ENI CBCMED Cooperating across borders in the Mediterranean

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BERLIN

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

Thematic Objectives: B.4 - Environmental protection, climate change adaptation and mitigation (Address common challenges in environment)
Priority: B.4.3 - Support cost-effective and innovative energy rehabilitations relevant to building types and climatic zones, with a focus on public buildings
Countries: Cyprus, Greece, Israel, Italy

Output nº: 3.1
Output Title: Pilot actions in buildings in 4 countries
Activity nº: 3.1.1
Activity title: Identification of existing situation, state-of-art in each region, policies, etc.

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	Ben Gurion University	Israel
	Deloitte Limited	Cyprus
	Hevel Eilot Regional Council	Israel

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 nanogrid 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. Specifically, six 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 (Activity 3.1.1: Identification of existing situation, state-of-art in each region, policies etc.) 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. In addition, 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 nanogrid concept in those regions.

3 State of the art in MED regions

3.1 Renewable energy sources in MED countries

3.1.1 Cyprus

Renewable energy sources have been introduced to the energy mix of Cyprus over the past few decades, as a result of the generous subsidies offered. Also, the recent system price reductions aided in the adoption of RES. Nonetheless, the integration of variable distributed generation sources in a weak and isolated power network, such as the distribution grid in Cyprus, poses several technical and financial challenges. The target set by the European Union (EU) for RES generation by 2020 is 20% of the total gross energy consumption. Cyprus foresees that in the same timeframe 13% of the gross national consumption of energy will be covered by RES. The new target for RES set by the EU Commission is 23% by the year 2030.

Nowadays, the electricity generation mix in Cyprus relies heavily on imported fossil fuels and is the first among the EU countries on conventional energy sources dependence [1]. A total installed capacity of 1478 MW provides the bulk of the electricity generation, through three main power stations [2]. As the statistics provided by the Cyprus Transmission System Operator (CTSO) show in Figure 1, approximately 91% of the total energy demand of Cyprus is covered by conventional energy sources, such as imported crude oil, whereas RES account for the remaining 9%. More specifically, wind energy is the dominant RES in Cyprus, owning a share of about 4.4% of the energy demand. Photovoltaics on the other hand, have a share of 3.9%, whereas the remaining 0.72% of the energy demand is covered by biomass.

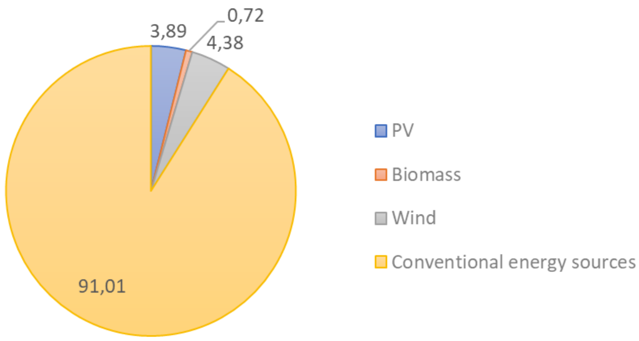

Figure 1: RES penetration to the annual electricity demand in Cyprus as of December 2019 [2].

According to the information available by the Cyprus Energy Regulatory Authority (CERA), the total RES installed capacity has amounted to 289.9 MW, thus generating a total of 452,008 MWh for 2018. The installed capacity and electricity penetration for the various RES in Cyprus are presented in Figure 2 and Figure 3, respectively. As shown, wind energy contributes to 54.3% of the total RES share, generating a total of 220,611 MWh. Similarly, PVs contribute to 42.3%, generating a total of 195,294 MWh, whereas biomass represents 3.3% of the installed RES capacity, thus generating 36,103 MWh for 2018.

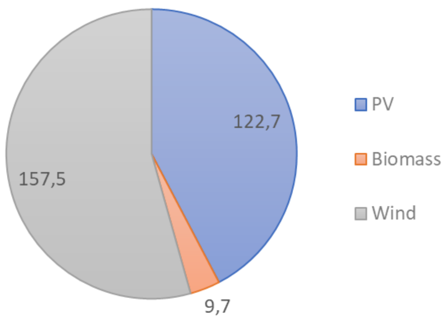

Figure 2: Total installed capacity in Cyprus (MW) per RES [2].

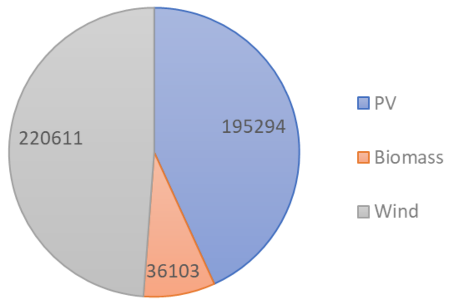

Figure 3: Total energy generation in Cyprus (MWh) per RES [2].

In response to the EU energy framework, Cyprus has set very ambitious national targets to be achieved by 2020. According to the forecasting data provided by the Ministry of Energy, Commerce, Industry and Tourism (MECIT), which is presented in Figure 4, the contribution of RES to the annual gross electricity demand was predicted to be 12.4% by the end of 2018 and reach up to 16% by the end of 2020 [3]. However, as shown earlier, the total share of RES by the end of 2018 in Cyprus was approximately 9%. Although a great effort is put towards increasing the installed RES in the electricity network, issues associated with grid integration of RES arise, which should be tackled considering the fact that Cyprus uses a small isolated power distribution network.

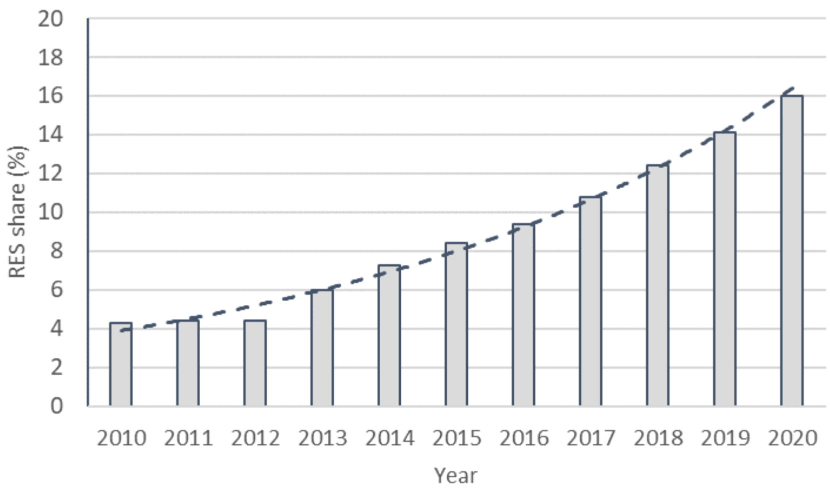

Figure 4: Electricity generation in Cyprus from RES (%) for the years 2010-2020 [3].

3.1.2 Greece

The produced electrical energy in Greece is characterized by a mix of conventional and renewable energy sources, with a total installed power capacity in October 2019 of 18,038 MW. Greece has many islands with autonomous electrical grids, dividing Greek electrical network in two parts, each one characterized by a different energy mix: the interconnected network (ICN) and the non-interconnected network (nICN). The ICN delivers electricity to the Mainland Greece, whereas the nICN refers to small autonomous networks existing on the islands.

From Figure 5 that presents the installed power capacity at Greek ICN by October 2019, it can be observed that renewable energy sources hold more than 34% of the installed electrical power at the ICN, reaching a total of 6063 MW, by October 2019. Coal and natural gas power plants hold almost half of the installed power in Greece, i.e. 49%, while installed hydro power reaches 3,410 MW including small hydro as well.

Figure 6 presents the share of different RES technologies among the total RES installed capacity. Recently, wind power has regained the first place and now has a share of 52%, followed by ground mounted PVs (37%). Rooftop PVs have remained stable for a long period, comprising just 6% of the total RES installed power.

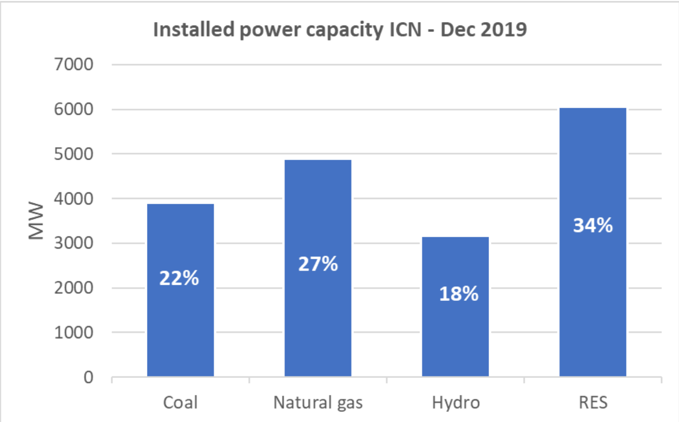

Figure 5: Installed power capacity at Greek ICN by October 2019.

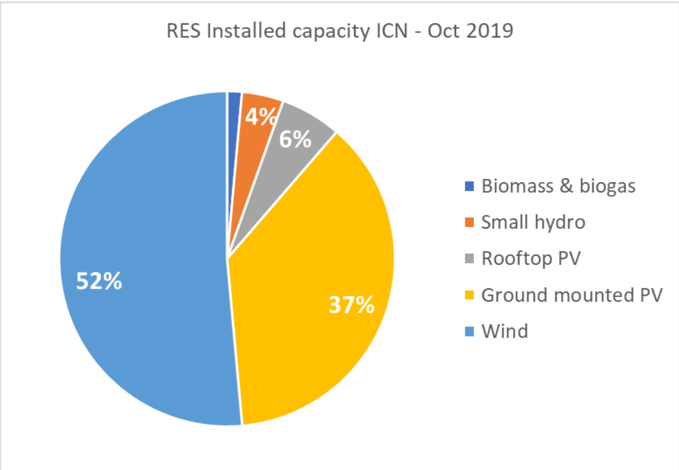

Figure 6: Installed capacity of different RES at Greek ICN by October 2019.

As presented in Figure 7, in 2018 the declining trend of coal power in Greece continued, amounting 33% compared to 36% in 2017. On the other hand, the share of RES increased further at 25%, compared to 23% in 2017.

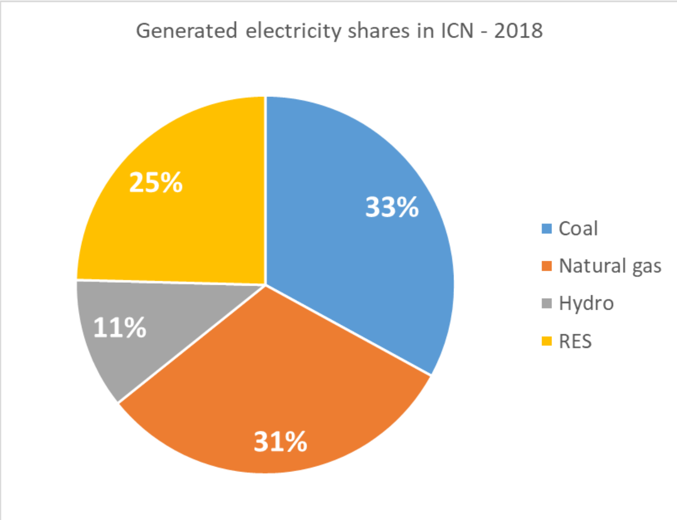

Figure 7: Total generated electrical energy in Greece during 2018 (ICN).

The nICN has a total capacity of 1757 MW (79%) of thermal power plants, and 466.22 (21%) MW of RES plants, as of July 2019, which is depicted in Figure 8. This clearly shows the different characteristics of this network compared to the ICN. Wind power has the highest installed capacity with 66% in the nICN, followed by PVs (total of 33.4%), as shown in Figure 9.

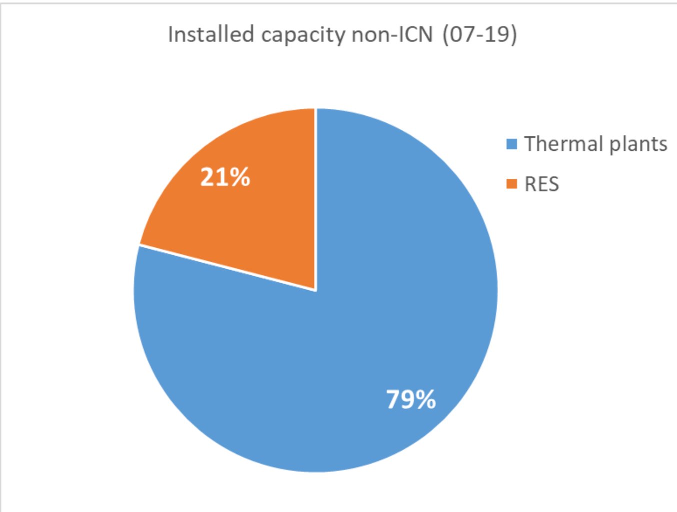

Figure 8: Installed power capacity at Greek nICN by November 2017.

The new National Plan for Energy and Climate (NPEC) that has been announced in December 2019 sets more ambitious targets for RES until 2030. In fact, the main target is that RES should have a 61% share in electricity consumption by 2030, covering part of the generation share that is currently from coal (lignite) power plants. Such plants are set to seize their operation by 2028. In order to achieve this, a total 18.9 GW of RES capacity should be installed by 2030.

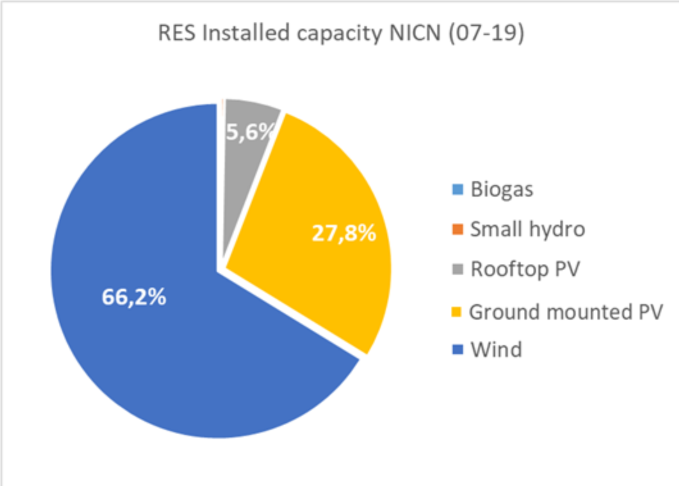

Figure 9: Installed capacity of different RES technologies at Greek non-ICN at July 2019.

3.1.3 Israel

In 2016, the Israeli government decided on a series of steps designed to ensure that Israel meets its target of 17% RES electricity production (in energy terms), and 17% reduction in electricity use by 2030 [4]. The RES target includes interim targets of 10% in 2020 and 13% in 2025. During 2016-2017, the Public Utility Authority (PUA) allocated a quota of 1600 MW for PV, which led, in 2018, to the installation of 475 MW (Figure 10). The total RES capacity in Israel has increased accordingly to 1450 MW, a 37% increase in total solar capacity compared with 2017; a fourfold increase in annual installations compared with the previous year, and twice the installations of the former best year (2015). Overall, Israel has reached the level of about 4% of RES electricity generation in 2018. PV systems are still the most abundant RES resource in Israel, accounting for approximately 95% of installed capacity. The amount of electricity produced from solar energy at the end of 2018 exceeded 5% of total electricity consumption for the first time.

The year 2018 marked a significant change in Israel's energy market with a major reform in the Israeli energy market, the publication of the 2030 objectives for the energy market, and strong promotion for rooftop solar. The electricity sector in Israel is dominated by the vertically integrated Israel Electric Corporation (IEC). On June 2018, the Israeli government approved a reform initiated by the Ministry of Energy, Ministry of Finance, and the PUA. The reform was designed to increase competition in the electricity generation market by reducing IEC shares in the generation segment, separate the system operator activity from the IEC, open the supply segment to competition, and strengthen IEC in the transmission and distribution segment. The reform provides great opportunities for new investors in the market and is expected to have a significant impact on the electricity market in Israel.

- Publication of the Ministry of Energy Plan for the Year 2030: In 2018, the Ministry of Energy published its long-term plan to "Rescue Israel from Polluting Energy".
- Discontinuation of the Use of Coal: By the year 2030, coal will not be used in electricity production, except perhaps as emergency backup.
- Integration of Renewable Energy: A target of 17% production from renewable energy by the year 2030 with interim targets of 10% by the year 2020 and 13% by 2025. The plan specifies that the targets will be re-evaluated in 2022, with the option to raise them, if it is technologically favourable.
- Transition to Clean Transportation: Electricity and Natural Gas. By the year 2030, import of gasoline- or diesel-fuelled automobiles to Israel will be prohibited.
- Transition to Clean Energy in the Industrial Sector based on natural gas.
- Promotion of Energy Efficiency to meet the goal of electricity consumption reduction objective of at least 17 % by the year 2030.

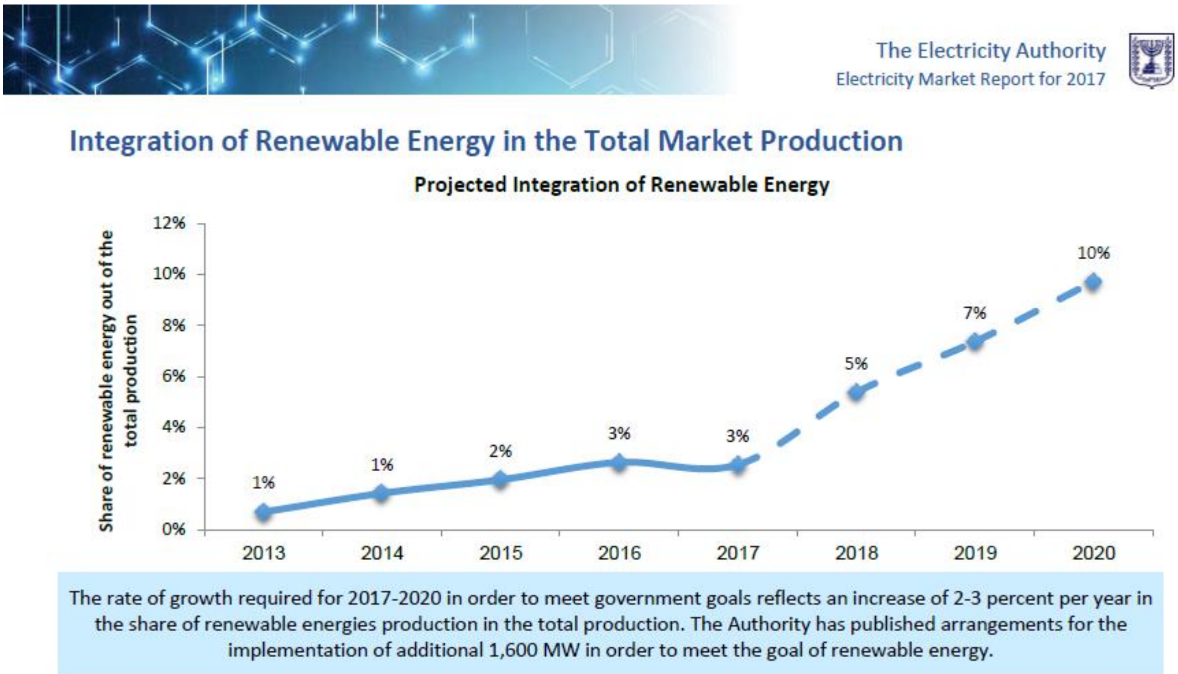

Figure 10: Projected integration of RES in Israel [5].

