Revision of Cyprus Energy and Climate Plan

Deliverable 3

Trinomics

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In association with:

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Table of Abbreviations

AC	Avoidance Cost
ACER	European Union Agency for the Cooperation of energy Regulators
CEER	Council of European Energy Regulators
CERA	Cyprus Energy Regulatory Authority
CHP	Combined Heat and Power
CO2	Carbon Dioxide
COSMOS	Cyprus Organisation for Storage and Management of Oil Stocks
CY	Cyprus
DSO	Distribution System Operator
EAC	Electricity Authority of Cyprus
EE	Energy Efficiency
EU	European Union
EV	Electric Vehicle
GHG	Greenhouse Gas
GW/GWh	Giga Watt/ Giga Watt hour
HECHP	High Efficiency Combined Heat and Power
IRR	Internal Rate of Return
JRC	Joint Research Centre
kW/kWh	Kilo Watt/ Kilo Watt hour
LCOE	Levelised cost of electricity
LV	Low Voltage
MS	Member State
MV	Medium Voltage
MW/MWh	Mega Watt/ Mega Watt hour
NECP	National Energy and Climate Plan
NPV	Net Present Value
PBP	Payback Period
PPA	Power purchase agreement
PSO	Public Service Operation
PV	Photovoltaic
RES	Renewable Energy Sources
SCADA	Supervisory Control and Data Acquisition
SDE+	Stimulering Duurzame Energieproductie/Encouraging Sustainable Energy Production
SME	Small and Medium-sized Enterprises
SO	System Operator
SWH	Solar Water Heater
TSO	Transmission System Operator
UK	United Kingdom
V+C	Volumetric + Capacity
VAT	Value Added Tax

Glossary

Term	Definition
Energy price	This is the price that electricity users pay for each kWh of electricity they use. It does not include network costs, other costs and taxes.
Purchase/export price	Price paid to generators of electricity from renewable sources that export to the main power grid
Avoidance Cost	Methodology to quantify the purchase price of electricity from renewable sources, based on the estimated generation cost of traditional operators in the given month. This is the current methodology in Cyprus.
Volumetric charge	A volumetric charge is a cost charged to energy users which is based on a fixed rate per unit of energy (€/kWh) and the volume (amount in kWh) of energy used. Energy costs are in general volumetric, but often also network costs are charged on a volumetric basis. In this report, the term *volumetric charges* usually refers to network costs.
Capacity charge	A capacity charge is a cost charged to energy users which is based on a fixed rate per unit of installed capacity (€/kVa) and the total installed capacity (kVa).
Net Present Value (NPV)	Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. NPV is used to calculate the current value of a future stream of payments from an investment.
Internal Rate of Return (IRR)	The internal rate of return (IRR) is a metric used in financial analysis to estimate the profitability of potential investments. The internal rate of return (IRR) is the annual rate of growth that an investment is expected to generate. IRR is calculated using the same concept as net present value (NPV), except it sets the NPV equal to zero.
Payback Period (PBP)	The payback period (PBP) is the length of time it takes to recover the cost of an investment or the length of time an investor needs to reach a breakeven point.

Executive summary

The aim of this study is to evaluate the current renewable support schemes for the promotion of electricity produced from renewable energy sources (RES) for self-consumption in Cyprus, to propose a compensation mechanism for the remuneration of surplus energy for the beneficiaries of those schemes, and to review the methodology to calculate network charges applied to users benefitting from the support schemes. Even though the three objectives are related to renewable energy and support schemes, they require different approaches to assess the current implementation and evaluate alternatives.

The evaluation of the renewable schemes for self-consumption was conducted by **measuring the effectiveness and cost efficiency** of the schemes. Effectiveness was assessed by examining the **uptake of installations** under each scheme and the **investment stimulated,** disaggregated between consumer and government costs. The efficiency of the schemes was assessed by evaluating whether the expected revenues (grants and income from energy generation) provide a fair return to users that decide to invest in solar PV (or PV system with batteries). Investment costs are derived by looking at average installation costs reported by applicants to the schemes, while the revenues from energy generation are estimated by measuring savings on the annual energy bill of a user with a PV installation compared to a user with an identical energy consumption profile but no PV installation. The difference between the two annual bills (a notional cash flow) is used to estimate the **payback period (PBP)** and the **internal rate of return (IRR)**.

The identification of a compensation mechanism for exported and surplus energy was performed by comparing the current methodology in Cyprus with other geographically similar countries in the EU (Italy, Greece and Malta), yet considering the specific context of the country, i.e., the absence of wholesale, balancing and retail markets, and the absence of interconnectors. Further, considerations on how generation could be remunerated according to the benefits and costs it imposes on the system are provided.

To evaluate the impact of network charges, **we compared three different methodologies and their effects on different types of users** (differentiated by aspects such as total consumption, PV capacity installed, consumption profile, tariff applicable). The three methodologies are: the old methodology applied in Cyprus prior to the implementation of Decision 28/2020 (charges levied on net energy imported from the network), the current methodology (charges levied on total energy imported from the network), and a new methodology based on a volumetric + capacity approach, which includes a capacity component in addition to the volumetric one used in the current tariff.

The numerical analysis conducted under the three sub-tasks of this study carried out using a bespoke model that allows to estimate the impact of different subsidy schemes and network tariffs methodologies on different consumers, in particular changes in their energy and network cost, and the profitability of different investments according to grants available.

Main findings and recommendations on the renewable support schemes

The evaluation of the support schemes showed that **net metering is particularly successful in Cyprus, and a very profitable investment for the consumers, with payback period being generally under 6 years (equivalent to a 20% annual return)**. Net billing (only taken up by commercial users at the moment) is also a very profitable investment, even though less profitable than net metering. Given Cyprus' solar radiation and current tariffs, is a good investment to install PV even without a grant, which means that the current subsidy scheme may be over-rewarding users. Therefore, in line with the European recommendations, net metering

should be phased-out, as it reduces incentives for self-consumption during generation hours and may increase system costs. Instead, net billing should be promoted, and potentially in combination with the installation of storage systems. In addition to making net billing scheme more attractive, residential batteries may also help reducing grid reinforcement needs and grid instability due to high ramp up and ramp down requirements.

The recently introduced scheme for **the installation PV systems for the charging of electric vehicles or hybrid plug-in vehicles has the potential to increase the uptake of both PVs and batteries, yet only if the users combine the installation of both technologies and if battery size is kept to a very minimum.**

Finally, **solar water heating (SWH) is a well-established technology in Cyprus.** There are some benefits to be derived by replacing an old solar water heater, potentially reducing the energy bill up to 50% per year. However, compared to other investments such as PV, **providing support for the replacement of a SWH generates relatively low benefits in terms of renewable energy generated, and given the popularity of this technology it is uncertain whether the government's support is needed.** Therefore, MECI should evaluate whether funds allocated to support SWH could generate higher benefits if spent towards other measure, such as insulation or even water-heating technologies that generate electricity when the hot water tank is full.

Main findings and recommendations on exported and surplus energy

The review of the methodology to compensate exported and surplus energy in Cyprus showed that **the avoidance cost methodology has several shortcomings** as it does not represent the actual cost of RES generation, it does not capture some negative externalities such as air pollution, and it leads to windfall profits for renewable generators when international fuel prices are very high. Therefore, until there is a sufficiently functioning market in Cyprus, the regulator should:

- **continue supporting the uptake of Power Purchase Agreements,** so that less energy has to be remunerated at the export and surplus tariff. Both the regulator and MECI should consider options to make these contracts more available and easy to access also for small users.
- **consider more granular (hourly) export tariffs that are more reflective of costs and benefits generated by producing energy at certain times of the day.** This tariff could either be set based on a detailed analysis of the costs and benefits apported to the system by different technology (and therefore being technology-specific) or be based on proxy indicators that estimate cost and benefits based on system indicators, such as hourly demand and load factor of Cyprus' main generation plants. Such a tariff would encourage less costly generation and self-consumption pattern, by incentivising prosumers to use their own electricity when rates are low, and to export it when they are high. Such a tariff would also improve the case for investing in batteries, especially if reflected by a consumption tariffs that varies along similar hourly slots.

Main findings and recommendations on network tariffs

The analysis of the impact of network charges on different types of consumers showed that **a switch to a volumetric + capacity (V+C) charge would overall reduce costs for high users and increase them for low users with and without PV,** which means that, to some extent, charges would move back towards the level set by the old methodology. While this may to some extent provide a perverse incentive to use more, it is more cost-reflective, as a large portion of network cost are independent from consumption and dependent on capacity. Low users (with and without PVs) would pay more under the new volumetric + capacity methodology given that it has a fixed capacity component that all users pay regardless their monthly consumption.

However, the analysis showed that the cost increases are limited. Small users (around 2,000 kWh annual consumption) would see a 13% increase in the total energy bill (equivalent to €45 per year), while larger consumers (~ 7,500 annual consumption) would see a decrease of 4% (€48 per year). Even though some vulnerable consumers might be included in the group of low users (in which case they should be supported via the vulnerable tariff) **it is expected that the higher costs of the volumetric + capacity tariff methodology would affect mainly second homes and holiday flats which are not used frequently.**

The analysis also showed that the impact of moving from the old tariff (charges on net energy imported from the network) to the current tariff (where charges are levied on all imported energy) are also rather limited for different consumption levels, with some users benefitting and other being worse off. In particular, the removal of the fixed charge (the "Producer's fee") and charging the "producer's YDO" and the fee for "RES Fund & ES Producer" based on imported energy benefits users with lower total energy import and penalises those with high import.

The analysis also showed that, **for potential PV users, the change to a V+C tariff would have very limited impact on any investment decisions, as payback period increases only by a few months**. When it comes to the returns of the investment, **under the three tariffs the typical user would achieve a return of between 10% (without a grant) and 18% per year (with the grant) which corresponds to a payback period of between 5 and 7.7 years.** Moving from the current tariff to a volumetric + capacity tariff would slightly reduce returns (by between 1.3 percentage points and 0.8 percentage points) and increase payback period accordingly, due to less savings achieved in the 15 years period. These differences are unlikely to be material in an investment decision.

The analysis looked also into the effect of different methodologies of network charges for commercial and industrial users. The results showed that **the swich to a volumetric + capacity tariff would result in total energy bills up to 14% higher for PV users, but small decreases in the range of 0% to -5% for no PV users.** However, high users (e.g., commercial MV) would pay less than they currently do because their energy use is high compared to their load entitlement, a conclusion which is aligned with the principle of cost reflectivity. Therefore, based on the abovementioned results and in line with the recommendations of ACER, CEER and the JRC, **the regulator should consider moving to a volumetric + capacity methodology for network charges, and expect this would have limited negative impact on total billing costs of different users, and minimal impacts on investment decisions.**

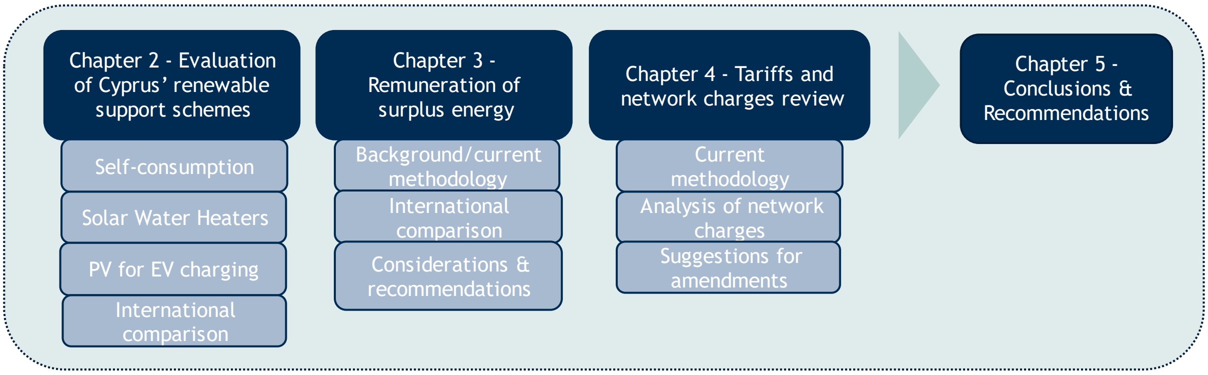
1 Introduction

This report is the main output of Deliverable 3 of the study *Revision of Cyprus Energy and Climate Plan*, which aims to support the Government of Cyprus in adopting a new legislative and regulatory framework to achieve the EU climate targets, including via an increased penetration of RES and strengthening the role of consumers.

The objectives of Deliverable 3 are to provide an evaluation of the current renewable support schemes for the promotion of electricity produced from RES with the aim of providing recommendations for further improvements; a proposal for the remuneration of surplus energy coming from beneficiaries of support schemes; and suggestions for a methodology for evaluating network charges related to systems covered by the major support schemes, with focus on schemes supporting RES for self-consumption. Even though the three objectives are related to renewable energy, they are not closely related on the specific content.

The report is structured according to these three objectives, as shown in Figure 1-1.

Figure 1-1 Schematic representation of the chapters



In **Chapter 2**, we provide an overview of the three main schemes supporting renewable electricity and renewable water heating, namely:

1. Support scheme for the production of electricity from renewable energy sources for own use (with a focus on net metering and net billing schemes and their respective grants);
2. Grants for Solar Water Heaters;
3. Grant Scheme for the installation / expansion of photovoltaic systems and the installation of electricity storage in houses for the charging of electric vehicle or hybrid plug-in vehicles.

For each case, we provide a description of the current scheme, an overview of the uptake and costs to date based on current data, an analysis of the profitability of an investment in the respective system (PV, SWH, battery), as well as several recommendations for the improvement of the existing schemes. Finally this chapter concludes with the comparison of similar support schemes implemented in other Member States (Greece, Italy, Spain and Malta) that demonstrate similarities with the climate of Cyprus as well as with the geographical location of the country.

Chapter 3 discusses the current methodology applied in Cyprus for the remuneration of exported and surplus energy, provides an overview of similar mechanisms used in other countries, and it details some specific examples of remunerating energy in three other Member States (Italy, Spain and Malta). Finally, several considerations to be taken into account when developing the methodology for surplus energy are presented as well as several options that may be adopted by the regulators in Cyprus.

Chapter 4 provides an overview of current network charges, taking into account the energy tariff structure and CERA's decision 28/2020 on the amendment of the methodology of network charges, and gives some examples on how the current network tariffs affect the customers with PV systems. Based on those, suggestions for amendment of the network charges' methodology are provided.

Finally, **Chapter 5** summarises the main findings of this study and provides recommendations regarding the three objectives of Deliverable 3.

At the end of the report, two Annexes have also been included that present the data and assumptions that were used for the analysis, as well as further details on the support schemes reviewed under this study (net metering and net billing).

2 Evaluation of Cyprus' renewable support schemes

Cyprus provides several financial incentives to support the production of electricity for self-consumption from renewable energy sources (RES), with a particular focus to photovoltaic (PV) installations. The incentives come in the form of grants and compensation mechanisms for the electricity production from RES. In the following sections, an overview of the main support schemes requested by MECI is provided and this chapter concludes with a comparison of similar support schemes across other MSs and the main takeaways of the analysis of the schemes.

2.1 Self-consumption

2.1.1 Description of the schemes

Cyprus is currently implementing the policy "Support scheme for the production of electricity from renewable energy sources for self-consumption" [1,2] that provides the framework for the licensing and operation (including the compensation mechanisms) for all the RES self-consumption options. The scheme has been updated in August 2022[3], and it is expected to be implemented with the new rules after the public consultation phase (closed 30/8/2022[4]). However, according to MECI, some characteristics of the scheme might be further amended in the next iteration.

The current updated scheme provides the framework for the following five categories:

A. Net metering
    1. PVs in residential buildings
    2. PVs in non-residential buildings
B. Net billing
C. Autonomous RES systems not connected to the network
D. Virtual net metering
E. Virtual net billing

The following sections provide a high level description of the schemes and the grants provided under each one. More detailed information on the schemes (for net metering and net billing) can be found in Annex II.

A. Net metering

Net metering is a compensation mechanism that allows the consumers to use the electricity generated by their own installed PV system (up to 10.4 kW[5]) on site, and pay only for the net electricity that they import and use from the grid. Any surplus of energy that is not used immediately in the premise is exported to the grid and it

[1] Σχέδιο για την παραγωγή ηλεκτρικής ενέργειας από ΑΠΕ για ιδία κατανάλωση, 2021

[2] MECI website

[3] Σχέδιο για την παραγωγή ηλεκτρικής ενέργειας από ΑΠΕ για ιδία κατανάλωση, 2022

[4] Ανακοίνωση για Παράταση Δημόσιας Διαβούλευσης (30.8.2022)

[5] PV systems above 10.4 kW can be included under the net billing scheme

can then be reimported and used at a later stage. According to the rules applied to this scheme up to 2022, any accumulated surplus energy after the end of the contract (15 years) would be compensated at the ongoing export price of energy set by EAC[6]. However, this compensation policy is currently under revision.

The government provides also grants in order to support home owners[7] to acquire PV systems under the net metering scheme. More specifically, the RES & EE fund[8] sponsored in part with the European Commission's NextGenerationEU fund and with a total budget of €30 million, encourages the installation of PVs and other energy efficiency measures with the following grant schemes:

Table 2-1 Grants provided in Cyprus under the net metering scheme (eligible in 2022)[9]

Grant title	Amount	Maximum amount
Category 2: Roof thermal insulation in combination with the installation of a PV system in households with the net metering or virtual net metering method	Roof insulation: 55% of the eligible costs	€2,750
	PV installation: €450 per installed kW	€1,800
Category 3A: Installation of Photovoltaic System in households with the Net Metering	€375 per installed kW	€1,500
Category 3B: Installation of Photovoltaic System with the Net Metering method in households of vulnerable consumers	€1,000 per installed kW	€5,000

Source: RES & EE fund

B. Net billing

Net billing is a form compensation mechanism that aims to incentivize generation and self-consumption of electricity for big prosumers. It applies to PV systems as well as to biomass/biogas systems up to 1 MW (previously 8 MW) in residential and industrial units (e.g., public buildings, schools), for an aggregate installed capacity of 20 MW per year. The capacities of the systems eligible under net billing might be re-evaluated in the next iteration of the scheme.

Even though there are no dedicated grants for the installation of PVs under the net billing scheme, consumers can benefit from financial support for the installation of energy saving measures under the schemes "Saving – Upgrading of Households"[10] and "Saving – Upgrading for Enterprises"[11] of the Recovery and Resilience Plan. More specifically, the first scheme concerns residential buildings and provides a financial support of €500/kW for normal consumers and €950/kW for vulnerable consumers for the installation of a PV system under the net billing scheme up to 10 kW. Regarding the support to enterprises, the financial support for the installation of the PV system applies either to SMEs or to NGOs and cover 40% and 60% of the eligible costs respectively, with a maximum amount of €150,000. Further, additional support (which covers the same share of costs and has the

[6] Σχέδιο για την παραγωγή ηλεκτρικής ενέργειας από ΑΠΕ για ιδία κατανάλωση, 2022

[7] With building licenses before 01/01/2017.

[8] https://resecfund.org.cy/el/sxedia

[9] Note that the amounts for grants of Category 2 and 3A are increased by 50% for mountainous areas.

[10] Saving – Upgrading of Households

[11] Saving – Upgrading for Enterprises

same maximum amount as with the PV) can be provided for the installation of a storage system for the electricity produced by the PV system.

C. Autonomous RES systems not connected to the network

This scheme concerns installations of autonomous PV Systems, autonomous systems of biomass / biogas and other RES technologies that are not connected to the grid without a restriction in the maximum capacity of the system and all consumers are eligible to apply for the scheme. Under this scheme the prosumers are encouraged to install a storage system, thus limiting the export of energy

The agricultural and farm units can benefit further from the support, as through this scheme the applicants can apply for a grant for the installation of autonomous PV or biomass systems through the Cyprus Rural Development Programme[12]. However, the applicants should first obtain a license approved and provided by CERA that allows them to install such systems.

D. Virtual net metering

The virtual net metering scheme for self-consumption concerns the installation of PV systems connected to the grid of residential buildings and agricultural premises (including wine producers) but in this case, the PV systems are installed in a different location than the premises that they are supplying. The maximum installed capacity of each PV system allowed is 10.4 kW for residential consumers and 100 kW for (professional) farmers. The scheme covers PV systems with a total installed capacity of 10 MW.

Similarly to the net metering scheme, the virtual net metering is based on the comparison between the exported and imported electricity, which is conducted by the supplier either every one or two months. Any surplus of electricity is transferred to the next billing period while any deficits are invoiced within the respective billing period. If there is a surplus in the last bill of a 12-month period, it will be transferred to the next billing period, while if after the end of the contract (i.e., after 15 years for residential consumers or 10 years for farmers) there is still surplus energy, the prosumer will be compensated according to the current price of electricity. However, a major difference compared to the net metering scheme is that the consumers cannot self-consume the electricity produced, therefore all the electricity used is imported, hence network and other charges are increased, leading to an overall higher energy bill. Additionally, the installation costs may be higher than in the case of net metering, making the investment less profitable. Nevertheless, the consumers can apply for the grants in Categories 2, 3A and 3B of the RES & EE fund[13] (detailed in section 4.1.1.A "Net metering"). The amount and the technical specificities of the grants are the same as in the case of net metering. As a result of the abovementioned reasons, virtual net metering scheme is suggested only to the consumers that cannot install a system in their actual premise.

E. Virtual net billing

The final category regards the virtual net billing which applies to all consumers including hotels and touristic accommodations. According to the description of the ongoing scheme, the maximum installed capacity of the PV system differs depending on the type of consumers, namely:

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[12] http://www.paa.gov.cy/moa/paa/paa.nsf/index_gr/index_gr?opendocument

[13] https://resecfund.org.cy/el/sxedia

- 150 kW for hotels and touristic accommodations;
- 50 kW for military units;
- 20 kW for the other categories of consumers.

However, those specificities might change in the next iteration of the scheme.

The compensation mechanism and the respective restrictions are the same as in the net billing scheme (e.g., electricity production capped at 20% of the total yearly electricity consumption, same formula for the calculation of maximum installed capacity). The contract of the scheme is valid for 10 years, while the scheme will be open until the 1st of August 2023 (or until the maximum amount of capacity is reached). The scheme covers PV systems of aggregated 20 MW installed capacity.

2.1.2 Comparison between net metering and net billing scheme

As the majority of the residential and commercial consumers are either under net metering or net billing scheme, the remaining of this section will focus on the analysis and comparison of those two compensation mechanisms.

Table 2-2 summarizes the main differences between net metering and net billing schemes. Besides the differences in the capacities of the systems, the beneficiaries and the period of settlements, the main difference of the two schemes concerns the method of calculating the costs for the consumed electricity. For larger installations (above 1MW) different rules apply as these are considered commercial generators.

Table 2-2 Differences between the net metering and net billing scheme

	Net metering	Net billing
Capacity	Up to 10.4 KW	Up to 1 MW
Beneficiaries	All consumers	Residential buildings, commercial and industrial units, public buildings, schools, military camps, agricultural and livestock units, fishing enterprises
Offset Unit	Electricity (kWh)	Bills (€), energy costs
Non-consumed energy	Transferred to the next billing period	The amount of money equal to the retail price from RES is being credited and transferred to the next billing period
Period of offsetting	Every 1-2 months	Every 1-2 months
Period of surplus settlement	February/March	October/November
Energy cost	Imported price on the net energy	Imported and exported energy are charged separately and they are subtracted
Contract duration	15 years residential buildings 10 years for non-residential buildings	10 years

Source: Own elaboration based on MECI information

Cost assumptions

For the analysis of government support schemes, and in particular net metering and net billing, the current methodology for electricity and network charges as determined by CERA in 2020 was considered, including the monthly charges presented in Table 2-5, which correspond to the charges applied in Cyprus for the period January-July 2022. This period was chosen instead of the more recent one (July-December 2022) due to the fact those prices are significantly higher than usual due to the global energy crisis, and they would give unrealistic results in the long term.

Additionally, while the fuel adjustment cost is normally part of the electricity bill paid by the consumers, this factor has also been excluded from the calculations of the energy bill as it would also lead to unrealistic results in the long term. This is because fuel costs have increased significantly in 2022, leading to an average adjustment cost of €0.15/kWh for 2022 (additional to the energy cost) compared to previous years when, on average, it remained below €0.03 – €0.04 per kWh. As an indication, a normal consumer with an annual consumption of 7,000 kWh would see the difference in its energy bills as presented in Table 2-3**Error! Reference source not found.**.

Table 2-3 Difference of annual costs with and without the inclusion of the fuel adjustment cost for a normal consumer with annual consumption of 7,000 kWh with and without PV

Annual energy cost (€)	Without Fuel Adjustment	With Fuel Adjustment
No PV	1097	2332
PV	313	368

Source: Own elaboration based on EAC and CERA data

Given than the profitability of investments is calculated on the basis of the savings made against the case with no PV, the inclusion of fuel adjustment would significantly increase the returns of the investments. For the example shown in Table 2-3, returns would increase from 18% to 50%, while the payback period would be reduced from 5 years to only 2 years. Due to this significant impact on the results, the analysis in this report have been produced excluding the fuel adjustment costs from the calculations. This means that, in practice, the results slightly underestimate the returns achievable.

When it comes to vulnerable consumers, the tariffs include a component for the energy consumption (€/kWh) and a fix charge (€/month). Network and other charges are not applied. However, vulnerable consumers also pay the fuel adjustment cost, but due to the reasons described above, this element is excluded from the calculation of the energy bill for vulnerable consumers as well. The tariffs used in this analysis are provided in Table 2-4.

Table 2-4 Monthly tariffs applicable on the electricity bill for vulnerable consumers, January-July 2022

Units (KWh)	Total Units	€/kWh	€/monthly
The first 500 units	0-500	0.0563	0.67
The next 500 units	501-1000	0.063	2.14
Any additional units	1001+	0.07505	2.68

Sources: EAC: Domestic Use tariffs

Table 2-5 Charges and respective tariffs applicable on the electricity bill for normal consumers in the period January-July 2022; monthly prices[14]

Charges	Tariffs

[14] The provided fees concern the domestic, low voltage connections

$Energy\ cost = (imported\ electricity - exported\ electricity) \times energy\ price$	Import: 0.0882 €/kWh Export: 0.0711 €/kWh
$Network\ cost = imported\ electricity \times network\ price$	0.0302 €/kWh
$Anciliary\ services\ cost = imported\ electricity \times anciliary\ services\ price$	0.0066 €/kWh
$Public\ service\ operation\ cost = imported\ electricity \times Public\ service\ operation\ fee$	0.00035€/kWh
$RES\ \&\ EE\ Fund\ cost = RES\ \&\ EE\ Fund\ fee\ x\ imported\ electricity$	0.005€/kWh
$Meter\ reading\ charge\ (fixed\ fee)$	0.490 €
$Supply\ charge\ (fixed\ fee)$	2.320 €

Sources: EAC: Domestic Use tariffs, EAC: Fuel price adjustment, CERA: Decision 114/2022

Table 2-6 provides two fictitious examples of billing under the net metering scheme based on the tariffs provided in Table 2-5; the premise is assumed to have a PV installation of 4 kW and total yearly consumption of 6,000 kWh in the case of surplus of electricity (imported electricity lower than exported), and 7,000 kWh in the case the premise has deficit of electricity (imported electricity higher than exported). The energy cost is calculated on the net energy consumed (imported-exported) accounting for any surplus throughout the year based on the retail price of electricity, while network and other costs are calculated based on the imported energy. As shown from the breakdown of the costs, network costs constitute the majority of the energy bill, while the energy cost account for only about 10% of the total costs. This result indicates that the users are incentivized to increase their self-consumption so that they import as less electricity as possible and therefore reduce their network (and other) costs. However under the net metering scheme, the consumers use the grid as a battery cost-free, which creates significant problems to the stability of the grid.

Table 2-6 Examples of billing with the net metering scheme (alternative user)

	Case 1: Surplus	Case 2: Deficit
PV capacity (kW)	4	
Energy Data (kWh)		
Total consumption	6000	7000
Imported electricity	4338	5138
Exported electricity	4777	4581
Net electricity	-438	557
Electricity charged (including any monthly surplus electricity)	164	308
Costs (€)		
Energy costs	17	32
Network costs	188	215
Other costs	56	66
Total costs incl. VAT(€)	**260**	**313**

Source: Own elaboration based on EAC and CERA data

Table 2-7 provides the same example of billing yet under the net billing scheme based on the tariffs provided in Table 2-5, in the case that the premise has surplus of electricity (imported electricity lower than exported) and in the case the premise has deficit of electricity (imported electricity higher than exported). The imported and exported electricity are charged at different rates and the consumers pays the difference between those two costs (i.e., imported cost-exported cost). The remaining charges, as with the net metering, are charged on the total imported energy.

Table 2-7 Fictive examples of a monthly bill under the net billing scheme (alternative user)

	Case 1: Surplus	Case 2: Deficit
PV capacity (kW)	4	
Energy Data (kWh)		
Total consumption	6000	7000
Imported electricity	4338	5138
Exported electricity	4777	4581
Net electricity	-438	557
Costs (€)		
Energy costs	51	152
Network costs	188	215
Other costs	56	66
Total costs incl. VAT(€)	**260**	**432**

Source: Own elaboration based on EAC and CERA data

Compared to the net metering results, net billing is less cost effective for the consumers both in the case of surplus and deficit of yearly electricity, by 13% and 38% respectively. This difference is based on the higher energy costs the consumers pay due to the different price of importing and exporting electricity (see Table 2-5). Therefore, net billing is a more expensive choice from a user's perspective, yet more efficient from a power-system point of view. However, by taking into account the total savings (compared to the case with no PV) in a period of 15 years and the current available grant for net billing (€2,000) for PV installation, net billing is still a profitable investment, with a payback period of around 5 years in both cases.

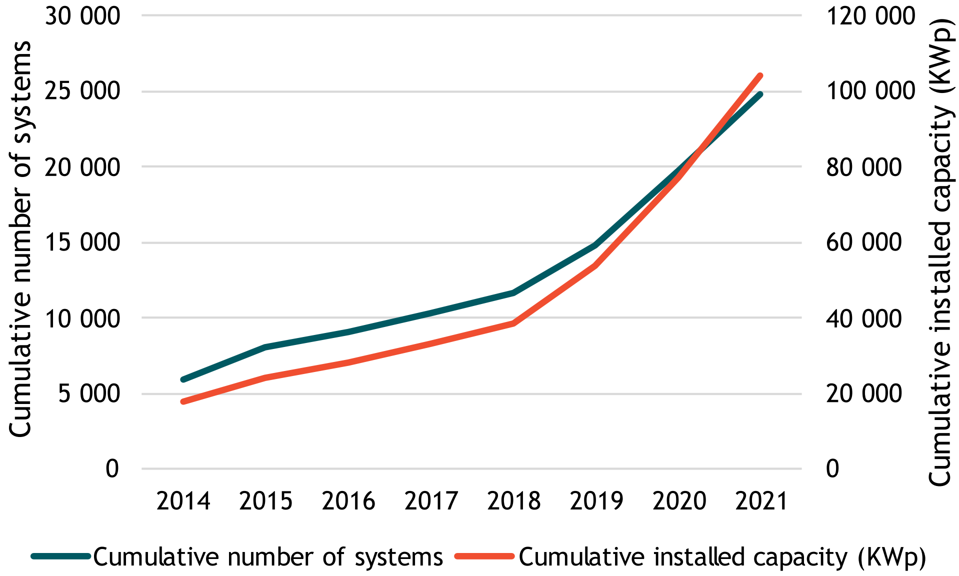
2.1.3 Uptake and costs to date

2.1.3.1 Net metering

The number of installed PV systems under the net metering scheme (

Figure 2-1) has increased consistently since 2014, although the annual uptake decreased during the period 2015-2018, from 5,000 units in 2014 to an average of 1,000 in 2016. The numbers rose again in 2019 with more than 3,000 units and reached a peak in 2021 with more than 5,100 units (approximately the same amount as for 2014). The total installed capacity shows the same trend, i.e., recording minimum values in 2016 with 4.1 MWp, while the maximum installed capacity was recorded in 2021 with 26 MWp. Up to 2021, the cumulative number of systems installed under the net metering scheme were approximately 25,000 units, while the corresponding cumulative installed capacity reached 107 MWp.

Figure 2-1 Number of systems and installed capacity (KWp) under the net metering scheme for the period 2014-2021

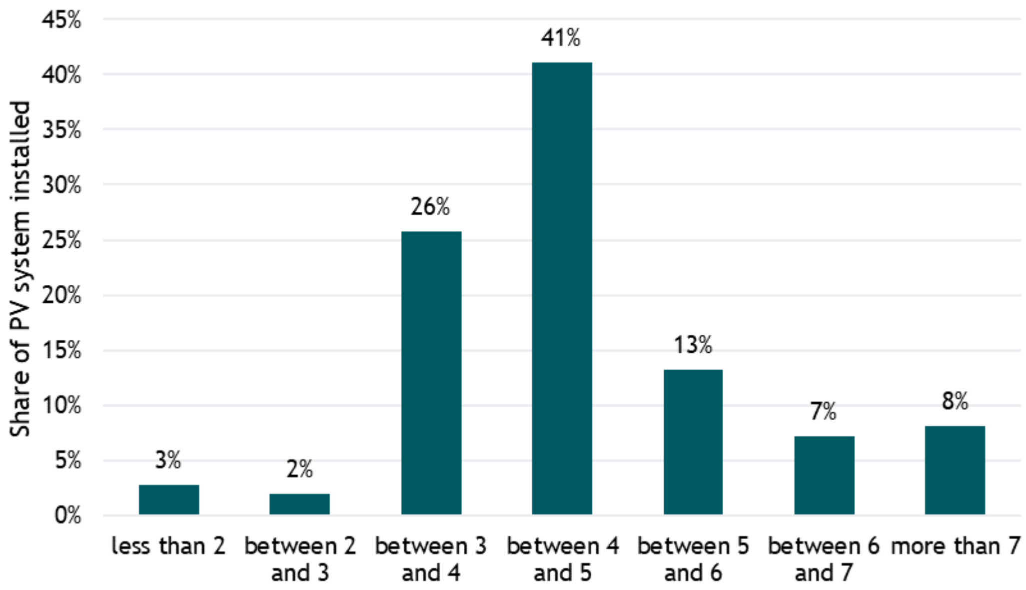


Source: Own elaboration based on MECI data

The majority of PV systems installed are between 3 kWp and 5 kWp, with the most common model being a 3.9 kWp size (

Figure 2-2).

Figure 2-2 Distribution of size of PV systems (kWp) installed (2019-2021)

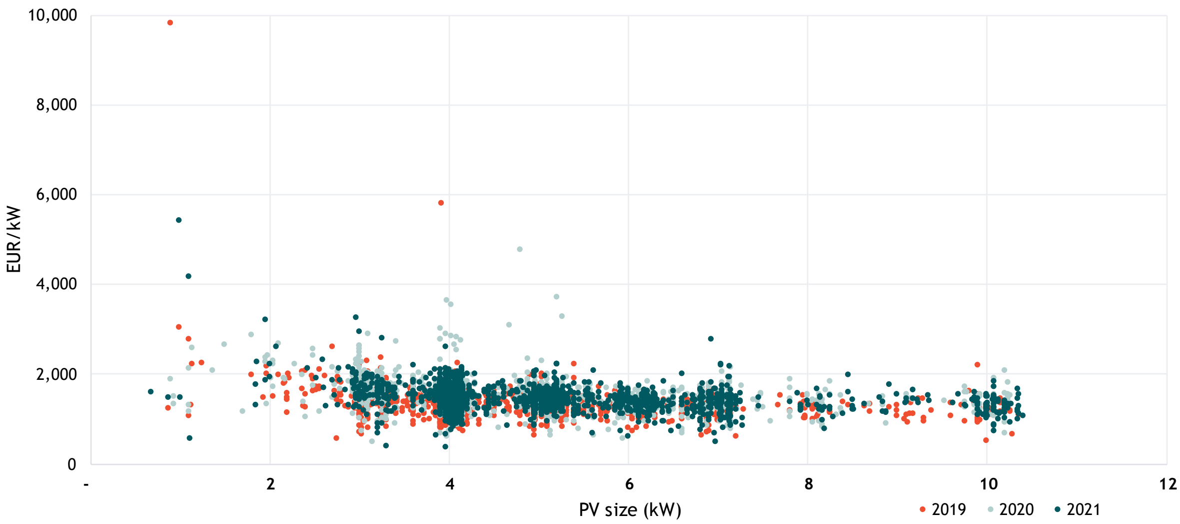


Source: Own elaboration based on MECI data

Concerning costs, the median total system installation cost (including VAT) between 2019 and 2021 was €6,108, with an average of €6,440. As expected, smaller systems cost more per kWh installed, with a 2 kWp system costing on average €1,440 per kWp installed and a 6 kWp system costing €1,102 per kWp installed.

