23rd International Conference on Renewable Energies and Power Quality (ICREPQ'25)
Tenerife (Spain), 25th to 27th June 2025
ISBN-13: 978-84-09-66511-2

Impact of the new network tariff system on end users of electricity utilizing green transition technologies: A case study for Slovenia

J. Počivalnik[1], D. Kuhar[1], E. Simonič[1], S. Seme[1,2] and K. Sredenšek[1,2]

[1] Faculty of Energy Technology, University of Maribor
Hočevarjev trg 1, 8270 Krško, Slovenia
e-mail: jernej.pocivalnik@um.si; domen.kuhar@um.si; eva.simonic@um.si; sebastijan.seme@um.si; klemen.sredensek@um.si

[2] Faculty of Electrical Engineering and Computer Science, University of Maribor
Koroška cesta 46, 2000 Maribor, Slovenia

Abstract.
The paper examines the impact of the new network tariff system on end users utilizing green transition technologies in Slovenia. Using 15-minute electricity consumption measurements, the current situation was analyzed. Solar radiation data was used to estimate the expected electricity production from a photovoltaic system. Additionally, the influence of battery storage on grid electricity consumption was considered. The final results present the consumer's monthly electricity costs under three different scenarios: the current situation, with a photovoltaic system, and with a photovoltaic system and battery storage. Electricity costs were calculated based on the updated methodology of the new network tariff system. The paper also evaluates the investment payback period for implementing green transition technologies. Considering the new network tariff system, the findings provide valuable insight into how individual consumers can optimize their electricity consumption and reduce dependence on the grid.

Key words.
network tariff system, electricity consumption, electricity production, electricity costs, payback period

1. Introduction
An increasing number of PV systems, heat pumps, battery storage systems, and electric vehicles, coupled with the general growth in electricity consumption, significantly impacts the electricity grid [1], [2]. In addition to the increasing emphasis on the green transition and stable electricity supply, these factors require a robust, flexible and, above all, well-maintained electricity transmission and distribution system. Funds for upgrades and maintenance of these systems are provided by paying network charges [3].
Methodologies for calculating network fees vary across Europe, reflecting different national regulatory approaches and energy market structures. The European Union Agency for the Cooperation of Energy Regulators (ACER) ensures that these methodologies align with key principles such as non-discrimination, transparency, simplicity, stability, predictability, and sustainability, preventing market distortions. In approximately 75 % of EU jurisdictions (22 out of 29 member states), the National Regulatory Authority (NRA) defines the tariff methodology. In the remaining jurisdictions, the NRA either oversees compliance with existing methodologies or does not have direct authority over tariff determination. [4]
According to [4], [5] and [6] network charge calculations follow different models. Some countries, such as Bulgaria, Romania, and Spain, use energy-based methodologies, while others, like Iceland and the UK, apply power-based models. However, the most common approach is a combination of energy and power-based charges, as seen in Croatia, Germany, and Slovenia, with the ratio of each component varying by country.
Additionally, European countries incorporate different time-based elements into their transmission tariffs to enhance grid stability and efficiency. Belgium, France, and Spain use seasonal, peak/off-peak, and dynamic pricing structures to better reflect demand fluctuations. Estonia and Norway require mandatory time-based tariffs for all users, while Croatia and Slovenia (until October 1, 2024) provide optional time-of-use pricing for smaller consumers. Portugal and the UK employ a mix of seasonal and peak pricing, with some regions incorporating dynamic adjustments. As mentioned in [5] and [7], these diverse approaches aim to create accurate price signals, promote efficient electricity consumption, and support grid management in response to the increasing integration of renewable energy sources. Adopting the Legal Act on the methodology for determining the network charges for the electricity system operators (Official Gazette of the Republic of Slovenia, No. 146/22) [8] marked the beginning of preparations for changes in network charge calculation in Slovenia. The new approach introduces numerous changes that will undoubtedly significantly impact the structure of electricity costs for every consumer.
This paper analyzes a household electricity consumer, comparing electricity costs across three scenarios: the current situation without any electricity production or battery storage units, a scenario with an included photovoltaic (PV) system, and a third scenario incorporating both a PV system and a battery storage unit.