RES in Israel has one of the lowest penetration rates in the world, especially in comparison with European countries, which have far less sunshine than Israel. According to IEC, the amount of installed electrical capacity of solar electricity production systems in the electrical grid is already 2,200 MW, double the capacity of five years ago (Figure 11). There are approximately 7,000 pending requests from entrepreneurs for connecting to the grid. This amounts to about 1,500 MW of solar electricity production systems, for connection to the grid in the next two years. The main obstacle to speeding up the rate of connecting solar devices to the electricity grid is the need to expand the conduction and distribution network. For every MW of renewable energy installed in the distribution network, IEC together with Israeli government invested 1 million Israeli Shekel (ILS) – equivalent to approximately €250,000, resulting in a total investment worth billions of shekels throughout the network.

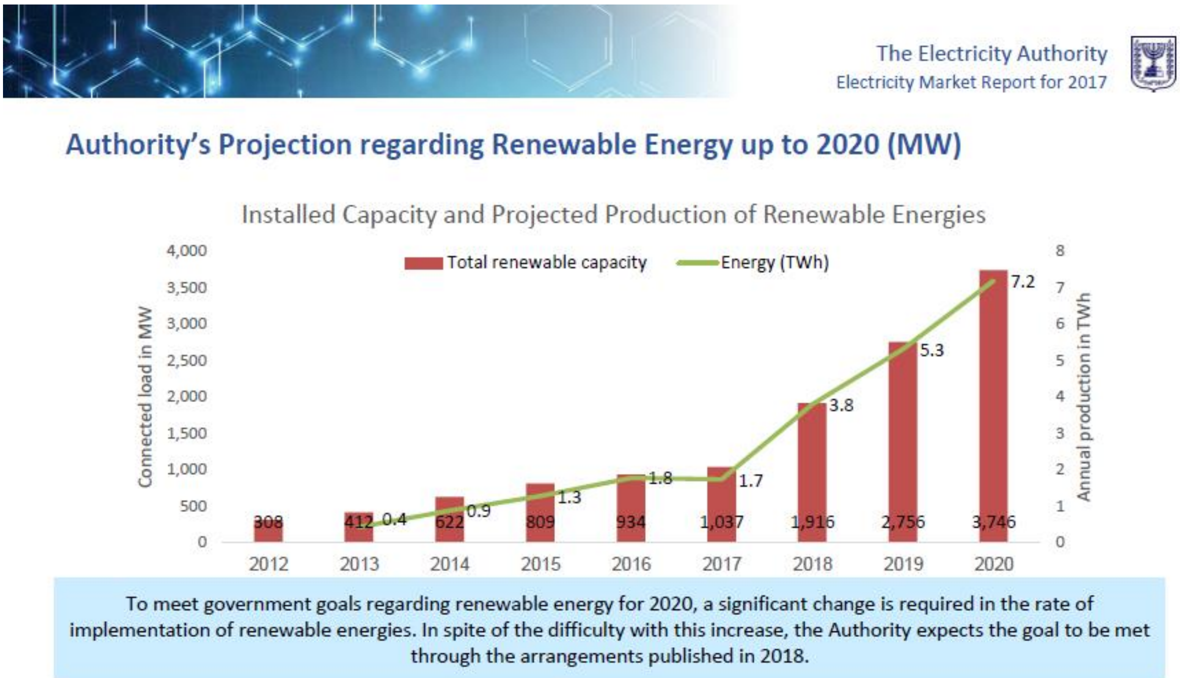

Figure 11: Installed capacity and projected production of RES in Israel.

3.1.4 Italy

A priority for Italy is to resume sustainable growth, from both economic and environmental perspective. The energy sector has a fundamental role to play in the growth of the economy of the country and achieving a more competitive and sustainable energy is therefore one of the most significant challenges in Italy.

Italy is one of the countries that are most committed to pursuing the objectives that aim to environment protection, energy security, and the reduction of polluting and climate-changing emissions laid down by the EU. Called upon to draw up a proposal for the 2030 National Energy and Climate Plan, Italy has created an ambitious strategy that will allow the country to contribute in a massive way to the achievement of the goals set by the Energy Union. The protagonists of this transition, which will bring benefits at a global level, are citizens and businesses. The main objectives of the new plan are:

- Reinforcement of markets integration
- Promotion of the active role of demand, RES integration

- Reinforcement awareness and active role of the consumer:
  - Self-production and adoption of storage systems
  - Choice of the contractor and evaluation of offers and services
  - Actions of demand response (DR)

The PNIEC (Piano Nazionale Integrato per l'Energia e il Clima - Integrated National Plan for Energy and Climate) is the timeline that the Italian Government has developed in 2019, on the basis of European objectives, for the development of the energy market between 2021 and 2030. The Plan is designed to implement a vision for wide-ranging transformation of the economy, in which decarbonization, the circular economy, efficiency and the rational use of natural resources represent an objective for an economy more respectful of the people and the environment. For the first time in several years, PNIEC introduces a sustained growth for RES, especially for PV and wind power. The forecast annual installations are in the GW order (an order of magnitude that has not been reached for several years) and with a growth trend, that today is almost as impressive, especially in the period 2025-2030, if compared with what has been observed in the last few years.

The PNIEC includes in the first section national targets, contributions, policies and measures for each of the five dimensions of the Energy Union. The second section of the plan shows the analytical basis of the plan, including Reference and Policy scenarios assessing the relevant impacts of the policies and measures proposed.

- a BASELINE scenario that outlines an evolution of the energy system on the basis of current policies and measures;
- a policy or PNIEC scenario that quantifies the strategic objectives of the Plan.

The primary objectives of the PNIEC are illustrated in Table I and compared with the EU goals.

Table I: Primary Objectives on Energy and Climate, EU and Italy.

	2020 objectives		2030 objectives	
	EU	Italy	EU	Italy (PNIEC)
RES				
Share of energy from RES in the gross final consumption of energy	20%	17%	32%	30%
Share of energy from RES in the gross final consumption of energy in the transport sector	10%	10%	14%	21.6%
Share of energy from RES in the gross final consumption of energy for heating and cooling			+1.3% p.a.	+1.3% p.a.
Energy efficiency				
Reduction in primary energy consumption compared to the European PRIMES 2007 scenario	-20%	-24%	-32.5%	-43%
Final consumption savings as a result of compulsory systems for energy efficiency	-1.5% p.a.*	-1.5% p.a.*	-0.8% p.a.*	-0.8% p.a.*

Greenhouse gas emissions				
Reduction in GHG vs 2005 for all plants subject to ETS rules	-21%		-43%	
Reduction in GHG vs 2005 for all non- ETS sectors	-10%	-13%	-30%	-33%
Overall reduction in GHG compared to 1990 levels	20%		40%	

* Without transport sector

The first part of the 2030 National Energy and Climate Plan deals with the target that Italy aims to reach in terms of renewable energy, emissions and energy efficiency. The forecasting made in the energy field demand are encouraging; as much as 30% of gross final consumption will be covered by renewable sources by 2030. The industrial sectors will contribute differently to the achievement of the target. In the electricity segment, 55.4% will be achieved, in transport 21.6% and in heating 33%. For the energy efficiency, it has been estimated a reduction in primary energy consumption of 43% and final energy of 39.7% compared to what was reported in the previous energy plan. Regarding emissions, the target is a 33% reduction in greenhouse gases for all sectors not covered by the ETS (EU Emission Trading System).

Full integration of new RES capacity by 2030 will require adequate upgrade of the transmission and distribution grid, increased availability of storage systems, participation of non-programmable renewables to reserve services, use of DSM approaches (e.g. dynamic recharge of electric vehicles), diffusion of distributed storage.

In 2018 the share of RES in the gross final consumption of energy reached 17%. Actually, Italy has reached its objectives on RES share (17%) five years in advance, mainly thanks to a sharp increase in non-hydro power production capacity between 2008 and 2012.

The last data published by the Italian Transmission System Operator (TSO), TERNA, reveals that Italy in 2018 covered 39.5% of its electricity needs (322 TWh) with renewable energy, on the rise in respect of the previous year (35.1%). In Figure 12 the evolution of the RES gross electricity production in Italy in the period 2004-2018 is reported. In 2018 (last consistent data published by TSO [6]) the recorded amount of energy from RES was 114.4 TWh. Specifically, 48.7 TWh of energy came from hydro plants, 22.6 TWh from solar PV installations, 17.7 TWh from wind, 6.1 TWh from geothermal units, and 19.1 TWh from bioenergy units.

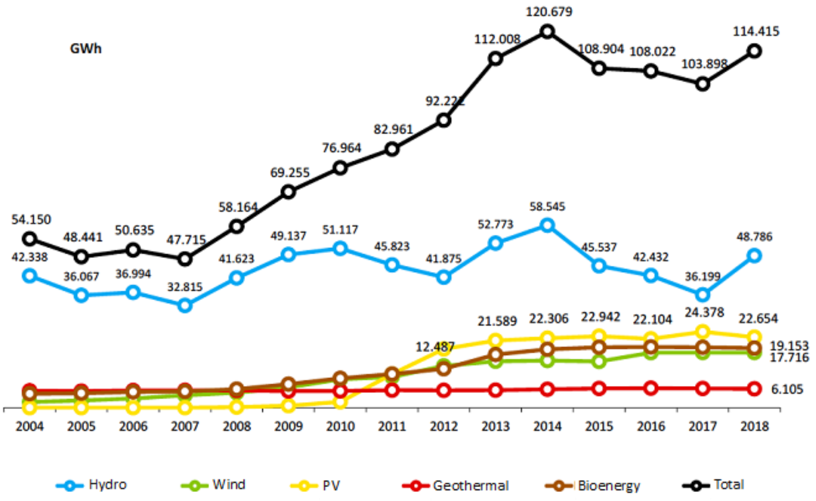

Figure 12: RES production in Italy

Figure 13 shows the RES cumulative installed capacity in Italy (2004-2018). The new installed capacity from RES in 2018 was approximately 1,042 MW, which is over 40 MW higher than that installed capacity for the year 2017. The total installed power from renewables exceeds 54 GW (35 GW if the "historic" hydroelectric that was already installed in Italy before the '00s is excluded), that is about 45% of the Italian generation park (equal to about 118 GW, and which has not seen any increase in power connected from traditional sources over the last year).

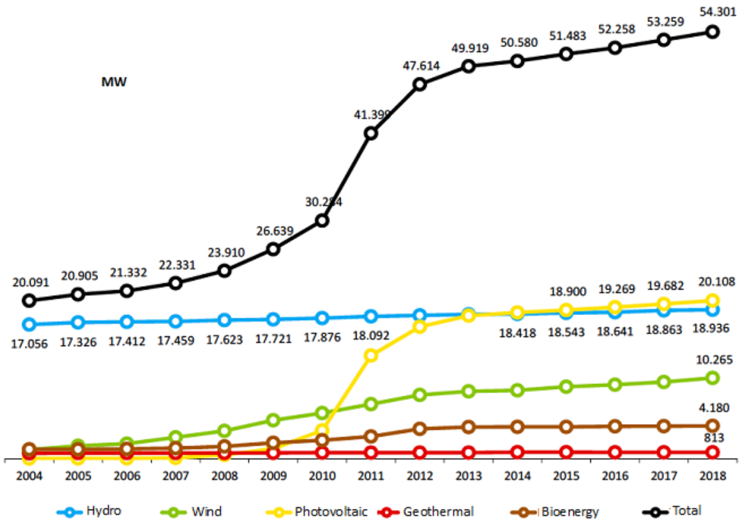

Figure 13: RES generation capacity in Italy

The contribution of RES, as of 2030, is divided among the 3 sectors: Generation, Thermal and Transport sectors. The objective of the PNIEC is calculated by using the sum of the three contributions divided by the gross final consumption. Figure 14 depicts the share of RES between the years 2011 and 2017 and the expected share on gross final consumption towards 2025 and 2030.

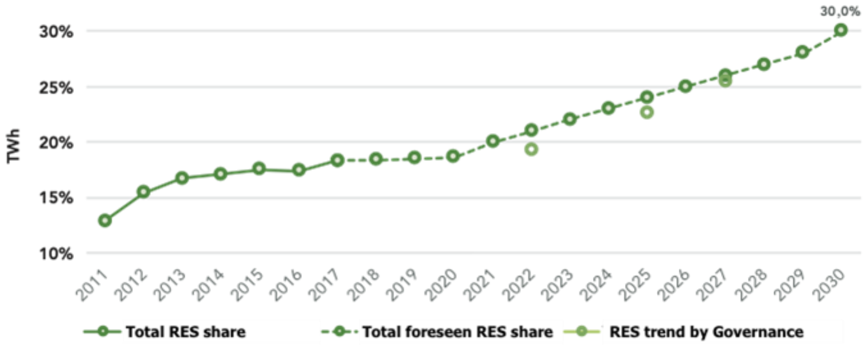

Figure 14: Expected trend of the RES share on gross final consumption in Italy.

Considering the objective of the PNIEC in the electricity generation sector, in Figure 15 the expected profiles of the RES and energy consumption towards 2025 and 2030 are shown, with an ambitious target of 55.4% of energy consumption coverage through RES by 2030. It should be noted that, due to a rising level of energy efficiency, consumption is expected to fall between now and 2030.

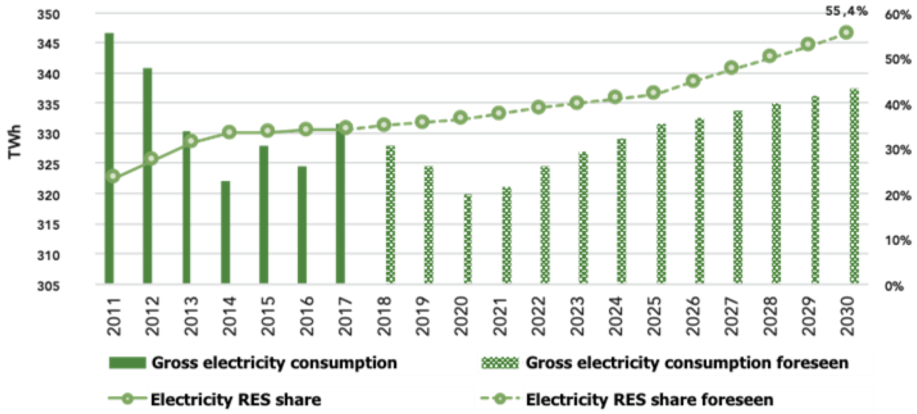

Figure 15: Expected trend of the RES share on electricity consumption in Italy.

Finally, Figure 16 illustrates the expected trend of generation from RES per source in the same period. It can be seen that the expected contribution from PV stands out.

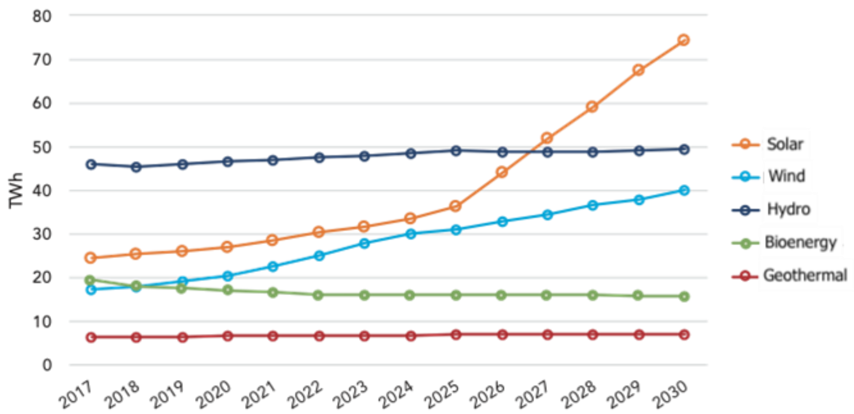

Figure 16: Expected trend of the RES generation in Italy.

3.2 Photovoltaics

3.2.1 Cyprus

For the past few years the photovoltaic market in Cyprus has flourished. As indicated in Figure 17, there has been a steady growth in the installed PV power capacity, as a result of favourable PV policies, such as net – metering, coupled with grid parity conditions. Continuous efforts aiming towards further utilisation of PV technologies are made in Cyprus through various financial programmes. In 2010, the first support scheme was launched by the Cyprus Authorities, which offered Feed – in Tariff (FiT) incentives in an effort to achieve the 2020 national energy targets through PV penetration. Thus, incentives for small- and large - scale PV systems (maximum of 20 kWp) were the most favourable, which led to the installation of 1907 PV systems by the end of 2013, with an aggregated installed capacity of 43 MWp.

In addition, a similar scheme was announced in the same year promoting large scale PV plants, in excess of 150 kWp through competitive bidding. The initial public tender was organised by MECIT for a total available capacity of 50 MWp. Due to the high interest and competitiveness, as well as the overall reduction of the PV system cost, an average tender price of 8.66 c€/kWh was achieved. Thus, by the end of 2016 a total capacity of 53 MWp was installed under FiT incentives.

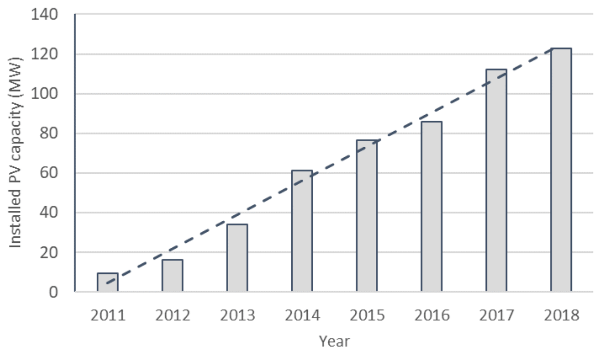

Figure 17: Installed PV power capacity for the years 2011 – 2018 [2].

