PV INTEGRATION IN THE MOLDOVAN POWER SYSTEM

MOLDOVA ENERGY SECURITY ACTIVITY

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TABLE OF CONTENTS

USE OF CAPACITY LIMITS ON PHOTOVOLTAIC SELF-CONSUMPTION

Aggregate and individual capacity limits for photovoltaic (PV) systems can serve as important mechanisms for achieving a balance between promoting renewable energy adoption, safeguarding utility financial stability, and ensuring grid reliability.

Individual capacity limits (i.e., capacity limits on individual PV systems) are usually used to define the suitability of self-consumption systems and typically consider the specific technical requirements and characteristics of the network. These caps serve as a means to identify the types of systems that can be seamlessly integrated into low-voltage networks while adhering to the national rules governing grid connection of generators. Stability and reliability of the network are often considered when defining these caps, which means that distribution network operators are usually consulted before applying them. In general, as shown in the benchmarking of similar regulations included in this report, countries include in their regulations a limit that is equal to the connection capacity of the consumer. This limit ensures that the rating of existing equipment is sufficient for a PV installation even under the extreme scenario of maximum power injection to the grid.

On the other hand, aggregate capacity limits have a broader scope, helping utilities but also addressing the concerns of policymakers regarding the support scheme of distributed PV energy and self-consumption. Aggregate limits offer distribution system operators the ability to manage the integration of low-voltage PV systems smoothly, allowing them to easily calculate the impact on their networks and on their revenues and costs. For policymakers, aggregate limits enable the careful management of subsidies and other incentives, ensuring that costs remain in harmony with the available budget. Furthermore, when these limits are triggered, policymakers can reevaluate and adjust support policies based on the current socioeconomic and technological conditions. Of course, aggregate limits have disadvantages, especially if not chosen carefully, because they can prove detrimental to the growth of renewable energy in a country and prevent consumers from generating their own electricity, creating an unnecessary and unwanted barrier to the increase of self-consumption.

To align Moldova's efforts to reach national targets regarding the share of energy from renewable sources and to offer final consumers the ability to contribute to the decarbonization of the national economy, the amendments included in Articles 10 and 39 of the Renewable Energy Law establish the government's obligations to approve capacity quotas for each category of final beneficiaries to be offered for the implementation of the net billing mechanism, for which individual capacity ceilings may be established per power plant.

EUROPEAN UNION DIRECTIVES AND ENERGY COMMUNITY RECOMMENDATIONS

EUROPEAN UNION DIRECTIVES

The European Union (EU) Clean Energy for All Europeans package, encompassing directives such as the Renewable Energy Directive (RED II), the Electricity Directive, and the Energy Performance of Buildings Directive, collectively underscores the commitment to advancing renewable energy and sustainability. RED II has set ambitious targets for the deployment of renewable energy sources, including PV systems, to combat climate change and foster energy security. Central to this endeavor is the concept of PV self-consumption, which allows consumers to generate and utilize solar energy on site, reducing reliance on conventional power sources. The Electricity Directive complements this effort by recognizing the rights of consumers to generate, consume, and store their own renewable energy, promoting a decentralized and resilient energy system. These directives emphasize minimizing bureaucratic obstacles, ensuring fair compensation mechanisms, fostering a friendly environment toward self-consumption, and encouraging the formation of energy communities.

Notably, RED II focuses specifically on simplifying the notification procedures for grid connections. Member States are required to establish a simple notification procedure for installations or aggregate production units of renewable self-consumers and demonstration projects with an electrical capacity of 10.8 kW or less. This streamlined process involves notifying the distribution system operator, which has a limited time to accept the connection or propose alternatives based on safety or technical concerns. Additionally, Member States have the option to extend a simple notification procedure for installations with capacities exceeding 10.8 kW but not surpassing 50 kW, provided that grid stability, reliability, and safety are maintained. This paper's benchmarking section shows that some Member States have aligned these limits for simplified procedures with individual limits for self-consumption compensation mechanisms.

Furthermore, the Energy Performance of Buildings Directive, although not explicitly addressing self-consumption, indirectly supports the concept by promoting energy efficiency measures, thereby creating an environment in which energy consumption is minimized. Such an environment also facilitates on-site renewable energy generation. Collectively, these directives empower consumers to actively participate in the generation and consumption of renewable energy, aligning with the EU's broader goals of achieving a low-carbon future. Fair grid access for all citizens is the crucial factor that policymakers must consider when trying to transpose these directives into national laws.

Another aspect of this issue is the current energy crisis and how the EU has shown its determination to highlight the critical role of renewable energy in addressing this challenge. Proposed emergency legislation seeks to expedite the rollout of renewables and act as a bridge until the finalization of the updated Renewable Energy Directive (RED III).[1] At their core, the proposed regulations highlight the need for streamlined permitting processes for renewables, but most importantly, they underscore the resolve of EU leadership to prioritize renewables. This approach also suggests that Member States and Energy Community (EnC) Contracting Parties should focus on promoting renewable energy and eliminating barriers to its growth. One of the key factors to consider is how to incentivize and promote self-consumption, which is an important pillar for the growth of renewables.

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[1] SolarPower Europe, "EU proposes Emergency Legislation to accelerate renewable deployment," https://www.solarpowereurope.org/press-releases/eu-proposes-emergency-legislation-to-accelerate-renewable-deployment

ENERGY COMMUNITY RECOMMENDATIONS

The EnC Secretariat has published recommendations for the Contracting Parties on the transposition of EU directives into their legal and regulatory frameworks. These recommendations focus on improvements to primary legislation governing renewable energy accompanied by detailed secondary acts defining procedures, terms, and conditions for grid connection and market integration of self-consumption.

According to these recommendations, the legal framework should preserve the rights of self-consumers (prosumers) without discrimination in support schemes and define clear criteria and procedures for their renewable installations. Streamlined authorization procedures and transparent support schemes are vital; compensation mechanisms for the electricity produced should consider at least the market value of the electricity at the time of its injection to the grid. In this way, prosumers' security of investment can be preserved, which is pivotal for the growth of self-consumption.

