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THE INTERCONNECTION BETWEEN REGULATION AND TECHNOLOGICAL EFFICIENCY FOR SOLAR POWER PLANT DEVELOPMENT

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Abstract. In Lithuania, solar energy is expanding rapidly. In 2020, the installed capacity of solar power plants was 170 MW, and by 2025, it exceeded 900 MW. This growth reflects not only technological progress but also an increasing interest from consumers and businesses. With rising electricity consumption and more solar modules being installed, it is becoming increasingly important to analyse how technological efficiency is evolving in the Lithuanian climate and the influence of the legal framework on this process. Properly coordinated technical and legal development can ensure the sustainable and long-term advancement of solar energy. This research paper explores the interplay between legal solutions and technological efficiency in the development of solar power plants, analyses the main challenges facing Lithuania and the EU, and identifies areas that remain underexplored. Directions for further research are provided, emphasising system optimisation and long-term performance.

Keywords: solar power plants, regulatory framework

1. Legal Regulation and Sanctions for Solar Power Plant Activities

The development of solar power plants in Lithuania is grounded in a clear legal framework. This framework includes support mechanisms, grid connection procedures, and principles for balancing production with consumption. The legal documents shape the overall policy in this area, directly impacting investment, public involvement, and the structure of the energy system.

In Lithuania, solar power plants are governed by several key laws, which have been continuously revised over the past decade to promote the development of renewable energy sources and ensure the achievement of national climate goals. Lithuanian legislation is closely aligned with EU law. Directive (EU) 2018/2001 on the Promotion of Renewable Energy Sources (RED II) establishes a target for renewable energy to constitute a significant share of the EU's energy mix by 2030 (European Parliament and Council, 2018).

The State Energy Regulatory Council (SERC) undertakes control functions and has the authority to impose sanctions for illegal connections to the grid, breaches of security requirements, or failure to provide data (SERC, 2023). The principal document, the Law on Renewable Energy, adopted in 2011, outlines the principles and support mechanisms for utilising energy from solar, wind, biomass, and other sources, and establishes the status of a generating consumer (Law on Renewable Energy of the Republic of Lithuania, 2011).

The Code of Administrative Offences stipulates fines for operating solar power plants without permits, violating connection conditions, or failing to comply with the established requirements (Code of Administrative Offences of the Republic of Lithuania, 2015). The legislation also addresses the liability and sanctions applicable in cases of violation of the requirements for energy sector activities.

Since 2019, Lithuania has been applying the prosumption model, which allows electricity consumers to become producers. Residents or businesses can install solar power plants, use the electricity they generate, and transfer the surplus energy to the grid using a virtual storage service (National Energy Regulatory Council, VERT, 2022).

Another important document is the Environmental Protection and Climate Change Management Programme 2022-2030, which was approved by the Ministry of the Environment in 2022 and focuses on solar energy (Ministry of Environment, 2022).

The Agency is responsible for monitoring; it assesses whether solar power plant projects adhere to environmental standards and draws conclusions on their implementation. Finally, the APVA, which manages the funding for the projects, distributes the support. From 2024 onwards, all projects must meet the established criteria of being environmentally sound and operating in accordance with the law (Lithuanian Ministry of Energy, 2024).

In addition to energy issues, the development of solar power plants is closely linked to environmental law. Since 2012, important legislation has been adopted that requires developments to comply with the principles of Environmental Impact Assessment (EIA) (Law on Environmental Impact Assessment of the Republic of Lithuania). Larger projects, particularly those planned in protected areas such as national and regional parks, biosphere reserves, or Natura 2000 sites, are subject to the EIA procedure.

Major projects, particularly those planned in protected areas such as national and regional parks, biosphere reserves, or Natura 2000 sites, are subject to an EIA procedure. In its examination of the impact of proposed wind farms, the Environment Agency stated that projects in Natura 2000 sites cannot proceed without adequate evidence that the planned activity will not have significant adverse effects on the habitats and species of the protected areas (under Article 6(3) of the Habitats Directive)(Environmental Protection Agency, 2021).