The analysis was based on electricity consumption data measured at 15-minute intervals, obtained from the Slovenian electricity consumption database, which is available for all users with digital electricity meters. Expected electricity production from the PV system was calculated using annual solar radiation data provided by the Slovenian Environment Agency (ARSO), with values interpolated to 15-minute intervals to match the time resolution of the consumption data throughout the entire year.The calculation used an established model based on the fundamental astronomical relationships between the Sun and Earth [9]. A simplified model that adheres to the physical principles governing battery operation was used to simulate the battery storage system. Finally, the costs of each system (PV system and battery storage) were incorporated, and the annual savings achieved through their implementation were calculated. Based on this data, the payback period was determined, enabling an assessment of the impact of the new tariff system and available support schemes on investments in electrical energy production and battery storage systems.

2. Network tariff system

Network charges are mandatory costs included in electricity bills, paid by all power system users as compensation for accessing and utilizing the grid infrastructure. These charges cover a wide range of expenses related to the operation, maintenance, and development of both transmission and distribution networks, ensuring grid stability and the continuous delivery of electricity. They also help finance system services such as frequency regulation, voltage control, and integrating renewable energy sources.

In Slovenia, the Energy Agency of the Republic of Slovenia (AGEN) determines the methodology of the network tariff system, which consists of four key components, each addressing different aspects of power system costs:

- transmission system network charge,
- distribution system network charge,
- connection power charge,
- excess reactive power charge [10].

The previous methodology of the network tariff system had been in place for more than two decades and was primarily consumption-based, meaning network charges were largely determined by the amount of electricity (kWh). Similar problems have already been described in [11], where it was found that old approaches became outdated due to the rapid decentralization of the grid and ongoing electrification trends. Several key factors highlighted the need for change:

- Growth of distributed electrical energy resources – The increasing adoption of PV systems, battery storage, heat pumps, and electric vehicles significantly changed consumption patterns, making the old methodology less effective in reflecting actual network usage.
- Peak load challenges – As mentioned in [12], ensuring sufficient power always may be more challenging than delivering energy. Older systems did not account for this and failed to incentivize consumers to reduce demand during peak hours.
- Fair cost distribution – Consumers with self-generation (e.g., PV systems) but high peak demand are often underpaid for their impact on the grid [13], [14].

The Legal Act on the methodology for determining the network charges for the electricity system operators (Official Gazette RS, No. 146/22) was introduced to address these challenges. After multiple delays, the new tariff system officially took effect on October 1, 2024. This reform represents a major shift in how electricity users are charged for grid access and aims to create a fairer and more efficient system.

Under the new methodology, consumers are classified into five consumption groups based on their connection type and grid access point. Additionally, a seasonal pricing structure has been introduced, distinguishing between a high season during winter, when tariffs are higher due to increased demand, and a low season in summer, when tariffs are lower, to encourage more balanced electricity consumption throughout the year. Another significant change is transitioning from the previous two-period system (higher and lower tariff) to a five-time block model, which better aligns pricing with real-time grid demand.

Furthermore, the new system introduces the concept of an agreed power limit, which defines the maximum power a user can draw from the grid without incurring additional costs. This default limit is determined based on the consumer's past consumption profile to ensure a fair allocation. However, consumers can request an adjustment if they believe the assigned limit does not accurately reflect their actual needs. If a consumer exceeds this limit, an excess power charge will apply. [8]

3. Technical analysis

A. Scenario 1 – without a PV system and battery storage unit

The analyzed consumer is a single-family house located in the eastern part of Slovenia, where a five-member family lives. An air-water heat pump is used for heating and domestic hot water preparation. The house is connected to an electrical grid via a three-phase connection protected by a 3x25 A fuse package. The consumption data reveals an unbalanced electricity consumption profile with an average power usage of 1,457 kW. The highest measured peak power demand reaches 8,42 kW, while the total yearly consumption amounts to 12.759 kWh. The reason for the relatively unbalanced consumption throughout the year is that heating is provided by a heat pump (air-water), which operates with a lower coefficient of performance (COP) in winter due to lower outdoor air temperatures. The consumption profile is shown in Figure 1a.

