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New methodology for network charge calculation in Slovenia: Case study for balcony solar power plant and battery storage system

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Abstract. This paper aims to examine a new methodology for calculating network charges in Slovenia, using the example of an apartment with and without a balcony solar power plant and an energy storage system. A balcony solar power plant is defined as a plug-in generation unit installed on a balcony or another suitable surface. It is connected solely to the internal electrical installation of a household consumer. Since changes to the calculation of network charges were introduced by the new network tariff model in Slovenia, an analysis of costs and the viability of investing in a balcony solar power plant and an energy storage system was conducted. Annual electricity costs were analyzed based on 15-minute data on household electricity consumption and electricity generation from the balcony solar power plant. The feasibility of investing in a balcony solar power plant was also assessed, considering the new methodology for network charge calculation.

Key words. network charge, electricity consumption, balcony solar power plant, battery storage system, and investment.

1. Introduction

Due to the increasing demand for electricity, the rapid development and integration of renewable energy sources into the power grid, and the evolution of electricity pricing mechanisms, an increasing number of European Union countries are facing complex challenges in planning and managing the power system as well as developing the electricity market [1]. The growing use of electric vehicles, battery storage systems, and heat pumps contributes to rising electricity demand. At the same time, integrating renewable energy generation sources, such as wind and solar power plants, affects electricity price volatility in wholesale markets, further driving demand dynamics [2]. Transmission and distribution system operators finance the operation and maintenance of the grid through the network charge, which serves as a fee for using the power system.
Peak loads in the distribution network account for only a portion of the investment costs of the power system, with this share increasing as the integration of renewable energy generation units grows. Due to the widening gap between peak and low loads, traditional fixed or uniform network charge tariffs are becoming increasingly inadequate for power systems with a high share of solar power plants, heat pumps, and electric vehicles. If the network charge scheme were not updated, there would be a risk of further increases in peak loads and stranded investments, where additional costs would not be specifically directed at users, driving the need for further grid investments. To address these challenges, introducing more advanced network charge calculation models, such as multi-tariff network charge systems [3,4] and dynamic network charge pricing [5], has become essential. Similar developments have been observed in other European countries. In Finland, Honkapuro et al. [6] and Lummi et al. [7] examined power-based pricing models aimed at improving cost allocation and managing peak demand. Wang et al. [8] provided a broader overview of dynamic tariff systems, noting the challenges related to user behaviour and regulation. The Slovenian five-block structure builds on these concepts by introducing time-based differentiation while maintaining consumer predictability.
Dynamic network charge tariffs, combined with load forecasting tools, enable distribution companies to send stronger price signals with prior notice, particularly in rare but intense peak loads. The use of smart metering technology with 15-minute granularity provides accurate real-time data, allowing dynamic price signals to be sent to consumers. These signals facilitate more cost-effective grid management and encourage consumer behavioral changes, aligning with the demand response principle. For example, during periods of grid congestion, when losses increase, operators can raise the network charge to incentivize consumers to reduce their electricity consumption. Consequently, users can shift their consumption to periods with lower network charge prices, generating savings for themselves and the overall power system.
In Slovenia, a new methodology for network charge calculation was implemented on October 1, 2024. This paper will present the price impact of the new network

charge calculation model using the example of a household consumer (apartment) with and without a balcony solar power plant and a battery storage system. Additionally, an assessment of the feasibility of investing in a balcony solar power plant will be provided.

2. The old and new methodology for network charge calculation in Slovenia

A. The old methodology for network charge calculation in Slovenia

The old network charge calculation system was defined by the Act on the Methodology for Determining the Regulatory Framework and the Methodology for Network Charge Calculation for Power System Operators [9]. It specified 14 consumer groups, classified based on voltage level, connection type, and consumption type. The classification of consumers into consumer groups is presented in Table I [10].

