Cost-effective rehabilitation of public buildings into smart and resilient nano-grids using storage

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4 Contents

1 Project summary

In an effort to address high energy consumption in the building sector that is mainly fossil - fueled, support rural areas and areas powered by weak grids, which are common in the MENA region, and achieve higher grid penetration of renewable energy sources (RES) while maintaining grid stability and power quality, this project aims at the implementation of cross border pilots that will support innovative and cost - effective energy rehabilitation in public buildings based on the nano-grid concept. Thus, BERLIN project focuses on the increase of photovoltaics (PV) penetration, which coupled with energy storage and demand - side management (DSM) will increase the energy efficiency (EE) of the buildings. The implementation of these technologies in a cost - effective way will result in high level of self - resilient public buildings that are green, smart, innovative and sustainable. A total of 6 pilot buildings will be implemented: 1 in Cyprus, 2 in Greece, 2 in Israel and 1 in Italy.

The project has started in September 2019 and is expected to be completed within 36 months.

2 Introduction

This report provides an analysis of the current situation in each participating country; Cyprus, Greece, Israel and Italy regarding renewable energy sources (RES), energy storage systems (ESS) and Demand - Side Management (DSM). Through the information provided by each partner, the status for RES, and particularly for photovoltaics (PV), ESS and DSM in each participating country has been analysed. In addition, the state of the art regarding legislation and energy policies, as well as barriers that might exist in each country for further deployment of PV, ESS, and DSM are discussed.

Moreover, the solar potential for each region is presented. Also, the electricity tariffs in effect and typical PV system cost are presented, which provide comparisons between the participating countries. Finally, current local practices on building energy rehabilitation are discussed for each country.

To conclude, this report will be used as the starting point for the current state in the Mediterranean (MED) region, with particular focus in the participating regions. Thus, the gathered information will be utilised for the further promotion of PV, ESS, and DSM under nano-grid concept in those regions.

3 State of the art in MED regions

3.1 RES (and PV) penetration

Renewable energy sources have been introduced to the energy mix of the participating countries as a result of the generous subsidies offered. As the focus of each country is on increasing the RES penetration and thus, reduce their dependence on conventional energy sources, the National Energy and Climate Plan (NECP) of each country has set ambitious targets regarding RES growth. Currently in Cyprus, the RES share to the electricity consumption is around 9% with the 2030 RES-e target set at 30% without interconnection and 50% with interconnection. Similarly, the RES share of Greece is around 34%, whereas it is expected to rise to 61% by 2030. For Israel, the electricity share generated from RES is 4%; forcing the country to set the target at 17% by 2030. Finally, Italy has reached its 2020 target of 17% five years in advance and has set its target for 2030 at 55%. In summary, each of the participating countries has focused on increasing their RES penetration and reduce their dependency on fossil fuels and other conventional sources.

The penetration of PVs in all the participating countries has been increasing in past decade, as a result of favourable policies for both small- and large-scale systems, aided by the system price reduction in the PV industry. Cyprus, Israel and Italy have recorded a relatively steady growth of their total PV capacity. On the other hand, in Greece the PV share in the total electricity generation has remained stable in the past years, however, market analytics forecast increase of the PV capacity installed in Greece in the following years.

3.2 Energy Storage System installation

The current status regarding energy storage systems varies between the participating countries. In particular, adoption of energy storage solutions currently in Cyprus has not been achieved due to high cost of storage technologies in combination with the absence of incentive frameworks. Thus, the utilisation of battery energy storage systems (BESS) is not favourable at the moment, especially in residential installations where the net-metering policy is still in effect.

In Greece, energy storage is mainly based on the pumped-storage hydroelectric technology, whereas BESS has not been widely employed at the moment. However, with the 2030 NECP it is expected that approximately 1.3 GW of BESS will be installed.

Similarly, Israel relies heavily on pumped-storage hydroelectric and other steam-based energy storage, but BESS have not been installed at a large scale as of today.

In contrast, Italy has a combination of ESS and relies both on pumped-storage hydroelectric plants and BESS for energy storage. More specifically, in 2015, Enel Green Power (EGP) inaugurated the first Italian large-scale solar-plus-storage facility in Catania. The 1 MW/2 MWh battery facility, which uses the Durathon sodium-metal halide technology developed by General Electric, is connected to EGP's 10 MW Catania 1 solar plant and aims to increase flexibility in management of the power plant, smooth the electricity flows, reduce intermittence and provide auxiliary services to the grid. Moreover, EGP also inaugurated a 2 MW/2 MWh storage facility, comprised of Samsung lithium-ion batteries and located at the 18 MW Potenza Pietragalla wind farm, in the region of Basilicata. Finally, 50% subsidies are available in some Italian regions, in an effort to promote residential BESS installations.

