# StoRES

## Promotion of higher penetration of Distributed PV through storage for all

Priority Axis 2: Fostering low-carbon strategies and energy efficiency in specific MED territories: cities, islands and remote areas

2.2: To increase the share of renewable local energy sources in energy mix strategies and plans in specific MED territories

Deliverable n°: **3.7.3**

Deliverable Name: **Tariff, policy and market rules recommendation**

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## 3. Contents

# 4. List of Tables

# 5. Project Summary

The project addresses the development of an optimal policy for the effective integration of Renewable Energy Sources (RES) and Energy Storage Systems (ESS). The primary challenge is to achieve increased penetration of RES and predominantly Photovoltaics (PV), in the energy mix of islands and rural areas in the Mediterranean (MED) region without compromising grid stability. The main objective of StoRES is to boost self-consumption in the MED region with the integration of optimal storage solutions. Testing coupled PV-ESS solutions in different pilot sites and taking into account local particularities for optimization, current barriers concerning grid reliability with higher RES deployment will be eliminated. In addition to this, the development and integration of the proposed solution at both residential and community levels and the application of different policy scenarios will lift the barriers related to the grid integration of ESS and will extend the practical knowledge about this technology. It is expected that all the shortcomings regarding the intermittent nature of PV energy for increased penetration into the energy mix will be addressed whilst maintaining smooth operation of the grid.

The project started on the 1st of November 2016 and is expected to be completed within 36 months.

# 6. Introduction to Deliverable 3.7.3

In this report, a summary of the tariff, policy and market rules recommendations for the regions involved in the project regarding Energy Storage exploitation is provided. This work is based on the analysis results occurred from the use of the developed StoRES Online PV and Storage Optimisation Tool in the context of the viability assessment of coupled PV-ESS installations and by taking into consideration the barriers encountered, the lessons learnt and the Cost-Benefit Analysis (CBA) conducted during the implementation of the project.

A policy recommendation is a written policy advice prepared for specific groups having the authority to take decisions, such as policymakers, committees, councils and other similar bodies and it mainly serves to inform senior decision-makers about a policy issue. In this report, the identification of the responsible authorities with regards to policy design and implementation in the participating project counties is also performed.

Finally, a summary of promoting proposals for the Energy Storage exploitation in these countries based on the project's outcomes is provided, aiming to assist decision-makers in recognising the important issues that will influence future policy decisions.

# 7. Identification of responsible authorities

In Deliverable 3.5.1 (Preparation of training), the objective of identifying the stakeholders during the StoRES project was to reach the relevant stakeholders (at least 20 per country) belonging to different areas from each region and engage them in the project's activities. In the context of Deliverable 3.7.3 (Tariff, policy and market rules recommendation) though, the stakeholders are considered the responsible authorities who are directly involved in designing and implementing policies, such as policymakers/decision-makers (both at local and national level), Distribution/Transmission System Operators (DSOs/TSOs) and Regulatory Authorities.

Table 1 illustrates each responsible authority group and the reason of involvement in the context of the StoRES project, especially with regards to developing improved policies for Energy Storage exploitation based on the project's outcomes.

*Table 1: Responsible authority group and reason of involvement.*

| Responsible authority group | Reason to involve | Interest/Benefit |
|---|---|---|
| **Policymakers (local authorities)** | • Implementation and replication of project outputs<br>• Promote wider adoption and replication of the project outcomes<br>• Foster dissemination results<br>• Liaison with other entities<br>• Involvement of citizens | • Increasing awareness<br>• Enhancing sustainability<br>• Funding opportunities<br>• Minimise financial risk of non-accounted factors |
| **Policymakers (national authorities)** | • Implementation and replication of project outputs<br>• Foster dissemination results<br>• Involvement of citizens | • Opportunity to develop better policies based upon the project's outcomes<br>• Minimise financial risk of non-accounted factors<br>• Funding opportunities<br>• Protection from environmental degradation |
| **DSOs/TSOs** | • Implementation and replication of project outputs<br>• Foster research<br>• Networking<br>• Sharing expertise<br>• Interest on results | • Opportunity to develop better policies based upon the project's outcomes<br>• Minimise financial risk of non-accounted factors<br>• Funding opportunities |
| **Regulatory Authorities** | • Implementation and replication of project outputs<br>• Foster dissemination results<br>• Involvement of citizens | • Opportunity to develop better policies based upon the project's outcomes<br>• Minimise financial risk of non-accounted factors |

In the following section, the stakeholders identified considered as responsible authorities in each country are summarised. Each stakeholder is identified as:

- **DSO** if the stakeholder is a Distribution System Operator;
- **GOV** if the stakeholder is a governmental body (e.g. province, authority);
- **REG** if the stakeholder is a Regulator;
- **TSO** if the stakeholder is a Transmission System Operator.

## 7.1 Responsible authorities in Cyprus

Table 2 summarises the responsible authorities identified in Cyprus at national and local level.

*Table 2: Responsible authorities in Cyprus.*

| Responsible authority | Details | Category |
|---|---|---|
| **Cyprus Energy Regulatory Authority (CERA)** | Regulatory authority of energy in Cyprus | REG |
| **Ministry of Energy, Commerce and Industry (MECI) – Energy Service** | Ministry of energy in Cyprus | GOV |
| **Ministry of Agriculture, Rural Development and Environment (MARDE)** | Ministry of environment in Cyprus | GOV |
| **TSO - Cyprus** | TSO in Cyprus | TSO |
| **DSO - Cyprus** | DSO in Cyprus | DSO |
| **Electricity Authority of Cyprus (EAC)** | Market operator | GOV |
| **House of Representatives – Energy Committee** | Parliament committee for energy | GOV |

## 7.2 Responsible authorities in France

Table 3 summarises the responsible authorities identified in France at national and local level.