Through the FiT support scheme, the installation of stand - alone and grid - connected PV systems was promoted under two separate subsidy schemes with a duration of 20 years. Grid - isolated areas were the primary candidates for stand - alone systems, however, governmental subsidies could potentially cover up to 55% of the total system cost including storage systems for up to €44,000, as a result of the high retail price of PVs. On the other hand, for grid - connected PV systems two different policy frameworks were applicable. More specifically, a 55% subsidy could be received of up to €33,000 from MECIT in conjunction with a FiT of 22.5c€/kWh for excess energy fed back to the grid. The second case involved a FiT of 38.3 c€/kWh earned by the prosumers, as the PV plants were designed with the intention of feeding the whole production to the grid. However, the FiT was eventually eliminated in 2013 due to the low cost of electricity generation from PV systems.

In 2013 under Law No.112(I)/2013, the programme "Solar Energy for all" was established by MECIT, which included the net – metering support scheme. According to the initial program guidelines, under the net – metering scheme the maximum allowable capacity for residential PV system was 3 kWp, which was increased to 5 kWp in 2015 according to the framework amendment. The net – metering scheme was the only available policy in Cyprus for PV installations of residential buildings with a total approved capacity cap of 23 MWp by 2015. Governmental subsidies for vulnerable prosumers, such as low – income families, aimed at further promoting the utilisation of net – metering PV systems, by offering funding up to €2700 on the PV system cost. The adoption of small - scale PV systems under net - metering resulted in increasing the number of PV systems to approximately 8000 under that scheme with a total installed capacity of 28.25 MWp.

3.2.2 Greece

The installed capacity of Photovoltaics in Greece has been stable over the past 5 years. At the end of 2018 it was 2645 MWp, while at the end of 2014 it was 2595 MWp. This accounts for an average of 10 MWp per year of new installations, which is a very low number compared to the enormous growth experienced during 2008-2013.

The share of PV generated electrical energy in the total electricity generated in Greece, in both the ICN and nICN grids, has remained relatively stable the last few years. It amounts of approximately 7% on average, after the large increase seen during 2012-2014, as shown in Figure 18.

Market signs in 2019 show that in the following years a revamping of new PV installations is very likely, mainly driven by competitive auctions and large PV plants. As a matter of fact, the latest available data reveal that at the end of December 2018 (Figure 19) the total installed PV capacity in Greece was 2701 MWp, a growth of 56 MWp in a period of 7 months.

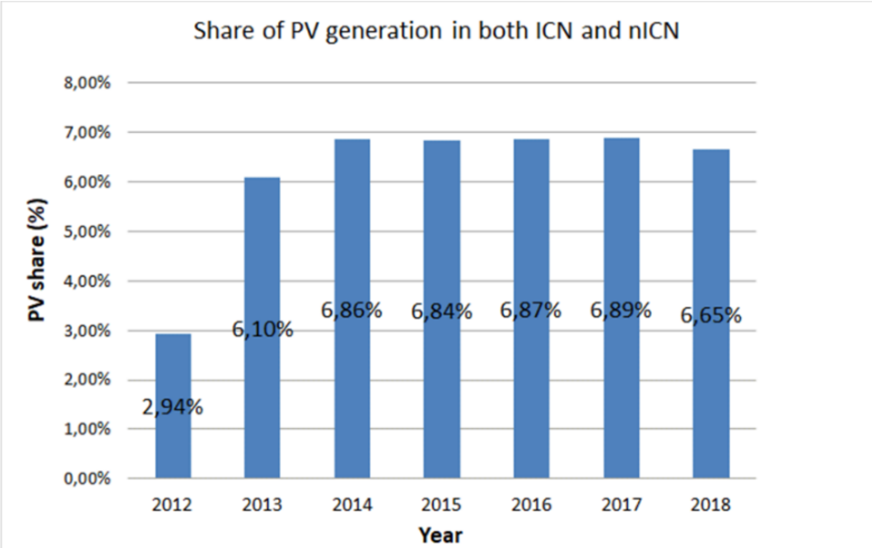

Figure 18: PV share of IC and NIC system in Greece from 2012 to 2018.

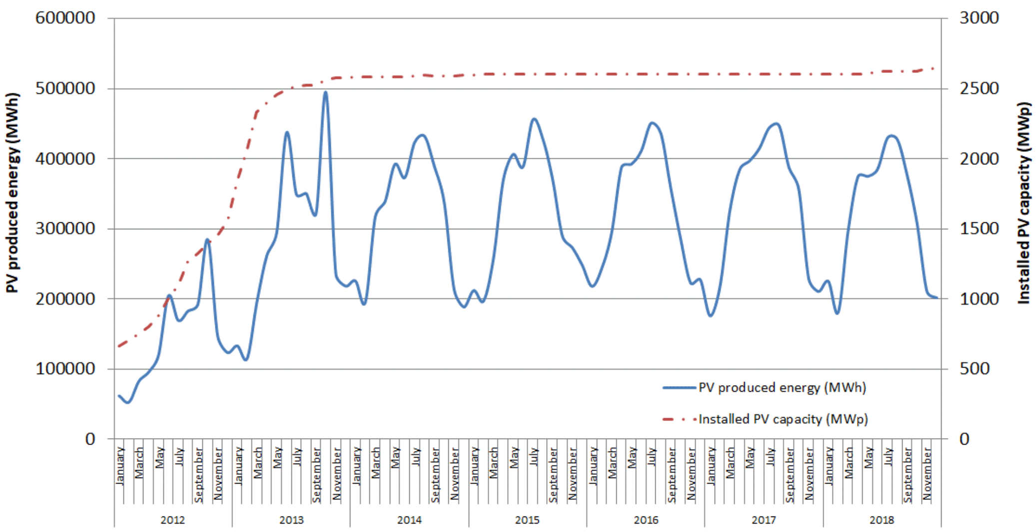

Figure 19: Evolution of PV installed capacity and PV produced energy by December 2018.

The PV installed capacity in Greece is of varied sizes. Without taking into consideration the roof-top installations that are exclusively of sizes below 100 kWp, the percentage of low capacity PV installations (<100kWp) is 37%. Even when adding the rooftop installations, this percentage rises to 45%, which is still below 50%. This means that the majority of PV capacity currently installed in Greece consists of large PV plants. Figure 20 shows the percentage distribution of PV capacity according the size of the PV plant.

For PVs, the new NPEC until 2030 sets as target to have a capacity of 7.7 GWp, which means that the current capacity should be increased by approximately three times. These PVs should generate 12.1 TWh of electricity, an expected share of more than 21% of the total electricity generation.

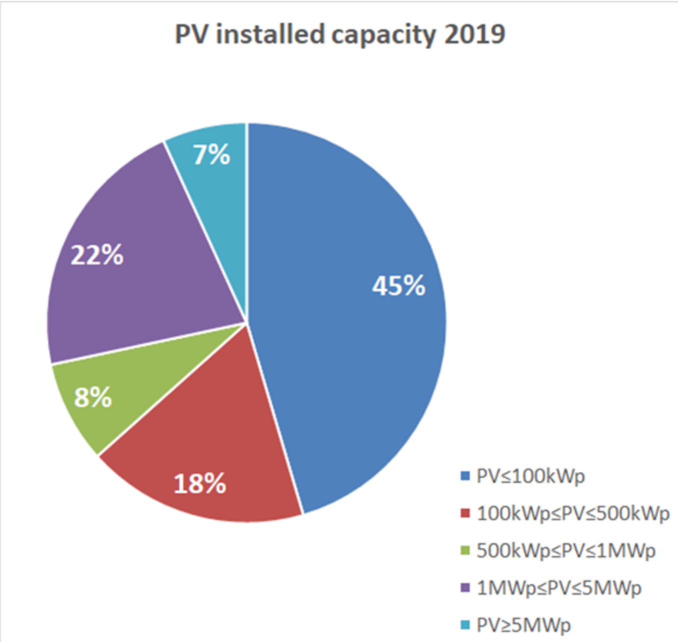

Figure 20: Distribution of installed PV capacities based on the size of the plant (October 2019).

3.2.3 Israel

The use of solar energy in Israel began in the 1950s with the development of a solar water heater to address the energy shortages that plagued the new country. Israel is one of the world leaders in the use of solar thermal energy per capita [7]. As of the early 1990s, all new residential buildings were required by the government to install solar water-heating systems, and Israel's National Infrastructure Ministry estimates that solar panels for water-heating satisfy 4% of the country's total energy demand. Israel is among the per-capita leaders in the use of solar hot water systems with over 90% of homes using them. The Ministry of National Infrastructures estimates that solar water heating saves Israel’s 2 million barrels (320,000 m^3) of oil per year. Nevertheless, solar energy production rate was very low until the policy changed several years ago. In 2002 the government in Israel set for the first time a substantial goal for the installation of RES. The goal which was set determined that by the year of 2007 2% of the supplied energy will be from RES and 5% by the year 2016, most of which by PV solar plants. This goal was changed in 2017 and the bar was set for 13% until 2025 and 17% until 2030. So far, at the end of 2019 Israel is far from the declared goals, as shown in Figure 21.

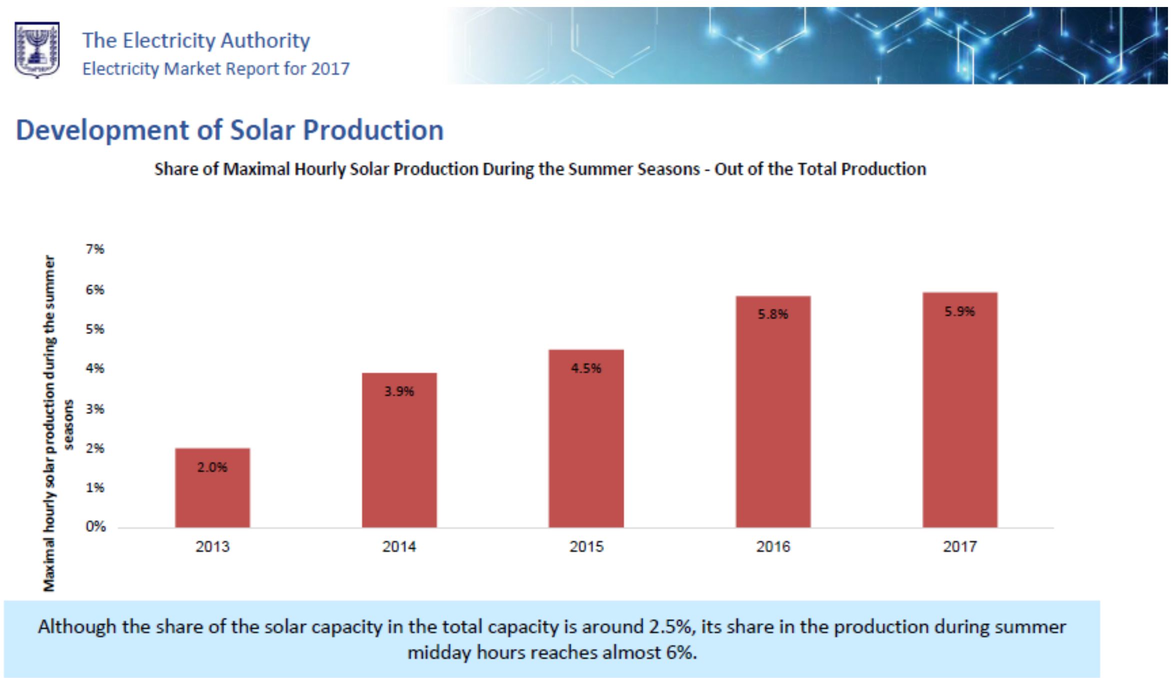

Figure 21:Development of solar production; Maximum hourly solar production during the summer seasons.

In 2018, the PUA published a new 1800 MWp rooftop regulatory framework for the next three years. The scheme included net-metering, FITs for small-scale solar, and a series of tenders. The scheme regulates the PV installation on household roofs, commercial and industrial facilities, public buildings, parking lots, pergolas, water reservoirs and fish ponds. Under the new framework, PV projects up to 15 kWp will be eligible for net-metering, or apply for a 25-year FiT (not indexed to inflation) of 0.48 ILS/kWh. Furthermore, the framework will support PV systems ranging in size from 15 kWp to 100 kWp, with a 25-year FIT of 0.45 ILS/kWh (not indexed to inflation). The framework entails a series of tenders, while the minimum capacity to be allocated in a single tender will be 50 MWp. A participant can either sell all electricity to the grid at the winning tariff, or sell the electricity to other consumers who are connected to same solar rooftop. Lastly, the PUA permits the installation of PV outside of the framework for self-consumption with a low tariff of only 0,16 ILS/kWh for the surplus. This is a major change of PUA rules, as in Israel the bilateral sale of renewable electricity was not allowed prior to the introduction of these new provisions. Quota for net-metering were finished in 2018 and are not expected to be extended.

In the recent years, several large PV projects became grid connected. Solar plants of 60 MWp in Mashabei Sadeh and 120 MWp in Tzeelim were operated in October 2018 and 2019 respectively. Two more projects, the largest Concentrated Solar Power (CSP) fields in Israel, 242 MWp in total, located at Ashalim (Figure 22), were inaugurated in September 2019.

Figure 22: Ashalim Solar Power Plant

Combined with other projects in development, PV installations in 2019 might reach 700 MWp. During 2018, several steps were taken to simplify new PV construction and strong incentives were given to rooftop PV, as it is the easiest and quickest to install (in comparison to solar fields). As shown in Figure 23, the rooftop efforts are expected to yield approximately 480 MWp in 2019.

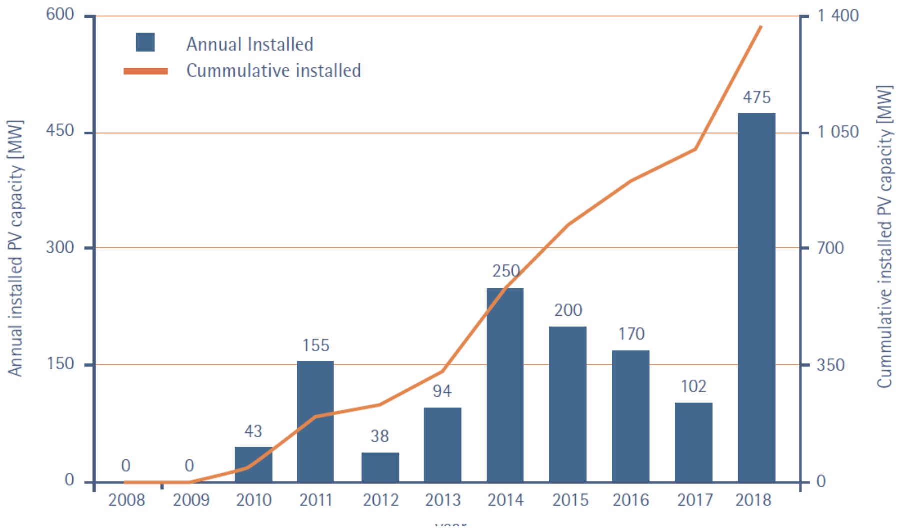

Figure 23: Annual installed PV capacity in Israel.

3.2.4 Italy

In the past ten years, the number and capacity of PV plants in Italy grew at a very sustained pace. From January 2009 to July 2013, new PV systems with minimum capacity of 1 kWp were eligible for installation under the Italian Feed-in-Tariff (Conto Energia). With the end of these incentives, the rate of new PV installations in Italy has declined compared with the previous years, with the majority of solar being added through the Italian net-metering scheme. Nevertheless, a positive trend is expected in the next years. In fact, the New Italian RES Decree 2019 defines new incentives scheme for RES.

According to the Gestore Servizi Energetici (GSE) [8], the state-owned company responsible for the promotion of RES and implementation of support policies in Italy, by the end of 2018 more than 822,300 PV plants were installed, for a total power capacity of 20.1 GWp (Figure 24).

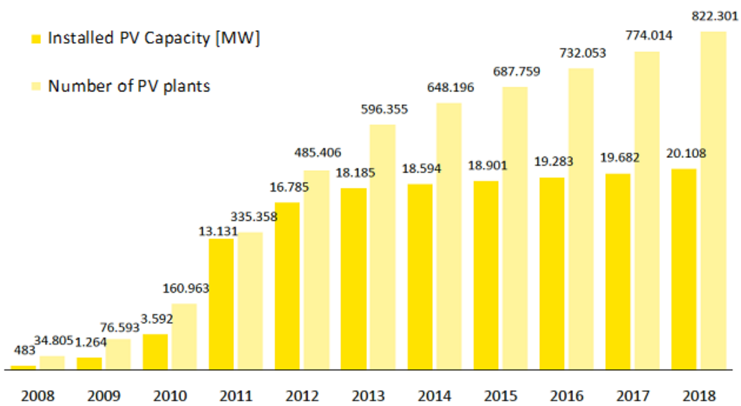

Figure 24: PV total installed capacity and number of plants in Italy.

During the year, the PV plants generated 22,654 GWh (-7% compared to 2017, mainly due to worse irradiation conditions). This corresponds to solar PV systems covering 8% of the country's electricity mix.

In Figure 25 the distribution of power plants subdivided by nominal capacity is reported, highlighting that the majority of power plants have small size. Small plants (power less than or equal to 20 kWp) make up about 90% of the total in terms of number and 21% in terms of power; the average size of the plants is 24.5 kWp. The vast majority of power plants installed are connected to the low voltage network (97.5%). The remainder, consisting of around 20,000 plants, are connected to the medium voltage. Finally, a small number of installations is connected to the high voltage network.

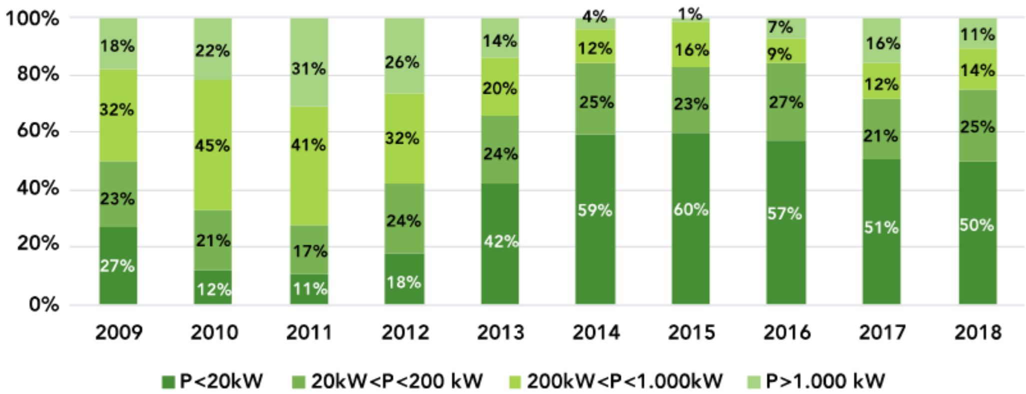

Figure 25: PV distribution per nominal capacity in Italy.