Table I. - Classification of consumers under the old network charge system

CONSUMER GROUPS		
Voltage level	Connection type	Consumption type
HV		T => 6000 h
		6000 > T => 2500 h
		T < 2500 h
MV	Busbars MV	T => 2500 h
		T < 2500 h
		T => 2500 h
		T < 2500 h
LV	Busbars LV	T => 2500 h
		T < 2500 h
		T => 2500 h
		T < 2500 h
		EV charging
		Without power measurements
		Household

The voltage level and connection type are fixed based on the location of the grid connection. The consumption type is determined according to the number of operating hours, which is calculated as the ratio of the annual consumed active energy to the highest measured 15-minute active power demand, as shown in equation (2.1).

$$T = \frac{W_{\text{annual}}}{P_{\max}} \tag{2.1}$$

Where T represents the number of operating hours, W_{annual} is the annual consumed active energy, and $P_{\max}$ is the highest measured 15-minute active power demand.
The network charge tariff for power (EUR/kW/month) is defined for each consumer group. The total network charge for power is calculated as the product of the network charge tariff and the billing power of the connection. Each consumer group may have up to two tariffs for consumed active energy. The network charge for consumed active energy can be calculated based on a higher tariff (HT) and a lower tariff (LT) or based on a single tariff (ST).
For two-tariff network charge calculation, HT applies on weekdays from 6:00 AM to 9:00 PM, while LT applies during all other hours and on non-working days. This schedule is not dependent on the season. For single-tariff network charge calculation, ST is always applied. Table II presents the duration of LT and HT under the old network charge calculation system.

Table II. - Display of MT and VT duration according to the old network charge calculation system

Hour of the day	Working day in S1*	Working day in S2*	Non-Working Day in S1	Non-Working Day in S2
0	LT	LT	LT	LT
1	LT	LT	LT	LT
2	LT	LT	LT	LT
3	LT	LT	LT	LT
4	LT	LT	LT	LT
5	LT	LT	LT	LT
6	HT	HT	LT	LT
7	HT	HT	LT	LT
8	HT	HT	LT	LT
9	HT	HT	LT	LT
10	HT	HT	LT	LT
11	HT	HT	LT	LT
12	HT	HT	LT	LT
13	HT	HT	LT	LT
14	HT	HT	LT	LT
15	HT	HT	LT	LT
16	HT	HT	LT	LT
17	HT	HT	LT	LT
18	HT	HT	LT	LT
19	HT	HT	LT	LT
20	HT	HT	LT	LT
21	HT	HT	LT	LT
22	LT	LT	LT	LT
23	LT	LT	LT	LT

*S1 represents the colder period of the year, covering the months of January, February, November, and December, when electricity consumption is generally higher.
*S2 represents the warmer period of the year, including the months of March, April, May, June, July, August, September, and October, when electricity consumption is generally lower.

B. The new methodology for network charge calculation in Slovenia

With the adoption of the Act on the Methodology for Network Charge Calculation for Power System Operators [8], preparations for implementing a new network charge calculation system began, which was originally scheduled to take effect on January 1, 2024. Due to the increased complexity of the calculation compared to the previous system, the implementation date was postponed multiple times, ultimately to October 1, 2024 [11]. In the new system, the previous 14 consumer groups have been replaced by five, which are defined solely based on voltage level and connection point. Table III presents the classification of consumers under the new network charge calculation system.

Table III. - Classification of consumers under the new network charge system

User group 0	System users connected to an LV feeder with a nominal voltage of 400/230 V.
User group 1	System users connected to LV busbars in a transformer substation.
User group 2	System users connected to an MV feeder with a nominal voltage of 35, 20, or 10 kV.
User group 3	System users connected to MV busbars in a distribution-transformer substation.
User group 4	System users connected to an HV feeder with a nominal voltage of 400, 220, or 110 kV.

The connection power tariff is replaced by five tariffs for the agreed power, which apply to each of the five time blocks. The highest price is set for Time Block 1, while the lowest applies to Time Block 5. Additionally, a tariff for excess power is introduced in cases where the agreed power exceeds the allowed limit. The network charge for consumed active energy, which was previously calculated using HT, LT, and ST tariffs, is now replaced by five tariffs, each linked to a specific time block. The allocation of time blocks depends on whether the day is a non-working day, the hour of the day, and the season. Within a single day, a maximum of three different time blocks can occur. Table IV presents the duration of each time block under the new network charge calculation system [12].