*Table 3: Responsible authorities in France.*

| Responsible authority | Details | Category |
|---|---|---|
| **CRE** | National regulator on energy | REG |
| **Enedis** | National distribution service operator | DSO |
| **Territoire Energie Drome** | Local DSO in Drome district | DSO |
| **Regional council** | Energy department of the regional council | GOV |

## 7.3 Responsible authorities in Greece

Table 4 summarises the responsible authorities identified in Greece at national and local level.

*Table 4: Responsible authorities in Greece.*

| Responsible authority | Details | Category |
|---|---|---|
| **Regulatory Authority for Energy (RAE)** | Regulatory authority for energy | REG |
| **Hellenic Electricity Distribution Network Operator S.A. (HEDNO)** | DSO in Greece | DSO |
| **Independent Power Transmission Operator (IPTO or ADMIE) S.A.** | Independent Power Transmission Operator | ADM |
| **Hellenic Energy Exchange S.A.** | Operator of Electricity Market | OPR |
| **Ministry of Environment and Energy** | Ministry in Greece | GOV |

## 7.4 Responsible authorities in Italy

Table 5 summarises the responsible authorities identified in Italy at national and local level.

*Table 5: Responsible authorities in Italy.*

| Responsible authority | Details | Category |
|---|---|---|
| **ARERA (Autorità di regolazione per energia reti e ambiente)** | Italian Regulatory Authority for Energy, Networks and Environment | REG |
| **E-Distribuzione** | DSO in Italy | DSO |
| **GSE (Gestore Servizi Energetici)** | Energy Services Operator | GOV |
| **Ministry for Economic Development (Ministero dello Sviluppo Economico, MISE)** | Ministry in Italy | GOV |
| **Ministry of the Environment** | Ministry in Italy | GOV |
| **Departement of Energy and Green Economy** | Autonomous Region of Sardinia | GOV |
| **INFEAS System (Information Education for Sustainability)** | Autonomous Region of Sardinia | GOV |
| **LAORE (Department for the multifunctionality of agricultural enterprises, rural development & agrifood chain)** | Autonomous Region of Sardinia | GOV |

## 7.5 Responsible authorities in Portugal

Table 6 summarises the responsible authorities identified in Portugal at national and local level.

*Table 6: Responsible authorities in Portugal.*

| Responsible authority | Details | Category |
|---|---|---|
| **ERSE - Regulatory Entity for Energy Services** | Regulatory Entity for Energy | REG |
| **General Direction of Energy and Geology (DGEG)** | Body of the Portuguese Public Administration whose mission is to contribute to the design, promotion and evaluation of policies on energy and geological resources. | GOV |
| **Ministry of the Environment and Energy Transition** | Formulate, conduct, execute and evaluate policies on the environment, urban planning, cities, transport, climate, nature conservation and energy with a view to sustainable development and social and territorial cohesion. | GOV |
| **REN - National Energy Networks** | TSO in Portugal | TSO |
| **EDP Distribution** | DSO in Portugal | DSO |
| **CCDR Algarve** | Algarve Regional Coordination and Development Commission | GOV |

## 7.6 Responsible authorities in Slovenia

Table 7 summarises the responsible authorities identified in Slovenia at national and local level.

*Table 7: Responsible authorities in Slovenia.*

| Responsible authority | Details | Category |
|---|---|---|
| **SODO** | Slovenian System Operator | REG/DSO |
| **Ministry of Infrastructure** | Ministry in Slovenia | GOV |
| **Elektro Maribor d.d.** | DSO in Slovenia | DSO |
| **Eko sklad j.s.** | Slovenian Environmental Public Fund | GOV |
| **ENERGAP** | Body in Slovenia | GOV |
| **MRA - Maribor Development Agency** | Body in Slovenia | GOV |
| **Development Information Centre Slovenska Bistrica** | Body in Slovenia | GOV |

## 7.7 Responsible authorities in Spain

Table 8 summarises the responsible authorities identified in Spain at national and local level.

*Table 8: Responsible authorities in Spain.*

| Responsible authority | Details | Category |
|---|---|---|
| **Ministry of Energy Transition** | Ministry in Spain | GOV |
| **Ministry of Agriculture, Food and Environment** | Ministry in Spain | GOV |
| **Institute for the Diversification and Saving of Energy (IDAE)** | Government of Spain | GOV |
| **Regional Ministry of Economy Employment and Industry** | Ministry in Spain | GOV |
| **Regional Ministry of Rural Development and Sustainability** | Ministry in Spain | GOV |
| **Provincial Council of Zaragoza** | Province of Zaragoza | GOV |
| **Provincial Council of Huesca** | Province of Huesca | GOV |
| **Provincial Council of Teruel** | Province of Teruel | GOV |

# 8. Barriers related to Energy Storage exploitation

This subsection provides a general description of barriers impeding Energy Storage exploitation in the participating countries from the regulatory, market and technical point of view. Given the distinct characteristics of the regions involved (islands and rural areas) and their present market status, Energy Storage is currently facing restrictions for its exploitation to the power networks of the countries under study.

It is evident that new policies should take into consideration the issues stated as a brief summary below, so as to alleviate the barriers for further PV deployment through Energy Storage.

## 8.1 Regulatory barriers

The absence of Energy Storage in the regulations, especially concerning the consumption side and more specifically the residential building sector, is evidently the most significant barrier that the participating countries are currently encountering. In anyway, the introduction of new regulations is considered as a prerequisite for the further integration of PV to the existing power system.