B. Scenario 2 – with PV system

In the second scenario, the objective was to design a PV system capable of producing approximately 20% more electricity than the total electricity consumption. The created PV system consisted of 24 BISOL BB0 450 photovoltaic modules, each with a nominal power of 450 W. This configuration gives the power plant a total nominal capacity of 10,8 kW. Figure 1b shows the calculated electricity production of the PV system, while Figure 1c shows the difference between electrical consumption and electricity production (negative values indicate electrical energy imported into the grid).

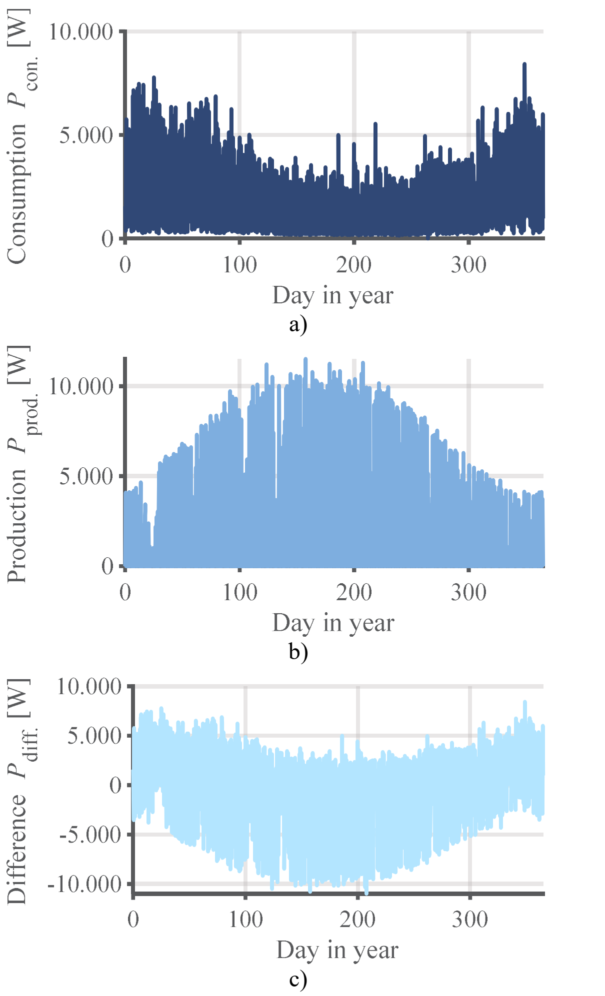
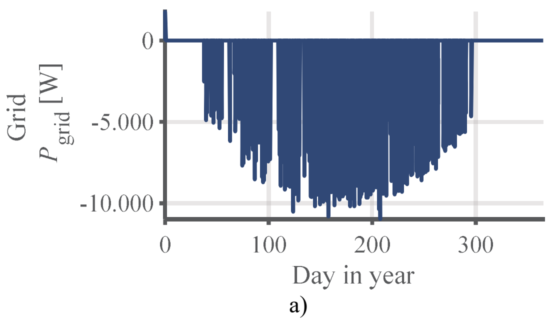


Fig. 1. Electricity consumption, estimated electricity production, and the difference between them for our analyzed consumer.

From Fig. 1b, it is evident that the plant produced an average of 1,549 kW of power, with a peak electricity production of 11,523 kW. Annually, the PV system produced a total of 13,564 kWh of electricity.

C. Scenario 3 - with PV system and battery storage unit

In the third scenario, better self-sufficiency was achieved with battery storage. A LiFePO4 battery storage system with a capacity of 22,1 kWh and a maximum charging and discharging power of 20,45 kW was selected. Its estimated price used in further economic analysis was 11.500 EUR.



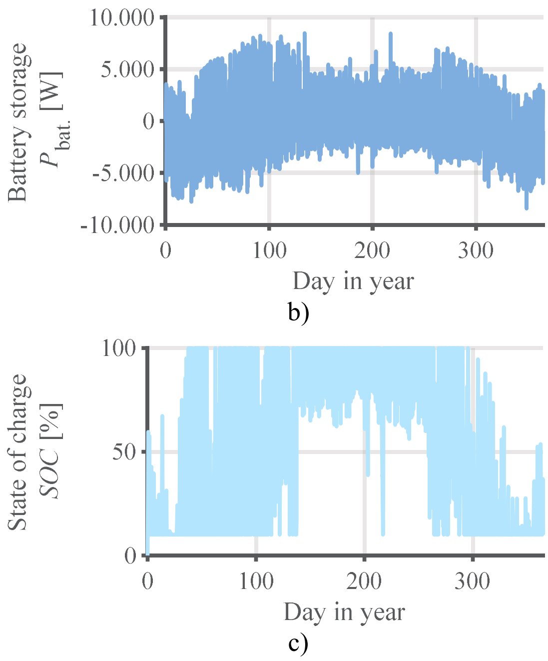


Fig. 2. Power flow into/from grid and battery storage, State of charge for battery storage