Table IV. - Duration of each time block under the new network charge calculation system

Hour of the day	Working day in S1*	Working day in S2*	Non-Working Day in S1	Non-Working Day in S2
0	4	5	5	5
1	4	5	5	5
2	4	5	5	5
3	4	5	5	5
4	4	5	5	5
5	4	5	5	5
6	2	4	5	5
7	1	3	4	5
8	1	3	3	5
9	1	3	3	4
10	1	3	3	4
11	1	3	3	4
12	1	3	3	4
13	1	3	3	4
14	2	3	4	5
15	2	3	4	5
16	2	3	4	5
17	1	3	3	5
18	1	3	3	5
19	1	3	3	5
20	2	4	3	5
21	2	4	4	5
22	4	4	5	5
23	4	5	5	5

*S1 represents the colder period of the year, covering the months of January, February, November, and December, when electricity consumption is generally higher.
*S2 represents the warmer period of the year, including the months of March, April, May, June, July, August, September, and October, when electricity consumption is generally lower.

The following section presents the new methodology for network charge calculation in Slovenia using the example of a household consumer (apartment) with and without a balcony solar power plant and a battery storage system.

3. Analysis of electricity consumption, production, and storage in a household consumer with and without a balcony solar power plant and a battery storage system

This section analyzes electricity consumption for a household consumer (apartment) with a floor area of 74 m² in a multi-apartment building. The apartment is situated in the northeastern region of Slovenia, characterized by warm summers (average daily temperature of 26°C) and cold winters (average daily temperature of 2°C). An electric water heater provides domestic hot water, while heating is supplied via infrared (IR) panels, which operate as electricity consumers. The apartment has a contracted connection power of 6 kW, with a supply via an LV cable (1x25A).
Figure 1 presents 15-minute resolution electricity consumption data for the household consumer over one year. The analysis indicates an average electrical power demand of 545.4 W, a peak demand of 4,824 W, and an annual electricity consumption of 4,777.4 kWh.

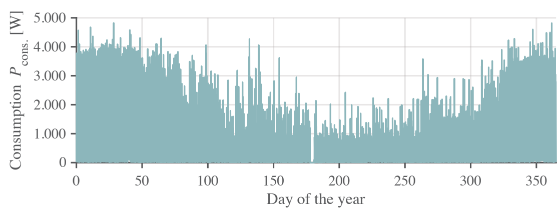

Fig.1. Electricity consumption of the analyzed household consumer

The total costs for the household consumer (apartment) are presented in Figures 2 and 3, considering both the old and new network charge calculation methods.

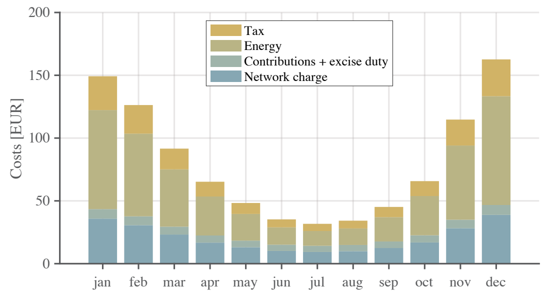

Fig.2. Cost structure of electricity in the case of the old network charge calculation system without a balcony solar power plant

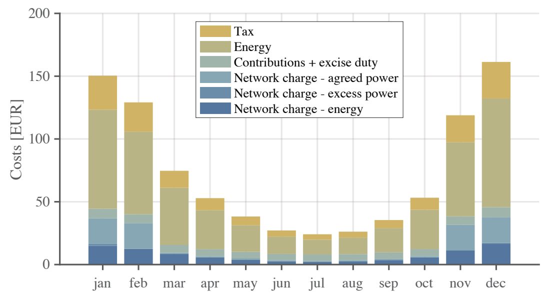

Fig.3. Cost structure of electricity in the case of the new network charge calculation system without a balcony solar power plant

Figures 2 and 3 illustrate the electricity cost structure under the old and new network charge calculation systems for the household consumer (apartment) monthly. The annual electricity costs under the old network charge system amount to 970.13 EUR, whereas under the new system, they total 891.81 EUR, representing an 8% reduction in household expenses.