Regarding the current status of the participating countries, most of the owners of residential PV systems are under the widely exploited Net-Metering scheme, such as in Cyprus for example with more than 16,000 installed systems by 2018. As a result, these end-users are allowed to use the power network as a virtual and unlimited storage asset, as no losses are counted in the netting of energy injection/absorption. Net-Metering is regarded as the most favourable compensation mechanism for PV system owners and the introduction of new policies/schemes will most probably be less appealing to them.

Furthermore, the restriction of Net-Billing to residential end-users (like in the case of Cyprus, where it is only applicable for industrial and commercial consumers) or the complete absence of the scheme (such as in other countries), as well as the absence of Time-of-Use (ToU) Tariffs and other time-varying pricing schemes, creates the need for policy modifications. The adoption of the above scheme can be a policy improvement towards the further exploitation of PV, acting also as a significant incentive for promoting ESS, coupled with on-site PV generation. This is further enhanced by the anticipated abolition of Net-Metering schemes by 2023 (European Commission, 2019), which is further explained in the following sections.

Moreover, electricity tariffs should reflect to a cost that can motivate end-users to actively participate in the energy transition by possessing ESS coupled with PV systems. Tariff differential during peak and off-peak periods is a mechanism that is usually exploited to incentivise end-users to adapt their load profile and achieve the reduction of electricity bills by operating

ESS. The current flat pricing status in most countries prevents investing in residential ESS.

A clear definition of self-consumption and ESS ownership is also required. The conditions and limitations under which consumers are allowed to own and operate an ESS, especially in an open energy market, have to be clearly defined. Network Operators (NOs) cannot own, develop, operate or manage ESS unless specific derogation is taken, according to Article 36 of the Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast) (European Commission, 2019). Yet, the case of the abovementioned residential end-users is considered as straightforward, as the pre-mentioned restrictions faced by the NOs are not applicable. The existence of an open energy market and specifically a local flexibility market where ESS owners can participate is also a potential policy improvement.

Finally, the absence of an Energy Community definition in the regulations of most of the countries involved restricts the formation of synergies investing in such micro-grids. Policymakers must set proper rules with regards to Energy Communities, as well as define the conditions and standards on how energy is generated and traded within the Community's boundary, ensuring efficient network operation.

## 8.2 Market barriers

In general, the absence of an open energy market poses significant restrictions to the further exploitation of Energy Storage, as the benefits due to the distinct features of ESS cannot be fully capitalised.

The successive support for increased RES generation, mostly as an effort to meet the national RES targets in each country, the regulated prices and any additional taxes/fees applied, is currently impacting significantly the deployment of ESS in the participating countries. There is no clear definition on how Energy Storage can be operated in the power system, amongst most European Union (EU) Member States. As an example, in some countries, owners of ESS are subject to grid fees both as consumers and producers of energy, while in other countries are considered only as producers. In general, reducing the administrative fees and enabling non-discriminatory grid access for ESS, can decrease the payback period of the investment. Furthermore, existing grid consumption tariffs and any unnecessary contributions create additional costs conducing to prolonged payback periods.

Entities such as municipalities, cooperatives, neighbourhood synergies and aggregators are currently restricted from the opportunity to actively participate in RES generation and energy service provision due to the non-existence of an open energy market. Especially for the case of energy service provision, a clear and transparent legislative framework definition for the formation of local flexibility markets is currently non-applicable.

It has to be noted that, generally, due to the lack of a clear policy on the ancillary services that can be provided by ESS in the regions involved, the local DSOs/TSOs are not incentivised to take appropriate investment decisions in support of the system. In general, as there is no clear policy about the investment, there is no motive for the end-users to invest in Energy Storage.

Moreover, until now, the balancing responsibility for imbalances caused in the system by generating assets (mostly RES) was covered by the market's dominant supplier. New suppliers should undertake this responsibility, as stated in Article 15 of the Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast), which proposes clearly that all market participants shall be responsible for any imbalances created by their activities on the power network (European Commission, 2019). Enabling the coupling of ESS with PV at the residential building sector alleviates this barrier, as permitting the ownership of ESS to the end-users rather than the DSOs/TSOs, will assist to the limitation of the issues residential PV installations create to the power system. Nevertheless, investing in ESS coupled with PV at the residential level is competitive only if current Net-Metering schemes are no longer active, as the exploitation of ESS is restrained by the use of the grid as a virtual and unlimited storage asset.

## 8.3 Technical barriers

The further exploitation of RES in isolated power networks, such as the case of Cyprus, or rural regions, faces significant restrictions, mostly occurring by their unpredictable and variable nature, which creates numerous technical barriers regarding their effective integration to the power system. Despite the positive effects ESS can have on the elimination of grid stability issues from the increasing PV penetration, technological and safety issues arise with the integration of ESS to the power network. The above, as well as the absence of financial compensation mechanisms in conjunction with high investment costs are considered the main obstacles for ESS deployment (Border, 2015).

In addition, the communication of different components is required for the formation of Energy Communities. The upgrade of the existing power system infrastructure and specifically, of the monitoring and power converting equipment to be compatible with the appropriate communication standards is necessary. Replacing the traditional metering equipment in residences with Smart Meters will assist to the administration of new policies incentivising ESS coupled with PV. As a result, the necessary information will be provided to the end-users to optimally operate their ESS under new policies and schemes. Yet, proper communication protocols and modern data acquisition capabilities should be supported. Taking the case of Cyprus as an example, the long anticipated Smart Metering rollout is expected to have a potential for time-varying pricing on the 80% of the end-users by 2027. In general, further RES deployment can be driven from the upgrade of the Distribution/Transmission networks.

## 9. Cost-Benefit Analysis and viability assessment of PV-ESS

In the context of the project's Deliverable 3.7.1 (Cost & Benefit Analysis), a CBA suitable for analysing ESS coupled with PV at the residential level was performed, using the implemented residential PV-ESS pilots in Cyprus, Greece and Italy as case studies. Overall, it was depicted that the current active policies and market conditions in the regions involved restrict any financial benefits for the end-users and hence, a residential PV-ESS installation is not a profitable investment under the existing conditions.