PNIEC indicates the generation trend between 2017 and 2030, while for installed power the expected values for 2025 and 2030 are shown. Figure 26 shows the expected trend of generation from Solar source and the installed power in the development scenario presented by the PNIEC. It can be seen that the expected contributions from PV stand out (+30 GWp). For the generation from solar sources, an average annual growth rate is forecasted, in the medium term, equal to +1.5 TWh/year, accompanied by about 900 MWp of new installations every year. Even more accentuated is the increase that is expected between 2025 and 2030: the average annual growth rate of installations must be equal to +4.8 GWp/year, while generation will have to grow, on average, by 7.6 TWh/year in the long term.

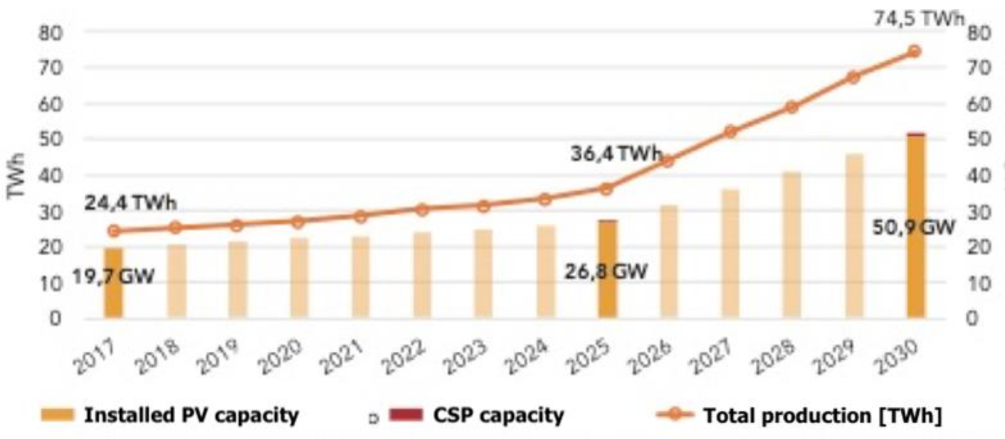

Figure 26: Expected trend of the RES generation in Italy.

3.3 Energy storage system

3.3.1 Cyprus

Cyprus relies on a traditional isolated distribution grid that is heavily dependent on imported fossil fuels. The further increase of RES penetration combined with the absence of energy storage and DR schemes poses significant challenges that are crucial for the power network. Therefore, mitigation actions should be taken in order to avoid issues related to grid stability. In addition, an open energy market is not currently available in Cyprus and no policies are available for active customers. Instead, customers only have the right to generate, as they are currently unable to store, sell or provide services. Net – metering is a significant barrier for the deployment of residential energy storage, as under the specific scheme the electricity network can be utilised as a virtual and ideal storage of the excess production. Moreover, despite that there are Time of Use (ToU) tariffs available, these are only limited to industrial and commercial applications. Finally, the vast majority of the buildings are equipped with standard power meters instead of smart meters. Currently there are 10 residential ESS pilots installed in Cyprus, while another 5 pilots will be implemented in the near future. The aforementioned pilots are equipped with a battery energy storage system (BESS) of 2.5 kW/9.3 kWh usable capacity, which is AC coupled to a 3 kWp PV system. In addition, a BESS system of 15 kW/27.9 kWh usable capacity and AC coupled to a 12 kWp PV system, has been installed on a public building. More specifically, the new Nicosia town hall was selected as a pilot due to it bioclimatic design principles, which are a step forward towards nearly zero–energy buildings (NZEBs).

According to the regulatory decision 03/2019 of CERA, which was taken on 05/07/2019, Cyprus should follow the Directive (EU) 2019/944 of the European Parliament and the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast), in which the common rules for the generation, transmission, distribution, energy storage and supply of electricity, together with consumer protection provisions are stated. The directive aims at integrated, competitive, consumer – centred, flexible, fair and transparent electricity markets in the EU. More specifically, CERA's regulatory decision includes Front-the-Meter (FtM) energy storage without on – site consumption for services' provision to the grid. In addition, it was decided that energy storage assets will not be required to pay for network usage fees during their charging cycle. Moreover, in the same decision the CTSO is invited to submit plans to CERA for the modification of the regulations, for the non – discriminatory participation of FtM ESS by 31/07/2020, which will provide the ability to FtM ESS to fully participate in all the markets, such as day – ahead, flexibility market, capacity market, etc. by both energy injection and absorption.

In summary, 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 BESS is not favourable, especially in residential installations.

3.3.2 Greece

Energy storage in Greece is mainly implemented by hybrid power generation units and in most cases by Pumped-storage hydroelectric (PSH) power plants. There are two main PSH units in the Greek interconnected transmission network. The first is located in Sfikia-Veroia in the northern part of Greece with installed capacity equal to 315 MW and the second one near to the city of Drama (northern-eastern part of Greece) with an installed capacity of 384 MW. However, these pumping stations that belong to the Public Power Corporation (PPC) are not operative as of July 2019, and are used only as traditional hydro plants.

Concerning pumped-hydro, there is increased interest in the development of new installations, which are costly and complicated in general. The latest installation of a pumped storage clean energy plant is the project "Naeras" and constitutes one of only two hybrid energy projects in Europe that combine wind and hydraulic power. The plant has been installed in Ikaria Island and is operating since June 2019. It consists of a wind park with a total of 2.7 MWp capacity, one small hydroelectric plant with 1.05 MWp turbine, another small hydroelectric plant with two turbines and a total capacity of 3.1 MWp, two reservoirs of 80,000 m^3 of water, which will serve the needs of the pumped water for the storage of wind energy and a water reservoir of a total volume of approximately 910,000 m^3, and finally 3MW of pumping power.

Other planned pumped-hydro installations include a 680MW (production) – 730MW (pumping) station in Amphilochia, and a hybrid pumped-hydro station in Amari Crete of 89MW wind power, 93MW hydro plant and 140MW of pumping power.

For other ESS technologies, the market is not significantly developed and only some pilot sites with battery storage systems have been installed during the past two years (e.g. STORES and PV–ESTIA projects).

The implementation of electrical storage systems in PV prosumers with net metering was officially introduced in 2018, along with energy communities. Following that, in March 2019 a ministerial decree set the technical specifications and conditions for operation of ESS. However, it wasn't until very recently (September 2019) that the installation of BESS has been practically possible, with the issuing of complete technical and licensing procedures by the distribution system operator (HEDNO). Thus, it is still too early to observe any results from the above legislation in real installations.

Finally, the Regulatory Authority of Energy has committed to provide a first draft of a new regulatory framework for the installation, operation and pricing of storage plants in the electricity transmission and distribution networks by the end of 2019.

All the above have been slowly setting the scene for the increase of the share of ESS in the energy mix of Greece. In fact, the updated national plan for climate and energy until 2030, issued on November 2019, has set the target of achieving 61-64% of RES in the total electricity generation. This will be achieved by more than doubling the installed PV and wind power (to reach ~15GW by 2030), and by new storage installations of 2.8GW, out of which ~1.3 GW of battery energy storage.

3.3.3 Israel

There are different means of storing energy, with the most suitable approach would be to use a mix of technologies. Some are suitable only in grid scale, like pumped hydro storage, while others are modular, for example batteries, and are applicable at different scales. Given that the primary energy source is usually heat, resulting from fuel burning or solar radiation, it is worthwhile to consider storing heat from which electricity would be produced according to demand, instead of producing electricity and storing it as such.

Besides hydro-pumped storage, other storage technologies include heat storage, fly wheel, compressed air, and electro-chemical methods, which include various types of batteries. In Israel, as in any country, there are many obstacles to implementation, not only financially, but also in terms of regulations.

According to the PUA 2017 annual report, the Israeli storage quota of 800 MW is partially fulfilled up to 644 MW only (Figure 27).

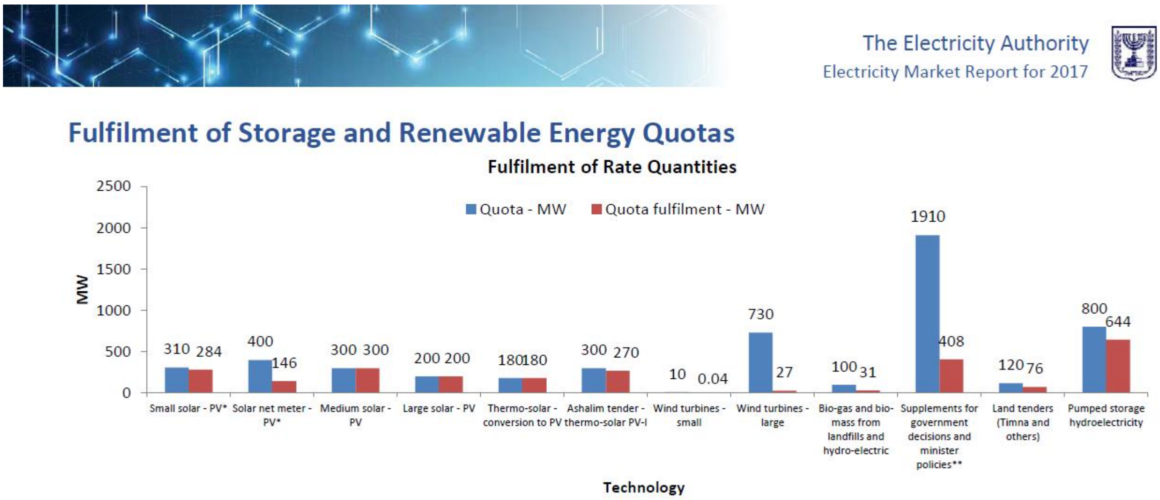

Figure 27: Fulfilment of rate quantities.

The are several major storage projects across Israel. Brenmiller Energy, a developer of advanced ESS, announced in 2018 that two storage plants will be constructed, called Rotem 1 and 2, in the southern Israeli town of Dimona at an investment of 76M ILS. The Investment Center in the Ministry of the Economy and Industry has approved a grant of 20% of the total investment, according to the company. Brenmiller's storage system is charged from various energy sources, among them sun and wind, natural gas, and residual heat, and generates a stable flow of steam for electricity production or industrial applications. The first one is due to be connected to Israel's power grid in the first quarter of 2019. Rotem 1 is based on innovative storage technology that makes possible the production of clean electricity from solar energy even at night. The other project, Rotem 2, is expected to be connected to the power grid in the second quarter of 2020. The combined cost of the two projects is around 200M ILS. The production centre in Dimona will be one of the most advanced in the energy storage industry, which is expected to grow substantially in the coming years.

Another project is the pumped-storage plant in the Manara Cliff, located in Northern Israel, south of the town of Kiryat-Shmona, with a planned capacity of 156 MW. Yet because of regulatory and financial difficulties, the project was suspended in November 2019.

Yet there are other projects, which are not based strictly on solar energy, but involve chemical phenomena to enable energy storage. The basic idea involves a pond of saline water, about 2 m in depth, which is artificially maintained so that the degree of its salinity (and consequent density) is higher at the bottom than at the surface. Absorption of solar radiation by the floor of the pond heats the lower depths of water, which are prevented from rising by their high density relative to the upper layers. Therefore, the temperature of water at the bottom of the pond continues to rise and is found to attain temperatures close to 100°C. Furthermore, since the ponds are very large - one demonstration pond, at Beit Ha'aravah, has an area of 250,000 m^2 – they can accommodate a huge amount of stored energy. The Ormat Corporation, who pioneered such ponds, developed a special low-temperature turbine which enables the hot pond water to convert an organic fluid to vapor and thus produce electricity. For the Beit Ha'aravah pond, a 5 MW turbine was built.

The thermodynamic efficiency of such a comparatively low-temperature power-producing system is very small, approximately 1% at best. Accordingly, one would expect such a pond to produce, on average, only about 570 kW of electrical power. A 5 MW turbine would therefore, at first glance, appear to be hopelessly optimistic. However, the unique feature of solar ponds, compared with all other solar technologies, is their built-in storage capacity. It takes several weeks until the pond temperature achieves a steady state at its lower depths, after which, provided one does not withdraw energy at an average rate that exceeds the nominal 570 kW on an annual basis, one can in fact achieve vastly greater power outputs for a few hours each day - typically during the morning and evening peak load periods. In effect one allows the pond to absorb solar energy during the day but only operates the turbine in the early morning and late afternoon hours. Ormat's organic fluid turbine has turned out to have such a long life-time, partly because it is a totally sealed unit, that such devices are to be found all over the world in situations where low-temperature heat sources are available and electric power is required.

The two biggest challenges in solar energy today are how to increase its efficiency and how to store utility-scale electricity at competitive prices. Until now, the only method to reliably store such energy has been thermal energy storage (TES) which is combined with CSP. Yet, while the demand for CSP is increasing, the combined production and storage cost is still much higher than photovoltaics. A patented method combines the strengths of CSP and PV technology. Using a Luminescence Solar Power (LSP), the ground-breaking scientific methodology promises to deliver clean, storable energy at record low costs. The method uses photoluminescence to separate the thermal portion and the free energy portion of each single solar photon. The free energy is harvested by PV while the heat, that is 50% of the energy and which reaches 600°C, is converted to electricity using a turbine at 40% efficiency, which doubles the overall efficiency. The team is now demonstrating the technology in a real environment, building a 0,1 MW demonstrator with double efficiency that is more than with conventional CSP. The research is led by Prof. Carmel Rotschild from the Excitonic Lab at the Technion.

3.3.4 Italy

The energy storage question arises quite naturally due to the high penetration of renewables in the Italian power system. However, another reason why energy storage has emerged in energy discussion in Italy is the large number of net-metered installations. The Law Decree 91/2014 increased the upper limit for net-metered systems from 200 kW to 500 kW per installation. Based on the GSE data, at the end of 2015 there were approximately 520,000 generation plants using net-metering, corresponding to approximately 4.47 GW of installed power capacity. Of those 520,000 plants, about 96% are installations smaller than 20 kW, and most of them are PV systems.

The approximately 7 GW of installed storage in Italy is almost entirely attributable to hydroelectric pumps. The other part is represented by small pilot projects:

- 75 MW are already operational projects, and in TERNA’s design phase, they employ electro-chemical and electrical types (Li / ion, Na / NiCi, Flow, Supercaps) for a total investment of over 250M €;
- 4 to 8 MW are referred to domestic "batteries" (from 2,000 to 3,000 units);

In September 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. Two months later, in November 2015, 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.

Moreover, storage installations as a retrofit of existing residential solar array are starting in the North of Italy, opening the opportunities of a domestic market.

The cumulative number, power and nominal capacity of energy storage systems installed in Italy (data of March 2019) are shown in Figure 28.

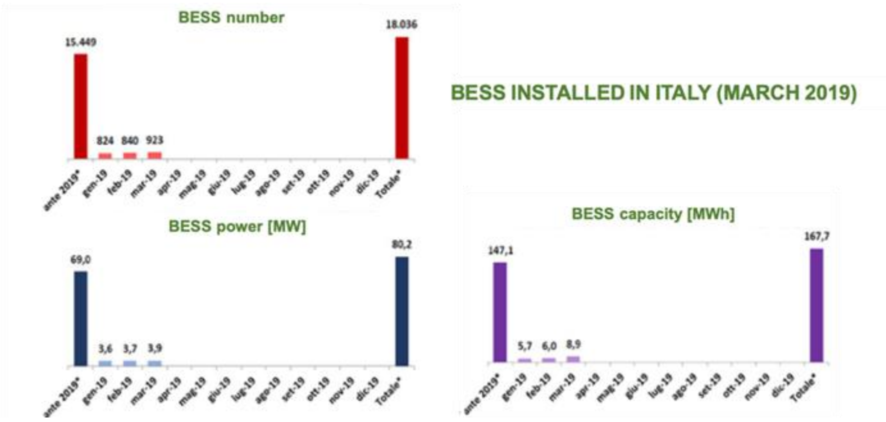

Figure 28: BESS installed in Italy (March 2019).

In some regions, new schemes have been launched to promote residential BESS, including 50% subsidy on the purchase cost, and an income tax deduction. Examining the regional data shown in Figure 29, it can be seen that Lombardy is the region with the largest number of systems installed (6,414 BESS for a power of 25.6 MW and capacity of 49.7 MWh) thanks to the two calls for tender with a loan of 9M € in total and the "fly" effect they created. The number will tend to grow in 2019 and 2020 thanks to 3.4M € (up to 4.4M € depending on the regional budget) allocated with the recent trend. The Veneto Region registers with 2,668 BESS for a power of 11.6 MW and a capacity of 19.3 MWh which will see further development thanks to the regional tender of 2M €.

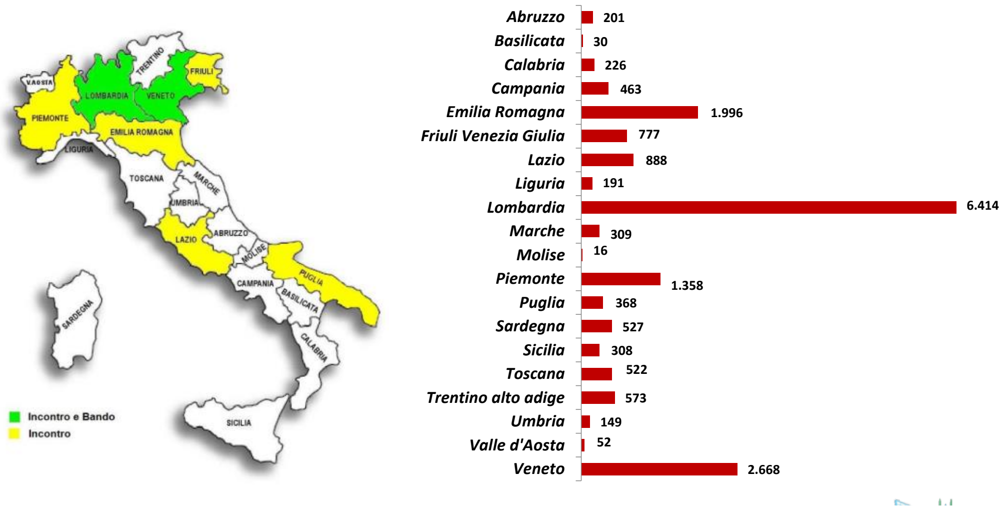

Figure 29: BESS distribution per region in Italy (2019)

By comparing installed residential PV systems (450,000, incentives and non-incentives) and the coupled BESS, it is estimated that only 2.6 out of 100 PV plants are equipped with a storage system. Referring to the technology adopted, the majority are Lithium Ion batteries (Figure 30), and with capacity smaller than 20 kWh (Figure 31).

