BREAK-EVEN POINT OF STORING ELECTRICITY IN LITHIUM BATTERIES FOR PROSUMERS IN ROMANIA

Vladimir ABLAI[1], Gheorghe SAMOILESCU[2], Valerian NOVAC[3]

The introductory part of the work presents the Romanian National Energetic System and the roles of prosumer. The work then proceeds with a detailed overview of the regulatory framework for consumers and prosumers, instilling confidence in the thoroughness of the research. The article's method chapter proposes investigating the economic opportunity to use photovoltaic systems with batteries for energy storage. In the concluding section of the article, the authors compared injecting energy into the National Energetic System and storing it in life-cycle batteries, emphasizing the efficiency of the latter.

Keywords: prosumer, battery, energy, electricity storage, photovoltaic system

List of abbreviations

NES	National Energetic System
PROSUMER	PROducer conSUMER
RON	ROmanian New currency
kWh	kilowatt hour
VAT	Value Added Tax
GW	Giga Watt
MW	Mega Watt
DC	Direct Current
AC	Alternating Current
U_{mpp}	Voltage at maximum power peak
V_{dc}	Voltage direct current
V_{ac}	Voltage alternating current
PV	Photovoltaic
PVS	Photovoltaic System
PVGIS	Photovoltaic Geographical Information System
cm/s	Cubic meter per second
LFP	Lithium iron phosphate

[1] PhD Student, Military Technical Academy ”FERDINAND I”, Bucharest, Romania, e-mail: vladimir_ablai@yahoo.com
2 Professor, Military Technical Academy ”FERDINAND I”, Bucharest, Romania, e-mail: samoilescugheorghe@yahoo.com
3 PhD Student, ”Dunarea de Jos” Galati University, Galati, Romania, e-mail: valerian.novac@ugal.ro

NMC	Nickel Manganese Cobalt
NCA	Nickel Cobalt Aluminum
SB	Sell buy
Ah	Ampere hour
U	Voltage
C	Capacity
DoD	Depth of Discharge
η	Efficiency
CL	Cycles
Et	Total energy
P_{us}	Energy storage
P_a	Purchase price

1. Introduction

Our research takes a unique approach, aiming to uncover the minimum efficiency threshold at which the cost of lithium battery storage aligns with that of injecting into Romania's national grid. This novel perspective adds a fresh dimension to the energy sector discourse.

This paper offers a timely snapshot of the current situation amidst the ever-changing landscape of regulations and system costs, influenced by global price trends, electricity price fluctuations, and the Romanian tax system. Our extrapolations of the general trend provide practical and invaluable guidance for policymakers and industry professionals, aiding in their decision-making processes.

Romania's National Energy System (NES) [1] is crucial in transmitting electricity from various sources (nuclear, thermal, hydropower, wind, and photovoltaic) to consumers. This complex system, similar to those in other developed countries, forms the backdrop of our research.

Consumers who use renewable sources like wind and photovoltaic play a pivotal role in balancing their consumption with the fluctuating production. This active participation is challenging, as production often falls short of requirements, leading to a shortfall in the grid. At other times, production exceeds consumption, resulting in an unused surplus. This surplus underscore the crucial importance of some energy storage systems on site or on grid scale.

2. Snapshot of Romanian legislation

The legislation aims to regulate when a consumer can inject electricity into the grid to avoid losing unused energy. Electricity can only pass through a bidirectional energy meter after an approved project. All the equipment used complies with technical standards accepted at the national/European level. The consumer who can inject electricity into the grid is called the PROSUMER (combination of PROducer and conSUMER) [2].

The National Energy Regulatory Agency, a key authority in the energy sector, houses the legislation that governs prosumers.

It's crucial to understand that every consumer has the right to inject surplus renewable electricity into the grid, if their installation design meets the distributor's requirements. This right is not just a privilege, it's a guarantee of fair treatment and security, ensuring consumers are on par with suppliers [3].