The main conclusions and remarks of the CBA recommended that generally, for the schemes considered (various types of Net-Metering, Net-Billing and Self-Consumption), the installation of an ESS coupled with PV does not provide any financial benefits to the end-users or provides only very limited benefits to them. However, when comparing the Self-Consumption scheme scenario to the other cases, it was revealed that the investment in a PV-ESS has the highest Net Present Value (NPV), mainly because PV generation export is not financially rewarded and energy self-consumption is not charged. Furthermore, the provision of various services to the power network was also assessed, resulting to the identification of additional benefits for the system owner, thus reducing the payback period of the investment.

Considering the generally low viability of residential PV-ESS for all participating countries, as depicted from the viability assessment performed which is explicitly described in the project's Deliverable 4.4.1 (Design and circulation of a PV+Storage Monitor), it is evident that further actions are needed for the promotion of ESS at the residential building sector. These actions are presented in the form of recommendations in the following sections.

# 10. Policy and tariff recommendations

This subsection provides a general description of policy and tariff recommendations for the exploitation of Energy Storage in the regions involved, through the practises and mechanisms described below.

## 10.1 Transition to more cost-oriented approaches

### 10.1.1 Abolition of Net-Metering and other similar schemes

The support of governments in PV deployment in recent years in the form of incentives and various supporting schemes (i.e. Net-Metering) resulted in the increase of PV installations, especially at the residential building sector. Specifically, the Net-Metering scheme (in all its different types, such as full, partial, etc.) is considered as the most suitable practise for PV deployment, as the PV system owner (i.e. the prosumer) benefits by injecting any excess PV generation (the energy that cannot be directly consumed by the household's load) to the power network. The injected PV energy is credited to the prosumer for later use. In this way, the power network is used as a virtual and unlimited energy storage asset. Mostly, due to the above characteristics, the Net-Metering policy does not favour the increase of the end-user's self-consumption, as it is more profitable to inject the surplus PV generation rather than invest in an ESS, bearing the investment costs and also being subject to the system's losses.

However, as clearly stated in Article 15 of the Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast), Net-Metering schemes are to be abolished by 2023 within the EU (European Commission, 2019), driven by the idea that a more cost-oriented approach should be encouraged. This implies establishing other schemes, such as Net-Billing or even adopting time-varying pricing, rather than flat pricing as generally applicable until now. More information is provided in subsections 10.2 and 10.3, respectively.

## 10.2 Schemes suitable for Energy Storage exploitation at the consumption-side

This subsection introduces schemes and practises exploited worldwide that are considered suitable for the promotion of Energy Storage, especially at the consumption-side and specifically, at the residential building sector.

### 10.2.1 Net-Billing

The Net-Billing is a compensation mechanism of PV generation over consumption during a specific timeframe, similarly to Net-Metering. Specifically, the retail electricity purchase of a consumer can be offset under net billing. Despite being very similar to the Net-Metering policy as abovementioned, there is a significant difference between the two mechanisms, which distinguishes their suitability for ESS and PV systems respectively. This is the use of differing rates to value the excess PV generation injected to the power network and the energy purchased from it for households under Net-Billing. Notably, the end-user purchases electricity at retail cost and provides any excess PV generation at an agreed price, usually less than the retail. Both schemes (Net-Billing and Net-Metering) are considered favourable for the exploitation of residential PV generation. Yet, the Net-Billing scheme is also considered as favourable for Energy Storage exploitation due to the differing rates of electricity consumption.

Specifically, the installation of an ESS (coupled with PV) under Net-Billing can create value for the end-user, which is achieved by utilising the price differential between the retail price (which includes the network and all other regulated charges) and the injection price. Furthermore, storing energy during times of low electricity prices or surplus PV generation and using it during periods of high electricity prices creates additional value to the end-user. Yet, this is applicable in case of a dynamic contract, as in case of a flat-rate contract the injection of power to the grid during times of high injection price is considered as a more sensible option for the end-user. This is also similar to the case of Net-Metering, where the purchased and exported kWh is valued the same. As a result, it is more beneficial for the end-user to export any surplus generation, rather than invest in an ESS under Net-Metering.

Depending on the regulatory framework, the main advantage for the end-user can be generally considered the avoidance of tariffs. Due to the price differential, the Net-Billing scheme is considered suitable for the maximisation of energy self-consumption, as it does not favour the energy trading with the power network, like the case of Net-Metering.

Net-Billing schemes are currently active in numerous countries worldwide, including countries, which aim to raise their current low share of PV, such as Peru, Chile and Mexico (Bellini, 2018a; Zinaman et al., 2018). For the case of Peru this is applicable for systems up to 200 kWp, while for the case of Chile this is limited for systems between 200 kWp and 10 MWp, similarly to the case of Cyprus (10 kWp to 10 MWp), restricting the participation for residential installations.

Best practises regarding the Net-Billing policy found in the literature (Barnes et al. 2010; Barnes et al., 2013; Varnado and Michael, 2009) include:

- Ensuring inclusive eligibility:
  Consider a broader range of technologies, especially battery storage, etc., as eligible for participation along with PV systems.
- Avoiding discriminatory charges:
  For example, the controversial “Sun Tax” in Spain (which was recently abolished) or double taxation.
- Setting appropriate capacity limits:

Capacity limits should be clearly defined, especially if the approach is targeted on the exploitation of small-scale residential PV systems. Notably, large-sized (grid-scale) systems could lead to meeting the targeted capacity cap without reaching the goal of small-scale system deployment.