The following section examines electricity costs when using a balcony solar power plant. A balcony solar power plant is a portable device that is plugged into a standard socket and features a built-in microinverter with a cable and plug. The output power of a balcony solar power plant must not exceed 600 W. Providers of these systems state that they can be connected to a socket like a household appliance, eliminating the need for professional installation. Manufacturers offer balcony solar power plants as complete kits that can be self-assembled and include all necessary components for operation [13].

This study analyzes the use of a balcony solar power plant with a nominal power of 400 W, an inclination angle of 90° (mounted on a balcony railing), and an azimuth angle of 0° (facing south). Figure 4 presents the electricity generation of the balcony solar power plant.

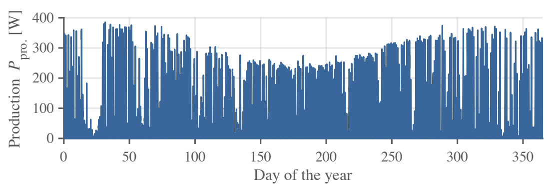

Fig.4. Electricity generation of the balcony solar power plant for the analyzed household consumer

Figure 4 shows that the balcony solar power plant has an average generated electrical power of 53.43 W, a maximum electrical power of 385.35 W, and an annual electricity generation of 468.1 kWh.

Since electricity consumption and generation are calculated based on 15-minute data, 2.07 % of the generated electricity is fed into the grid, while 97.93 % is consumed from the grid, as shown in Figure 5.

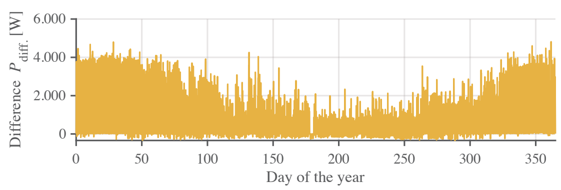

Fig.5. Difference between electricity consumption and generation of the balcony solar power plant for the analyzed household consumer

Using the balcony solar power plant results in a 7.3% cost reduction, bringing the annual electricity cost to 834.80 EUR. Figure 6 presents the electricity cost structure under the new network charge calculation system for the household consumer with a balcony solar power plant.

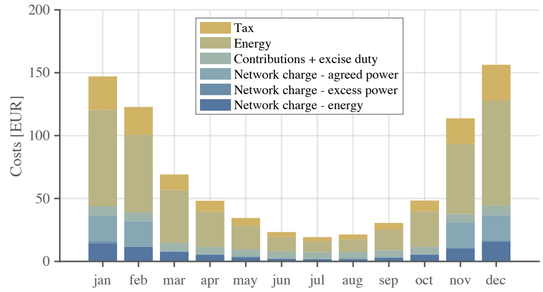

Fig.6. Cost structure of electricity in the case of the new network charge calculation system with a balcony solar power plant

Including a battery storage system with a capacity of 1000 Wh, a charging and discharging power of 800 W, and a cycle life of 4000 further reduces the annual electricity costs. Figure 7 presents the power flow profile to and from the grid, the charging and discharging profile of the battery storage system, and the state of charge of the battery storage system.

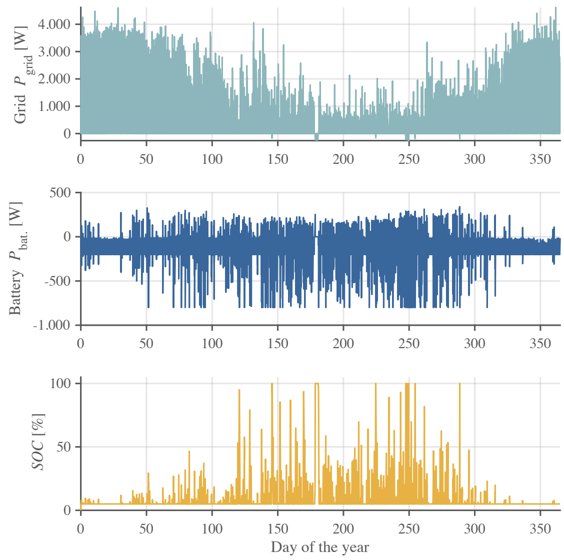

Fig.7. Power flow profile to and from the grid, to and from the battery storage system, and state of charge of the battery storage system

In the case of using both the balcony solar power plant and the battery storage system, the energy taken from the grid is 3,363 kWh. The reduction in the share of energy taken from the grid when using only the balcony solar power plant is 23.6 %. The energy fed into the grid is only 5.38 kWh. Additionally, the reduction in the share of energy fed into the grid compared to using only the balcony solar power plant is 94.2 %. The cost structure of electricity in the case of using the new network charge calculation system with a balcony solar power plant and a battery storage system is presented in Figure 8.