2. Comparison of EU Requirements between Lithuania, Estonia, Latvia, and Poland

The development of renewable energy is closely linked to climate change mitigation goals. The European Union is committed to becoming a climate-neutral community, a goal supported by one of its major policy initiatives, the European Green Deal, launched in 2019 (European Commission, 2019). The document aims to achieve a climate-neutral energy sector by 2050 by reducing dependence on fossil fuels and increasing the production of renewable energy sources. A subsequent document, the REPowerEU plan, emphasises the need to accelerate the development of solar and other sources to at least double the EU's solar capacity by 2030 (European Commission, 2022).

Regulation (EU) 2018/842 obliges Member States to reduce their greenhouse gas emissions (European Parliament and Council, 2018), and Lithuania's legal framework is continually being adapted to these EU instruments. The EU establishes common climate and renewable energy development targets for all Member States, but each country adjusts these targets at the national level, according to its own baseline, economic structure, and technological potential. While the general orientations remain consistent, the practical commitments differ.

A primary reason for developing renewable energy is to reduce carbon dioxide (CO_2) emissions. In countries where a significant amount of energy is still generated from fossil fuels, these emissions remain elevated. The more coal or shale is utilised, the greater the proportion of emissions stemming from the energy sector.

A comparison of the 2030 targets for Lithuania, Estonia, Latvia, and Poland reveals significant differences (Invest in Estonia, 2022). The data is presented in Figure 1.

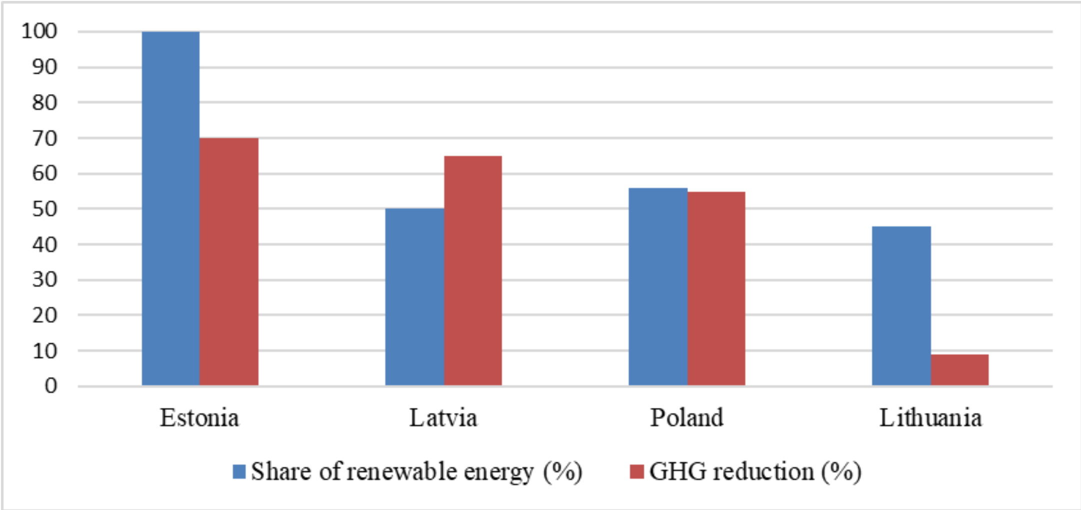

Figure 1. Renewable energy share and greenhouse gas emission reductions projected for Lithuania, Latvia, Estonia and Poland in 2030 (%). Source: Invest in Estonia, 2022; European Commission, 2020; Latvia's Ministry of Economics, 2020; Republic of Lithuania, 2020; Reuters, 2024.

Estonia has one of the most ambitious plans in the region, aiming for 100% of its electricity to come from renewable sources by 2030. Additionally, greenhouse gas (GHG) emissions are projected to be reduced by 70%, and potentially by as much as 80% by 2050, in comparison to 1990 levels (European Commission, 2020). Meanwhile, Latvia projects that by 2030 the share of renewable energy in final consumption will reach 50%, and the GHG reduction target is 65% compared to 1990 levels (Latvijas Ministry of Economics, 2020).

Poland's targets are somewhat more modest: although it remains one of the most coal-dependent countries in the EU, by 2030 as much as 56% of the country's electricity will come from renewable sources, and GHG emissions will have decreased by 55% (Reuters, 2024).

According to the approved national plans, Lithuania anticipates that the share of renewables in final energy consumption will reach 45% by 2030, while GHG emissions are expected to decrease by 9% compared to 2005 (Republic of Lithuania, 2020). Lithuania's National Energy Independence Strategy (2018) is aligned with EU direktives and outlines the following key objectives:

- Transition to renewables.
- Promoting decentralised generation (e.g. solar power plants for residents).
- Support and reduction of administrative barriers.

