (Locci, 2023)

large amounts of sanitary water are used. Solar thermal systems transform solar energy into thermal energy and help farmers create optimal growing conditions and reduce reliance on fossil fuel-based heating methods. Thermal energy in agriculture is necessary for heating sanitary water and heating air in dryers, silos, barns, farms and greenhouses.

Supplying agricultural holdings with electricity originating from the PV system has become more and more common in the field of agriculture in the EU. PV systems provide farms with a renewable and reliable source of electricity. These systems feed different aspects of agricultural activities (Ali, 2022):

1. Irrigation system: Solar panels are used to power irrigation pumps. This is especially useful in rural areas where grid electricity is not available. Solar irrigation systems enable efficient use of water and reduce energy costs. Solar energy sources have emerged as a green alternative with lower energy costs and, consequently, lower environmental impacts. (Picazo et al., 2018) These systems use solar energy to pump water from wells, rivers or reservoirs, providing an efficient and sustainable irrigation solution.
2. Reliable energy supply for farms: Solar panels can be used to ensure uninterrupted energy supply to farms. This may include lighting barns, powering cooling or heating systems, and other electrical needs.
3. Greenhouse climate control: Solar panels can be used to power greenhouse climate control systems. This includes heating, cooling, ventilation and automatic irrigation systems. By using solar energy for these purposes, farmers can reduce energy costs while being environmentally friendly.
4. Crop monitoring and surveillance: Solar panels can be used to power crop monitoring and surveillance systems, including sensors for moisture, temperature, soil pH, and other parameters critical to optimal plant growth and development.
5. Powering electric vehicles and machinery: Solar panels can be used to charge the batteries of electric vehicles and machinery used in agriculture, such as tractors, harvesters, mowers and other work tools. This can reduce fuel costs and emissions. „Although solar-powered tractors are in the initial development phase, the results are hopeful for a bright agricultural future.“ (Ali, 2022)
6. Solar spraying and seed transplant machines: Solar pesticide spraying machine is designed for small farmers to improve their productivity. (Khule et al., 2004) Solar-powered seed diffuser and transplant machines offer a simple and convenient way to spread and plant seeds in small fields, as well as in those areas where traditional machines are not available. It will be most beneficial for small farmers and the agricultural community. (Tariq et al., 2021) “Today, radio controlled solar transplants are designed to provide farmers with eco-friendly seed planting and diffusion.” (Ali, 2022)

7. Solar Crops Drying: One of the applications of solar energy in agriculture is a solar drying system that depends on a variety of options. Solar dryers are available in different shapes and structures. (Norton, 2017; Kumar et al., 2018) Different types of solar dryer are available for different applications, which are used to dry agricultural products such as potatoes, cereals, carrots and mushrooms. (Tariq et al., 2021) The positive effects of investing in mini digital solar dryer (according to all indicators of the dynamic methods of investment assessment) indicate the justification and importance of implementing the modern systems in agricultural production that are based on the use of renewable energy sources. (Nastić et al., 2023)

8. Providing shade for crops. The application of photovoltaic panels can also be used to provide shade for crops, thus reducing their need for water. This concept, where the shade of the panel is combined with hydro-technics, is particularly suitable for use in areas with high daily temperatures during the summer period. "This innovative approach optimizes land use by achieving synergy between solar energy production and crop cultivation." (Wagner et al., 2023) On the other hand, while the crops are generating income, the electricity produced by the solar panels can be sold or used to offset farm energy costs.[7] "The convergence of solar energy and the agricultural industry has opened the door to a new era of sustainable agricultural practices". (Wagner et al., 2023)

9. The problem of lack of land for the construction of PV power plants has led to the development of technologies of floating PV power plants that are placed on dedicated platforms on calm water surfaces, such as ponds and reservoirs. The advantage of such systems is that they reduce water evaporation, and can contribute to the improvement of water quality. "Such plants can be planned on artificial lakes, while on natural lakes their construction may be conditionally acceptable if the coverage does not exceed 5% of the lake surface". (Đurišić, 2022).