For a household consumer, the active electricity price represents about one-third of the total (the difference comes from taxes, green certificates, excise duties, subscriptions, services, etc.). For injected energy, most suppliers pay the difference between the energy consumed and the energy injected within the maximum period allowed by law—24 months. Prosumers do not pay taxes or duties on the amounts collected [4].

In Romania, until 31 March 2025, prices have been capped as follows:

- for domestic consumers consuming less than 100kWh/month, the price is capped at a maximum of 0.68 RON/kWh;

- for household consumers consuming between 100.01 and 255 kWh/month, the price is capped at a maximum of 0.80 RON/kWh;

- non-household and household consumers exceeding 255 kWh/month, the maximum ceiling is 1.3 RON/kWh [5].

Prices include all taxes. Exchange rate: 1 RON is about 0.20 EUR.

The key difference between the contract and capped prices is that the latter comes with subsidies, providing financial relief for consumers. Moreover, vulnerable consumers are also supported, both by being included in the minimum ceiling even if they exceed the consumption thresholds, and by an energy card that provides them with a sum for the purchase of electricity, heating coal, wood or heating fuel. This comprehensive support ensures that the energy market is inclusive and caters to every consumer [6].

Various programs are in place to promote energy efficiency and environmental sustainability. These include producing energy from renewable sources, installing heat pumps, replacing central heating and household appliances with more efficient ones, and reducing heat loss from buildings. In 2023, there is also a measure to reduce VAT to 5% for photovoltaic panels, solar thermal, and high-efficiency low-emission heating systems (heat pumps). In 2024, this increased to 9%, still reduced from the general 19%. These initiatives reduce energy costs and contribute to a greener and more sustainable future [7].

To understand the renewable electricity market in Romania, we have simplified the main benchmarks for consumers or specific prosumers. This picture is constantly changing. Currently, prosumers have an estimated capacity of 1.5 GW. This capacity will increase by at least 300 MW following the "Green House

2023" program, "Green House 2024" program and independent installations [8, 9].

3. Photovoltaic system and payback time

We will focus on photovoltaic systems (PVS) as other systems are insignificant in terms of share for prosumers.

Any photovoltaic system is composed of:

- photovoltaic panels (semiconductors that produce energy due to the photoelectric effect);
- the power conditioning subsystem (also known as inverter);
- batteries (i.e., lead-acid, lithium);
- complementary energy source (grid, diesel generator).
- accessories: fixing or sun-tracking system, cables, protection devices, and others [10].

The principle diagram of a photovoltaic system is shown in Figure 1.

The photovoltaic generator consists of series/parallel connected cells that produce direct current at a specific voltage and current. Depending on their technical characteristics, each panel produces maximum power at an instantaneous solar irradiance around the Umpp voltage (mpp - maximum power peak). The electricity produced by the panels requires conversion to a standardized value: 12 Vdc, 24 Vdc, 48 Vdc for direct current and 230 Vac, 400 Vac at 50 Hz (for Europe) for alternating current, by the inverter [12, 13].

The inverter keeps the panels in the maximum power zone and provides a standard voltage at the output. When strings have differently oriented panels (tilt and azimuth), a system optimizer is required to keep the string panels in the Umpp, maximum output voltage zone. Some systems also have mechanical devices that orient the panels towards the sun (sun tracker) [14-16].

To estimate the yield of a system, we can use online simulator software like PVGIS [15]. For a monoracial PV system outside Constanta, in the Romanian coastal area, with 10 kW coupled to the grid, south-oriented and tilted at the optimum of 35° with losses of 14%, we have estimated monthly production done by PVGIS (rounded values in kWh) in Table 1 (where PVG is the abbreviation of PVGIS).