This demonstrates that Lithuania's national energy policy aligns with EU priorities and incorporates these objectives into its legislation and investment decisions. In Lithuania, as much as 70% of electricity in 2023 was generated from renewable sources – solar, wind, hydro (Ministry of Energy of the Republic of Lithuania, 2024). As a result, total CO_2 emissions are lower than in many other countries in the region. Decentralisation is increasing in Lithuania; however, the national power grid is approaching its capacity limits. While the quality of technology is improving (Solitek), historical projects still pose challenges.

\- Latvia faces slower development, a lack of information, and network limitations.

- Estonia has a progressive strategy aiming for 100% NPP by 2030; however, it faces challenges with the shale industry and requires investment.
- Poland has ambitious plans for 56% solar energy, but faces significant obstacles, including bureaucracy, a lack of certification, and infrastructure limitations.

Estonia continues to depend on shale, a highly polluting fuel type, resulting in high emissions (Ignitis Group, 2023). Meanwhile, Latvia harnesses a significant amount of bioenergy and hydropower; however, its overall electricity production is lower, generating approximately 4963 GWh in 2023, 30% of which comes from solar and wind (Verslo žinios, 2024). Poland remains reliant on coal for the majority of its electricity, ranking as one of the highest emitting countries in the EU. Although a transformation is planned, the process is progressing slowly (Confederation of Lithuanian Industrialists, 2024).

Statistics indicate that all four countries are aligned with EU policies; however, national targets differ significantly based on economic conditions, energy dependence, and technological capabilities. Estonia's plans are regarded as some of the most ambitious, whereas Poland encounters greater hurdles due to its reliance on coal-fired power plants. In summary, Lithuania and Latvia have already made strides towards a cleaner energy balance, Estonia is in a transitional phase, and Poland continues to grapple with significant challenges owing to the system's dependence on coal.

3. Legal framework for solar energy in Lithuania

An important change took place in 2012 when the pace of acquisition and installation of solar power plants in Lithuania began to increase rapidly. In that year, according to a report by the Ministry of Energy (Ministry of Energy of the Republic of Lithuania, 2013), approximately 15,000 applications for the installation of solar power plants were submitted, with a total capacity of about 500 MW (Ministry of Energy of the Republic of Lithuania, 2012). Most of these plants were small—up to 30 kW—and therefore small-scale producers were actively involved. This rapid expansion entailed certain risks: it was estimated that subsidies could cost around €145 million, which might impact electricity prices.

The Lithuanian Parliament responded to this situation by adopting amendments to the Renewable Energy Law in 2013 (Renewable Energy Law of the Republic of Lithuania, 2011, ed. 2013). Support tariffs for new projects were suspended, the permitting procedure was made stricter, and additional supervision was implemented. In the subsequent years, the law was enhanced with a section on generating consumers, facilitating residents and businesses in generating electricity for their own use.

After the changes in 2013, the market temporarily stabilised, but from 2018 onwards, solar power plants began to expand once more. The government introduced new support measures, including reimbursements for equipment purchases and streamlined procedures for both residents and businesses. This has facilitated the further development of decentralised generation.

The results of the study demonstrate that the legal framework directly influences the volume of investment and the selection of technological solutions. These developments in Lithuania have become particularly pronounced since 2012, when the legal and financial environment established by the state has encouraged both small and large investors to engage in the solar energy sector. The efficiency analysis also indicates a need to enhance technological solutions and foster innovation to achieve long-term sustainable development objectives. Moving forward, it is vital to ensure the coherence of legislation and the effectiveness of support mechanisms to facilitate the continued development of solar energy and contribute to climate change mitigation objectives.

4. Analysis of the Illumination in Lithuania

The efficiency of solar power plants is closely linked to the amount of solar radiation a location receives; the more sunshine per year, the more electricity can be generated. It is, therefore, essential to consider the variations in illumination (insolation) between countries and regions, as these have a direct impact on both the amount of electricity generated and the system's profitability.

According to the European Commission's Photovoltaic Geographical Information System (PVMIS), the average annual horizontal solar irradiance (GHI) in Lithuania and its neighbouring countries ranges from approximately 900 to approximately 1250 kWh/m² per year, depending on the location.