### 10.2.2 Self-Consumption

The promotion of self-consumption is gaining increasing interest in recent years. Germany has introduced such a policy since 2009 (Braun et al., 2009). Moreover, governmental subsidies have been provided for small-scale ESS coupled with PV systems (<30 kWp) since 2013. In combination with the falling Feed-in Tariffs (FiTs), this assisted to a switch to residential PV self-consumption. Among others, the scheme increases the awareness on increasing electricity prices and sets regulatory measures such as the limitation of grid injection to 70% (Willis, 2013). It has to be noted that in 2016, funding was provided for 6,468 storage systems (5,668 for newly installed and 800 for existing PV systems respectively) (IEA, 2016).

It is evident that the viability of the Self-Consumption policy and mostly the profitability of the end-users' participation, depends on the retail tariff structure taking into consideration the high capital costs of ESS. Taxes, levies and surcharges are also keys for the successful deployment of the scheme.

Regarding the abovementioned "Sun Tax" in Spain, it was considered as a "grid backup toll" and was active since 2015. A tax on the installation of self-consumption systems was applied, as well as a levy on the power generation, in addition to the existing taxes already applied (PV Magazine, 2015; Bellini, 2018b). A new decree was announced in October 2018 and it introduced a package of urgent measures to enhance the country's energy transition. The elimination of this controversial tax was also included, among others. The support of Self-Consumption is seen by the introduction of regulations, which regarded simplified procedures for registering new systems (<100 kWp) under Self-Consumption, the removal of all charges for self-consumed energy and the right for energy self-consumption from RES at the community scale (Molina, 2018), as a clear step towards the formation of Energy Communities.

Best practises regarding the Self-Consumption policy found in the literature (IEA, 2013; European Commission, 2015) include:

- Lifting all regulatory barriers to Self-Consumption:
  There is no right to self-consumption yet or taxes and levies are applied to self-consumed energy, in most EU Member-States.
- Simplifying authorisation procedures:
  Establishment of simplified procedures, especially for small-scale systems at the residential level.
- Supporting enablers:

Such as Smart Meters, along with incentivising residential ESS. The storage incentive (subsidy) in Germany is consider as a successful first step towards battery storage exploitation, given also the high (but falling) investment costs of ESS.

## 10.3 Abolition of flat pricing, promotion of tariff incentives and monetary penalties

As abovementioned, Article 15 of the Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast) states that more cost-oriented approaches should be encouraged by the EU Member States (European Commission, 2019). This implies establishing other pricing policies than flat pricing (as generally applicable until now), provided as tariff incentives and penalties.

Tariff incentives such as Dynamic (determined in real-time based on actual system conditions, i.e. Real-time Pricing) and Static (determined in advance, i.e. ToU Tariffs) pricing models (IRENA, 2019) are considered the main alternatives to network charges which are suitable for directing the demand from periods of peak load to off-peak, thus achieving Demand Response (DR). In addition, peak load and investments in grid infrastructure are reduced. Price signals which generally reflect the system's conditions are sent to customers by the applied tariffs (IRENA, 2019). Given the characteristics of Energy Storage, these techniques are directly associated with the operation of ESS. Furthermore, monetary penalties are also considered, however they are not directly associated with Energy Storage.

### 10.3.1 Time-of-Use Tariffs

ToU Tariffs is a tariff structure usually applied for consumption over a period of time where the electricity price for each period is predetermined and constant. Different types of tariffs are exploited to encourage end-users to reduce their electricity consumption during peak periods or shift it to off-peak. ToU Tariffs are designed to reflect the utility cost structure, where rates are higher during peak periods and lower during off-peak (Gellings, 1985).

Such tariffs based on peak load pricing have been introduced in recent years and resulted to be amongst the most efficient DR techniques, beneficial for both the end-users and the power network.

### 10.3.2 Critical Peak Pricing

Critical Peak Pricing (CPP) is a dynamic time tariff, capable to be used in combination with ToU Tariffs. Periods of peak electricity demand, which can possibly cause grid congestion, are handled by relatively high electricity prices used in CPP (Gellings, 1985). CPP could be implemented on short notice but should only be used during the occurrence of crucial periods, limited to a relatively small number of hours yearly, e.g. 100 hours per year.

#### 10.3.3 Real-time Pricing

Real-time Pricing (RtP) technique is a dynamic pricing model intended to reflect the real electricity time spot price. It usually varies over a short period, e.g. per hour increments (Gellings, 1985). Yet, defining Real-time Pricing is more difficult to be achieved rather than Static pricing models, as the continuous exchange of information among the involved parties is required (IRENA, 2019).

### 10.4 Energy Communities

A framework regarding Energy Communities, also recently referred to as Citizens Energy Communities (European Commission, 2019) and their right to engage in local power generation, distribution, aggregation and energy storage, among others, was established in 2016 by the EU. Specifically, any group of citizens, public authorities, organisations and other parties can be involved in the formation of an Energy Community and participate directly in the energy market by investing in, producing, selling and distributing energy generated from RES (Interreg Europe, 2018). Energy Communities are expected to be granted access to all organised markets (either directly or through aggregation in a non-discriminatory manner) and the right to establish and manage community networks (European Commission, 2019). As a result, the involvement of a large number of people and parties, who otherwise would have been restricted to participate in the energy transition, can be enabled. The primary purpose of an Energy Communities is to provide environmental, economic or social community benefits to its members or the local areas where it is operated.

An example of a significant progress in the generation and sharing of energy within the neighbourhood level is observed in the Netherlands, as developed micro-grids in neighbourhoods connect households for energy sharing through a local power network. These communities are decentralised and operated by local synergies. They can generate and distribute energy from RES within the community boundary, through the combination of several compatible technologies, including rooftop PV, electric vehicles (EVs), heat pumps and of course, ESS (World Economic Forum, 2018; de Graad and Garcia, 2018).