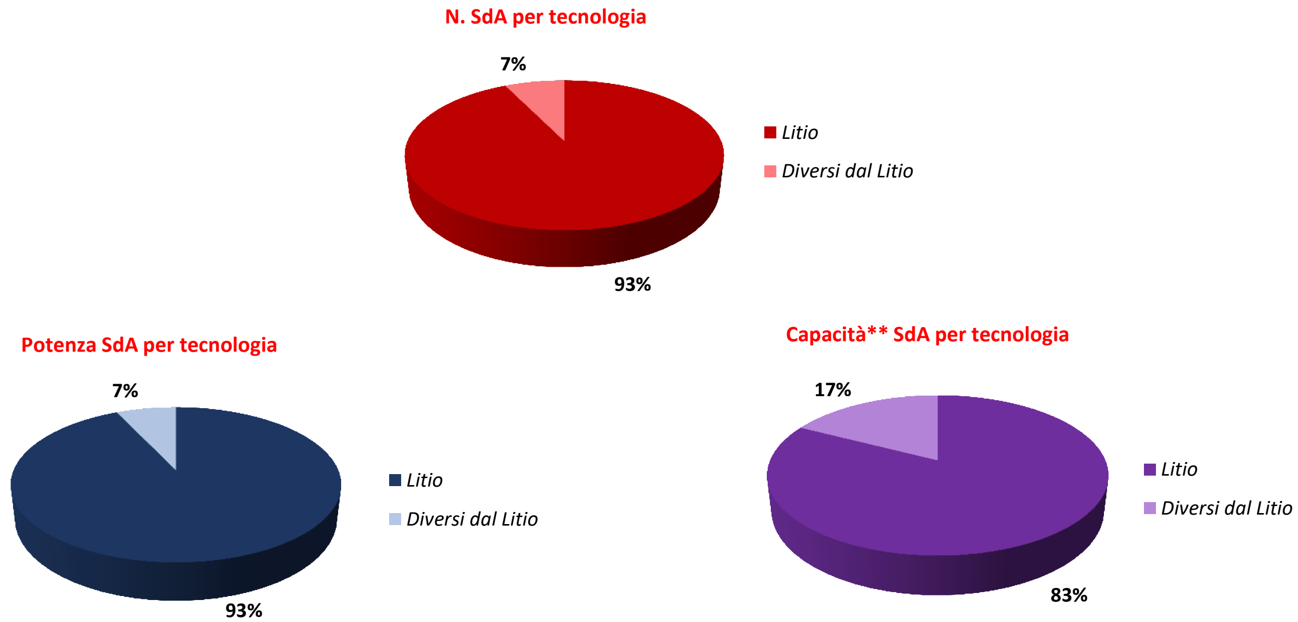

Figure 30: BESS distribution per technology.

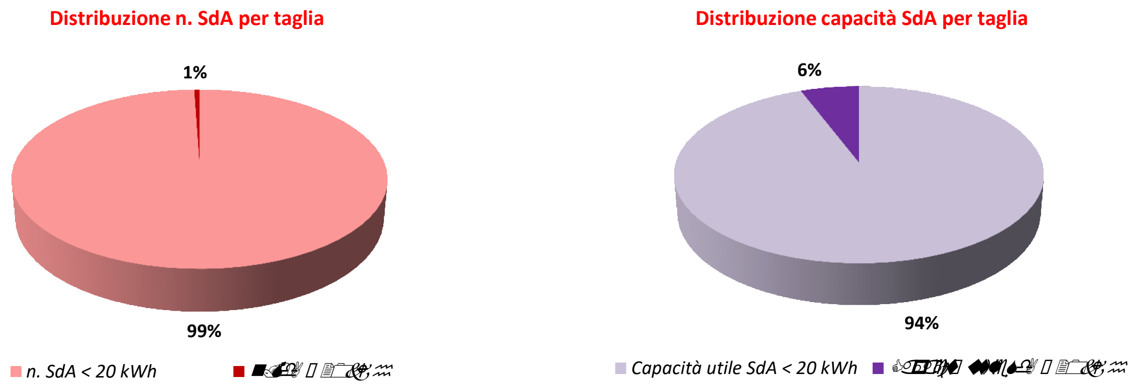

Figure 31: BESS distribution per capacity range.

3.4 Demand – side management

3.4.1 Cyprus

Currently in Cyprus there are no schemes or policies available for aggregation and DR. In addition, dynamic pricing is not available. Instead, there is mainly a flat – rate pricing, at predefined regulated prices. Moreover, the ToU tariffs are limited to two blocks per year.

The scarcity of land that Cyprus is currently facing, in combination with the high solar potential of the island shall steer the focus towards local energy generation and on the demand – side, thus the buildings.

Policies or regulations considering citizen energy communities, such as microgrids and nanogrids, have not been established in Cyprus so far. In addition, smart metering is not applicable yet, however, it is expected to be adopted within the next decade.

The design and implementation of micro- and nanogrids aiming at performing DSM have been investigated through research programs in Cyprus, including Pegasus, GoFlex and Apollo. Through Pegasus, a nanogrid has been designed based on the current infrastructure available at the University of Cyprus (UCY), whereas GoFlex offered a flexibility platform for aggregators that can be used for avoiding scenarios such as overloading of the grid. Finally, Apollo is an ongoing project that aims in performing demand – side management on the UCY's network, which will have the architecture of a microgrid. A total PV capacity of 5 MWp and 2.35 MWh battery storage will be installed in the first phase of the project, which will be expanded to 10 MWp and 7.5 MWh in the second phase, respectively.

3.4.2 Greece

Demand side management and demand response is not widespread in Greece, mainly due to the lack of available programs or incentives to the electricity consumers. One of the main reasons for that is the still low penetration of smart meters at the low-voltage level, in spite of the previously announced plans. Due to this fact, there are no dynamic electricity tariffs available at the moment, and thus not adequate incentives to consumers to alter their behaviour. Another reason for not having dynamic pricing in Greece is the fact that typical load profiles for average consumer types are not available or widely accepted by retailers, and thus dynamic pricing cannot be available without a smart meter.

The new NPEC that has been announced in December 2019 sets DSM and DR as a priority. This applies not only for large industrial consumers, but also for all consumers, either individually or through an aggregator. The NPEC sets as a goal to design specific schemes and measures to support demand side management and demand response, in order to enhance security of electricity supply in the new environment without coal power plants (Priority PP4.4 for energy security).

Currently, the main options available that can be considered relevant to DR or DSM are the following:

- Two-zone tariffs at low voltage (LV) or medium voltage (MV) level are available (ToU energy price) for electricity consumers. The two zones are constant and correspond to day tariff (peak) and night tariff (off-peak). The exact period changes twice per year (summer and winter). In order to be billed under this ToU tariff, one has to install a special meter.
- An interrupt mechanism exists for high demand consumers, in order to face the (rare) problems in electrical power adequacy. Auctions are held once per year, and only certain high demand industries may participate, getting a compensation for providing this service to the distribution service operator (DSO) (interrupt length from 1h to 48h). This measure is set to disappear in 2020. A new flexibility mechanism is likely to replace it.
- Schedules from the TSO about the interruption of irrigation (that policy is under the Ministry of Development and the Regulatory Authority for Energy decisions). A yearly approximation is about 3 or 4 days maximum under requested demand reduction.
- The recent law for Energy Communities enables them to manage demand for reducing final energy consumption, but without other specific provisions. In addition, Energy Communities could enter into partnership agreements with network operators to exploit technologies such as demand response through digital platforms.
- Demand side management as a service appears also as a means to manage the power flows by the TSO. The TSO can establish contracts with entities offering services based on DSM, only when this is required for the provision of ancillary services and to balance production - demand divergences when operating the system in real time.
- Units offering flexibility to the system can be systems based on demand management and/or storage. Such systems can participate in the transitional flexibility compensation mechanism (valid

until end of 2019) and get compensation for their services by the TSO. However, only flexibility service providers (enrolled in a special register) offering at least 8 MW of flexibility for at least 3 hours after notice can participate. The compensation is decided upon a call by the TSO and offers by the flexibility providers (flexibility market).

3.4.3 Israel

On 29 September 2015, Israel committed to contribute to the global effort to achieve the targets of the United Nations' (UN) Framework Convention on Climate Change. Based on the work of the inter-ministerial committee on examining the potential of emissions mitigation, the Ministry of Environmental Protection, the Ministry of Finance and the Ministry of National Infrastructures, Energy and Water submitted a joint document that defines Israel's target and was approved by the Israeli Government [9]. Below are the targets of the Israeli Government, as they were defined:

1. Energy Efficiency (EE) – a reduction of 17% in the total national electricity consumption compared to the projected consumption in 2030 without assuming additional energy efficiency actions.
2. Renewable energy – 17% of the national electricity consumption will be provided through renewable energy in 2030.
3. Public transport – transition of 20% due to use of public transport instead of private vehicles.

The plan specifies the steps each sector is required to take, defines priorities and demonstrates the actions the Ministry of National Infrastructures will lead, and recommendations for future actions required to boost the EE trend in the Israeli economy.

The PUA set a number of regulations to advance DSM and EE, mainly focusing on the demand to reduce consumption during peak hours. The regulation includes operations such as ToU, initiative reduction, and more. The goals include the reduction of at least 17% of the electricity use by the year 2030. In recent years the Ministry of Energy and the Ministry of Environmental Protection unprecedented calls for proposal for EE actions in the public and private sectors, such as securing a budget of 300M ILS for 5 years to advance DSM and EE projects.

Among others, Israeli authorities promote the use of a smart grid, as it is a crucial component in the preparations for integrating electrical vehicles in large numbers in the near future. Upgrading the existing electricity network to a smart grid involves major challenges, both in the physical infrastructure and the information technologies. The network will be required to efficiently manage thousands of users with varying outputs and develop storage technologies for various ranges. Advanced information technologies will be implemented for the collection and analysis of extensive information in real time, via control and monitoring systems in many locations on the grid. Developing the smart grid requires significant planning and infrastructure resources, posing substantial financial and social challenges. The success of the network will require the development of new business models and management of the consumers' and energy producer's behaviour via tariff arrangements and advanced and flexible regulation. The Israeli Chief Scientist Office sees the development of the smart grid as an important milestone in the transition to smart energy, which will include combined and smart management of the consumption and distribution of the entire energy system, including electricity, gas, water and fuel.

3.4.4 Italy

Italy has one of the best examples of a successful smart meter mass-rollout strategy in Europe. The Italian regulatory authority ARERA recognised the benefits of smart metering and made the installation of smart meters mandatory in 2006. Today, more than 99% of electronic meters have already been installed in Italy. The DSO is now installing the second generation of smart meters to replace the old ones at the end of their expected lifetime of 10-15 years. A new generation of even more advanced meters is required to meet the future demands of digitalisation in the energy industry. Key improvements compared to the first-generation smart meters include 15-minute data resolution, easy access to data for consumers and faster response times for actions such as change of suppliers. The second-generation meter also acts as a smart network sensor, 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 thus 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.

Enabling flexible resources and their use by TSOs to meet their requirement for services will progressively assume a structural role on a global level. It is estimated that in 2050, DR from industrial, tertiary, residential and transport sectors (essentially due to the development of electric vehicles) in Europe may reach 150 GW. Currently, in Italy, UVAM (Virtually Aggregated Mixed Units) are enabled to provide services such as congestion resolution, balancing, and tertiary reserve. TSO's intention is to test out UVAM participation in other services (such as secondary frequency/power regulation) and to also progressively involve consumers in the tertiary and/or domestic sectors.

The spread of energy production plants from non-programmable renewable sources requires greater flexibility of the electricity system to ensure network stability. Active demand management programs ensure greater flexibility and efficiency of the energy infrastructure.

In 2020 Enel X, the Enel Group business line that focuses on innovative products and digital solutions, launches the first project of DSM in Italy, to aggregate residential storage units offering network balancing services. For the first time, residential energy storage systems will be able to offer balancing services to the electricity grid thanks to the pilot launched by Enel X, in collaboration with RSE (Ricerca Sistema Energetico). The project was launched in the provinces of Brescia, Bergamo, and Mantua and the first residential storage systems were included in the UVAM aggregates at the end of December 2019. It allows for the aggregation of residential energy storage systems in order to enable private users to participate also in active demand management programs through the UVAM aggregates. The latter units allow the distributed resources to participate in the supply of flexibility services to the electricity network; a prerogative that until recently was reserved only for large production plants or industrial loads. With this initiative, the first residential storage systems managed by Enel X, as an aggregator, are also included in the UVAM aggregates within a sort of virtual plant offering network services.

The programme, which will end at the end of 2020, already includes the participation of more than 100 PV+ESS systems. Enel X 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.

At policy level, the energy regulator ARERA (Autorità per l'energia elettrica e il gas) has been working on gradual reform to network tariff structures for households and in 2015 issued a final proposal on redesigning the tariff system for households, eliminating historical progressivity with electricity consumption that was introduced in the 1970s as a first energy efficiency measure. From 2017, network tariffs for households became linear, cost reflective (largely capacity-based) and homogenous for all low voltage users (households and business customers), providing the right incentives for energy efficiency and self-consumption. From 2018 tariff components related to system charges (levies for RES support and other public interest policies related to electricity) are completely linear, with holidays houses paying a higher fixed yearly amount than primary residence homes (mirroring a differentiation widely used in the Italian fiscal system).

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 II, are used for defining attributes of the available support schemes in each region.

Table II: 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 III lists all the parameters for each participating country.

Table III: 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.

		Cyprus	Greece	Israel	Italy
	Maximum timeframe for compensation	One year	Three years	None	None
	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).

4.1 Cyprus

In an effort to initiate the promotion of PV systems in Cyprus, the FiT support scheme was introduced for both stand - alone and grid connected systems by the MECIT under two different subsidy schemes for a maximum duration of 20 years. The stand - alone systems mainly aimed at rural and grid - isolated areas. To offset the high retail price of PV systems in 2010, a maximum of 55% governmental subsidy was offered to prosumers under FiT for up to €44,000. In contrast, the policy framework regarding grid connected PV systems was divided in two pillars. More specifically, a 55% subsidy was offered to prosumers by MECIT for up to €33,000 in combination with a FiT of 22.5c€/kWh for any excess PV energy that was fed back to the grid. On the other hand, a FiT of 38.3c€/kWh was offered to prosumers with no subsidy with the whole PV energy produced fed back to the grid. Due to the low cost required for PV electricity generation, FiT was later reduced and eventually eliminated in 2013.

Due to the departure of FiT, net - metering framework was introduced by the law N.157(I)/2015 under "Solar Energy for All", which is still in effect. Under net – metering, a maximum PV capacity of 4.16 and 10 kWp can be installed for single- and three- phase systems. Moreover, a subsidy of €900/kWp was offered for the first three kWp towards vulnerable customers. Under net - metering the generated PV energy is fed directly to the grid and the net energy balance is measured through a bidirectional energy meter. The billing period is every two months, whereas the liquidation period occurs once every year.

In addition to net - metering, the self - production scheme was also introduced through "Solar Energy for All". The amendment announced in 2015 aimed at promoting self - sufficiency and the utilisation of ESS. The scheme was promoted considering that grid parity has already been achieved in Cyprus for decentralised renewable energy sources, such as small - scale PV systems. Therefore, consumers can benefit by generating their own electricity rather than buying from the grid. There is a cap of 80% for each prosumer, which can be lifted in the case of ESS installation. A 50% governmental grant can be approved for ESS; however, it is only applicable for agricultural applications.

Net – billing scheme replaced self - production in 2018, aiming at industrial, commercial and public applications. The maximum installed capacity under this scheme is limited at 40 MWp and each system should be from 10 kWp to 10 MWp, 3 - phase. Energy storage is allowed through net - billing without any regulations or guidelines being provided.

In Table IV an overview of the various policies in Cyprus is presented.

Table IV: Overview of policies in Cyprus.

	Net – metering	Net – billing	Self – production
Capacity	Up to 10 kWp	10 kWp – 10 MWp	10 kWp – 10 MWp
Beneficiaries	Residential, industrial, office, and public buildings	Industrial, office and public buildings	Industrial, office and public buildings

	Net – metering	Net – billing	Self – production
Offsetting unit	kWh (energy)	Billing (money)	kWh (energy)
Non self - consumed energy	Credited for future usage	Paid at avoid cost	No compensation
Offsetting period	Every two months	Every two months	Every 20 minutes
Liquidation period	February/March	October/November	Not applicable
Fees / Network charges (according to CERA)	€37.03/kWp (based on installed capacity), Directive: 909/2013	Based on produced kWh. 2.01 c€/kWh for low, 1.63 c€/kWh for medium and 1.31 c€/kWh for high voltage	Based on produced kWh. 2.01 c€/kWh for low, 1.63 c€/kWh for medium and 1.31 c€/kWh for high voltage
Contract duration	Residential: 15 years Commercial: 10 years	10 years	25 years (CERA licence)
Useful for:	Residential houses, commercial buildings with low consumption	Consumers with daily and/or seasonal electricity consumption variation or variations between day and night.	Consumers with constant consumption throughout the day/month/year.

4.2 Greece

The current legislation for PV installations can be classified into three main categories, summarized as follows:

- **Feed-in premiums and Virtual Net-metering:**

The main current RES law in Greece is L. 4414/2016 (OGG A' 149). The main provision is that it favours a feed-in premium scheme for systems over 500 kWp. This mechanism is based on an auction procedure, held at least once per year by the Regulatory Authority of Energy (RAE), with a predefined power capacity limit. Investors make their bids stating both the desired feed-in tariff (Reference Price - RP) and the power capacity (in MW). Starting from the lowest bidder, the accepted investors claim the available power capacity until the limit is reached. The successful bidders earn a contract based on their bids, valid for 20 years, however the Reference (or feed-in) price may be increased if the market price is higher. This is depicted in Figure 32.

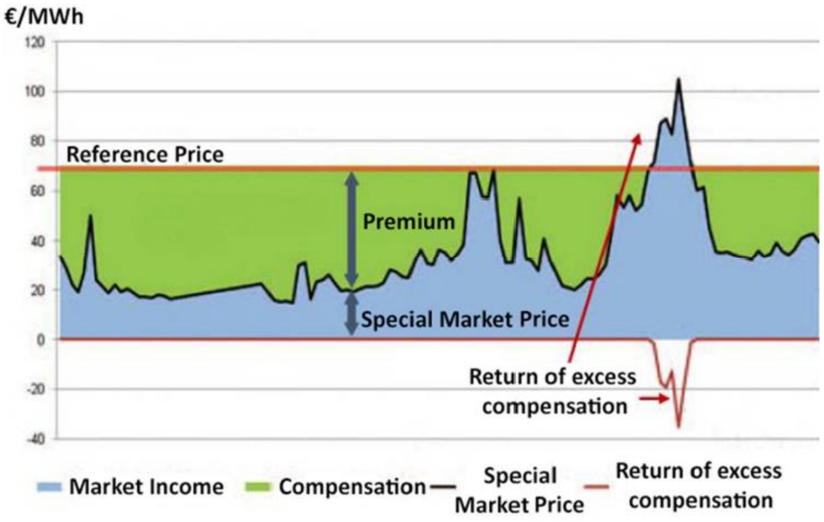

Figure 32: Feed-in premium example illustration (source RAE).

