Techno-Economic Analysis of PV Prosumer Profitability Under Croatia's Evolving Net Billing Scheme

Joško Novaković
Department for Power Engineering
FESB
Split, Croatia
jnovak01@fesb.hr

Damir Jakus
Department for Power Engineering
FESB
Split, Croatia
damir.jakus@fesb.hr

Josip Vasilj
Department for Power Engineering
FESB
Split, Croatia
jvasilj@fesb.hr

Danijel Jolevski
Department for Power Engineering
FESB
Split, Croatia
djolevski@fesb.hr

***Abstract*—This paper presents a comprehensive techno-economic calculator for evaluating residential photovoltaic (PV) system profitability in Croatia under two distinct regulatory frameworks: the legacy monthly net-metering scheme and the new 15-minute interval net-billing scheme mandated by the 2025 amendments to the Act on Renewable Energy Sources and High-Efficiency Cogeneration. The transition from monthly aggregation to sub-hourly settlement fundamentally alters the economic value of self-generated solar energy by requiring near-instantaneous matching of generation and consumption. Using high-resolution time-series modeling coupled with standard financial metrics —Net Present Value (NPV) and payback period— we quantify the profitability impact across realistic residential load profiles and Croatian-specific tariff structures. Results demonstrate that 15-minute settlement reduces NPV and extends payback periods compared to monthly net-metering, with the magnitude depending on self-consumption ratios, system sizing, and tariff parameters. For a representative 4.5 kW residential installation, the payback period increases from approximately 6 years under monthly net-metering to 12 years under 15-minute net-billing. The calculator provides transparent, reproducible decision support for Croatian prosumers navigating this regulatory transition and contributes methodological insights applicable to similar policy shifts across European Union member states.**

***Keywords*—Solar power, net metering, net billing, techno-economic analysis, photovoltaic profitability**

I. Introduction

The economics of residential photovoltaic installations depend on both technology price/performance and retail settlement design, and Croatia is now a clear case where regulatory architecture directly reshapes project outcomes [1]. The number of photovoltaic installations in Croatia increased from 3,757 at the end of 2021 to 38,947 at the end of 2025, with total installed PV power rising to just over 1.1 GW [2]. Around 75% of those are residential PV installations with an average installed power of 7.6 kW. Rapid household PV adoption under a favorable net-metering scheme has been followed by reforms that align compensation with market-oriented transactions and network cost signals [3].

Net metering schemes, which allow prosumers to offset their electricity consumption with self-generated solar energy, have been instrumental in driving PV adoption across Europe and worldwide [4], [5]. However, the economic viability of these investments is highly sensitive to the specific design of net metering policies, particularly the temporal granularity at which energy exchanges with the grid are settled [6], [7]. The transition from monthly netting to 15-minute settlement is therefore a structural market redesign rather than a marginal tariff update [8].

New amendments to the Act on Renewable Energy Sources and High-Efficiency Cogeneration [3] adopted in 2025 introduce a new prosumer billing scheme, replacing net metering with net billing. Net billing is applied to all new residential PV installations in Croatia starting from January 2026, while prosumers with existing PV plants keep the more favorable net-metering scheme for another 10 years. Under monthly net metering, households effectively used the grid as a virtual monthly storage mechanism, allowing daytime surpluses to offset later consumption with limited temporal penalty [9]. In contrast, interval-based net billing values imports and exports differently at fine granularity, introducing a persistent spread between buying and selling electricity and reducing the private value of exported PV energy. This shift elevates load timing, controllable demand, and storage-assisted self-consumption as primary profitability drivers [10].

The broader literature supports this transition narrative: compensation design is repeatedly shown to influence payback strongly as hardware costs and efficiency mature in PV markets [11].Energy balance alone is no longer sufficient for bankable feasibility analysis [12]. As export remuneration falls relative to retail import prices, digital simulation tools and flexible operation strategies become central to practical investment decisions [13]. Empirical evidence from Croatian case studies confirms that 15-minute net-metering produces less profitable outcomes and longer investment return periods compared to monthly aggregation [7].