Figure 2-3 shows the cost distribution for 2019, 2020 and 2021 according to PV size. The trendline evolves as expected, although there are some outliers for systems below 5 kW.

Figure 2-3 Distribution of total installation cost (including VAT) according to system size

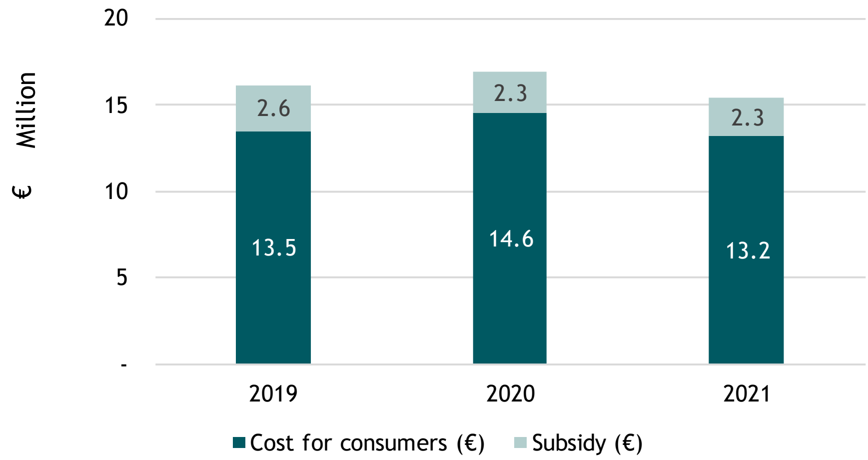


Source: Own elaboration based on MECI data

Half of the systems that operate under the net metering scheme received a grant either under the Categories 3A (normal consumers) or 3B (vulnerable consumers) in 2020, with an average subsidy amount of €967 and €3,323, respectively. Figure 2-4 and Figure 2-5 present the costs for the consumers as well as the costs paid by the government in the form of subsidy for normal and vulnerable consumers respectively. It shows that between 2019 and 2021 the net metering scheme stimulated households and SME's investment of between €15 million and €18 million per year for standard users, plus the investments from vulnerable consumers amounting to €2.6 million in 2019 and €2 million in 2020. Data for 2021 is not yet available.

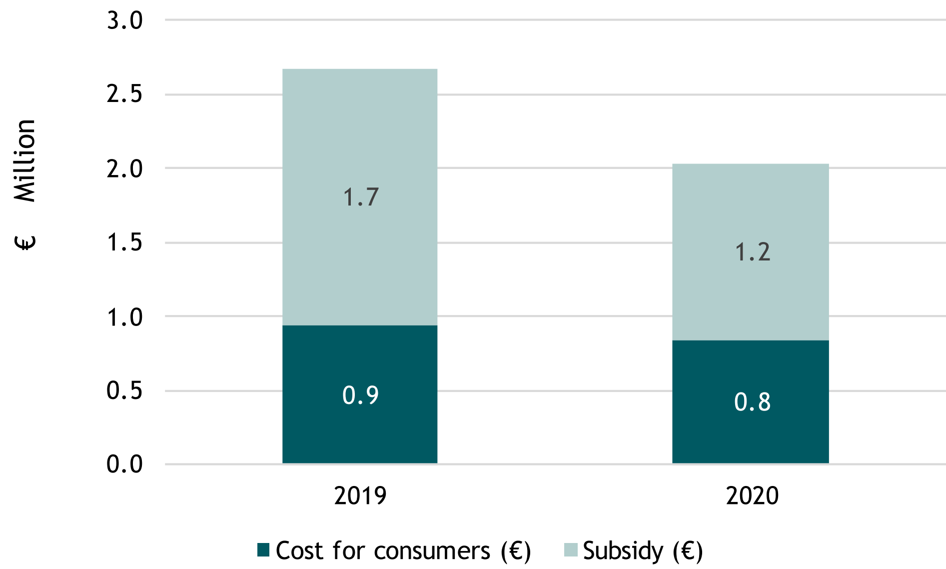
For normal consumers the government covered on average 15% of the total installation costs for the period 2019-2021, while for vulnerable consumers it covered the majority of the costs, averaging 62% for the years 2019 and 2020. In 2020, the government spent €3.5 million for normal users, which corresponds to 19% of the total installation costs, plus an additional €1.2 million for vulnerable consumers. Note that for 2021 the status of application for vulnerable consumers is not available, therefore those costs are not included in Figure 2-5.

Figure 2-4 Total installation costs of PVs including the cost for normal consumers and the respective government subsidy under the net metering scheme for the period 2019-2021



Source: Own elaboration based on MECI data

Figure 2-5 Total installation costs of PVs including the cost for vulnerable consumers and the respective government subsidy under the net metering scheme for the period 2019-2020

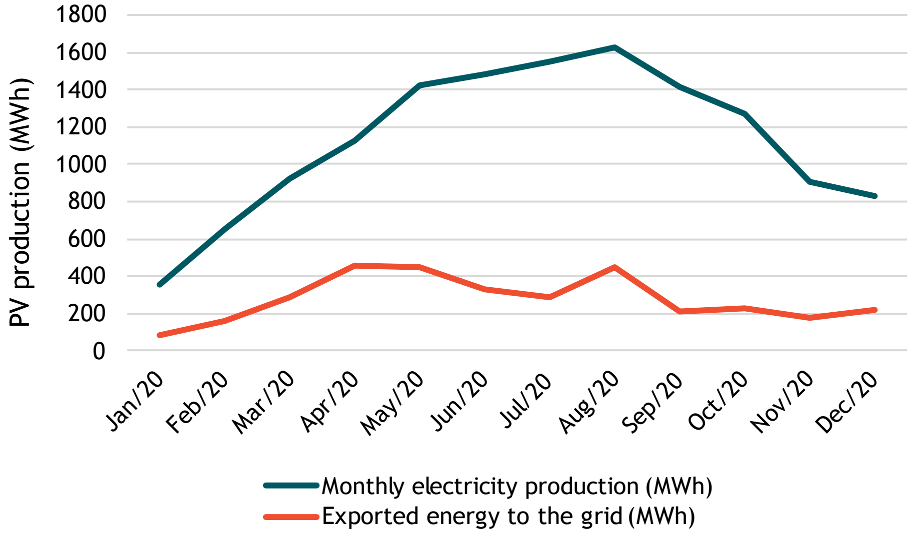


Source: Own elaboration based on MECI data

2.1.3.2 Net billing

With regard to the net billing systems in Cyprus, based on data reported by EAC, in 2020 the cumulative number of PV systems was 1,371 with a cumulative installed capacity of 148 MWp. During this year, the PV production of the systems was over 13.5 GWh and the respective exported electricity to the grid amounted to 3.3 GWh, meaning that 75% of the electricity production was used by the premises on site. However, provided the installed capacity of the systems, the expected PV production is around 180 GWh, which is significantly higher than the generation reported by EAC.

Figure 2-6 Monthly electricity production from PV systems under the net billing scheme and the respective exported electricity in 2020



Source: Own elaboration based on CERA data

2.1.4 Profitability of PV investments

To assess how the grants provided by the government affected the profitability of PV investments, a model[15] was used to simulate the cash flow of different users with different consumption patterns. The model evaluates the profitability of an investment in PV over a period of 15 years by considering the savings on the energy bills' that a consumer under the net metering scheme would have, compared to a consumer with the same consumption profile but no PV system installed. The model allows to vary:

- Consumption profiles;
- Total annual consumption;
- The size of the PV system (with installation costs of the PV system varying accordingly);
- The grant amount, depending on the scheme and on the size of the system[16].

The model also allows to see how result vary under the three types of network tariffs methodologies considered under this study:

- Previous tariff methodology (old): consumers with PV under a net metering or net billing contract pay network charges only on the net electricity imported from the network, but there are some fixed fees charged based on the size of their PV system;
- Current tariff methodology: consumers with PV pay network and other charges (levies, taxes etc.) based on the total amount of electricity imported, but the fixed charges are removed;
- New tariff methodology, based on the approach recommended by JRC in 2018 (volumetric + capacity charges) (V+C): the network charges are split to a volumetric component, charged on the total imported electricity, and to a capacity component, based on the allowed capacity of

[15] The numerical analysis presented in this report is based on a bespoke model developed specifically for this study. The model allows to estimate the impact of different subsidy schemes and network tariffs methodologies on different consumers, in particular changes in their energy and network cost, and the profitability of investing in a PV system, behind-the-meter storage and replacing their solar water heater. For more information and details on the methodology and data used, please refer to Annex I.

[16] Note that the grant amounts for mountainous areas have not been taken into account

the connection (9.2 kVA). The remaining of the charges are the same as for the current methodology.

The model allows to analyse different types of consumers based on their level of energy consumption and their PV installations. Further details on the modelling methodology and assumptions are provided in Annex I.

The profitability of investments is expressed in terms of Internal Rate of Return (IRR) and Payback Period (PBP), considering a 0% discount rate. The 0% discount rate has been chosen because, while for public policies a 3.5% discount rate (social discount rate) is accepted as standard, there is no agreement on an appropriate discount rate to be used when looking at individual consumer choices. For analysing businesses investments a 7% to 10% discount rate would be typically applied, but for household there is less agreement on which is an appropriate rate to use, and there is substantial difference among the preferences expressed by households in empirical studies[17]. Providing the analysis for a zero discount is more transparent under this point of view. Also, IRR and discount rate are directly related (the IRR is the discount rate that makes the net present value of future cash flows equal to zero). As a rule of thumb, each 1 percentage point increase in discount rate would reduce IRR by 1 percentage point, slightly above 1 percentage point for discount rates close to zero. This is further discussed in section 6.6.

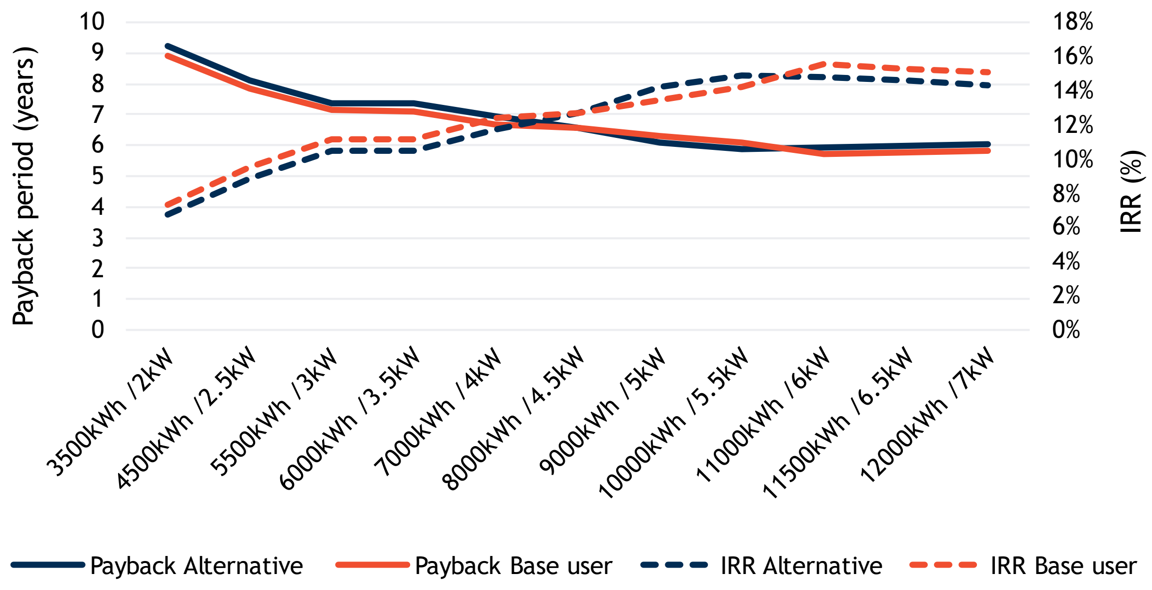
The assumed energy cost throughout the investment period considered (15 years) is €0.0882/kWh, which corresponds to the energy tariff of the period January-July 2022.

2.1.4.1 Net metering

As a reference point, we first examine the case when **no grant** is provided, considering the case of users with two consumption profiles and different levels of annual consumption, also adjusting the size of the PV system to provide around 90% of energy needs. Given that no grant is included, profitability is based only on the energy savings and savings on network costs for the consumer. Overall, IRR increases as the size of PV systems and the energy consumption increase, yet it stagnates for systems above 6 kW and for consumption above 11,000 kWh respectively. For base users the IRR ranges from 7% to 15% for small and large consumers respectively, while for alternative users the return is about 1% lower. In terms of PBP, this varies between 9 to 6 years. The growing returns with size of the PV are due to smaller systems being more expensive per kW installed.

[17] see for example https://link.springer.com/article/10.1007/s00148-016-0623-y

Figure 2-7 IRR variation with consumption and PV capacity- no grant

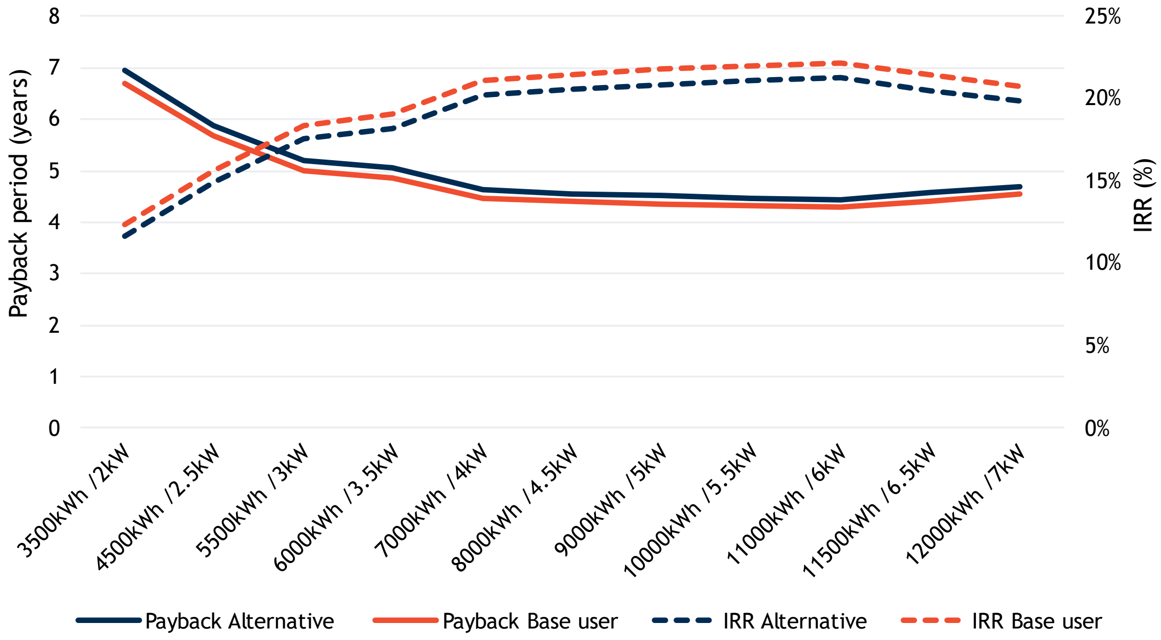


Source: Own elaboration based on MECI, CERA and EAC data

The introduction of the grants significantly improves the IRR and PBP in all cases and methodologies. The scheme **"Roof thermal insulation in combination with the installation of a PV system"** provides a grant of 450 €/kW of installed capacity capped at €1,800, so ranging from 900 €/kW for a 2 kW PV system to 1,800 €/kW for 4 kW and above systems. When it comes to insulation, the scheme covers 55% of the eligible costs with a maximum of €2750. For small prosumers with a normal profile (base user), the IRR increases from 12% per year for a 2 kW system to 18% for a 3 kW system, while larger users' returns peak at 21% for 5 to 6 kWp systems (

Figure 2-8). The PBP is accordingly reduced, starting from 7 years for small prosumers to 5 years for large prosumers. As for the case of no grant, consumers with an alternative profile show returns which are around one percentage point lower.

Figure 2-8 IRR and PBP variation with consumption and PV capacity for recipient of grant Roof thermal with PV



Source: Own elaboration based on MECI, CERA and EAC data

As part of this scheme, users could also reduce their energy use, thanks to roof insulation, but have to invest more to cover the cost of insulation. Given the increased costs to combine the installation of a PV system with roof insulation measures (which can be over €10,000 excluding grants), the investment is more cost efficient for houses with poor energy efficiency rating. Considering the grants provided under the current scheme, an inefficient house that energy savings could reach 25% per year, the investment is paid back in 7 to 8 years, which adds around 3 years compared to the case where only a PV of 4 kW is installed (see Text box 1) .

Text box 1 Impact of investing in roof insulation combined with PV system

To understand the effect of roof insulation in combination with the installation of a PV system in the profitability of the investment, we consider the case of a single family house with an average size of 141 m^2 [18] (which corresponds to a roof of about 70 m^2 assuming a 2-store house) and an annual consumption of 7,000 kWh (alternative user profile) and we compare it with a reference case where no PV is installed and no insulation measures are applied. This household would pay yearly around €1,100 for electricity, which leads to about €16,500 in 15-years period.

Case 1: Application of insulation measures

If this household decides to invest only in roof insulation, the PBP ranges from 12 years (IRR of 3%) when the insulation allows to achieve 10% yearly energy savings (i.e., bring down yearly consumption of 6,300 kWh), to PBP of 5 years (IRR of 19%) for 25% yearly energy savings (i.e., yearly consumption of 5,250 kWh). Therefore the investment is highly profitable only for the more inefficient houses that would reduce significantly their energy consumption after the implementation of insulation measures.

Case 2: Installation of a 4 kW PV system

Assuming the initial total annual consumption (7,000 kWh), the installation of a 4 kW PV system alone would save already 70% of the energy costs in 15 years period under net metering. Considering the PV installation costs and the grant that the household can receive under this scheme (i.e., €1,800), the investment would have an IRR of 20% and a PBP of 4.6 years, which makes it a profitable investment.

[18] Based on Cyprus' LTRS (2020)

Case 3: Installation of a 4 kW PV system and roof insulation in a fairly efficient house (10% energy savings)

Now we assume that this household is fairly efficient, yet the owners decide to proceed to a roof insulation at a cost of 40 €/m^2 [19] that would lead to energy savings of 10% per year (i.e., yearly consumption of 6,300 kWh), in combination with the installation of a 4 kW PV system. The combination of the measures would lead to a reduction of 75% of energy costs in 15 years, yet since the total investment cost would be increased compared to investing only in PV, the IRR would decrease to 15% and the PBP would increase to 6 years.

Case 4: Installation of a 4 kW PV system and roof insulation in an inefficient house (25% energy savings)

However, considering that the same house is rather inefficient, which is the case for the majority of the buildings in Cyprus[20], and assuming that the roof insulation would lead to energy savings of 25% per year (i.e., yearly consumption of 5,250 kWh), the investment becomes more profitable, with the IRR being decreased to 16% and the PBP of 5.6 years. Compared to the case of installing only insulation measures, the additional investment in a PV would add less than a year to the payback of the investment, which makes it still a valid option.

Similar trends emerges also when the analysis is repeated for the "**Installation of PV System with the Net Metering method in households**" scheme, which provides 375 €/kW installed with a maximum of 1,500 €. However, given that the grant amount is lower, the IRR achieved is between 1 and 2 percentage points lower than the figures for the PV + roof insulation scheme.

The above results are based on an energy price of €0.0828 per kWh, which is substantially below the prices seen in 2022 across the European market. If the current price is increased by 50%, the returns achieved would increase considerably: a 7,000 kWh/4 kWp user (receiving a €1,500 PV grant) would achieve a return of 40% under net metering, while a 11,000 kWh / 6 kWp user (also receiving a €1,500 PV grant) would achieve return of between 43%, equivalent to payback period of just 2.3 years.

This is significantly lower than payback period seen across Europe. For example, a recent study[21] found payback periods around Europe range mostly around 6 to 10 years (although the study considered installation cost of €1,800 kWp, substantially above what was observed in Cyprus). These returns suggest that the scheme offer a significant incentive to consumers, and under the current international prices are a further incentive for the installation that for the majority of users would have very short payback period.

When it comes to vulnerable consumers, the investment in a PV is very profitable, especially for the medium-size users, given that the energy costs are reduced by around 90% compared to the no PV case. Specifically, the IRR can reach almost 50% in the best case (5 kW PV system with 9,000 kWh annual consumption), while after that point IRR is reduced due to the fact that the investment costs increase while the grant remains constant (capped at €5,000 for 5 kW systems and above).

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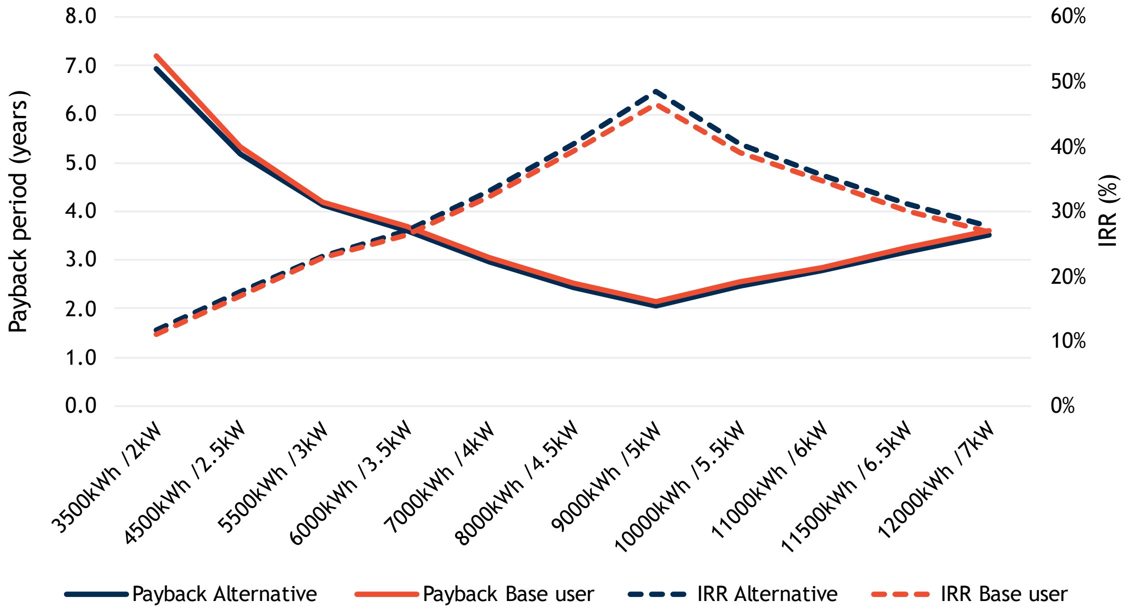
[19] Indicative insulation cost derived in consultation with MECI. Note that the cost can vary significantly depending on the type of insulation.

[20] According to Cyprus' LTRS, the majority of the household buildings where constructed before 2007 when the energy efficiency requirements were introduced, therefore they have poor or medium energy efficiency rating.

[21] https://www.otovo.no/blog/solenergi/the-otovo-solar-insight-solar-payback-trends-2019/#:~:text=Under%20the%20current%20FIT%2Dscheme,the%20range%208%2D10%20years.

Figure 2-9 IRR and PBP compared to PV capacities and energy consumption with grant Installation of PV System with the Net Metering method in households of vulnerable consumers



Source: Own elaboration based on MECI, CERA and EAC data

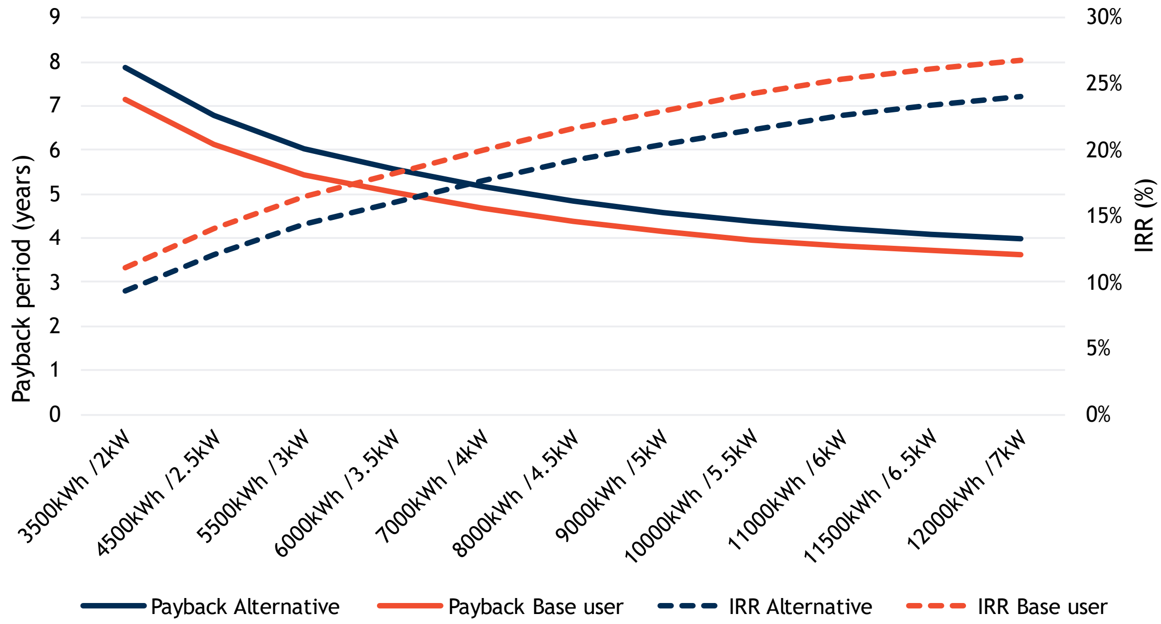
2.1.4.2 Net billing

As described in section 2.1.1, Cyprus introduced a grant scheme for residential consumers for the installation of a PV system under net billing scheme of 500 €/kW with a maximum amount of €5,000 for normal consumers and 950 €/kW with a maximum amount of €9,500 for vulnerable consumers. Nevertheless, given that the grant was introduced only in 2021, there is no data available on the uptake so far.

The introduction of the grant improves the PBP by on average 3 years while the IRR is increased by on average 10%. For a base user, depending on the size of the system, the PBP ranges from 7 to 4 years, with the IRR ranging from 11% to 27% respectively, while for an alternative user the PBP ranges from 8 to 4 years (Figure 2-10).

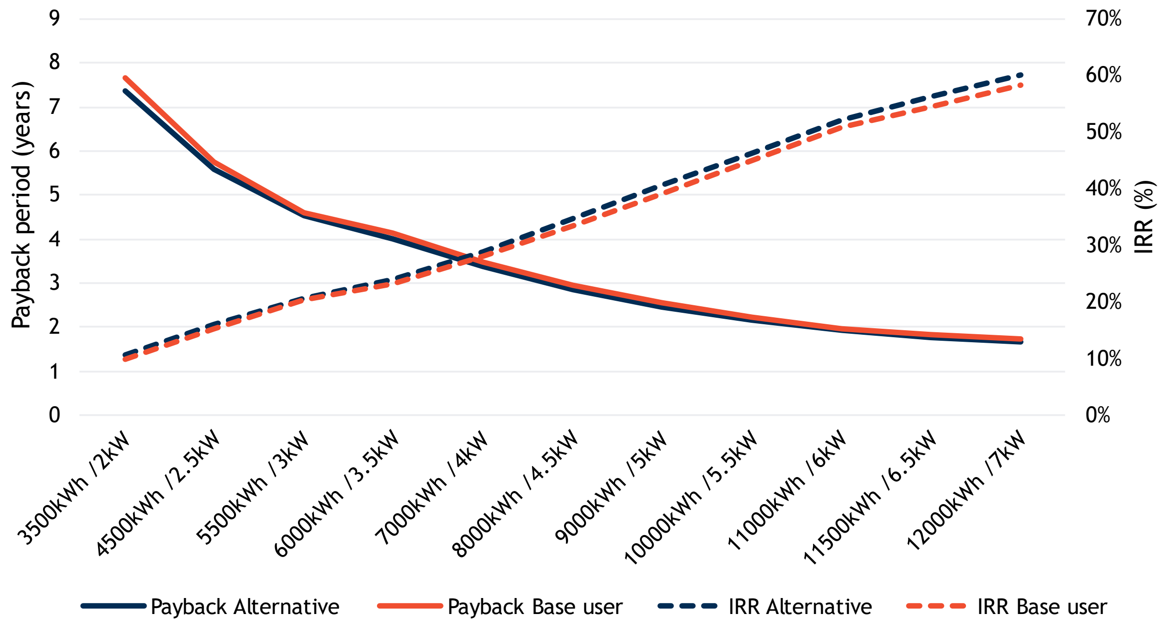
When it comes to vulnerable consumers, investing in a PV system under this grant can be a very profitable investment especially for large consumers with high building consumption and large PV capacities, given that the cap of the grant is set at €9,500, which is reached only in the case of 10 kW and above systems. The IRR starts from 11% for small users (3,500 kWh/2 kW) and goes up to 60% for large consumers (12,000 kWh/ 7 kW), corresponding to a PBP period range of 7 to 2 years (Figure 2-11).

Figure 2-10 IRR and PBP compared to PV capacities and energy consumption with grant PV with net billing in households of normal consumers



Source: Own elaboration based on MECI, CERA and EAC data

Figure 2-11 IRR and PBP compared to PV capacities and energy consumption with grant PV with net billing in households of vulnerable consumers



Source: Own elaboration based on MECI, CERA and EAC data

Compared to the net metering case, the installation of PV under net billing scheme is less profitable for both normal and vulnerable consumers, nevertheless, the users under net billing still have significant savings on the energy bills compared to the no PV case (in the range of 60% to 70%), while the investment is paid back within a reasonable period, and closer to the average PBP observed in the rest of Europe.

2.1.5 Options for improvement

2.1.5.1 Net metering/net billing

The Directive (EU) 2019/944 of 5 June 2019 (art. 15) on common rules for the internal market for electricity states that: *Member States that have existing schemes that do not account separately for the electricity fed into the grid and the electricity consumed from the grid, shall not grant new rights under such schemes after 31 December 2023. In any event, customers subject to existing schemes shall have the possibility at any time to opt for a new scheme that accounts separately for the electricity fed into the grid and the electricity consumed from the grid as the basis for calculating network charges.* Essentially, the Directive forbids Member States from allowing new customers into a net metering scheme, with the aim of discouraging this practice.

Recommendation 1: Based on the accepted guidance, the net metering scheme should be phased out as they provide an unfair advantage to self-generators, that use the network as a "storage device" for a price that is not cost-reflective[22]. The net metering scheme should be immediately closed to new applicants (for instance after 2023), while existing prosumers should be incentivised to move to net billing. Net billing, in particular if accompanied by a variable export price, would provide stronger incentives to prosumers to shift their consumption patterns and to install a battery. The (likely) negative public reaction can be mitigated by, for example, offering grants for the purchase of a battery (which would reduce the exported electricity) even in the absence of an electric vehicle.

Text box 2 Profitability of investment in battery

Based on high/level calculations, in order to be profitable to invest in a battery, assuming a cost of €1,000 per kWh installed, energy savings on bills, for each kWh installed, should amount to:

- €100 per year, in order to pay back the battery in 10 years (at a 0% discount rate), or
- €70 per year, to payback the battery in 15 years (also at a 0% discount rate).

At a 5% discount rate savings would have to amount to

- €140 per year per kWh to pay the battery in 10 years, or
- €100 per year to pay it back in 15 years.

Assuming the best case above (minimum savings of €70 per year) means that, for each kWh installed, the battery should avoid users paying:

- €70 less in network costs and imported energy cost (including VAT), in the case of smart metering
- €70 less in network costs, imported energy cost and energy price differential (price of imported – price of exported energy).

Based on our analysis (based on 2022 tariffs), a typical user with net metering (alternative profile), with an annual consumption of 7000 kWh and a 4 kW PV system, pays €175 per year in volumetric network costs (based on total imported electricity, equal to 5138 kWh) and €32 of electricity, for a total of €207. This gives a cost per kWh of €0.0403 (this is the average cost of the service for the total 5138 kWh imported). In order to reach the required €70 in savings, each kWh of the battery should run for 1737 cycles per year, or 4.8 times per day.

[22] https://www.acer.europa.eu/Official_documents/Position_Papers/Position%20papers/WP%20ACER%2001%2017.pdf

The case for a net billing user is slightly better. The same user as above, under a net billing scheme, would pay an additional €119 of electricity costs during the year, for a total of €294 per year or €0.057 per kWh (including the volumetric share of network costs). In order to reach the required €70 in savings, each kWh of the battery should run for 1223 cycles per year, or an average of 3.3 times per day. As a system run from solar can only charge the battery once per day, a battery will not be convenient in any of the scenarios presented above.

Overall, a battery will make economic sense over 15 years of potential life if it is able to generate between €0.19 and €0.38 per day in savings from network tariffs and from energy imports for every kWh of storage (this is likely be higher for small batteries and lower for larger ones). As the battery does not generate any electricity, these savings must come from avoided network tariffs and price differential between imported and exported energy (including extra charges levied on imported volumes). If we assume network tariffs are fixed (around €0.04-€0.05 per kWh), this means that consuming a kWh during non-generating hours should be between €0.15 and €0.33 more expensive than the export price. While this is historically not the case, the exceptional prices seen in 2022 were not too far from these values, for example when the fuel adjustment cost reached around €0.15. However, if we assume a shorter life (10 years) and higher discount rate, the revenue per kWh stored that the battery has to generate increase substantially.

Recommendation 2: Given that net metering is a highly profitable scheme for the prosumers, the government needs to provide strong incentives in order to convince them to switch to net billing- if not under a mandate. Therefore the following actions are suggested:

- While net metering still active, abolish the grants under the net metering scheme and shift them to net billing PV installations. In that way the new users will have higher returns in their investments if they enter the net billing scheme, while the returns of the net metering will be based solely on energy bill savings. The grants can be also differentiated by PV capacities; for instance, smaller users may receive higher grants, or the grant may have a fixed component and a capacity-based component (e.g., €300 + €250/kWp installed).
- Provide a grant for battery installation under net billing scheme. This recommendation has a two-fold result: on the one hand, it will allow the users to reduce their imported energy and therefore their energy bill. On the other hand, it will reduce the dependency of the users on the grid and can limit the instability during the evening hours, when the demand is high.
- Allow consumers in net billing to produce more than their consumption, while consumers in net metering less. Currently, net billing and net metering consumers can sell or re-import from the network an amount of electricity not higher than 90% of their annual consumption (this limit has been revised during the last update to the scheme). By increasing the thresholds of electricity net billing customers are allowed to sell back to the grid, their investment can be more profitable, especially if they have large roof availability but low consumption.

2.2 Grants for solar water heaters

2.2.1 Description of the scheme

The scheme aims to provide financial support in the form of a grant for the installation or replacement of solar water heaters (SWH) in existing buildings.[23,24] While the scheme has been issued already in the past, the current total budget amounts to €600,000 and it is funded by the European Union- NextGenerationEU as part of the Recovery and Resilience Plan of Cyprus. The scheme provides €450 per installation/application/residence while the amount increases up to €900 for residences in mountainous areas. In July 2022, a further €350,000 was added to the fund, which means a total of 1,800 applicants are expected. The grant awarded per system has been increased compared to the previous years (from €350 to €450), but the requirements to be eligible for the grant are stricter (i.e., installation of cylinder and solar panel, the installation should be implemented from certified installers only and cylinders up to 200 L should be at least energy class B).

Furthermore, an additional scheme has been introduced under the RRP, namely "Saving – Upgrading of Households", where a subsidy is provided for the purchase and installation of SWH for residential buildings, with a grant of €1,200 per SWH. However, in order to be eligible for the grant, the premise for which the application is submitted, should be lower than energy class C, as well as not to have received similar grants from the previous scheme or from the RES & EE fund.

