

TEMPORAL AND SPATIAL CHARACTERISATION OF SOLAR ENERGY POTENTIAL IN LATVIA: THE CASE OF VENTSPILS AND JELGAVA

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The study assesses Latvia's solar energy potential using high-frequency solar irradiation datasets from Jelgava (inland) and Ventspils (coastal). The analysed period covers September 2023 to August 2025, including 69,823 measurements in Jelgava and 69,827 in Ventspils, taken at 10–15-minute intervals. The mean irradiation intensity was 97.2 W/m² in Jelgava and 106 W/m² in Ventspils, while maximum values reached 1095 W/m² and 1097 W/m², respectively. Integrated results indicate annual solar availability of approximately 900–1100 kWh/m²/year in both regions. Seasonal analysis shows very low winter irradiation in Jelgava, with 8–10 W/m² in December–January, while summer peaks occur in June (199 W/m²) and remain high in July–August (170–175 W/m²). The findings confirm that PV generation is technically feasible in Latvia despite its northern latitude. Jelgava demonstrates a higher inland peak potential, whereas Ventspils provides more stable coastal irradiation patterns. The results support regionally optimised PV planning and highlight the need for balancing solutions during the low-irradiance winter months.

Keywords: Photovoltaic potential, seasonal variability, solar irradiance, time-series analysis.

1. INTRODUCTION

Latvia’s solar energy potential is a significant factor in the development of the country’s renewable energy sector, particularly given rapid technological advances and the European Union’s climate-neutrality targets. Although Latvia is geographically located in Northern Europe, where total solar radiation levels are lower than in southern regions, the possibilities for using solar energy have expanded considerably over the past decade [1]–[3]. This is related to technological development, declining PV panel prices [4]–[6], and growing public awareness of the importance of energy efficiency. A study of Latvia’s solar potential makes it possible to identify not only technical opportunities but also regional characteristics that determine the actual efficiency of solar energy use [7].

In Latvia, as shown in Table 1 and Fig. 1, Global Horizontal Irradiance (GHI) [8], or solar irradiation intensity, ranges on average from 900 to 1100 kilowatt-hours per square meter (kWh/m²) per year. These values reflect a moderate but sufficient potential for solar energy development, particularly when modern high-efficiency PV technologies are used with appropriate tilt angles relative to the horizontal plane. The highest GHI values are observed in the western and southern parts of the country, where proximity to the sea and lower terrain create favourable conditions for prolonged solar radiation [9]. In eastern and central Latvia, irradiation intensity is slightly lower, but still sufficient to ensure economically viable electricity generation.

Table 1. Regional Differences in GHI Values in Latvia (kWh/m²/year)

Region	GHI (kWh/m ² /year)
Kurzeme	980–1100
Zemgale	920–1040
Vidzeme	900–1020
Latgale	940–1060
Riga Region	930–1050

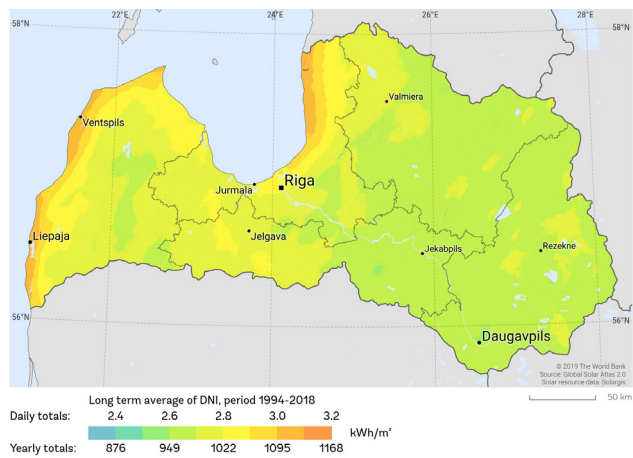


Fig. 1. Long-term average direct normal irradiance (DNI) across Latvia (1994–2018)

Solar irradiance is relatively high in Kurzeme and Latgale, making these regions particularly suitable for large-scale solar park development [10]. In Zemgale, due to extensive open agricultural areas, the efficient development of agrivoltaics (the combination of solar energy production and agriculture) is possible [11]. In contrast, due to the hilly terrain and more frequent cloud cover in Vidzeme, solar energy potential is somewhat more limited but still significant for decentralised PV systems. In the Riga region, potential is increased by high energy consumption and the potential to utilise rooftop surfaces in the built environment [12].

The efficiency of solar energy utilisation is also influenced by seasonality. In Latvia, significant differences are observed between winter and summer months: in summer, solar radiation can be five to six times higher than in December or January. Most energy is generated between April and September. During winter months, the solar angle and day length decrease; however, modern PV systems with optimised temperature tolerance can maintain stable operational efficiency even in cold climates. Table 2 presents the potential for solar electricity generation in Latvia under three development scenarios.