Against this backdrop, transparent and accessible decision-support tools are essential for prosumers to evaluate the financial viability of PV investments under evolving regulatory conditions. This paper addresses that need by presenting a web-based calculator that integrates high-resolution time-series energy modeling with standard techno-economic metrics. The calculator is specifically tailored to Croatian regulatory parameters, tariff structures, and typical residential load profiles, enabling prospective prosumers to compare profitability under both the legacy monthly net-metering scheme and the new 15-minute net-billing framework.

The primary contributions of this work are threefold. First, we provide a detailed comparative analysis of the two Croatian prosumer billing schemes, quantifying the economic impact of the transition from monthly to 15-minute settlement intervals. Second, we present a methodologically rigorous calculator that combines quasi-static energy balance modeling with financial evaluation, following best practices identified in recent techno-economic literature [14], [15], [16]. Third, we offer transparent documentation of all input parameters, assumptions, and data sources to ensure reproducibility and facilitate adaptation of the tool to other jurisdictions undergoing similar regulatory transitions.

The remainder of this paper is organized as follows. Section II reviews the regulatory evolution in Croatia, detailing the differences between the Self-supplied customer (net-metering) and Customer with own production (net-billing) models. Section III describes the calculator's architecture, modeling framework, financial metrics, and input data sources. Section IV presents results comparing profitability under the two schemes for a typical system size and load profile. Section V concludes with recommendations for future work.

II. Regulatory Evolution in Croatia: Net Metering vs. Net Billing

To understand the implications of Croatia's regulatory shift, a detailed comparison between the two primary models for prosumers is required: the outgoing model named *Self-supplied customer*, which functions as a hybrid net-metering system, and the model named *Customer with own production*, which operates as a net-billing system. The *Self-supplied customer* net-metering model is being phased out and is no longer available for new installations after January 1, 2026. Prosumers already using this more favorable model will be allowed to continue using it for the next 10 years.

A. The Self-supplied customer (Net Metering) Model

Under the *Self-supplied customer* model, billing is based on net energy: the difference between energy imported from the grid and energy exported to the grid by the prosumer over a monthly billing period. If there is an energy deficit at a certain time interval, when PV production is smaller than the residential load, additional energy is drawn from the grid (E_{imp}). In the same way, surplus energy is exported to the grid (E_{exp}). If the total E_{imp} is greater than the total E_{exp} for a certain billing period (month) prosumer pays for the difference at a price:

$$p_{imp} = (p^{Grid} + p^{E} + p^{E}) \cdot (1 + VAT) \tag{1}$$

which includes grid costs (p^{Grid}), energy production costs (p^E) and renewable sources (RES) compensation p^E. If the monthly (E_{exp}) is greater, the surplus is compensated at a reduced price:

$$p_{exp} = 0.8 \cdot p^{E} \tag{2}$$

Calculation is done separately for two time-of-use (ToU) tariffs: high tariff (HT) and low tariff (LT) with different electricity prices. Since high tariff is valid during daytime hours during which PV production occurs, the prosumer will always pay for the total energy imported during LT hours, while any possible surplus can only occur during HT hours.

This model completely ignores the precise timing of energy flows within the month. Only the monthly net energy in each tariff is required to calculate the energy cost for each month. A kilowatt-hour generated during peak solar hours directly offsets a kilowatt-hour imported from the grid during evening peaks or non-solar periods, effectively eliminating the financial penalty for temporal mismatch. The grid is used as a perfectly efficient virtual energy storage without compensation, eliminating the need for on-site energy storage and maximizing financial gains from PV investments for prosumers.