Table 1. Average Annual Global Horizontal Irradiance (GHI) in Lithuania and Neighbouring Countries According to the European Commission's PVMIS Data

Country / Region	Medium GHI (kWh/m² per year)	Comment
Lithuania (south - Alytus, Marijampolė)	~1120–1150	The largest lighting in Lithuania.
Lithuania (middle - Kaunas, Jonava)	~1080–1120	Very favourable area for solar power plants.
Lithuania (west - Klaipėda, Tauragė)	~1050–1100	Cloud cover may affect production.
Lithuania (north - Šiauliai, Panevėžys)	~1000–1050	Average illumination.
Lithuania (east - Vilnius, Utena)	~980–1020	Lowest illumination in Lithuania.
Latvia (medium)	~950–1100	Similar to northern and eastern Lithuania.
Country / Region	~900–1050	Lowest illuminance in the region.
Lithuania (south - Alytus, Marijampolė)	~1050–1150	Similar to southern Lithuania.
Lithuania (middle - Kaunas, Jonava)	~1150–1250	Best lighting in the region.

Source: based on European Commission, 2024.

The efficiency of solar energy in Lithuania is directly dependent on the insolation of the region—the average annual amount of solar radiation reaching a horizontal surface. The average global horizontal irradiance (GHI) in Lithuania ranges from approximately 900 to 1120 kWh/m² per year. Due to its geographical location, the Klaipėda region enjoys one of the highest insolation levels in the country.

According to the European Climate Initiative (ECI), the average annual GHI value in Klaipėda is approximately 1062 kWh/m², with even higher values on the south-west coast. This figure provides favourable conditions for the operation of solar power plants, resulting in greater efficiency, particularly in comparison to the eastern or northern regions of the country (EUKI, 2019).

Table 2. Average Annual Global Horizontal Irradiance (GHI) by City in Lithuania

City	Average GHI (kWh/m² per year)
Nida	1073
Klaipėda	1062
Kaunas	1058
Vilnius	990
Šiauliai	974

Source: European Climate Initiative (EUKI), 2019

From this data, we can conclude that the Klaipėda region is one of the most favourable areas in Lithuania for constructing solar power plants, both in terms of efficiency and payback.

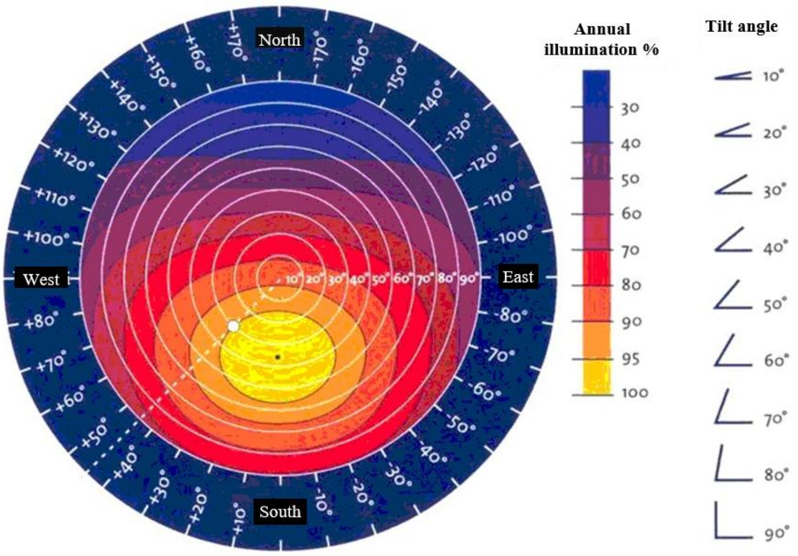

Figure 2. Optimal angle of inclination for solar modules
Source: European Climate Intiative (EUKI), 2019.

Figure 2 demonstrates that the highest efficiency is achieved with a 35° tilt angle and a south orientation. Tilting to the east or west reduces efficiency by approximately 5-10%, while a tilt of 15° further decreases it by an additional 10-12%.