Figure 2a shows that using battery storage, only 0,442 kWh of electricity was drawn from the grid, which is 99,99 % less compared to the scenario where the analyzed consumer only had a PV system. Using a sufficiently large battery storage system, almost all surplus electricity produced by the PV system was stored throughout the year, resulting in minimal electrical energy being consumed from the grid. Figure 2b shows the power flow into/from battery storage. Figure 2c shows the state-of-charge profile of the battery storage. In winter, battery storage SOC rarely reaches 100 % due to the reduced PV system production during this period. On the other hand, in the summer months, when PV system production is higher, the SOC rarely drops below 50 %.

4. Economical analysis

A. Scenario 1 – without a PV system and battery storage unit

Using electricity consumption data (Figure 1a) and the relevant tariff rates, a total annual electricity cost of 2.374 EUR was calculated for this type of consumer. This amounts to an average monthly expense of 198 EUR. The distribution of costs across different months is shown in Figure 3. The overall cost structure consists of six main components: electrical energy charged at a single tariff, various contributions (including the energy efficiency contribution, the renewable energy and cogeneration contribution, and the market operation contribution), excise duties, network charges (covering electrical energy, agreed power, and excess power), and value-added tax (VAT).

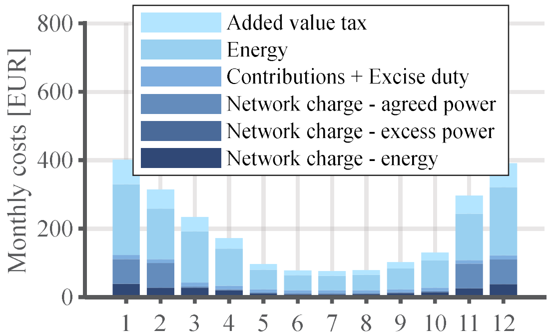


Fig. 3. Cost structure for analyzed consumer in scenario 1

B. Scenario 2 – with PV system

For the consumer with a PV system, economic indicators are largely influenced by the support scheme, specifically, the system that considers surplus electrical energy production, i.e., the electricity that is not immediately consumed at the production site. In our case, two subsidy schemes were considered, including the NET-METERING system, which applies to all PV systems with connection approvals issued before January 1, 2024. In this system, a yearly balance is made, and if the amount of produced electrical energy exceeds consumption, the consumer is exempt from paying for the electrical energy and any related energy taxes and fees [15]. Considering this support scheme and the assumption that production in the given year exceeds consumption, such a consumer would incur electricity costs of 381,5 EUR. The cost distribution throughout the year is shown in Figure 4. Based on the investment price, which was determined according to the estimated cost for installing such PV systems, as indicated by Borzen's (Slovenian electricity market operator) Guide for setting up smaller plants [16] and amounted to 11.880 EUR—the payback period for this investment was calculated to be approximately 6 years. The investment return dynamics are shown in Figure 5.

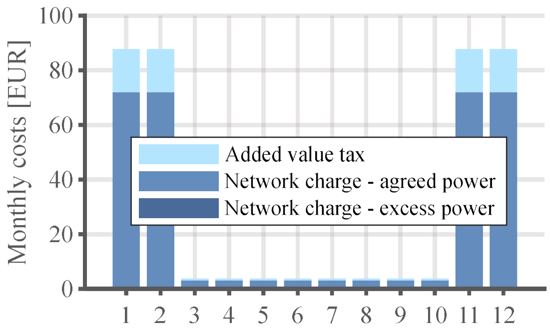


Fig. 4. Cost structure for analyzed consumer with PV system and support scheme NET-METERING