2.2.2 Uptake and costs to date

The interest for the grant scheme for the solar water heaters has been generally high as shown in

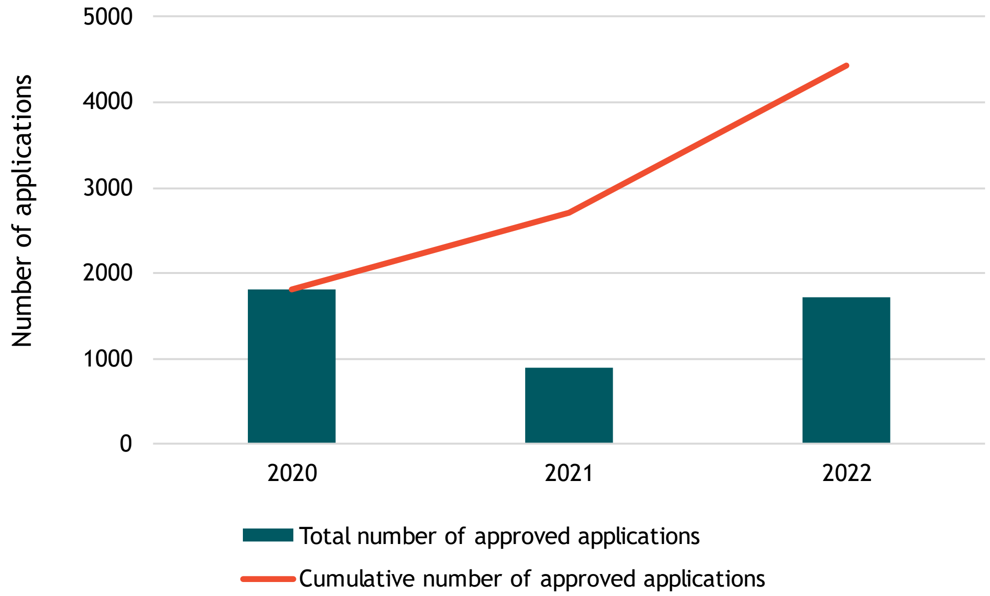
[23] https://resecfund.org.cy/sites/default/files/2022-05/Sxedio_Iliakon_2022.pdf

[24] https://www.resecfund.org.cy/iliaka_2022

Figure 2-12. In 2020 and 2022 more than 1700 were approved each year, while the decrease in approved applications in 2021 could be explained by the stricter application requirements introduced[25]. The total installation costs of SWH for the period 2020-2022 amounted to €5.6 million with the respective government subsidy corresponding to €1.8 million (on average the government covered 30% of the total installation costs) (Figure 2-13).

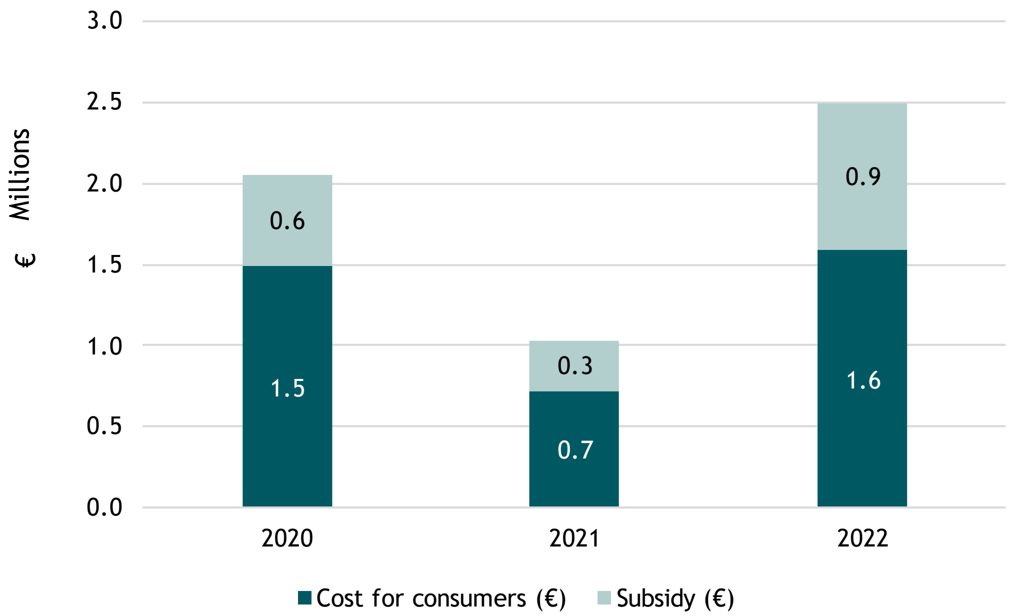
[25] See description of the scheme.

Figure 2-12 Total number of applications of SWH per year and cumulative number of applications for the period 2020-2022 in Cyprus



Source: Own elaboration based on MECI data

Figure 2-13 Total installation costs of SWH including the cost for consumers and the respective governmental subsidy amounts for the period 2020-2022 in Cyprus



Source: Own elaboration based on MECI data

2.2.3 Profitability of SWH investment

In Cyprus, about 24% of the total domestic energy consumption is used to heat water[26], while about 90% of the households have a solar water heating system installed; in fact, after 2007, the installation of such systems is required by law in new residential buildings. Compared to the case with no SWH installed, a SWH can save up to 75% of energy used for water heating, which means up to 18% savings on the total energy consumption of the average household in Cyprus.

Given the widespread diffusion of SWH, some of which have now reached the end of their life, savings are also achieved by replacing an old SWH with a new one. Based on data collected for a recent study[27], replacing an old SWH with a new (A rated) would increase thermal yield by between 7% and 200% (depending on the temperature of the collector). For an average user this corresponds to energy savings between 7% and 67% (according to set water temperature), assuming a total cost of €0.17/kWh[28] and the use of two modules[29]. Based on 2022 energy prices, and on the savings assumed from the replacement of an old with a new SWH over 15 years, the investment would have a PBP of 8 years and IRR of 9% with the old grant (€350), while with the new grant (€450) the PBP is reduced by almost a year and the IRR is improved by 2%.

Table 2-8 Profitability of replacing an old SWH with a new one for a household using 5000 kWh/year

	No grant	Grant size	
		€350	€450
IRR (%)	4%	9%	11%
Payback period (years)	11.2	8.2	7.3

Source: Own elaboration based on MECI data

Because of the effective returns depends on the amount of heated water used (utilisation factor), larger households are likely to benefit more from the installation of a SWH, shortening the payback period. On the other hand, smaller users will require longer to recover the investment.

2.2.4 Options for improvement

A recent study from IRENA[30] found that Cyprus is second only to Barbados in terms of total SWH capacity installed in 2018 (~420 kWh per 1,000 inhabitants), which shows the good level of popularity of the technology. SWH are also stimulated because of minimum efficiency standards in new buildings, which is also responsible for a good amount of the uptake.

Further, the ceiling to the grant ensures the supply chain can only apply limited price gauging. Therefore, only limited improvement options are suggested:

[26] Based on data from https://www.cea.org.cy/wp-content/uploads/2021/07/ethniko-ktiriako-apothema_cea.pdf

[27] Έκθεση αποτελεσμάτων Προσδιορισμός θερμικής απόδοσης ηλιακού συλλέκτη σύμφωνα με το πρότυπο ISO 9806

[28] The total cost per kWh was calculated by dividing the total annual costs for a user with no PV (including energy and network costs, levies and taxes), based on the tariffs shown in Table 2-2, with its yearly energy use.

[29] It is assumed that two modules are enough to heat 150-180 litres of water.

[30] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jul/IRENA_Leveraging_solar_water_heaters_2021.pdf

- Currently, applications are limited by the annual budget assigned to the measure, which means the schemes have a regular start and stop. The Ministry should consider setting up multiannual budgets (if necessary, with annual ceiling) to provide long term stability and certainty.
- Given the returns achieved, and the familiarity of Cyprus consumers with the technology, it is unclear whether grants so generous are justified. Keeping the grants at the old level may be sufficient to ensure a constant upgrade of the current systems.
- Replacing a 2-module SWH would cost around €1,300 and save between 1,800 and 7,000 kWh (compared to an old one) over 15 years. This results on a cost effectiveness of the investment of between €0.72 per kWh and €0.19 per kWh, which is significantly lower than the cost effectiveness of a Solar PV over the same 15 years (which require an investment of between €0.07 and €0.04 per kWh produced). On the other hand, the savings achievable by installing a new SWH where does not exist one are comparable to the savings from a PV system. However, it is worth considering the benefits to the transmission and distribution network deriving from SWH, as avoiding the use of electricity for water heating reduces substantially the need for network reinforcement. For this reason, continuing to support SWH is recommended, but care should be taken in not overcompensating users and investing in the technology at the detriment of other renewable investments.
- Options to integrate smart solutions and PV systems for electricity production with SWH should be considered as part of the support schemes. For example, new devices allow to store part of the energy generated by the solar PV system directly to a hot water tank, removing the need for a separate SWH system and allowing on-site storage in much cheaper form than via batteries. When the heating of the tank is controlled via smart devices, it can also produce substantial benefits at system level if the right market signal are provided (for example, low export rates during peak solar generation hours, so that users are incentivised to time the hot water heating for the afternoon).

2.3 Grant Scheme for the installation PV systems for the charging of electric vehicles or hybrid plug-in vehicles

2.3.1 Description of the scheme

The government provides financial support in the form of a grant scheme for the installation of a PV system or extension of an existing one, for the purpose of charging an electric vehicle or a plug-in hybrid vehicle type.[31,32] The secondary aim of the scheme is to collect information regarding the charging of electric vehicles (EV) and / or plug-in hybrid vehicles in Cyprus, with the aim of boosting the use of the EVs and RES in general, as well as to monitor the achievement of the RES objectives of Cyprus.

The total budget of the scheme amounts to €1.5 million, which corresponds to approximately 500 applications[33], and it is funded by the European Union- NextGenerationEU as part of the Recovery and Resilience Plan (RRP) of Cyprus. This scheme is a continuation of the previous one provided in 2021[34], yet slightly amended, and will be on effect until December 2023 (or until the budget is exhausted).

The grant applies to all natural persons that fulfill simultaneously the following conditions:

- The electricity bill of the residence is issued in their names;

[31] https://resecfund.org.cy/sites/default/files/2022-04/Sxedio_echarging_2022_1.pdf

[32] https://www.resecfund.org.cy/ev_charging_2022

[33] https://resecfund.org.cy/sites/default/files/2022-04/Parousiasi_Sxediou.pdf

[34] https://resecfund.org.cy/el/sxedio6

- They own an electric or hybrid plug-in vehicle;
- The PV system that has been installed in the residence based on this support scheme for the purpose of changing the electric or hybrid plug-in vehicle should be included in the net metering, net billing or virtual net metering scheme.

The grant covers the expenditures presented in

Table 2-9.

Table 2-9 Mandatory and optional expenditures of the grant for installation PV systems for the charging of electric vehicle or hybrid plug-in vehicles

Type of expenditure	Grant amount
Mandatory expenditure	
A. Installation (or extension of an existing) PV system (**one** vehicle)	€750 per KW installed with a maximum grant of € 1,500 per vehicle
A. Installation (or extension of an existing) PV system (**more than one** vehicle)	Maximum grant of €3,000
Optional expenditure	
B1. Purchase and installation of charger	€600
B2. Conversion of electrical installation of the house from single-phase to three-phase	€450
B3. Purchase and installation of battery*	€750 per kWh of storage capacity (maximum subsidy amount is €2,000 per application)

Source: RES & EE fund

Note: the grants are paid after the purchase and installation of the respective system.

** The expenditure is not eligible if the installation of the PV is done under the virtual net metering scheme.*

Due to the fact that this scheme aims to collect information regarding the charging of the EVs and hybrid vehicles, the applicants are obliged to declare for 5 years several statistical information related to the use of the vehicle, such as the kilometers covered. In addition, the applicants are required to participate for the first 5 years after the application in a survey that aims to collect further information regarding the charging of the vehicle. For the purposes of the survey, the installation of a separate meter in the house of the applicant and only on the charging equipment of the vehicle for a certain period of time might be required.

2.3.2 Expected uptake and costs

The vehicle stock of Cyprus in 2020 amounted to 870,000, with the majority of them being passenger cars (580,000 cars), according to Eurostat[35]. Electric and hybrid cars are still playing a marginal role in Cyprus, with both categories combined accounting for less than 1.2% of the total passenger cars stock (240 EVs and 9,992 hybrid electric-petrol cars are currently registered)[36]. In 2021, 308 additional EVs (of which 120 passenger cars) and 4,556 hybrid vehicles (of which 4,513 passenger cars) were registered[37], which shows a considerable

[35] https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQS_CARPDA__custom_3286098/default/table?lang=en

[36] Based on Eurostat data (ROAD_EQS_CARPDA)

[37] Registration of motor vehicles January-December 2021

increase compared to the existing vehicle stock. Nevertheless, Cyprus is planning to significantly increase the numbers of EVs to 41,770 passenger cars and the hybrid passenger cars to 59,927 by 2030 in the conservative With Existing Measures (WEM) scenario, as highlighted in the NECP[38].

Based on the latest trends, it is possible to envisage that the number of applications estimated for the scheme (500 applications) will be reached well ahead of the time limit for the scheme (20.12.2023). However, it is unclear whether the scheme will have any additionality impact (i.e., probably the beneficiaries would have purchased an EV anyway). However, the scheme may prompt the purchase of an EV for households with PV panels that would not have otherwise bought it.

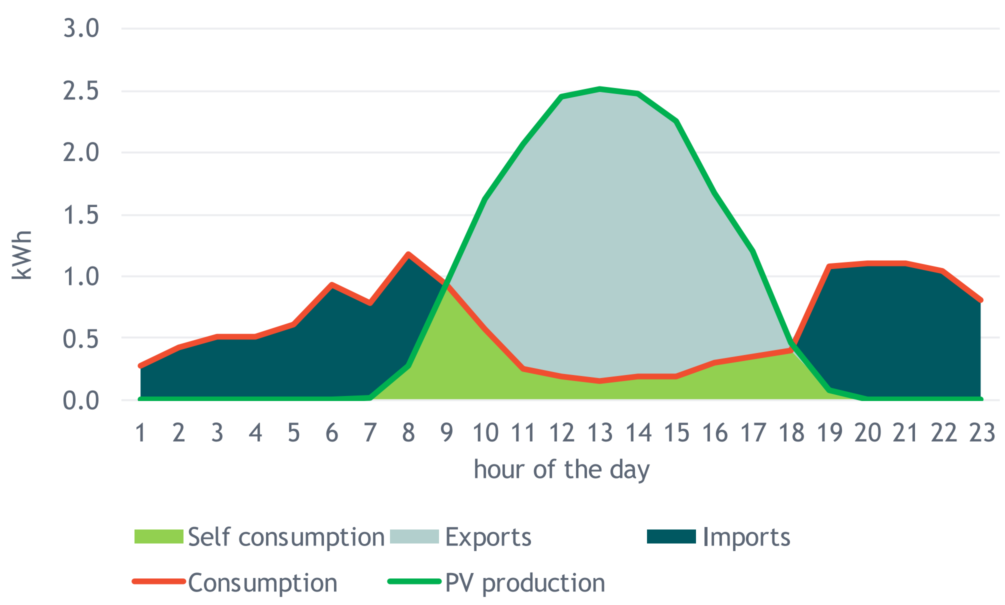
2.3.3 Profitability of PV and battery investments

Below, we provide an analysis of the grants for the installation of a PV system and the purchase and installation of a battery under the current scheme, based on the ongoing methodology of network charges, both under net metering and net billing scheme. From the analysis, the cost for the charger, meter and conversion to three-phase are not included (it is assumed that the grant covers the majority of the costs).

We consider a case of an alternative user (see section 6.2), with a PV system of 4 kW, a building consumption of 7,000 kWh per year and an EV consumption of 3,650 kWh per year (equivalent to 10 kWh per day). The profile of the energy use is depicted in Figure 2-14.

First we consider the case when a PV is installed with no battery. Considering only the grant for the installation of the PV (€1,500), the investment will be paid back in 5 years under net metering and 5.8 years under net billing scheme (Figure 2-16Figure 2-16), while the IRR is 18% with net metering and 15% with net billing (graph not shown).

Figure 2-14 Daily energy profile of an alternative user with 4 kW PV and EV in March



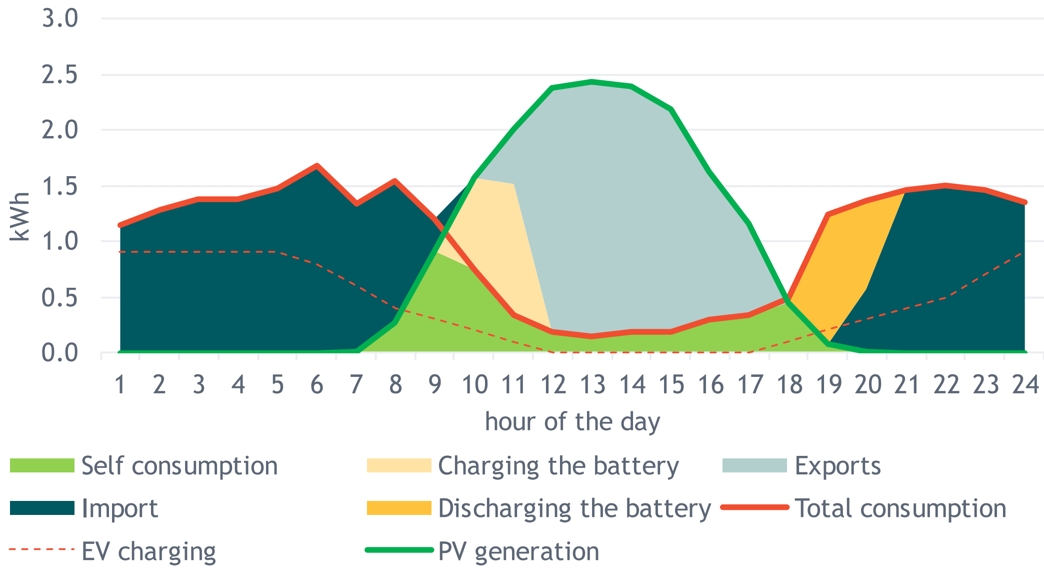
[38] Cyprus National energy and Climate Plan

Source: Own elaboration based on CERA data

In the same energy profile, we also include a battery of 2 kWh (

Figure 2-15). A battery would allow consumers to save on their energy bills by reducing consumption-related network and other charges, yet only marginally (around 7-8% of reduction).

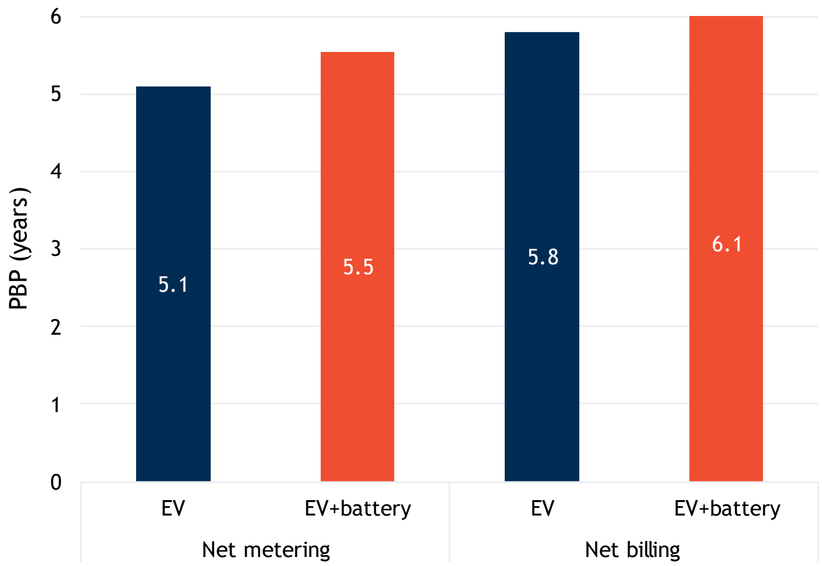
Figure 2-15 Daily energy profile of an alternative user with 4 kW PV, EV and a battery of 2 kW in March



Source: Own elaboration based on CERA data

Adding a 2 kWh battery for a cost of €2,000 and extending the grant accordingly (hence totalling €3,000 for PV and a battery) would increase the investment by around €500 compared to installing only a PV. Due to the fact that the savings from the battery are less than €500 over the 15-years period, the investment becomes less profitable, with the PBP being increased to around 5.5 years and the IRR being decreased to 16% for net metering while for net billing the PBP is 6 years and the IRR 14%. However, it is important to consider that the 2 kWh battery covers around 3% of the average daily energy use (68.5 kWh/day).

Figure 2-16 PBP for a user with EV and a battery considering the grant EV and EV + battery under net metering and net billing scheme



Source: Own elaboration based on MECI, CERA and EAC data

To investigate whether the investment in battery alone is profitable, we take the grant provided under this scheme (€750/kWh hence €1,500 for 2 kWh battery) and we compare the savings against the case when PV with no battery is applied, considering the same total consumption (10,615 kWh/year, including building and EV consumption). The installation of a battery provides annual energy savings of 4% and 5% for net metering and net billing respectively (Table 2-10).

Table 2-10 Annual energy savings with and without a battery under net metering and net billing scheme

Annual energy costs (€)	Net metering	Net billing
Without battery	888	978
With battery	853	929
Difference (absolute value)	35	49
Difference (%)	-4%	-5%

Source: Own elaboration based on MECI, CERA and EAC data

Considering an investment cost of €1,000/kWh and a subsidy of €750/kWh, the installation of a 2 kWh battery alone is barely a profitable investment for a timespan of 15 years as the IRR is below 1% and the payback period just below 15 years under net metering. The investment only in battery under the net billing scheme is more profitable, with the IRR being 5% and the payback period 10 years, yet still less competitive than the other options provided to the consumers.

Table 2-11 Profitability of battery installation only with grant of €750/kWh

Battery size	Indicators	Net metering	Net billing
2	IRR (%)	0.3%	5%
	PBP (years)	14.6	10.2

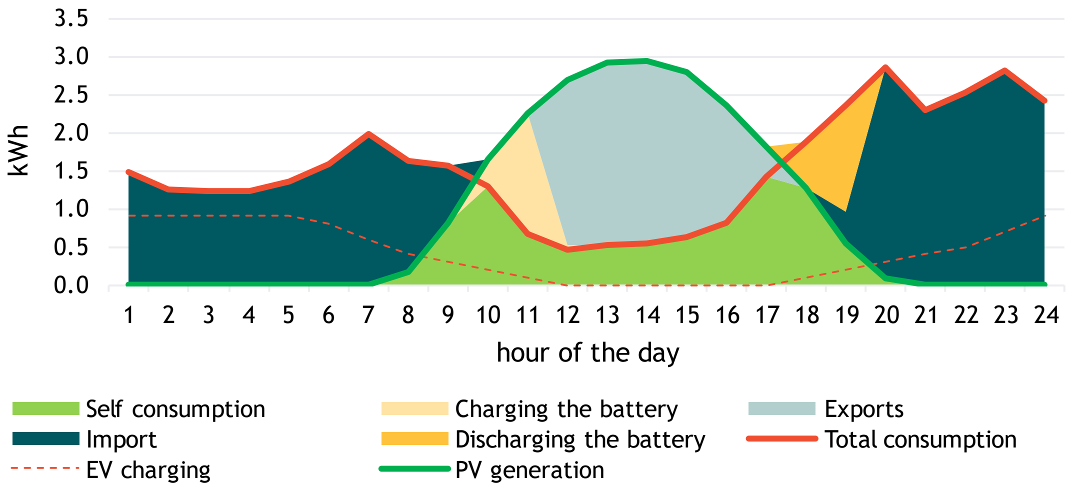
Source: Own elaboration based on MECI, CERA and EAC data

Text box 3 Battery and peak shaving

Curtailing battery charge

The model allows users to estimate the effect that curtailment on battery charge may have in reducing the peak. Figure 2-17 shows how a 4 kW PV would charge a 2 kWh battery within the first few hours of sunlight, if the self-consumption is low. Therefore, the battery is not able to reduce exports in the hours of highest solar outputs. Similarly, if we assume the EV is put to charge at around 5 to 6 PM, the battery would be depleted before the peak consumption is reached.

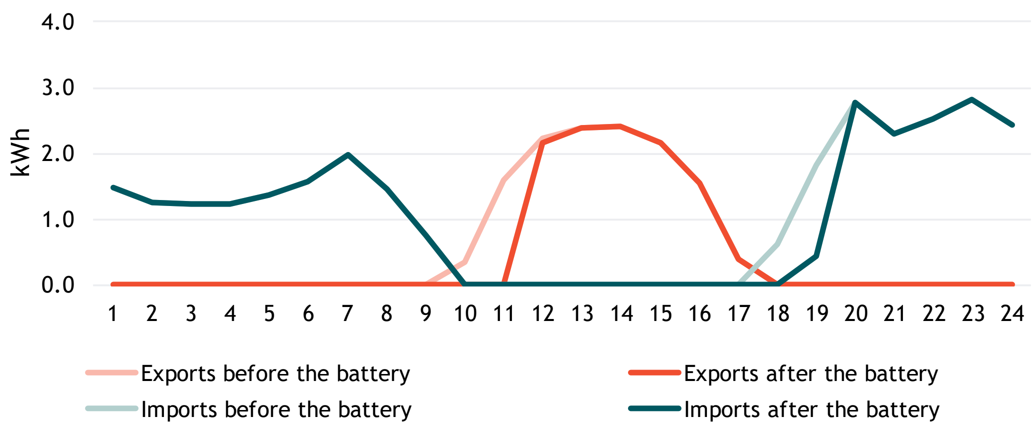
Figure 2-17 Alternative user August profile, 4 kW PV, 6,500 kWh/year consumption, EV (charged 10 kWh/day), 2 kWh battery, no curtailment



Source: Own elaboration based on CERA data

As shown in Figure 2-18, the export and import profile with the battery are steeper than they were before. Assuming a widespread diffusion of 2 kWh batteries, the combined effect on the network could be substantial, especially if it is assumed that they would all reach full charge at around the same time and will start discharging at the same time.

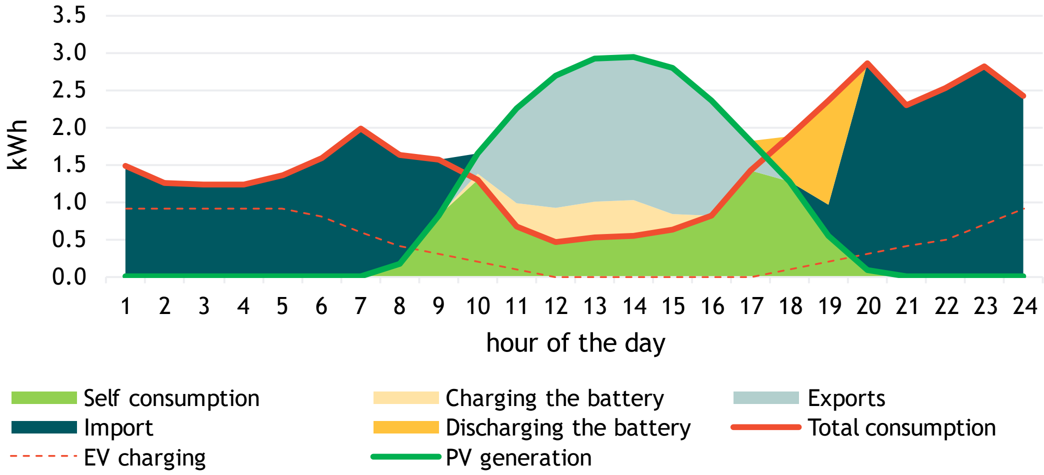
Figure 2-18 Import and export profile before and after the battery



Source: Own elaboration based on CERA data

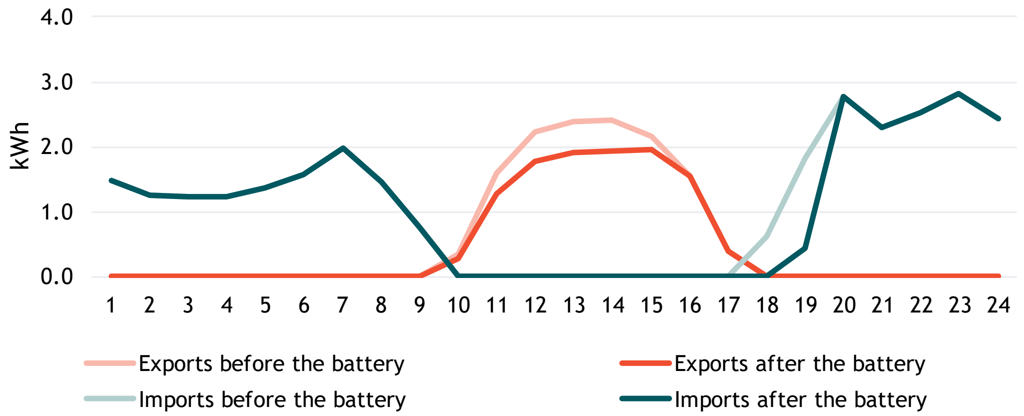
If however batteries are equipped with a control for curtailment that limits the speed at which the battery can be recharged, it is possible to “shave” the generation peak. Figure 2-19 show a much slower charging load of the battery in the afternoon, and Figure 2-20 shows that the battery is effective in shaving peak generation, by about 20% during the more critical hours. A similar control will have to put in place to slow down the release of energy from the battery, in order to avoid the evening ramp up, which has become steeper after the introduction of the battery.

Figure 2-19 Alternative user August profile, 4 kW PV, 6,500 kWh/year consumption, EV (charged 10 kWh/day), 2 kWh battery, 80% curtailment



Source: Own elaboration based on CERA data

Figure 2-20 Import and export profile before and after the battery with curtailment



Source: Own elaboration based on CERA data

2.3.4 Options for improvement

As it is currently designed, the scheme to support the uptake of batteries in combination with PV for recharging electric vehicles provides limited benefits from a system perspective.

Recommendation 1: to effectively use residential batteries to help reduce grid instability due to high ramp up and ramp down requirements, ensure that it is possible to control their charging and discharging patterns to effectively smooth peaks and troughs.

Recommendation 2: if the objective is to deploy rapidly flexibility mechanisms, solutions targeted at large consumers or grid services (e.g., grid-connected batteries) should be considered. While behind-the-meter batteries have some advantages compared to grid-level solutions (e.g., they may reduce network reinforcement costs) they are less cost efficient, more difficult for the SO to control and, in the long term, they will reduce the business case for the commercial operation of grid-connected storage, once a flexibility market is in place.

2.4 Renewable support schemes in other Member States

This section provides a description and a comparison of support schemes similar to those provided by Cyprus other Member States.

2.4.1 Overview of support schemes for self-consumption in other Member States

2.4.1.1 Greece

The main schemes available in Greece to promote the installation of RES systems are:

- **Net metering and Virtual net metering**, available to all types of consumers;
- Sliding **Feed-in-Premium (sFiP)** eligible for commercial consumers (commercial RES power plants);
- **Grants for installation of hot water systems** for residential buildings.

Greece's net metering scheme[39,40] applies to all types of consumers, entered into force in 2013, and it has been reshaped multiple times since then. At present, the scheme applies to all RES technologies with a maximum installed capacity of 20[41] kW for residential and commercial users; the limit goes up to 1 MW for medium-voltage self-consumers or consumers providing services of public interest. The duration of the net metering contract is 25 years. Greece uses the classic concept of net metering, i.e., the imported and exported electricity to the grid are compared, and in case the imported electricity exceeds the exported, the prosumers are charged for the net electricity consumption at retail price. In the opposite case, the electricity credit is transferred to the next billing period. Besides the costs of energy, the consumers are charged for network and system costs (based on the imported energy), an environmental fee for the reduction of pollutant gas emissions (charged on the imported energy) and a fee for the Public Services Operation (charged on the net consumed energy). Every three years the final settlement occurs, when any excess of electricity resets to zero. Installation costs are not covered by this scheme or any other grant, which hinders the fast development of RES systems, given the current economic challenges faced by many Greek households.

Greece also applies a **virtual net metering scheme**[42] since 2017, which is available to natural or legal persons providing services of public interest, as well as to farmers. Under this scheme, the electricity consumed by the prosumer's facilities is offset against the electricity produced by the remote RES plants and any excess of electricity is transferred to the next billing period. In the settlement of the three-year period, any excess of electricity resets to zero. The main condition of the scheme is that at least one of the facilities of the prosumer is not located in the same area as the RES plants, or, if they are, they are connected through a different line[43]. The main rules related to the contract and installations' capacities are the same as with the net metering scheme.

Additionally, starting from 2016, Greece introduced the sliding **Feed-in-Premium (sFiP)** which applies to all RES and CHP power plants that are part of the interconnected system of the country and they participate in the electricity market[44]. The premium is expressed in monetary value per unit of electricity (€/MWh) and it is calculated at a monthly basis as the difference between the Special Market Price of the specific RES or CHP

[39] DEDDIE (2019)-net metering

[40] Ministerial Decision 2019- ΥΠΕΝ/ΔΑΠΕΕΚ/15084/382/2019

[41] The limit is reduced to 10 kW for non-connected islands

[42] DEDDIE (2019)- virtual net metering

[43] Greek NECP

[44] Law 4414/2016

technology and the Reference Tariff falling under the Sliding Premium Operating Aid Contract"(SEDP)[45] for the respective technology[46]. The support scheme has a duration of 20 years for RES and CHP projects and 25 years for small PV plants up to 10 kW and CSP plants[47]. For small plants, such as wind plants with capacity up to 3 MW and other RES plants up to 500 kW, as well as for project part of the non-interconnected islands, the support is provided at a fixed price, which is equal to the Reference Tariff of the technology in question.

The extent to which similar approaches can be implemented in Cyprus is discussed in section 2.5.

Greece provides also grants for the installation of **hot water systems** by RES for residential buildings, which includes technologies such as heat pumps and solar water heaters. The scheme applies only to natural persons that have legal rights to the residence and it is subject to financial criteria.

The available grants per category are[48,49]:

- Solar water heater: €1,100 per application;
- Solar water heater with forced circulation: €3,000 per application with a maximum amount of €6,000 for apartment buildings;
- Solar water heater with space heating: €10,000 per application with a maximum amount of €25,000 for apartment buildings;
- Heat pump: € 1,500 per application.

2.4.1.2 Italy

Italy has three main schemes to support energy efficiency and renewables installations in buildings:

- **Scambio sul posto**, equivalent to a net billing scheme for small to medium applications
- **Conto termico**, aimed at public administrations and SMEs
- **Tax returns** for the installation costs of charging points, aimed at individuals and companies
- **Superbonus 110%,** aimed at homeowners

Scambio Sul Posto (SPP), launched in 2009, concerns all RES technologies and it is managed by the Italian Energy Services Operator (Gestore dei Servizi Energetici, GSE). Depending on the year of operation and the type of technologies the maximum installed capacities differ, namely

- 20 kW for renewable systems stating operation up to 2007;
- 200 kW for renewable systems stating operation up to 2014;
- 200 kW for high efficiency cogeneration plants;
- 500 kW maximum total capacity of the production plants.

The concept of the SSP is that the prosumers are paying the electricity bill to the GSE monthly and once per year the GSE offsets the imported and exported electricity to the grid. If the yearly exported electricity is higher than the imported, then the reimbursement of the prosumers is calculated based on the sum of:

[45] The values of the Reference Tariff are provided in the Law 4414/2016, Article 4

[46] https://dione.lib.unipi.gr/xmlui/bitstream/handle/unipi/12729/The%20RES%20Auctions%20in%20Greece.pdf?sequence=1&isAllowed=y

[47] https://helapco.gr/pdf/New_Greek_support_scheme_Aug2016.pdf

[48] https://exoikonomisi-b.ypen.gr/documents/10182/3568822/6%CE%97+%CE%A4%CE%A1%CE%9F%CE%A0+%CE%9F%CE%94+%CE%95%CE%9E%CE%9F%CE%99%CE%9A_II_B%27+2019.pdf/d39f3537-6035-4e09-8fee-cba9e53723fb

[49] VAT is considered as eligible cost

- the value of the yearly imported electricity: 70% of the bills paid during the year (excluding the taxes and the MCT (Misure di Compensazione Territoriale) component); and
- the value of the yearly exported electricity: equals to the electricity exported into the grid multiplied by the energy selling price per kW, which depends on the electricity market zone[50] of the system being installed and the average market price of the previous year[51,52].

Therefore, the concept of the SSP scheme is closer to the net billing scheme rather than to the traditional net metering scheme.