Furthermore, the support schemes and compensation mechanisms should have clear eligibility criteria about installed capacity, voltage level of connections, and metering requirements. Installed capacity limits for self-consumption should generally not exceed the connection capacity of the customer. The EnC Secretariat suggests a limit for net metering at around 30 kW but generally recommends shifting to net billing or feed-in tariff mechanisms and underlines the importance of having clear deadlines in the legislation for the transition of all customers to the new regime.

Another important point mentioned in the recommendations is the need to incentivize self-consumption while ensuring in parallel that all network costs for grid usage will be retrieved by the operator. Finally, energy storage systems should be defined and included in the legal and regulatory framework, allowing their installation and operation. The EnC suggests including clear capacity and size limits for energy storage systems that can be installed for small-scale applications.

THE EVOLUTION OF RENEWABLE SOURCES IN MOLDOVA

Moldova's first attempts to promote the development of the renewable energy sector were in 2007 (Renewable Energy Law 160), but the results recorded until 2018 were rather modest. With the approval of the Law on the Promotion of the Use of Energy from Renewable Sources (Law no. 10/2016), through which EU Directive 2009/28/EC (RED I) was transposed, renewables acquired a new dimension and began growing exponentially. Although not all the support schemes established in Law 10/2016 have been fully implemented, the electricity generation projects from renewable sources, especially solar and wind, have fully benefited from the adapted legal framework, the opportunities offered by the developing electricity market, and the decreasing investment costs for these technologies. Thus, since 2018, the installed capacity of renewable energy sources has increased almost fivefold, from 37.2 MW to 174.7 MW as of the end of August 2023.

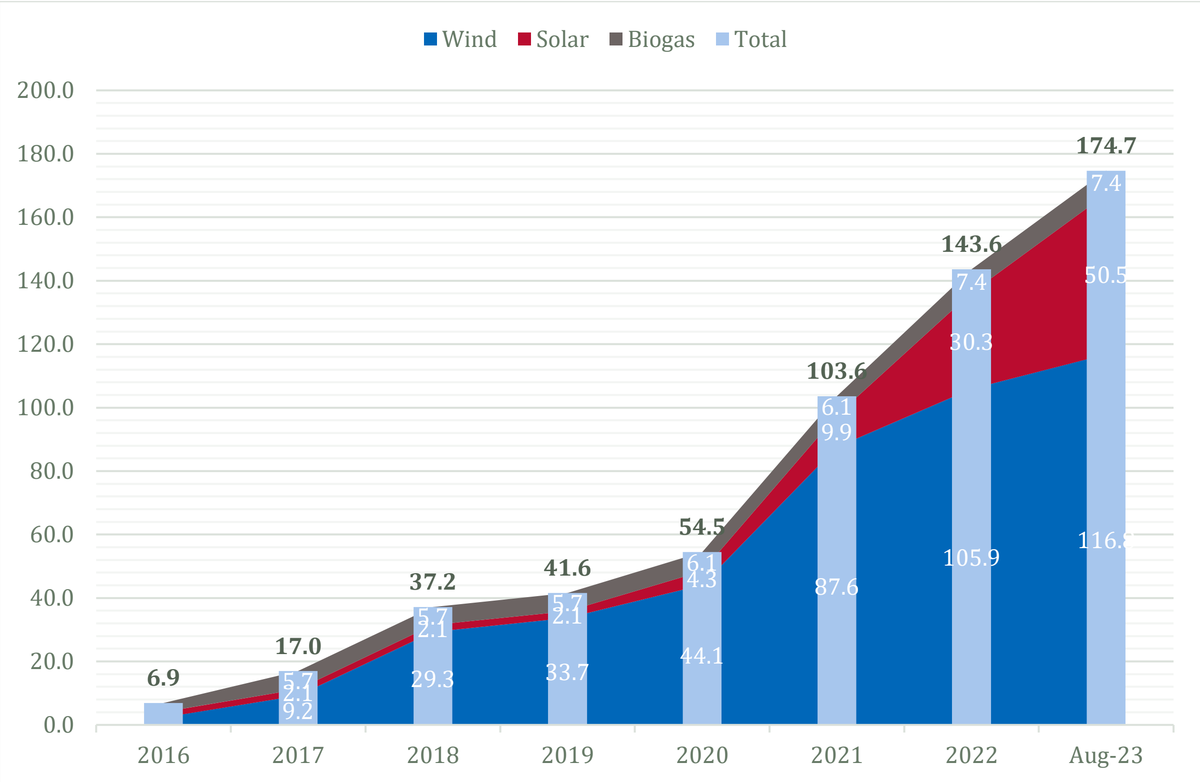
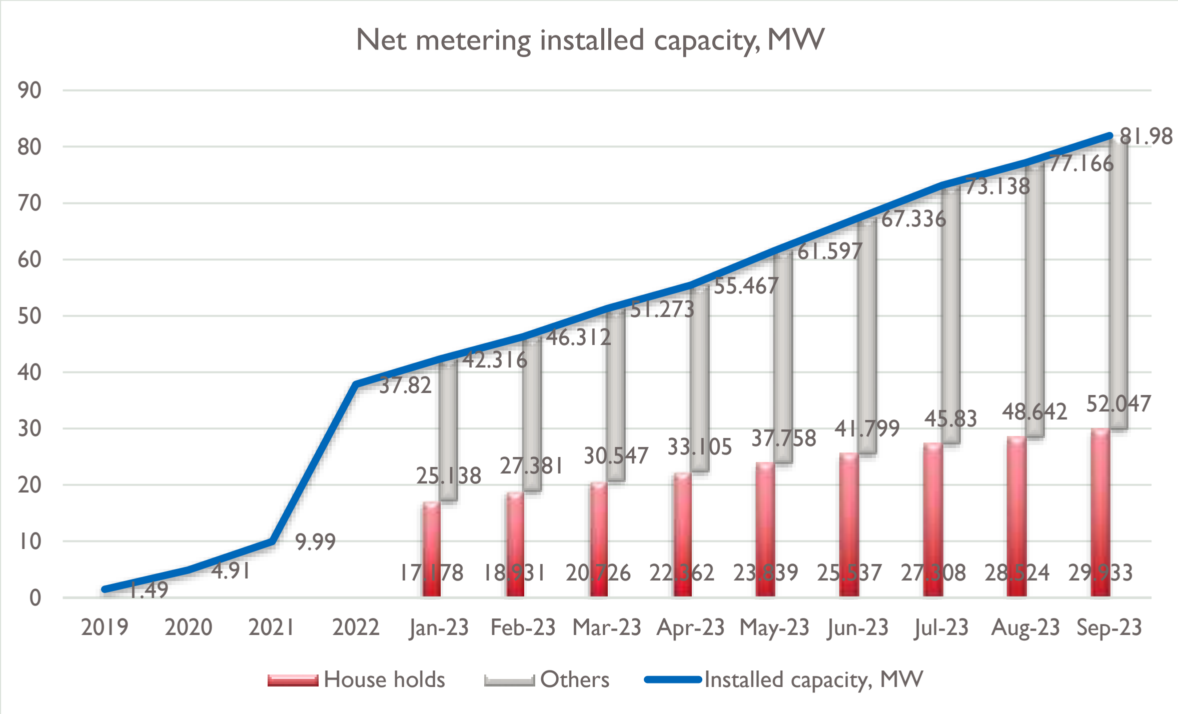