In 2019 two auctions were held in July and December, with a centrally set maximum allowed bid of 69.26 €/MWh (OGG B' 1341:18-3-2019). In July, the Reference Prices of successful bidders ranged from 67.7 €/MWh to 61.95 €/MWh and the weighted average price (WAP) was 62.78 €/MWh. In December, the bidding prices were even lower, with the lowest being 53.8 €/MWh and the majority being in the region of 60-61 €/MWh.

- Feed-in tariffs (FiTs):

After a long time waiting for the new FiTs for PVs under 500kWp, the new provisions set by Official Government Gazette (OGG) A' 45/09-02-2019 state that the FiTs are dependent upon the weighted average price of the last 3 competitive procedures for large PVs (>500kWp), plus a 5% premium. Taking into account only the last WAP of July 2019, the resulting FiT for a new PV plant under 500kWp of installed capacity would be 65.92 €/MWh.

- Net-metering:

This policy was initiated on April 2015 by a Ministerial Decision published on the OGG B′3583/31.12.2014 and has been updated since then mainly by OGG A' 9/23.1.2018 and OGG B' 759/5.3.2019. Net-metering is a three-year offset between the energy produced by the PV system and the energy consumed in the installation of the prosumer. Net-metering is applicable in both ICN and nICN electrical networks, as follows:

- Considering the ICN network, the maximum PV installed capacity is limited either to 20 kWp or to the 50% of the agreed power of consumption of the installation (in kVA), if it exceeds 20kWp. Nevertheless, in case of either governmental or non-governmental not-for-profit organizations, the capacity of the PV installation can reach up to 100% of the agreed power of consumption of the installation.

In the second case of the nICN network, PV system capacity is limited either to 10 kWp or to the 50% of the agreed power of consumption of the installation (in kVA), if it exceeds 10kWp. For the islands of Crete and Rhodes the above power quantities are higher. In any occasion, the overall PV power cannot exceed 100 kWp for Crete and Rhodes, 50 kWp for the islands of Kos, Lesvos, Chios, Santorini and Samos, and 20 kWp for the rest nICN network.

The net metering contract between the prosumer and the electricity supplier is valid for 25 years, starting from the date of the PV system connection.

The maximum eligible PV capacity operating under this scheme has increased recently to 1 MWp for medium voltage installations and 100 kWp for low voltage ones. Net-metering has expanded since March 2019 to other technologies as well (small wind plants, biomass, biogas, small hydro, etc) and hybrid technologies. It may also include storage systems up to 30kVA. The current framework allows virtual net-metering also, but only for public entities, professional farmers and energy communities.

As of September 2019, a total of 1245 installations have been connected under the net-metering scheme with a total PV capacity of 24 MWp. Out of them, around 50% are systems under 10kWp, probably installed in buildings.

- Storage:

Until recently, energy storage systems appeared in Greek legislation only when referring to hybrid power plants, which are a combination of a renewable energy system and a storage system. More specifically, a hybrid station (HS) is a unit that:

- Uses at least one RES technology
- The annual energy consumed from the grid is not more than 30% of the total energy, which is consumed for charging the energy storage of the station
- Maximum RES generation capacity cannot exceed the 120% of the installed energy storage capacity

Within this framework, the Greek RAE issued in recent years several licenses of HS, with a total capacity of about 200 MW in some large islands (Crete, Rhodes, Lesvos), accompanied by detailed pricing produced energy, different for each island, depending on the average annual variable costs of conventional peak units.

This situation has been changed by the recently published law (L. 4513-28/01/2018, OGG A' 9) regarding the energy communities, where the implementation of electrical storage systems in PV prosumers with net-metering is introduced. This was the first attempt set by the Greek Government for the wide integration of the energy storage systems in the grid.

With a Ministerial Decision in 2019 (OGG B' 759-5/3/2019), the installation of energy storage systems up to 30kVA alongside systems operating under net-metering has been allowed. The power capacity of the storage system should not exceed that of the RES system. In addition, no exchange of power should happen between the storage system and the grid.

The Greek DSO (HEDNO) has issued on September 2019 a set of Q/A targeting the prosumers that aim to install energy storage systems alongside RES. Both AC and DC coupled systems are allowed.

- **Energy metering:**

In the LV network PV net-metering installations, use 2 energy meters according to the following arrangement illustrated in Figure 33.

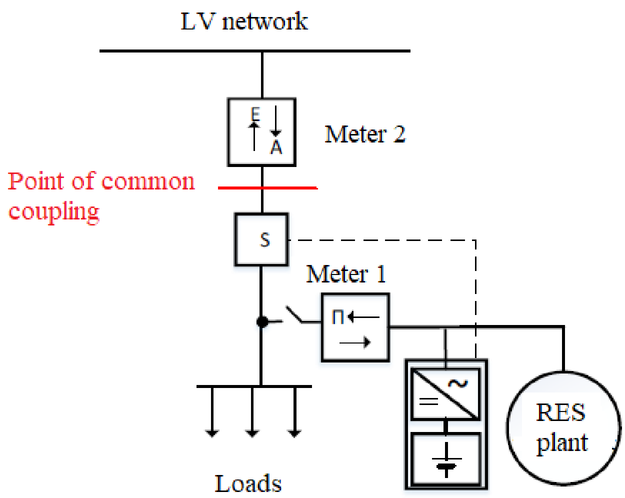

Figure 33: Low Voltage PV net-metering installation with storage under AC-coupling (adapted from HEDNO).

The main energy meter is installed by the DSO at the point of common coupling. It is a 4-quadrand meter capable of measuring both the imported and exported energy.

At the PV system connection point a second meter is installed, in order to measure the generated PV energy.

- **PV System Protection**

The DSO has the following technical specifications for the protection settings of PV system:

Voltage Protection Settings	+15% / -20% of nominal Voltage (230V)
Frequency Protection Settings	+-0,5 Hz in Mainland and IC Islands -2,5 Hz/+1,5 Hz in NIC Islands
Protection Time Setting	0,5 sec.

Reconnect Time Setting	3 min
Maximum THD DC current diffusion	5% Less than 0,5%
Anti-Islanding Protection	VDE 0126 or equivalent Maximum time 5 sec.

The same technical characteristics apply for storage inverters as well.

4.3 Israel

The Israel energy market is going through substantial changes in the last three years and especially because of the exploration of the Natural Gas off the shore of Israel. In the last three years, Israel is changing from centralized energy production from fossil fuels to decentralized production of renewable energy, which mostly concerns solar PV [10].

The goal of the ministry of energy is defined in the ministry website [11] as follows: “The Ministry of Energy acts to develop and integrate renewable energies into Israel's energy sector, in accordance with the government's decisions and with the goal of achieving energy security and independence for Israel and protect the environment by reducing greenhouse gas emissions and air pollution.” Achieving these goals contributes to the development of the Israeli technology industry and innovation, and to the development of sources of employment, especially in the periphery.

In order to achieve the ministry goal, Israel is promoting two parallel routes:

1. Diversifying the energy use by establishing Natural Gas power stations and privatizations of part of the power stations.
2. Encouraging the use of renewable energy sources mostly solar PV.

4.3.1 The energy sector reform

The electricity sector in Israel is almost entirely controlled by the Israel Electric Corporation Ltd. (the “IEC”), which constitutes a vertical monopoly that operates throughout all of the sector’s segments - generation, transmission, distribution, supply and system management. Although in recent years there has been a process of unlocking the generation and supply segments to the competition by granting licenses to Independent Private Producers, de facto, the Company still produces approximately 70% of the electricity and provides consumers with approximately 85% of the electricity in Israel. After more than 20 years of negotiations for a large-scale structural change in the IEC, which aimed reforming the electricity sector, on May 17, 2018, the Minister of Energy signed the “Document of Principles for Structural Changes in the Electricity Sector and the Israel Electric Corporation” (the “Reform”). A Letter of Undertaking from the IEC was attached to the principles document, in which the IEC undertook to comply with the principles specified, subject to satisfaction of certain conditions. On June 3, 2018, the Israeli Government passed a decision approving the details of the Reform, in accordance with the principles document (the "Government Resolution"). This recently agreed Reform heralds' great opportunities for new investors in the energy market in Israel and is expected to have a significant impact on the electricity sector and the economy in general. The principal objective of the Reform is to increase competition in the electricity sector, with this objective being achieved through the following actions:

- Reducing the Company's share of the generation segment through sale of power stations.
- Separating the system management activity and transferring it to a separate government owned company.
- Opening the supply segment to competition.
- Focusing and increasing the Company's activity in the transmission and distribution segments.
- Improving the financial strength of the Company and adopting an efficiency model in the Company, primarily by reducing the number of employees.
- Reducing the use of coal-fired power stations by the Company.

It is important to note that the implementation of the Reform is still conditional upon legislation, inter alia, through the amendment of the Electricity Sector Law 5756-1996 (the "Electricity Law"), promulgation of secondary legislation and updated regulations of the Electricity Authority and entry into force of the collective agreement with the Company's employees. We note that the Memorandum for Amendment of the Electricity Law in accordance with the Reform, has already been published for public hearing (The Reform in the Israeli Electricity Sector, June 2018, Meitar) [12].

In the generation segment, the IEC will reduce its activity in the production through the sale of existing power stations. The IEC will be permitted to construct two-generation units subject to certain reform.

Over the period of five years, the IEC is required to sell about half of its Natural gas fired stations with total capacity of 4,500 MW. The sale includes the infrastructure and connected land. The sale will be done in a way of a tender, as described in Table V.

Table V: Sites to be sold by IEC.

Name of site	Last date for delivery of possession*
Alon Tavor 600 MW	18 months from the Government Resolution Date**
Ramat Hovav 1,137 MW	30 months from the Government Resolution Date
Reading 428 MW	36 months from the Government Resolution Date
Hagit (the part of the site that contains an E-type combined cycle area), approx. 697 MW	48 months from the Government Resolution Date
Eshkol 1,693 MW	60 months from the Government Resolution Date

* These dates will remain in effect as long as the legislation required in connection with the Reform has been passed by November 30, 2018.

** Government Resolution Date: 03/06/2018

Once the Reform has been implemented, IEC's market share of installed capacity in the generation segment will decline from about 80% in 2017 to about 45% in 2026 and approximately 33% several years later.

4.3.2 The renewable energy market and policy

The Israeli renewable energy market was formed in 2002 when a governmental decision set a national goal of 5% renewable energy electricity production to be reached by 2016. In 2009 the goals were changed and an operative governmental decision has set a goal of reaching 5% production of electricity from renewable sources by 2014 and 10% by 2020. Those goals were translated by the Ministry of National Infrastructures to an installed capacity goal of 2,760 MW by 2020.

Implementation begun by 2007, when tenders, for two large-scale CSP plants and a large-scale PV plant, were introduced by Government. In 2008 the first regulative FiT framework was introduced for small scale PV systems setting a quota of 50 MW for residential consumers (systems up to 15 KW/15 MW quota) and commercial consumers (systems up to 50 KW/35 MW quota).

In December 2009, the quota for small-scale commercial consumers was exhausted and in August 2010 a new quota of 120 MW was introduced alongside with an unlimited quota for residential consumers (2011 only). A new governmental decision in 2011 has set a quota of 110 MW for the years 2012-2014.

In January 2010 a FiT regulative framework for medium-size installations, for rooftops and ground installations, was approved and a quota of 300 MW was introduced. The framework is licensed to produce electricity and a power purchase agreement to be signed with the Israeli Electric Company. A separate quota of 60 MW was approved in 2011 for medium size ground installations, which are introduced by governmental tenders.

Small-scale wind turbine FiT was also approved in 2009 introducing 30 MW quota (consumers up to 15 KW and commercial up to 50 KW turbines) and medium & large wind turbine FiT was approved in 2011 introducing a quota of 800 MW.

Large-scale plants regulative framework FiT, for CSP and PV, was approved in 2011 introducing a quota of 460 MW, of which 200 MW is secured for CSP plants and 60 MW is secured for the Timna park governmental tender, planned for mid-2012.

In addition, in 2011 a new FiT for biogas electricity production plants was introduced with a cap of 160 MW. Biomass new FiT with the cap of 50 MW and innovative technology pioneer plants cap of 50 MW were planned for 2012. But almost none was used or established. Total Quotas approved by February 2012 have reached 2.1 GW.

In January 2013, a new net-metering regulation was adopted and a quota of 400 MW was approved reflecting the financial benefit between the local irradiance and system prices.

Between 2014 and 2017 the energy market in Israel slowed down as Natural Gas was introduced to the energy mix, but on 2017 up to these days new quotas where introduces and today there are several regulations for the installation of PV:

- Small rooftops up to 15 kw/200 MGW quota with a FIT of 0.48 NIS per kWh.
- Small rooftops between 15kW to 100kW / 200MGW quota with FIT of 0.45 NIS per kWh.
- Any size of roofs with open quota for self-use.
- Large scale Roofs with more the 700kW installed – tenders are published about twice a year when the second lower bidder price set the FIT. In the last tender a FIT of 0.25 NIS per kWh was declared.
- Large scale land PV fields tenders are published about twice a year when the second lower bidder price set the FIT. In the last tender, a FIT of 0.19 NIS per kWh was declared.

4.4 Italy

The current legislation for RES installations include different support schemes, summarized as follows:

- **Premium tariff:** Renewable energy installations are promoted through a simplified purchase from GSE at a guaranteed minimum price ("Ritiro Dedicato").
- **Net-metering:** Interested parties can make use of net-metering ("Scambio sul Posto", SSP).
- **Tax regulation mechanisms:** Photovoltaic and wind energy plants are eligible for a reduced VAT of 10% (instead of 20%). This tax benefit applies to enterprises, professionals and private individuals. Furthermore, it is possible to receive a real estate tax reduction for buildings equipped with renewable energy installation from the municipality.

Only for PV plants, Italian Government defined a fiscal subtraction (equal to 50% of the investment costs, up to a maximum cost of € 96,000). This support is provided only if PV plants are installed on buildings during their renovation works. The 50% of CAPEX tax deduction, which has been one of the main drivers of the Italian residential solar market over the past years, may now also help the residential storage business to gain market shares in Italy, taking advantage of the vast amount of rooftop PV systems installed across the country in the past decade.

The net-metering SSP is a form of self-consumption that allows prosumers to offset the electricity produced and fed into the network at a certain moment with the energy taken from the grid and used. Therefore, the electricity system is used as a tool for the virtual storage of electricity produced but not self-consumed in the moment in which it is produced. The SSP can be combined with tax deductions but cannot be combined with the "Ritiro Dedicato".

Net-metering can be applied to final customers with RES plant up to 500 kW or high efficiency CHP plants up to 200 kW. It is not a physical compensation between electricity withdrawn from the grid and electricity injected into the grid, but an economic compensation between their market values. Moreover, the Gestore dei Servizi Energetici S.p.A. (GSE) recognizes a financial contribution, equal to the variable part (in c€/kWh) of network charges and of general system charges for the minimum between electricity withdrawn from the grid and electricity injected into the grid, just as if that energy hadn't used the grid. Plant operators receive credit for the produced electricity, that will be available for an unlimited period.

4.4.1 Right to Self- consumption of electricity

Self-consumed electricity is exempted from the variable part (in c€/kWh) of network charges and of general system charges, regardless of sources. Furthermore, incentives are applied also to self-consumed electricity in case of electricity produced by PV plants and in case of incentives, which have substituted green certificates.

4.4.2 New FiT (RES 1 Decree 2019)

On July 8, 2019, the Italian Government signed a Ministerial Decree that will grant new incentives to renewable energy sources (so-called "RES1 Decree"). Six years after the expiry of the fifth Conto Energia, also PV plants can again benefit from new incentives. Other sources benefitting from the scheme include onshore wind, hydroelectric and sewage gases. The scheme will apply until the end of 2021 and will provide new incentives of about €1bn per year. The Government expects that it will allow for the construction of new plants with a total capacity of about 8,000 MW and with investments estimated to be in the region of €10bn.

Under the RES1 Decree, RES plants with a nominal capacity exceeding 20 kW are admitted to the new incentive mechanism.

Projects below 1 MW will be selected based on a combination of environmental and economic priority criteria. For larger projects, the incentive will be set through a competitive bidding process open to all types of installations, irrespective of the renewable technology used.

Successful projects will receive support in the form of a premium on top of the market price. This premium cannot be higher than the difference between the average production cost for each renewable technology and the market price.

The RES1 Decree includes a clawback mechanism to ensure that the governmental support is limited to the minimum necessary: if, in the future, the market price was to move above the average production cost for each renewable technology, the selected installations not only would no longer receive a premium but they would instead have to give back to the Italian authorities the additional revenue.

In awarding incentives, the RES1 Decree gives priority to:

- plants built on closed landfills and on sites of national interest for the purpose of reclamation;

- integrated photovoltaic systems
- built on schools, hospitals and other public buildings or on rural buildings with removal of asbestos; those plants will be entitled to an additional premium of 12 €/MWh
- hydroelectric plants complying with the criteria set by the previous Ministerial Decree of 23 June 2016
- plants fuelled by sewage gas or processing fermentation residues;
- plants connected in "parallel" with the electricity grid and with recharging stations for electric vehicles (provided that the recharging power is not less than 15% of the plant's power and that each station has a power of at least 15 kW).

For power plants up to 100 kW on buildings, by participating in auctions and registers GSE (also aggregated <=1MW), new incentives are provided, and the net production quota consumed on site is awarded a premium. The award is recognized *a posteriori* provided that, on an annual basis, the self-consumed energy is higher than 40% of the net production of the plant. This bonus related to the self-consumption open new opportunities to the storage market.

The Italian Regulatory Authority for Energy, Networks and Environment (ARERA) is committed to reform the Italian electricity market and has released important resolutions aimed at developing the usage of storage. Resolution n. 574/2014 [13] defines how storage systems can access and use the electricity grid, and resolution n. 642/2014 [14] complements the n. 574/2014 by defining the grid services to be provided by storage systems. Furthermore, in 2019 the Italian Electrotechnical Committee (CEI) updated the technical requirements CEI 0-16 for HV and MV applications and CEI 0-21 for LV applications [16] to fulfil the regulations EU 2016/631, EU 2016/1388 and EU 2016/1447. These requirements define the connection diagrams of the power plants and storage systems to the grid, with relative measurement and protection systems, and the grid services required for effective integration.