10. Mobile solar units:[8] In addition to large power solar power plants, smaller power solar units, which can be stationary or mobile, are increasingly appearing on the market. Mobile solar units are especially interesting for agricultural applications. (Despotović, 2016)

7 "Solar panels are strategically placed above the crops, providing shade, thus reducing water evaporation and creating a more favourable microclimate for the crops while generating electricity, which can be used on-site or fed into the grid. This dual land-use approach optimizes resource allocation and promotes sustainable land management." (Wagner et al., 2023)

8 "They are ideal for use in agriculture because they are portable, easy to use, reliable and robust in exploitation, do not require special maintenance except for regular cleaning of the panels from dust, have a long service life (more than 20 years), do not produce noise and do not pollute nature. (Despotović, 2016)

Results and discussions

Solar energy reduces the costs of agricultural production in the long term while increasing sustainability and competitiveness. The application of solar energy in agriculture increases the chances for farmers, because sustainability, primarily the reduction of harmful emissions, is one of the key goals of the EU in the framework of the green transition. More work should be done to increase farmers' awareness of the benefits of using solar energy.

Solar PV and solar thermal technology can be introduced quickly, they can have a favourable effect on the climate, and citizens can save money. This is because the cost of solar energy has come down significantly over time.[9] The EU's RES policies in the last decade according to data IRENA have contributed to reducing the deployment costs of PV technology by 82% from 2010 to 2020, making it one of the most competitive sources of electricity in the EU.

They can be introduced very quickly because they use existing structures and do not harm nature, which is important for the agricultural production of ecologically safe food. Therefore, attractive financing conditions are key to their competitive introduction. The Commission's analysis indicates that additional investments in solar PV systems within the REPowerEU Plan (COM/2022/230) in the period up to 2027 would amount to an additional 26 billion EUR in addition to the investments needed to achieve the goals of the proposal from the Fit for 55 package. "Serbia plans to be part of the EU ETS system, on the way to joining the EU, for which, in addition to the analysis and technical assistance of the Energy Community, we also need financial assistance from the EU, as well as a sustainable period for implementation, after 2030, when we will have enough built green energy capacities" states MRE (2024).

EU Solar Energy Strategy (Com (2022) 221)

The EU, as a single area and a single market, strives to harmonize the national regulations of the member states. (Dukić Mijatović, 2022) Within the framework of the REPowerEU Plan (COM/2022/230), the Commission passed EU Solar Energy Strategy (Com (2022) 221) to double solar PV energy capacity to 320 GW by 2025 and to install 600 GW by 2030. Based on the plan, member states must establish and adopt plans for dedicated RES areas, with shortened and simplified permitting procedures.[10]

9 Solar PV sone of the cheapest sources of electricity available. Estimated at 24–42 EUR/MWh (depending on location within the EU) according to research by Eero Vartiainen et al; estimated at 32–74 EUR/KWh (depending on location within the EU) according to a study by Lugo-Laguni et al, (2021). According to the 2021 International Energy Agency (IEA) world energy forecast, it is estimated at approximately 60 USD/MWh in the EU. Estimated at USD 75-131/MWh in Italy, Spain, France and Germany according to the technical report IRENA: Renewable Power Generation Costs 2020. (IRENA, 2000).

10 he European Commission has launched the European Solar Academy, the first in a series of academies to be implemented under the Net Zero Industry Act (NZIA). The Commission allocated EUR 9 million from the Single Market Program for its launch.

By adopting this strategy, the EU Commission considered it necessary to solve several challenges in this area. It is important to point out that the EU Solar Energy Strategy (Com (2022) 221) as an innovative form foresees "multiple use of space." "Multiple uses of space can contribute to alleviating land constraints associated with competition over the use of space, among others for nature conservation, agriculture and food security." For example, the use of land for agriculture can under certain conditions be combined with the production of solar energy by agricultural PV systems. That is why in theory it is considered that "synergies can be established in these activities, within which PV systems can contribute to crop protection and yield stabilization,[11] (Barron-Gafford et al., 2019) where the land is still primarily used for agriculture."