3.3 Demand Side Management exploitation

The state regarding DSM varies among the participating countries. In Cyprus, there are no schemes or policies available for aggregation and demand response (DR) at the moment. Also, dynamic pricing is not available. Instead, there is mainly a flat – rate pricing, at predefined regulated prices. Moreover, the Time of Use (ToU) tariffs are limited to two blocks per year. In addition, policies or regulations considering citizen energy communities, such as microgrids and nano-grids, have not been established in Cyprus so far. Finally, smart metering is not applicable yet, however, it is expected to be adopted within the next decade.

Similarly, in Greece the implementation of DSM and DR is not widespread at the moment, due to the lack of available programs or incentives and the low amount of installed smart meters. Instead, policies such as ToU and interrupt mechanisms for high-demand consumers in case of electrical inadequacy are in effect.

In Israel, DSM is not used at the moment, although great efforts are put towards reduction of the consumption during peak hours and implementation of a smart grid.

As with BESS, Italy is the most advanced out of the participating countries with regards to DSM. The installation of smart meters became mandatory in 2006. As a result, more than 99% of establishments are equipped with smart meters, which act as smart network sensors, enabling continuous grid quality-of-service monitoring, near real-time identification of network faults and renewable micro-generation. In Italy some of the DR programmes in place have far focused on large industrial users: Interruptible Programmes and Load Shedding Programmes. With Interruptible Programmes participants are required to reduce their load to predefined values. With Load Shedding Programmes utilities have the possibility to remotely shut down participants' equipment at short notice. One significant difference between these two programmes is that for Interruptible Programmes participants who do not respond can face penalties. In order to expand the set of resources that can provide flexibility services, the Italian Authority (ARERA) has lowered the minimum power threshold (up to 1 MW) to be eligible for the participation to the Ancillary Services Market, opening also to the aggregation of smaller resources (Virtual Aggregated Units). The most promising aggregation is the so-called UVAM (Virtual Aggregated Mixed Unit), that can include generators, controllable demand and storage. The first project of DSM in Italy will be launched in 2020, which aggregates residential storage units in UVAM. This pilot has been established by the energy and digital services company Enel X, in collaboration with the Italian public-interest company of research on Power System, RSE ("Ricerca Sistema Energetico"), in some provinces of the northern part of Italy (Brescia, Bergamo, and Mantua). With this project, private users of home energy storage can participate in active demand management programs and, through the UVAM aggregates, provide flexibility services to the electricity network. The programme, which will finish at the end of 2020, already includes the participation of more than 100 PV+ESS systems. Enel X, which acts as the aggregator, installs a communication and remote-control system for the storage unit, which can be called upon to provide services for the power system by taking into account the usual self-consumption functions, with a management that at the same time aims to minimize the impact on the battery's state of charge and availability.

4 State of the art legislation in MED regions

This section aims at describing the existing legislation in each participating country; Cyprus, Greece, Italy and Israel. Hence, relevant parameters, which are analysed in Table I, are used for defining attributes of the available support schemes in each region.

Table I: Set of parameters used for analysing net – metering and self – consumption schemes in MED regions as of December 2019.

PV self – consumption	Right to self – consume	Right to self – consume the on – site produced electricity.
	Revenues from self – consumed PV	Savings on the variable price of electricity and any additional revenues such as self – consumption bonus.
	Charges to finance T&D cost	Additional costs such as taxes and fees.

Excess PV electricity	Revenues from excess electricity	Any compensation the consumer will receive for injected electricity to the grid such as credit in kWh or credit in monetary unit.
	Maximum timeframe for compensation	Refers to schemes that allow credits for all electricity injected and the compensation is permitted during a certain period of time.
	Geographical compensation	Right to compensate consumption and generation in different locations (i.e. Virtual net-metering).
Other system characteristics	Grid codes and additional taxes	Refers to the additional costs such as self-consumption fee, balancing cost and which specific grid codes can be applied.
	Other enablers of self – consumption	Refers to additional supports to self-consumption such as DSM, Storage or ToU tariffs.
	System capacity limit	Maximum PV capacity limit as applied by the compensation scheme.