Figure 1. Evolution of installed renewable energy capacity in Moldova

As shown in Figure 1, the technologies preferred by local developers are wind and solar, but their development is driven by different considerations. In the case of wind sources, these represent projects with small installed capacity using one or several wind turbines, nearly all previously used in other countries and imported to Moldova secondhand. The exponential development of these sources in Moldova is largely due to the regulatory framework of development that allowed the connection of installations featuring used equipment without conformity testing, the lack of financial responsibility for imbalances (applied only from June 2022), and the increase in wholesale electricity prices.

In contrast, solar sources have been developed mainly with new equipment, benefiting from the reduction of capital expenditure and better market conditions for this technology as well as the feed-in tariff support scheme.

At the same time, the exorbitant increase in energy prices after the start of the war in Ukraine and the energy crisis determined the accelerated development of PV projects used within the net-metering mechanism. This mechanism allows final consumers (individuals, companies) to produce and consume their own electricity. Thus, at the end of September 2023, 4,071 beneficiaries were registered, of which 3,236 were household consumers, and the electricity production capacity through PV panels was 81.9 MW, including 29.9 MW developed by household consumers.



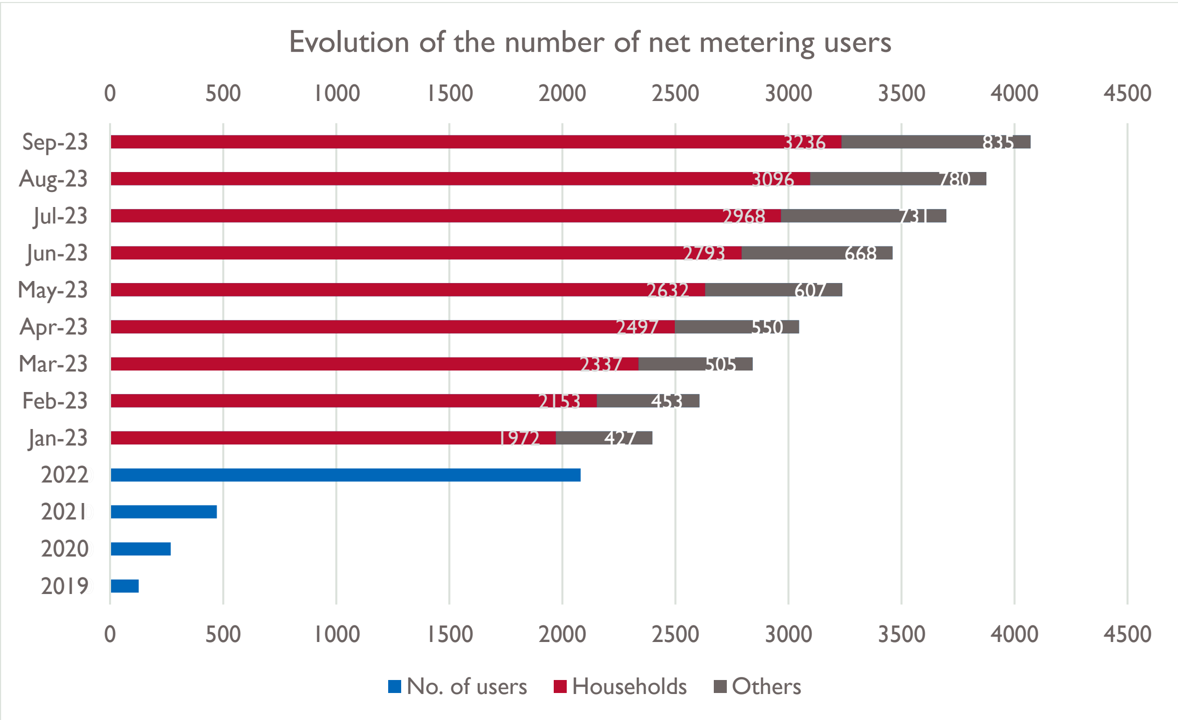


Figure 2. Evolution of number and installed capacity of net-metering projects

In Moldova's case, the net-metering mechanism has fully achieved its initial objective of increasing final consumers' interest in developing self-consumption projects by offering incentives to reduce those consumers' electricity costs. The increase in electricity prices has led to a significant increase in installed capacity of renewable sources for net-metering projects, which has increased eightfold since the beginning of 2022. In 2023, the PV capacity used under net metering doubled in less than eight months.

However, this type of support has its limits. An essential drawback of the net-metering mechanism is that it does not take into account the monetary value of the electricity generated in the system. Another factor is related to the creation of cross-subsidies for the network charges between final consumers; that is, people without financial means to install a PV system must pay the network charges to cover for those who can afford such installations. Furthermore, net metering is not possible for apartment owners in multistory buildings.