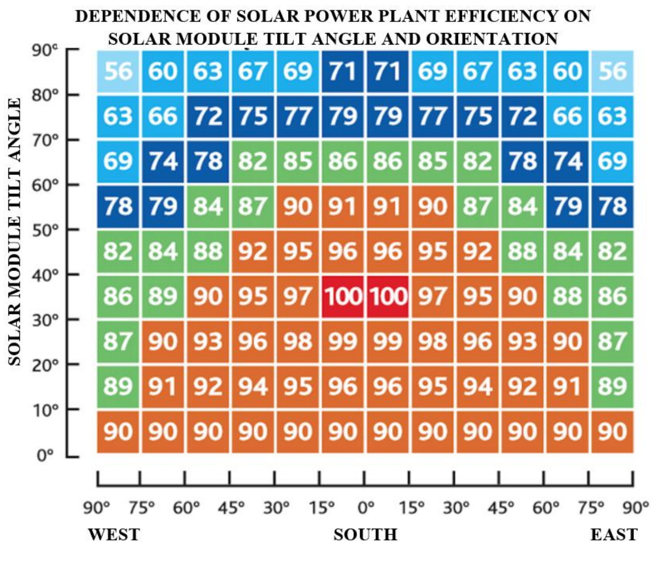

Figure 3. Effect of direction and angle on performance
Source: Zaliasvatas.lt, 2022

This colour scale illustrates the efficiency percentages at various angles. This enables designers to select the installation direction not only based on the roof's position but also considering the climate.

Solet		Azimuth												
		East						South						West
		90°	115°	140°	150°	160°	170°	180°	190°	200°	210°	220°	245°	270°
		-90	-65	-40	-30	-20	-10	0	+10	+20	+30	+40	+65	+90
Tilt (degrees)	0°	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%	82%
	10°	82%	85%	88%	89%	90%	90%	90%	90%	90%	89%	88%	85%	82%
	15°	81%	87%	91%	92%	93%	93%	93%	93%	93%	92%	90%	86%	81%
	20°	80%	87%	93%	94%	95%	96%	96%	96%	95%	94%	92%	87%	80%
	25°	79%	88%	94%	96%	97%	98%	98%	97%	96%	95%	93%	87%	78%
	30°	78%	88%	95%	97%	98%	99%	99%	99%	98%	96%	94%	86%	77%
	35°	77%	87%	95%	97%	99%	100%	100%	99%	98%	96%	94%	85%	74%
	40°	75%	86%	95%	97%	99%	100%	100%	99%	98%	96%	93%	83%	72%
	45°	73%	85%	94%	97%	98%	99%	100%	99%	98%	96%	94%	85%	74%
	50°	71%	83%	93%	96%	97%	98%	99%	98%	97%	94%	91%	82%	70%
	55°	69%	82%	91%	94%	96%	97%	97%	96%	95%	93%	90%	80%	67%
	60°	67%	79%	89%	92%	94%	95%	95%	94%	93%	90%	87%	77%	65%
	70°	61%	74%	83%	86%	88%	89%	89%	88%	87%	84%	81%	72%	60%
	80°	55%	67%	76%	78%	80%	81%	80%	80%	79%	76%	74%	65%	54%
	90°	48%	59%	67%	69%	70%	71%	70%	70%	69%	67%	65%	57%	48%

Figure 4. Realistic comparison of installation options
Source: Solet.lt, 2021

Several technical solutions are presented along with their paybacks. For instance, the vertical installation position (next to the fence) is up to 15-20% more efficient than the pitched roof installation. The graph illustrates that power plants of identical capacity can yield significantly different results depending on the installation orientation and angle.

4.1. Effect of temperature on PV module efficiency

Although sunlight is the primary source of energy for photovoltaic (PV) modules, the efficiency of these modules is also directly influenced by the ambient temperature. At elevated air temperatures, the properties of the semiconductors alter, resulting in a voltage drop across the modules. Consequently, at temperatures exceeding 25 °C (standard laboratory condition), the efficiency of most modules declines by approximately 0.3-0.5% for each additional degree (Green, M.A., et al., 2020).

This is particularly true in summer, when, despite the high solar content, the heat diminishes energy conversion efficiency. Consequently, in Lithuania, mid-summer energy production is not always at its peak – optimal results are often attained in spring or autumn, when solar radiation is adequate and air temperatures are cooler.

4.2. Issues and challenges in the development of solar power plants

Photovoltaic module technology directly influences the efficiency, durability, reliability, and even safety of solar power plants. Various manufacturing methods affect the cost of the modules, their resistance to environmental factors, operational failures, and fire hazards.