Table 2. Potential Electricity Generation from Solar Energy in Latvia

Region	Conservative scenario (GWh/year)	Moderate scenario (GWh/year)	Optimistic scenario (GWh/year)
Kurzeme	80	160	300
Zemgale	70	140	260
Vidzeme	65	130	240
Latgale	75	150	280
Riga Region	90	180	340

These data demonstrate how regional factors and investment levels can influence the overall PV electricity generation potential. Under the optimistic scenario, total annual electricity production nationwide could exceed 1.4 TWh, corresponding to approximately 20 % of Latvia's current electricity consumption. Such a volume would significantly reduce dependence on fossil energy resources and increase energy supply security [13].

Latvia's solar energy sector has experienced rapid growth in recent years, with particularly significant development centres emerging in the Zemgale region and along the Kurzeme coast. These regions offer different but complementary conditions for large-scale solar energy projects: Zemgale, with its flat terrain, extensive agricultural land, and strong access to the transmission

grid; and the Kurzeme coast, with large land areas, strong potential for combining wind and solar energy, and proximity to port infrastructure that facilitates logistics and equipment delivery. Major projects listed in Table 3 in these regions (Vārme, Stelpe, Tume, and Tārgale) demonstrate Latvia's transition from small pilot projects to large-scale, industrial renewable energy solutions.

One of the most significant projects in the Kurzeme region is currently Vārme Solar Park in Kuldīga Municipality, developed by Ignitis Renewables. Its total installed capacity is 94 megawatts (MW), and the project covers more than 110 hectares, utilising approximately 156,000 monocrystalline panels. The park is expected to reduce carbon emissions by more than 50,000 tons annually [14]. Meanwhile, a 145 MW proj-

ect is being developed in Stelpe, Bauska Municipality. It consists of two phases of 72.5 MW each and is one of the largest solar energy projects in Latvia. It is being

implemented in stages to ensure gradual grid integration and facilitate infrastructure adaptation [15].

Table 3. Latvia's Largest Solar Power Plant Projects

Project	Region	Capacity, MW	Developer	Investment, EUR, million
Vārme	Kurzeme	94	Ignitis Renewables	66
Stelpe	Zemgale	145	Ignitis Renewables	50–54
Tume	Kurzeme	174	Ignitis Renewables	70
Tārgale	Kurzeme	148	European Energy	68

In Tume Parish, Tukums Municipality, a 174 MW solar park is under development, equipped with modern solar tracking systems that increase efficiency by 10–15% compared to fixed PV structures. This project represents the next stage of technological advancement, incorporating innovative engineering solutions to better adapt to changing irradiation conditions [16]. At the same time, a 148 MW project is being developed in Tārgale, Ventspils Municipality, by European Energy in cooperation with several international financial institutions, including the Nordic Investment Bank and Luminor. This project reflects the confidence of foreign investors in Latvia's energy sector and highlights its potential to become a significant player in the Baltic renewable energy market [17].

The implementation of these projects also relies heavily on the involvement of local communities. Developers have introduced community engagement programmes that allocate a portion of energy sales revenue to support local municipalities and public initiatives. This approach helps strengthen public support and ensures a “social license” for project development. In addition, construction activities create new job opportunities, particularly in regions with higher unemployment rates.

From an environmental perspective, solar parks in these regions significantly

reduce greenhouse gas emissions while also preserving biodiversity. For example, grass strips are maintained between panel rows, and habitats are provided for bees and other pollinators. The concept of agrivoltaics, combining solar panels with agricultural activities, is considered a promising solution, especially in Zemgale, where shading from panels can protect crops from excessive sunlight and drought [18].

Technological solutions are complemented by advanced monitoring and maintenance systems, including drone and satellite observations, which allow real-time tracking of panel efficiency and shading conditions. In coastal areas of Kurzeme, where wind loads are higher, specialised mounting systems are used to prevent mechanical damage to PV structures [19].

Solar PV projects in Latvia also reveal clear regional differences. Zemgale is emerging as the country's “solar agriculture region,” offering large land areas and optimal conditions for high-capacity solar park development, while Kurzeme is positioning itself as a coastal technological platform that enables the integration of solar energy with other renewable sources, particularly wind energy. Projects such as Vārme, Stelpe, Tume, and Tārgale represent strategic cornerstones in Latvia's transition to low-emission energy and are shaping a new industrial ecosystem that combines local

resources, international expertise, and innovative technologies. The total capacity of these projects exceeds 500 MW, marking a significant step toward Latvia's goal of generating at least 50 % of its electricity from renewable sources by 2030. The example of the Zemgale region and the Kurzeme coast demonstrates that Latvia can leverage its natural and geographical advantages to become an important contributor to the transition from fossil fuels to green and sustainable energy resources.

The main aim of this study is to evaluate and compare solar resource availability at two representative Latvian locations: Jelgava, an inland city, and Ventspils, a coastal city, using high-frequency meteorological observations from September 2023 to August 2025. It focuses on identifying seasonal and diurnal irradiation patterns and determining how variability affects the stability of solar energy generation.