Table 2-12 Energy costs and revenues for a user on the SSP scheme

Electricity and costs	Annual values
Annual Energy Data	
Imported electricity (kWh)	7,200
Exported electricity (kWh)	7,700
Tariffs	
Tariff of imported electricity (€/kWh)	0.08
Tariff of exported electricity (€/kWh)	0.06
Annual bill	
Cost of imported electricity (€)	576.00
Cost of exported electricity (€)	462.00
Offset (€)	-114.00

Source: Own elaboration based on information from GSE

Note: the calculations omit any additional charges such as network charges. The example considers only the cost of imported and exported electricity.

As part of the national scheme **Conto Termico**[53], Italy provides incentives to increase energy efficiency and thermal energy production, including grants for the installation of **solar thermal collectors**[54]. The scheme is aimed mainly at public administrations and SMEs, and concerns systems up to 2,500 square meters,[55] it covers up to 65% of the installation costs and it is eligible to public administrations, companies and private individuals.

Further, Italy supports the deployment of EV infrastructure in the form of **tax returns for the installation costs of charging points**. More specifically, individuals and companies are eligible for a tax deduction of 50% for the purchase and installation costs of EV chargers, with a maximum amount of €3,000[56].

Finally, a 2020 general budget provision, extended by a 2021 decree[57], called **Superbonus** 110% allows homeowners to deduct up to 110% of the cost of building renovations and renewable energy from their tax bill

[50] Italy's electricity market is divided in six zones

[51] https://www.tgreen.it/risparmio-fotovoltaico-cos-e-lo-scambio-sul-posto-ssp#:~:text=Definizione%3A%20lo%20Scambio%20Sul%20Posto,eccesso%20dal%20suo%20impianto%20fotovoltaico

[52] https://www.sorgenia.it/guida-energia/scambio-sul-posto-come-funziona

[53] https://www.gse.it/servizi-per-te/efficienza-energetica/conto-termico

[54] https://www.gse.it/servizi-per-te/efficienza-energetica/conto-termico/interventi-incentivabili/solare-termico-2c

[55] https://solarthermalworld.org/type_of_incentive/italy-conto-termico-financed-through-levy-natural-gas-tariffs/

[56] https://blog.wallbox.com/italy-ev-incentives/

[57] https://www.agenziaentrate.gov.it/portale/documents/20143/233439/Guida_Superbonus110.pdf/49b34dd3-429e-6891-4af4-c0f0b9f2be69

over a period of 5 years. Under the new decree, home owners are eligible for an “eco-bonus” from 50% to 110% for PV installations and storage systems, with a maximum of €2,400 per kW installed for PVs and €1,000 per kW for storage systems. However, the PV systems that might not qualify for the 110% eco-bonus, will receive the 50% tax break. Superbonus applies also for the installation of charging points for EVs. Energy exported to the grid from PV systems (including PV systems with battery) is not remunerated (essentially, homeowners can use and store as much electricity as they can, but any excess exported to the grid is not remunerated nor netted off the energy bill).

2.4.1.3 Spain

For the promotion of the installation of RES systems and in particular of PVs, Spain has several schemes and compensations mechanisms namely:

- **Decree 244/2019** regarding the self-consumption of electric energy from RES (mainly PVs), applied both to residential and industrial/commercial consumers;
- Scheme about **renewable energies in self-consumption, storage, and thermal residential sector**, applied to individuals, public entities as well as companies;
- **Aid for investment in photovoltaic solar technology electrical energy production facilities**, applied to legal entities (industrial/commercial entities);
- Scheme for **implementation of thermal renewable energy facilities** in different sectors of the economy, applied to individuals, companies, industries and public sector (depending on the incentive programme);
- Support schemes for the installation of EV charging points
    - **MOVES II**, applied to public and private properties;
    - **MOVES III**, applied to individuals, companies, public sector;
    - **MOVES FLEET**, applied to companies.

In 2019 the Spanish government passed the royal Decree 244/2019, which regulates the administrative, technical and economic conditions of the self-consumption of electric energy. Under the new decree, the self-consumption can be categorized in two types:

- **Supply with self-consumption without surpluses:** the prosumer uses the electricity produced by the RES system and a mechanism is installed to prevent exporting excess of electricity to the grid.
- **Supply with self-consumption with surpluses:** the prosumers can sell the excess electricity to the grid in two ways, namely:
    - Via the net billing scheme: the import and export costs are calculated based on the import and export electricity and the respective fees (the fee of electricity exported to the grid is valued at wholesale price in the case of a contract with a regulated retailer, or at a price agreed by all parties in the case of a free market electricity retailer[58]). The offset occurs at a monthly basis and the discount from the surplus energy, if applicable, is subtracted directly in the electricity bill. Under the new decree, the consumers are exempt from grid-access charges for the surplus electricity that are exporting to the grid.[59] The net billing scheme can be applied to installations with capacities up to 100 kW, and the profits from the

[58] Prol et al. (2020) Photovoltaic self-consumption is now profitable in Spain: Effects of the new regulation on prosumers’ internal rate of return

[59] In Spain producers pay a share of network charges

surplus electricity cannot exceed the value of the energy consumed (i.e., in the best case the offset will result to a zero bill for the energy component).

- Directly sell the surplus electricity to the grid: in that case, the producers sell the electricity at wholesale price subtracting the 7% generation tax and the corresponding grid-access charge (0.5 €/MWh). This option is not restricted by maximum capacities or by monthly billing[60].

The decree also introduces the concept of collective self-consumption (both for residential and industrial consumers), under which more than one consumers will be able to join the same RES installation, provided that the installations are nearby.

Table 2-13 Fictive example of charges without and with surplus in Spain

Without surplus

Fees	kW	€/kWh/year	€/month
Access fee	5.75	38.043	18.2
Marketing margin	5.75	3.113	1.5
Total			19.7
Energy consumed	kW	€/kWh	€/month
Cost of energy	400	0.069	27.6
Access fee	400	0.044	17.6
Total variable			45.2
Subtotal			64.9
Electricity tax (5.11%)			3.3
Meter rental			0.8
Subtotal			69.0
VAT (21%)			14.5
Total			€ 83.55

With surplus-net billing

Fees	kW	€/kWh/year	€/month
Access fee	5.75	38.043	18.2
Marketing margin	5.75	3.113	1.5
Total			19.7
Energy consumed	kW	€/kWh	€/month
Cost of energy	280	0.069	19.3
Access fee	280	0.044	12.3
Surplus PV	380	0.05	-19.0
Total variable			12.6
Subtotal			32.4
Electricity tax (5.11%)			1.7
Meter rental			0.8
Subtotal			34.8
VAT (21%)			7.3
Total			€ 42.14
Difference			-50%

Source: Own elaboration based on information from various sources[61,62]

Furthermore, the Spanish government offers several grant schemes that promote the installation of **RES systems**.

[60] Prol et al. (2020) Photovoltaic self-consumption is now profitable in Spain: Effects of the new regulation on prosumers' internal rate of return

[61] https://www.tienda-solar.es/blog/en/surplus-compensation-solar-pv-system/

[62] Prol et al. (2020) Photovoltaic self-consumption is now profitable in Spain: Effects of the new regulation on prosumers' internal rate of return

Renewable energies in self-consumption, storage, and thermal residential sector[63]

This scheme includes 6 initiatives targeting the installation of PV, wind and storage systems and it applies to individuals and public entities as well as companies. With regards to the PV installation the two main initiatives include the following grants:

- Program 1 - Realization of self-consumption installations, with renewable energy sources, in the services sector, with or without storage: €460 - €1,188/kWp (15% – 45% aid on eligible cost).
- Program 4 - Realization of self-consumption installations, with renewable energy sources, in the residential sector, public administrations and the third sector, with or without storage: €300 - €600/kWp for residential sector and €500 – €1,000/kWp for public sector.

The support scheme is funded the NextGenerationEU fund in the frame of the Recovery and Resilience Facility with a total budget of €660 million and it will run until 2023.

Aid for investment in photovoltaic solar technology electrical energy production facilities located in the Balearic islands (SOLBAL 2)[64]

This support scheme includes three initiatives targeting the installation of PV systems with installed capacities greater than 100 kW. The scheme applies to legal entities and has a total budget of € 18.77 million (funded by the European Regional Development fund). The scheme covers three types of projects:

- **IT1:** Photovoltaic installation on roof or in parking, with a maximum grant of 240,000 €/MWp.
- **IT2:** Photovoltaic installation on the ground with a power equal to or less than 5 MWp, with a maximum grant of 173,000 €/MWp.
- **IT3:** Photovoltaic installation on the ground with a power greater than 5 MWp, with a maximum grant of 134,000 €/MWp.

The grants in all categories are capped at €15 million per project.

Implementation of thermal renewable energy facilities in different sectors of the economy[65]

The scheme aims to promote the thermal renewable energy installations in several sectors of the economy (industry, agriculture, services, residential). The scheme will run until 2023 with a total budget of €150 million (funded under the NextGenerationEU fund in the frame of the Recovery and Resilience Facility) and the thermal renewable technologies covered are solar thermal, biomass, geothermal, hydrothermal or aerothermal. The support scheme includes 2 initiatives, namely:

- **Incentive program 1 :** Realization of thermal renewable energy installations in the industrial, agricultural, services and/or other sectors of the economy, including the residential sector. The initiative is addressed to individuals, legal person, public entities and associations and it provides a support of 35% of eligible costs for large companies, 40% for medium-size companies and 45% for small companies.
- **Incentive program 2 :** Realization of thermal renewable energy installations in non-residential buildings, establishments and infrastructures of the public sector. The initiative is addressed to local territorial entities, public entities and associations and it provides a support of 70% of the eligible installation costs.

[63] https://www.idae.es/ayudas-y-financiacion/para-energias-renovables-en-autoconsumo-almacenamiento-y-termicas-sector

[64] https://www.idae.es/ayudas-y-financiacion/para-instalaciones-de-produccion-de-energia-electrica-con-eolica-y/solbal-2

[65] https://www.idae.es/ayudas-y-financiacion/para-la-implantacion-de-instalaciones-de-energias-renovables-termicas-en

Further, the Spanish government launched several support schemes to promote electric mobility through the Recovery and Resilience Plan. The first scheme, called **MOVES II**[66], has a total budget of € 100 million and provides among others direct grants for the installation of EV charging points in public and private properties of 30%-40% of the eligible costs (depending on the type of applicant), with a limit of €100,000. The scheme applies to individuals, communities of owners, legal and local entities as well as the public entities. Similarly, the support scheme **MOVES III**[67] has a total budget of €400 million and provides a grant for the installation of charging points for EVs that ranges from 40% to 80% depending on the type of beneficiary (see Table 2-14).

Table 2-14 Grant amounts for the Spanish programme MOVES III

Beneficiaries	Grant (% of eligible cost)	
	General location	Municipalities <5,000 inhab
Self-employed, individuals, Communities of Owners and administration without economic activity	70%	80%
Companies and public entities with economic activity, recharging public access and P ≥50kW	35% (45% Medium company) (55% Small company)	40% (50% Medium company) (60% Small company)
Companies and public entities with economic activity recharge private access or public access with P <50kW	30%	40%

Source: IDEA, MOVES III

In addition, the support scheme **MOVES FLEET**[68], also funded under the Recovery and Resilience Mechanism (total funding of €50 million), complements the scheme MOVES III by providing grants for the electrification of light vehicle fleets for companies. Part of this scheme targets the installation of EV charging points in the parking of the companies and the support amounts to 40% of the eligible costs, with a potential of an increase up to 50% for medium-size companies and 60% for small companies.

2.4.1.4 Malta

Malta promotes the installation of PV systems in buildings with the following schemes:

- Grants for the **installation of PV systems** aimed at residential consumers and non-residential consumers;
- Fixed **Feed-in-Tariff (FiT**) aimed at residential and non-residential consumers;
- Grants for the installation of solar water heaters, aimed at residential consumers.

Malta provides a support scheme in the form of a grant for the **installation of PV systems** for residential consumers and non-residential consumers that are not carrying out economic activities[69]. The grant includes four categories namely:

- **PV system with standard solar inverter:** covers the eligible costs up to 50% with a maximum of €2,500 per system and €625/kWp; or

[66] https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/plan-moves-ii

[67] https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/programa-moves-iii

[68] https://www.idae.es/ayudas-y-financiacion/para-movilidad-y-vehiculos/programa-moves-flotas

[69] https://www.rews.org.mt/#/en/sdgr/463-2021-renewable-energy-sources-scheme

- **PV system with hybrid[70] inverter:** covers the eligible costs up to 50% with a maximum of €3,500 per system and €750/kWp;
- **Hybrid/Battery inverter and battery:** covers the eligible costs up to 80% of the battery storage up to a maximum of €3,600 per system and €600/kWh plus 80% of eligible costs of the hybrid inverter up to a maximum of €1,800 per system and € 450/kWp;
- **Battery Storage:** covers the eligible costs up to 80% of the battery storage up to a maximum of €3,600 per system and €600/kWh

In addition, the government compensates for the electricity generated from PV systems with a fixed **Feed-in-Tariff (FiT)**[71], which replaces the net metering scheme previously taking place. However, the consumers (residential and non-residential consumers) that installed their PV systems under the net metering scheme (prior to 2010) can continue to benefit from it[72].

The FiT scheme applies to all PV systems with capacities between 1 kWp and 40 kWp and compensates 15 c€/kWh for 20 years, in the case that the consumers haven't received the aforementioned grant. In the opposite case, the FiT amounts to 10.5 c€/kWh for 20 years, if the grant doesn't exceed 50% of the eligible costs[73].

Under the FiT scheme, the consumers can opt either to sell all the electricity they produce to the grid (i.e., full export), or to consume the electricity they produce onsite and export only the excess electricity (i.e., partial export). In the case of full export, the prosumers sell the total electricity they produce at feed-in tariffs and they pay the total electricity they consume at retail price. In the case of partial export, the prosumers sell only the net PV electricity produced at feed-in tariffs (total PV generation-consumed electricity) and they pay only the imported electricity from the grid at retail price. In the partial export, the consumers are billed monthly and in case the amount of invoiced electricity is less than amount resulting from the electricity produced by the PV, the credit is transferred to the next bill. A settlement occurs every second month, when any credit from excess electricity is paid to the prosumer.

[70] A hybrid inverter allows the operation of solar PV, a battery storage system and grid connection, managing the conversion from AC to DC and vice-versa and managing automatically electricity flows.

[71] https://www.rews.org.mt/#/en/fa/32

[72] It is not possible to switch from the net metering to the FiT scheme as of 2015.

[73] Otherwise, the FiT is reduced by 0.2 c€ for every 1% of grant received above the 50% of eligible costs.

Table 2-15 Fictive example of charges with full export and partial export of electricity in Malta under the FiT scheme

Full export		Partial export	
Fees (€)		Fees (€)	
FiT	0.15	FiT	0.15
Cost of energy	0.07	Cost of energy	0.07
Electricity (kWh)		Electricity (kWh)	
Import	6748	Import	6748
Export	552	Export	552
PV Generation	1837	PV Generation	1837
Net PV	1285	Net PV	1285
Net consumption	8033	Net consumption	8033
Paid to the consumer	€ 275.6	Paid to the consumer	€ 82.8
Paid by the consumer	€ 562.3	Paid by the consumer	€ 472.4
Difference	*€ 286.8*	*Difference*	*€ 389.6*

Source: Own elaboration based on information from Regulator for Energy and Water Services

Finally, Malta provides a support scheme in the form of grant for the purchase of **solar water heaters** in the residential sector. Under this scheme, the applicants are being reimbursed 75% of the costs of the solar water heater (including VAT) with a maximum amount of € 1,400. In addition, the applicants receive € 500 after 5 years of the installation to cover the maintenance costs of the system.

2.4.2 Comparison

Table 2-16 provides a comparison between the net metering and net billing schemes among Cyprus, Greece, Italy, Spain and Malta as well as for the grants they provide for the installation of PV systems and SWH. With regard to the net metering scheme, only Cyprus and Greece still implement it. In their essence, the schemes are very similar however several differences are identified concerning the size of the systems, the settlement periods, the contract duration and the RES technologies that can be included under the scheme. On the other hand, in Italy[74] and Spain inly a net billing-type of schemes are available, which have some differences compared to the Cypriot one in terms of size limitation and technologies included.

In terms of grants for the promotion of RES, all 5 countries provide some financial support for the purchase and installation of thermal energy systems (mainly for SWH), while Greece is the only country that currently does not provide any support for the installation of PV systems. Finally, regarding subsidies for charging stations for EVs, Italy provides tax deductions and Spain covers part of the installation costs, while no grant is given in Greece and Malta at the moment.

[74] Italy's scheme SPP is not a net billing scheme per se, but since they calculation of energy costs is similar to the net billing methodology, it is considered as net billing scheme in the frame of this study.

Table 2-16 Comparison of the main compensation mechanisms and grants for PV and SWH (Cyprus, Greece, Italy, Spain and Malta)

	Cyprus	Greece	Italy	Spain	Malta
Net metering					
Open to new applications?	Yes	Yes	n/a	n/a	No
RES technology	PV	All RES			n/a[75]
Size limit (kW)	10.4	20			
Other limitations	Yearly electricity produced by the PV cannot exceed 90% of the yearly electricity consumption of the premise that is used for	Maximum capacity of a production system cannot exceed 1 MW (except for small wind turbines)			
Billing period	Monthly/bi-monthly	3-4 months			
Settlement period	Every year	Every 3 years			
Duration of contract	15 years (residential consumers) 10 years (non-residential consumers)	25 years			
Network charges methodology	Charges applied on the imported energy	Charges applied on the imported energy			
Virtual net metering	Yes	Yes			
Net billing					
Open to new applications?	Yes	n/a	Yes	Yes	n/a
RES technology	PV, biomass		All RES	PV	
Size limit	8 MW		500 kW	100 kW	
Other limitations	The maximum installed capacity of the system cannot exceed 80% of the users' maximum consumption, unless there is a storage system installed		What is the case here?	PV installation can't be having any additional remuneration	
Billing period	Monthly/bi-monthly		Monthly	Monthly	
Settlement period	Every year		Every year	n/a	

[75] No information available online as the scheme is not open for new applications as per 2010.

Duration of contract	10 years		20 years	n/a	
Network charges methodology	Charges applied on the imported energy		Charges applied on the imported energy	Charges applied to the energy consumed[76]	
Grants for thermal energy					
RES Technology	Solar water heaters	Solar water heaters	Solar thermal collectors	Solar thermal, biomass, geothermal, hydrothermal or aerothermal	Solar water heaters
Aid	€450 per application €950 per application for mountainous areas	€ 1,100 per application	65% of the installation costs	Program 1: 35% of eligible costs for large companies, 40% for medium-size companies and 45% for small companies Program 2: 70% of the eligible installation costs	65% of the installation costs (maximum of €1,400) + €500 after 5 years for maintenance
Grants for PVs					
Aid	Category 2: €450/kW (maximum of €1,800) Category 3A: €375/kW (maximum grant of €1,500) Category 3B: €1000/kW (maximum grant of €5,000)	n/a	Max of: €2,400 per kW and €48,000 per system, only for the storage system investment If additional energy efficiency measures are supported, max aid is of €1,600 per kW[77]	Program 1 €460 - €1,188/kWp (15 - 45% aid on eligible cost) Program 4 Residential sector €300 - €600/kWp Public sector €500 - €1,000/kWp	PV system with standard solar inverter: up to 50% of eligible costs (maximum of €2,500/system and € 625/kWp) PV system with hybrid inverter: up to 50% of eligible costs (maximum of €3,500/system and € 750/kWp)
Grants for EV charging points					
Aid for charging point installation	€600	n/a	Tax deduction of 50% (maximum amount of €3,000) (Tax deduction of 110% under the Superbonus scheme is applicable)	MOVES II 30%-40%[78] of the eligible costs MOVES III 30%-80%[79] of eligible costs MOVES FLEET 40% of eligible costs	n/a

[76] Article 17(2)

[77] https://www.agenziaentrate.gov.it/portale/documents/20143/233439/Guida_Superbonus110.pdf/49b34dd3-429e-6891-4af4-c0f0b9f2be69

[78] Depending on the type of applicant

[79] Depending on the type of applicant

Other aid (related to EV charging points)	€750/kW (maximum of €1,500 per vehicle) for installation of PV system €450 for conversion of electrical installation of the house from single-phase to three-phase €750 per kWh of storage capacity for Purchase and installation of battery	n/a	n/a	n/a	n/a

2.5 Conclusions

Cyprus has excellent geographical and climate conditions for the development of renewable energy, and specifically of solar energy. Based on the uptake figures, the net metering scheme is a very effective measure to enhance the deployment of PVs in the residential sector. In addition, the grants provided by the government for the installation of PV systems contribute significantly to the profitability of the investments from the user's perspective, with the PBP being generally under 8 years, depending on the size of the system. The government supports also vulnerable consumers in terms of self-consumption schemes, as with the introduction of the tailored grant investment in PV are paid back in less than 4 years.

Net billing is used only by commercial users at the moment, although efforts are being made to include more residential consumers under this scheme (e.g., by providing a grant for the installation of PV under net billing). Compared to the net metering grants and based on the annual energy of the consumers, net billing is not as profitable as net metering even with the introduction of the grant, but the PV installation is paid back in 6 to 10 years and the users still save 60% to 70% on the energy bill compared to the no PV case.

When it comes to SWH, the installation of such systems is already a well-established practice, making Cyprus the frontrunner across the EU in the specific technology. The replacement of an old SWH with a new one would provide annual savings of 33% on the energy bill, while the introduction of the grant improves further the profitability of the investment.

The recently introduced scheme for the installation PV systems for the charging of electric vehicles or hybrid plug-in vehicles has the potential to increase the uptake of both PVs and batteries, but only if the users combine the installation of both technologies. As the analysis showed, if the consumers use this grant to only install a PV the returns are lower compared to the other grants provided under net metering; however, if they combine it with the installation of a battery (yet a small one of around 2 kWh) the investment improves significantly and can be competitive compared to the grants provided both under net metering and under net billing scheme. Installing a larger battery will not make economic sense, and indeed, the installation of a battery alone under this scheme is generally not a profitable investment especially for a battery with larger capacity (e.g., anything above 4 kWh).

Other countries analysed often use similar combinations of grants and operational support (the latter by remunerating the exported electricity). Common approaches in this sense, such as CfDs and feed-in premiums, are based on the market price, and have proven successful as they are more aligned with the investment risk profile of renewables such as solar and wind. Generally, for large installation they are awarded via competition, while for smaller ones the offer is set by the government.

No example could be found of similar schemes applied to an economy with regulated prices. In theory, both CfDs and Feed-in premiums could be applied in power systems that do not have a good market price. Both contracts offer a premium above (and in the case of CfD, also a penalty) a certain reference price, which could be different from the market price. For example, it could be a regulated price, or it could be the price of another market, or an index. In the case of a regulated price, there is however a conflict deriving from the asymmetry of power: one party in the contract (the government) may influence the regulated price, which puts the other party at disadvantage. Linking the contract to another price or an index (for example, the AC price with a fixed methodology for the duration of the contract) could be perceived as a fairer option. Energy suppliers would be obligated to purchase the energy generated via these contracts according to their market share.

However, it is worth questioning whether is worth investing in this type of schemes, given the legal and administrative complexity they entail, especially those awarded via competitive processes. In large economies, the diversity of technologies, applications and competitors is an efficient way to let the market discover the cheapest solution. In Cyprus, this is probably less of an issue, as the applications are limited. Further considerations in regard to CfDs and Feed-in premiums are provided in the next section.

3 Remuneration of exported and surplus energy

Surplus energy is defined as the net exported electricity to the power network from renewable power generation systems installed primarily for self-consumption (also called export price). In Cyprus, this is remunerated via an administratively-set price, calculated by the TSO (EAC) according to a methodology defined by CERA. The same methodology is applied also to other cases where renewable generators export to the network, such as net billing and for commercial plants (without self-consumption). The current methodology is based on the avoidance cost, i.e., renewable generation is paid according to the estimated generation cost of traditional operators in the given month. This chapter aims to review this approach and to identify possible opportunities for improving the methodology or to adopt a different one if necessary.

3.1 Background

Broadly speaking, the approaches to remunerate exported energy can be grouped in four categories:

- No price is paid. This is the case where, for example, the government or private investors pay for the installation of the generation system in its entirety. The homeowners can use all the energy they produce for free, but will not receive any compensation for the energy produced and not consumed (exported to the grid).
- Regulated price. The price is set by the regulator or by the government according to some parameters, for example, the avoidance cost or the wholesale market price. In case of fixed price, this is more similar to a feed-in tariff, while variable prices are equivalent to feed-in premiums. The current remuneration mechanisms for Cyprus fall into this category, with the price based on the avoidance cost.
- Market price. The price is set based on the wholesale price of electricity by a private purchaser (often the energy supplier) that offers a purchase contract. The price paid, while based on the wholesale price, can be below or above the actual market price, and is often calculated for large intervals (e.g., it varies monthly and may have a single or dual daily rate). Only few operators across the world currently offer a remuneration based on real time energy price.[80]

IRENA[81] identifies three possible methodologies to calculate compensation tariff for excess electricity injected under net billing schemes based on market value.

[80] For example Octopus energy in the UK offers to prosumers a variable half-hourly tariff based on the day-ahead price. See https://octopus.energy/outgoing/

[81] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Net_billing_2019.pdf?la=en&hash=DD239111CB0649A9A9018BAE77B9AC06B9EA0D25

Table 3-1 Methods for determining the compensation tariff for excess electricity injected under net billing schemes

Method		Description
Time-of-use tariffs	Static Tariffs	Determined in advance and based on historical power system balance.
	Dynamic	Tariffs determined in real time and based on actual power system balance or linked to wholesale market electricity prices .
Location-varying tariffs		Tariffs based on grid congestion at different nodes, including among other environmental factors.
Tariffs based on the avoided cost of electricity		Tariffs based on the marginal cost of electricity procurement that was avoided by retailers/system operators because of the injection of one unit of renewable electricity into the grid

Source: IRENA

On the long term, when distributed generation and prosumers will generate a more substantial share of energy, it is desirable to move to compensation linked to high-frequency market prices (e.g., half hourly based on day ahead price). This is because high-frequency market-based tariffs incentivise more efficient behaviours and allow to capture the true value of renewable electricity at the time of injection into the grid, especially if the consumption tariffs also mirror higher frequency prices.[82] Essentially, consumers will be incentivised to consume their own energy when system costs are low, and to inject into the grid when prices are high. In the long term, they would also incentivise more efficient use of behind-the-meter storage, and allow more users to exploit arbitrage opportunities.

This has also additional positive impacts for prosumers (lower energy bills) and for retailers, as it avoids the risk of "death spiral". If prosumers are overcompensated for the energy they feed into the grid, there may be often times of oversupply, which will lead to increased supplier costs due to integration challenges, while resulting in revenue losses for retailers and utilities. As a consequence, retailers may be forced to increase tariffs, which would result in increased self-consumption and exacerbates the situation further; network operators will also increase tariffs on the single user, as the amount of energy withdrawn from the network decreases. Higher tariffs further increase the economic incentives to become a self-consumer, creating a vicious circle.

There are further considerations in relation to the price of surplus energy according to the business model and other elements.[83] For example, where the user is a single customer, a group of customers or an Energy community; whether there is any element of the network owned or managed by users and so on. This section only considers the case of individual self-consumption.

3.2 Current methodology in Cyprus

Currently the main two compensation mechanisms for remuneration of exported and surplus energy by RES in Cyprus are the net metering and net billing schemes. Households and small commercial users with PV installations up to 10 kW are usually under the net metering scheme, while large users with PV installations above 10 MW are under the net billing scheme. However, the net billing scheme can be accessed by all consumers, and it also covers also biomass/biogas systems. For users of the net metering scheme, energy exported to the grid is implicitly paid the same rate as the imported energy.

[82] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Net_billing_2019.pdf?la=en&hash=DD239111CB0649A9A9018BAE77B9AC06B9EA0D25

[83] https://www.ceer.eu/documents/104400/6509669/C18-CRM9_DS7-05-03_Report+on+Regulatory+Aspects+of+Self-Consumption+and+%20Energy+Communities_final/8ee38e61-a802-bd6f-db27-4fb61aa6eb6a?version=1.1

Overall, in Cyprus, there are three different methodologies that the regulator uses to define the price paid to private generators:

- The wholesale price, paid to private traditional (non-renewable) generators in regime of non-competition. The price offered is based on international fuel prices[84] [85]
- The avoidance cost, paid to private renewable generators, both commercial scale and for self-consumption. Renewable energy is remunerated according to the avoidance cost methodology approved by CERA.[86] The price for buying electricity from RES or HECHP is the sum of a reference price, which is checked and recalculated if needed every six months, and a fuel price adjustment part, which is calculated every month. In the future, once the new market arrangements are operational, the price at which energy generated from commercial RES and HECHP is bought will be linked with the electricity wholesale price at high frequency[87].
- A provisional market price, for those installations that currently operate in the transitional market arrangements and will end-up operating in the competitive electricity market. The methodology is set by Regulatory Decision 257/2022[88]. According to this Decision, the market price for RES system operating in the competitive electricity market is set as the average purchase price from RES for the decade 2013-2022 and it corresponds to 11 c€/kWh for low voltage consumers, 10.5 c€/kWh for medium voltage and 10 c€/kWh for high voltage consumers. This amendment was decided in order to reduce the windfall profits from the RES projects included in this regime, due to the high market prices currently occurring, and it has a provisional effect.

The avoidance cost (hereinunder purchase price from RES), which is the price that the electricity produced by RES systems under the net billing scheme is sold at, is calculated every month and it consists of 1) the Basic price (c€/kWh) and 2) the Fuel adjustment cost (c€/kWh).

1) The Basic price is adjusted every six months and it depends on:
   a) the Basic fuel cost (set at 300 €/MT) adjusted with the fuel adjustment coefficient; and
   b) the Average Variable Maintenance Cost (c€/kWh), which is the result of a simulation model.
2) The Fuel adjustment cost equals the subtraction of:
   a) The Weighted Average Fuel Cost (WAFC); and
   b) the Basic fuel cost (300 €/MT)

and it is adjusted by the fuel adjustment coefficient. The fuel adjustment coefficient reflects the efficiency of the electricity production system and is calculated monthly based on the expected fuel consumption (given by a simulation model), the total corresponding sales from conventional production at all voltage levels and the losses at all voltage levels.

WAFC is calculated also monthly according to fuel consumption and the costs of fuel, as following:

$$\mathrm{WAFC} = \left(\frac{\text{Cost of fuel consumption of the month}\left(\frac{€}{\mathrm{MT}}\right) + \text{COSMOS avoidance cost}\left(\frac{€}{\mathrm{MT}}\right) + GHG\ avoidance\ cost\left(\frac{€}{MT}\right)}{Quantity\ of\ fuel\ consumed\ during\ the\ month\ (MT)} \right)$$

[84] https://www.eac.com.cy/EN/RegulatedActivities/Generation/Documents/Wholesale%20Tariff-example_2020.pdf

[85] https://www.eac.com.cy/EN/RegulatedActivities/Generation/Pages/ditimisihondrikis.aspx

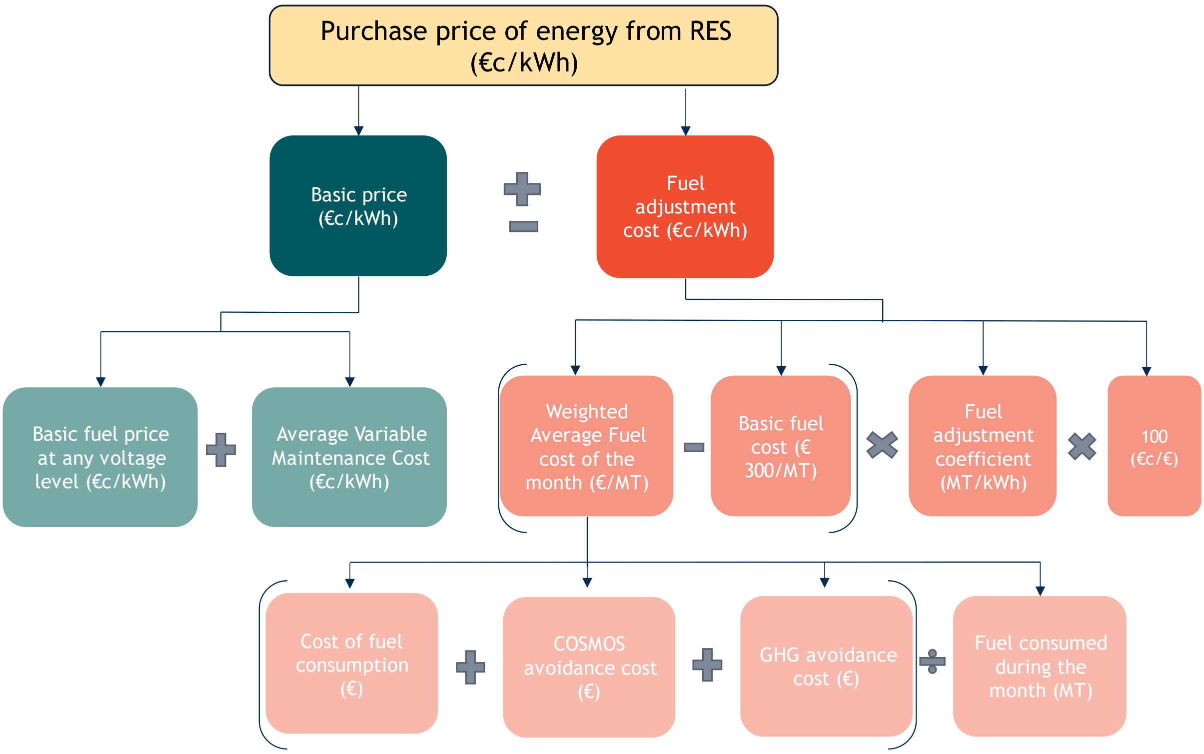
[86] https://www.eac.com.cy/EL/RegulatedActivities/Supply/renewableenergy/resenergypurchase/Pages/default.aspx

[87] JRC (2018) Technical support in the field of Energy Union: Governance, internal market and infrastructures- Deliverable 2.3

[88] https://www.cera.org.cy/Templates/00001/data/nomothesia/ethniki/rythmistikes_apofaseis/2022_06.pdf

Figure 3-1 provides a flow chart of how the purchase price form RES is structured.

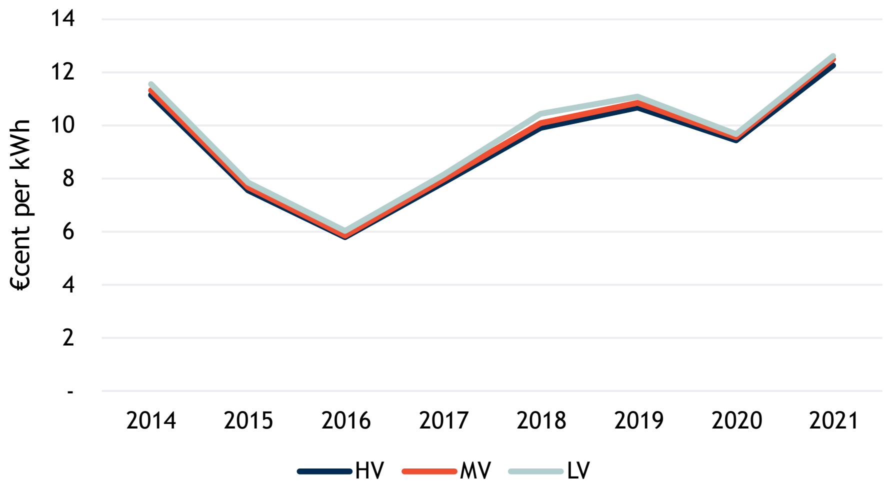
Figure 3-1 Structure of the purchase price for electricity produced from RES in Cyprus as per 2018



Source: *CERA (2018)*

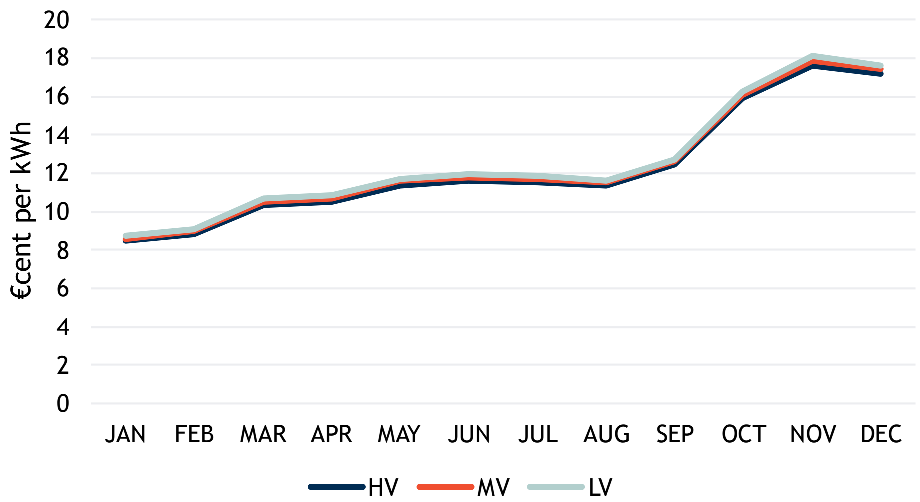
In the period from 2016 to 2021 the avoidance cost has showed an increasing trend for all voltage level users, with the average price rising from 6 c€ to more than 12 c€ over this period (Figure 3-2). During 2021 (Figure 3-3) the avoidance cost showed small fluctuations from April to August, while a continuous increase was recorded in the following months, closing the year with 17 c€, which corresponds to a double price compared to January 2021.