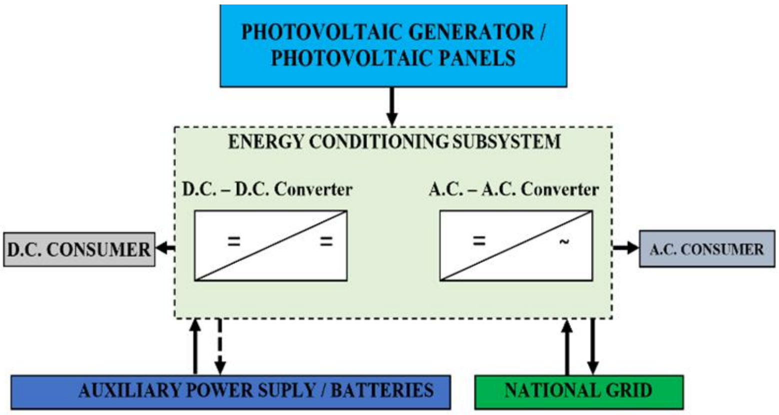

Fig. 1. On-grid photovoltaic system [11]

Values can differ from reality and are influenced by air temperature, dust, and clouds [16 -18]. Estimation is given by the meteorological database used to calculate energy production (in PVGIS, we used the SARAH2 database). Thus, in some years, the model will fit better than in other years [19].

Table 1

Estimated monthly production [kWh]

Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
PVG	627	699	1,177	1,310	1,436	1,459	1,559	1,591	1,274	960	635	575	13,302

We chose a 10kW system because it is easy to scale, covers 500 kWh/month (normal household consumption in Romania), and is achievable with a single-phase alternating current connection. A functioning system with the necessary injection approvals costs about 35,000 RON in Romanian currency (the medium price is 700 EUR/kW for the 3-10kW range). As a consumer, you hold the power to choose your electricity supplier. While the purchase price remains the same as in the supply contract, this can vary depending on the supplier and the area. You can select from various tariffs listed on the National Energy Regulatory Agency website, catering to both domestic and non-domestic consumers who require a competitive offer for 500 kWh/month. We present two well-known companies: Hidroelectrica S.A. (SPEEH) and Electrica Furnizare S.A. (EF). However, it's important to note that the information is less detailed compared to 2023, and the offers list the amounts paid directly by the consumer, not the price cap subsidy to deduce what would be the price evolution after the subsidy stops.

At the end of January 2024, the proposal for 'household consumer' and 'non-household consumer ', terms used in Romanian legislation, was as detailed in table 2.

Table 2

Comparative costs of the energy among two suppliers

Consumer type	Supplier	Monthly consumption [kWh]	Monthly invoice value [RON]	Annual cost [RON]	Overall energy price [RON/kWh] 6 = 4/3	Supplier active energy price [RON/kWh]	Distribution/ transport cost and fees [RON] 8 = 6-7
1	2	3	4	5	6	7	8
Household	SPEEH	500	419.27	5,031.24	0.84	0.28382	0.55
	EF	500	650	7800	1.30	0.66499	0.64
Non - household	SPEEH	500	632.28	7,587.36	1.26	0.64182	0.62
	EF	500	650	7,800	1.30	0.6684	0.63

In the worst-case scenario, where the consumer needs energy at night when solar power is not available, all the energy is delivered to the grid. In Table 3, column 8, we calculated the system's payback period (35,000 RON) as follows.

Table 3

The payback period

Consumer type	*Supplier*	*Annual production of the photovoltaic system [kWh/ year]*	*Supplier active energy price [RON/kWh]*	*Annual value of energy injected [RON] 5=3x4*	*Photovoltaic system cost [RON]*	*Profitability 7=5/6*100 [%]*	*Return on investment [years]*
1	2	3	4	5	6	7	8
Household consumer	SPEEH	13,300	0.28	3,775.47	35,000	11	9.27
	EF	13,300	0.66	8,845.70	35,000	25	3.96
Non-household consumers	SPEEH	13,300	0.64	8,537.49	35,000	24	4.10
	EF	13,300	0.67	8,891.06	35,000	25	3.94

The payback period is 4-9 years, depending on the situation. In reality, it is about two years late because most suppliers prefer to pay for the energy injected now at the 24-month limit allowed by the current legislation. There are exceptions—suppliers who pay in the month following injection [24, 25].