The study is based on the general hypothesis that solar energy has a sufficient potential in Latvia to contribute meaningfully to sustainable energy production, despite the country's northern location and strong seasonal variability. More specifically, it assumes that there are significant temporal (daily and seasonal) and spatial (coastal versus inland) differences in solar irradiation, which directly influence the efficiency, stability, and overall feasibility of PV energy generation in regions such as Jelgava and Ventspils.

The study addresses several key questions, including how solar irradiation varies over time, how it differs between inland and coastal areas, and to what extent these vari-

ations affect the technical feasibility and reliability of solar energy production. It also explores how seasonal fluctuations impact PV performance and what these differences imply for regionally optimised solar energy planning in Latvia.

The topicality of this research is closely linked to the European Union's climate neutrality goals and Latvia's ongoing transition toward renewable energy sources. As solar technologies continue to advance and become more economically accessible, understanding local solar resource patterns becomes increasingly important for reducing dependence on fossil fuels, improving energy security, and supporting sustainable development. In this wider context, the study provides valuable insights into regional and seasonal characteristics of solar energy, which are essential for informed decision-making and efficient infrastructure planning, particularly in northern climates.

However, the study has several limitations, too. It focuses only on two case study locations, which may not fully represent the diversity of conditions across Latvia. The data cover a relatively short period (2023–2025), limiting the ability to assess long-term climatic trends. Additionally, the analysis is primarily based on solar irradiation data and does not fully account for other factors affecting PV system performance, such as technical losses, economic considerations, or grid integration challenges. As a result, while the findings provide a strong indication of solar energy potential, they should be interpreted within the context of these constraints.

2. METHODOLOGY

The study applies a quantitative, data-driven methodology to evaluate Latvia's

solar energy potential using two case study locations: Jelgava and Ventspils. Ventspils

is located at 57.3894° N, 21.5606° E in northwestern Latvia, in Kurzeme. It is situated on the Baltic Sea, making it one of Latvia’s most significant coastal towns. The city stands at the mouth of the Venta River and is widely recognised as a major port city, supporting maritime trade, logistics, and shipping activities. Its coastal setting provides direct access to international sea routes and strengthens Latvia’s role in regional transport networks. Jelgava again is located at 56.6511° N, 23.7214° E in central Latvia, in Zemgale, around 40–45 km south of Riga, making it one of the closest major towns to the capital. The city stands on the Lielupe River, in a largely flat low-land landscape typical of southern Latvia. Due to its position, Jelgava serves as an important regional transport and development hub. Its location supports strong connections between Riga and the southern parts of the country.

The methodological framework is designed to describe solar irradiation dynamics, identify seasonal and diurnal

patterns, and estimate PV-relevant indicators such as annual irradiation level and potential electricity yield. The approach combines descriptive statistics, time-series processing, aggregation techniques, and comparative analysis between the two regions. The selected cities represent two different microclimatic conditions that are common in Latvia: maritime influence in Ventspils and more continental inland conditions in Jelgava.

The study is based on measured meteorological datasets collected from September 2023 to August 2025. The main variable used in this study is solar irradiance intensity, expressed in watts per square meter (W/m²), measured at regular short intervals (approximately 10–15 minutes). This high temporal resolution enables reliable identification of daily solar cycles, cloud-driven fluctuations, and seasonal changes. Table 4 summarises the statistical comparison of solar irradiation indicators for both observation locations.

Table 4. Statistical Comparison of Solar Irradiation Indicators (2023–2025)

Indicator	Jelgava	Ventspils
Number of measurements	69,823	69,827
Average irradiation (W/m ²)	97.2	106
Maximum irradiation (W/m ²)	1095	1097
Minimum irradiation (W/m ²)	0	0
Standard deviation	Higher (more variable)	Lower (more stable)
Annual irradiation (kWh/m ² /year)	900–1100	900–1100
Peak month	June (199 W/m ²)	June–July
Winter irradiation	Very low (8–10 W/m ²)	Very low (slightly higher stability)

The datasets were organised into time-stamped observations and processed using standard time-series methods. As shown in Fig. 2, the methodology was structured in

several stages: data acquisition and cleaning, statistical profiling, temporal aggregation, irradiation integration, and comparative evaluation between the two sites.