Figure 3-2 Average annual avoidance cost 2014-2021



Source: Based on data provided by MECI

Figure 3-3 Monthly avoidance cost 2021



Source: Based on data provided by MECI

This trend has been further amplified in 2022, as it is shown in Table 3-2 and Table 3-3, with the purchase price of electricity from RES in September 2022 reaching 25 c€.

Previously all the RES prosumers could sell their electricity based on the monthly avoidance cost. However, due to the continuously increasing prices affected by the global crisis of the electricity market, the avoidance cost is currently used only by the consumers under the net billing scheme (therefore for users that primarily use PV systems for self-consumption) and by PV Plants under Grant Schemes that operate in the transitional arrangements market.

Table 3-2 Basic price (c€/kWh) as of 2022

Voltage level	Basic price Jan-June 2022 (c€/kWh)	Basic price July-Dec 2022 (c€/kWh)
Low	6.960	7.502
Medium	6.890	7.439
High	6.801	7.338

Source: EAC

Table 3-3 Fuel adjustment cost (c€) and RES purchase price ranges(c€) as of 2022 (bi-monthly)

	Range (min-max)	
	Fuel Adjustment Cost (c€)	Purchase Price (c€)
Jan	10.3 - 10.5	17.1 - 17.5
Feb	9.0 - 9.3	15.8 - 16.2
Mar	8.4 - 8.6	15.2 - 15.6
Apr	11.8 - 12.1	18.6 - 19.1
May	12.4 - 12.7	19.2 - 19.7
Jun	13.7 - 14	20.5 - 21.0
Jul	17.9 - 18.4	24.7 - 25.3
Aug	17.7 - 18.1	25.0 - 25.6
Sep	17.7 - 18.1	25.0 - 25.6

Source: EAC

3.3 Similar initiatives across other countries

The IEA report Renewables 2019[89] categorises distributed solar PV remuneration schemes into five main categories:

1) buy-all, sell-all;
2) net metering;
3) real-time self-consumption at the wholesale price (net billing);
4) real-time self-consumption at a value-based price (usually between the wholesale and retail price), whereby utilities or regulators estimate the value of PV generation based on avoided generation capacity expansions, fuel expenditures and any additional costs, and on benefits to the system or society (grid integration costs, CO2 reduction value, capacity credits, etc.);
5) real-time self-consumption at zero remuneration. With this approach, the consumer generally receives an incentive for the installation of the PV system and is allowed to consume directly as much energy as required, but any exported energy is fed into the network for free.

Often, owners are allowed to choose from among two or three policy alternatives targeting the consumption and sale of electricity.

[89] https://iea.blob.core.windows.net/assets/a846e5cf-ca7d-4a1f-a81b-ba1499f2cc07/Renewables_2019.pdf

Table 3-4 provides an overview of the existing PV policies applied in several countries globally, including several EU MSs. Most of the European countries do not implement net metering schemes, while they opt either for buy-all, sell-all models (France) or for real-time self-consumption

Models (Germany, Spain, Sweden, Denmark and Italy). Table 3-5 provides some details on the remuneration schemes for exported energy of several countries.

Table 3-4 Current distributed PV policy

Location	Buy-all, sell-all model	Net metering		Real-time self-consumption models	
		Energy accounting	Remuneration of grid exports beyond energy accounting	Energy accounting	Remuneration of grid exports
China	Y	N	N/A	Y - real time	Value-based
New York (USA)	N	N	N/A	Y - real time	Value-based
California (USA)	N	Y - annual	Value-based	N	N/A
Germany		N	N/A	Y - real time	Value-based
Japan	Y	N	N/A	Y - real time	Value-based
Australia	N	N	N/A	Y - real time	Value-based
France	Y	N	N/A	Y - real time	Value-based
Spain	N	N	N/A	Y - real time	Wholesale or value-based
Turkey	N	Y - monthly	Value-based	N	N/A
Flanders (Belgium)		Y - annual	Value-based	Y	Zero- to wholesale price
Netherlands	N	Y - annual	Retail	N	N/Al
United Kingdom	N	N	N/A	Y	Value-based
Maharashtra (India)	N	Y - annual	Value-based	N	N/A
Telangana (India)	N	Y - biannual	Value-based	N	N/A
Israel	Y	Y - monthly	Value-based	N	N/A
Vietnam	Y	N	N/A	N	N/A
Chinese Taipei	Y	N	N/A	N	N/A
Sweden	N	N	N/A	Y - real time	Value-based
Denmark	N	N	N/A	Y - real time	Value-based
Italy	N	N	N/A	Y	Value-based
Indonesia	N	N	N/A	N	N/A
Thailand	N	Y - annual	Value-based	N	N/A
Philippines	N	Y - monthly	Wholesale	N	N/A
Mexico	Y	Y - annual	Value-based	Y	Wholesale

Source: IEA, 2019

Table 3-5 Exported energy remuneration schemes[90]

Country	Net billing and net metering framework details
Indonesia	As per net metering regulations in Indonesia, electricity injected into the grid by prosumers will be settled at a maximum of 85 % or 100 % of the local generation cost, depending on whether the local generation cost is higher or lower than the national average generation cost (Tongsopit et al., 2017)
Italy	The Italian net billing scheme calculates the value of the excess electricity fed into the grid at wholesale price, and this value can be either used as a credit for subsequent consumption periods or paid back to the consumer (European Commission, 2015).
Mexico	Under the revised net metering regulations in Mexico, renewable energy fed back into the grid will be settled according to hourly time-of-use tariffs (Jimenez, 2016).
Portugal	As per recent Portuguese self-consumption regulations, excess injection of electricity into the grid will be settled at 90 % of the average Iberian spot price; 10 % is deducted to cover the grid integration costs of renewable electricity (European Commission, 2015).
United States (Arizona)	In December 2016, the Arizona Corporation Commission voted to replace net metering with net billing under which the renewable energy injected into the grid would be compensated on the "avoided cost rate", to be calculated by the commission for each utility (DSIRE, 2017).
United States (New York)	In March 2017, the New York Public Service Commission approved the first phase of the Value of Distributed Energy Resources Order, which sets a formula to compensate the injection of renewable electricity from installations owned by commercial, industrial, non-profit and government entities, combining the wholesale price of energy with the distinct elements of DER that benefit the grid: avoided carbon emissions, cost savings to other customers and utilities, and other savings from avoiding expensive capital investments (Roselund, 2017).

Source: *IRENA, 2019*

3.4 International comparison

This section presents the approach to remunerating export and surplus electricity in Italy, Spain and Malta.

3.4.1.1 Italy

In Italy the price for renewable electricity is set differently according to the two schemes available to prosumers:

- **Incentivi luglio 2019**: net billing scheme that offers administratively-set prices for generation from different sources, at different prices;
- **Scambio sul posto**, a net billing scheme, where the surplus energy price is determined by the zonal energy prices, by the technology, and by the metering frequency (hourly, multi-hour, monthly, monthly during daytime).

More details are provided below.

3.4.1.1.1 Incentivi Luglio 2019

The *Incentivi Luglio 2019* is a scheme accessible by new and existing renewable plants up to 500 kW. Italy's *Incentivi Luglio 2019* determines the tariff to be paid (or discounted) to users following a number of steps:[91]

1. The TSO/DSO records the amount of gross energy produced and the amount injected into the power network

[91] DM FER 2019 Regolamento Operativo per l Accesso agli incentivi con Allegati.pdf (gse.it)

2 Determination of the energy absorbed by the auxiliary services, of the energy attributable to the losses in the main transformers and to the line losses up to the point of delivery of the energy to the grid, expressed in terms of percentage of gross energy produced
3 Estimate of the net energy produced based on 1 and 2
4 Estimate of the appropriate tariff, based on the technical characteristics of the installation
5 Estimate of the tariff due, based on the quantity of electricity injected in the network and other parameters. These include the discount offered by the applicants at the moment the request is submitted or during a public auction.

Point 4, the estimate of the appropriate tariff, is based on a Reference rate (determined according to the source, type and power of the plant) adjusted according to other specific conditions or time-limited offers. The tariff is fixed for each user for the entirety of the contractual period. The contractual period and the tariff varies according to the table below and which is regularly updated by the SO.

Table 3-6 Tariffs based on the renewable energy system

Technology		Power (kW)	Useful life (years)	Tariff (€/MWh)
Wind	Onshore	1<P<100	20	150
		100<P<1,000	20	90
		P≥1000	20	70
Hydro	Flowing water	1<P<400	20	155
		400<P<1,000	25	110
		P≤1000	30	80
	Basin	1<P<1,000	25	90
		P≥1,000	30	80
Residual gases from purification processes		1<P<100	20	110
		100<P<1,000	20	100
		P≤1,000	20	80
Solar PV		20<P<100	20	105
		100<P<1,000	20	90
		P≥1,000	20	70

Source: GSE

As described in point 5, reductions based on several factors will be applied to the maximum tariff presented in the table. In particular, different tariffs apply in the case of new plant, full reconstruction, reactivation, upgrading, renovations, and hybrid systems (mix of generation).

New larger installations (above 250 kW) can either accept the regulated tariff above or agree a different tariff, based on hourly zonal price of the area in which the electricity produced by the system is fed into the grid (called incentive).[92]

[92] DM FER 2019 Regolamento Operativo per l Accesso agli incentivi con Allegati.pdf (gse.it)

3.4.1.1.2 Scambio sul posto[93]

Scambio sul posto is available to small prosumers that have a consumption and production equipment connected to the same supply point. The maximum rating of the RES installation is 500 kW.

Scambio sul posto tariffs have 3 rates:

- the net amount of energy withdrawn from the network is paid according to the Unique National Price (national price of reference);
- the amount of energy injected into the network and then withdrawn again is remunerated according to a lower tariffs (as it excludes network charges and other fixed costs)
- any additional amount injected into the network is remunerated at a lower rate (around €0.03 kWh) and paid back to the user annually.

Italy's Scambio sul Posto calculates four different energy prices according to the metering arrangement frequency and to the subject. These prices are calculated over the respective intervals based on the zonal prices.

- Hourly prices
- Average prices over a number of hours
- Monthly average prices
- Monthly average prices between 8:00 and 20:00 for solar PV

In the absence of networks not connected to the zonal networks, a unique national price is applied.

Network tariffs are applied to the entire energy withdrawn from the network, with the charges being estimated on the basis of the national unique price (rather than on kWh used or on the basis of the zonal prices).

3.4.1.2 Spain

The Spanish market operates in a regime of full competition, where energy suppliers can offer different tariffs to consumers for the withdrawal of their surplus energy. Each supplier will offer either fixed or indexed tariffs both for the withdrawal and the injection into the grid.[94]

However, consumers can also access la comercializadora de referencia[95] (suppliers of last resort) which offer regulated tariffs (named PVPC[96]) both for withdrawal and for injection). The tariffs are variable (hourly) and set by the methodology established by Ministry of Industry, Trade and Tourism[97] (and calculated by Red Eléctrica de España) one day ahead. The methodology is set by the Royal Decree 216/2014[98], which establishes that the energy cost for the small consumer should be calculated according to: *a) The cost of electricity production, which will be determined based on the hourly price of the day and intraday markets during the period to which the billing corresponds, the costs of the system adjustment services and, where appropriate, other costs associated with the supply as established in this royal decree*. Essentially, the energy price is calculated according to the day and intra-day market prices.

[93] Da: (gse.it)

[94] Tarifas solares para la compensación de excedentes en autoconsumo (selectra.es)

[95] Regulated electricity tariff: Price and Schedule of the PVPC 2.0TD (selectra.es)

[96] Voluntary Price for the Small Consumer

[97] Methodology for regulated tariffs https://www.boe.es/diario_boe/txt.php?id=BOE-A-2014-3376

[98] BOE.es - BOE-A-2014-3376 Real Decreto 216/2014, de 28 de marzo, por el que se establece la metodología de cálculo de los precios voluntarios para el pequeño consumidor de energía eléctrica y su régimen jurídico de contratación.

The price for the injected energy is calculated as the PVPC price minus network and balancing cost, which means that injection price is usually substantially lower than the withdrawal price. Red Eléctrica de España publishes also the prices for the injection of electricity one day ahead in an app and on its website[99].

3.4.1.3 Malta

Compared to Italy and Spain, Malta presents a situation more similar to Cyprus. Enemalta, Malta's system operator and main supplier, and ARMS (a subsidiary of Enemalta), which manages payments, implement the system to remunerate exported energy.

In Malta prosumers get a FiT contract, which pays an amount set annual for each kWh they export to the grid. ARMS applies a ceiling to the amount payable, calculated as kWp installed * 1,600 up to a maximum of 4,800 kWh/annum per residential customers and 160,000 for commercial customers. Any unit exported above this limit is paid by Enemalta at the marginal generation cost.

3.5 Considerations concerning the current methodology

Compared to other countries, Cyprus' specific physical and regulatory characteristics (in particular the absence of wholesale, balancing and retail markets, although the forward market is available) means it has fewer solutions to ensure an efficient and fair remuneration system for RES generators. Countries with regulated prices use different methods to determine the price of export and surplus electricity, but in the vast majority of cases this is based on national or regional market prices.

In the medium/long term, Cyprus is expected to align to other EU countries and to develop markets sufficiently liquid to ensure low cost generation and distribution of electricity. However, in the short term, there are a number of factors that limit its options when it comes to define the best method to remunerate RES generation:

- Lack of a short-term wholesale and balancing market.
- Lack of smart meters for the majority of small prosumers.
- Lack of interconnection to foreign grids.
- A relatively limited diversification of power generation plants. Three thermal power stations have a total capacity of 1,480 MW, out of total generation capacity of less than 2,000 MW (it was 1,775 MW in 2020, but large amount of solar have been installed since).

The methodology adopted by CERA (Avoidance Cost, AC), considers average fuel and maintenance cost, with the former including COSMOS and GHG costs. This methodology includes all the costs incurred when generating power from fossil fuels, but:

- AC does not represent the actual cost of RES generation, nor a realistic market price (as the current prices are fixed monthly, rather than vary by hour of the day);
- AC does not capture some negative externalities that are not considered in the price for fossil fuel generation, such as air pollution. Further, while GHG allowance price is a commonly used metric to price impacts on climate change, other methodologies look at a modelled cost, generally much higher. There are several approaches to measures the cost of carbon, depending on framework and application. Two common examples of methodologies are the *social cost of carbon* and the *marginal*

[99] Análisis | ESIOS electricidad · datos · transparencia (ree.es)

abatement cost (MAC) approach. See for example ***Estimating the Value of Carbon: Two Approaches***[100]**,** which provides further details on how they are applied.

- While the AC methodology has offered relatively stable and "realistic" prices during the last decade, renewable investors were achieving excessive profits under the current international fuel price. This is happening throughout Europe (because of market dynamics). Therefore, while the avoidance cost methodology works well during times where the LCOE of renewables and fossil fuels is about the same, it does not work as well during long period of high or too low fossil fuel prices. This situation also happens in market running an open market regime, and it has attracted the attention of regulators across Europe and EU leadership.[101] A direct market intervention, although not yet agreed, is considered a realistic proposal

Avoidance cost prices paid in Cyprus in mid-2022 were in the range of 18 c€/kWh. This is substantially higher than the cost of other commercial scale systems in Europe. A recent paper[102] found a LCOE of between $0.1035 and $0.1147 per kWh for commercial-scale PV systems installed in Cyprus in 2018 (and a discount rate of 8%). At a 2018 exchange rate ($1.18 per €), this is equivalent to an LCOE of between €0.0877 and €0.0972 per kWh, which is just below the temporary price set in 2022 (11 c€/kWh).

Many renewable incentive schemes (such as feed-in premiums) would similarly provide excessive returns to renewable generators in this context. However, schemes such as contracts for difference or fixed feed-in tariffs would instead ensure better outcome for the consumers. In particular, contracts for difference have renewable generators returning any revenue above the agreed strike price. The UK government is currently offering the opportunity to existing generators to enter the scheme;[103] under this proposal, generators would sign a contract for a fixed energy price in the long term (similar to a PPA), which will see them relinquishing some profits now in exchange for long term profitability and removed market risk.

It is also worth discussing whether is appropriate to support RES via a combination of measures (in this case, via the AC price and via other government subsidy scheme). Until a sufficiently liquid market is in operation, it may be more desirable to set a remuneration mechanism for electricity that is independent from the amount of carbon it emits, and then a transparent public support measure to incentivise the required quantities of low carbon generation.

Given the regulatory basis for the export price, the regulator has however different options:

1. Let renewable generators accrue profits. An informal agreement could be reached where these profits are reinvested in new renewable generation. The windfall (excess) profits could be estimated by comparing the price received to the historic price. Operators will be allowed to keep these if they reinvest these in new renewable generation within the next three (or five) years.
2. Amend the AC methodology to be less responsive to high international energy prices, or more cost reflective. For example:
    a. Introduce a fixed ceiling to renewable price. This is the approach of CERA decision 257/2022 to cap prices, although in this case the limitation was imposed only on systems included in the support schemes under the *Plan for the generation of electricity from*

[100] https://media.rff.org/documents/RFF_NYSERDA_Valuing_Carbon_Synthesis_Memo.pdf

[101] https://ec.europa.eu/commission/presscorner/detail/en/IP_22_5489

[102] https://www.academia.edu/43517976/ASSESSMENT_OF_PV_INVESTMENTS_IN_NORTHERN_CYPRUS

[103] https://www.bloomberg.com/news/articles/2022-09-08/uk-plans-shift-in-renewables-pricing-to-help-combat-gas-costs

RES resulting in competitive market. The AC could be set as the lower between the current methodology and the average AC price in the last X years;

   b. the AC could be adjusted dynamically based on the evolution of key market indicators, so that is more reflective of the cost RES impose to the system (see below);

3. Replace the AC methodology with another method, for example one based on LCOE. An LCOE approach would transform the export price in a fixed technology-specific support price.
4. Offer larger generators benefitting from the AC tariff a PPA at fixed price, either temporary until a market regime is fully operative, or long term. A similar solution was introduced in the UK and considered in other MS.

3.6 Further considerations and potential effects on the competitivity of the energy market in Cyprus

It is worth considering the different aims that an export price and government support schemes have. The table below identifies the three main aims associated with the remuneration of RES generation, and practical policy options to achieve that aim.

Table 3-7 Objectives and available options to achieve them

Objective	Considerations	Options to consider
Remunerate the sale of electricity	• Cyprus lacks an active short-term electricity market, although a forward market should be operational soon • A regulated purchase price of electricity should aim to mimic the features of a market price (such as cost reflectivity, correlated to demand) • It may be preferable to have a price that does not tries to achieve other policy aims than incentivising efficient generation and consumption (such as promoting renewables)	• Add a correction factor to the current AC methodology. The correction factor should aim to avoid excessive profits but also incentivise the right forms of generation at the right time, as well as investments in flexibility. This can be set via an analysis that estimates the values of different technologies, a proxy that represents market demand and offer, or linked to a different market • Introduce an obligation for the incumbent to trade certain volumes of electricity on organized markets. This would speed up the formation of a more realistic market price

Incentivise private generators to invest in RES	• This is the role of government (rather than the regulator), and the right choice of instrument depends on the problem(s) that the government is trying to solve in relation to lack of investments in RES. For example,
	  ○ If the problem is lack of funds to invest, a dedicated loan scheme may be sufficient.
	  ○ If the problem is insufficient revenues to recover the investment, a feed-in premium type of instrument may be the best choice.
	  ○ If the problem is uncertain revenues, a CfD-type of support can be preferable to reduce revenue risk
		Traditional government support schemes: FiTs, FiPs, CfDs, guarantees. These can be based on consideration of different generation costs (LCOE)

Stimulate the uptake of renewables via demand	• The government may use its purchasing power to stimulate the market • The government can also try to lower the barriers to private investments in generation, for example supporting operators and buyers to meet in the absence of a full market	• Source government's own energy use exclusively from renewables, via PPA contracts with new generators • Actions to further simplify the uptake of PPAs (for example, provide guarantees for contracts with multiple counterparts, standardised terms, other actions to link offer and demand)

The regulatory options to remunerate the sale of electricity (first point in Table 3-7) are detailed further below.

3.6.1 Remunerate the sale of electricity

Broadly speaking, there are two ways in which electricity generators sell the energy they produce:

- over the counter, when a seller contracts directly with a buyer (whether final user or reseller, usually called energy supplier). The price paid is negotiated bilaterally.
- in power markets, which may have different time-frames ((multi-)year ahead, month ahead, day ahead, intra-day). The price paid is set via market mechanisms and depends on demand and offer.

Traditionally, when electricity supply was mainly provided by installations that use primary energy (such as coal or gas), electricity markets were an efficient way of setting the wholesale price based on the variable cost of the marginal power plant (= most expensive unit in the merit order). However, in RES dominated markets where near-zero marginal cost renewable electricity installations are increasingly becoming the marginal production unit in the merit order, the wholesale price set on that basis is becoming less reflective of the average production cost. Therefore, fixed-price long term contracts, such as PPAs, are seen as an effective way to remunerate electricity production, while also providing price stability to the concerned end-users or retailers.

3.6.2 PPAs and CfDs

Generally speaking, a power generator would choose a PPA if the estimated market based revenues throughout the contractual period are expected to be below the PPA contract revenues, adjusted for the different risks of the two options (market price is intrinsically more volatile and hence riskier than a long term contract that guarantees a minimum level of profitability). At the end of the period, the buyer is better off if the price paid via the PPA is lower than what it would have paid on the market, and vice-versa, it is worse off if the price paid is higher than procuring the same energy on the market. However, even in a future market dominated by long-term contracts, short-term energy markets are still expected to play a significant role.

Contracts for difference (CfDs) are a derivative-type of instrument and a particular type of PPA, used by governments to promote low carbon power generation. Similar to a privately-negotiated PPAs, generators get a fixed price for the energy they generate. The difference is that the buyer (government, government agency or designated party) does not use the electricity itself, but sells it to the market at the market price, making either a loss or a gain.[1] While CfDs are usually tied to the market price or market index (typical for non-energy CfDs), they could also be set against a regulated purchase price. Again, a generator would opt for a CfD if the contractual price is above the expected regulatory price for the duration of the CfD contract according to its expectations.

This means that, in Cyprus, the government, a government agency or a private entity could offer generators PPAs and take the reselling risk (private companies would do it if they could see the case for arbitrage). But there are important considerations:

[1] In practice, often it is the generator that sells to the market, and the government only pays or received the difference between the market price and the contract price.

If in Cyprus already exists a sufficient demand for PPAs, a government-led CfD scheme risks inflating the price and causing administrative interventions and costs without effectively increasing the offer of renewable electricity generation.

If, however, the offer and demand of PPAs are not well matched (for example, a single contract would generate too much electricity for a single buyer that would otherwise be interested), there may be a role for a government scheme that helps overcome these barriers, for example by acting as a guarantor where there are multiple buyers; if electricity generators prefer to sell according to AC terms, this means that their expected revenues via AC are higher than what they could get via a PPA. This is not necessarily a bad outcome (given that these higher potential profits will incentivize more investments in new generation) as long as the AC methodology effectively represents the true value of this additional energy. As discussed in the report, the current methodology sets this price by estimating the cost of producing the same electricity via traditional sources, but does not fully account for system integration costs, for example the need for flexibility, standby capacity and general network reinforcement. If this was the case, a prospective generator would see that (for example) as more and more solar PV capacity is added to the system, the cost of maintaining adequate capacity and adequacy margins increases, and therefore they can expect an AC-based price to be lower in the long term. There is quite a lot of research done that tries to estimate these costs, including some specific for islands [104] but these costs are very location-specific, and depend a lot on the characteristics of the conventional generation installed.

Further, in order for the AC price to be cost reflective of the elements described above, it should have a much higher granularity, and differentiate between controllable and variable renewables (with variable + batteries being in a different category) and also by technology. For example, both wind and solar energy are variable but:

- solar energy is easily predictable and all installations generate at the same time (given limited size of the island)
- wind energy is less predictable and can vary from location to location.

3.6.3 Options for modifying the AC methodology

In the long term, the price at which exported electricity is paid should be driven by the market value, but it may take some time before this market is sufficiently liquid. So there are two main options:

1. **Speed up the development of the market**, for example by imposing an obligation on the incumbent to trade certain volumes of electricity on organized markets; this has been done, for example, in the electricity and gas market[105]. This market should be open to all generators and impose some strict conditions for the incumbent concerning whether it can refuse a trade. However, this solution requires a minimum numbers of potential generators (sellers) and of buyers (suppliers or final users). It may be difficult to bring into the market a sufficient number of the latter and with sufficient buying needs.

2. Modify or replace the AC methodology. Different options are presented below:

[104] https://pure.tudelft.nl/ws/portalfiles/portal/45458539/1_s2.0_S0306261918308249_main.pdf

[105] https://www.energy-community.org/dam/jcr:6bb112a3-526e-4ebf-b265-84d6b392241c/PG_01_2019_ECS_WM_EL.pdf

a. ***Remunerate renewable generation based on its costs (LCOE).*** This is a rather simple and direct option, which will drive investment in the technology supported (as long as the price is sufficient) but will not drive further investments (for example in storage) or in beneficial behaviour (for example, shift in consumption time). This means that investors may overinvest in the same technology, but this would generate reduced returns for the collectively, as the marginal value of each kWh produced will keep decreasing over time (due to the small size of Cyprus and to the simultaneous generation of solar PV).

   Paying a price to RES generators based on LCOE would invalidate one of the conditions set above (separate the RES remuneration price from government support) and would be overall an inefficient market solution (the electricity would be more expensive than it needs to be). It would invalidate the separation between the remuneration of electricity produced and government support because implicitly, by paying exactly the same commodity differently, the export price would act as a support mechanism. An option where all generators will be based the same LCOE-based price (an LCOE calculated across the entire generation mix) will also not be a good solution, as in a market dominated by thermal generation as the current one (see Figure **3-4**) such a price will be very similar to the current AC-based price.

b. ***Evaluation-based coefficient to adjust a base value (AC price for example).*** As discussed above, a regulated price that achieves the objectives of a market price should value the benefits provided to energy system, but also the costs imposed on the energy system by different technologies – such as system integration (balancing, flexibility, and capacity and adequacy reserves) and network reinforcement. A dedicated study should be commissioned to estimate the benefits and the system integration cost of different renewable energy sources, including how the cost they impose on the system evolves as their penetration increases. The study would provide appropriate coefficients to be used to adjust a base price (for example, the AC price) according to the technology. The study may devise a methodology also to update the different coefficients on an annual basis, so that they can better reflect the evolution of the energy system over time. Similar to LCOE, this approach is technology-specific, as remuneration would vary with technology, but generation will be remunerated according to the value it provides, rather than its generation cost. For example, solar PV provides substantial benefits as it generates during hot afternoons when total demand is at its peak, but also require substantial backup capacity as they do not generate during the evening peak. An example of this analysis is provided at EU level in the report ***External costs***, part of *Energy costs, taxes and the impact of government interventions on investments*. [106]

c. ***Proxy adjustment.*** Use a proxy indicator to estimate the value of generation at a different times of the day and of the year, and then remunerate production according to a scale attached to this proxy. For example, providing a higher price when conventional generation is stretched, providing all or the majority of demand (Figure **3-4**), or when conventional generation provides a high share of total generation (Figure **3-5**), or a combination of both (Figure **3-6**). To provide sufficient incentives to drive behaviours, the percentages could be cubed and grouped for similar values.

[106] https://op.europa.eu/en/publication-detail/-/publication/91a3097c-1747-11eb-b57e-01aa75ed71a1/language-en

Figure 3-4 Conventional generation as share of demand (measures utilisation of capacity margin)

Conventional generation as share of average conventional generation

	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	47%	42%	39%	38%	39%	43%	48%	54%	56%	55%	53%	52%	54%	54%	55%	60%	66%	77%	82%	80%	79%	75%	70%	66%
Feb	41%	37%	35%	35%	36%	39%	45%	48%	48%	45%	42%	42%	42%	42%	43%	46%	53%	63%	71%	71%	69%	66%	61%	57%
Mar	40%	36%	34%	34%	35%	39%	45%	47%	45%	44%	42%	40%	40%	40%	41%	44%	50%	60%	72%	73%	71%	67%	62%	55%
Apr	33%	32%	31%	32%	36%	41%	44%	43%	41%	38%	36%	35%	33%	33%	35%	39%	45%	51%	59%	59%	55%	50%	45%	44%
May	39%	38%	38%	39%	40%	45%	48%	49%	48%	47%	47%	46%	44%	45%	47%	50%	54%	57%	60%	61%	57%	53%	51%	50%
Jun	47%	45%	45%	45%	47%	52%	57%	60%	60%	58%	57%	56%	55%	57%	59%	62%	65%	68%	69%	69%	67%	64%	62%	60%
Jul	75%	72%	69%	68%	68%	72%	80%	85%	88%	89%	89%	91%	93%	96%	98%	99%	99%	98%	97%	97%	98%	98%	96%	97%
Aug	77%	73%	70%	69%	69%	71%	76%	83%	86%	87%	86%	88%	90%	94%	96%	99%	100%	100%	100%	100%	100%	100%	100%	100%
Sep	44%	43%	42%	41%	42%	46%	50%	54%	55%	54%	53%	52%	52%	54%	56%	60%	66%	72%	78%	76%	72%	69%	67%	67%
Oct	35%	34%	34%	34%	36%	41%	45%	46%	45%	44%	43%	42%	42%	43%	45%	50%	57%	65%	69%	64%	60%	56%	52%	53%
Nov	33%	31%	29%	29%	29%	31%	36%	40%	40%	38%	37%	36%	37%	37%	40%	45%	52%	61%	66%	64%	61%	56%	53%	50%
Dec	42%	38%	35%	34%	35%	37%	43%	48%	49%	48%	46%	46%	47%	48%	50%	55%	63%	75%	82%	81%	79%	76%	72%	67%

Figure 3-5 Demand variation

	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	76%	69%	65%	63%	64%	70%	78%	90%	99%	102%	103%	105%	106%	104%	102%	102%	107%	121%	125%	123%	118%	111%	99%	88%
Feb	66%	60%	57%	56%	58%	63%	74%	84%	90%	91%	91%	91%	91%	89%	87%	86%	87%	99%	108%	107%	103%	97%	87%	76%
Mar	68%	62%	59%	58%	61%	66%	78%	87%	92%	94%	95%	95%	94%	91%	89%	88%	89%	97%	111%	112%	107%	99%	88%	75%
Apr	54%	52%	52%	53%	58%	67%	76%	83%	86%	87%	87%	87%	84%	82%	80%	81%	81%	84%	92%	92%	84%	74%	66%	59%
May	65%	63%	62%	63%	64%	72%	84%	93%	99%	102%	105%	105%	103%	102%	100%	98%	96%	93%	94%	95%	89%	81%	74%	69%
Jun	76%	73%	72%	72%	73%	83%	97%	108%	115%	119%	121%	121%	120%	120%	119%	118%	114%	110%	106%	107%	102%	96%	89%	81%
Jul	119%	113%	109%	107%	105%	113%	131%	147%	157%	163%	168%	173%	176%	178%	177%	173%	165%	155%	146%	146%	145%	141%	134%	126%
Aug	123%	117%	112%	109%	108%	110%	123%	141%	153%	160%	164%	169%	174%	177%	177%	174%	167%	158%	150%	151%	148%	145%	139%	131%
Sep	85%	81%	78%	77%	79%	85%	97%	112%	121%	127%	129%	131%	131%	131%	130%	128%	124%	119%	120%	117%	110%	104%	96%	90%
Oct	70%	67%	66%	66%	70%	78%	87%	98%	105%	108%	110%	111%	109%	108%	106%	105%	104%	107%	109%	103%	95%	87%	79%	76%
Nov	63%	59%	57%	56%	57%	62%	70%	81%	89%	93%	95%	95%	95%	94%	93%	91%	93%	101%	103%	101%	95%	87%	79%	70%
Dec	82%	74%	69%	67%	68%	72%	83%	94%	103%	107%	108%	109%	110%	110%	109%	109%	113%	126%	131%	130%	125%	117%	107%	95%

Figure 3-6 Combined utilisation and demand coverage (cubed and rounded)

	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	60%	50%	40%	40%	50%	50%	60%	70%	80%	80%	70%	70%	70%	70%	80%	80%	100%	120%	130%	130%	120%	110%	90%	70%
Feb	50%	40%	40%	40%	40%	50%	60%	60%	60%	50%	50%	50%	50%	50%	50%	60%	70%	90%	100%	100%	100%	90%	70%	60%
Mar	50%	40%	40%	40%	40%	50%	60%	60%	60%	50%	50%	50%	50%	50%	50%	50%	60%	80%	110%	110%	100%	90%	70%	60%
Apr	40%	40%	40%	40%	40%	50%	50%	50%	50%	40%	40%	40%	40%	40%	40%	40%	50%	70%	80%	80%	70%	60%	50%	40%
May	50%	50%	50%	50%	50%	50%	60%	60%	60%	60%	60%	60%	60%	60%	60%	70%	70%	80%	80%	80%	70%	60%	60%	50%
Jun	60%	60%	60%	60%	60%	70%	80%	90%	90%	90%	90%	90%	80%	90%	90%	90%	100%	100%	100%	100%	90%	80%	70%	60%
Jul	120%	110%	110%	100%	100%	110%	140%	160%	170%	180%	190%	200%	210%	220%	220%	210%	200%	190%	180%	180%	170%	160%	150%	130%
Aug	130%	120%	110%	100%	100%	110%	120%	150%	160%	170%	180%	190%	200%	210%	210%	220%	210%	200%	190%	190%	180%	170%	160%	140%
Sep	70%	70%	60%	60%	70%	70%	90%	100%	100%	100%	100%	100%	100%	110%	110%	110%	120%	120%	120%	120%	110%	100%	90%	80%
Oct	50%	50%	50%	50%	50%	60%	70%	80%	80%	70%	70%	70%	70%	70%	70%	80%	90%	110%	110%	100%	80%	70%	60%	60%
Nov	50%	40%	40%	40%	40%	40%	50%	60%	60%	60%	60%	50%	60%	60%	60%	70%	80%	100%	100%	90%	90%	70%	60%	50%
Dec	70%	60%	50%	50%	50%	60%	70%	80%	80%	80%	80%	80%	80%	80%	90%	90%	110%	130%	140%	140%	130%	120%	100%	80%

Figure 3-7 Combined utilisation and demand coverage with possible tariff boundaries

	-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	60%	50%	40%	40%	50%	50%	60%	70%	80%	80%	70%	70%	70%	70%	80%	80%	100%	120%	130%	130%	120%	110%	90%	70%
Feb	50%	40%	40%	40%	40%	50%	60%	60%	60%	50%	50%	50%	50%	50%	50%	60%	70%	90%	100%	100%	100%	90%	70%	60%
Mar	50%	40%	40%	40%	40%	50%	60%	60%	60%	50%	50%	50%	50%	50%	50%	50%	60%	80%	110%	110%	100%	90%	70%	60%
Apr	40%	40%	40%	40%	40%	50%	50%	50%	50%	40%	40%	40%	40%	40%	40%	40%	50%	70%	80%	80%	70%	60%	50%	40%
May	50%	50%	50%	50%	50%	50%	60%	60%	60%	60%	60%	60%	60%	60%	60%	70%	70%	80%	80%	80%	70%	60%	60%	50%
Jun	60%	60%	60%	60%	60%	70%	80%	90%	90%	90%	90%	90%	80%	90%	90%	90%	100%	100%	100%	100%	90%	80%	70%	60%
Jul	120%	110%	110%	100%	100%	110%	140%	160%	170%	180%	190%	200%	210%	220%	220%	210%	200%	190%	180%	180%	170%	160%	150%	130%
Aug	130%	120%	110%	100%	100%	110%	120%	150%	160%	170%	180%	190%	200%	210%	210%	220%	210%	200%	190%	190%	180%	170%	160%	140%
Sep	70%	70%	60%	60%	70%	70%	90%	100%	100%	100%	100%	100%	100%	110%	110%	110%	120%	120%	120%	120%	110%	100%	90%	80%
Oct	50%	50%	50%	50%	50%	60%	70%	80%	80%	70%	70%	70%	70%	70%	70%	80%	90%	110%	110%	100%	80%	70%	60%	60%
Nov	50%	40%	40%	40%	40%	40%	50%	60%	60%	60%	60%	50%	60%	60%	60%	70%	80%	100%	100%	90%	90%	70%	60%	50%
Dec	70%	60%	50%	50%	50%	60%	70%	80%	80%	80%	80%	80%	80%	80%	90%	90%	110%	130%	140%	140%	130%	120%	100%	80%

Figure 3-8 Averages within the time slots identified

<table>
<tr><th></th><th>- to 5</th><th>6 to 16</th><th>17 to 21</th><th>22 to 23</th></tr>
<tr><td>Jan
Feb
Mar
Apr
May
Jun</td><td>55%</td><td>70%</td><td>99%</td><td>55%</td></tr>
<tr><td>Jul
Aug</td><td>119%</td><td>187%</td><td>181%</td><td>119%</td></tr>
<tr><td>Sep
Oct
Nov
Dec</td><td>55%</td><td>70%</td><td>99%</td><td>55%</td></tr>
</table>

While a proxy will not be very precise, it could offer the right incentives and vary according to desired path (lower remuneration when more renewables come online) and incentivize desirable investment (for example in storage) and behaviours (self-consumption). The tariff could be set according to the percentages included in the figure above and set one year ahead. This means that, for example, energy sold at midnight in January will be remunerated at 55% of the monthly AC price, while energy sold in the afternoon in July would get 187% of the AC price. As this may not be sufficient with prices as high as they currently are, the new methodology could:

- be based on the previous year AC price, rather than monthly, which would smooth temporary peaks.