For example, if a prosumer used an average of 300 kWh of his production, which is 60% of his monthly energy needs, the amount paid to the supplier would be reduced, and the surplus would bring financial benefits. The difference in annual bills paid with and without PV would be as follows:

Table 4

The extra cost of grid energy without solar component

Consumer type	*Supplier*	*Annual energy consumption [kWh/ year]*	*Self-consumption [kWh/ year] 4=3x0.6*	*Energy from grid [kWh/ year] 5=3x0.4*	*Overall energy price [RON/ kWh]*	*Annual grid energy costs [RON]*	*Annual costs of grid energy without solar*	*Annual difference [RON] 9=8-7*

						7=5x6	*system [RON]*	
1	2	3	4	5	6	7	8	9
Household consumer	SPEEH	6,000	3,600	2,400	0.84	2,016	5,031.24	3,015.24
	EF	6,000	3,600	2,400	1.3	3,120	7,800	4,680
Non-household consumers	SPEEH	6,000	3,600	2,400	1.26	3,024	7,587.36	4,563.36
	EF	6,000	3,600	2,400	1.3	3,120	7,800	4,680

Table 5 column 7 presents the value of the energy fed into the grid in national currency.

Table 5

Energy fed into the grid

Consumer type	Supplier	Annual production of the photo-voltaic system [kWh/ year]	Self-consumption [kWh/ year]	Energy sent to grid [kWh/ year] 5=3-4	Supplier active energy price [RON/ kWh]	Injected energy value [RON] 7=5*6
1	2	3	4	5	6	7
Household consumer	SPEEH	13,302	3,600	9,702	0.28382	2,753.622
	EF	13,302	3,600	9,702	0.66499	6,451.733
Non-household consumers	SPEEH	13,302	3,600	9,702	0.64182	6,226.938
	EF	13,302	3,600	9,702	0.6684	6,484.817

On the one hand, such a consumer pays lower bills, and on the other, he benefits from the value of the energy injected. The system promoted for prosumers in Romania has enabled the rapid development of photovoltaic energy, which will continue to develop rapidly [26].

The two advantages outlined above can be combined, with the result that the return on investment in the photovoltaic system is entirely achievable in this way: The payback occurs with an increase in the percentage of energy consumed by self-consumption. Thus, the payback decreases from 9 years when all energy is injected into the grid to only six years when self-consumption is 60%, while for other consumers, it decreases to 3 years from 4, as presented in Table 6.

Table 6

Return on investment

Consumer type	*Supplier*	*Injected energy value [RON/year]*	*Annual difference [RON/ year]*	*Total [RON/ year]*	*System cost [RON]*	*Return on investment [years] 7=6/5*
1	2	3	4	5	6	7
Household consumer	SPEEH	2,753.62	3,015.24	5,768.86	35,000	6.07
	EF	6,451.73	4,680	11,131.73	35,000	3.14

Non-household consumers	SPEEH	6,226.94	4,563.36	10,790.3	35,000	3.24
	EF	6,484.82	4,680	11,164.82	35,000	3.13

In conclusion, for prosumers, the efficient way is to cover most of their own consumption. For selling energy, it is better to become a producer because they receive also "Green Certificates" (money) for energy delivered. But the accelerated and uneven development of prosumers photovoltaic systems in Romania can strain segments of the grid. In areas with a lot of PVS, the voltage rises above the permissible limit at midday, and at evening peak the voltage drops near the acceptable limit. Mainstream producers also have to adjust their production according to the output of PVS and wind systems, which can vary rapidly. While hydropower seems simple when there is water in the ponds, starting up a conventional fuel plant is a process that takes many hours. If these thermal power plants are kept ready to supply energy, this means consuming fuel to keep the plants preheated and the steam under pressure, ready for use. We will see in the future whether a charge for balancing the grid from renewables due to keeping some plants in reserve and whether the energy injected is charged as a source of income for individuals or companies [27, 28].