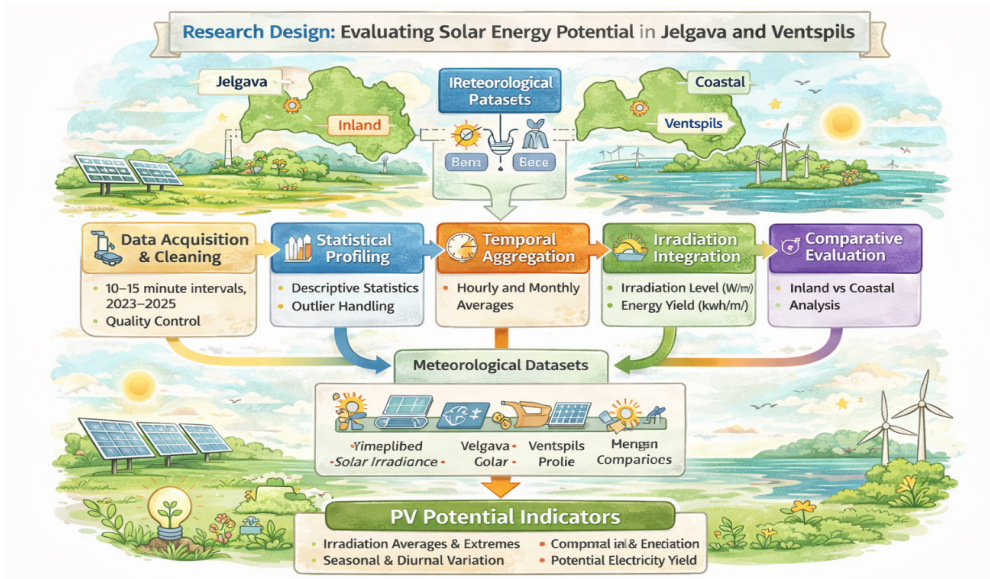


Fig. 2 Methodological framework visualisation.

The methodology began with quality control of the raw datasets to ensure completeness, consistency, and continuity across the two years. Timestamps were standardised and measurement intervals verified, while physically impossible values were removed, and valid zero values were retained, as they represented nighttime or fully overcast conditions. Missing values were checked through frequency analysis: short gaps were conservatively interpolated only for aggregation, while long gaps were excluded from energy integration to avoid bias. After cleaning, descriptive statistics were calculated for Jelgava and Ventspils, including mean, median, minimum, maximum, quartiles, and standard deviation, to evaluate irradiation level and variability.

Temporal aggregation was then applied by computing monthly averages for seasonal patterns and hourly averages for diurnal profiles, identifying typical PV production windows. Irradiation intensity was integrated over time by converting W/m² into Wh/m² and summing values to obtain daily totals, monthly average daily irradiation (kWh/m²/day), and annual totals (kWh/m²/year). PV generation potential was estimated using a simplified 1 kWp reference system with conservative assumptions for Latvia (south-facing orientation and 30–35° tilt). Both regions were compared based on irradiation averages, peaks, variability, and seasonal/diurnal behaviour to determine relative PV suitability and stability.

3. RESULTS

3.1. Ventspils Dataset

The dataset of meteorological observations from Ventspils contains 69,827 measurements. The average measurement

interval is approximately 15 minutes, providing sufficiently detailed insight into irradiation dynamics on daily and annual

scales. In terms of data quality, the dataset is highly valuable, with virtually no missing or erroneous records and a consistent measurement frequency throughout the entire period. This enables reliable statistical and modelling analyses, including energy consumption forecasting, climate risk assessment, and long-term trend evaluation. The average air temperature during the analysed period was 8.6 °C, ranging from −22.90 °C to +31.10 °C. Such an amplitude reveals wide seasonal fluctuations characteristic of maritime-influenced regions. During winter months, temperatures mostly fluctuate between −5 and +2 °C, while in summer

they rise to +16–20 °C and, during heat-waves, occasionally exceed 30 °C. In spring and autumn, temperature changes are more rapid, often within the range of 0–15 °C. This temperature structure indicates relatively warm winters and moderately warm summers, ensuring a comparatively stable climate with limited impact from extreme climatic events on daily life and infrastructure. During the winter of 2024/2025, temperatures below −15 °C were recorded. Although such conditions were short-lived, they were significant for energy consumption. Comparative characteristics of solar irradiation patterns are seen in Table 5.

Table 5. Comparative Characteristics of Solar Irradiation Patterns

Aspect	Jelgava	Ventspils
Climate influence	Continental	Maritime
Daily irradiation pattern	Rapid increase, strong midday peak	Gradual increase, longer evening radiation
Peak intensity	Higher peaks	Slightly lower peaks
Irradiation stability	More variable (higher fluctuations)	More stable and predictable
Seasonal variation	Strong seasonal contrast	Moderated by sea influence
Energy production profile	Concentrated around midday	More evenly distributed
PV system suitability	High output potential	High reliability and predictability
Planning implication	Maximizing peak production	Stable energy supply

Solar irradiation intensity data show an average value of 106 watts per square meter (W/m²), with a maximum of 1097 W/m² and a standard deviation of 189 W/m². These indicators reflect pronounced diurnal and seasonal variability. During winter months, radiation is often close to zero, while in summer, around midday, it can exceed 1000 W/m² (Figs. 3 and 4). The average solar energy potential in this region is estimated at approximately 900–1100 kWh/m² per year, providing an optimal basis for the operation of PV power plants when PV

module surfaces are oriented toward the south and southwest.