- supported by variable consumption tariffs, which will also contribute to align the peaks and troughs to renewable generation.
- include a further remuneration (which could be fixed) based on the controllability – i.e., whether the System Operator is able to request the generator to scale up or down generation with short notice.

Such a tariff should be imposed on all prosumers as soon as they receive a smart meter, while in the meantime remuneration could be based on monthly differences around a base price (such as the AC price, or an LCOE-based price).

Table 3-8 Average monthly variation around a central price

Month	Average variation
January	79%
February	62%
March	61%
April	49%
May	61%
June	81%
July	163%
August	163%
September	95%
October	72%
November	62%
December	88%

d. ***Market-based price.*** The export price could be linked to a different market or index . This would require a sufficiently liquid market, which means implementing this option will have to be delayed for some time if the chosen market is the forward electricity market in Cyprus. The reference price could also be an index or a separate market, but this solution will suffer from the same issue as the AC price107, that an exceptional increase in this index may lead to significant windfall gains.

There are advantages and disadvantages to these different options:

Table 3-9 Advantages and disadvantages of alternative to the current AC price methodology

	Advantages	Disadvantages
LCOE based	• Easy to setup and manage • Generators receive a sufficient revenue to repay their investment	• It does not consider the cost and benefits that the technology is providing to the system • May led to significant curtailment • Wrong assumptions may lead to insufficient or excessive remuneration
Evaluation-based adjustment coefficient	• A robust method may give long term certainty, and help investors to make a choice beneficial to the market	• Wrong assumptions or results in the study may lead to unwanted market distortions
Proxy coefficient	• Dynamically set tariff would generally give the right incentives to standalone generators and prosumers	• Could lead to complex and very detailed tariff schedule (although similar approaches are used in other countries, for example in Spain the prices are

[107] The AC methodology is essentially apply this same principle, by rewarding power generation based on international oil prices.

	Advantages	Disadvantages
	• If the tariffs are updated annually (for example, based on the previous year consumption) the methodology would reflect changes in the energy system and incentives would strengthen in the desired direction	linked to the day ahead market, so they vary daily and are published the day before) • May generate strategic behaviours which may have negative impacts on the system. For example, many prosumers may switch from self-consumption to export at the mark of the hours when prices become more convenient, generating spikes in the system • May be more suited to medium generators, rather than household prosumers • Unlikely to stimulate investments to solve seasonal variation, which in Cyprus is very high
Marked linked value	• It is the methodology more widely adopted when it comes to regulated prices	• It is not possible to be applied until the forward market is operative and sufficiently liquid, unless an unrelated market or indicator is chosen

3.6.4 Integration of CfDs and LCOEs

In regard to the integration of the AC price and a potential FiT or CfD scheme, all options considered above could potentially be suitable, as long as some conditions are met. However, as discussed in section 2.5, for investors to have faith in the reference price, this should be perceived to be independent from the counterpart in the contract, which may not be the case (as the government would sign the contract and play a part in setting the methodology, or control some factors in the methodology). A price linked to an independent index would avoid lack of perceived independence to some extent, but would suffer from similar issues to the AC price.

Concerning the award of the CfDs and Feed-in premiums, should be also considered that:

- The success of the schemes across Europe is often due to the fact that these contracts were competitively awarded, for example via auction. However, an auction system will be excessive for small prosumers, an indeed most countries opt for regulated tariffs, or allow competition between buyers (generally, these will be the same retailers/suppliers serving the prosumer).
- If a CfD or Feed-in premium approach is pursued, there should be a ceiling to the price generators are allowed to bid for. This price should be estimated based on the expected revenues according to a reference price (such as the AC method), minus a margin that represents the reduced market risk for the generator. For example, if the expected average long term price according to the adjusted AC methodology for solar energy is €0.08 per kWh, the limit for the bid could be set at €0.075.
- An alternative (or a complementary feature) of a CfD scheme would be a scheme (or a provision) for LCOE when setting up support for different technologies.
    - an alternative to CfDs could be a government scheme that guarantees a certain price (tariff) per kWh based on the technology. This scheme would allow new and currently less competitive technology to come online, so it should be targeted to those technologies that, while currently not competitive, may do so after learning curves and economies of scale are reached.
    - an LCOE approach could also be integrated into a CfD type of scheme. For example, CfD bids or agreements could have a different ceiling to the price paid according to the technology (similar to SDE +).

However, CfDs or competitively-set feed-in premiums are complex instruments, that may not return the expected results if, for example, it ends up disincentivising private PPA agreements or if not enough prospective generators submit an offer.

3.7 Differentiating export and surplus price

Two different prices could be provided for energy exported up to total consumption level and for surplus energy, with the latter being awarded a lower price. This means that the tariff will be better targeted to support correctly-sized systems and less generous towards users with oversized systems. This will reduce excessive returns that some users with high level of surplus energy may make, especially those under the net metering scheme, and bring the scheme closer to the aim of self-consumption. There are different options on how this could work in practice. The remuneration of surplus energy could be differentiated by government scheme, for example in terms of:

- Different surplus price based on the scheme. Net metering users will receive a lower price than net billing users.
- When the lower rate kicks in. Consumers under the net metering scheme may switch to the lower tariff for all their surplus energy, while consumers under the net billing scheme (less generous for users) may be remunerated at the full export price up to 150% of their consumption or with no ceiling. Users that do not benefit for government incentives may be allowed any amount of surplus energy to be remunerated at market price.
- If there is a ceiling for maximum surplus energy remunerated. For example, surplus energy will not be paid above 100% of total consumption for net metering users.

Further, rules regarding bankability (carrying over to previous years) may be modified so that the balance is paid every year.

However, a different (lower) surplus price will also create some perverse incentives and have other consequences:

- As the remuneration is lower, it may discourage investments in energy efficiency, energy storage, and in energy saving behaviours.
- From an energy system point of view, there is no reason to reward differently based on consumption level of the producer, and - if anything - this will lead to the installation of smaller systems which are generally more expensive per kW installed.
- As part of the new proposal for the revision of the Energy Market[108], the European Commission is considering an option to give all citizens the right to sell their excess energy to neighbours. This means that users will be selling according to these new rules, which may not be in line with the option of a lower rate for surplus energy. Further, this provision shows that the Commission is actually keen for prosumers to overinvest compared to their consumption, as this is the only way in which consumption from the building sector as a whole can progress along a net zero trajectory.
- Finally, as both net metering and net metering provide a ceiling to the grant, any PV system beyond a certain size will offer lower returns to users. This means that the more the users overproduce, the lower their return would be, so overproduction is already disincentivised by the current design.

[108] https://ec.europa.eu/commission/presscorner/detail/en/IP_23_1591

3.8 Recommendations

In the long term, Cyprus will move to a fully functioning energy market, with a degree of competition that should be sufficient to produce cost-reflective market prices. As this happen, the avoidance cost should be substituted for a price linked to a market price, and the EAC has already moved in this direction for new commercial-scale generators.[109]

In the long-term, also residential and small-commercial prosumers should be moved to a similar arrangement, along with the deployment of smart meters. This means transitioning from the current net metring to a net billing scheme, which would be a "*more mature compensation mechanisms that capture the true value of renewable electricity at the time of injection into the grid. As such, a compensation at wholesale electricity market price (e.g. when trading day-ahead platforms are established and liquid) might reflect more accurately the value of electricity injected into the grid*".[110] If the use of smart meters is combined with variable tariffs and in-home displays and other smart devices, consumers could be able to provide substantial amount of demand response in the long term, although the effectiveness of these practices is yet to be tested in the real world. A promising application of this more active consumer participation could start from smart EV charging (where the charging of the EV is managed by a software according to hourly prices), as already happening in some countries. For example, in the UK several suppliers offer managed EV tariffs[111], and a recent report from the Regulatory Assistant Project provides a comprehensive overview of the status of smart tariffs across Europe.[112]

Further, to speed up the benefits of a dynamically-set export price, the installation of smart meters should be prioritised for users with PV systems (both new and existing installations).

However, there are two issues that needs to be dealt with currently:

- in the very short term, how to avoid windfall profits for RES generators?
- in the medium term, how to ensure a more effective export and surplus price in the absence of a market to link it to?
- In the long term, is there a more efficient way to remunerate RES generation, whether a functioning market exists or not?

Concerning the first question, the approach implemented by the regulator in 2022 (a fixed price calculated on previous years' Avoidance Cost) seems appropriate to deal with the issue effectively in the short term. This was a temporary measure that has been withdrawn once energy prices have converged to their long term value.

In the medium term, also considering the delays to the launch of the forward market, the regulator should consider an adjustment to the AC price to make it more reflective of the costs and benefits provided by additional generation to the energy system. As the system costs and benefits are dependent on the time of generation and the controllability of the source, the remuneration main element should be time-dependent (prices varying hourly) and it may also include an element which is technology-dependent to reflect the fact that some sources would be able to reduce the ramp-up and ramp-down curves experienced by the main thermal generation in Cyprus and reduces flexibility investments.

[109] https://www.eac.com.cy/EN/RegulatedActivities/Supply/renewableenergy/Pages/saah.aspx

[110] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Net_billing_2019.pdf?la=en&hash=DD239111CB0649A9A9018BAE77B9AC06B9EA0D25

[111] https://lovemyev.com/explore/ev-tariffs/managed-ev-tariffs

[112] https://www.raponline.org/wp-content/uploads/2022/04/rap-jb-jh-smart-charging-europe-2022-april-26.pdf

If properly set, this measure would incentivise commercial generators currently receiving the avoidance cost remuneration to move to PPA contracts at a long-term fixed price. Generators would give up some short-term gains in exchange for long-term income security. These contracts should also be offered to new generators (we understand that new generators are already not able to access Avoidance Cost remuneration). PPA for RES generation have two main advantages compared to market price:

- The cost structure of RES generation (high capex, very low opex – near zero marginal generation cost) means that it is easy to determine a realistic long term price to remunerate the investment;
- Fixed price contracts means that RES generator avoid market risk, which means the return required on their investment is lower – which in turn means they can offer electricity at cheaper prices.

While in Cyprus there is a decent market for PPA, the government may step in to further facilitate their uptake, for example by providing guarantees and standard rules to protect smaller consumers that want to enter a similar contract. Ideally, the agreements supported by a public sector scheme will be signed at a price which is competitively set, for example via public auctions.

Prosumers should be offered the possibility to access (or mandated into) a variable price tariff as soon as they have a smart meter installed. However, as soon as the market starts generating at cost-reflective energy prices, the remuneration for prosumers should also be linked to this price – for example the day-ahead price – to incentivise more efficient response behaviours. In the meantime, prosumers without a smart meter that can allow them to sell the electricity at a variable export price should be offered a revised price, rather than the current one based on the AC methodology.

The option to provide two different prices for energy exported up to total consumption level and for surplus energy (with the latter being awarded lower prices) should be considered with care. The tariff will be less generous towards users with oversized systems, but may discourage investments in energy efficiency and in energy saving behaviours.

4 Tariffs and network charges review

This section provides and overview and analysis of current network charges, and options for their amendments, in particular considering residential users with a PV installed. Two main aspects are considered:

- The consumption figure to be used for the calculation of network charges. This could be either the total consumed energy, the total energy imported from the network, or the net energy imported from the network;
- The parameters to be used for calculating the network charges (distribute the total cost among users). Parameters considered are energy use (kWh) and capacity level. As the analysis focusses on households, it is assumed that all users are at the same capacity level (9.6 kW).

4.1 Current network charges methodology

The ongoing methodology for the calculation of electricity tariffs in Cyprus is based on the Regulatory Decision No 01/2021 by CERA, which describes the general structure of the electricity tariffs and provides the details of the methodology.

The main objective of the regulation is to enable the competitiveness of the Cypriot economy, protect the interest of the consumers and ensure the energy supply while promoting the energy efficiency principles. The main principles of the tariffs are to[113]:

a) reflect the cost of the service so as to enhance cost-effectiveness;
b) allow a reasonable prospect of recovering cost-effective
c) be fair and non-discriminatory between consumers, unless justified on the basis of other pricing objectives, such as enhancing economic efficiency;
d) avoid cross-subsidization between different activities in the electricity sector (i.e., generation, transmission system ownership, transmission system management, distribution system ownership, distribution system management and supply or other non-regulated activities);
e) be simple, transparent and predictable;
f) encourage efficient consumption by consumers;
g) be compatible with the clear environmental objectives set by the Republic of Cyprus;
h) enable the recovery of costs incurred on an efficient basis in relation to utility obligations and by promoting the production of electricity from renewable energy sources and high-efficiency cogeneration;
i) encourage the security of energy supply;
j) provide incentives to regulated companies to operate efficiently, and costs;
k) promote the efficiency and quality of services provided by Licensees.

[113] CERA Regulatory Decision no. 01/2021-Statement of Regulatory Practice and Electricity Tariffs Methodology

According to CERA's tariffs methodology,[114] the recovery of the allowed total revenue of the Transmission/Distribution System Owner is based on charges which are levied on the basis of the connection power (power charges, €/MW) and on the basis of energy exchanged with the network (energy charges €/MWh). Power charge mainly reflects the capital expenditure (CAPEX), while energy charge reflects mainly operating costs (OPEX). However, the methodology set the share of power-based transmission and distribution charges at 0%, which means that charges are entirely based on energy use, although the different tariff tiers with voltage level reflect different network usage. Following a recent review, all charges fixed or levied on energy capacity have also been removed.

There is however a distinction between connections at different voltage levels (low voltage - at or below 1kV, medium voltage - greater than 1kV and less than 36kV, and high voltage - 36kV and above) to reflect the fact that users connected at higher voltage levels do not use the part of the network at lower levels. Further elements of discrimination result in Cyprus having several distinct tariffs, although in some cases the resulting charges on users are often the same:

- single or two rate domestic use (codes 01, 02 and 08)
- single or two rate commercial and industrial use per voltage level (codes 10, 20, 30, 40 and 50)
- for public lighting (code 36),
- storage of thermal energy (code 56)
- water pumping (code 46)

Within the tariffs above, the relative share of power and network charges is periodically reassessed by CERA. The methodology also gives CERA the right to include another charge element, related to the number of consumers or on the basis of the agreed power of the respective consumers.

Table 4-1 provides an overview of the current network charges for electricity, from 01/01/2021 until June 2022.

Table 4-1 Network charges in Cyprus (€ cents / kWh) (in force from 1/1/2021 until June 2022)

Abbreviation	Type of tariffs	Low	Medium	High
T-NH	Transmission Network use	0.77	0.76	0.48
T-NM	Distribution network use	0.91	0.89	-
T-NL	DSO tariff	1.03	-	-
T-TSO	Tariff for the recovery of the costs of the Cyprus TSO	0.09	0.09	0.09
T-AS	Ancillary services	0.66	0.65	0.64
Total		3.46	2.39	1.21

Source: CERA

As shown above, network tariffs are charged entirely according to energy used (kWh), which is defined as "volumetric charge", with the main variation among users being dependent on the connection voltage. Users connected to lower voltages pay higher charges as they use both high, medium and low voltage networks.

[114] Regulatory Administrative Act No 359/2021 REGULATORY DECISION NO. 01/2021, Statement of Regulatory Practice and Electricity Tariffs Methodology https://www.cera.org.cy/Templates/00001/data/nomothesia/ethniki/rythmistikes_apofaseis/2021_01_en.pdf

A volumetric-only network tariffs as in Cyprus has a number of advantages and disadvantages.

Table 4-2 Advantages and disadvantages of volumetric only network tariffs

Advantages	Disadvantages
• Easy to understand for consumers • Provides an additional price signal to energy cost, as network costs increase proportionally with use • Cost-reflective as far as the use if different voltage level is concerned • It incentivises users to reduce network use, for example by installing PV systems with behind-the-meter storage	• Network reinforcement costs are related to peak use (at national and distributional level), so the allocation based on use is not cost-reflective • By incentivising users to reduce network usage, it pushes an increasing share of the cost to users that do not have a PV system installed; this increases the benefit to install PV system, further increasing the charges for those that cannot install one. In the long term, vulnerable users are those more likely to pay higher network charges

4.1.1 Energy cost tariffs structure

According to the EAC, there are three types of domestic tariffs[115]:

- Single rate Domestic Use Tariff
- Two Rate Domestic Use Tariff
- Special tariff for vulnerable customers, with rising-blocks cost according to consumption.

The single and two-rates tariffs include a small, fixed charge for meter reading and supply, but the majority of costs are levied on a per kWh basis for energy, network and ancillary services costs (see Table 4-3).

Table 4-3 Monthly domestic tariffs for January-July 2022 in Cyprus

	Single Rate Domestic Use Tariff	Two Rate Domestic Use Tariff	
		Standard periods (09:00 - 23:00)	Economy periods (23:00 - 09:00)
Normal consumers			
Energy Charge per unit (kWh)	€ 0.088	€ 0.094	€ 0.077
Network Charge per unit (kWh)	€ 0.028	€ 0.028	€ 0.028
Ancillary Services Charge per unit (kWh)	€ 0.007	€ 0.007	€ 0.007
Meter Reading Charge	€ 0.49		
Supply Charge	€ 2.32		
Vulnerable consumers			
Units (KWh)	Total Units	€/kWh	€/monthly
The first 500 units	0-500 kWh	0.056	0.670

115 https://www.eac.com.cy/EN/RegulatedActivities/Supply/tariffs/Documents/Domestic%20Tariffs-%CE%A0%CE%95%CE%A1%CE%99%CE%A6%CE%95%CE%A1%CE%95%CE%99%CE%95%CE%A3%2024.1.2022.pdf

The next 500 units	501-1000 kWh	0.063	2.140
Any additional units	1000+ kWh	0.075	2.680

Source: EAC

Tariffs for Commercial and Industrial Users[116] are instead differentiated according to:

- Voltage level (low and medium)
- User type (industrial vs commercial)
- Single vs two-rate tariff
- Load Entitlement (below or above 70 kVA)

For industrial and commercial users, a more sophisticated ToU approach is used (Table 4-5), with different energy charges according to peak/off-peak, weekday/weekend and holidays and winter/summer months. As for domestic customers, the entirety of the bill is levied on a per kWh basis.

Table 4-4 Single monthly rate use tariff for industrial and commercial users for 2022 in Cyprus (low voltage-LV)

Bi-monthly Low Voltage Single Rate Use Tariff		
	Commercial- LV	Industrial - LV
Energy Charge per unit (kWh)	€ 0.0908	€ 0.0914
Network Charge per unit (kWh)	€ 0.0282	€ 0.0282
Ancillary Services Charge per unit (kWh)	€ 0.0066	€ 0.0066
Meter Reading Charge	€ 0.49	€ 0.49
Supply Charge	€ 2.32	€ 2.32

[116] https://www.eac.com.cy/EN/RegulatedActivities/Supply/tariffs/Documents/Commercial%20and%20Industrial%20Use-%CE%A0%CE%95%CE%A1%CE%99%CE%A6%CE%95%CE%A1%CE%95%CE%99%CE%95%CE%A3%2024.1.2022.pdf

Table 4-5 Seasonal rate use tariff for industrial and commercial users for 2022 in Cyprus (low voltage)

Tariff Charges (c€/ kWh)	Periods	October - May		June - September		Monthly Charge
		Week-days	W/ends and Holidays	Week-days	W/ends and Holidays	
Energy Charge	Peak	€ 0.0847	€ 0.0814	€ 0.1326	€ 0.0828	-
	Off-Peak	€ 0.0744	€ 0.0709	€ 0.0811	€ 0.0791	
Network Charge	Peak	€ 0.0282	€ 0.0282	€ 0.0282	€ 0.0282	
	Off-Peak	€ 0.0282	€ 0.0282	€ 0.0282	€ 0.0282	
Ancillary Services Charge	Peak	€ 0.0066	€ 0.0066	€ 0.0066	€ 0.0066	
	Off-Peak	€ 0.0066	€ 0.0066	€ 0.0066	€ 0.0066	
Meter Reading Charge	-					€ 0.49
Supply Charge	-					€ 2.32

Source: EAC

4.1.2 JRC review

In 2018 and 2019, the JRC reviewed the tariff structure in Cyprus[117], and proposed a number of improvements to ensure charging principles were more closely applied:

- Purely volumetric charges (as they are currently applied) can raise serious concerns for the cost allocation of past network investments between consumers benefiting from support schemes and consumers that do not.
- An alternative to purely volumetric charges is to include fixed and capacity-related charges. Capacity charges can either be raised on contracted capacity or on measured capacity.
- Capacity-based, in particular capacity usage-based, tariffs allow better cost reflectivity, in particular they introduce an equalising factor on network cost allocation between customers benefiting from support schemes and customers that do not.
- However, implementing a contracted capacity charge, care should be taken to avoid significant impact on the allocation of the return of allowed revenues between customer classes.
- On the other hand, a hybrid tariff (fixed plus capacity plus volumetric) will result in dampening the Use-of-Network charges differential between customers that benefit from support schemes and customers that do not.
- The percentage of allowed revenues corresponding to the fixed charges should only correspond to costs that are independent of the capacity or energy consumption of a consumer.

[117] Methodological proposals for determining the use of network charges

The report then provides further observations in regard to the methodology to calculate the usage-based capacity charge and considerations over the introduction of smart meters.

The observations made by the JRC still apply to the current tariff structure, as no significant change has been made at this regard. However, CERA has acted on the basis of a MEMO provided by the JRC as part of the same assignment[118], and has decided to levy network charges on all energy consumed imported from the grid (rather than only on the difference between imported energy and generated energy) with CERA decision 28/2020. Other minor changes (such as the removal of adjustments for losses and removal of fixed fees) were also introduced. The following section provides more details over the CERA decision.

4.1.3 CERA Decision 28/2020

CERA's decision 28/2020[119] concerns Charges for Auxiliary Services, Network Use and other Services for Generation of Electricity from Renewable Energy Sources for Own Consumption for consumers under renewables Support Scheme (net metering and net billing).

CERA decided to charge participants in schemes related to the Production of Electricity from Renewable Energy Sources for own Consumption, the following approved prices[120], according to the amount of electricity imported from the network:

I. Transmission System Usage Rating (T-NH)
II. Distribution System usage rating (average voltage: above 1kV and below 36kV) that includes a billing element associated with the Distribution System Operator (DSO) (T-NM)
III. Distribution System usage rating (low voltage: up to 1kV), which includes a charging element related to the DSO (T-NL)
IV. Valuation for the provision of Auxiliary Services and long-term reserve (T-AS)
V. Estimation for the recovery of the expenses of the Cyprus Transmission System Operator (T-TSO)
VI. and the current charges for PSO and any other charges provided in relevant decisions of CERA.

The decision means that users enrolled in the net metering or net billing scheme are subject to network charges also for the energy that they have produced, exported to the network and then subsequently re-imported from the network. The decision was taken on the basis of fairness (towards users and generators that do not participate in support schemes), and cost reflectivity (energy exported to and re-imported from the network uses assets and network services).

[118] Technical support in the field of Energy Union: Governance, internal market and Infrastructures: Propose adjustments required in the potential future support schemes

[119] https://www.cera.org.cy/en-gb/apofasis/details/apofasi-28-2020

[120] https://www.cera.org.cy/Templates/00001/data/hlektrismos/cost_of_use.pdf

4.1.4 The debate

CEER defines self-generation as the use of power generated on-site by an energy consumer in order to reduce, at least in part, the purchase of electricity from the grid.[121] Besides the benefit in terms of clean energy (most installations for self-generation are clean technologies), self-generation is also beneficial as it allows to reduce the utilisation of the network, which means reduced need for network reinforcement. Further benefits of self-generation include network losses reduction, improved demand response, bill savings and CO2 abatement. [122] For this reason, electricity generated for self-consumption generally does not pay network charges, although most Electricity System Operators require at least part of network charges to be levied in relation to the installed withdrawal capacity. In this case, users are paying for the benefit of potentially using the network to withdraw electricity, in case they need to.

When net metering is introduced, however, prosumers use the grid as a virtual storage system for free by injecting or drawing electricity at any time for the same price, which reduces consumers' sensitivity to volatile electricity prices and hence undermines efforts to further develop demand-side response[123]. Further, network tariffs cover other costs, such as supply and balancing costs, which are affected by users inputting energy into the network; in particular, because of simultaneous generation from distributed generation (e.g., solar PV), these systems can impose additional substantial costs to the System Operator. Oversupply of renewable electricity into the grid during time intervals of low demand could lead to curtailment or to the formation of negative electricity prices in wholesale markets, which are costs generally recovered by network tariffs. [124]

One of the key principles recommended by CEER is that Tariffs should be cost-reflective. Prosumers that use the energy network should face network tariffs which are cost-reflective in the same manner as consumers that exclusively rely on the network for their energy supply. In particular, network tariffs should be designed to reflect the value of the network to all those connected – costs and benefits - irrespective of the type of consumer involved. All consumers should face relevant price signals. Network tariff structures should be non-distortionary: recovery of the fixed costs of building, operating and maintaining networks should be designed to avoid unintended distortions in decisions around investment in self generation.[125] For this reason, CEER expressively recommends to avoid net metering, It reduces consumers' time value sensitivity to volatile energy prices and reduces incentives to develop flexibility and demand-side response.

The 2018 JRC review indeed recommended that CERA abolishes the general network usage fee and move to levy 100% of network usage charges (T-NH, T-NM, T-NL) on the total energy taken from the grid. That is, the grid usage charges should be calculated on the energy withdrawn from the grid, without deducting the output of the photovoltaic system.[126]

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[121] https://www.ceer.eu/documents/104400/-/-/3f246c2a-d417-2a29-d8eb-765bd6579581

[122] https://www.ceer.eu/documents/104400/-/-/3f246c2a-d417-2a29-d8eb-765bd6579581

[123] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Net_billing_2019.pdf?la=en&hash=DD239111CB0649A9A9018BAE77B9AC06B9EA0D25

[124] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Feb/IRENA_Net_billing_2019.pdf?la=en&hash=DD239111CB0649A9A9018BAE77B9AC06B9EA0D25

[125] https://www.ceer.eu/documents/104400/-/-/3f246c2a-d417-2a29-d8eb-765bd6579581

[126] https://www.cera.org.cy/en-gb/apofasis/details/apofasi-28-2020

4.1.5 Complaints addressed to CERA from consumers and Cyprus Association of RES Enterprises

A few customers complained with CERA about its regulatory decision 28/2020. Below are the main points raised by them:

- Users have decided to install a photovoltaic system based on financial calculations which estimated network costs based only on net energy imported from the network. The decision should apply only to new users, or at least should have become operational after the end of the settlement period.
- Applying network charge to all energy imported is discriminatory towards those users that are unable to consume the electricity during the day (for example, because they are away from home for work).
- The new charging structure reduced the incentive to install larger system, as users may be unable to use all energy they produce on the spot.
- The new charging structure may penalise customers with particular metering arrangement. For example, a user with a one-phase PV system and a 3-phases connection was importing more electricity than necessary at any given time and re-exporting some to the network.

Some complainants also raise some issues which are instead factually incorrect:

- The fact that all energy not utilised on the premises will be lost to the producers unless immediately utilised. This is incorrect, as the energy is indeed usable for free at a later time, it is only the network charge that has to be paid (a sort of “storage cost”), which creates an incentive to reduce the use of the network.
- The fact that CERA has introduced a new charge. This is incorrect, as the charge is the same but the way it is calculated has changed.

CERA has made available to the contractor the complaints received and the reply provided by CERA to each complainant. Broadly speaking, the contractor agrees with the response provided: CERA had the right to make the change, and the new charging structure is fairer towards users without a PV system. While PV prosumers are worse off than they were before the change, the net metering arrangement is still advantageous for them, and the principle of the net metering approach is maintained.

There is some merit on the complaints that users may have taken a decision based on the original methodology for calculating network charges, but the difference over the lifetime in terms of their return is rather limited.

Table 4-6 Differences of charges between the old and the current methodology

Cost type	Old methodology	Current methodology
Energy costs	Charged on the net electricity consumed (imported-exported) including any excess of electricity from the previous month	Charged on the net electricity consumed (imported-exported) including any excess of electricity from the previous month
Network costs	Charged on the net electricity consumed (imported-exported)	Charged on the imported electricity
Ancillary Services costs	Charged on the net electricity consumed (imported-exported)	Charged on the imported electricity
Meter Reading Charge	Fixed fee	Fixed fee
Supply Charge	Fixed fee	Fixed fee
Public service operation costs	€0,191 per installed kW	€0.00035 per kWh imported electricity
RES & EE Fund costs	€2,683 per installed kW	€0.005 per kWh imported electricity
Producer Fixed Fee	€4,828 per installed kW	Not applicable

Source: Own elaboration based on information from EAC and CERA

Table 4-7 estimates how the returns for a prosumer with a PV under net metering scheme have changed since the introduction of the new charging methodology. We investigate the case of two users, one that self-consumes instantaneously 31% of the PV-generated electricity and another that consumes 75%. According to the old methodology, the share of self-consumption affects slightly the energy bill, only with regard to the energy component, since the network costs are based on the net electricity and the other levies on the capacity of the PV system. Therefore the return of this investment in both cases is similar (IRR of 13% and 14% respectively). Contrarily, the new methodology incentivizes the users to consume the electricity produced by their PV, since the network charges and the other levies are now charged on the total imported electricity, meaning that the more they self-consume the less they pay on charges. Therefore, the user that consumes 75% of the PV production will see a decrease of 34% in the annual bill (compared to the 31% self-consumption case), while the IRR for the PV installation will increase to 25% from 14% for the user with the high share of self-consumption.

Table 4-7 Effect of decision 28/2020[127]

	Previous charges		Current charges	
	User 1	User 2	User 1	User 2
PV system size	4 kW	4 kW	4 kW	4 kW
Annual generation	6,408 kWh	6,408 kWh	6,408 kWh	6,408 kWh
Annual consumption	8,000 kWh	8,000 kWh	8,000 kWh	8,000 kWh
Share of self-consumption (instantaneous)	31%	75%	31%	75%
Imported electricity	5,955 kWh	3,180 kWh	5,955 kWh	3,180 kWh
Annual bill (€)				
Energy cost	72	52	72	52
Network charges	236	237	242	148
Other costs	77	77	77	41
Total cost	**384**	**366**	**391**	**241**
Profitability				
PBP (years)	4.8	4.6	4.6	3.9
IRR (annual return, %)	19%	20%	20%	25%

Source: Own elaboration based on data from EAC and CERA

Prices include VAT

The JRC analysis[128] carried out in 2018 provides a comparison of 64 users profiles, in particular showing how the equivalent network charge per kWh of imported electricity varies with users due to the different self-consumption percentages. The analysis shows that, under the previous CERA charges, users were paying substantially different rates for the energy they import from the network, varying from 2.09 c€/kWh and 4.38 c€/kWh. The new methodology instead has a fixed 3.64 c€/kWh charge. On average, the implementation of the JRC proposal would result in an increase of the network charges recovered by net-metering customers by 4.67%, but a reduction of network charges recovered by net-billing customers by 14.75%.

[127] Based on the PBP and IRR results, it appears a mistake that bills of similar level generate different returns. This is however correct and consistent with the methodology, as the counterfactual against which the notional returns used to calculate the IRR varies between the old and new tariff.

[128] See JRC methodology report

4.2 Analysis of network tariffs and their implication for PV customers

This section aims to explore how different charging methodologies would affect domestic customers with different usage patterns and PV size. In particular, it will be compared the case of:

- Previous tariff methodology, where consumers with PV under a net metering or net billing contract would pay network charges only on the net electricity imported from the network, but there will be charged some fees according to the size of their PV system, i.e., producers fixed fee, Public service operation costs and RES & EE Fund costs;
- The current tariff methodology, where consumers with PV pay network charges based on the total amount of electricity imported, but other fixed charges have been removed;
- A new tariff methodology, based on the approach recommended by JRC in 2018 (volumetric + capacity charges). A few different options for the implementation of this tariff will be considered.

The new tariff is calculated by allocating a certain share of the total revenue to be recovered from domestic customers to the volumetric component, with the remaining share recovered via capacity charges. For example, if total recoverable amount is €50 million and the volumetric share is set at 50% €25 million will be recovered via the volumetric and €25 million via a capacity charge. Unless differently specified, a 50% capacity/volumetric is used throughout the analysis.

Vulnerable users would still receive a discount, which would be compensated by an increase in the tariff of normal users. An option is to cover the outstanding amount via a transfer from the general budget, which is a more progressive way of supporting vulnerable users.

4.2.1.1.1 Base case

Table 4-8 shows different network charges for a small, medium and large user, with and without PV. The consumer is assumed to have an alternative consumption profile and the PV is sized to provide just over 100% of the energy use.

Table 4-8 Comparison of 3 users by consumption level and tariff methodology (alternative users)

Net metering		Small user		Medium user		Large user	
		PV	No PV	PV	No PV	PV	No PV
PV size	kW	2		4.5		7.5	
Energy use	kWh	3,000	3,000	7,000	7,000	12,000	12,000
Energy generated (PV)	kWh	3,204	0	7,209	0	12,377	0
Energy imported	kWh	2,169	3,000	5,097	7,000	6,996	12,000
Production/consumption	%	107%		103%		100%	
Self-consumption	%	25%		26%		27%	
Old method	Energy costs	9	313	22	731	42	1 253
	Network costs	112	140	201	274	309	441
	Other costs	32	23	72	55	121	94
	Total costs	**153**	**477**	**296**	**1 060**	**472**	**1 788**
Current method	Energy costs	9	313	22	731	42	1 253
	Network costs	114	142	213	277	337	446
	Other costs	28	38	65	90	112	153
	Total costs	**150**	**493**	**300**	**1 097**	**491**	**1 852**
Volumetric & capacity method	Energy costs	9	313	22	731	42	1 253
	Network costs	155	169	205	238	268	323
	Other costs	28	38	65	90	112	153
	Total costs	**192**	**521**	**292**	**1 058**	**422**	**1 730**

Source: Own elaboration based on data from EAC and CERA

Prices include VAT

The analysis shows that:

- Compared to the old method, under the current method all users with PVs are paying slightly less. Users without PV would pay marginally more.
- Moving to a volumetric + capacity charge, large users with and without PVs would pay slightly less than they currently do, but smaller users (with and without PV) and medium users without PV would pay more. This aligns with the principle of moving to a partial-capacity charge, as users are charged for the cost of being connected, rather than for the use of the network.