As a prosumer, you have the power to contribute to grid balancing. One least known practical measure is to mount your panels oriented differently from the theoretical optimum (east or west), i.e. peak production should occur in the morning or evening when southbound production falls. Additionally, if your panels are tilted above the recommended optimum of 35%, this can also help to reduce peaks in summer but with more production in winter. Some studies propose this option for reducing storage capacity [29].

Even time-of-use energy meters can help regulate the market and stimulate the consumer to offset the panels. Suppliers will be able to better pay for energy injected at peak consumption time [30].

4. Method

As mentioned above, a prosumer can inject surplus energy and take the difference between demand and production from the grid.

However, the reality is not as straightforward. The effectiveness of prosumer systems is highly dependent on the location of the PV system. In areas where the grid is not designed to accommodate prosumers, such as neighborhoods with multiple prosumers, the voltage can exceed the inverter's operating limit at midday. This leads to a temporary halt in energy injection until the voltage drops below the permissible limit, highlighting the need for grid adaptation or for installing some energy storage system.

Today, there are many energy storage systems: thermal, mechanical, electrochemical, electrostatic, electromagnetic, etc. Each system has advantages or disadvantages that prevent implementation at the local or energy system level.

At the grid level, the most ambitious storage system in Romania is a project more than 30 years old, the Tarnița-Lăpuștești dam, whose primary data:

- Upper lake Lăpuștești – 10,000,000 cubic meters;
- Lower Lake Tarnița – 15,000,000 cubic meters;
- Mean falls 564 m;
- Equipment - reversible hydro-aggregates 4x250 MW;
- Generator flow 212 cm/s;
- Pumping flow 152 cm/s;
- Efficiency 0.78;

in accordance with [31].

Fig. 2. Tarnița – Lăpuștești pumped storage plants [31]

We will see if this project ever materializes, so it cannot be an energy storage solution for prosumers in the short to medium term. Lead-acid and, more recently, lithium batteries are the most popular storage solutions accessible to the general public [32].

We will not analyze lead-acid batteries, because they cannot be a renewable electricity storage solution. Although they have evolved over more than a hundred years and despite some definite advantages, such as cost, easy recycling, and resistance to temperature variations, the main problems remain: low energy density, self-discharge, a low number of charge-discharge cycles, and regular maintenance. With the advent of lithium-based cells, we've witnessed significant advancements in energy storage technology. These cells are now used in series or parallel to accomplish the required voltage and current. The most expensive batteries are high voltage ones because they apply patented technologies for safety and long life. Low-voltage batteries (48, 24 and 12 V) are somewhat cheaper in stationary storage systems [33].

In the article published in collaboration with three other colleagues [11], we looked at two types of batteries (Orient Power OP48V230 and Huawei Luna 2000-10-S0) used for storing electricity.

We concluded that for the situation in 2023, only one of the two analyzed (OP48V230) can be cost-effective compared to grid injection. Huawei Luna 2000-10-S0, a high-voltage battery, is more expensive and has a lower cycle count than the competitor mentioned. Even so, the payback time was more than 14 years unless conditions for prosumers changed radically. The prices were cut, but storage is still costly. In stationary applications for energy storage, lithium iron phosphate (also called LFP or LiFePO4) batteries are emerging as a promising solution. They have a marginally lower energy density than other lithium alternatives but have the advantages of a low fire risk and a low price. Other less common lithium-ion types are also used for storage: nickel manganese cobalt (NMC), nickel cobalt aluminum (NCA), etc. [34, 35].