B. The Customer with own production (Net Billing) Model

The *Customer with own production* model uses a 15-minute netting interval, meaning that any energy produced that is not consumed during that interval is sold at a price lower than the import price. While the import price is the same as in the net metering model (1), the export price is calculated as follows:

$$p_{exp} = 0.9 \cdot p^{E}_{avg} * E^{month}_{imp} / E^{month}_{exp} \tag{3}$$

$$p^{E}_{avg} = (p^{E,HT} * E^{month,HT}_{imp} + p^{E,HT} * E^{month,LT}_{imp}) / (E^{month,HT}_{imp} + E^{month,LT}_{imp}) \tag{4}$$

where p^{E}_{avg} is the average energy production price, and E^{month}_{imp} and E^{month}_{exp} are the total energy imported and exported to the grid for a given month. If $E^{month}_{imp} \geq E^{month}_{exp}$, p^{E}_{avg} is then equal to $0.9 \cdot p^{E}_{avg}$, ensuring that $p_{exp} \leq 0.9 \cdot p^{E}_{avg}$ for all billing periods [3]. During months with a significant excess of produced energy, the export price is significantly reduced. While the export price in this model is similar to that in the net metering model when there is no significant monthly energy surplus, the 15-minute netting interval still penalizes the temporal mismatch between energy production and consumption. The grid can no longer be used as a free virtual energy storage and becomes a transactional interface in which prosumers buy at retail (import) rates and sell at lower (export) rates. For reference, the current import price p_{imp} that includes grid fees in Croatia is 0.20 €/kWh in high tariff, while energy production costs (p^E) are 0.097 €/kWh, resulting in a maximum export price p_{exp} of 0.087 €/kWh. A surplus kilowatt-hour produced during a 15-minute netting interval compensates only 43.5% of the kilowatt-hour imported during a non-solar 15-minute interval in the best case scenario. This makes immediate utilization of self-generated solar power (**direct self-consumption**) the most economically valuable mode of operation for a PV system.

III. Methodology and Application Design

The web application (Fig.1) analyzed in this paper is built upon a modular architecture using the Streamlit framework, facilitating an interactive and data-driven user experience [17].

Overall application architecture is as follows:

- Front-end: Streamlit UI (tabs for location and PV system design, PV production profile, consumption profile, billing, financial analysis).
- Back-end: Python modules for PV simulation, consumption profile generation, billing engine, and financial calculations.

A. Input Data and Pre-processing

The first application tab requires input of user-defined parameters: system location, installed PV capacity (P_{inst} in kWp), PV module type and tilt, system losses, and azimuth. These parameters are essential to calculate PV system production over the course of a calendar year. Since net billing requires detailed energy flows in high-resolution (15-minute), the application utilises PVGIS [18] to generate the production profile. Overview of the basic production details: total annual energy production, specific annual yield (kWh/Wp), plant capacity factor, and average daily production is shown in the second tab after production calculation.

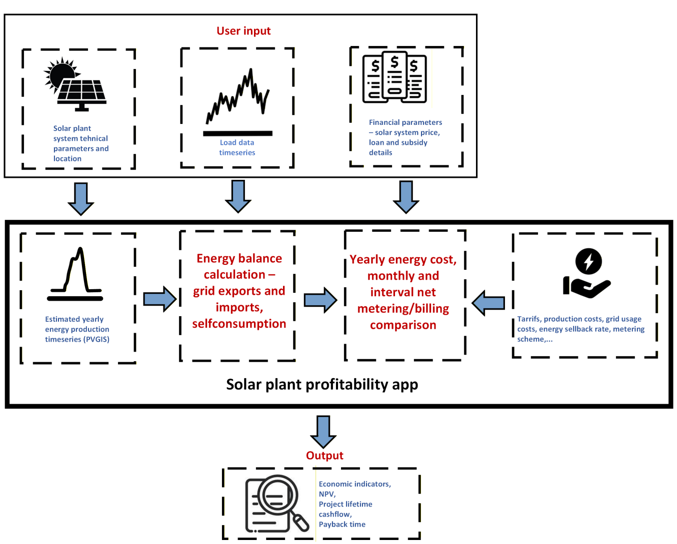

Fig. 1. Solar profitability app overview

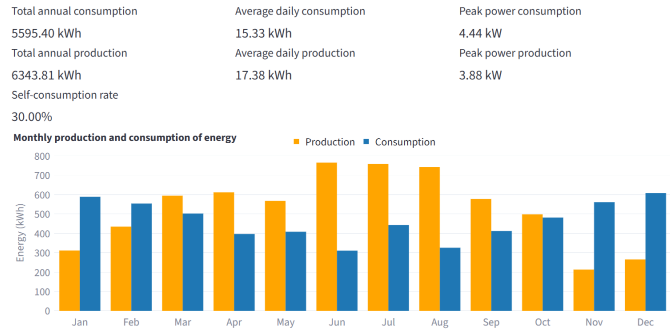

Fig. 2. Monthly energy production and consumption.