This option would have a negative effect on low users, which could be classified in 2 categories:

- Vulnerable users living in small apartments. These users save energy because they cannot afford energy-using equipment (for example, air conditioning units) or via conscious behaviour;
- Second houses or holiday properties, which are used few weeks per year. These are generally owned by well-off individuals.

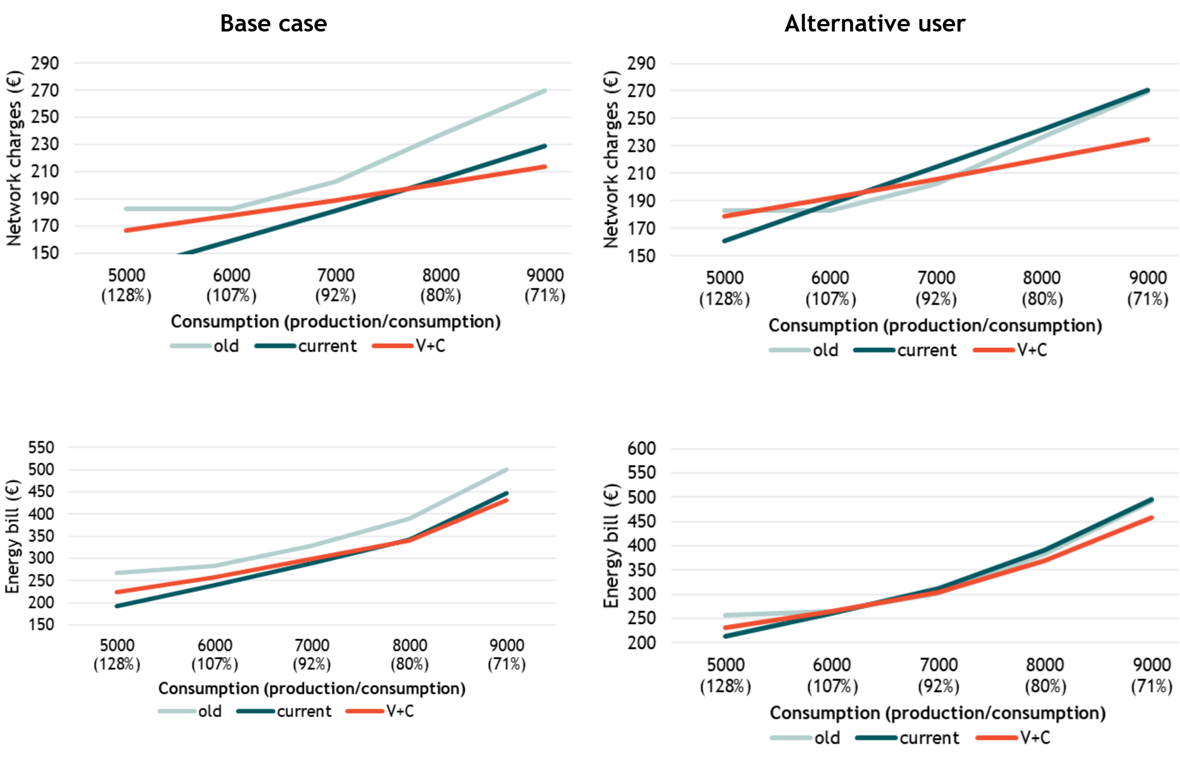
While from an energy system point of view both users may impose a similar cost, from a fairness point of view the two categories are very different. The current structure of the vulnerable tariff in Cyprus ensures that it is exactly the low users that benefit the most from it (rather than, for example, large vulnerable households). For this reason, it is recommended to review the rates provided via the vulnerable tariff (and possibly also reconsider the rules to access it) if and when such a reform of network tariff is launched. It should be relatively straightforward to estimate which change in the vulnerable tariff is required based on the change in the network tariff for users consuming within the bands identified by the vulnerable tariff.

4.2.1.2 The typical user with PV

By analysing all PV installations carried out since 2019 under government schemes, the median user has a 4.08 kW system, while the most common size installed is 3.9 kW. Therefore, for this analysis, a 4 kW system will be considered.

Looking at network charges variation according to consumption level, it is possible to see that for the typical user with PV, network tariffs are flatter (i.e., the vary less with consumption). Compared to the current one, a V+C converge when consumption is around 100%, but diverge for higher and lower users. A V+C tariffs would be lower for high users (depending on the consumption profile) but not too different from the old tariff for lower users. For a user which consumes 7,000 kWh/year, the old network tariffs were more expensive for some users but less expensive for other users, depending on usage profile. This is also the case for a new V+C tariff, which would be more or less expensive, also depending on the user profile. In general, consumers would pay substantially more above a 100% production/consumption ratio (i.e., when they do not use all the electricity they produce).

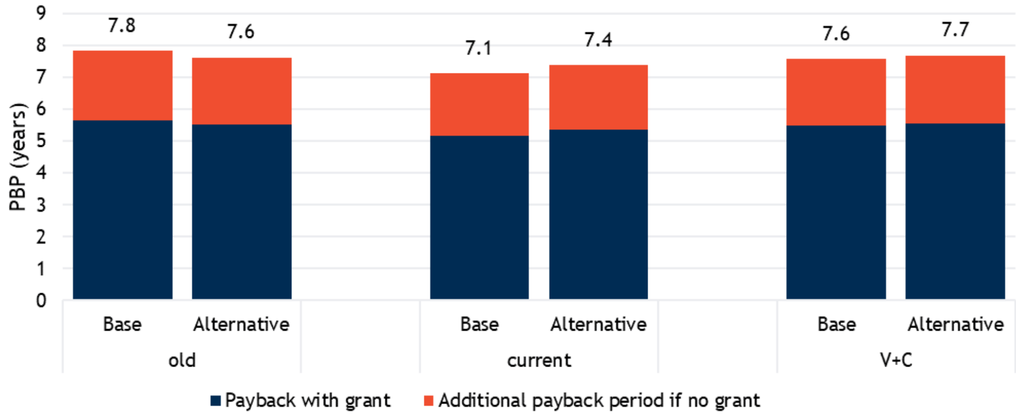
Figure 4-1 How network charges and the energy bill change with energy consumption for a user with a 4 kW PV installation



Source: Own elaboration based on CERA and EAC data

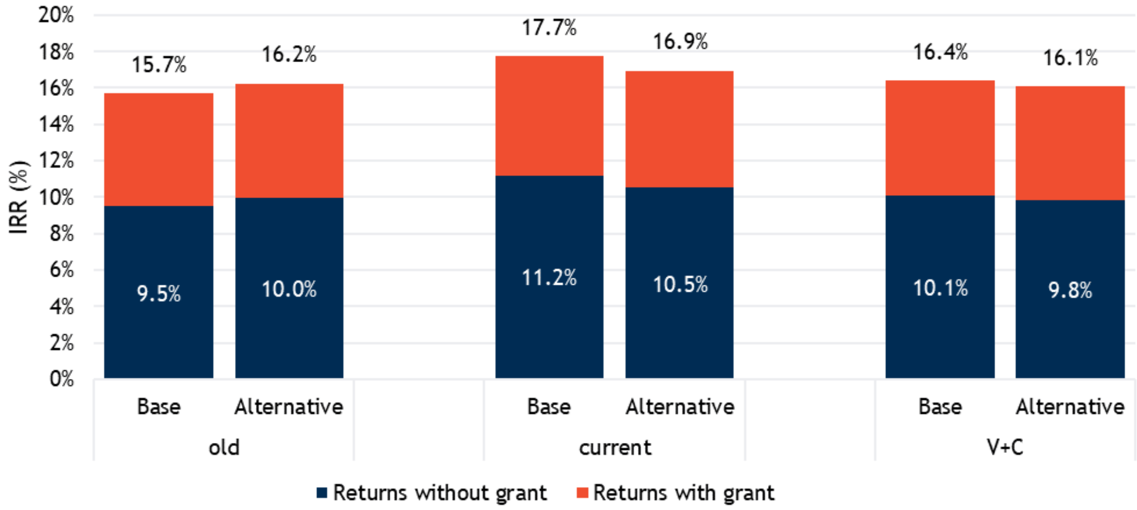
It is also important to see how changes in network tariffs may affect investing decisions of prosumers over the years. The analysis is limited to 15-years, to reflect the shorter time preferences typically associated with domestic consumers. PBP and IRR are considered for the entirety of the bill (including other fixed charges and VAT, but excluding the fuel adjustment cost) and includes the purchase grant “Installation of Photovoltaic System with the Net Metering method in households” according to the rules currently set by MECI. The discount rate is set at 0%, as this would vary greatly among residential users, which means that in general the returns presented are overestimated. The analysis also considers the new maximum allowed limit of 1.2 as the ratio between PV output and annual consumption.

Figure 4-2 Comparison between payback period of an investment in PV generation under the three tariff examined and two users profiles, including the impact of the grant (4 kW PV, 6,500 kWh/year)



Source: Own elaboration based on CERA and EAC data

Figure 4-3 Comparison between returns of an investment in PV generation under the three tariff examined and two users profiles, including the impact of the grant



Source: Own elaboration based on CERA and EAC data

The analysis of IRR and NPV for the typical user shows that:

- Under the three tariff regimes, the typical user would achieve a return of around 10% per year even without a grant. This means that the users would double the value of their initial investment in less than 15 years. Once the grant is added, returns of over 16% are achieved under every tariff option.
- These returns correspond to payback period of around 7.5 years (no grant) and around 5 years (when grants are introduced)
- Both the base and alternative profile PV user would see their return decrease slightly by moving to a V+C tariff, therefore increasing their payback period.

- Moving to a V+C tariff would slightly reduce returns and increase payback period even though the energy bill would be lower compared to the current tariff. The main reason behind the reduced returns is because of the counterfactual terms: in a V+C tariff, a 7,000 kWh/year user without PV would see its cost decrease compared to the current case, which means that the savings achievable with a PV system are less. However, if the current costs for a non PV user are taken as the counterfactual, the typical user would achieve a slightly higher return over 15 years, both in the base and alternative case. Essentially, PV users would achieve slightly higher returns under the new tariff compared to the current situation. Table 4-9 shows that the typical PV user currently saves between €736 and €763 per year compared to the same user without a PV; the move to a new V+C tariff would see savings, compared to the current tariff, of between €738 and €749. However, the new V+C tariff would also reduce the cost of a typical user without PV, hence the savings compared to a no PV users under the same tariff would be higher or lower, depending on the consumption profile.

Table 4-9 Savings generated by a PV system against different counterfactual (4 kW PV, 7,000 kWh/year)

	Current tariffs		V+C tariff	
	Base	Alternative	Base	Alternative
Savings generated by a PV system	763	736	763	707
Savings compared to no PV costs under the current tariff	--	--	749	738

Source: Own elaboration based on CERA and EAC data

Based on the calculation above, investing in PV remains a strong financial choice for the typical PV user (using 7,000 kWh/year and installing a 4 kW PV system), independently from the consumption profile and from the network tariff structure. Change in network tariffs would have a minimal impact on investment decisions.

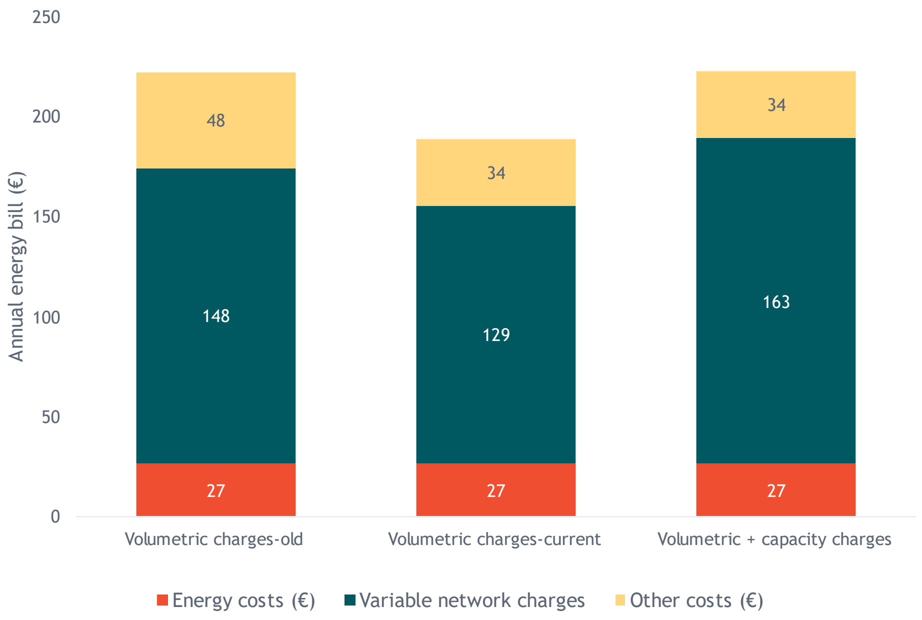
4.2.1.3 Small electricity user

This section looks at how the assessment above changes for a smaller user, with an annual demand of 4,500 kWh. This user may install a PV system rated for 3 kW, producing around 4,951 kWh/year (110% of energy needs).

A user with a base profile would be currently paying less (€189/year) than they were under the previous tariff (€223/year). Switching to a V+C tariff would see their costs increase to €223/year, same costs as with the old methodology (Figure 4-4). However, a user with the same annual total consumption but with the alternative consumption profile would be currently paying slightly less than they were under the previous tariff (€205/year compared to €209/year). Switching to a V+C tariff would see their cost increasing to €229/year, which is very similar to the base user costs under V+C methodology (

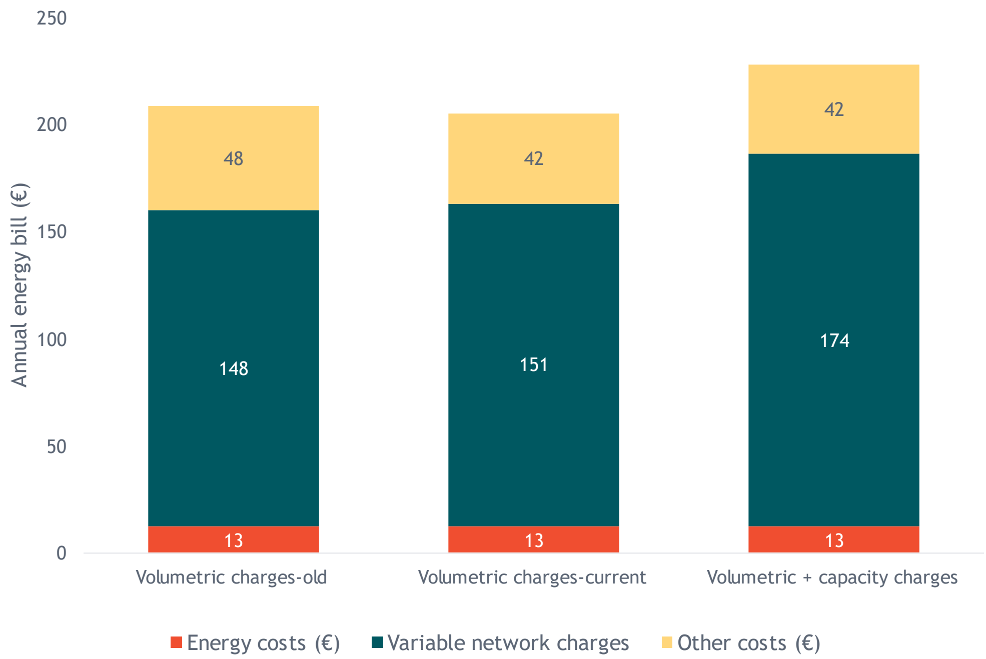
Figure 4-5).

Figure 4-4 Base user with PV, annual cost under three tariffs



Source: Own elaboration based on CERA and EAC data

Figure 4-5 Alternative user, annual cost under three tariffs



Source: Own elaboration based on CERA and EAC data

In terms of investment profitability in the long term, the picture is similar to the case of the 4 kW/ 7,000 kWh/year user, although for smaller users payback period is longer (between 8 and 9 years without grant, reducing to 6-7 years with grant). Moving to a V+C tariff would reduce annual returns and increase payback period for both base and alternative users compared to current tariffs.

4.2.1.4 Users with no PV

Based on the model assumptions, the tariffs of consumers with no PV will be affected as presented in Table 4-10. The users seeing an increase in their bills will be those using less than 4,500 kWh/year (around half of consumers), while all other users will see a decrease. Similarly, all users with PV that import less than 4,500 kWh/year will see an increase in their bill.

Table 4-10 Annual bill and network charge comparison between the current and V+C method for users with no PV

Consumption	Network charges			Bills		
	Old / current method (€/year)	V+C method (€/year)	Change	Old / current method (€/year)	V+C method (€/year)	Change
1,500	91	144	58%	267	319	19%
2,000	108	152	41%	342	387	13%
4,500	192	195	2%	720	722	0%
5,500	226	212	-6%	871	857	-2%
6,500	260	229	-12%	1022	991	-3%
7,500	294	246	-16%	1173	1125	-4%
8,500	327	263	-20%	1324	1260	-5%

Source: Own elaboration based on CERA and EAC data

As shown in Table 4-10, low users will be substantially penalised by the change. Although the change in their electricity bill is low in absolute terms (estimated at €52/year), this is substantial in relative terms (+19%). However, it is worth considering who the lowest users are: these are likely to be accounts associated with second homes or holiday flats, which reach so low consumption because of sporadic use. While it is possible that some vulnerable consumers are included, these should be supported via the vulnerable tariff, rather than hidden cross-subsidisation via network tariffs.

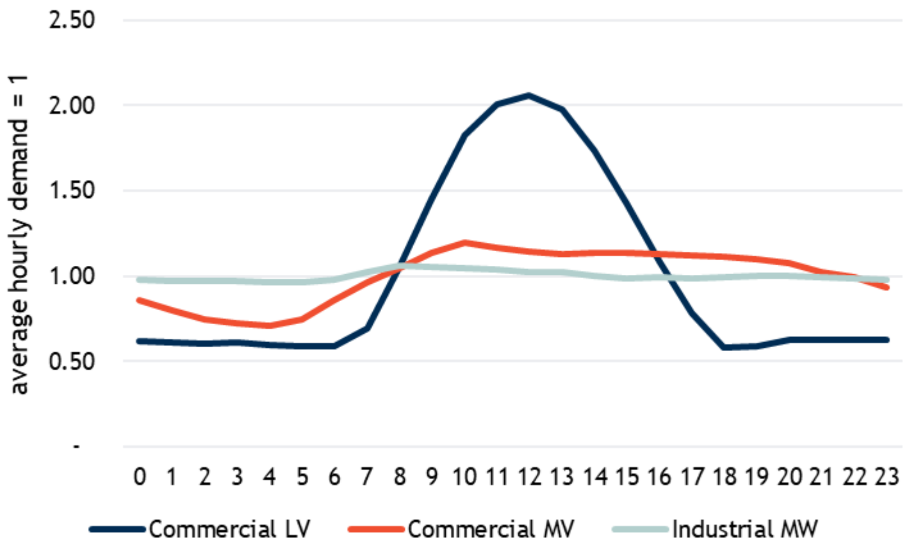
4.2.1.5 Commercial and industrial users

The model also allows to explore how commercial and industrial users in a net billing tariff would be affected by a move to a volumetric + capacity charge.

Based on the data provided by CERA, the following three users were analysed:

- A Commercial user connected to the low voltage network
- A Commercial connected to the medium voltage network
- An industrial user connected to the medium voltage network

Figure 4-6 Average daily consumption pattern by profile



Source: Own elaboration based on CERA

As for residential users, the model allows to explore network and total costs of these users by adjusting total energy used during the year and the size of the PV panels installation. Further methodological details are included in Annex.

In order to set the rates for the volumetric + capacity (V+C) tariff, the following assumptions have been considered:

- 50% charges to be paid via volumetric rates, maintaining the same total amount recovered by commercial and industrial consumers. As both total amount to be recovered and total electricity consumption by sector are known (published by the EAC), the following calculations were made:

Table 4-11 Assumptions used to calculate the V+C tariff (2019 values)

	Electricity consumption (MWh)	Current network charge per unit (€)	Total recovered amount (€)	Volumetric rate to recover 50% of network charges (€)
Commercial	1,854,824	0.0282	52,306,037	0.0141
Industrial	848,901	0.0282	23,939,008	0.0141

Source: EAC

- As not sufficient data was provided to estimate capacity charges, the values used by JRC (2018)[129] were used to estimate the contracted capacity per level.

[129] JRC (2018) Methodological proposals for determining the use of network charges

Table 4-12 Contracted tariff capacity per level

Level	€/kVA/year
T-NH	8.1
T-NM	9.9
T-NL	11

Source: JRC (2018) Methodological proposals for determining the use of network charges

A V+C tariff would have the following effect:

Table 4-13 Electricity costs by category for three fictitious commercial and industrial consumers

		Commercial LV		Commercial MV		Industrial LV	
		With PV	Without PV	With PV	Without PV	With PV	Without PV
Contracted load entitlement	kVA	150	0	450	450	110	110
PV size		85		150		35	
PV generation as share of consumption		70%		19%		80%	
Energy use	kWh	200,000	200,000	1,300,000	1,300,000	72,000	72,000
Energy generated (PV)	kWh	140,270	0	247,535	0	57,758	0
Energy imported	kWh	77,546	200,000	1 167 350	1,300,000	42,384	72,000
Old method (network costs charged on net energy)	Energy costs	6 084	20 705	115 911	142 546	1 788	7 362
	Network costs	5 113	6 752	29 864	29 673	1 773	2 456
	Other costs	1 843	1 571	11 444	10 944	675	565
	Total costs	13 040	29 028	157 220	183 164	**4 235**	**10 384**
Current method (network costs charged on imported energy)	Energy costs	6 084	20 705	115 911	142 546	1 788	7 362
	Network costs	2 675	6 835	24 975	30 263	1 480	2 486
	Other costs	997	2 571	14 866	18 019	545	925
	Total costs	9 756	30 111	155 752	190 828	**3 812**	**10 774**
Volumetric + Capacity method	Energy costs	6 084	20 705	115 911	142 546	1 788	7 362
	Network costs	3 087	5 193	23 455	27 711	2 026	2 535
	Other costs	997	2 571	14 866	18 019	545	925
	Total costs	10 168	28 469	154 232	188 276	**4 358**	**10 822**
Difference between V+C and current	**Network costs**	15%	-24%	-6%	-8%	37%	2%
	Total cost	4%	-5%	-1%	-1%	14%	0%

Source: Own elaboration based on CERA and EAC data

Compared to the current tariff methodology, some users will pay significantly higher network costs if switching to a V+C methodology, which would result in total energy bills up to 14% higher for the PV user in the example. Smaller increases are expected for non-PV consumers. On the other hand, the largest user in the example (commercial MV) would pay less than it currently does because its energy use is high compared to its load entitlement.

This conclusion is in line with the result observed by JRC (2018): a V+C charge would penalise commercial users with high load entitlement (or load peaks, in case the capacity charges is used on metered demand) and low demand and reward users with relatively low entitlement but high volumetric consumption. This again reflects the principle of cost reflectivity, where a network costs are dependent on maximum load rather than only on electricity use. Costs also generally decrease for users with PV, compared to current and previous tariffs, but there are exceptions.

The results obtained are only illustrative, i.e., different costs would be returned if different volumetric and/or capacity rates are assumed.

4.3 Suggestion for amendments to the current methodology for levying network charges

The JRC analysis concludes that, besides the changes to the basis to be used to impose network charges (all imported electricity rather than net electricity imported), CERA should consider moving towards the introduction of a capacity charge. Ideally, this would be calculated according to each consumer's actual max demand and its contribution to system peak demand, but this would require the availability of smart meters. Therefore, the JRC concludes that the introduction of a capacity charge based on contracted capacity should be considered.

Opting for a contract-based capacity charge would also be in line with one of the key principles of tariff design (predictability) as consumers' cost will not be based on other consumers behaviour and only known afterwards (this would be the case of a tariff based on actual maximum load). Further, Cyprus' smart meters rollout is still ongoing and MECI does not expect coverage of all users would be achieved. Introducing such a charge risks further discouraging the uptake for those users with high peak demand, unless an incentive for installing smart meters is provided by allowing users with smart meters to move to an actual maximum load-based tariff. This means that all users without smart meters would pay maximum contracted capacity (9.2 kVA) while users with smart meters will likely pay less unless they reach that load (which is relatively high for a household). Having a capacity charge would also provide benefits at the point when more consumers may decide to install a home fast charger for EVs, as this may require a separate supply point which could be set on a specific contract.

The analysis presented in this chapter shows how costs for prosumers and users without PV system have changed compared to the previous regime and how they will change with the introduction of a volumetric + capacity charge. As an assumption, this has been set as 50% consumption based and 50% capacity based, which means that difference from the current tariff will be dampened if the share of capacity-based charges is less than 50% and increased if the capacity-based charge is higher than 50%.

Overall, a V+C tariff increases costs for low users and decreases them for high users; it also increases the costs for those users that export more compared to their usage, and lowers them for those users with higher simultaneous consumption. While there are fairness considerations to be made (for example, towards vulnerable low users), both results are desirable, the first because it is more reflective of system costs (which are driven not only by consumption but also by capacity requirements), the second because it incentivises self-consumption even in users with net metering, which means these users will have an incentive that currently is missing because of the lack of hourly tariffs.

For commercial consumers the conclusion is more complex, as tariffs depends on a number of factors. In this case, load entitlement and allocation of costs among voltage level play a significant role, and these depends in part on how the costs are allocated at system level, and in part on businesses' load needs.

5 Conclusions and recommendations

This section provides overall recommendations concerning grant schemes, remuneration of surplus energy and review of network tariffs.

Overall, some characteristics of the energy market in Cyprus limit the possibilities of solutions to be adopted both in terms of government support for renewable deployment and in terms of tariffs. The main limiting factors are:

- There is yet not a sufficiently developed energy market at any level. Some suppliers are emerging and challenging the incumbent position, but their market share is still too marginal. This limits the offer of tariffs to consumers and options that private generators have to sell their electricity.
- Lack of interconnectors limits the possibility to have a proxy market price to be used as reference.
- The smart meters rollout is significantly behind schedule. This limits the possibility to apply smart tariffs, and to offer user more sophisticated tariffs with more granular prices than two-rates tariffs.
- There are limited options for incentivising the deployment of energy storage and flexibility.

However, there are also conditions that offer Cyprus a good opportunity to exploit:

- optimal solar irradiation;
- widespread use of solar water heaters;
- competitive business case for solar energy, even in the absence of subsidies;
- positive perception of solar energy and renewables among citizens;
- positive perception of PPAs.

5.1 Main findings

The main findings concerning government support schemes, remuneration of surplus energy and network tariffs are listed below:

1. Given its geography and climate, Cyprus has the ideal conditions for the deployment of solar energy. An analysis of PV installations for residential consumers under varying conditions shows "healthy" payback periods even in the absence of any government support.
2. Once government support is considered, returns achieved from a solar PV installation are very good, especially for smaller users able to self-consume the majority of the energy they produce (smaller users achieve better returns because of the cap on the grant at €1,500, which means that the bigger the system is, the lower is the share of cost covered by the grant). Larger users are however still able to pay back their installation in 6-7 years, which is still a good return.
3. Even after the change in tariff methodology set by CERA Decision 28/2020, investing in PV offers a very good return for most consumers. In particular, for consumers that are able to self-consume a large portion of their production (*base user* in this analysis), Decision 28/2020 has a negligible effect.
4. An analysis of the current scheme for PV and battery suggests that there is no incentive for consumers to co-invest in storage capacity. Given the maximum amount of the grant (€2,000 per customer for the battery), users would be incentivised to install only systems that cost €2,000 or less (equivalent to a battery of around 2 kWh).
5. However, a 2 kWh battery would provide limited benefit in shifting the two critical peak hours in Cyprus (peak production at the hour of highest PV generation, when thermal plants have to be

ramped down significantly, and peak demand "dinner time" peak, between 6 PM and 8 PM, that requires thermal plants to ramp up very fast). See Text box in section 2.3.2 for details.

6. From a system perspective, it is worth considering whether supporting behind-the-meter batteries is the best solution for the problem. The main advantage of behind-the-meter batteries is that they avoid an excessive amount of power running through distribution networks with limited capacity, and therefore reducing reinforcement cost; as demonstrated, they can play a role in peak-shaving and reduce the steepness of ramp up/down curves, but their cost is substantially higher than commercial-scale batteries, that would be also easier to control and better suited for the task.

7. Further, from a cost-efficiency point of view, installing many small batteries is definitely more expensive than installing few large ones, with possibly similar impact at system level. Smaller batteries are more expensive per kWh because of fixed costs (that do not scale with size, or scale less-than-proportionally to size) such as installation and inverters. SCADA controllers may allow batteries to generate higher benefits at system level, but users have no incentives to install them, so they are either mandated (which would further discourage investment in storage) or their cost should be socialised (paid by networks or government).

8. From a user perspective, an investment in battery storage would make sense if the avoided costs are sufficient to cover the investment. Home batteries which costs of around €1,000 per kWh need to save users between €0.19 and €0.38 per kWh of storage installed per day to be profitable. Given the current tariff structure and the availability of the net metering scheme, users can only recover their cost by the avoided network costs for exported and reimported electricity. As these are quite low, batteries cannot be paid back within their useful life. There are different options to create incentives for investing in batteries, including moving users to a net billing scheme (where an additional source of revenue will be the differential between the energy import and export cost) and provide hourly tariffs tied to a solar generation profile.

9. In the medium-to long term, shifting users to a net billing scheme with a more cost-reflective export price is the solution more effective from a system-wide perspective. The current Avoidance Cost methodology suffers from some significant shortcomings and does not offer the right signals to prosumers and commercial generators (to invest in storage) and to consumers (to shift consumption).

10. To avoid the issues associated with the AC tariff, options to further incentivising a shift to fixed rate remuneration (PPAs) for commercial generators and to a variable consumption and export tariff for domestic prosumers should be considered. The latter however, depends on smart meters, so it is a solution for the medium term. Other options available to update or improve the outcomes of the AC methodology include:
    a. Remunerate all or part of the exported generation based on its costs (LCOE).
    b. Set coefficients to remunerate different technologies according to the costs and benefits they bring to the market via a dedicated analysis.
    c. Set coefficients for based on time of generation based on proxy indicators that may simulate a market price.
    d. Link the remuneration price to another market or index.

11. In terms of network tariffs, this analysis explored the application of a volumetric + consumption (V+C) tariff, and how it affects different residential users compared to the old volumetric tariff (charged

only on net imports) and the current one (charged on all imports).[130] A V+C tariff would overall reduce costs for high users and increase them for low users with and without PV, which means that, to some extent, charges would move back towards the old methodology. While this may provide a perverse incentive to use more electricity, it is more cost-reflective, as a large portion of network costs is independent from consumption and dependent on capacity.

12. For potential PV users, the change in tariff would have very limited impact on any investment decisions, as payback period increases only by a few months.
13. For small users (with and without PV), the changes in tariff will be high proportionally but low in absolute terms. Further, considering that vulnerable users have access to dedicated tariffs and that a large share of low users will be second homes and holiday flats, the social impacts should be limited.

5.2 Recommendations

5.2.1 Support schemes for self-consumption (MECI)

Recommendation 1: Based on the accepted guidance, the net metering scheme should be phased out as it provides an unfair advantage to self-generators, that use the network as a “storage device” for a price that is not cost-reflective[131]. The net metering scheme should be immediately closed to new applicants (for instance by 2023), while existing prosumers should be incentivised to move to net billing. Net billing, in particular if accompanied by a variable export price, would provide stronger incentives to prosumers to shift their consumption patterns and to install storage devices (batteries, but also electric water heaters for thermal storage in buildings with no SWH), generating increasing system-level benefits as solar PV generation increases.

Recommendation 2: Given that net metering is a highly profitable scheme for the prosumers, the government needs to provide strong incentives in order to convince them to switch to net billing- if not under a mandate. Therefore the following actions are suggested:

- while net metering still active, abolish the grants under the net metering scheme and shift them to net billing PV installations. In that way the new, users will have higher returns in their investments if they enter the net billing scheme, while the returns of the net metering will be based solely on energy bill savings. The grants can be also differentiated by PV capacities; for instance, smaller users may receive higher grants, or the grant may have a fixed component and a capacity-based component (e.g., €300 + €250/kWp installed).
- provide a grant for battery installation under net billing scheme. This recommendation has a two-fold result: on the one hand, it will allow the users to reduce their imported energy and therefore their energy bill. On the other hand, it will reduce the dependency of the users on the grid and can limit the instability during the evening hours, when the demand is high. Further considerations concerning buttery purchase support schemes are provided below.
- Allow consumers under net billing to produce more than their consumption, while consumers in net metering less. Currently, net billing and net metering consumers can sell or re-import from the network an amount of electricity not higher than 90% of their annual consumption (this limit has been revised during the last update to the scheme). By increasing the thresholds of electricity net billing

[130] Both the old, current and the analysed volumetric + capacity tariff also include some fixed elements.

[131] https://www.acer.europa.eu/Official_documents/Position_Papers/Position%20papers/WP%20ACER%2001%2017.pdf

customers are allowed to sell back to the grid, their investment can be more profitable, especially if they have large roof availability but low consumption.

Recommendation 3: when setting up the level of support for Solar Water Heater, the government should consider if the funds could be more effectively invested in other RES technologies by comparing the cost per kWh generated/saved and estimating network reinforcement costs that different solutions may entail. Our analysis (section 2.2.4) shows that, while SWH have an LCOE similar or even better to that of solar PV (below €0.10 per kWh), the savings achievable by replacing an old but still functioning SWH are much lower. This means that, for example, €1 of government funds will generate much higher energy savings if spent on a new PV system compared to replacing an inefficient SWH. Further, it is unclear whether subsidies are actually necessary, given how well developed the technology is and that SWH are generally perceived as a good investment. There may be instead more added value if the support schemes targeted water heating solutions that provide additional advantages at system level. For example, water heating can be provided via a normal PV system powering a resistance in a hot water tank or hot water heat pump. In this case, the hot water tank will essentially act as a battery, storing the energy produced during peak hours by the system.

Recommendation 4: to effectively use residential batteries to help reduce grid instability due to high ramp up and ramp down requirements, ensure that it is possible to control their charging and discharging patterns to effectively smooth peaks and troughs. However, considering the significant costs of the remote controls, this solution should be considered together with the financing of larger batteries for larger PV installations only.

Recommendation 5: if the objective is to deploy rapidly flexibility mechanisms, solutions targeted at large consumers or grid services (e.g., grid-connected batteries) should be considered. While behind-the-meter batteries have some advantages compared to grid-level solutions (e.g., they may reduce network reinforcement costs) they are less cost efficient, more difficult for the SO to control and, in the long term, they will reduce the business case for the commercial operation of grid-connected storage, once a flexibility market is in place.

5.2.2 Remuneration of exported and surplus energy and network tariffs (CERA)

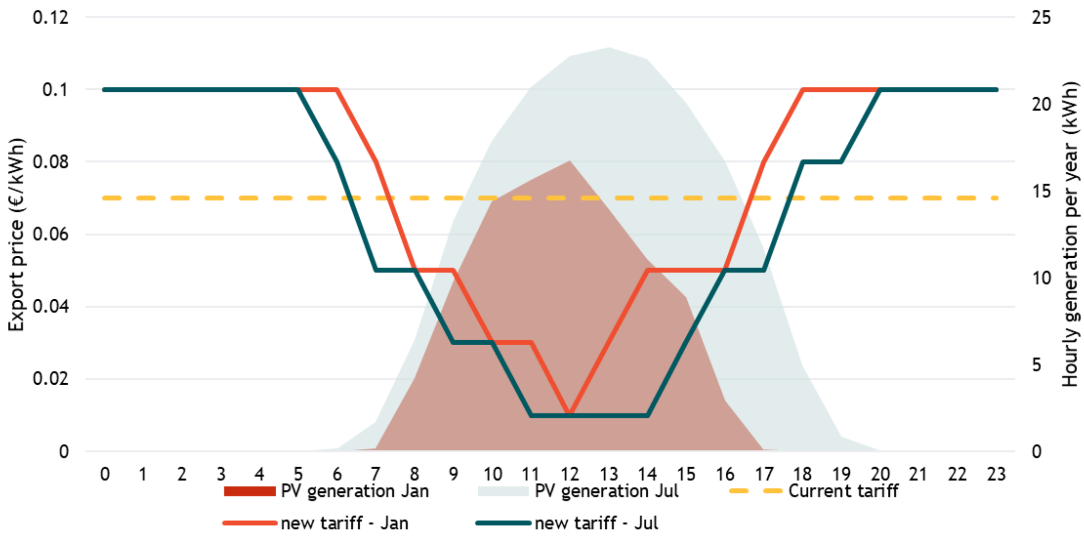
Recommendation 6: when possible, prosumers should be fully exposed to market rates and remunerated for the electricity they provide to the network according to market prices (e.g., day ahead prices), and at a corresponding level of granularity (e.g., 1-hour or 15-minutes settlement). While this may not be feasible in the short term, plans to implement this in the long term should be drawn and communicated ahead of time.