Net metering enables prosumers to offset their electricity bills by exporting excess energy to the grid, which is then credited for future consumption. Its primary advantage lies in its simplicity, making it easy for both system owners and utilities to understand and implement. It also requires minimal regulatory changes and exploits existing metering infrastructure, allowing for reduced implementation costs. However, the main disadvantage of net metering is that it usually provides an imprecise reflection of the actual value of the electricity produced. That is, net metering implies that the rate of energy consumed is equal to the rate of energy produced. This is often beneficial to the prosumers because they enjoy a higher production rate than other renewable generator owners get from participating in the electricity market.

Also, some developments with the installed PV capacities of final consumers signal the unsustainability of this mechanism in the long term. The capacity used within the net-metering mechanism (82 MW) represents more than 10 percent of the maximum consumption load of the distribution networks, while the number of beneficiaries (4,071) is only 0.28 percent of the total number of final consumers. Therefore, there is an unequal distribution of benefits and expenses between final consumers.

Another aspect that creates long-term uncertainties is the average installed power of a household consumer's PV system. According to the National Agency for Energy Regulation (ANRE) Activity Report for 2022, the average annual consumption of a household consumer in Moldova was about 1,200 kWh.[2] If the average installed power of a PV system used by household consumers is 9.25 kW, at a capacity factor of 0.15 it can produce over 12,000 kWh, which is the annual consumption of ten household consumers with average electricity consumption. In Moldova, more than half of final consumers use less than 1,200 kWh per year, with another 27 percent of household consumers using between 1,200 and 2,400 kWh.

In the case of non-household consumers, the average project capacity is 62.33 kW, which, similarly to the above calculation, could produce over 81 MWh per year. More than 88 percent of non-household consumers in Moldova have an average annual consumption of less than 25 MWh.

This suggests that the prosumer is over subsidized for the electricity they produce, which could affect utilities' revenue. Furthermore, under net metering, the prosumer is not incentivized to prioritize self-consumption, which negatively affects the deployment of behind-the-meter storage systems and generally leads to suboptimal usage of electricity in the network. All these characteristics render the net-metering mechanism ideal for boosting PV self-consumption in the initial stages of the deployment of such systems, but it is not recommended for long periods of time.[3]

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[2] https://anre.md/raport-de-activitate-3-10

[3] Energy Community Secretariat, Policy guidelines on Integration of renewables self-consumers, 2020

Conversely, net billing offers a more accurate approach to compensate electricity injected into the grid because the rate for electricity produced can be tailored to match its actual value. This can encourage self-consumption, especially if the sell rate is lower than the retail rate. Under this mechanism, the prosumer can also benefit from injecting the surplus electricity to the grid and thus supporting their investment with this additional income. However, this benefit is lower under net billing than under net metering because the excess energy is bought by the grid at wholesale prices or other fixed rates lower than the retail ones.[4] The different rates imply that production and consumption should be monitored separately, which is an additional cost for the installation. In any case, this financial structure motivates prosumers to optimize the sizing of their PV systems to maximize the percentage of self-consumed energy, thus elevating the overall return of their investment. Increasing self-consumption also benefits the grid operators because it reduces the possibility of congestion in the network elements and consequently defers costly network upgrades.

Nonetheless, increasing self-consumption can also pose a challenge to utilities' revenue. The decision to transition from net metering to net billing depends on a country's energy policy goals and the balance it seeks between promoting renewable energy adoption, ensuring fair compensation, and maintaining the financial stability of utilities. The EnC Secretariat has suggested such a transition, which is in accordance with RED II. Adoption of net billing can be considered a means to address concerns related to oversubsidization and the long-term financial viability of utilities, especially in countries where net-metering programs have been proven successful in promoting PV installations in the low-voltage network.

Considering these aspects, through amendments to Law 10/2016, which transposes the provisions of RED II, the government proposed to replace the net-metering mechanism by promoting the concepts of prosumers and energy communities, with the creation of the necessary legal framework. This will allow the prosumer to sell their surplus electricity at a price set by ANRE, which will reflect the market value of the energy generated and allow the PV owners to recover their installation investments. Thus, an attractive and sustainable environment for self-consumption development will be created based on market-driven price signals. At the same time, the law provides the right to install and operate electricity storage systems (combined with installations that produce electricity from renewable sources) without having to pay any double fee, including network fees for the stored electricity that remains on the prosumers' premises. This includes the right to receive, through support schemes, remuneration that reflects the market value of the electricity produced by renewable sources.

[4] Montenegro stands out as an exception, with a net-billing scheme that compensates the surplus energy at the retail rate as dictated by its Energy Law. https://www.gov.me/en/documents/726c38c9-c915-44dd-b5eb-721e08948644

ASSESSMENT OF THE PV CAPACITIES THAT CAN BE CONSIDERED FOR SELF-CONSUMPTION

Based on a request from the Ministry of Energy, the amount of renewable energy capacity (solar and wind) that could be integrated in the Moldovan power system for the period 2024–2030 was estimated. The approach involved an expert assessment from the power system perspective based on dispatch simulation (ANTARES) and metadata processing. To assess the amount of renewable energy capacity that can be integrated at the system level by 2030, generation dispatch analysis was performed using ANTARES software. ANTARES is a sequential Monte Carlo simulator designed to study large, interconnected power grids by simulating the economic behavior of the transmission-generation system on an hourly basis. The key methodological steps included the following:

1. Analyzing the whole power system to determine the total amount of renewable energy capacity that could be connected from the market perspective, i.e., taking into consideration merit order, cross border exchanges, must-runs, startups/shutdowns, etc., while avoiding curtailments;

2. Analyzing key power system nodes' load to determine the level of PV capacity that could be connected on the distribution level, avoiding reverse flows from distribution to the transmission system (metadata processing); and

3. Combining these analyses to separate the amount of PV capacity that could be connected on the distribution level from the capacity that could be put on auction.

MODELING APPROACH

The modeled region for this exercise is shown in Figure 3. Links between nodes represent real connections between nodes, and they are characterized by net transfer capacity in both directions. ANTARES hourly simulations were performed for each year from 2024 to 2030.