Household energy consumption details can be provided by the user in the third application tab. Since most of the residential owners can not provide hourly or 15-minute consumption profiles, the typical Croatian household energy consumption profile is already provided by the application, which can be scaled to match the users' total annual consumption. Self-consumption rate is calculated at this step as the most important indicator of a temporal mismatch between energy production and consumption. Monthly energy production and consumption (Fig. 2) are shown in this tab, along with the most important parameters.

B. Billing Calculation Logic

The core of the application's analytical power resides in the energy billing module, separated into two parts: energy balance calculation and annual/monthly bill calculation. Energy balance and billing calculation are implemented in two distinct billing logics:

1) Monthly Netting Logic (Net metering): For the monthly netting simulation, the application aggregates total consumption and production over each calendar month. The key calculation steps are:

1) Calculate monthly total consumed energy (E_{load}^{month}) and total PV generated energy (E_{PV}^{month}).
2) Determine the net monthly energy balance:

$$E_{net}^{month} = E_{load}^{month} - E_{PV}^{month} \tag{5}$$

These are calculated separately for high and low tariffs.

3) If $E_{net}^{month} > 0$, the prosumer is charged for this net import $E_{imp}^{month} = E_{net}^{month}$ at the full retail price p_{imp} (1).
4) If $E_{net}^{month} < 0$, the surplus energy $E_{exp}^{month} = -E_{net}^{month}$ is valued at a reduced rate (2), and credited against the bill.
5) Fixed fees are applied to the resulting base HT and LT charges:

$$\begin{aligned} &E_{imp}^{month,HT} \times p_{imp}^{HT} + E_{imp}^{month,LT} \times p_{imp}^{LT} \\ &-E_{exp}^{month,HT} \times p_{exp}^{HT} - E_{exp}^{month,LT} \times p_{exp}^{LT} \end{aligned} \tag{6}$$

2) 15-Minute Netting Logic (Net Billing): The net billing simulation operates at a significantly finer temporal granularity. For each 15-minute interval i:

1) The instantaneous energy balance B_i is calculated as:

$$B_i = E_{load,i} - E_{PV,i} \tag{7}$$

2) Imported energy $E_{imp,i}$ and exported energy $E_{exp,i}$ are determined:

$$E_{imp,i} = \max(B_i, 0) \tag{8}$$

$$E_{exp,i} = \max(-B_i, 0) \tag{9}$$

3) The monthly total cost is computed as:

$$\sum_i (E_{imp,i} \times p_{imp} - \sum_i (E_{exp,i} \times p_{exp}) \tag{10}$$

plus fixed charges, where p_{exp} is determined by (3), and p_{imp} is equal to import price under the net metering model (1).

The calculation of p_{exp} under net billing (Customer with own production) is intricate as it depends on the ratio of total monthly import to total monthly export. The tool dynamically adjusts this export price for each month using monthly energy totals and energy prices set by [19] and [20], which are already loaded to the application.

C. Financial analysis

The web application provides a comprehensive output designed to offer deep insights into the financial implications of PV investments under both regulatory regimes. The fourth application tab provides a comparison of annual energy costs across three scenarios: (1) a baseline without a PV system, (2) a PV system operating under monthly netting, and (3) a PV system operating under 15-minute net billing, shown in Fig. 3. This visualization effectively highlights the "seasonal gap" phenomenon, where monthly netting allows summer energy surpluses to financially offset winter deficits, a benefit largely absent under the granular 15-minute netting scheme.