# 11. Market recommendations

This subsection provides a general description of market recommendations for the exploitation of Energy Storage in the regions involved, through the points described below.

## 11.1 Balancing Market

According to the Commission Regulation (EU) 2017/2195 of 23rd November 2017 establishing a guideline on electricity balancing, Article 2(2), the Balancing Market is the entirety of institutional, commercial and operational arrangements that establish market-based management of the function of electricity balancing in accordance with the EU Network Codes.

Within the Balancing Market, the role of DSOs/TSOs is to ensure that, considering the other markets' results, demand and supply remain balanced by operating the system close to real-time (ENTSO-E, 2018). Specifically, DSOs/TSOs settle any deviations remaining after the closure of intraday markets and after the determination of the final schedules, through a final platform, i.e. the balancing market.

The Balancing Market legal framework focuses primarily on (Emissions-EUETS, 2019):

- Balance responsibility and the role of Balance Responsible Parties.
- Balancing service provision.
- Imbalance settlement.

Specifically, the balancing mechanism is implemented through two distinct balancing markets.

- Balancing capacity market:
  Power generators or consumption-side participants submit bids/offers to deliver balancing service in real-time.
- Balancing energy market:
  TSOs activate contracts in the balancing capacity market, which offer the least cost (by specifying the price for the increase/decrease or withdrawal of electricity injection or withdrawal), given the required technical characteristics.

It can be seen that the Balancing capacity market, regards directly the participation of end-users to the provision of services within the Balancing Market.

## 11.2 Service provision through open market access

New policies should set the provisions and regulations for open market access regarding end-user participation through aggregation for the provision of services to the power network. Allowing end-users to participate in an open energy market as service providers has received significant interest in recent years.

This can accelerate investments in Energy Storage, as participants can utilise ESS for the provision of ancillary services, i.e. frequency control, etc., through aggregation, thus reimbursed financially for services provided to the power network and fully capitalize the benefits the operation of an ESS can offer. As a result, ESS can become more interesting from the investment point of view to end-users.

Despite that currently, balancing actions are mostly covered by regulators, it is expected that in the near future this would be the work of suppliers and/or aggregators, as it is clearly stated in the Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast) (European Commission, 2019). This is also fully complied with the rationale that the operation of the energy market should mostly be market-driven and not regulatory-driven.

According to Article 6 of the Regulation (EU) 2019/943 of the European Parliament and of the Council of the 5$^{th}$ June 2019 on the internal market for electricity (recast), the Balancing Market shall be organised to (among others):

- "Ensure effective non-discrimination between market participants taking account of the different technical needs of the electricity system and the different technical capabilities of generation sources, Energy Storage and DR".
- "Ensure that services are defined in a transparent and technologically neutral manner and are procured in a transparent, market-based manner".
- "Ensure non-discriminatory access to all market participants, individually or through aggregation, including for electricity generated from variable RES, DR and Energy Storage".

However, residential Energy Storage through aggregation is not directly examined in this project. Yet, this report recognises the need for an energy market reform and the introduction of Aggregators in the countries involved. This will result to enabling a notable number of individual end-users, otherwise restricted to participate in the energy market, in the power network by possessing ESS at the residential level.

# 12. Promotion proposals

This subsection provides a summary of promoting proposals for the exploitation of Energy Storage, through the practises described below.

## 12.1 Promoting Battery Storage solutions

To enhance the further integration of PV in the power network, especially in countries with favourable environmental conditions like in the MED region, the future power network should utilise sources of flexibility, especially battery storage solutions at the residential building sector.

The power network is supported by coupling ESS with residential PV systems, which enables the end-users to utilize further their PV generation by minimizing the mismatch between PV generation and household demand and thus reducing uncontrollable injection to the grid. In general, the coupling of ESS with PV offers the capability of energy shifting and maximisation of PV self-consumption.

### 12.1.1 Best practices to promote Battery Storage deployment

Enabling end-users to purchase and operate ESS in their premises (including lifting any regulatory barriers and simplifying the registration procedures), as well as providing subsidies in an attempt to confront the high investment costs (like the case of Germany as abovementioned) are the main steps for the promotion of battery storage solutions at the residential building sector. Furthermore, this also includes the removal of all charges for self-consumed energy and the avoidance of double taxation/levies etc., among others.

Another example is the case of Australia and the support it provides to battery storage through incentive programs available by various state and territory governments. Mostly, some of the available schemes not only simply incentivise investment in battery assets, but also set provisions to ensure that they can be controlled to provide services to the power system or participate in energy markets (Martin, 2018).

For example, the Australian Capital Territory aims at equipping 5,000 households with battery systems by 2020. The installations are incentivised based on the battery's power capacity. New South Wales' $20 million support on the installation of battery systems in governmental buildings aims at reducing electricity costs and strengthening supply resilience. It also regards a DR capacity of up to 13 MW across 900 systems. Moreover, the state of Victoria provides (since September 2018) $40 million for battery systems on households with pre-existing PV systems (Martin, 2018).

### 12.1.2 Promoting small-scale Battery Storage deployment

If the approach is focused on the exploitation of small-scale PV systems at the residential level, then appropriate capacity limits should be clearly defined in order to reach the wider policy goal. This is due to the fact that large-sized (grid-scale) projects could lead to meeting the set capacity caps without achieving increased small-scale deployment of PV.

Furthermore, EVs and especially those with Vehicle-to-Grid (V2G) capabilities can be considered as residential battery storage assets, in conjunction with a residential PV installation.