Table II lists all the parameters for each participating country.

Table II: Energy policy analysis for the participating countries.

		Cyprus	Greece	Israel	Italy
PV self – consumption	**Right to self – consume**	Yes	Yes	Yes	Yes
	Revenues from self – consumed PV	Net – metering: credit (kWh) Net – billing: avoided cost	No direct revenue. Avoided cost only	Net-Metering – Self Consumption FIT for each kWh produced.	Avoided cost; FiT bonus if Self-consumption> 40% p. a.
	Charges to finance T&D cost	A fee per consumed kWh	No	Fee for network backup	A fee per consumed kWh
Excess PV electricity	**Revenues from excess electricity**	Net metering: Credits to be used in the next billing period. Net – billing: avoided cost	Net-metering. Credits rolled to the next billing period	Excess energy is sold to the grid.	Net-metering SSP; Economic credit, used to buy electricity in unlimited period of time, or paid yearly to the SSP user.
	Maximum timeframe for compensation	One year	Three years	None	None

		Cyprus	Greece	Israel	Italy
	Geographical compensation	On – site only	Virtual net-metering available for certain prosumers (farmers/public bodies)	None	Virtual net-metering "SSP altrove" available for public bodies (Municipalities with less than 20,000 inhabitants and the Defence Ministry).
Other system characteristics	Grid codes and additional taxes	Grid codes and taxes on generation	Grid codes, no additional taxes	Grid Codes, No taxes	Grid Codes, No taxes
	Other enablers of self – consumption	Storage option, tax exemptions for energy that is self – consumed for net – billing	Storage option since Sept. 2019. Less profit for excess PV energy than self-consumed	Storage option from Feb 2020, tax exemption for PV	Storage: tax deduction up to 50% CAPEX. Self-consumed electricity exempted from network/system charges.
	System capacity limit	Net – metering: 1 – ph: 4.16 kWp, 3 – ph: 10 kWp Net – billing: 10kWp – 10 MWp	Net-metering (partial): 20kWp or 50% of installed power. 100% for public bodies or non-profit organizations Max: 1MWp (MV) or 100kWp (LV)	Net-metering – any size. FIT – up to 200 kw peak.	Net-metering SSP – 500kW. New FIT: min 20kW – up to 1MW (registers), or >1MW (auctions).

5 Barriers for further PV, ESS, and DSM deployment in MED regions under nano-grid

5.1 Cyprus

In Cyprus, the main barriers for further implementation of PV and ESS, and eventually, the utilisation of DSM through micro- and nano-grids are mainly the lack of BESS installations, as a result of no grid rules, market rules and tariffs that will favour the utilisation of storage systems and therefore, promote their wider usage. As mentioned earlier, incentives for BESS are only available for agricultural applications, which combined with the net – metering currently available for residential applications pose significant barriers for BESS adoption. Finally, existing (and even new) buildings are not equipped with smart loads or smart meters, which will allow the deployment of DSM on a large scale.

5.2 Greece

The main barriers towards the widespread of nano-grid buildings in Greece are the following:

1. One of the main technical/legislative barriers is that even after the updating of legislation to allow energy storage installations, the full potential of energy storage is untapped. The problem is that discharging to the grid is not allowed, and hence possible profit mechanisms such as energy arbitrage cannot be implemented.
2. Still, the Greek DSO (HEDNO) does not officially allow an installation to connect/disconnect from the grid at will. Only in cases of outage the building manager can employ a standby generator to electrify the building. This is a technical barrier.
3. Energy communities and aggregators, although defined in recent legislation, are not yet active and widespread so that they can play the pivotal role they can. This is a social/economic barrier.
4. Technical solutions related to nano-grids/microgrids are not widely available in the Greek market (e.g. storage and load control solutions) and practicing engineers are not aware of them when they design or refurbish buildings. This is a market/educational barrier.
5. Load control in buildings is not widespread and can be found mainly in non-residential buildings. Moreover, thermal loads are still mostly covered by fossil fuels (natural gas/oil), and hence controllable electrical loads such as heat pumps cannot be widely employed to offer demand response or demand side management.
6. The lack of smart metering especially in the LV network is a market/technical barrier that inhibits the advancement of demand side management or demand response schemes, which in turn will make nano-grids an interesting alternative.
7. The profits for a building operating as nano-grid are not enough to constitute a valid business case. The main reason for that is the lack of dynamic or multi-zone electricity tariffs. This again is a legislative/market barrier, but can be considered as economic barrier as well, since the installation of smart meters is required.
8. With the current prices of electricity and mainly with flat or two-zone tariffs, the current costs of storage and the generally low loss-of-load probability, the benefits of operating a building as nano-grid are not enough to cover the associated costs.