Meanwhile, the government-owned energy agency GSE has published new rules for the technological improvement of existing PV installations. The new rules are intended to simplify the technical and bureaucratic procedures for the revamping and repowering of PV power systems installed under the country's FIT scheme "Conto Energia", which was closed in mid-2013. The revamping procedure is intended to restore original performance to an existing PV installation, while the repowering procedure, which includes the substitution of modules and inverters, is aimed at increasing capacity and production.

5 Barriers for further PV, ESS, and DSM deployment in MED regions under nanogrid

5.1 Cyprus

In Cyprus, the main barriers for further implementation of PV and ESS, and eventually, the utilisation of DSM through micro- and nanogrids 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 nanogrid 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 no charging/discharging from/to the grid is allowed, and hence possible profit mechanisms such as energy arbitrage cannot be implemented.
2. Still, 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 nanogrids/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 nanogrids an interesting alternative.
7. The profits for a building operating as nanogrid 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 nanogrid 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 so-called collective self-consumption. That 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 Solar resource, PV system cost and existing electricity tariffs

6.1 Solar resource

6.1.1 Cyprus

The annual global horizontal irradiation in Cyprus is shown in Figure 34. It reaches up to 1,800 kWh/m^2 in the mountainous regions, where the expected generated electricity for horizontally mounted PV systems is 1,300 kWh/kWp, considering a performance ratio of 0.75. Similarly, for urban and seaside regions, the annual global horizontal irradiation reaches 2,000 kWh/m^2, resulting in a generated electricity of 1,500 kWh/kWp for horizontal inclination, by assuming the same performance ratio.

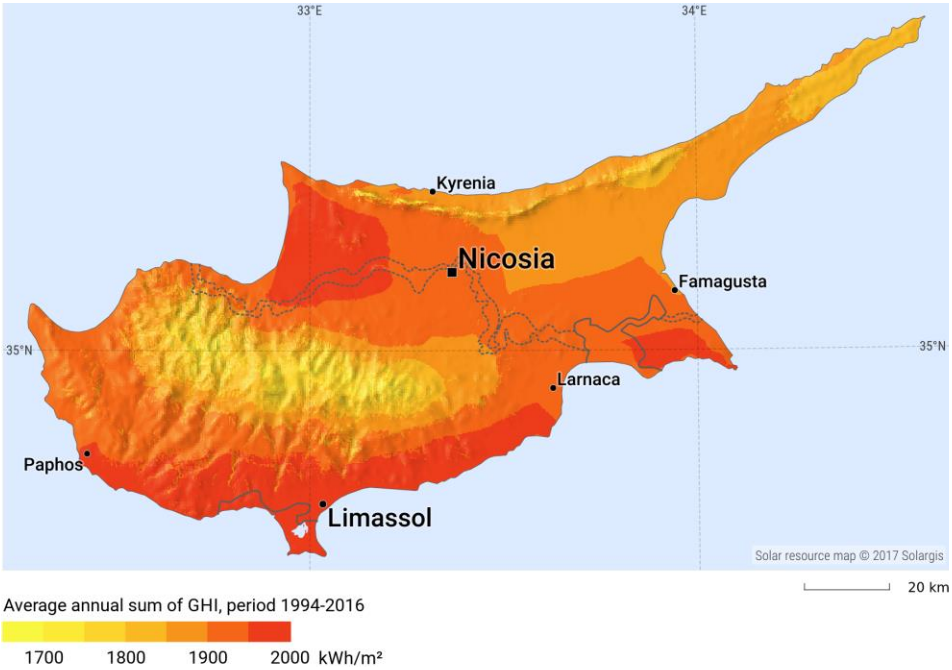

Figure 34: Annual global irradiation on the horizontal plane – Cyprus [17].

6.1.2 Greece

The annual sum of the global irradiation on a horizontal plane in Greece is shown in Figure 11. In northern Greece the solar energy potential is above 1,400 kWh/m^2. In southern Greece, including the islands, the solar power potential is considerably higher than 1,600 kWh/m^2.

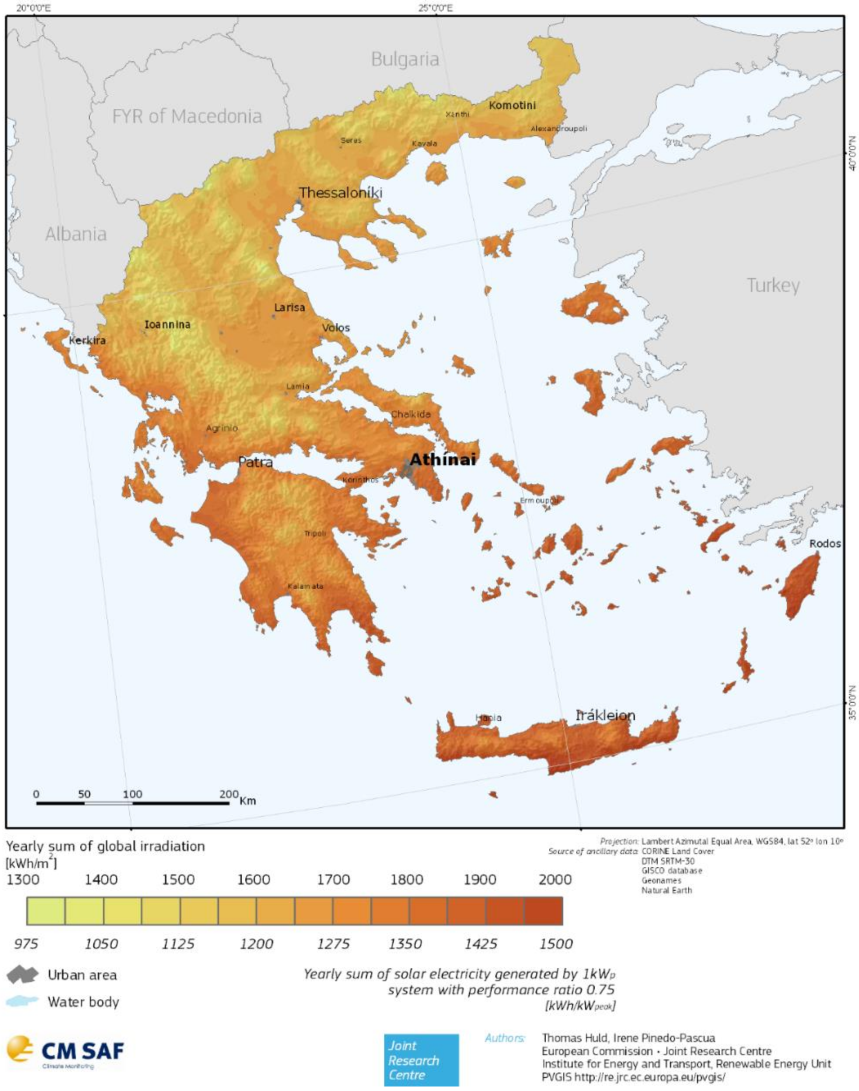

Figure 35: Annual global irradiation in Greece on the horizontal plane form (source PVGIS).

The actual energy generation from the installed PVs in Greece over the last 5 years when the PV capacity has been almost stable, may reveal the average potential for PV generation in country. The following Table shows that the average PV generation over the installed capacity is almost equal to 1500 kWh/kWp, which is in line with the solar map of Figure 35.

Table VI: Average annual energy PV generation over installed capacity in Greece.

Year	Annual Total Generation from PVs per installed capacity (kWh/kWp)
2014	1479
2015	1498
2016	1509
2017	1532
2018	1447
Average	1493

6.1.3 Israel

Solar energy has to be highly attractive for Israel, because of the abundance and strength in Israel of the sun's rays and Israel's geographic latitude location is on the 30^{th} parallel north.

The figure below shows the annual sum of the global irradiation on a horizontal plane in Israel. In southern Israel, the Negev desert and the city of Eilat area, the horizontal irradiation is up to 2330 kWh/m^2. Even in northern areas, including the mountains, the horizontal irradiation is higher than 1800 kWh/m^2.

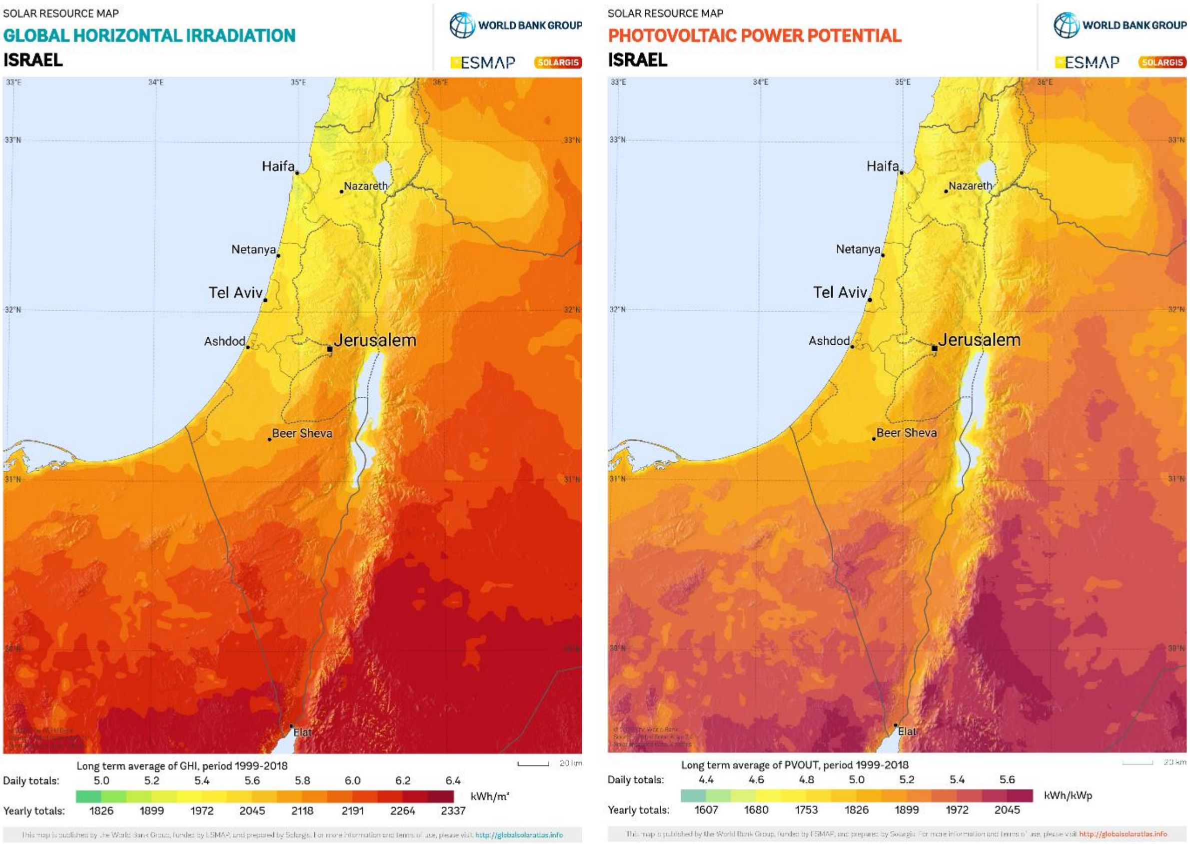

Figure 36: Annual global irradiation on the horizontal plane and PV power potential – Israel [17]

Following the impressive irradiation numbers, the solar energy potential is very high especially in the southern areas, reaching up to the 2000 kWh/m^2.

6.1.4 Italy

Italy is characterized by high potential for solar energy production, ranging from 3.6 kWh per square meter per day in the Po river (North part) plain to 5.4kWh per square meter per day in Sicily. Consequently, some regions have a production potential that is very high, however, it can be said that the entire national territory is characterized by very favourable conditions for the installation of plants for the production of solar power. The 2019 global irradiation and solar electricity potential is shown in Figure 37 [Source: EU PVGIS].

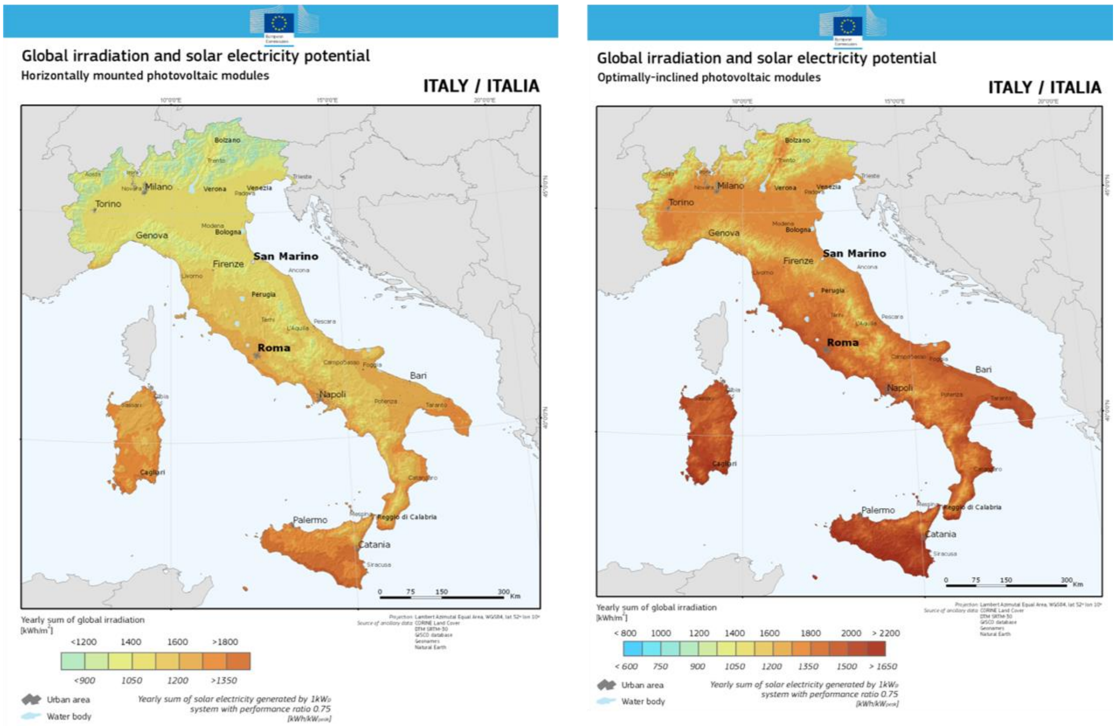

Figure 37: Map of solar irradiation in Italy in 2019. [Source: EU PVGIS].

6.2 Electricity tariffs

6.2.1 Cyprus

The cost per kWh that is currently in effect in Cyprus for domestic use is shown in Table VII, according to the pricing as of December 2019. Based on the coefficient of fuel adjustment per 1 c€, which is 4.403 c€/kWh for December 2019, and the 19% VAT the total cost per kWh is 22.13 c€/kWh.

Table VII: Electricity price breakdown per kWh in Cyprus (December 2019)

Fixed charges		
Meter reading	0.98 €	
Electricity supply	4.68 €	
Charges based on consumption		**%**
Electricity generation	9.23 c€/kWh	
Network usage	3.21 c€/kWh	
Ancillary services	0.67 c€/kWh	
Basic fuel price	300 €/MT	
Fuel adjustment charge	(Current fuel price – Basic fuel price) * Coefficient of fuel adjustment / 1 c€ 4.403 c€/kWh as of December 2019	
Public service obligations (PSO)	0.083 c€/kWh	
Fund for RES and ES	1 c€/kWh	
VAT	19%	
Cost (inc. VAT)	22.13 c€/kWh	

6.2.2 Greece

To derive the electricity tariffs presented in Table VIII, a consumption of **550 kWh per month** was assumed in a three-phase installation, which is similar to the EU household average electricity consumption. The production cost shown is that of the most common provider (PPC S.A.), which is higher than most of the other providers. The alternative providers though, depend their production (competitive) charges on the average marginal electricity price cost from the market, and hence their prices may vary considerable throughout the year. That is why we choose to depict the price of the most common tariff here, which is independent from the electricity market and target mainly low consumption residential consumers.

A major change in 2019 was the reduction of the VAT (from 13% to 6%) that reduced the overall cost but not to the extent that was originally designed. This was due to the increase in the production cost imposed by the PPC.

Another important change in 2019 was the inclusion of an added cost based on the price of CO_2 emissions in the market and a certain calculation procedure that results in a unite charge for CO_2 emissions (T_{CO2n}). If T_{CO2n} exceeds the limit of 0.01568 €/kWh, then an extra charge is imposed on the consumer. This charge is not included in Table 2 as it varies according to external parameters.

Finally, the production cost offered by alternative providers (other than PPC) is nominally lower. However, most of these providers depend their tariffs on the monthly average marginal system price (MSP) of the electricity market. In fact, the resulting cost for the consumer may vary between months, when the average MSP is higher than a certain threshold. Taking into account this and moreover the fact that PPC still holds ~71% of the market share, we do not include here tariffs from other providers.

Table VIII: Electricity price breakdown per kWh in Greece (December 2019).

Allocated Cost	¢€/kWh	%
Production Cost	11.94	58.47
Network Cost	2.92	14.29
Standing Fees	1.07	1.07
Taxes	4.19	20.53
Total Before VAT	20.11	-------
VAT	1.15	5.64
Total	21.26	100.0

6.2.3 Israel

The price of electricity is 16 c€/kWh for households and 10 c€/kWh. for businesses which includes all components of the electricity bill such as the cost of power, distribution and taxes. For comparison, the average price of electricity in the world for that period is 14 c€/kWh for households and 11 c€/kWh for businesses. We calculate several data points at various levels of electricity consumption for both households and businesses but on the chart we show only two data points. For households, the displayed number is calculated at the average annual level of household electricity consumption. For businesses, the displayed data point uses 1,000,000 kWh annual consumption.

Electricity rates should fall by about 5% or even 9% in 2020 as estimated by the energy sector specialists. The rate for next year will be set at the end of December 2019 by the Public Utilities Authority, which is the government authority responsible for setting the price for both household and industrial consumers.

Last year the Public Utilities Authority announced at the beginning of December that prices were rising by 7-8%. However, after public anger, Minister of Finance Moshe Kahlon cancelled a new tax on coal and instituted other measures resulting in just a 2.9% rise.

No such problems will confront MoF this year. The price of coal, the main factor pushing up prices last year, has fallen 40% this year, and this has been accentuated by the strengthening of the Israeli Currency, the shekel. The prices of natural gas, which also provides much of the fuel for the electricity production of the Israel Electric Corporation (IEC), has fallen from €5.8 per thermal unit in the old tender for Tamar gas to €4.4 per thermal unit in the new tender for Leviathan gas.