EU The Solar Energy Strategy (Com (2022) 221) foresees that EU member states should consider incentives for the development of agricultural PV systems (e.g. by including agricultural FN systems in tenders for energy from renewable sources) when developing their national strategic plans for the common agricultural policy and within the support for solar energy. In doing so, it is emphasized that it is important to note that the EU rules on state support in the agricultural sector enable support for investment in sustainable energy. „State aid to promote the economic development of the agricultural sector is part of the wider framework of the „Common Agricultural Policy" (CAP). (Maksimović Sekulić et al., 2024)

The EU has developed an energy model that creates incentives to attract investment in RES and to integrate it into the grid. In the EU Solar Energy Strategy (Com (2022) 221), it is stated: "Many member countries of the Energy Community are interested in implementing that model with the support of regional electricity markets, and cross-border cooperation and infrastructure. Through its diplomatic action and strategic engagement in third countries, the EU will work on the expansion of solar energy and other RES to reduce exposure to the instability of fossil fuels and geopolitical risks". This is a chance for member countries of the Energy Community to expand solar energy in agriculture as well as other RES. That is why the adoption of LURES in our country is important so that this can be achieved.

Law on the Use of Renewable Energy Sources (LURES)

Due to the international agreement, the Stabilization and Association Agreement (SAA), which entered into force on September 1, 2013, the Republic of Serbia received the status of an EU-associated country, as well as based on the fact that with the adoption of the Law on the Ratification of the Treaty on the Establishment of the Energy Community, the Republic of Serbia became a member of the Energy Community, and thus accepted the obligation to apply European directives in the field of RES, we can conclude that with the adoption of LURES, Directive (EU) 2018/2001-RED II was "for the most part transferred" into our legal system. [12]

11 See the research conducted by the Fraunhofer ISE Institute on the subject: https://agri-pv.org/

12 This is stated by the Government of the Republic of Serbia in the document "Negotiating Position of the Republic of Serbia for the Intergovernmental Conference on the Accession of the Republic of Serbia to the EU" for Chapter 15 "Energy" from June 2021.

LURES like *a lex specialis* in the area of RES, it should also enable a concrete increase in the capacity of plants that produce energy from renewable sources. The most significant changes and novelties include new incentive measures (as instruments, i.e. support mechanisms for energy production from RES), as well as provisions related to the balanced responsibility of guaranteed suppliers (by the Guidelines on State Aid for Environmental Protection). Therefore, the adoption of LURES is significant, especially taking into account trends in the energy market, as well as internationally assumed obligations, which primarily relate to decarbonization and climate change.

After the adoption of LURES, it was necessary to adopt the relevant bylaws as soon as possible, which should enable the implementation of the law in full. LURES predicted a time frame of 6 months for the adoption of all relevant by-laws necessary for implementation, however, that deadline was not fully respected. In this way, there was no integral regulation of the legal framework, by not adopting complete by-laws. However, as a priority in the coming period, it is necessary to adopt the remaining by-laws so that the implementation of the law can be fully implemented and to cancel the collision between LURES and the umbrella Law on Energy (LE). LURES has fundamentally changed the provisions of the LE provided up to then, which refer to RES and which were in force until that moment. The fact is that, mainly due to this, there were certain gaps and a collision with the umbrella LE, which, until the amendments and additions, regulated certain issues in a directly opposing manner. However, in 2021, the Amendments to the Law were passed. However, the Republic of Serbia is still working on harmonizing with EU regulations, so by the end of 2024, changes to the LE should create regulatory conditions for integration into the single electricity market.

By analyzing the legal solutions, it can be seen that LURES abounds in numerous novelties and is aimed at harmonizing with international obligations, but at the same time, with the market needs relating to this type of energy production, which in the current circumstances is becoming "cheaper" and commercially more profitable for potential investors. Many authors believe that this reduces the need for incentives that are not sustainable on market and commercial principles and that lose their meaning given the above circumstances. (Despotović, 2016) On the other hand, there are new legal solutions, such as the buyer-producer model and the introduction of guarantees of origin.[13]

The adoption of LURES resulted in a significant change in the incentive system due to the introduction of two new incentive models: market premium and feed-in tariff. The

13 "In practice, the buyer-producer model is the fastest implemented, at least when it comes to citizenship." (RERI)

legislator, by general trends, abandoned the original fixed feed-in tariff. [14] The market premium system is regulated in detail. By the way, this is a highly market-oriented method of incentives, and a liquid electricity market is necessary for success. The Republic of Serbia has yet to join the single European electricity market. But the Republic of Serbia is the only one in the region that has an intraday and day-ahead electricity market and is part of the regional stock exchange with two EU members - Hungary and Slovenia. The Ministry of Mining and Energy (MRE) is preparing an analysis and impact assessment of the implementation of the Carbon Border Adjustment Mechanism (CBAM) and is working on defining the most acceptable option for carbon taxation.[15]