In addition to these types, we have promising alternatives like pumped electrolytes ("redox flow"), solid-state, or early-stage sodium batteries. Redox flow battery consists in two tanks with liquid electrolytes, pumps, and electrodes separation ion transfer membrane. Tanks can be sized according to capacity needed. Although they are theoretically low-priced, due to the fact that they are not mass-produced for small consumers, they cannot currently compete with lithium ones [36, 37].

In order to compare NES with battery storage, we will calculate the cost of lithium battery storage and compare it with grid injection. Thus, storing a kWh in batteries will have to be less than the difference between the final price billed and the price of the active energy injected [38], however the prosumers must be furnished with local storage devices (batteries) to prevent the direct transfer to the NES. For simplicity, we'll call it the SB difference (sell-buy). It represents the price difference between 1 kWh consumed and 1 kWh injected, billed by the supplier. This difference includes all taxes, excise duties, tariffs, certificates, contributions, and other fees paid to transport 1 kWh from the supplier to the consumer. SB difference is calculated in Table 7.

Table 7

Sell-buy difference

Consumer type	*Supplier*	*Overall energy price [RON/ kWh]*	*Injected energy price [RON/ kWh]*	*Injected price/final price ratio [%] 5=4/3x100*	*SB difference [RON/ kWh] 6=3-4*
1	2	3	4	5	6
Household consumer	SPEEH	0.84	0.28382	33.79	0.55618
	EF	1.3	0.66499	51.15	0.63501

Non-household consumers	SPEEH	1.26	0.64182	50.94	0.61818
	EF	1.3	0.6684	51.42	0.6316

If the price of storing a unit of energy is higher than SB difference, is more advantageous to inject into the grid and directly collecting the value of the energy supplied. But in cases where the interruption of energy can cause significant damage to the consumer is it justified to use storage to avoid interruptions in energy supply. We underline that most suppliers make payments towards the limit of the 24 months allowed, so this is where inflation comes in [39].

We have to take in account unavoidable losses like: self-discharge, the conversion losses of DC from panels to DC current required by the accumulators and of DC from accumulators to AC required by consumers, resistive losses, and other types of loses.

Also, the wear/degradation of batteries is inevitable. The capacity (C - measured in Ah) of a battery is not constant over time. As time passes and charge-discharge occurs, the capacity reduces. Also, battery voltage U varies with charge. By multiplying the Un-rated voltage and C, we will find the stored energy in the battery. Therefore, the battery will be kept in the optimum temperature range and charged-discharged up to a limit expressed as a percentage of capacity/hour. It is recommended to avoid discharging below a certain threshold (usually 0.2 C), so manufacturers give the number of charge-discharge cycles from 100% to 20% C (known as 80% or 0.8 DoD - Depth of Discharge), usually stated as 3000-10000 cycles (CL) until the capacity drops to 0.8 C. This is practical the lifespan of the battery, regardless of the technology on which it is based. The overall efficiency is η. We can consider η value to be 0.8, an achievable value under normal operating conditions if we consider that the battery efficiency is above 0.9.

In conclusion, the total energy (E_t) stored over the lifetime of the battery is [40] presented in the next formulas:

$$E_t = U_n \times C \times DoD \times CL \times \eta \qquad [Wh] \tag{1}$$

Usually, we use kWh, so energy is:

$$E_t = U_n \times C \times DoD \times CL \times \frac{\eta}{1000} \quad [kWh] \tag{2}$$

The unit price of energy storage (Pus) is the ratio of the price of acquisition (Pa) of the battery to the total energy (Et). It means how much it costs to store energy until the battery's end of its lifecycle.

$$P_{us} = \frac{P_a}{E_t} \quad [RON/kWh] \tag{3}$$

$$Pus = Pa/((Un \times C \times DoD \times CL \times \eta/1000)) \ [RON/kWh] \quad (4)$$

If storing a kWh in a battery is more cost-effective than the average SB difference, then it presents a promising opportunity to store energy in batteries [41].