Beyond high-level totals, the tool generates a simulated annual bill summary. This detailed table provides a line-by-line breakdown of all cost components, including distribution and transmission fees, supply costs (distinguishing between subsidized and unsubsidized consumption), total VAT, and the total value of energy exported to the grid. This granular reporting allows users to precisely identify how each tariff component contributes to the overall bill under different operational and regulatory scenarios. Users can download annual and monthly bills, which are formatted identically to the bills that prosumers receive from their electricity supplier.

PV plant profitability analysis over the entire project lifetime requires users to input financial data, including: PV costs per kW installed, project lifetime duration, loan details, percentage of subsidy received, and maintenance costs. Detailed annual cash flow is generated after cost calculation for each year of the project's lifetime. To determine the payback period, annual savings are calculated as the difference between baseline annual electricity costs without a PV system and annual

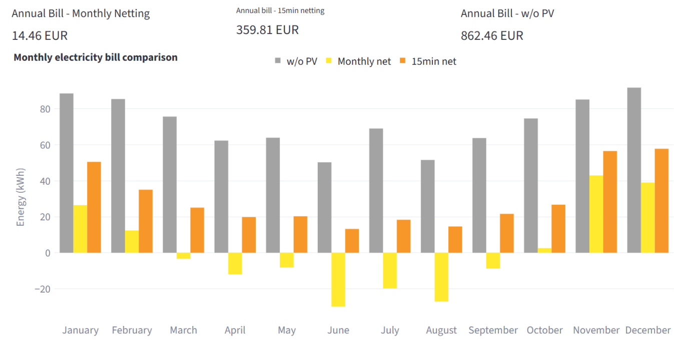

Fig. 3. Electricity cost comparison under different billing schemes.

Fig. 4. Energy balance under monthly (top) and 15min netting (bottom)

electricity costs under net metering and billing models. Annual savings are discounted to the starting year of the PV project, and the PV project's net present value (NPV) is calculated as:

$$NPV = -C_0 + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} \tag{11}$$

where C_0 is the starting investment (PV system cost), n is the project lifetime, and C_t is the net annual saving for year t, after maintenance costs. Fig. 6 shows discounted annual and cumulative savings for both billing models, providing a direct comparison between them. NPV value, payback period, and annual savings amount are also shown in the fifth application tab.

IV. Results Synthesis and Discussion

Production and consumption for a typical Croatian household situated in the Dalmatia region with a self-consumption ratio of 30 % are shown in Fig. 2 and resulting electricity

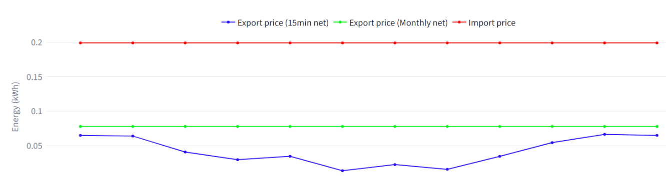

Fig. 5. Electricity prices comparison under different billing schemes.

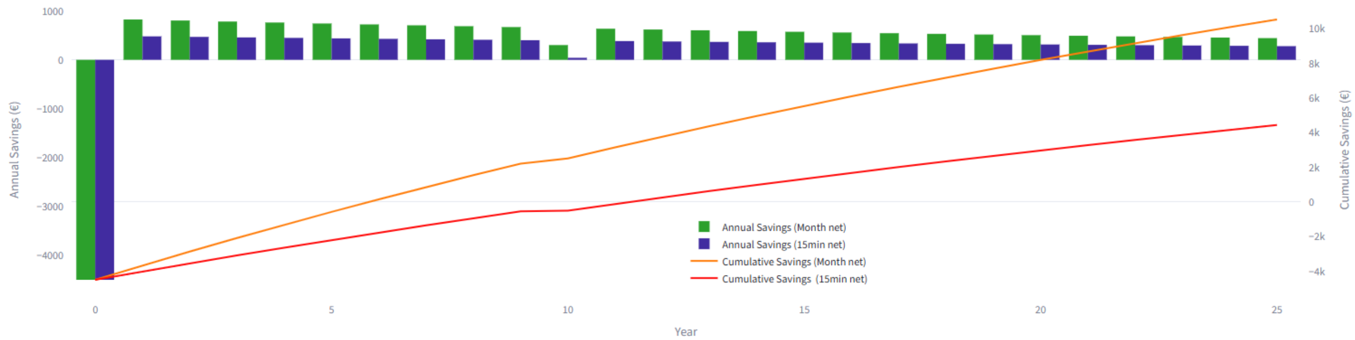

Fig. 6. Cash flows comparison over project lifetime.