5.3 Israel

The main barriers for developing solar energy in Israel are:

- High initial investment is expressed at a high cost per kilowatt compared to conventional power plants.
- Irregular energy production on cloudy days and at night at power plants without additional storage or energy source.
- The concept of a relatively large area for generating electricity in the conventional method of coal, liquid fuel or gas.

With a view to overcoming the shortcomings, there are proposals to set up integrated stations that will supply both solar and wind energy, with the aim of utilizing the area at night as well. Second, many research institutions, such as the Centre for Nanotechnology at Bar-Ilan University, are trying to develop solar panels whose surface area will be smaller, by using nanotechnological components, thus increasing the energy production capacity per square meter.

There are research and development bodies that are trying to improve their efficiency and lower the price of photovoltaic cells. Government investments are increasing every year, and commercial entities are doing the same. Despite extensive research and huge investment, and despite projections, a breakthrough in photovoltaic cell efficiency has yet to be achieved. For practical needs, it is acceptable to calculate up to 10% efficiency. It should also be borne in mind that there are theoretical barriers to solar energy efficiency: 22% for photovoltaic cells.

5.4 Italy

The current regulatory restrictions in Italy limit the full potential of *prosumer*.

The concept of Virtual energy for a geographic compensation is still limited: in order for net-metering SSP to apply, electricity must be supplied to and received from the grid at one and the same connection point (Art. 1 ARG/elt 570/2012/R/efr). Only public bodies as municipalities with less than 20,000 inhabitants and the Defence Ministry are enabled to make use of net metering without being obliged to use the same connection point to supply and receive electricity (Art. 27 par. 4 L 99/09).

According to current legislation, it is not possible to operate the so-called collective self-consumption. Which means, that in an apartment building, the electricity generated by a PV system may not be used in the individual apartments, but only for shared use (e.g. elevator, lighting in the stairwell etc.). This restriction also applies to the tertiary sector (e.g. the various users of a shopping centre) and the industrial sector (e.g. the various plants in a production area).

Referring to the incentive mechanisms, the incentives in the old promotion model ("Conto Energia") were easy to understand: monetary revenues were mainly linked to the energy produced so that it was not necessary to analyse the details of the later use of the energy produced when drawing up a business plan. The current model (RES1 Decree) it is not easy to understand and to access for the prosumers, since it is based on energy savings through solar energy and refers to key parameters that must now be taken into account, such as the costs for the kWh of electricity drawn from the grid and the level of captive use.

Access to the incentives will either be by registration in Registers or participation in competitive lowest unique bid Auctions. Moreover, only renewable energy plants with a nominal capacity exceeding 20 kW are entitled to have access to this incentive mechanism.

6 Conclusions

This report has provided an overview of the state of the art in the MED region, and especially in the participating countries (Cyprus, Greece, Israel and Italy) regarding RES, with particular focus on PVs, ESS, and DSM. In this study, the current and forecast PV penetration in each country is presented, highlighting that all participating countries aim at further increasing their RES share and therefore, their PV installed capacity. In addition, the adoption of ESS and DSM for the specific countries is presented, clearly showing that BESS and DSM are not widely utilised. In addition, barriers towards further penetration of PVs, ESS and DSM in the participating regions are discussed.

Moreover, an overview of the legislation and incentive schemes are presented for the participating countries. A range of energy frameworks and incentives including FiT, net – metering, self – production and net – billing exist in each region, while different capacity limits apply depending on the size and population of each one. Through this report, it is demonstrated that new policies and incentives are required for the promotion of ESS, which are vital for the wider adoption of DSM. Currently, the existence of net – metering as a virtual energy storage solution directly to the grid, discourages the utilisation of ESS.

In conclusion, this study presents the current situation in the participating Mediterranean regions regarding RES, ESS and DSM and it forms the baseline of the BERLIN research project. The current status of each country and legislations in effect will be considered towards the design of the nano-grid pilot buildings and to face the main barriers that prevent the deployment of those technologies.