We will figure the maximum purchase price of an LFP battery used in stationary storage solutions: 3.2 V, 280 Ah, 0.8960 kWh. As we mentioned before, in order to achieve a designed number of cycles, we do not exceed 0.8 DoD, meaning a maximum of 0,717 kWh is usable. With these inputs, we will find the break-even price of the complete system (case, battery management system, display, other devices, and components). In a similar way, we have to quantify the cost of storing one unit of energy (Pus, in kWh) for the situation when the storage is equal to the for different types of batteries (depending on the number of cycles). We will thus find the threshold at which storage becomes financially profitable. The Pus will represent the maximum price per kWh paid for storage to be efficient, on a par with SB difference. If it is higher, it is more cost-effective to sell the energy produced.

5. Results and discussion

In this chapter, the authors evaluate different types of batteries and search for the optimum ratio between Pus, number of cycles, and costs [42]. In Table 8, we calculate the break-even price of a 280Ah LFP battery and of a stored energy unit (1 RON=0.2 EUR). The usable energy was determined as a mean value for a full-day time interval.

Table 8

The Pus for 3,000 cycles battery

Consumer type	*Supplier*	*Usable energy [kWh]*	*CL [cycles]*	*η*	*Stored energy [kWh]*	*SB difference [RON]*	*Maximum purchasing price of 280Ah battery [RON]*	*Pus [RON/ kWh]*
Household consumer	SPEEH	0.72	3,000	0.8	1,720.32	0.56	956.81	1,334.83
	EF	0.72	3,000	0.8	1,720.32	0.64	1,092.42	1,524.02
Non-household consumers	SPEEH	0.72	3,000	0.8	1,720.32	0.62	1,063.47	1,483.63
	EF	0.72	3,000	0.8	1,720.32	0.63	1,086.55	1,515.84

According to the Table 9 [43], we have proportionally higher values for the same battery but certified with 6,000 cycles.

Table 9

The Pus for 6,000 cycles battery

Consumer type	*Supplier*	*Usable energy [kWh]*	*CL [cycles]*	*η*	*Stored energy [kWh]*	*SB difference [RON]*	*Maximum purchasing price of 280Ah battery [RON]*	*Pus [RON/ kWh]*
Household consumer	SPEEH	0.72	6,000	0.8	3,440.64	0.56	1,913.62	2,669.66
	EF	0.72	6,000	0.8	3,440.64	0.64	2,184.84	3,048.05
Non-household consumers	SPEEH	0.72	6,000	0.8	3,440.64	0.62	2,126.93	2,967.26
	EF	0.72	6,000	0.8	3,440.64	0.63	2,173.11	3,031.68

Corresponding to a battery with 8,000 cycles [44], we obtained the values in Table 10.

Table 10

The Pus for 8,000 cycles battery

Consumer type	*Supplier*	*Usable energy [kWh]*	*CL [cycles]*	*η*	*Stored energy [kWh]*	*SB difference [RON]*	*Maximum purchasing price of 280Ah battery [RON]*	*Pus [RON/ kWh]*
Household consumer	SPEEH	0.72	8,000	0.8	4,587.52	0.56	2,551.49	3,559.55
	EF	0.72	8,000	0.8	4,587.52	0.64	2,913.12	4,064.06
Non-household consumers	SPEEH	0.72	8,000	0.8	4,587.52	0.62	2,835.91	3,956.35
	EF	0.72	8,000	0.8	4,587.52	0.63	2,897.48	4,042.24

Lately, there have been batteries that promise 10,000 cycles [45], and we get values in Table 11.