costs in Fig. 3. While the resulting annual costs under the net metering model are negligible, the resulting annual costs under the net billing model with an 15min interval amount to €360. The main motivation for creating a tool like this is to provide clarity and a better understanding of different billing policies. Energy balance shown in Fig.4, also available in the application, reveals a clear distinction in the energy balance calculation under different billing models.

Under the monthly netting scheme, energy produced by a PV system is considered self-consumed if it does not exceed consumption during a given month. Only surplus energy (marked by blue-green color Fig. 4) on a monthly level is billed at a lower export price. Under the 15min netting scheme, 15min interval energy surpluses are billed at a lower export price (blue color). From Fig.4 it is clear that a much larger portion of energy produced by the PV system is billed at a lower export price in 15min netting scheme. This also results in a larger amount of energy imported from the grid at a higher import price (red).

The economic imbalance between the two models is also created by the difference in export price shown in the Fig. 5. During the month with largest energy surplus, export price drops to 0.013 €/kWh in the 15min net billing model, which significantly reduces the economic gains from exporting large amounts of energy to the grid.

Higher annual bills reduce savings shown in Fig. 6. This resulted in doubling the payback period for 15min netting model in the test case (12 years), compared to the monthly netting model (6 years). Value of NPV is also much lower (€4,439.30 vs €10,531.08).

Initial simulations performed using the tool reveal several critical economic insights:

- **Profitability Gap:** The 15-minute net billing scheme consistently results in higher annual electricity costs compared to monthly net metering for comparable PV system capacities, with margins depending on the load-generation profile mismatch. This is primarily due to the reduced ability of summer daytime surpluses to offset winter and evening imports under the fine-grained settlement.
- **Enhanced Value of Self-Consumption:** Under the new net billing scheme, the economic value of a kilowatt-hour consumed directly on-site is more than double that of a kilowatt-hour exported to the grid. This creates a strong financial incentive for prosumers to optimize their direct self-consumption, for instance, by implementing ”load shifting” strategies where high-power appliances are operated during periods of peak solar generation [21].
- **Justification for Battery Storage:** The tool serves as a powerful instrument for evaluating the economic justification of battery energy storage systems. By simulating how a battery can capture low-value exported energy (E_{exp}) and subsequently use it to offset high-value imported energy (E_{imp}), users can quantify the precise reduction in grid charges and determine the viable economic price point for battery integration [22].

These findings are consistent with international research on the impact of temporal settlement granularity on prosumer economics [9], [11].

V. Conclusion and Future Work

The transition from net metering to net billing in Croatia signifies the end of a relatively straightforward era for residential solar investments. As the regulatory framework becomes more sophisticated and market-oriented, the demand for advanced analytical tools to evaluate these investments grows proportionally. The web application synthesized in this paper provides a robust, data-driven solution to this challenge. By leveraging high-resolution temporal data and a detailed implementation of Croatian billing laws, the tool offers a realistic and transparent perspective on PV system profitability under both current and future regulatory regimes.

Future enhancements to the application will focus on several key areas. Implementation of consumption profile generation for different types of consumers using dedicated Python libraries would improve calculation accuracy for users without their own detailed consumption data. The development of a dedicated module for battery storage optimization, including algorithms for optimal charging/discharging strategies based on dynamic tariffs, is also planned. Furthermore, incorporating uncertainty analysis to account for variations in electricity prices and load profiles will provide a more robust risk assessment for investors. The ultimate goal is to provide a vital tool for a transparent transition to a new billing policy, facilitating informed decision-making in a rapidly evolving energy market.

REFERENCES

[1] European Union, "Directive (eu) 2019/944 on common rules for the internal market for electricity." Official Journal of the European Union, 2019.