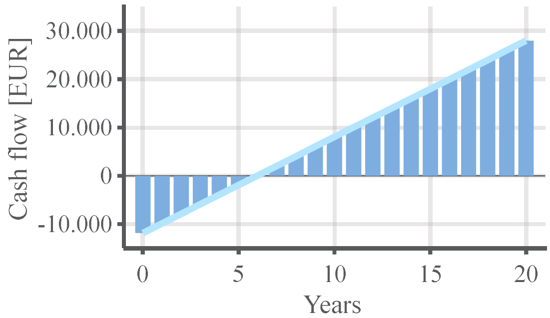


Fig. 5. Investment payback period for PV system with support scheme NET-METERING

The second support scheme is the so-called "CREDIT NOTE," offered by the electricity trader GEN-I d.o.o. after the termination of the NET-METERING system. This scheme works by paying the consumer credit for each kWh of electricity fed into the grid, which can be used to offset future electricity payments in the coming months or cashed out at the end of the year. [17]

Considering this subsidy scheme, the annual electricity costs would amount to 1.255 EUR. With the same initial investment of 11.880 EUR, the payback period increases to about 10,6 years. Figure 6 shows the annual electricity cost structure, while Figure 7 shows the dynamics of the investment return, which would take approximately 8 years.

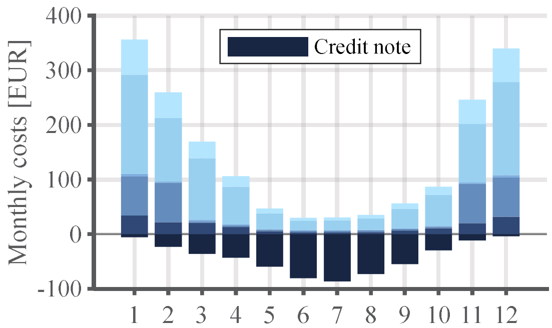


Fig. 6. Cost structure for analyzed consumer with PV system and support scheme CREDIT NOTE

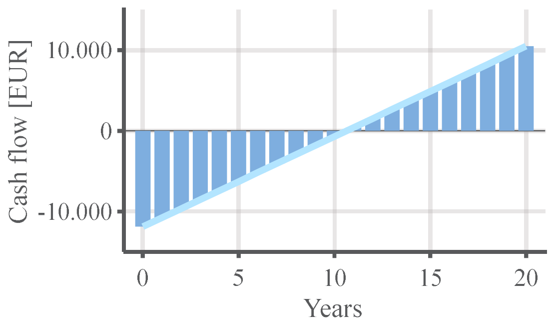


Fig. 7. Investment payback period for PV system with support scheme CREDIT NOTE

C. Scenario 3 - with PV system and battery storage unit

A scenario involving a combination of a PV system and a battery storage system was also analyzed. Similar to Section 4.B, both support schemes (NET-METERING and CREDIT NOTE) were considered. The investment was calculated as the sum of the cost of the PV system (described in Section 4.B) and the battery storage system. The price of the battery storage was estimated based on publicly available information from the seller's website [18]. In this case, the total investment amounted to 23.380 EUR. By considering the NET-METERING support scheme and assuming that the yearly electricity production exceeds consumption, the annual electricity costs were calculated to be 381,5 EUR. The payback period for this investment was calculated at 11,7 years. Figure 8 represents the monthly costs of electricity. Figure 9 represents the dynamics of the investment return.

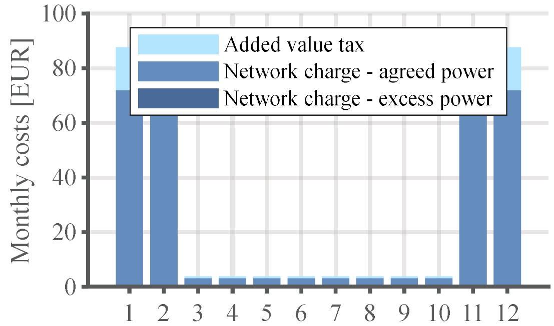


Fig. 8. Cost structure for analyzed consumer with PV system, battery storage and support scheme NET-METERING