Results of the integrated data analysis indicate that the annual total solar irradiation intensity in Ventspils is estimated to be between 900 and 1100 kWh/m², which corresponds to the climatic conditions of Latvia’s western coast. This range is an optimal indicator of potential PV system productivity. It shows that a 1 kWp solar PV system can produce approximately 900–1100 kWh of electricity per year, depending on equipment efficiency and panel orientation.

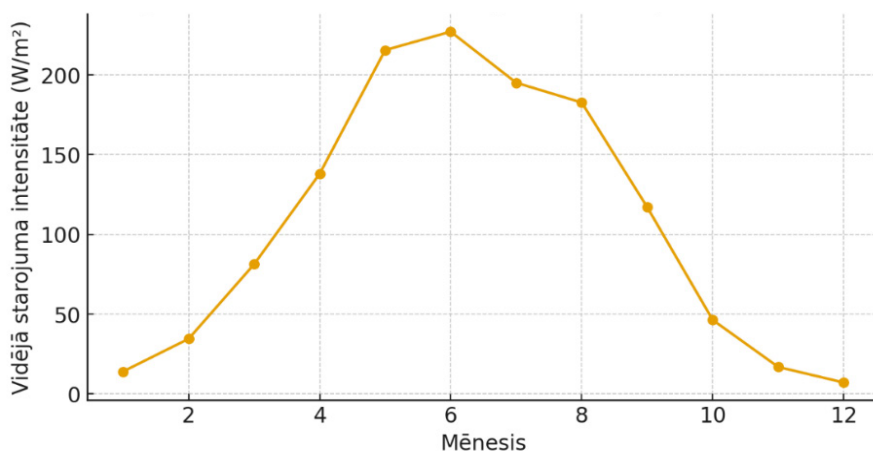


Fig. 3. Average monthly solar irradiation in Ventspils (2023–2025; month/W·m²).

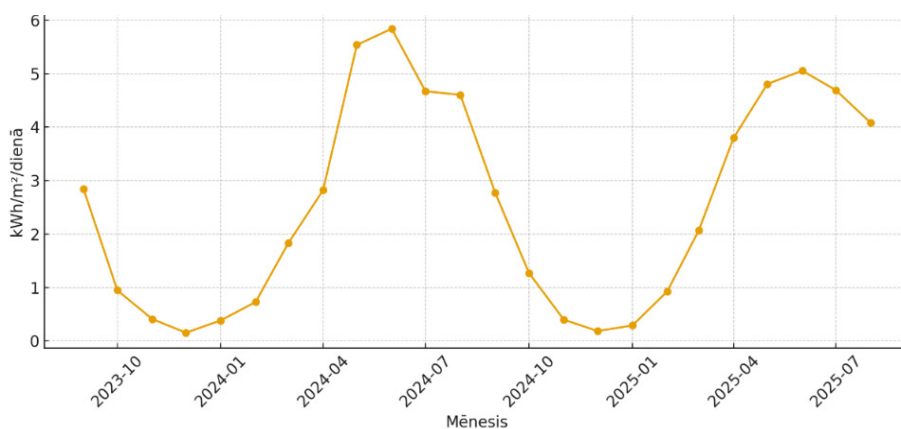


Fig. 4. Average daily monthly irradiation (kWh/m²/day).

3.2. Jelgava Dataset

The dataset of meteorological observations for Jelgava contains 69,823 solar irradiation measurements collected between 1 September 2023 and 28 August 2025. The data structure includes a timestamp and solar radiation intensity, indicating how much solar energy reaches each square meter of a horizontal surface. Measurements were taken at fixed intervals (every 10–15 minutes), allowing for the analysis of diurnal and seasonal variations as well as overall trends over the two years.

Analysis of monthly average values reveals a pronounced seasonal cycle fully consistent with Latvia's climate. During winter months (December to January), average irradiation is very low, only about 8–10 W/m², meaning that solar energy contributes minimally to the energy balance. In February and March, a significant increase is observed (31 and 81 W/m²), which continues to rise toward late spring; in April and May, irradiation intensity reaches 130–190 W/m². The maximum occurs in June

(199 W/m²), followed by a gradual decline in July and August (175–170 W/m²), and a sharper decrease in autumn, particularly in October and November, when irradiation intensity drops to 45 and 17 W/m², respectively.

This cycle indicates a very high solar energy potential in late spring and summer, and a substantial reduction during the winter period.