At present, monocrystalline silicon modules dominate the market in Lithuania, achieving efficiencies of 20-22%. They are characterised by a long lifespan and reliable performance at lower temperatures; however, their cost is higher (Parida, B., Iniyan, S. & Goic, R., 2011). Polycrystalline modules are more affordable (efficiency 15-17%) but necessitate a larger area (Green, M.A. et al., 2020). Thin-film technologies (e.g. CdTe, CIGS) are flexible and inexpensive, yet they exhibit efficiencies of only 10-13% and limited durability (Current Challenges in Operation, Performance, and Maintenance of Photovoltaic Panels, 2024). Table 3 presents a comparison of the main modules.

Table 3. Comparison of the efficiency, advantages and disadvantages of solar module types

Module type	Efficiency	Advantages	Disadvantages
Monocrystalline	20–22	High performance, long life, compact	High cost
Polycrystalline	15–17	Lower cost, easy production	Larger area, shorter lifetime
Thin film (CdTe, CIGS)	10–13	Flexible, lightweight, cheaper	Low efficiency, short lifetime, waste problem

Source: Adapted from Green, M.A. et al. (2020); Parida, B., Iniyan, S. & Goic, R. (2011); Current Challenges in Operation, Performance, and Maintenance of Photovoltaic Panels (2024).

Local manufacturers, such as Solitek, are gaining traction in the Lithuanian market by offering certified, high-quality solutions. However, it remains common for products of uncertain origin to be selected, which leads to operational problems and fire risks (Solitek, 2023). Suggestions include promoting higher quality modules, ensuring supervision certification, educating consumers, and linking support to quality criteria. The analysis indicates that to address the technological and operational challenges faced, it is imperative to enhance the technological solutions employed and to foster innovation. This approach would not only ensure greater efficiency for solar power plants but also contribute to long-term sustainable development objectives.

4.3. Technical and operational challenges related to the integration into the electricity network

Technical challenges pertain to the quality of installation, selection of equipment, maintenance, and the absence of diagnostic systems. Common hazards include:

- Risk of fire due to faulty components, improper connections, overheating (ScienceDirect, 2021);
- Reduction in efficiency resulting from environmental influences (shadows, snow, dust) (ResearchGate, 2021);
- Lack of maintenance - without it, modules can lose up to 20% of their efficiency within a few years (ResearchGate, 2024);
- Lack of monitoring systems - consumers are frequently unaware that the plant is not operating optimally (MDPI, 2024).

It is recommended that professional diagnostics are conducted at least once a year and that smart monitoring is incorporated into new projects.

4.4. Problems of integration into the electricity network

The growth of decentralised generation has highlighted the limitations of the network (ResearchGate, 2020):

- The variability of generation poses voltage and frequency balancing issues;
- Grids are unsuitable for low-power power plants, particularly in older areas;
- Some municipalities in Lithuania and Latvia face grid capacity limits, preventing new power plants from connecting without upgrades (European Commission, 2020);
- There are regulatory gaps, as support schemes emphasise installation rather than grid development (Reuters, 2024).

A comprehensive approach is necessary, involving grid modernisation, balancing algorithms, and clear regulations. Even the most sophisticated equipment will be ineffective without the requisite expertise:

- Unqualified installers elevate risks due to incorrect connections and weak fixings (Solitek, 2023);
- Failure to meet user expectations occurs when promising ‘100% payback’ but selecting the wrong equipment (ResearchGate, 2021).
- The confusion surrounding permitting and subsidy procedures in some municipalities hinders the process (Law on Renewable Energy of the Republic of Lithuania, 2011);
- Poland has very high bureaucratic barriers, while Estonia and Latvia lack centralised information (Latvia's Ministry of Economics, 2020).

The solution involves education, clearer rules, and digitisation. Technological progress does not resolve every issue; both technological and institutional compatibility are important. Efficient solar energy requires the selection of quality, certified modules, regular maintenance and diagnostics, adapting the grid to variable generation, consumer education, and transparent rules. Only an integrated approach will produce a reliable, safe, and sustainable system.

5. Practical significance

Even small differences in insulation (e.g. 100 kWh/m²/year) can significantly impact the amount of electricity generated. For instance, a 10kW solar plant in southern Poland can produce up to 1000-1500 kWh more per year than an identical system in northern Estonia. This directly leads to a quicker return on investment and higher efficiency.