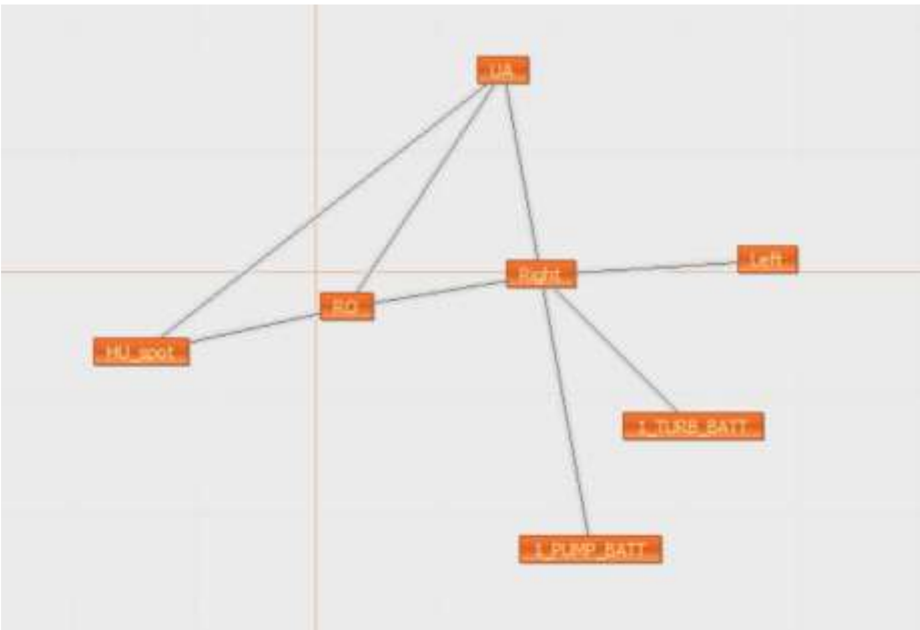

Figure 3. The region considered for ANTARES modeling

Moldova was considered to comprise two regions: the left and right bank of the Nistru River, without any transmission congestion between them. Ukraine and Romania were modeled explicitly, and the rest of Europe was represented as the Hungarian power exchange (HU_spot) with hourly marginal prices. Thermal power plants were modeled on a unit level and hydropower plants on a power plant type level. A must-run constraint was introduced in combined heat and power units to correctly model operation when heat and electricity are produced.

DATA AND ASSUMPTIONS

Moldova's electricity demand was calculated based on the projections of the load increase used in the analytical part of the draft National Energy and Climate Plan (NECP) and the historical hourly load for 2022. The evolution of yearly demand for Moldova is presented in .

TABLE 1. CONSIDERED DEMAND FORECAST

LOAD (GWH)	YEAR							
	2023	2024	2025	2026	2027	2028	2029	2030
Left bank of Nistru	1,723	1,750	1,776	1,802	1,828	1,854	1,880	1,907
Right bank of Nistru	4,158	4,221	4,284	4,347	4,410	4,474	4,537	4,600
Total	5,881	5,971	6,060	6,149	6,238	6,328	6,417	6,507

Additionally, the modeling exercise included the following assumptions:

- There will be no curtailment of new renewable energy capacity.
- Electricity market development was assumed to be sufficient for regional market integration.
- Restrained exports from Ukraine will last at least until 2025.
- Coal-fired MGRES capacities will not operate due to the shortage of Donbas coal.
- There will be no export to Ukraine at night.
- The new Balti – Suceava interconnection line will be in operation from 2030.

Solar and wind power plants were modeled at a system level (aggregate mode). All operating renewable energy capacities were considered in the baseline, and more specifically, 116 MW of wind power plants and 128 MW of solar power plants, out of which 78.5 MW of PV installation was used under the net-metering mechanism.

The level of new renewable energy was determined using a stepwise approach, increasing the capacity until it became necessary to curtail renewable energy sources emerged.

This assessment did not feature steady-state network calculations, which could potentially reduce the level of renewable energy integration due to existing bottlenecks in the Moldovan internal grid. Balancing reserve analysis was also not involved in the assessment. Lack of balancing capacities in Moldova could potentially further reduce the level of renewable energy integration.

RESULTS OF THE MARKET ASSESSMENT

The result of the modeling exercise showed that even with significant PV development over the last years, there is still plenty of room for additional capacity (**Table 2**).

TABLE 2. POTENTIAL PV CAPACITY THAT CAN BE INTEGRATED IN THE POWER SYSTEM

YEAR OF INSTALLATION	PV CAPACITY THAT CAN BE INTEGRATED IN THE SYSTEM WITH CONSIDERED CURTAILMENT (EXPORT), %					
	0% CURTAILMENT	5% CURTAILMENT	10% CURTAILMENT	0% CURTAILMENT	5% CURTAILMENT	10% CURTAILMENT
	TOTAL INSTALLED CAPACITY AT THE SYSTEM LEVEL, MW			TOTAL CAPACITY THAT CAN BE INTEGRATED AT THE DISTRIBUTION LEVEL, MW		
2024	220	370	570	220	370	470
2025	250	450	650	250	450	520
2026	250	450	650	250	450	546
2027	250	550	750	250	550	556
2028	250	550	750	250	550	565
2029	250	550	750	250	550	574
2030	250	650	750	250	583	583

The results presented in Table 2 assume a fully restrained export regime; however, this approach does not consider the potential total welfare gains. Thus, the results refer only to the capacities that the government could consider if using these values to offer economic initiatives (support schemes) for the development of electricity generation projects using solar energy. There is even more capacity that can be integrated in an open market. The country is unlikely to be able to support full integration of the potential PV capacity within a year (in terms of permitting, designing, and implementing the projects), so it is recommended that the 2024 capacity additions be spread over several years.