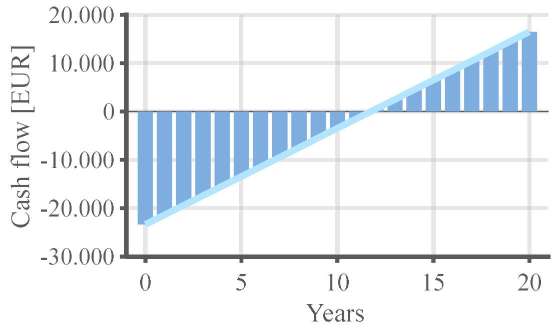


Fig. 9. Investment payback period for PV system and battery storage with support scheme NET-METERING

In the case of the CREDIT NOTE support scheme, the annual cost was 38,76 EUR. Considering the same investment cost of 23.380 EUR, the payback period of 10 years was calculated. Figure 10 represents the cost structure. Figure 11 represents the dynamics of the investment return.

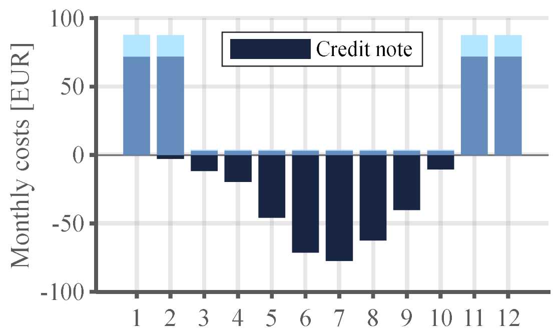


Fig. 10. Cost structure for analyzed consumer with PV system, battery storage and support scheme CREDIT NOTE

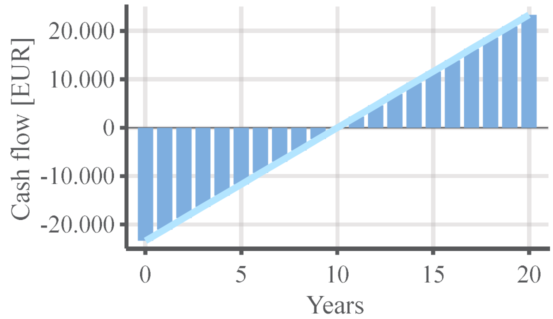


Fig. 11. Investment payback period for PV system and battery storage with support scheme CREDIT NOTE

4. Conclusion

This paper explores the impact of the new network tariff system on typical household electricity consumers who have either already invested in or are considering investing in PV systems or battery storage systems. Based on the data obtained on electricity consumption, estimated electricity production, and the consideration of two support schemes, it was found that NET-METERING had long been a relatively good investment, with payback periods of under 10 years for the average household consumer, which is considerably shorter than the expected lifespan of PV system components (25-30 years) [19]. In comparison, the CREDIT NOTE support scheme was much less advantageous in this particular case, with a calculated payback period nearly twice as long. From these results, it can be concluded that the new network tariff system, with its increased focus on current electrical energy consumption from the grid and the credit note support scheme, encourages the installation of battery storage systems. When combined with properly sized PV systems, a solution is provided that helps reduce consumer costs while easing the strain on the grid during periods of excessive electrical energy production or consumption. Furthermore, it is inferred that the new tariff system will facilitate the further integration of PV and battery storage systems into the distribution network, ensuring the continuous growth of these systems.

Acknowledgment

The authors acknowledge the use of research equipment DC power supply system for simulations of diffuse sources with an equipment set for managing energy systems together with a hybrid solar system, procured within the operation "Upgrading national research infrastructures – RIUM", which was co-financed by the Republic of Slovenia and the European Union from the European Regional Development Fund.

References

[1] K. Lummi, A. Rautiainen, P. Järventausta, P. Heine, J. Lehtinen, M. Hyvärinen and J. Salo, "Alternative Power-Based Pricing Schemes for Distribution Network Tariff of Small Customers," *2018 IEEE Innovative Smart Grid Technologies - Asia (ISGT Asia),* pp. 581-586, 2018.

[2] J. Tuunanen, S. Honkapuro and J. Partanen, "Power-based distribution tariff structure: DSO's perspective," *2016*

13th International Conference on the European Energy Market (EEM), pp. 1-5, 2016.

