SOLAR ENERGY OVERVIEW – EU27

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The European Institute for Innovation – Technology

Solar Energy Overview in the EU27

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1. Introduction

This paper provides an overview of the current status of solar energy within the EU27, its progression and levels of implementation in each member state. It identifies financial and policy instruments which have been introduced to stimulate the market and highlights financial models which have been developed to help encourage solar energy uptake. It covers solar photovoltaic (PV) and provides thoughts on best practice within the EU27. Finally, it looks at the socio-economic impact of solar energy uptake and looks at what might happen if it receives some further stimulus or if it fails to progress further.

The Europe 2020 Strategy requires European Union member states to agree to a target of *20% by 2020* (20-20-20). This is a legally binding commitment, introduced in 2007, enacted in law in 2009 and with a target date of 2020. It covers:

- 20% cut in greenhouse gas emissions (compared to 1990 levels)
- 20% of EU energy to be generated through renewable sources and
- 20% improvement in energy efficiency.

In June 2018, the EU enacted further legislation which sets a new binding renewable energy target for the EU for 2030 of 32%, including a review clause by 2023 for an upward revision of the EU level target (European Commission, 2018). Further to this, the European Commission introduced several pathway scenarios which reflect how to achieve targets by 2050.

Achieving this target will not be easy and, specifically for solar energy, the EU member states will require a combination of policy support, financial confidence (through subsidies, incentives or increasingly through positive returns on investment) and technological advances to overcome difficulties or hindrances associated with solar energy. This paper attempts to demonstrate how the EU27 could move from the current position shown in section 2 towards that target and how the various policy, financial and technological advances can help. It also considers best practice, and models which have not worked, in Europe's ongoing efforts to increase the uptake of solar energy.

1 Solar Energy Across the EU27

This section considers the proportion of energy consumption and production which is derived from renewable sources and whether targets are likely to be met. It further breaks down into types of renewable and focuses on the contribution of solar energy.

1.1 CURRENT RENEWABLE SHARE IN EU-27

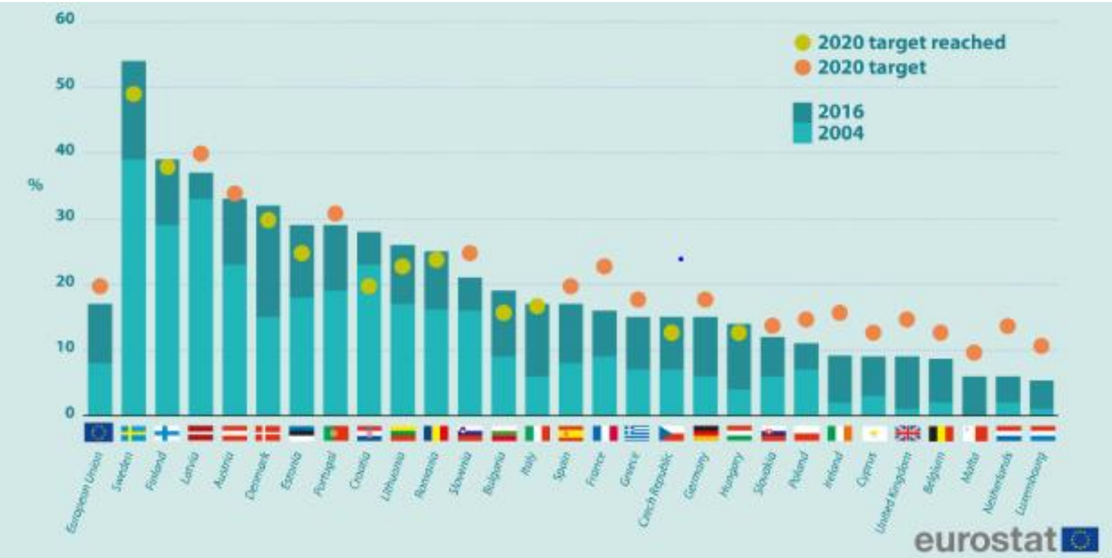

Figure 1: Share of energy from renewable sources, 2004 and 2016 (% of gross final energy consumption) *(Source: Eurostat, 2016)*

Due to different energy policies, regulations and public support programmes for renewable energies in the various countries, market conditions for solar energy differ substantially. Beyond these policy driven factors, there are other factors which have a significant influence on the economic attractiveness of installing PV systems. These include the levels of liberalisation in the domestic electricity markets, the maturity of the solar energy market and local financing conditions.