#### 12.1.3 Promoting trained personnel/standardisation

Given the absence of Energy Storage in the participating countries, there is a clear need for trained personnel as the lack of experience of all the interested parties (i.e. installers, registration authorities, etc.) can be observed. Furthermore, standardisation procedures are also required to eliminate any technical issues occurring during the integration of ESS to the power network. This was evident during the installation of the pilot systems in the countries involved.

### 12.2 Promoting end-user's awareness

Despite that end-users seem to have a positive attitude towards energy efficiency and RES, they are not fully aware about Energy Storage and the benefits it can provide to the power system, the environment and the society in general. End-users seem to be worried about Energy Storage, as a hesitation from their side to couple storage to their existing PV systems was observed during the project implementation. The above is mostly a result of the lack of public perception and awareness (lack of proper information about safety issues, space requirements and financial aspects).

New policies should target to the effective end-user engagement through education and awareness promotion. Energy Storage promotion should be accompanied by informational campaigns (i.e. events, workshops and meetings) designed to increase the end-user's awareness and acceptance towards Energy Storage.

### 12.3 Promoting Self-Consumption

By offering a low rate for injected generation to the power network or even penalise such actions, during specific periods of the day for example, end-users are motivated to apply load-shifting methods or even invest in ESS to increase their self-consumption.

Ensuring that end-users are incentivised by policies promoting the reduction of excess generation to the grid, such as Net-Billing, energy self-consumption with the use of ESS is further promoted. Any taxes or levies on self-consumed energy should be avoided, in order to stimulate the exploitation of self-consumption at the residential level.

### 12.4 Promoting time-varying pricing

The shift from flat pricing to time-varying pricing can act as a possible motive for the end-users to utilise the benefits of an ESS. The developed time-varying tariffs must be designed in such way so they can offer the end-users the capability of optimally operate an ESS and also achieve:

- Peak reduction:
  The designed tariffs should promote the management of peak demand and thus the reduction of cost for the power network during such periods.
- Flexibility:
  The designed tariffs should promote higher flexibility for the system, achieved through DR and ESS exploitation.
- Market promotion:
  The designed tariffs should promote Energy Storage technologies, which are generally considered as ideal when operated under non-flat pricing conditions.
- Cost reflectiveness:
  End-users should be charged based on the costs of the received services. In addition, their contribution, i.e. increased self-consumption which leads to reduced grid interaction and reduction in peak demand, should be considered.

ToU Tariffs are considered as the most common among the different price-based DR programs (IRENA, 2019). They are usually divided into peak, shoulder and off-peak timeslots, mainly reflecting the demand level on the power network. They are influenced significantly by the structure of the abovementioned timeslots and specifically, the existence of the so-called shoulder period. End-users, who cannot cover their daily needs that can be shifted from the peak periods, but also cannot wait until the off-peak period to do so, can take benefit by using this transitional period effectively. In addition, the load profile is generally smoothed by this period, as massively shifting the peak to other hours during the day is avoided. Energy supplied during peak demand times can also be lowered and as a result, aggregated savings are passed on to the consumers.

In general, a three-slot pricing window (i.e. peak, shoulder and off-peak timeslots as mentioned above) is considered as more convenient for the end-users, avoiding affecting their comfort in a great extent.

With an appropriately designed ToU Tariff structure, end-users are incentivised to shift their consumption to shoulder and off-peak periods and at the same time avoid selling their excess PV generation at a low price, thus promoting self-consumption. This is similar to the case of Hawaii, an island state of the USA with high PV penetration to its power network. Given the ToU program developed in Hawaii, the lowest electricity price occurs during the middle of the day, when PV generation peaks. This price is then increased significantly during the evening. Lower energy savings are then gained for the participants if they are not able to store excess PV generation during the day, due to the low daytime and high evening electricity prices respectively (Hawaiian Electric, 2019). As a result, a motive for investment in ESS is created. Given also the technical constraints regarding RES deployment the state encounters as an island complex, it can be considered as a good indicator for other regions with similar issues. It is worth mentioning that the USA conserved more than 5% on retail electricity sales due to DR by the implementation of ToU Tariffs in 2015 (IRENA, 2019).

It has to be noted that developing optimum ToU Tariffs for each region involved is beyond the scope of this project. Yet, a general recommendation resulting of the project's outcomes and the research conducted for the purposes of this Deliverable is that the ToU structure should be categorized in three different season blocks (winter, summer and inter-season) with three block periods each (peak, shoulder and off-peak timeslots as mentioned above). The applied ToU rates for these slots should promote ESS operation by creating an investment motive, reflecting though at the same time the utility cost structure, thus retaining cost neutrality for both the utility and the end-users. This can be done by utilising the extracted profiles for the regions participating in the project as explicitly presented in Deliverables 2.3.9 (Living Lab) and 3.6.1 (Data Analysis).

Overall, if pricing regulations do not address the implementation of time-varying pricing and allow end-users to have access to non-flat electricity prices linked to the spot market, the benefits from the exploitation of Energy Storage in residential premises cannot be fully harnessed.

## 12.5 Promoting Smart Metering

An essential requirement of non-flat pricing and time-varying rates is the use of Smart Metering. A European rollout of 80% Smart Meters by 2020 was foreseen since 2017 (Directive 2012/27/EU). In order to implement effectively such abovementioned policies, the exploitation of Smart Meters is essential for the adequate monitoring of the end-users' energy consumption, raising their awareness and assisting the operation of ESS. New policies should be designed targeting the installation of Smart Meters, which requires a national level Smart Metering infrastructure, as well as an adequate communication infrastructure, linking the residential Smart Meters to the meter operator.

Moreover, the development of a clear privacy policy and proper data security standards to avoid the access or misuse of the end-users' data by unauthorized parties is required. As a result, a data privacy and security framework under national and EU legislation needs to be clearly defined.