As for the PV capacities that can be considered for self-consumption projects (connected to the distribution grid), in the case of an even distribution of new solar capacities proportional to the electricity load consumption, almost all the newly installed capacity can be assimilated through self-consumption projects. The analysis shows that the limitation of PV capacities that can be easily integrated into the system is mainly dictated by the system constraints, not by constraints at the distribution level. This indicates that a high penetration of PV plants at the consumer level can limit the remaining capacity for utility-scale projects. Thus, when allocating the available capacity for new PV projects for each state support scheme, the summary socioeconomic effect and, mainly, the impact on the final consumers of electricity must be taken into account. Also, economies of scale suggest that utility-scale PV under competitive procurement (e.g., auctions) should lower electricity prices for all, in contrast to the case of self-consumption, in which there are "distributional effects" (high-income citizens may use the distribution network and have their costs socialized by network and supply charges).

Further analysis about specific capacities for self-consumption is found in Recommendations about capacity limits.

CAPACITY LIMITS ON PV SELF-CONSUMPTION IN EU MEMBER STATES AND ENERGY COMMUNITY COUNTRIES

This section investigates the capacity limits imposed on PV self-consumption in selected EU and EnC countries. By examining the policies, regulations, and practices surrounding capacity limits for PV self-consumption systems, we aim to highlight the nuanced approaches these countries have taken to foster renewable self-consumption. This overview shows that different countries have different approaches regarding capacity limits and support mechanisms for self-consumption.

Individual system size caps and thresholds are usually used to set eligibility limits for a surplus energy compensation program and incorporate the technical characteristics of the distribution network. On the other hand, aggregate thresholds are also political in nature and are used as a trigger for policymakers to reevaluate compensation mechanisms and renewable targets. Aggregate thresholds can be:

- A percentage of peak demand;
- Capacity or load in a given year;
- A fixed capacity; or
- Any other trigger mechanism, such as number of installed systems.[5]

This overview encompasses countries that have either transitioned from net metering or other schemes to net billing, those with both schemes in place, and those with other variations of support mechanisms for self-consumption. A key distinction in the countries' regulations is the establishment of capacity limits for PV self-consumption installations. Most countries have separated residential and nonresidential consumers by setting different limits. In most cases, it seems that the limits are closely tied to the technical constraints and grid considerations within each country. The existing capacity of consumer connections to the low-voltage network is usually the threshold countries use to ensure distribution grid reliability by minimizing the risk of overloading network elements such as distribution transformers.

Most countries studied do not use aggregate capacity limits for PV self-consumption, but rather choose to adopt national targets for self-consumption in their respective NECPs. Cyprus stands out as an exception, with its adoption of aggregate limits for different categories of prosumers. This approach is likely influenced by its unique position of not having any interconnections, which raises questions about similar strategies in other regions.

NETHERLANDS

The Netherlands, like many countries, currently operates under a net-metering system for households, in which excess energy generated by PV systems is credited to the consumers. The net metering scheme was introduced in 2004 to make solar panels attractive to consumers. It has been a widely successful program, evidenced by the fact that about 20 percent of all houses in the country have solar

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[5] NREL, Installed Capacity Caps for Distributed Photovoltaics and their Impacts on Compensation Mechanisms, https://www.nrel.gov/docs/fy19osti/71195.pdf

panels installed. It was first introduced with a maximum of 3,000 kWh/year of electricity per household that could be net metered; in 2011 this limit was increased to 5,000 kWh, and in 2012 the limit was abolished.[6] However, netting means that the consumer can always feed solar power to the grid at full price, even if that power is worth less at a certain time. Due to the widespread installation of such PV systems in the Netherlands, energy companies have had to raise electricity prices to account for the difference in energy value, which means that customers without solar panels pay higher electricity prices without the advantage of having solar panels installed.

As a result, the government has decided to slowly phase out the current net-metering scheme starting in 2025 by gradually reducing the percentage of energy produced that is subject to net metering. From 2025, only 64 percent of the energy produced will be deducted from the consumed energy. In the final stage, net metering will be phased out completely from 2031. For electricity that cannot be offset, prosumers will be able to receive reasonable compensation, which has not yet been determined.[7]

There are no capacity thresholds set in the Netherlands, neither under the net-metering scheme nor under the new scheme. There are also no targets or limits to the total PV capacity that can be installed for self-consumption. The only limit on PV installations is technical, and it is imposed by the connection type and its maximum capacity. Typical values for the maximum consumer connection power in the country are 17 kW, 25 kW, 35 kW, 44 kW, and 55 kW for three-phase low-voltage connections.

POLAND

Poland has transitioned from a net-metering strategy for self-consumption to a net-billing support scheme since April 2022. In 2015, the country introduced a net-metering system for PV systems with a capacity up to 10 kW. Under the scheme, 80 percent of the energy produced would offset the consumption of the prosumer within an annual energy settlement period (70 percent for installations between 10 kW and 50 kW). This support scheme, along with subsidies for small PV installations, resulted in Poland having more than 800,000 PV systems installed under net metering until 2021, with a total capacity of 6 GW.[8,9]

Owing to increasing costs for network operators and suppliers, grid stability issues, and the shift toward promoting large PV installations (above 1 MW), Poland decided to adopt a net-billing support scheme for PV self-consumption for all new installations under 50 kW. There are no targets or limits for the total PV capacity that can be installed for net billing in Poland. The 50 kW is the only threshold that remains for individual installations that can operate under the net billing regime for self-consumption.

CYPRUS

Cyprus is the only non-interconnected country in the EU. It has a national plan for producing renewable energy from prosumers that is updated annually by the Ministry of Energy, Commerce, and Industry. The plan defines five categories of installations for self-consumption: (1) net-metering installations, (2) net-billing installations, (3) autonomous installations, (4) virtual net-metering

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[6] Price Waterhouse Coopers, 2016, The Historical Impact of Net Metering; Research for the Ministry of Economic Affairs

[7] Dutch National Plan Energy and Climate 2021-2030, Netherlands - Draft Updated NECP 2021-2030 (europa.eu)

[8] Poland - Energy Sector (trade.gov)

[9] The assessment of solar photovoltaic in Poland: the photovoltaics potential, perspectives and development | Clean Technologies and Environmental Policy (springer.com)

installations, and (5) virtual net-billing installations. This overview focuses on net-metering and net-billing installations only.