Looking at the electricity system as a whole, a total of about 28.1 GW of new power generation capacity were installed in the EU last year and 12.1 GW were decommissioned, resulting in 15 GW of new net capacity (Agora, 2018). Renewable energy sources (RES) accounted for 23.7 GW or 84.5 % of all new power generation capacity. Solar PV electricity generation capacity accounted for 5.9 GW, or 21 % of the new installed capacity.

In terms of new net capacity, wind power was first with 15 GW, followed by solar PV 5.9 GW, hydro 1.1 GW biomass plants with 0.96 GW, natural gas 356 MW, CSP (Concentrated Solar Thermal Power) 118 MW and other sources 8 MW. The net installation capacity for coal- and oil-fired power plants as well as nuclear was negative, with a decrease of 4 GW, 2.2 GW and 1.3 GW, respectively.

1.2 CURRENT SOLAR ENERGY SHARE IN EU-27

Table 1: Renewable energy (%) by EU-28 Member State, solar highlighted for the benefit of this report *(Source: Eurostat, 2016)*

	Renewable energy	of which: Biofuels & renewable wastes (2)	Hydro power	Wind power	Solar energy	Geothermal energy
EU-28	13.2	8.6	1.8	1.6	0.8	0.4
Belgium	6.8	5.4	0.1	0.8	0.5	0.0
Bulgaria	10.7	7.2	1.9	0.7	0.8	0.2
Czech Republic	10.3	9.3	0.4	0.1	0.5	0.0
Denmark	28.7	21.7	0.0	6.3	0.7	0.0
Germany	12.3	8.2	0.6	2.1	1.2	0.1
Estonia	15.5	14.7	0.0	0.8	0.0	0.0
Ireland	7.5	3.4	0.4	3.6	0.1	0.0
Greece	10.9	4.8	2.0	1.8	2.2	0.0
Spain	14.3	5.6	2.6	3.4	2.6	0.0
France	9.9	6.6	2.1	0.7	0.3	0.1
Croatia	23.3	15.1	6.9	1.0	0.2	0.1
Italy	16.8	8.5	2.4	1.0	1.4	3.6
Cyprus	6.3	2.1	0.0	0.8	3.3	0.1
Latvia	37.0	31.8	5.0	0.3	0.0	0.0
Lithuania	20.8	18.7	0.6	1.4	0.1	0.0
Luxembourg	5.3	4.6	0.2	0.2	0.3	0.0
Hungary	11.7	10.8	0.1	0.2	0.1	0.5
Malta	3.4	1.3	0.0	0.0	2.1	0.0
Netherlands	4.7	3.5	0.0	0.9	0.2	0.1
Austria	29.7	17.3	10.1	1.3	0.8	0.1
Poland	8.8	7.4	0.2	1.1	0.1	0.0
Portugal	24.2	12.4	5.8	4.6	0.7	0.7
Romania	19.1	12.0	4.8	1.7	0.5	0.1
Slovenia	16.5	9.7	5.7	0.0	0.5	0.7
Slovakia	9.5	6.9	2.3	0.0	0.3	0.1
Finland	30.7	26.0	3.9	0.8	0.0	0.0
Sweden	37.1	23.6	10.8	2.7	0.0	0.0
United Kingdom	8.1	5.7	0.2	1.7	0.5	0.0
Iceland	82.7	0.3	20.8	0.0	0.0	61.6
Norway	50.1	5.3	44.2	0.7	0.0	0.0
Montenegro	33.7	17.6	16.0	0.0	0.0	0.0
Former Yugoslav Republic of Macedonia	14.2	7.5	6.1	0.4	0.1	0.2
Albania	42.0	11.9	29.5	0.0	0.6	0.0
Serbia	13.1	7.0	6.1	0.0	0.0	0.0
Turkey	12.3	2.2	4.1	1.0	0.7	4.3
Bosnia and Herzegovina	15.6	8.4	7.2	0.0	0.0	0.0
Kosovo(1)	14.3	13.5	0.8	0.0	0.0	0.0

ec.europa.eu/**eurostat**

The proportion of solar energy as a percentage of all renewable energy consumption in each European country is highlighted in the above table (Table 1). Taken from Eurostat, it refers to 2016, the latest year available.