6.2.4 Italy

The start of 2016 represents a crossroads in the application of various Italian Authority reforms: from the new period of electricity regulation to the new 'bill 2.0'. The clearer and less complicated 'bill 2.0': one single page with all the basic elements of costs and supply clearly highlighted, with a more straightforward, modern format and simplified terms.

The Authority intervention, decided upon at the end of a complex consultation process lasting over a year, also more than compensates, with reference to the average domestic customer, for the effects of the first stage of the domestic tariff reform decided by the Authority (resolution 583/2015/R/eel). Altogether, considering jointly both the gas and electricity sectors, with regard to the tariffs covering the network costs, the tariff reduction decided by the Authority, again for 2016, is worth around €1 billion.

Starting 1 January 2016, the resolution of 30 April 2015, 200/2015/R/COM - bill 2.0 – envisages a different aggregation of the individual components in end-user energy bills; in particular the entries that used to be included as part of Sales Services will merge to become part of the entry Energy material costs, whilst the entries that used to be included as part of Network services will become two separate aggregations, namely Transport and meter management costs (distribution, measurement, transport, transmission and distribution equalization, quality control) and Costs for system charges.

In Italy the typical family has an average electricity consumption of 2,700 kWh per year and a connected load of 3kW. In Figure 38 the trend in electricity prices for the average residential customer in Italy is illustrated for the last years, whereas in Table IX the electricity reference price during the first quarter of 2016 is analysed in details for two consumption categories: 1st category consumption between 2500-5000 kWh and 2nd category between 5000-15000 kWh [Source: EUROSTAT].

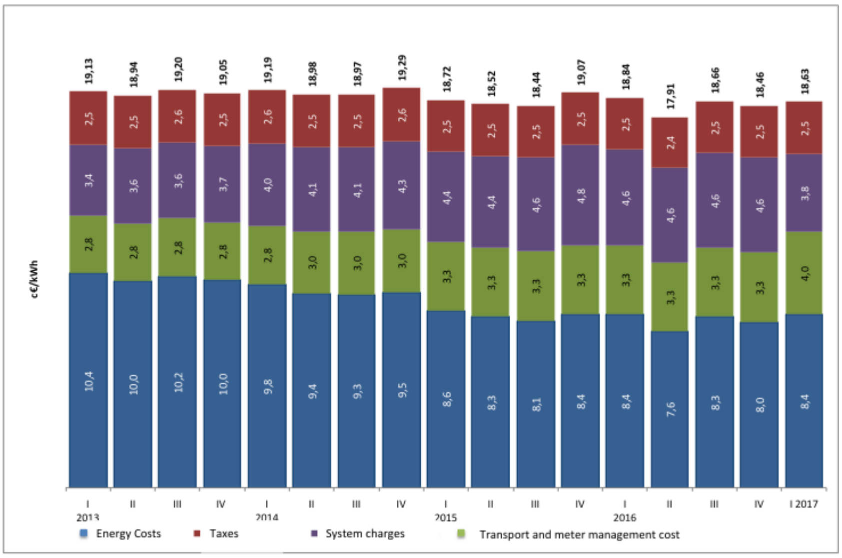

Figure 38: Trend in electricity prices for domestic consumers [18].

Table IX: Electricity price breakdown for Italy (I quarter 2016).

Energy consumption (kWh)	2500-5000		5000-15000	
Allocated charge	¢€/kWh		¢€/kWh	
Tariff	13.19	60.1%	14.77	57.4%
Standing fee	1.23	5.6%	1.20	4.7%
Taxes	7.52	34.3%	9.76	37.9%
Total before VAT	21.97		25.23	
VAT	2.19	10%	2.57	10%
Total	**24.13 ¢€/kWh**		**28.31 ¢€/kWh**	

6.3 Solar PV system cost

Technological advancements in the field of photovoltaics have contributed in considering solar energy as a viable alternative to conventional energy sources. Consequently, in the past years there has been a market growth that aided in the price reduction of PV systems over the years on a global scale, resulting in a price reduction of 80% from 2009 to 2016. Additionally, the cost for Balance of System (BoS) components has been also decreasing in the last few years. Therefore, the total system cost has been reduced by more than 65% in the past decade 0.

One of the deciding factors in installing PV systems is the payback time. It is a parameter that depends on multiple factors, such as the solar resource of the installation location, the electricity cost and usage, and the system size. The costs shown in Table X have been derived based on various retail quotations by PV suppliers and installers in each country. The cost per 1 kWp is presented for each country for residential systems of different size. The PV modules, the PV inverter, BoS components, and labour and administrative costs are included in the overall price. As observed from the analysis that follows for each country, PV panels possess the highest share of the cost.

Table X: Overall PV system cost (€/kWp) for each participating country, as of December 2019.

	3 kWp	5 kWp	10 kWp
Cyprus	1,666	1,528	1,320
Greece	1,216	1.142	989
Israel	1,375	1,375	1,375
Italy	2.200	1.980	1,540

6.3.1 Cyprus

The cost of a PV system in Cyprus for residential installations is presented in Table XI. The prices shown in the table were derived from quotations offered by various local vendors and suppliers. The administrative cost paid to EAC is fixed and independent to the PV system capacity for residential applications.

Table XI: Indicative PV cost (€) in Cyprus as of December 2019

	3 kWp	5 kWp	10 kWp
PV module	2,250	3,600	6600
PV inverter	800	1,200	2400
BoS components	650	920	1750
Labour cost	250	450	900
Administrative cost	250	250	250
Total exc. VAT	4,200	6,420	11,090
VAT (19%)	800	1,220	2,110
Total	5,000	7,640	13,200
Price/kWp	1,666	1,528	1,320

The turnkey prices of the ESS without considering the PV infrastructure can be between 1300-1600 €/kWh including the installation and labour cost, however, at the moment the market in Cyprus regarding ESS is limited.

6.3.2 Greece

The cost of PV systems at the residential level are shown in Table XII. We consider that systems under 5kWp can be single-phase, while 5kWp and more should be three-phase ones. In order to derive the costs, we conducted a survey in online shops for the PV panels and the inverter, using certain search engines, and for the labels available in Greece (on December 2019). In order to derive a representative cost for each category (monocrystalline, polycrystalline, inverter), we have used the median value of all the prices found in the survey (note that the average value is not that different from the median). This methodology for deriving representative costs should be considered as the upper limit, since special prices can be sought when getting a turnkey offer.

Also, a total of 15% of the combined PV panel and inverter cost is divided equally into a) the cabling-protection-mounting and b) the installation costs. The administrative cost referring to the licensing from the HEDNO (the DSO in Greece) is also included. Finally, the current VAT of 24% is added to obtain the final cost.

Comparing with a similar survey performed under the StoRES Interreg MED project in 2017, we note that the PV panel cost has considerably decreased, having a median value of 0.62€/Wp for monocrystalline panels and 0.54€/Wp for polycrystalline panels (including VAT). As the rooftop area is generally limited, we calculate the total cost using monocrystalline panels that have better efficiency. Concerning the cost of the inverters, this has been slightly increased since 2017. We have found a median value for 3kW inverters of 0.31€/W (including VAT), for 5kW inverters of 0.3€/W, for 7kW inverters of 0.35€/W, while for 10kW the cost drops to a median value of 0.2€/W.

Table XII: Typical allocated cost for residential PV installation for monocrystalline PV panels.

Allocated Cost (€)	PV system installed capacity		
	3 kW	5 kW	10 kW
PV panel	1507	2511	5023
Inverter	760	1201	1609
Cabling-protection-sensors	170	280	497
Installation	170	280	497
Administrative (licencing)	335	335	345
VAT	706	1106	1914
Total	3648	5713	9885
Total (per kW)	1216	1142	989

Regarding the cost for storage, the market in Greece is still literally non-existent, as of December 2019. The time passed since the official permission of storage is limited, and hence the market has not been able to offer such products yet at a scale where comparisons can be made. However, the PV market in Greece largely follows the German market, with similar prices, and even sometimes lower. Considering this, we conducted a similar online survey in German shops offering storage solutions. We have found that the price of lithium-ion storage ranges from 480 €/kWh (with large batteries of 14 kWh) to 900 €/kWh (with smaller batteries of 6 kWh), all excluding VAT. For capacities around 10kWh, a cost of 550€/kWh (excluding VAT) can be considered representative.

6.3.3 Israel

The price of a home solar system starts at a price of about 30,000 ILS. This amount sounds very high on the one hand, but in the end, if you do decide to invest, you can end up saving at least 14,000 ILS each year. The Government of Israel encourages the installation of the solar systems designed to generate electricity independently, and therefore special loans can be taken for the construction of solar systems under favourable terms of payments up to 10 years.

Starting on August 2019, the new regulation of an electric company is underway. This means that this time, the smaller systems are investing in private customers. Systems with a capacity of up to 15 kW will receive a tariff of 0.48 ILS per kWh. The tariffs will be guaranteed and protected in a contract with an electricity company for six months.

It is important to note about the VAT and income tax reporting for production with profits. Exemption from income tax for electricity generation under the new regulation is up to income of 24,000 ILS per year. VAT exemption for electricity generation is up to 70,000 ILS per year BUT ONLY for commercial users (not private HH or public buildings).

Table XIII: Indicative PV cost (€) in Cyprus as of December 2019

	3 kWp	5 kWp	10 kWp
PV module	1,410	2,350	4,700
PV inverter	352	587	1,175
BoS components	352	587	1,175
Labour cost	1,163	1,939	3,877
Administrative cost	247	411	822
Total exc. VAT	3,525	5,875	11,749
VAT (17%)	599	999	1,997
Total	4,124	6,873	13,747
Price/kWp	1,375	1,375	1,375

6.3.4 Italy

Regarding the payback period of net-metered PV plants in Italy, it depends on the size of the plant, the market value of a plant’s components, the electricity price when invoicing net-metered systems, the voltage level of the connection, the self-consumption rate, the solar irradiation in the site, the decay in performance of PV plants, construction costs, and so on.

In the following, general data about the PV and ESS installation costs are provided.

6.3.4.1 PV installation costs (Turnkey Prices)

PV costs are subdivided as in the following (Table XIV):

- PV panel cost (35%)

- Inverter cost (8%)
- Cabling-protection-sensors and anything else (24%)
- Installation and administrative (licencing) costs (33%).

Table XIV: Typical turnkey PV system cost (€) in Italy (2016).

	3 kWp	5 kWp	10 kWp
PV modules	2,100	3,150	4,900
PV inverter	480	720	1,120
BoS components	1,440	2,160	3,360
Installation	900	1,350	2,100
Administrative	1,080	1,620	2,520
Total exc. VAT	6,000	9,000	14,000
VAT (10%)	600	900	1,400
Total	6,600	9,900	15,400
Price/kWp	2,200	1,980	1,540

6.3.4.2 Storage installation costs (Turnkey Prices)

The turnkey prices of the ESS not including the photovoltaic installation are around 1200-1500€/kWh (average values including inverter and installation)

In case of RES-E plants connected to low and medium voltage grid, charges for connecting to the grid (paid by producers) are conventional (they are defined as a function of power and distance from the existing grid), whereas in case of other plants connected to low and medium voltage grid, charges for connecting to the grid are related to the standard cost of the real technical solution. In case of plants connected to high and very high voltage grid, charges for connecting to the grid (paid by producers) are related to the standard cost of the real technical solution.

7 Local practices on building energy rehabilitation

7.1 Cyprus

The European Union initiative towards minimization of the dependence on fossil fuels and other conventional energy sources requires that new buildings have very high energy performance. Hence, it is obligatory that new public and private buildings become NZEBs by the end of 2018 and 2020, respectively. Consequently, the energy requirements of each building should be covered by renewable sources, such as PV solar energy. In addition, any new buildings and existing buildings subjected to rehabilitation, that aim in fulfilling the NZEB requirements, shall have the following specifications:

1. Energy efficiency class A in the energy performance certificate of a building.
2. Maximum primary energy consumption in residential buildings of 100 kWh/m^2.
3. Maximum primary energy consumption in non - residential buildings of 125 kWh/m^2.
4. Maximum energy demand for heating for residential buildings of 15 kWh/m^2.
5. At least 25% of total primary energy consumption comes from renewable energy sources.
6. Maximum mean U – value for walls and load – carrying elements, which are part of the building envelope of 0.4 W/m^2K.
7. Maximum mean U – value for horizontal building elements and ceilings, which are part of the building envelope of 0.4 W/m^2K.
8. Maximum mean U – value for door and window frames (excluding shop windows), which are part of the building envelope of 2.25 W/m^2K.
9. Maximum mean installed lighting power for office buildings of 10 W/m^2.

7.2 Greece

Traditionally building energy rehabilitation in Greece has been an ad-hoc issue dependent on the attitude and financial capacity of the owner and the specific characteristics of each region. In fact, Greece is divided into 4 climatic zones shown in Figure 39, based on the range of heating degree-days needed. Zone A has on average 600-1100 heating degree-days per year, while Zone D has more than 2200 degree-days. These large differences between the heating needs of different regions in Greece, makes it difficult to have common measures or practices in all country.

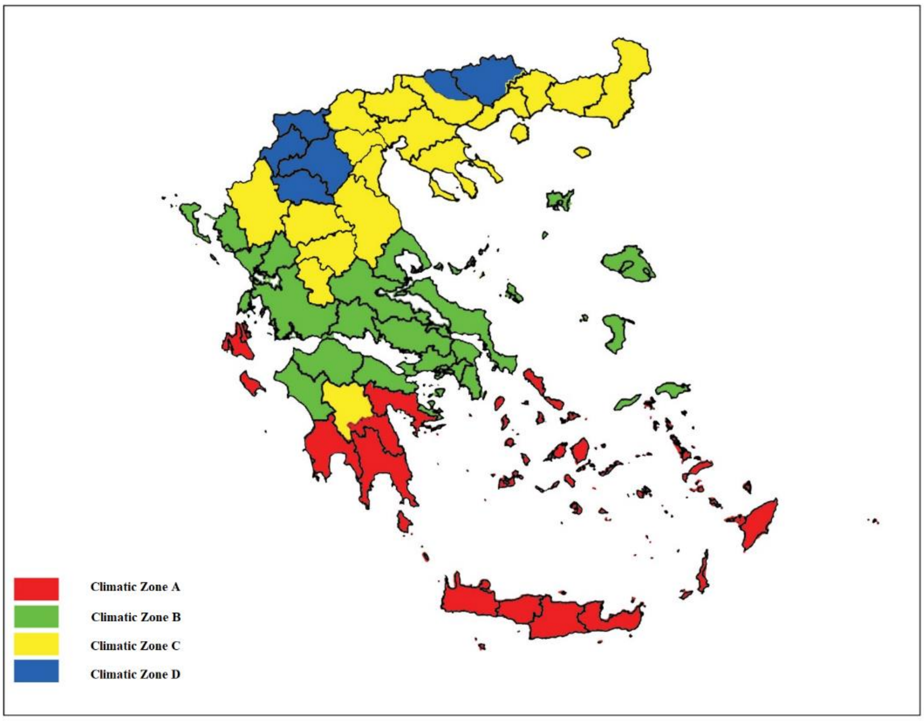

Figure 39: Climatic zones in Greece, based on the KENAK (building energy performance regulation).

Regarding the integration of renewables in existing buildings, there is no clear provision about the need to install such systems. For new buildings, there is the requirement to be nearly-zero energy ones, with most of their low energy demand coming from renewables on-site.

The systematic rehabilitation of buildings in Greece began after the issuing of a national building energy rehabilitation program, titled “Exikonomo” i.e. Home Energy Saving (HES) in 2010. This program was constructed based on the provisions of the recast of the European Energy Performance Building Directive (EPBD) and partly financed certain interventions in houses aiming to improve their energy performance.

The second edition of HES has been active since February 2019. The Program targets buildings used as the main residence and whose owners meet specific income criteria. In particular, the Program includes seven (7) categories of incentives in which Beneficiaries fall in respect to their income.

The eligible energy interventions are summarized as follows:

- Replacement of window frames
- Installation / upgrade of thermal insulation
- Upgrading of heating / cooling system
- Hot Water System (DHW) using Renewable Energy Sources (RES)

As it is apparent by the type of eligible interventions, the goal of the program is to reduce building energy consumption and thus do not cover electricity generation using renewables.

7.3 Israel

To facilitate higher penetration of PV systems, high priority research topics include improved efficiency of PV systems, and storage. In 2018, the Office of the Chief Scientist received a relatively large numbers of academic proposals especially in the fields of tandem cells and combination of CS and PV to increase efficiency. The office supported six projects related to solar and PV with total investment of ~1 M$ out of total budget of ~10 M$. Among the currently supported projects, there is the SolCold Ltd development of a nano-based coating material that creates cooling when exposed to sunlight. As cooling expenses are increasing year after year, the proposed technology reduces cooling costs and saves energy. The technology is a multi-layered material activated by anti-stokes fluorescence in response to sunlight, thus converting the internal heat into radiation and cooling below the ambient temperature. The cooling power is expected to reach 20 W/m2, which may save up to 60 % in air-conditioning costs. The material can be applied to buildings, cars, trucks, containers, airplanes, clothes, and many more items.

7.4 Italy

The implementation of strategies aimed at promoting energy efficiency and limiting energy consumption is clearly a fundamental aspect of renovation today.

In Italy, all new buildings and all buildings undergoing major refurbishment are obliged to integrate RES-E and RES-H. There are different obligations depending on the building type and size, and for public buildings the obligations are increased by 10%. The obligation to integrate RES-H and RES-E in buildings does not specify technologies but only the criteria that have to be respected.

In Italy, the training programmes for installers are regulated at central level but set up and managed at regional level. Each installer, after having installed a plant on any building, is required by law to release a certificate of compliance with a set of standards outlined in DM 37/08. Each installer, after having installed a plant on any building, is required by law to release a certificate of compliance with a set of standards outlined in DM 37/08. The certificates obligation applies to electricity production units and heating, cooling, air conditioning plants.

Moreover, the re-use of historical buildings, in some cases those that have been abandoned for years, is currently generating a lot of interest, and brings into discussion topics such as land recycling and the use of new resources. Technological innovation provide means of dealing with the difficulties of combining the preservation of architectural and morphological values of the building constructions with the new needs of contemporary living as well as compliance with current standards and legislation.

8 Conclusions

This report has analysed in detail 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 available DSM schemes. 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 schemes 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, the analysis 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 schemes. Currently, the existence of net – metering as a virtual energy storage solution directly to the grid, discourages the utilisation of ESS.

In addition, the high solar potential that is available in all the MED regions is presented, highlighting the urge for further utilisation of PV technology in those regions. Also, the electricity pricing and PV system cost is presented for each participating country. Finally, local practices on building energy rehabilitation are presented for each country.

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 existing legislation, electricity prices and PV system cost will be considered towards the design of the nanogrid pilot buildings and to face the main barriers that prevent the deployment of those technologies.

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