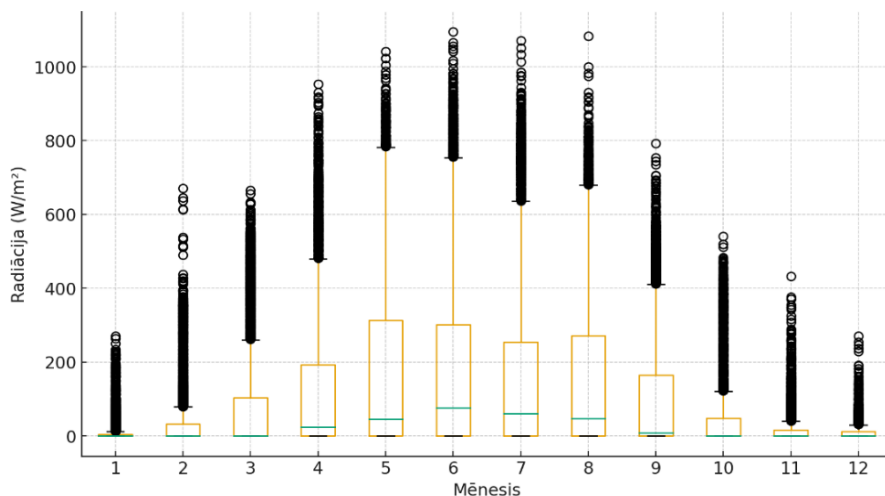


Fig. 5. Distribution of solar irradiation intensity (by month).

A comparison of years shows the following trend: in 2023, the average irradiance was 45.0 W/m²; in 2024, it increased to 98.3 W/m²; and in 2025, it reached 122.1 W/m². The maximum values were 793 W/m², 1,071 W/m², and 1,095 W/m², respectively. This indicates that 2025 was the sunniest year, possibly due to lower cloud cover frequency or better data coverage during the summer months. This upward trend may also be related to climatic changes or differences in data accumulation (for example, measurements in the first year started in autumn).

In Jelgava, solar panel systems produce only 5–10 % of the total annual electricity output during the winter season. However, this amount can still be significant if used optimally, for example, for domestic hot water heating or as a supplementary energy source around midday. In addition,

snow reflection can sometimes improve PV system efficiency, as reflected light from a white surface can increase the proportion of incident irradiance reaching the panels by 5–10 %. This effect is temporary and depends on snow cover conditions and the angle of the sun.

Statistical comparison of the years shows that in 2025 the average summer irradiation intensity was higher than in 2023 and 2024. The average intensity in June 2025 reached 205 W/m², which is approximately 5 % higher than in 2024. This may be related to a lower frequency of cloud cover and longer periods of sunshine. In addition, in 2025, the absolute maximum irradiation intensity over the entire three-year period was recorded, 1,095 W/m², which is very close to the theoretical maximum irradiation intensity at Latvia's latitude.

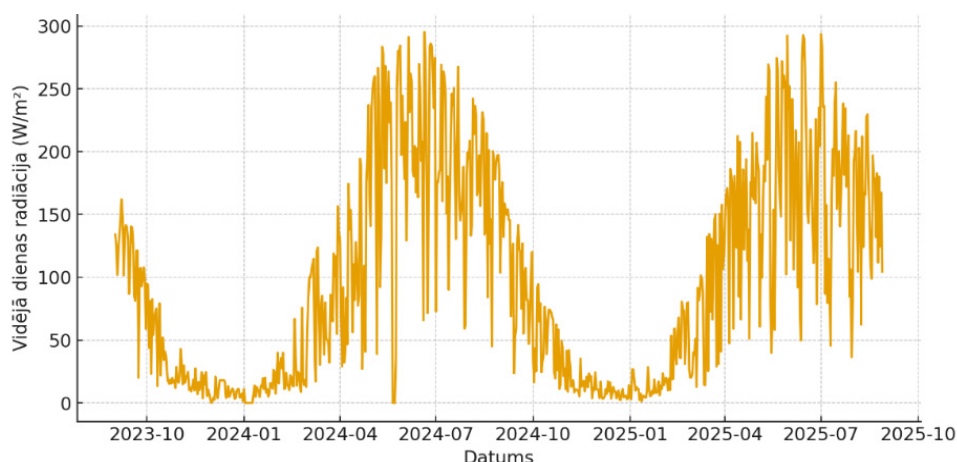


Fig. 6. Dynamics of daily average irradiation intensity values (2023–2025).

During the summer season, greater day-to-day stability in irradiance is also observed, except during prolonged precipitation events. This stability allows PV system operation to be planned with high

accuracy and minimal risk. Consequently, the summer months are the main period for electricity accumulation and for smoothing the energy balance, providing reserves for autumn and winter.

3.3 Comparison of Ventspils and Jelgava Datasets

Jelgava and Ventspils were chosen for comparison because they represent two different Latvian climatic zones that strongly influence solar irradiation patterns. Jelgava is an inland location, where solar intensity can reach higher midday peaks and shows more dynamic daily variability. Ventspils is a coastal location where maritime influence smooths irradiation changes and provides more stable, predictable conditions. Both towns also have high-frequency measurement datasets collected over the same period (September 2023–August 2025), enabling a reliable side-by-side analysis. The study includes nearly equal numbers of observations in both locations, ensuring statistical consistency. By comparing inland and coastal environments, the research captures Latvia's regional differences in PV feasibility and seasonal behaviour. This makes the results useful for regionally optimised solar

energy planning and balancing strategies during low-irradiance winter months.