Cyprus distinguishes net-metering installations in two subcategories: residential and nonresidential. Under the net-metering scheme, only installations up to 10.4 kW can operate. For one-phase connections, the threshold is 4.16 kW, which can rise to 5.2 kW provided that a battery of at least 1 kWh will be installed along the PV system. For three-phase connections, the limit is 10.4 kW, but a specific provision requests that prosumers submit a study, prepared by a certified engineer, that shows that the annual estimated energy produced by the PV installation will not be higher than the annual energy consumption of the premise. The total 2023 annual capacity limit for net metering in Cyprus is 30 MW: 20 MW for residential and 10 MW for nonresidential customers.

Net billing is applied to self-consumption installations for residential, commercial, military, agricultural, and industrial activities and refers to capacities up to 8 MW. For all net-billing installations, the capacity of the PV cannot be higher than 80 percent of the connection capacity (load entitlement of the consumer), unless it is paired with a storage installation that allows for a capacity equal to the load entitlement. The total 2023 annual capacity limit for net billing in Cyprus is 20 MW.[10]

The national plan states that the total capacity limits can be revised after consultation with the national transmission and distribution system operators and based on the available capacity of distribution substations and/or other technical constraints. The total PV capacity installed in Cyprus in 2022 was equal to 116 MW.[11]

SPAIN

In 2019, Spain adopted a new regulation for PV self-consumption that allowed prosumers to be compensated for any produced energy that was injected into the grid. The compensation mechanism follows the net-billing model and is applicable to PV capacities under 100 kW. When the new system was put in place, any capacity limits on PV systems for self-consumption were abolished. There are also no aggregate thresholds on PV total capacity for net billing. The Spanish NECP, however, mentions a target of 76 GW installed PV capacity by 2030, of which 19 GW would be PV capacity for self-consumption.[12]

GREECE

Since 2015, Greece has operated a net-metering support model for self-consumption with a three-year settlement period of electricity production and consumption.[13] The scheme can cover PV installations with a capacity up to 3 MW for the mainland and the interconnected islands. Different limits apply for the non-interconnected islands. Typical values for low-voltage maximum connection power in the country are 5 kW (single phase), 15 kW, 25 kW, 35 kW, 55 kW, 85 kW, 135 kW, and 250 kW. In both cases, the capacity of the installed PV cannot be higher than the connection capacity of the premises where the PV is installed. The PV installations for self-consumption can be paired with batteries, provided that the rated capacity of the battery converter is not higher than the PV capacity and has an energy size equal to the PV capacity for one hour. No other aggregate limits exist for the

[10] Cyprus National Energy and Climate Plan 2021-2030, https://commission.europa.eu/publications/cyprus-draft-updated-necp-2021-2030_en
[11] Cyprus Energy Profile, IRENA
[12] Spain National integrated Energy and Climate Plan 2023–2030
[13] CEER, Status Review of Renewable Support Schemes in Europe for 2020 and 2021

installed capacity of PVs for self-consumption. The Greek NECP sets a target of 1 GW of installed renewable capacity for self-consumption by 2030.[14]

FRANCE

France's provisions for self-consumption date back to 2015. A specific support framework for the development of self-consumption applies a feed-in tariff for surplus energy injected into the grid for solar installations up to 100 kW. No other limits are imposed on PV installations for self-consumption and there is no threshold on aggregate PV capacity for self-consumption. According to the latest Multiannual Energy Program of France, which is part of the NECP, an annual objective of installing 300 MW of small PVs (capacity up to 100 kW) shall be maintained.[15]

NORTH MACEDONIA

North Macedonia, an EnC Contracting Party, operates a net-billing support scheme for renewable generation with installed capacity up to 4 kW for residential and 20 kW for nonresidential consumers.[16] Similar to other EnC countries, the installed capacity of a prosumer should not exceed the distribution system operator permitted capacity for the premises where the self-consumption system is installed.[17] Other aggregate limits for PV self-consumption capacities do not exist in North Macedonia. The NECP submitted to the EnC Secretariat set a target of 250 MW installed PV capacity for self-consumption by 2030.[18]

IRELAND

As part of the country's efforts to transpose RED II into national law, in 2022 Ireland launched a microgeneration support scheme covering distributed generation installations up to 50 kW. The scheme, among other support mechanisms such as grants, compensates surplus electricity generated by distributed generation with a feed-in tariff. The tariff is different for projects up to 6 kW, for which it is tied to the wholesale market price, and for projects from 6 kW up to 50 kW, for which it is fixed for 15 years and applies to 80 percent of the annual energy injected into the grid. This limit was added in an effort to maximize self-consumption from larger installations and account for the possibility of lower electricity prices in the future. The program has set a target of 380 MW of installed PV capacity from microgenerators (out of 1 GW which is the national PV target for 2030) as part of the national Climate Action Plan. There are provisions to reevaluate the target after two years of implementation of the scheme.[19]

TABLE 3. PV SELF-CONSUMPTION CAPACITY LIMITS

Country	Compensation mechanism	PV system limits	Aggregate limits
Netherlands	Net metering until 2025 – Net billing from January 2025	Maximum connection capacity of the household	No limit

[14] Greece National Energy and Climate Plan 2021-2030
[15] France National Energy and Climate Plan 2021-2030
[16] Rulebook on Renewable Energy Sources, FinalRESRulebook.pdf (economy.gov.mk)
[17] Energy Community Regulatory Board, Prosumers in the Energy Community, 2020
[18] North Macedonia National Energy and Climate Plan, Governance and NECPs - Energy Community Homepage (energy-community.org)
[19] gov.ie - Micro-generation (www.gov.ie)

TABLE 3. PV SELF-CONSUMPTION CAPACITY LIMITS			
Country	Compensation mechanism	PV system limits	Aggregate limits
Poland	Net billing	50 kW	No limit
Cyprus	Net metering and net billing depending on the consumer category	Net metering One-phase: 4.16 kW (5.2 kW with battery Three-phase: 10.4 kW[20] Net billing 8 MW[21]	Net metering 20 MW/year for residential customers 10 MW/year for nonresidential customers Net billing 20 MW/year
Spain	Net billing	100 kW	No limit – 19 GW target by 2030
Greece	Net metering	Up to 3 MW – PV capacity cannot be higher than the connection capacity of the premises	No limit – 1 GW target by 2030
France	Feed-in tariff	100 kW	No limit – Target for 300 MW/year
North Macedonia	Net billing	4 kW for residential and 20 kW for nonresidential – installed capacity cannot exceed connection capacity of the premises	No limit – 250 MW target by 2030
Ireland	Feed-in tariff / feed-in premium	50 kW	No limit – 380 MW target[22] for the program (180 MW for systems up to 6 kW and 200 MW for systems up to 50 kW) – 1 GW target out of 8 GW of total PV capacity for 2030

[20] Annual production cannot be higher than the annual consumption under net metering.
[21] Provided that the PV capacity is not higher than the 80 percent of the connection capacity of the consumer unless it is paired with a battery, which allows it to increase to 100 percent.
[22] Target to be reevaluated after two years from adoption.