Table 11

The Pus for 10,000 cycles battery

Consumer type	*Supplier*	*Usable energy [kWh]*	*CL [cycles]*	*η*	*Stored energy [kWh]*	*SB difference [RON]*	*Maximum purchasing price of 280Ah battery [RON]*	*Pus [RON/ kWh]*
Household consumer	SPEEH	0.72	10,000	0.8	5,734.4	0.56	3,189.36	4,449.44
	EF	0.72	10,000	0.8	5,734.4	0.64	3,641.40	5,080.08
Non-household consumers	SPEEH	0.72	10,000	0.8	5,734.4	0.62	3,544.89	4,945.44
	EF	0.72	10,000	0.8	5,734.4	0.63	3,621.85	5,052.80

In conclusion, the penultimate columns in tables above show the maximum purchase price of an LFP 280 Ah battery so the energy stored in it is at least equal to the difference in price between selling and buying energy.

The last column allows us to calculate the price for a bank of batteries (whatever the capacity, but with the appropriate CL) like those in storage systems. Again, the purchase price must be less than the energy declared as stored in the system multiplied by Pus.

Today, most systems have 3,000 cycles. If we have a complete cycle of 100% charge and consumption up to 20% of capacity, every day, theoretically, the battery would wear out in over eight years. This usage will increase as production and consumption vary (depending on weather conditions, season, and others). Currently, the cheapest systems of stored energy are 1000-1500 RON/kWh (200-300EUR/kWh). In the same price zone, we have calculated the unit price of storage (for CL= 3,000), so for the time being, the system will only pay for itself.

Theoretically, after 3,000 cycles, the capacity will drop to about 0.8, so it can still get something until replacement. If the damage caused by power interruption is high, purchasing an energy storage system is the choice.

On the other hand, buying a storage system with 10,000 cycles for about 1,500 RON/kWh each kWh bought will bring a material benefit after 10,000 cycles of at least 4,400 RON (considering that these cycles mean over 27 years). For the prosumer who consumes on average 500kWh/month (16.7 kWh/day), the minimum storage system needed for 0.8 DoD is 21 kWh per daily cycle if he uses energy only at night. We take a covering value, i.e., 25 kWh (multiple of 5), which costs around 30,000 RON. Although this is above what is needed, oversizing is especially useful in winter when are more cloudy hours. On the other hand, as energy is not pulled out under the 0.2C threshold, battery wear will decrease, exceeding designed cycles.

All data above present a snapshot of the Romanian prosumer market today. The government planned to help consumers to purchase batteries and photovoltaic systems in the "Green House 2024"program by increasing the subvention (from 20,000 RON to 30,000 RON) and allowing battery purchasing/integration in the system.

6. Conclusions

A prosumer photovoltaic system can recoup its initial cost within a maximum of 4 to 9 years. This payback period can be reduced by using most of the energy directly for self-consumption, a practice that is gaining traction in Romania.

Adjustments can be made to the panel orientation needed to increase production at certain times of the day or year. Thus, grid load and storage capacity can be smaller, making integrating photovoltaics easier.

While the current price of energy storage systems (about 1,500 RON / kWh – 3,000 cycles) is on par with the value received for the injected energy, it's important to note that storage is still an expensive and relatively complex process to integrate. However, with the phasing out of energy subsidies, we can expect to see a shift in energy prices and with a boost from Green House 2024" we will see the increasing role of LFP battery storage in the Romanian energy landscape.

For other batteries whose cycles increase to 6,000-10,000, storage becomes cost-effective because the price difference is small, around 20% (considering valuable lives of more than 16 years) with proportional benefit. For these high-cycle batteries, storage is explicitly efficient compared with injection.

The vast majority of these LFP batteries are made in China, but in 10 years, more than 250 battery factories are expected to compete in the market in Europe [46]. Today, makers, mainly from China, are trying to open their European factories, so the European energy storage market will be very competitive. This array will firmly pull prices down, a beneficial fact for prosumers and NES.

In this light, we assume that storage will soon be based on lithium in the short and medium term, which will help to integrate renewables into the national grid.

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