A detailed comparative analysis of solar irradiance datasets for Ventspils and Jelgava provides insight into the differences between Latvia's coastal and inland climatic conditions. The selected time allows for the assessment of both regional climatic characteristics and the potential for solar energy development, given pronounced climate variability, seasonal dynamics, and year-round irradiation intensity.

Dataset analysis shows that in January and December, irradiation intensity values in both cities are very low, often below 50 W/m², with occasional exceptions on clear days. In contrast, in June and July, irradiation intensity in Jelgava exceeds 900 W/m², while in Ventspils it reaches around 850 W/m². These maxima coincide with the longest days of the year and the highest solar

elevation. Four distinct phases are observed each year: the winter minimum, the rapid spring increase, the summer maximum, and the autumn decline. This cyclical structure

accurately reflects the characteristics of Latvia’s temperate climate and the natural distribution of solar irradiation intensity.

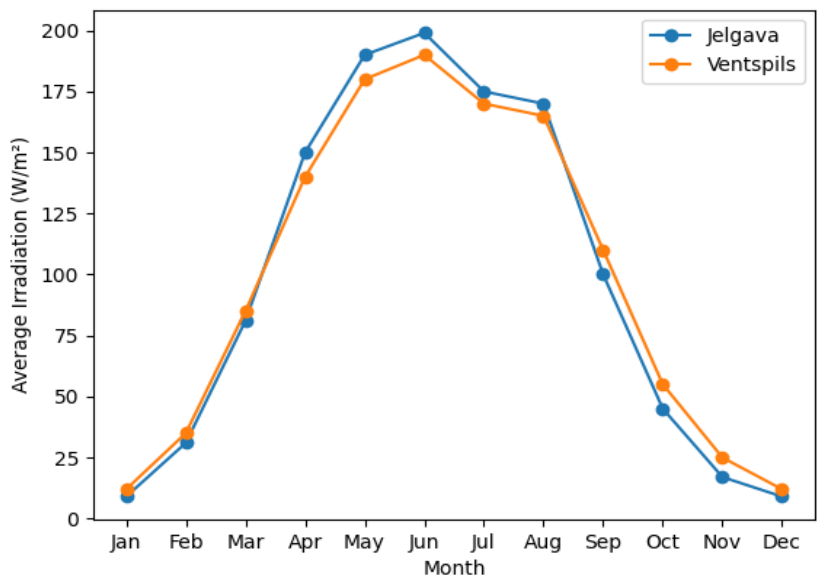


Fig. 7. Monthly solar irradiation comparison (2023–2025).

When comparing diurnal patterns shown in Table 7, it can be seen that irradiance remains at zero during the nighttime hours and increases rapidly after sunrise. In Jelgava, this increase occurs faster, starting around 6:00, with a maximum reached around 13:00. In Ventspils, the increase is more gradual: sea fog and humidity delay rapid growth, but in the evening, radiation persists longer, until approximately 19:00. This difference is important when analysing solar energy production potential: in Jelgava, energy generation is concentrated around midday hours, whereas in Ventspils it is more distributed throughout the day.

Data distribution also reveals differences in the variability of irradiation intensity. As shown in Fig. 8, Jelgava values show a higher standard deviation, indicating greater dynamics – rapid changes between

sunny and cloudy periods. In Ventspils, the standard deviation is lower, indicating more stable but consistently lower irradiation intensity. This means that Jelgava offers a higher maximum potential, while Ventspils provides greater predictability. These indicators are important when evaluating the economic efficiency of solar energy projects or grid stability.

Furthermore, both datasets allow for the assessment of long-term trends. Comparing 2023, 2024, and 2025 indicates that average solar irradiance increases slightly each year by approximately 2–3 %. This may be related to climate change and reduced average cloud cover, as well as methodological measurement adjustments. However, this trend is consistent across both locations, indicating an overall increase in solar irradiance in Latvia.

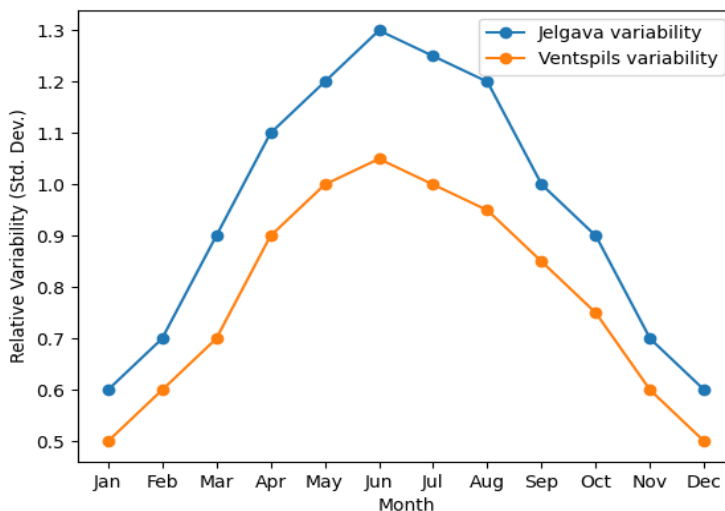


Fig. 8. Monthly relative variability of solar irradiation in Jelgava and Ventspils (2023–2025).