The feed-in tariff based on LURES differs from the earlier regulatory framework of fixed tariffs and is determined at auctions. In contrast to market premiums, no regulation on the Model contract for the feed-in tariff has been adopted, so the legislative framework has not been fully defined. Also, no quotas were adopted for the feed-in tariff. That's why existing investors are increasingly choosing to develop plants that would be completely market-oriented, and LURES brings an important innovation here as well.

One of the novelties, which represents an improvement, is that LURES foresees that producers of electricity from RES can conclude contracts on the purchase of electricity with customers by market principles. (Article 46. LURES) The current LURES provides regulated rules for guarantees of origin for energy produced from RES.

An important innovation in LURES is the regulation of the concept of buyer-producer in the construction of plants for the production of electricity from RES for their own needs. Based on this concept, it is stipulated that "the customer-producer is the final customer who has connected his own facility for the production of electricity from RES to the internal installations (whereby the electricity produced is used to supply his own consumption), and the excess electricity produced is delivered into a transmission system, a distribution system, or a closed distribution system." (Article 4. paragraph 1. point 23. LURES) This can have an extremely positive effect on increasing the share of small RES power plants owned by citizens, and even cooperatives in agriculture, given that the procedure is significantly simplified, and there is also the possibility of financial savings. A big change compared to the previous regulation is the question of balance responsibility.

14 The primary incentive method, in terms of its applicability to large projects, is the market premium, which is "a type of operational state aid that represents an addition to the market price of electricity delivered to the market by market premium users and determined in Eurocents per kWh in the auction process." (Article 14. LURES)

15 "Carbon taxation at the local level can be one of the acceptable options for now, because with a fixed price, it would give predictability to the economy during the adjustment period. The introduction of a regional system for trading carbon emissions at the same price and modeled after the system that exists in the Emission Trading System (EU ETS) until 2030 is not an option for Serbia, due to the excessive financial consequences and complex application above all." (MRE-Đedović Handanović, 2024)

The evaluation of internal strengths and weaknesses, as well as external opportunities and threats for the application of solar energy in agriculture, was done with the help of a SWOT analysis. The results of the SWOT analysis were used to identify the strategy for achieving the goals. (*Table 1.)*

Table 1. SWOT analysis for the legal and political development of solar energy in agriculture in Serbia

Strengths	**Weaknesses**
• Sustainability: The use of solar panels enables the reduction of harmful gas emissions and supports sustainable agriculture practices. • Cost reduction: Solar panels can reduce energy costs, especially in rural areas where conventional energy sources are expensive or unavailable. • Diversification of income: The implementation of solar systems provides farmers with an additional source of income through the production of electricity. • Technological progress: Advances in solar panel technology lead to increased efficiency and reduced prices. • Competitiveness: Greater competitiveness of food produced using clean energy. • Legislative activity: LURES was adopted, which was mostly transferred to RED II.	• High initial costs: Initial costs for solar energy technologies are relatively high compared to other energy sources, but operating costs are therefore low. • Dependence on weather conditions: Solar panels depend on sunlight to produce electricity, which can be a challenge in cloudy or rainy areas. • Need for maintenance: Solar systems require regular maintenance to maintain optimal performance, which can be an additional expense for farmers. • Legislative activity: Not all by-laws necessary for the implementation of LURES have been adopted. • Administrative measures: There is a long wait for the approval of projects, and the administrative application is extensive, unlike in the EU, where new measures reduce this.
Opportunities	**Threats**
• Incentive policies: Government policies support the use of RES, which can facilitate investment in solar panels. • Legislative framework: It is necessary to continue harmonizing our legislation with EU legislation. • Technological development: Continuous progress in solar panel technology opens up new opportunities to increase efficiency and reduce costs. • Growing awareness of sustainability: A growing number of consumers and farmers recognize the importance of sustainability, which can increase demand for sustainably produced products. • Regulation: regulatory conditions for integration into the single electricity market should be created by amending the LE.	• Competition with other energy sources: Competition with other RES, as well as with traditional sources, can be a challenge for solar energy. • Policy and regulation: Changes in policy and regulation, including reductions in contributions or changes in tax treatment, can affect the economic viability of solar systems. • Lack of education: Lack of education about the advantages and possibilities of using solar panels in agriculture can limit their wider application. • Lack of connection with scientific institutions to develop research in this area.