There are also notable regional differences in Lithuania, with increased light levels in the southern and central areas of the country, which means that solar plants installed here demonstrate greater efficiency. In contrast, the northern and eastern regions can achieve satisfactory results with the right selection of module orientation, tilt angle, and maintenance.

Regional variations in illuminance are a crucial factor in the planning and assessment of solar power plant development. Although the average illuminance in Lithuania is lower than in southern Europe, it remains sufficient for efficient operation, especially when appropriate technological solutions are adopted. Different regions present varying potentials, making it essential to base the irradiance on both the siting of the plants and public support policies (European Commission. Photovoltaic Geographical Information System (PVGIS)).

6. Methodological analysis: challenges of grid integration and power quality

Network capacity is the amount of electricity that can be transmitted through the existing infrastructure without congestion. In regions of Lithuania, particularly where the infrastructure is outdated, the connection of additional solar power plants leads to generation exceeding consumption, which is why ESO imposes power constraints (ESO, 2023). In such situations, investments in modernising transformers, installing voltage regulators, and reinforcing the grid are necessary.

Table 4. Assessment of network status, capacity constraints and investment needs by region

Region	Network condition	Power restrictions	Investment demand
Western Lithuania	Good	Small	Low
North-Eastern Lithuania	Poor (old network)	Yes	High
Central Lithuania	Medium	Local restrictions	Medium

Source: Author’s compilation based on ESO (2023).

This leads to another problem: the distortion of the electrical signal during harmonic oscillations, particularly when using unsynchronised inverters. This disturbance results in several issues:
• potential damage to sensitive electronics;
• reduced overall transmission efficiency;
• possible noise or power failures.

This issue is not only relevant in the industry but also affects household networks. Therefore, it is crucial to select high-quality, certified inverters with low harmonic distortion (THD) values (Mohajerzami, S, 2017).

Lithuania: ESO requires certified inverters, and larger power plants must carry out an environmental impact assessment (Ministry of Environment of the Republic of Lithuania, 2022). Latvia and Estonia: these countries do not yet have comprehensive harmonic flow monitoring, but pilot projects are already underway to assess grid quality (Latvia's Ministry of Economics, 2020). Poland: in some cases, harmonic disturbances cause inverters to send incorrect data, preventing other consumer protection systems from functioning properly (Reuters, 2024). Both grid constraints and harmonic disturbances require a systematic approach: deploying smart monitoring and balancing equipment, improving grid connection legislation, prioritising certified equipment (e.g. inverters with low THD values), employing real-time data analytics for planning and maintenance, and enhancing installer certification. Only a coordinated combination of legal, technical, and consumer awareness can ensure reliable grid integration.

7. Solar energy efficiency in Lithuania and Klaipeda region

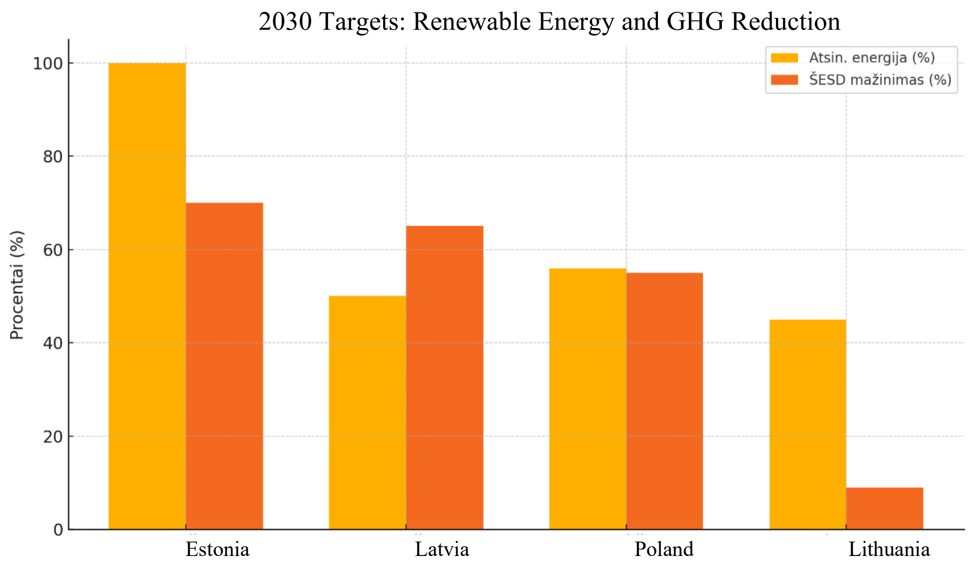

Figure 5. Four countries (Lithuania, Latvia, Estonia and Poland) 2030 targets: share of renewable energy and GHG emission reductions (%)
Source: European Commission (2020); Republic of Lithuania (2020); Latvian Ministry of Economics (2020); Reuters (2024).