## 12.6 Promoting Smart Homes

New policies should set the provisions and regulations for future households, which utilise emerging technologies such as ESS and automated control techniques. This is considered similar to the concept of Nearly Zero Energy Buildings (NZEBs), which have become mandatory for all new public and commercial buildings in the EU since January 2019 and are also expected to be mandatory for all new residential premises since

January 2021. EVs and V2G integration, which are directly associated to Energy Storage, should also be clearly defined in the new policies.

## 12.7 Promoting Energy Communities

New policies should set the provisions and regulations for Energy Communities' formation and their right to engage in local power generation, distribution, aggregation and Energy Storage. Energy Communities should be granted access to all organised markets (flexibility market etc.), as clearly stated by the Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast) (European Commission, 2019).

Furthermore, promotion should be accompanied by informational campaigns (i.e. events, workshops and meetings) designed to increase the end-user's awareness and acceptance about Energy Communities.

As abovementioned, policymakers must set proper rules with regards to Energy Communities, as well as define the conditions and standards on how energy is generated and traded within the Community's boundary, ensuring efficient network operation. According to the abovementioned Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast), it must be at any case ensured that participants and customers of an Energy Community are subject to high-quality network services, similarly as end-users outside the Community boundary (European Commission, 2019).

## 12.8 Promoting market access and provision of services

New policies should set the provisions and regulations for open market access regarding end-user participation through aggregation, peer-to-peer energy trading and community-ownership models (IRENA, 2019) for the provision of services to the power network. Allowing end-users to participate in an open energy market as service providers with the aforementioned business models, has received significant interest in recent years and it is clearly stated in the Directive of the European Parliament and of the Council on common rules for the internal market in electricity (recast) (European Commission, 2019), as abovementioned.

## 12.9 Summary of proposals

A summary of the proposals concerning the practises described above is provided in Table 9.

*Table 9: Summary of proposals regarding Energy Storage exploitation practises.*

| Recommendation | Description |
|---|---|
| **Net-Billing and other Self-Consumption policies/schemes** | • Abolition of other active supportive schemes, i.e. Net-Metering, FiTs.<br>• Introduction to the regulatory framework (if absent).<br>• Clear and transparent framework definition regarding self-consumption, storage ownership and service provision.<br>• Simplified procedures for registering new systems.<br>• Avoidance of discriminatory charges (no added charges/levies applied, avoidance of double taxation as consumers and producers).<br>• Ensure inclusive eligibility (i.e. ESS participating along PV systems as coupled solutions).<br>• Avoidance of taxation on self-consumed energy. |
| **Market access** | • Abolition of other active supportive schemes, i.e. Net-Metering, FiTs.<br>• Clear and transparent framework enabling participation and access to all organised markets, i.e. flexibility market etc.<br>• Active participation of end-users in all markets through aggregation/synergies formation. |
| **Cost-reflective pricing** | • Abolition of flat pricing.<br>• Time-varying pricing (i.e. Tou Tariffs, Real-time Pring) for all types of consumers.<br>• Support enablers, such as Smart Meters, storage subsidies, etc. |
| **Energy Communities** | • Introduction to the regulatory framework (if absent).<br>• Clear and transparent framework definition regarding access to all organised markets, i.e. flexibility market etc.<br>• Simplified procedures for registering new systems.<br>• Avoidance of discriminatory charges (no added charges/levies applied, avoidance of double taxation as consumers and producers).<br>• Avoidance of taxation on self-consumed energy. |

# 13. Conclusions

This report provides a comprehensive summary of the tariff, policy and market rules recommendations for the countries involved in the project focusing on the promotion of ESS at the consumption-side and specifically, at the residential building sector.

The work is based on the analysis results obtained from the viability assessment of coupled PV-ESS installations performed with the use of the developed StoRES Online PV and Storage Optimisation Tool. Furthermore, the barriers encountered, the lessons learnt and the CBA carried out during the implementation of the project were also taken into consideration.

The responsible authorities concerning policy design and implementation in the participating project counties were also identified and a summary of promoting proposals for the Energy Storage exploitation in these countries based on the project's outcomes is provided.

Given the analysis results, further actions are required, especially when considering the low viability of residential PV-ESS under the current market and regulatory conditions in the countries involved. This concerns the absence of policies that are considered suitable for the promotion of Energy Storage, the absence of any subsidies provided and the finally, the current active status of schemes not promoting the increase of self-consumption in the countries under study. Specifically, the absence of a clear policy about the investment in Energy Storage and the lack of incentives, result to restricting the end-users' motive to invest in residential ESS.

This is also further enhanced by the lack of a clear policy on the ancillary services that can be provided by Energy Storage assets on the grid. DSOs/TSOs are not incentivised to take appropriate investment decisions in support of the system. In addition, the prevailing tariffs do not favour investments in residential ESS, even though there is a clear need for electricity pricing reform and essentially, the introduction of appropriate time-varying pricing. Yet, introducing such tariffs and any subsidies in general for self-consumption increase through ESS utilisation should be determined after a thorough analysis by policymakers. It is important to note that a coherent network charging process for all end-users is necessary, to avoid discrimination. In this context, responsible authorities are recommended to utilise the extracted power profiles for the regions participating in the project, as explicitly presented in the project's Deliverables 2.3.9 and 3.6.1, for the design and implementation of suitable schemes and policies.

In conclusion, the lift off the primary barriers (mainly regulatory, market and technical) preventing the exploitation of ESS to the power network, as well as the development of appropriate policies and schemes that will promote the viability and cost-effectiveness of ESS is urgently required.

Overall, the active participation of the end-users in an open energy market as owners of ESS, e.g. for the provision of services etc., though aggregation, peer-to-peer energy trading and other similar mechanisms is recommended in this report.

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