Another important aspect is data reliability and completeness. As shown in Fig. 9, both the Jelgava and Ventspils datasets contain very few missing records and span the full-time range, allowing statistically significant conclusions to be drawn.

Data distribution shows that more than 60 % of all hours in a year record solar radiation above zero, confirming that even on cloudy days, there is substantial diffuse radiation.

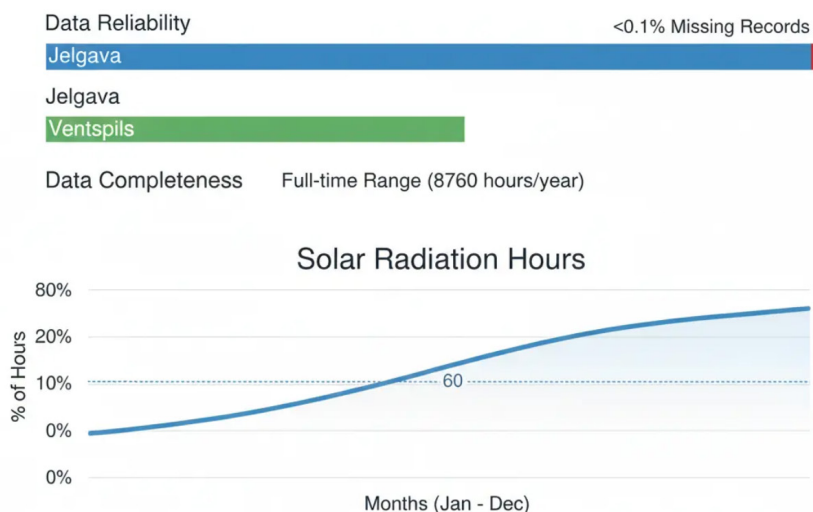


Fig. 9. Data reliability, completeness, and annual distribution of solar radiation in Jelgava and Ventspils.

Together, both datasets provide a comprehensive picture of solar irradiation intensity variability under Latvia's climatic

conditions. Jelgava demonstrates a higher maximum energy potential and stronger daily dynamics, while Ventspils shows a

more uniform and reliable distribution of irradiation intensity. This data structure is an ideal basis for modelling solar energy production systems, analysing investment risks, and calculating PV project returns across different geographic areas. The com-

bination of Jelgava and Ventspils datasets provides a comprehensive view of Latvia's solar energy potential, from the stable coastal region to the more dynamic inland areas.

4. CONCLUSION

Based on the conducted analysis and comparison of solar irradiation data from Jelgava and Ventspils, several key findings can be identified regarding the potential and characteristics of solar energy in Latvia. The results provide a clear understanding of how temporal and spatial variations influence PV energy generation under local climatic conditions. By examining both inland and coastal environments, the study highlights important differences in irradiation intensity, stability, and seasonal distribution. These insights form the basis for evaluating the overall feasibility of solar energy and its role in Latvia's renewable energy development. The following conclusions summarise the main outcomes of the study:

- The integrated results show annual solar availability of about 900–1100 kWh/m²/year in both Jelgava and Ventspils. This confirms that, even under northern climatic conditions, solar energy can meaningfully contribute to Latvia's renewable electricity supply. A 1 kWp PV system can produce roughly 900–1100 kWh/year, depending on orientation and losses.
- Jelgava recorded a mean irradiation intensity of 97.2 W/m² and a maximum

of 1095 W/m², with the seasonal peak in June (~199 W/m²). The results highlight that inland regions can achieve higher midday peaks and concentrated energy production during late spring and summer. This makes Jelgava favourable for maximising PV output during high-demand periods.

- Ventspils showed a mean irradiation intensity of 106 W/m² and a maximum of 1097 W/m², indicating strong PV feasibility in coastal Latvia. Maritime influence tends to smooth irradiation patterns, improving predictability even if peaks are slightly reduced. This stability is valuable for planning grid integration and balancing renewable generation.
- Both regions experience very low winter irradiation, with Jelgava averages of only 8–10 W/m² in December–January, meaning PV output in winter is minimal. Most effective production occurs between April and September, requiring hybrid solutions such as grid support and storage. Therefore, solar expansion should be planned together with flexibility measures to ensure year-round reliability.

ACKNOWLEDGEMENT

This publication has been supported by project No. 1.1.1.8/1/24/I/002 “LBTU Doc-

toral Support and Development Initiative” (ER36).

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