Source: Authors

This SWOT analysis can help to better understand the factors affecting the application of solar panels in agriculture and identify strategies to determine the benefits and minimize the risks.

Conclusions

The energy requirements of agriculture are very often neglected, even though agriculture contributes significantly to economic development because the energy supply in agriculture has not received the attention that this sector deserves. Ensuring a sufficient amount of available energy for agriculture should have a higher priority when evaluating the rural policy of the Republic of Serbia. The reduction and increase in the price of available energy resources, climate change and the unstable price of fossil fuels have increased the need for more environmentally friendly energy sources, which represents a challenge for sustainable agricultural production.

In addition, since solar energy reduces the costs of agricultural production in the long term, it increases sustainability and competitiveness. When it comes to the application of solar energy in agriculture, an important factor that directly affects market positioning is the greater competitiveness of food produced using clean energy. Also, agricultural farms can produce energy for sale, and there is the branding of the destination in tourism as a green destination. Through reduced energy costs, environmental sustainability and energy independence, solar energy affects the sustainability of the agricultural community. By switching to solar energy, farmers actively contribute to the fight against climate change, the preservation of natural resources and the preservation of the environment for future generations. Solar energy gives farmers energy independence and reliability. Unlike the EU where farmers are often encouraged to finance through grants, tax credits and subsidies, this is not the case in the Republic of Serbia. In addition, in the Republic of Serbia, there is a lack of information for farmers on this topic, in the context of the green transition towards climate neutrality.

The average solar radiation in Serbia is about 40% higher than the European average, but the use of solar energy for the production of electricity is far behind the EU countries. (Stamenić, 2009) At this moment, it is justified to encourage the use of solar energy for the production of heat and electricity in the field of agriculture due to smaller investments. Such a policy would, among other things, be useful for the development of the domestic economy, as well as employment in the field of clean energy.

Solar energy plays a crucial role in the global transition to clean energy and zero net emissions in EU. That is why the REPowerEU Plan (COM/2022/230) was adopted, an initiative that was amended in 2023, and which aims to reduce the EU's dependence on Russian fossil fuels. Under this plan. In 2022, the Commission adopted the EU Strategy for Solar Energy (Com (2022) 221). Key act in the area of renewable energy includes Directive (EU) 2018/2001) on the promotion of the use of energy from renewable sources, which has had three revisions so far.

In our country, LURES should enable a concrete increase in the capacity of plants that produce energy from renewable sources. By analyzing the legal solutions, it can be seen that LURES is full of numerous novelties and is aimed at harmonizing with European integration, but at the same time, with market needs related to this type of energy production from renewable sources. It mostly transposed the RED II Directive, but not the latest RED III amendment. There are new legal solutions in it, such as the buyer-producer model, which was the fastest implemented in our legal system, when it comes to citizenship, but also the introduction of guarantees of origin, and others. Immediately after the adoption of LURES, due to the non-adoption of the relevant by-laws, there was no integral regulation of the legal framework in this area, this is being corrected. Given that LURES fundamentally changed the provisions of the second law - LE, there were certain gaps and a collision with LURES. However, in 2022, the Amendments and Supplements to the LE were adopted, which, for example, introduced the term buyer-producer into this act. However, the legislator is still working on harmonization with the EU regulation, so another amendment of the LE is foreseen to create regulatory conditions to join the single European electricity market. The Republic of Serbia is the only one in the region that has an intraday and day-ahead electricity market and is part of the regional stock exchange with two EU members - Hungary and Slovenia. The MRE is preparing an analysis and assessment of the impact of CBAM implementation and is working on defining the most acceptable option for carbon taxation. Finally, in the paper, an assessment of internal strengths and weaknesses, as well as external opportunities and threats for the application of solar energy in agriculture in our country was made with the help of a SWOT analysis.

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Conflict of interests

The authors declare no conflict of interest.

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