[3] S. Honkapuro, J. Haapaniemi, J. Haakana, J. Lassila, N. Belonogova, J. Partanen, K. Lummi, A. Rautiainen, A. Supponen, S. Repo and P. Järventausta, "Development options for distribution tariff structures in Finland," *2017 14th International Conference on the European Energy Market (EEM),* pp. 1-6, 2017.

[4] European Union Agency for the Cooperation of Energy Regulators (ACER), "PRACTICE REPORT ON TRANSMISSION TARIFF METHODOLOGIES IN EUROPE," [Online]. Available: https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER%20Practice%20report%20on%20transmission%20tariff%20methodologies%20in%20Europe.pdf. [Accessed 6. 2. 2025].

[5] M. Hofmann, S. Bjarghov, H. Sæle and K. Byskov Lindberg, "Grid tariff design and peak demand shaving: A comparative tariff analysis with simulated demand response," *Energy Policy,* vol. 198, p. 114475, 2025.

[6] K. Wang, X. Lai, F. Wen, P. P. Singh, S. Mishra and I. Palu, "Dynamic network tariffs: Current practices, key issues and challenges," *Energy Conversion and Economics,* vol. 4, pp. 23-35, 2023.

[7] Market, DIRECTORATE B--Internal Energy, "Study on tariff design for distribution systems," *European Commission,* 2015.

[8] Official Gazette of the Republic of Slovenia no.146/22, "Legal Act on the methodology for determining the network charges for the electricity system operators," [Online]. Available: https://pisrs.si/pregledPredpisa?id=AKT_1266. [Accessed 6. 2. 2025].

[9] S. Seme, K. Sredenšek, B. Štumberger and M. Hadžiselimović, "Analysis of the performance of photovoltaic systems in Slovenia," *Solar Energy,* vol. 180, pp. 550-558, 2019.

[10] Energy agency of the Republic of Slovenia (AGEN), "Network charge," [Online]. Available: https://www.agen-rs.si/web/en/network-charge. [Accessed 6. 2. 2025].

[11] R. J. Hennig, D. Ribó-Pérez, L. J. de Vries and S. H. Tindemans, "What is a good distribution network tariff?Developing indicators for performance assessment," *Applied Energy,* vol. 318, p. 119186, 2022.

[12] M. Nijhuis, M. Gibescu and J. Cobben, "Analysis of reflectivity & predictability of electricity network tariff structures for household consumers," *Energy Policy,* vol. 109, pp. 631-641, 2017.

[13] M. Nijhuis, M. Gibescu and J. Cobben, "Assessment of the impacts of the renewable energy and ICT driven energy transition on distribution networks," *Renewable and Sustainable Energy Reviews,* vol. 52, pp. 1003-1014, 2015.

[14] C. Eid, J. Reneses Guillén, P. Frías Marín and R. Hakvoort, "The economic effect of electricity net-metering with solar PV: Consequences for network cost recovery, cross subsidies and policy objectives," *Energy Policy,* vol. 75, pp. 244-254, 2014.

[15] Energy agency of the Republic of Slovenia, "Self-supply with net-metering," [Online]. Available: https://www.agen-rs.si/web/en/self-supply. [Accessed 7. 2. 2025].

[16] Borzen, "Guide for setting up smaller power plants," [Online]. Available: https://www.borzen.si/Portals/0/SL/Kontaktna%20to%C4%8Dka%20OVE/Priro%C4%8Dnik%20za%20postavitev%20manj%C5%A1ih%20elektrarn%20na%20OVE%20in%20SPTE_web_.pdf. [Accessed 7. 2. 2025].

[17] Borzen d.o.o., "Self-sufficient supply," [Online]. Available: https://gen-i.si/en/support/electrical-energy/self-sufficient-supply/. [Accessed 6. 2. 2025].

[18] Solar top store, "BYD Battery-Box Premium HVM 22.1," [Online]. Available: https://www.solartopstore.com/collections/batteries/products/byd-battery-box-premium-hvm-22-1. [Accessed 6. 2. 2025].

[19] M. Sodhi, L. Banaszek, C. Magee and M. Rivero-Hudec, "Economic Lifetimes of Solar Panels," *Procedia CIRP,* vol. 105, pp. 782-787, 2022.