[2] Lider Media, "Solarni boom u Hrvatskoj: 80 posto kapaciteta drži biznis,." https://lidermedia.hr/zeleno-i-digitalno/solarni-boom-u-hrvatskoj-80-posto-snage-na-krovovima-drzi-biznis/, 2025. Accessed: 2026-02-13.

[3] Croatian Parliament, "Act on renewable energy sources and high-efficiency cogeneration." Narodne Novine, 2024.

[4] E. Union, "Directive (EU) 2019/944 on common rules for the internal market for electricity,," 2019.

[5] E. Union, "Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources,," 2018.

[6] HERA (Croatian Energy Regulatory Agency), "Methodology for determining tariff items for electricity distribution," 2025.

[7] L. Budin, D. Grdenić, and M. Delimar, "A quadratically constrained optimization problem for determining the optimal nominal power of a PV system in net-metering model: A case study for Croatia,," *Energies*, 2021.

[8] HERA (Croatian Energy Regulatory Agency), "Decision on tariff items for the use of the electricity distribution network,," 2025.

[9] D. Kurz and K. Nowak, "Analysis of the impact of the level of self-consumption of electricity from a prosumer photovoltaic installation on its profitability under different energy billing scenarios in Poland,," *Energies*, 2023.

[10] G. Zhao, J. Clarke, J. Searle, R. Lewis, and J. Baker, "Economic analysis of integrating photovoltaics and battery energy storage system in an office building," *Energy and Buildings*, vol. 284, p. 112885, 2023.

[11] P. Olczak, A. Żelazna, K. Stecuła, D. Matuszewska, and L. Lelek, "Environmental and economic analyses of different size photovoltaic installation in poland," *Energy for Sustainable Development*, vol. 70, pp. 160–169, 2022.

[12] G. Krishnan and K. V. Chandrakala, "Techno-economic analysis for the profitability of residential pv-battery system," in *Proc. 4th Int. Conf. Energy, Power, and Environment (ICEPE)*, pp. 1–5, 2022.

[13] HEP-ODS (Croatian Distribution System Operator), "Technical requirements for the connection of small-scale PV systems,," 2025.

[14] K. Pippi, T. L. Katsigiannis, and P. S. Georgilakis, "The net-metering practice in medium-voltage PV-BES prosumers: A techno-economic analysis of the Greek case,," *Grids and Networks*, 2023.

[15] K. Pippi, T. L. Katsigiannis, and P. S. Georgilakis, "Systematic techno-economic analysis of medium-voltage PV-BES prosumers operating under NEM policy,," 2022.

[16] S. Hashemi, M. Melgar-Dominguez, and M. Pourakbari-Kasmaei, "Rooftop solar with net metering: An integrated investment appraisal,," *Renewable Sustainable Energy Reviews*, 2023.

[17] Streamlit Documentation, "Building data applications with streamlit," 2025.

[18] European Commission, Joint Research Centre, "Photovoltaic Geographical Information System (PVGIS)." https://re.jrc.ec.europa.eu/pvg_tools/en/#PVP. Accessed: 2026-03-30.

[19] HEP Elektra, "Tarifne stavke (cijene)." https://www.hep.hr/elektra/kucanstvo/tarifne-stavke-cijene/1547. Accessed: 2026-03-30.

[20] HEP Operator distribucijskog sustava, "Tarifne stavke (cijene)." https://www.hep.hr/ods/kupci/kucanstvo/tarifne-stavke-cijene/160. Accessed: 2026-03-30.

[21] M. B. Sigalo, A. C. Pillai, S. Das, and M. Abusara, "An energy management system for the control of battery storage in a grid-connected microgrid using mixed integer linear programming," *Energies*, vol. 14, no. 19, p. 6212, 2021.

[22] D. Fioriti, L. Pellegrino, G. Lutzemberger, E. Micolano, and D. Poli, "Optimal sizing of residential battery systems with multi-year dynamics and a novel rainflow-based model of storage degradation," *Electric Power Systems Research*, vol. 203, p. 107675, 2022.