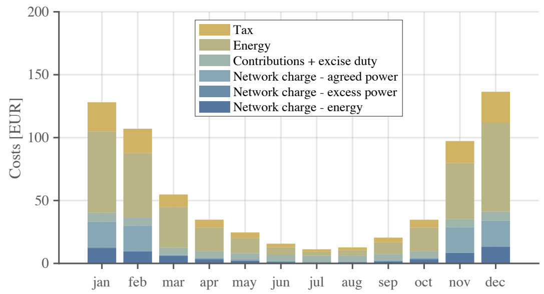

Fig.8. Cost structure of electricity in the case of the new network charge calculation system with a balcony solar power plant and a battery storage system

Using the balcony solar power plant and battery storage system results in a 23.9 % cost saving, with the annual electricity cost amounting to 678.03 EUR.
In this analysis, the investment cost for the balcony solar power plant is 300 EUR, while the investment cost for the battery storage system is 580 EUR. As a result, the payback period for the balcony solar power plant is 5.6 years. In contrast, the payback period for the balcony solar power plant combined with the battery storage system is 4.2 years. Figures 9 and 10 show the payback period for the investment in the balcony solar power plant and the combined investment in the balcony solar power plant and battery storage system.

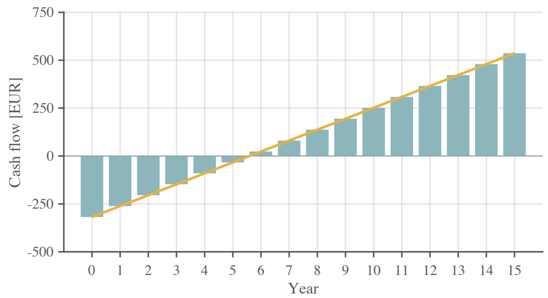

Fig.9. Payback period of the investment in the balcony solar power plant under the new network charge calculation system

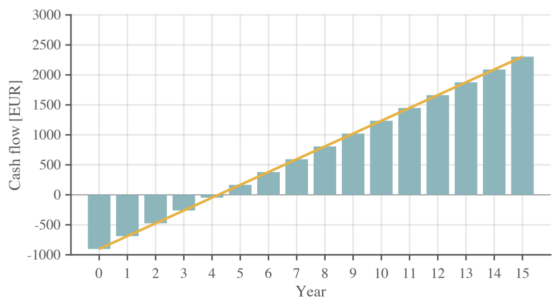

Fig.10. Payback period of the investment in the balcony solar power plant and battery storage system under the new network charge calculation system

The presented savings assume an ideal battery system. Losses due to charging and discharging, degradation over time, and maintenance costs are not included in the model.

4. Conclusion

The new methodology for network charge calculation in Slovenia introduces significant changes aimed at a fairer distribution of electricity costs from the network perspective. Additionally, the new system contributes to better stability and adaptability of the distribution network by encouraging active participation from users, such as prosumers. The article presents the case of a household electricity consumer (apartment) who can be actively involved in energy management. The presented results show that with the new network charge calculation model, the household consumer can actively participate in energy management and achieve cost savings. Considering that the investment cost for the household consumer (per apartment) is relatively low, this presents an additional opportunity for investing in a balcony solar power plant with a battery storage system.
Although the focus of this paper is primarily economic, the reduction in energy drawn from the grid—particularly during high-price periods—also suggests a potential for peak shaving and improved load balancing. These effects could have broader implications for network stability, which should be explored in future technical analyses.
Such considerations are also reflected in other EU countries, where dynamic network tariff models have been introduced to influence consumption behaviour through time-based pricing. While the Slovenian approach follows the same general objective, its five-block structure with fixed time allocation provides greater temporal granularity and may offer more predictable conditions for household consumers.

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