RECOMMENDATIONS ABOUT CAPACITY LIMITS

INDIVIDUAL CAPACITY LIMITS

Based on these EU and EnC countries' practices, individual capacity limits can be divided into two different categories. First, there is usually one limit that defines the eligibility of self-consumption and usually targets installations in the low-voltage network. All installations up to this limit are eligible for any support mechanisms for self-consumption and specifically for the net-billing mechanism that the Government of Moldova seeks to establish.

Second, most countries limit the eligible individual PV installations to the level of connection capacity of the premises. We suggest that this limit be included in the legislation and that the distribution system operator be responsible for checking that all applications comply with this requirement. Such a limit ensures that the network equipment can handle the injection of produced electricity without jeopardizing network operation. In addition, and in parallel to the net-billing mechanism, this will incentivize prosumers to size their PV installations to maximize the percentage of self-consumption.

Finally, to address the problem of oversizing PV installations, we suggest including a limit that is linked to the annual energy consumption of the premises. That is, the electricity production of the PV installation should not exceed the total annual energy consumption of the premises where it is installed. This can be evaluated by the distribution system operator considering a standardized annual energy yield per installed kW of PV in Moldova and based on the past annual energy consumption of the consumer.[23] This also means that if prosumers exceed the limit of energy production, they will not be compensated for the excess energy produced from their PV systems. This will also affect the prosumers transitioning from net metering to net billing in 2027 and will eventually lead to prolonged payback periods for their investment.

AGGREGATE CAPACITY LIMITS

As witnessed from the above benchmarking, countries do not usually use aggregate capacity limits. These types of limits may constrain grid access for various consumers and can often be perceived as discriminatory and biased. Of course, there are also network constraints that can be considered, because the grid can only accommodate a specific number of renewables capacity.

In accordance with Government Decision no. 401/2021, the following PV capacities to be allocated until 2025 were considered:

- Within the auctions—60 MW
- For projects that will benefit from the feed in tariff—120 MW, of which 20 MW will be installed on buildings

Starting in 2022, in accordance with the procedures established in the Regulation on the confirmation of the status of an eligible producer, ANRE approved a number of decisions on the allocation of capacities considered for the feed-in tariff support scheme. Thus, the capacity of 120 MW of PV assigned for stand-alone projects was exhausted, and of the 20 MW approved for rooftop projects, 16.2 MW were assigned as well. As of October 31, 2023, out of 135.9 MW allocated by ANRE, 47.8

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[23] For new buildings that apply for a PV self-consumption installation an average annual consumption can be used based on the existing data from similar installations in the country

MW were already commissioned, and another 88 MW of PV capacity are to be connected during 2024.

In another vein, at the end of 2023, the government proposes to launch the tenders for the status of eligible producer in order to allocate the 60 MW planned in this regard. In an optimistic scenario, only considering the maximum capacity quotas included in Government Decision 401/2021, by 2025 another 148 MW of PV may be connected to the grid.

Thus, when establishing the capacities for self-consumption projects, the government will want to base its decision on a conservative approach (a fully restrained export regime). From the 250 MW of PV capacity that can be integrated in 2025 according to the market analysis (see **Table 2**), approximately 100 MW can be considered for self-consumption projects. This restrained scenario leads to comparatively lower solar PV additions compared to the capacity that can be integrated in the Moldovan power system if the government considers up to 5 percent curtailment of annual energy yield. Five percent remunerable curtailment has been observed in EU practices.

Given that the individual system limit will be related to the annual energy consumption of the consumer, it follows that the distribution of the aggregate limit among different consumer categories should be linked to the annual energy consumption of each category. Thus, the aggregate limit of 100 MW can be allocated to different consumer categories based on each category's share of annual energy consumption in Moldova. The three categories can be:

- Residential consumers
- Nonresidential consumers
- Public institutions

For example, if the residential consumers' annual energy consumption represents a share of *A* percent of the total energy consumption in Moldova, the aggregate limit for residential consumers should be equal to *A* percent times 100 MW.

Special consideration must be given to transitioning Moldova from a net-metering scheme to net billing. Usually, this slows public demand for self-consumption, at least in the first phase of its implementation. As a result, we recommend reevaluating these aggregate limits every two years to closely monitor their effect on the growth of self-consumption in the country. Regular reevaluation of the limits will allow the government to intervene in case of a trend in self-consumption growth that is not aligned with the overall energy strategy.

Furthermore, it would be beneficial and aligned with best practices and recommendations for the Government of Moldova to adopt a national target for installed PV systems for self-consumption by 2030. This will provide a specific input to be considered for the medium-term plans of both policymakers and system operators. The target can be based on the results of our analysis of the integration of renewable energy in Moldova, as shown in TableTABLE 4.

TABLE 4. MOLDOVA PV SELF-CONSUMPTION CAPACITY LIMITS

COMPENSATION MECHANISM	PV SYSTEM LIMITS	AGGREGATE LIMITS
Net billing	• Eligible systems for net billing up to 200 kW • PV capacity cannot be higher than the maximum connection capacity of the premises • Annual PV energy production cannot be higher than the annual energy consumption of the premises	• 100 MW – to be reevaluated in 2025 • Further distribution of the aggregate capacity limit to residential, nonresidential, and public institution consumers • Category limit will be based on the share of annual energy consumption of each category