Figure 5 illustrates the primary targets for these countries by 2030, specifically focusing on the share of renewable energy in final energy consumption or electricity generation, as well as the projected percentage of greenhouse gas (GHG) emission reductions. The reference years differ: Lithuania uses 2005 as a benchmark, while the other countries reference 1990. Consequently, the targets are not directly comparable but serve to indicate the general direction. Estonia distinguishes itself with its notably ambitious goal of producing 100% of its electricity from renewable sources.

Conclusions

1. It has been found that the legal framework since 2012, including the Renewable Energy Law and related support mechanisms, has had a significant impact on the development of solar power plants in Lithuania. The results of the study indicate that the legal framework directly influences the volume of investments and the selection of technological solutions. Consistency in legislation and the effectiveness of support mechanisms are crucial for sustainable development.
2. The potential of solar energy in the country is uneven, with the most favourable conditions for the construction of power plants found in the Klaipėda region, where the annual radiation reaches up to 1062 kWh/m2. The most effective tilt angle for installing photovoltaic modules under Lithuanian conditions is approximately 35° towards the south, which optimises annual electricity production.
3. The rapid growth of solar PV development has introduced risks associated with the need for subsidies and electricity price regulation, necessitating improved management of financing mechanisms. The efficiency analysis indicates the necessity to enhance the technological solutions employed and to foster innovation to achieve long-term sustainable development objectives and ensure higher efficiency of solar power plants. To attain long-term sustainability and efficient development of solar energy, it is essential to promote advanced technologies, develop decentralised electricity generation, and modernise the electricity grid.

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Gintaras Taurinskas, as a student in the Integrated Engineering degree programme, is improving his knowledge on the technological efficiency of solar power plants, their safety and their impact on power quality. He pays particular attention to sustainable development aspects, putting into practice scientific insights on potential fire hazards and mitigation methods in PV systems.

Dr. Gintvilė Šimkonienė is a researcher in renewable energy and energy system reliability, with a particular interest in the challenges of integrating distribution grids and solar power plants. Her analysis of fire risk in PV systems draws on recent international studies, such as Aram et al. (2021), which highlight the need to improve protection mechanisms and maintenance methods.

TEISINIO REGULIAVIMO IR TECHNOLOGINIO EFEKTYVUMO SĄVEIKA PLĖTOJANT SAULĖS ELEKTRINES

Santrauka

Straipsnyje nagrinėjama saulės elektrinių plėtros sąveika su teisiniu reguliavimu ir technologiniu efektyvumu. Analizuojant teisės aktus ir strateginius dokumentus nustatyta, kad nuo 2012 m. Lietuvoje įvyko svarbių pokyčių atsinaujinančios energijos skatinimo srityje. Aplinkos apsaugos ir energetikos teisės aktai paskatino spartų saulės elektrinių plėtros didėjimą, tačiau tuo pačiu paaiškėjo ir ekonominės bei socialinės rizikos.

Mokslinės literatūros ir teisinių dokumentų analizė parodė, kad teisinis reguliavimas tiesiogiai lemia investicijų apimtis ir technologinių sprendimų pasirinkimą. Taip pat nustatyta, jog efektyvumo analizė rodo būtinybę gerinti technologinius sprendimus ir skatinti inovacijas, kad būtų įgyvendinti ilgalaikiai tvarios plėtros tikslai.

Atlikta analizė parodė, kad ateityje svarbu užtikrinti teisės aktų nuoseklumą ir paramos mechanizmų efektyvumą, siekiant sudaryti palankias sąlygas tolesnei saulės energetikos plėtrai ir prisidėti prie klimato kaitos mažinimo tikslų.

Pagrindiniai žodžiai: saulės elektrinės, teisinis reglamentavimas