Recommendation 7: a tariff more reflective of costs and benefits imposed by generators on the system should be developed. The tariff should incentivise users to consume their own electricity during peak generation times, for example by offering very low rates when most needed, and higher rates outside critical times. Similarly to a variable consumption tariff, it could be communicated ahead (e.g., the month ahead) so that consumers can plan accordingly. Ideally, this tariff would reflect system costs and system benefits, so to encourage the right generation and self-consumption pattern.

Text box 4 Variable export tariff structure

In order to define an export tariff that encourages self-consumption and the installation of batteries, this could offer rates that are inversely related to PV generation. Figure 5-1 provides an example of a 4-tier tariff, which becomes less generous in the summer when more PV generation is available.

Figure 5-1 Example of a PV generation based hourly export tariff



Source: Own elaboration based on CERA and EAC data

However, such a tariff does not properly include all costs and benefits generated by PVs. For example, it is true that in July solar PV is most abundant, but also total system demand is at its highest. So while this tariff would encourage more responsive behaviours from prosumers (e.g., increase self-consumption during peak generation, installation of batteries) it will not be fully reflective of the cost imposed onto and the benefits generated for the system.

Another way to look at the problem is to estimate system costs and benefits looking at the generation data from different sources. Surprisingly, this analysis suggest that the opposite should happen, i.e., that tariffs should increase during summer afternoons, as they are the period of peak demand and very high thermal generation.

Figure 5-2 shows the cubic ratio between the thermal generation and demand at each hour of the day and the annual average monthly demand and thermal generation. Essentially, it measures system cost (based on thermal generation, which is largely a fixed cost that has to be paid in order to maintain flexibility and peak capacity) and benefits (based on total demand), with the cubic element introduced to increase the differences among the intervals. It shows that running the system is cheaper during night hours (midnight to 6AM), except during summer, where the total demand and thermal generation are at or just above average. On the other hand, there is a large variation in afternoon costs and benefits, with winter being the lower and summer being the higher. This also shows that solar PV during summer is indeed a good fit for the demand curve.

Figure 5-2 Cubic ratio between the thermal generation and demand at each hour of the day and the annual average monthly demand and thermal generation

	-	1	2	3	4	5	6	7	8	9	10	11
Jan	60%	50%	40%	40%	50%	50%	60%	70%	80%	80%	70%	70%
Feb	50%	40%	40%	40%	40%	50%	60%	60%	60%	50%	50%	50%
Mar	50%	40%	40%	40%	40%	50%	60%	60%	60%	50%	50%	50%
Apr	40%	40%	40%	40%	40%	50%	50%	50%	50%	40%	40%	40%
May	50%	50%	50%	50%	50%	50%	60%	60%	60%	60%	60%	60%
Jun	60%	60%	60%	60%	60%	70%	80%	90%	90%	90%	90%	90%
Jul	120%	110%	110%	100%	100%	110%	140%	160%	170%	180%	190%	200%
Aug	130%	120%	110%	100%	100%	110%	120%	150%	160%	170%	180%	190%
Sep	70%	70%	60%	60%	70%	70%	90%	100%	100%	100%	100%	100%
Oct	50%	50%	50%	50%	50%	60%	70%	80%	80%	70%	70%	70%
Nov	50%	40%	40%	40%	40%	40%	50%	60%	60%	60%	60%	50%
Dec	70%	60%	50%	50%	50%	60%	70%	80%	80%	80%	80%	80%

	12	13	14	15	16	17	18	19	20	21	22	23
Jan	70%	70%	80%	80%	100%	120%	130%	130%	120%	110%	90%	70%
Feb	50%	50%	50%	60%	70%	90%	100%	100%	100%	90%	70%	60%
Mar	50%	50%	50%	50%	60%	80%	110%	110%	100%	90%	70%	60%
Apr	40%	40%	40%	40%	50%	70%	80%	80%	70%	60%	50%	40%
May	60%	60%	60%	70%	70%	80%	80%	80%	70%	60%	60%	50%
Jun	80%	90%	90%	90%	100%	100%	100%	100%	90%	80%	70%	60%
Jul	210%	220%	220%	210%	200%	190%	180%	180%	170%	160%	150%	130%
Aug	200%	210%	210%	220%	210%	200%	190%	190%	180%	170%	160%	140%
Sep	100%	110%	110%	110%	120%	120%	120%	120%	110%	100%	90%	80%
Oct	70%	70%	70%	80%	90%	110%	110%	100%	80%	70%	60%	60%
Nov	60%	60%	60%	70%	80%	100%	100%	90%	90%	70%	60%	50%
Dec	80%	80%	90%	90%	110%	130%	140%	140%	130%	120%	100%	80%

In summary, the following periods can be identified:

- Night time (22:00 to 6:00) excluding July and August
- Daytime (6:00 to 23:00) during July and August
- An evening peak (17:00 to 22:00), throughout the year
- An afternoon low during February, March and April (and to a lesser extent November)

The cubic average differences during the selected times slots look like in Figure 5-3

Figure 5-3 averages within the time slots identified

Based on the averages within the periods identified, it is possible to propose a tariff that varies in three time slots per day and has two periods during the year as presented in Table 5-1.

Table 5-1 Options for variation from central tariff according to time slot

Time	22:00 - 6:00	6:00 - 17:00	17:00 - 22:00
July - Aug	120%	190%	180%
Sept - Jun	55%	70%	100%

These adjustment factors can be recalculated every year based on the previous year total energy demand and total output from thermal generation. Such a tariff should be offered to all users with a PV system, and they should be selected for early installation of smart meters.

The main disadvantage of this option is that it may generate sudden spikes at the beginning and end of hours when a price change is foreseen and a high number of storage systems are deployed. Ideally, this would be solved by a market mechanisms that provides prices at higher frequency, and these prices will be used by individual systems to automatically switch on and off at different thresholds. Further, this option is not able to deal with ramp up and ramp down issues; given the time where ramp up and ramp down are activated, this would require much more granular tariffs (e.g., 15-minute or even 5-minute intervals). In order to have such a tariff, a higher degree of market digitalisation is required.

Recommendation 8: two different prices could be provided for energy exported up to total consumption level and for surplus energy, with the latter being awarded lower prices. This means that the tariff will be better targeted to support correctly-sized systems and less generous towards users with oversized systems. However, this option may discourage investments in energy efficiency and in energy saving behaviours. Also, from a system point of view, there is no reason to reward differently based on consumption level of the producers, and - if anything - this will lead to the installation of smaller systems which are generally more expensive per kW installed. The pro and cons of this option should be carefully evaluated to arrive at an appropriate rate only for surplus energy.

Recommendation 9: if the current metering equipment does not allow the application of more granular (hourly) tariffs, prosumers should be given the priority for the installation of smart meters, which would allow them to be moved into a more granular tariff.

Recommendation 10: develop a time of use tariffs that “mirrors” PV generation targeted at residential and non-residential users (both with and without PV), and to be offered to all new smart-meter users. The simpler option is to apply the same variation provided in Table 5-1, but starting from a different base price (as it currently happens, where import and export price have two different values. As in a market system, the price at which generators sell and the price at which consumers buy should be related, ideally at short intervals to be more cost reflective. This already happens in some markets (for example in Spain the export price is based on the day ahead market price and varies hourly, while other market base the export price on market price but with less granularity (e.g., month ahead).

Recommendation 11: both ACER and CEER consider "*appropriate a gradual move to increasingly power-based distribution tariffs to recover those costs which show correlation with contracted or peak capacity*".[132] While this analysis did not look at a breakdown of network costs incurred by the operator, the 50% - 50% capacity-distribution split of the tariffs explored is conservative at this respect (i.e., it is reasonable to expect a share larger than 50% of network costs may be correlated to capacity usage, rather than to volumes of energy withdrawn). The analysis shows that the impacts on different users of a move to a V+C tariff:

- Can be important but do not appear excessive and may actually go to penalise mostly users with holidays homes or second houses, which overall can be considered a fair outcome.
- Would have minimal impacts on investment decisions.

[132] See page 9 https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Report%20on%20D-Tariff%20Methodologies.pdf

6 Annex I : Modelling methodology

6.1 Introduction

The numerical analysis presented in this report is based on a bespoke model developed specifically for this study. The model allows to estimate the impact of different subsidy schemes and network tariffs methodologies on different consumers, in particular changes in their energy and network cost, and the profitability of investing in a PV system, behind-the-meter storage and replacing their solar water heater. Given the different target audience, two versions of the model have been developed:

- A "MECI" version, which focusses on the impact of different grants and support schemes. This tool allows to evaluate how current grants affect the overall profitability of investments in PV or PV + storage, in combination with the different methodologies applied to the compensation mechanisms (net metering, net billing, vulnerable consumer tariffs). Profitability is expressed as payback period, return on investment (IRR) or Net present value. The tool also allows to evaluate other elements, such the relationship between the size of the PV systems installed and returns achievable by different users according to their consumption profile and total annual consumption. The tool is also able to evaluate the profitability of an investment to replace a Solar Water heater.
- A "CERA" version, which focusses on the impacts on consumer bills of a change in tariff methodology. The tool considers three main tariffs:
    - Previous tariff methodology, where consumers with PV under a net metering or net billing contract would pay network charges only on the net electricity imported from the network, but will be charges some fixed fees according to the size of their PV system
    - The current tariff methodology, where consumers with PV pay network charges based on the total amount of electricity imported, but some fixed charges have been removed
    - A new tariff methodology, based on the approach recommended by JRC in 2018 (volumetric + capacity charges). To simplify the analysis, some fixed charges are kept, which means that the volumetric + capacity element only replaces the previously entirely volumetric element.

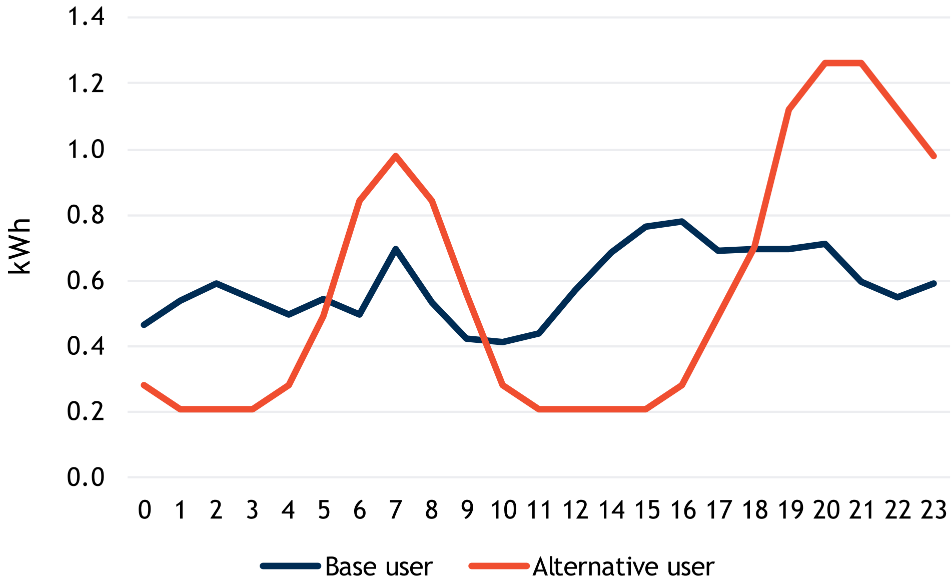
Both tools have been optimised for residential consumers, although some analysis of commercial and industrial users is also possible in CERA version.

The following sections provide first an overview of the methodological considerations used for the development of the model.

6.2 Energy consumption and PV production

The models allow users to set the amount of energy used, the size of the PV system installed and the user profile. User can set these parameters in the main dashboard. The user profiles are based on real data, and aim to represent two fairly different households (Figure 6-1 Average daily consumption for the two consumers profiles, one with a relatively stable consumption during the day and another with a morning and an evening peak (representing a family that regularly leaves the house during the day). These profiles are represented for each hour of the day as a monthly average value, i.e., it is possible to see how their consumption varies during the day and during the year, but no weekdays/weekend variability is presented.

Figure 6-1 Average daily consumption for the two consumers profiles, for an annual consumption of 7000 kWh



Source: Own elaboration based on CERA data

The model recalculates hourly average consumption in each month according to the total annual energy used.

Users are then able to enter the desired PV size. The annual PV production was calculated based on the formula $PV\ production = PV\ capacity\ (kW)\ \times 1600\ (kWh/kW)$, while the PV output profile during each hours for the different months of the year is based on EAC data for total PV production in Cyprus.

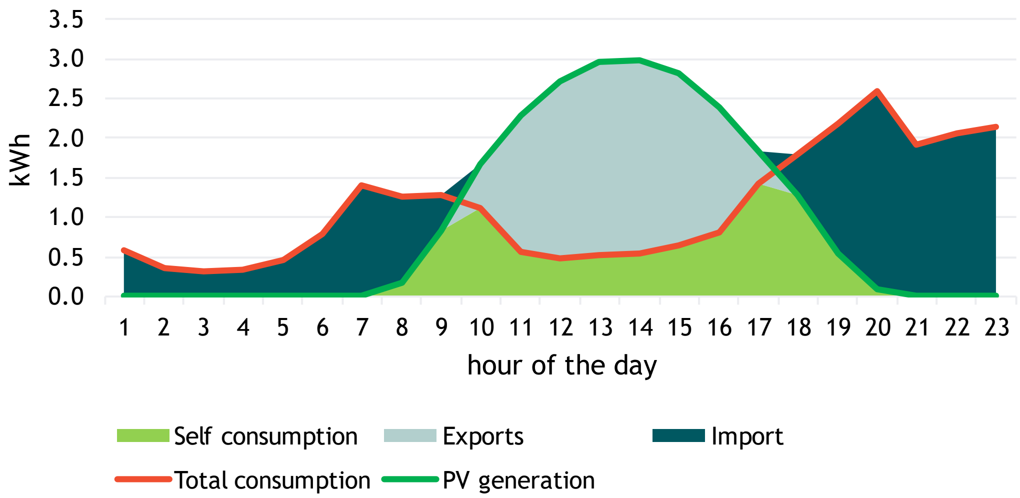
Based on the three factors, the model is able to estimate, for each hour:

- Energy demand
- Energy production
- Self-consumption (*energy demand* when *energy production* >0)
- Export to the grid (*energy production* – *energy demand* when *energy production* > 0)

The model also allows users to:

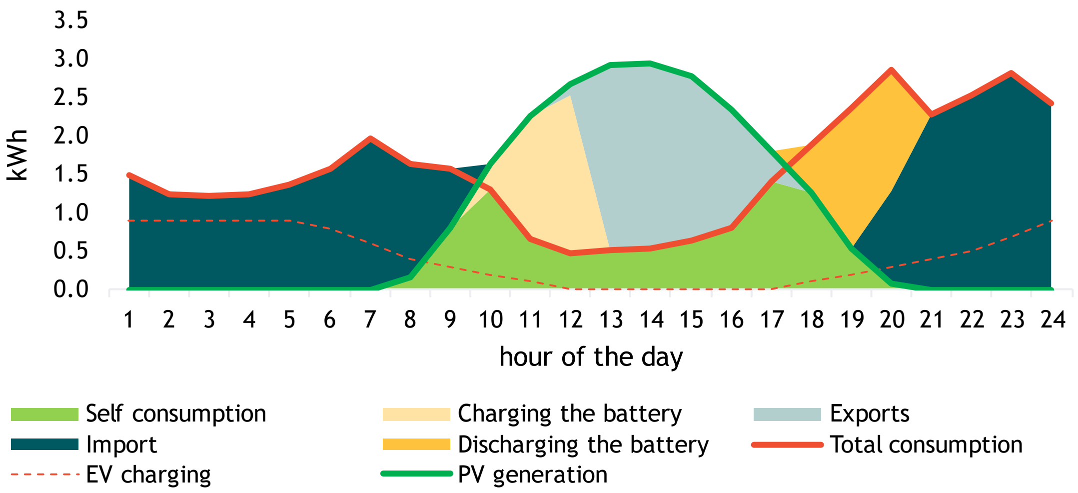
- Add consumption from an EV, including specifying the amount of average daily charge required. This load will combine with the load of the building
- Add a battery, including specifying the battery size and the share of curtailment. The battery will charge when *energy production* – *energy demand* > *0* and when the battery is not fully charged, and will discharge when *energy demand* > *energy generation*.

Figure 6-2 August profile of a base user with a 4 kW PV and 6,500 kWh use per year and no EV



Source: Own elaboration based on CERA data

Figure 6-3 August profile of an alternative user with a 4 kW PV, 4 kWh battery (no curtailment), 6,500 kWh use per year and EV being recharged 10 kWh per day



Source: Own elaboration based on CERA data

6.3 Energy costs and network charges

Aggregate consumption data is used to estimate consumer bills, broken down by energy cost, network costs and other costs. The model allows to estimate results based on tariffs available at different points in time. The main analysis is based on the tariffs presented in Table 6-1 from January to June 2022.

Table 6-1 Consumer tariffs from January to June 2022

Tariffs	Value	Unit
Import price	0.0882	€/kWh
Export price of energy	0.0734	€/kWh
Network charges (volumetric, current)	0.0282	€/kWh
Ancillary Services Charge	0.0066	€/kWh
Meter Reading Charge	0.49	month
Supply Charge	2.32	month
Public service operation fee	0.0004	€/kWh
RES & EE Fund fee	0.005	€/kWh
Fixed Fee	-	not applicable
VAT	19%	€
Old tariffs (monthly)		
Public service operation fee	0.096	€/kW
RES & EE Fund fee	1.342	€/kW
Fixed Fee	2.414	€/kW

Sources: EAC, CERA

Table 6-2 Types of charges applied in the electricity bill in all scenarios

Type	Charges
Energy	Energy cost (proportional to imported energy)
Network	Network charges
	Ancillary Services Charge
Fixed costs	Meter Reading Charge
	Supply Charge
Levies	Public service operation cost
	RES & EE Fund cost

Table 6-3 Tariffs for electricity and other charges (applicable as per March 2022[133])

Tariffs	Value	Basis
Import tariff (€/kWh)	0.0882	All imported electricity
Export tariff (€/kWh)	0.07502	All exported electricity
Network charges (€/kWh)	0.0282	All imported electricity
Ancillary Services Charge (€/kWh)	0.0066	All imported electricity
Public service operation fee (€/kWh)	0.00035	All imported electricity
RES & EE Fund fee (€/kWh)	0.01	All imported electricity
Meter Reading Charge (€)	0.49	Monthly
Supply Charge (€)	2.32	Monthly

Sources: EAC, CERA

Table 6-4 Vulnerable consumers tariff (energy only)

Units (KWh)	Total Units	€/kWh	€/monthly
The first 500 units	0-500	0.0563	0.67
The next 500 units	501-1000	0.063	2.14
Any additional units	1001+	0.07505	2.68

Source: CERA

The CERA model allows to calculate consumer costs according to different methodologies, which means applying the parameters above to different drivers. For example, the old network tariff would be charged only on net imported energy, while the current is charges on total imported energy.

Based on current tariffs, it is assumed that the current volumetric network charges (€0.0282) allow to recover €47 million per year).

6.4 Other key inputs and assumptions

To quantify the effective costs for different users, and to estimate alternative tariff design, a number of other key inputs and assumptions have been used. These are listed below:

6.4.1.1 User base

- All residential consumers are assumed to have a load 9.2 kVA.
- 2% of households have access to the vulnerable tariffs.
- There are a total of **375,210** active residential consumers. These are:
    - 297,122 houses occupied as a usual place of residence
    - 71,942 Second homes
    - 6,146 tourist apartment

[133] EAC (2022) Domestic Use Tariffs Codes 01, 02 and 08

These figures are derived from the 2020 Long Term Renovation Strategy.[134] The LTRS also include 54,651 empty homes and 1,198 homes intended for demolition or other use, but these have been excluded from the analysis (assumed that they do not have an active connection).

- According to a survey carried out in 2017[135], the current household consumption in Cyprus is distributed as presented in

- Table 6-5.

Table 6-5 Distribution of users across consumption classes

Consumption	Share	Total number of consumers
No information	4%	18,180
Less than 4,000	9%	40,904
4,001-5,000	17%	77,263
5,001-6,000	26%	118,167
6,001-7,000	15%	68,174
7,001-8,000	14%	63,629
More than 8,001	15%	68,174

Source: Own elaboration based on data from SmartPV project

However, the study was not a representative sample of the residential consumer base in Cyprus, as the study focussed on the benefits of PV and smart meters. Usually, PV users have consumption above the average, and do not include all different situations. Therefore, the distribution presented in Table 6-6 has been used to calculate alternative network tariffs.

Table 6-6 Assumed distribution of consumption by consumption classes

Assumed distribution	kWh imported (average)	Number of homes	Total consumption (kWh)	Notes
21%	1,500	78,088	117,132,000	Includes all second and holiday homes
18%	2,000	67,538	135,075,600	
15%	4,500	56,282	253,266,750	
13%	5,500	48,777	268,275,150	
12%	6,500	46,425	301,764,531	
11%	7,500	41,273	309,548,250	
10%	8,500	37,521	318,928,500	
100%		375,904	1,703,990,781	

[134] https://energy.ec.europa.eu/system/files/2020-07/cyprus_2020_ltrs_en_0.pdf

[135] http://www.smartpvproject.eu/uploads/C2%20SEIS_v.2.pdf

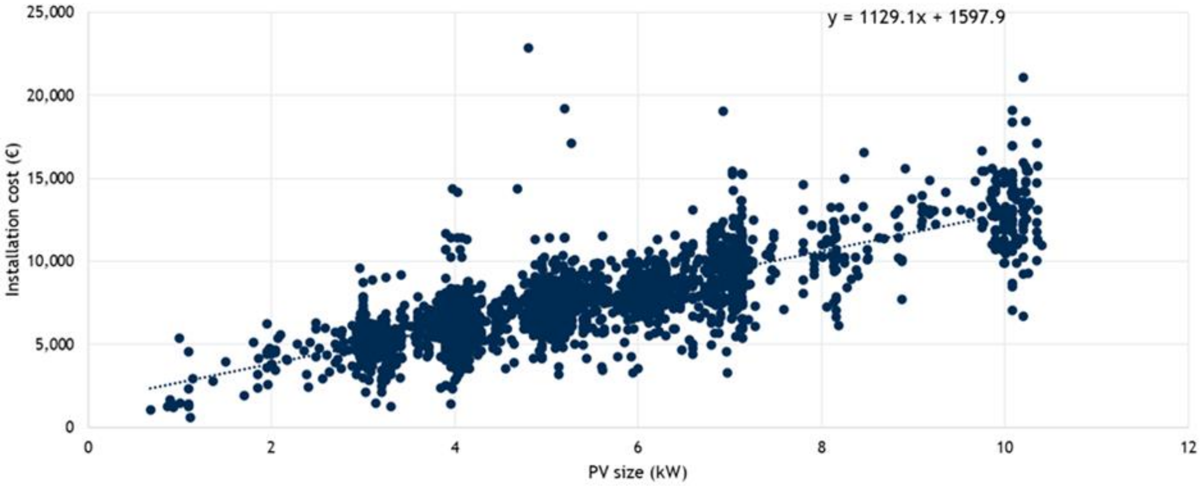
Source: Own elaboration based on data from LTRS

The total (1,700 GWh) is broadly equivalent to total energy sales to domestic consumers reported by the EAC.[136]

6.4.1.2 Costs

The costs of installed PV systems (purchase + installation cost) is calculated based on MECI's data for net metering, in particular using the regression equation presented in Figure 6-4.

Figure 6-4 Distribution of total PV cost



Source: Own elaboration based on data from MECI

[136] https://www.eac.com.cy/EN/EAC/FinancialInformation/Pages/StatisticalFigures.aspx

Figure 6-5 Total cost by PV size

PV capacity (kW)	Total installation cost (€)
2	4,126
2.5	4,691
3	5,255
3.5	5,820
4	6,384
4.2	6,610
4.5	6,949
5	7,513
5.5	8,078
6	8,642
6.5	9,207
7	9,772
7.5	10,336
8	10,901
8.5	11,465
9	12,030
9.5	12,594
10	13,159

Source: Based on data from MECI

A further fee of €270 is applied to each installation. The cost of a behind-the-meter battery is estimated at €1,000 per kWh. The cost of non-residential PV system for self-consumption (up to 375 kW) is estimated as €1,000 per kW.

6.4.1.3 Grants

Figure 6-6 Grants considered

Scheme	Title	Grant	
		Per unit (€/kW)	Maximum (€)
Residential users			
Net metering	Roof thermal insulation in combination with the installation of a PV system with the net metering or virtual net metering method in households	450	1,800
	Installation of Photovoltaic System with the Net Metering method in households	375	1,500
	Installation of Photovoltaic System with the Net Metering method in households of vulnerable consumers	1,000	5,000
Net billing	Saving - Upgrading of Households: PV with net billing	500	5,000
	Saving - Upgrading of Households: PV with net billing-vulnerable consumers	950	9,500
	Saving - Upgrading of Households: Battery with net billing	1,000	4,000
Solar Water Heaters	Installation / Replacement Of Solar Hot Water Production Systems For Residential Use (2022)	450	n/a

Scheme	Title	Grant	
		Per unit (€/kW)	Maximum (€)
	Installation / Replacement Of Solar Hot Water Production Systems For Residential Use (2021)	350	n/a
	Saving-Upgrading Households: Solar water heater	1,200	n/a
EV	Installation PV systems for the charging of electric vehicle	750	1,500
	Purchase and installation of battery	750	2,000
Commercial users			
Net billing	Saving - Upgrading for Enterprises: PV with net billing	40% of the eligible costs	150,000

Source: *RES & EE fund*

6.5 Calculation of a new volumetric + capacity network tariff

In order to estimate the impact on single users of a volumetric + capacity charge, the model allows the user to set the share of revenues to be recovered via capacity-based charges and the share of revenue to be recovered via volumetric-based charges.

To estimate the tariff, it is assumed that the same total amount will be recovered from users from different sectors, which means that the amount currently recovered from domestic consumers must be recovered with the new tariff. Based on current tariffs (0.0282 per kWh), a total of €47 million has to be recovered from residential consumers. From the analysis, it is assumed that vulnerable consumers do not pay network tariffs, and therefore the total energy consumption is reduced by that amount. Also, tariffs for the storage of thermal energy (code 56) are not considered.

Further, given that it is assumed all residential consumers will have a contracted capacity of 9.2 kW, this would effectively be a fixed charge on these user.

Based on these assumptions, the rates are calculated as:

- $Capacity\ rate\ (€/kW) = \frac{total\ revenues\ (€) * share\ to\ be\ recovered\ via\ capacity}{Total\ contracted\ capacity\ (kW)}$
- $Volumetric\ rate\ \ (€/kWh) = \frac{Total\ revenues\ (€) * share\ to\ be\ recovered\ via\ volumetric\ )}{Total\ electricity\ consumption\ (kWh)}$

Based on a 50%-50% split volumetric/capacity, the tariffs set are equivalent to:

- 0.0141056 kWh
- 0.5917573 kW/month

6.6 Methodology to evaluate profitability

Profitability of investing in a PV system or in a battery + PV system is calculated by comparing the annual bill of a user with the installation and a user with an identical consumption profile but no installation. The difference between the two annual bills is considered the notional cash flow of the investment, and the returns, payback period and IRR are calculated on the basis of this cash flow, with the installation costs as the negative flow in year zero. The latter is included as cost of the technology installed (according to size) minus the grant chosen. The model automatically selects grants amount according to the scheme, including maximum grant when size limit is reached.

The discount rate for the investment is set at zero, as there is no agreement in literature to what is an appropriate discount rate for households (on the other hand, for policy making a 3.5% discount rate is traditionally used, while for business decision this depends on the sector and gearing, but is usually set around 7% to 10%). Below we provide a suggestion on how a higher discount rate would affect the results provided in chapter 3.

Table 6-7 How profitability changes with increase in discount rates

User	Scheme	0%	3.5%	8%	12%
2.5 kW 4,500 kWh	PV investment under the net metering scheme without grant	IRR: 9% PBP: 8.1	IRR: 5% PBP: 9.7	IRR: 1% PBP: 13.6	IRR: -- PBP: --
	PV investment under the net metering scheme with grant	IRR: 14% PBP: 6.2	IRR: 10% PBP: 7.2	IRR: 5% PBP: 9	IRR: 1% PBP: 12.2
4.5 kW 8,000 kWh	PV investment under the net metering scheme without grant	IRR: 13% PBP: 6.6	IRR: 9% PBP: 7.6	IRR: 4% PBP: 9.7	IRR: 1% PBP: 13.7
	PV investment under the net metering scheme with grant	IRR: 19% PBP: 4.9	IRR: 15% PBP: 5.5	IRR: 10% PBP: 6.5	IRR: 6% PBP: 7.8
7 kW 12,000 kWh	PV investment under the net metering scheme without grant	IRR: 14% PBP: 6	IRR: 10% PBP: 6.9	IRR: 6% PBP: 8.6	IRR: 2% PBP: 11.4
	PV investment under the net metering scheme with grant	IRR: 19% PBP: 4.9	IRR: 15% PBP: 5.5	IRR: 10% PBP: 6.5	IRR: 6% PBP: 7.9

As a rule of thumb, and within the ranges considered, an increase of 1% in discount rate decreases IRR by 1%, although this goes above 1 when returns are close to zero. The relation with PBP is more complex, as for each 1% increase in discount rate it increases by growing proportions. For example, an investment returning 18.8% at 0% discount rate would return 8% at 10% discount rate (just above 1, on average), while payback period would go from 4.9 years to 7.1 years), varying between 3% and 5% increase per each 1% increase in discount rate.

In the case of Solar Water Heaters, a similar methodology to the one discussed above for solar PV is applied, but restricted to energy use for hot water (rather than the entire energy bill). The analysis aims to assess whether it is convenient to replace an old SWH with a new one, based on the efficiency gains provided in Table 6-8.

Table 6-8 Efficiency improvement of a new SWH module

Thermal yield per collector module (kWh/module)			
	Yield for three collector mean temperatures		
	25 ^{0}C	**50 ^{0}C**	**75 ^{0}C**
New	1,725	1,187	693
Old	1,605	791	229

To estimate the savings, it is assumed that:

- The average household will require two modules
- Energy cost per kWh (including energy, network and other charges) amounts to €0.58 kWh
- Only a share of the total hot water produced will be used. The higher the heating temperature, the lower the share of hot water utilised will be. The following factors have been used:
    - 25 ^{0}C: 95%
    - 50 ^{0}C: 85%
    - 75 ^{0}C: 75%
- The cost of a new SWH system (2 modules) is €1,300

The savings are estimated as the difference in generation between the two system, multiplied by the utilisation factor. The assumption is that the systems are correctly sized, which implies that an old system will need to be supported more extensively with an electric heater, costing more in electricity bill.

7 Annex II: Description of the support schemes

Net metering

Net metering is a compensation mechanism applied in Cyprus that allows the consumers to use the electricity generated by their own installed PV system (up to 10.4 kW[137]) on site, and pay only for the net electricity that they import and use from the grid. Any surplus of energy that is not used immediately in the premise is exported to the grid and it can then be reimported and used at a later stage. The scheme concerns both residential (category A1) and non-residential consumers (category A2), with the main difference being the length of the contract with the electricity supplier, i.e., 15 years and 10 years respectively, with a possibility of extension according to the respective legal framework.

The offset of imported and exported electricity is conducted either monthly or bi-monthly. In case the consumed electricity is lower than the produced, the surplus energy is transferred to the next billing period, while in case the consumed electricity is higher than the produced, the prosumer is charged only for the net electricity (imported-exported electricity) within the relevant billing period. Any surplus energy at the end of each year is transferred to the next billing period. After the end of the contract, the consumer may continue to operate the PV system according to the ongoing legal framework of the specific period (i.e., by self-consuming and selling the excess of electricity individually according to the respective provisions).

The net metering scheme is limited to an aggregate installed capacity of 30 MW, per year of which 20 MW concerns residential consumers and 10 MW non-residential consumers. The maximum PV electricity production cannot exceed the yearly electricity consumption of the premise that is used for (the former 90% restriction has been removed), while the maximum installed capacity of the PV system to be installed is calculated using the formula:

$$Maximum\ installed\ capacity\ of\ PV\ (kWp) = \frac{Total\ yearly\ electriciy\ consumption\ of\ the\ premise\ (kWh)}{1600\ \left(\frac{kWh}{kWp}\right)}$$

The updated scheme provides also the option to install a storage unit that can improve the self-consumption share. The capacity of the storage system cannot exceed the capacity of the PV system, while there is no subsidy provided for the installation of such system under this scheme.

In addition, the consumers have the option to offset the total electricity consumption and the PV production of the residence with the electricity consumption of the storage heaters, if applicable, provided that they are connected to separate meters. The surplus of electricity that results from the final offsetting in the bills of February/March from the net metering (according to the process described above) can be further offset retrospectively with the electricity consumption of the previous year of the storage heaters.

A. Net billing

Net billing is a form compensation mechanism that aims to incentivize generation and self-consumption of electricity for big prosumers. It applies to PV systems as well as to biomass/biogas systems up to 1 MW (previously 8 MW) in residential and industrial units (e.g., public buildings, schools), for an aggregate installed

[137] PV systems above 10.4 kW can be included under the net billing scheme

capacity of 20 MW per year. The capacities of the systems eligible under net billing might be re-evaluated in the next iteration of the scheme.

A smart meter records the PV production of the imported and exported electricity to the grid every 30 minutes and any excess electricity is exported to the grid and credited to the prosumer at a price determined by CERA (according to the avoidance cost methodology, see section 3) which is updated every month according to international fossil fuel prices. Every one or two months the offsetting of the import and export electricity is conducted, where any excess credit[138] is transferred to the next billing period and any deficits are being paid by the prosumer at retail electricity price. Prosumers are also charged with the cost of using the electricity network (network and ancillary charges) and they are taxed on the consumed electricity (VAT, RES levy)[139] . The final settlement of the year occurs in the month of October or November and the amount that corresponds to the accumulated excess of energy is being transferred to the next billing period. Under this scheme, it is also possible to install a storage system as well as to include two different RES technologies (e.g., PV and biomass system).

A basic requirement[140] for this scheme is that the maximum electricity produced by the PV is capped to 120% of the yearly electricity consumption of the premise (the excess electricity is not reimbursed). Moreover, the maximum installed capacity of the PV system cannot exceed 80% of the load entitlement of the premise that is used for, unless there is a storage system installed and/or a checking system of exporting electricity to the grid (Export Limitation Scheme), and it is calculated from the formula:

$$Maximum\ installed\ capacity\ of\ PV\ (kWp) = \frac{1.2\ \times (Total\ yearly\ electriciy\ consumption\ of\ the\ premise\ (kWh))}{1600\ \left(\frac{kWh}{kWp}\right)}$$

Furthermore, for systems larger than 7.14 kW, it is obligatory to install a remote control system ("Ripple Control"), while for systems larger than 20 kW the installation of a system for remote metering and data recording is obligatory.

The contract between the prosumers and the supplier is valid for 10 years with the possibility of extension according to the respective supporting scheme that will be in action at the time. If at the end of the 10-year contract there are any surpluses, the prosumer will be compensated by the supplier. As in the case of net metering, after the end of the contract, the prosumer can either sell the excess electricity individually or apply for a new self-consumption scheme according to the occurring framework of the given period.

It is allowed to the prosumers under the provision of the current scheme to move from net metering to net billing scheme, provided that they fulfill the respective criteria, yet with no possibility to return back to the net metering scheme. Moreover, the prosumers that were registered under the Feed in Tariff (FiT) scheme, can only be included in the net billing scheme.

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[138] The credit of the produced electricity is calculated based on a variable tariff, i.e., the avoidance cost (Source: Cyprus' NECP)

[139] https://energy.ec.europa.eu/system/files/2020-01/cy_final_necp_main_en_0.pdf

[140] Even though it is subject to be changed in the future

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