While there has been significant growth since 2016, the figures show that there is still a long way to go if new targets are to be met. It is suggested that, to achieve the new renewable energy target of 32% by 2030, the main contributions would have to come from solar and wind power (BNEF, 2018). However, the table indicates that among the EU27 there are many different starting points in terms of the development of solar energy to date, with countries such as Austria using hydro energy to achieve their targets and others such as Sweden and Finland using biomass and biofuels.

The required solar energy capacity to achieve the target could therefore be approximately 420 GW, potentially split 55% utility scale PV plants and 45% decentralised small systems. However, with a total installed capacity of about 110 GW at the end of 2017 and annual installations between 5.7 and 7.5 GW in the last three years, it will be difficult to reach this target. New policies or incentives would appear to be needed to allow for annual installation between 25 and 30 GW over the next 12 years, which are needed to reach the target. This means the annual market has to grow to three to four times the European market volume in 2017 (Jäger- Waldau, 2017; 2018a). Figure *1* above depicts the share in the EU market of renewables.

1.3 POTENTIAL FUTURE PROSPECTS OF SOLAR ENERGY

Table 2: European Solar Capacity and Potential with Political Support Prospects *(Source: Global Market Outlook, 2018)*

	2017 Total Capacity (MW)	2022 Total Capacity Medium Scenario by 2022 (MW)	2018 - 2022 New Capacity (MW)	2018 - 2022 Compound Annual Growth Rate (%)	Political support prospects
Germany	42,973	63,237	20,264	8%	
France	7,999	19,702	11,703	20%	
Turkey	3,420	14,320	10,900	33%	
Spain	5,627	14,460	8,833	21%	
Netherlands	2,681	11,430	8,750	34%	
Italy	19,392	26,924	7,533	7%	
Ukraine	1,152	4,435	3,283	31%	
Poland	261	2,361	2,099	55%	
United Kingdom	12,676	14,742	2,065	3%	
Switzerland	1,955	3,957	2,003	15%	
Russia	158	1,988	1,830	66%	
Austria	1,263	2,922	1,659	18%	
Belgium	3,708	5,325	1,617	8%	
Greece	2,623	4,210	1,587	10%	
Sweden	317	1,601	1,284	38%	
Rest of Europe	7,651	14,172	6,521	13%	

The latest figures (Table *2*) show that solar energy is likely to demonstrate strong growth within the EU-27 for the next few years for the following reasons:

- EU 2020 targets: Some EU governments, have increased support for solar energy largely because of the low cost and popular technology associated with solar, while increasing their renewables share and reducing CO2 emissions. The new targets for increasing renewable energy by 2030 should also focus Governments throughout the EU27 to help support or even stimulate solar energy uptake.
- Tenders: Solar tenders refer to projects which are funded by government or financial institutions. Tenders have increasingly been used instead of feed-in tariff schemes, which are more incentivised returns on procurement of energy rather than a funded project. Solar energy can win technology-neutral tenders due to lower costs and better returns. For example, in Denmark in 2017, the Danish government opened a tender opportunity for providers to quote to install a series of renewable energy systems smaller than 1MW, a project supported by the European Commission. This gave the Danish population opportunities to finance solar energy installations where it would have otherwise been uneconomical.

- Self-consumption: Solar energy is much cheaper than retail electricity in most European markets and continues to reduce in cost, leading to greater investment in on-site power generation. Increasingly, battery energy storage combined with the benefits of digital and smart energy products supports the sales case for solar energy.
- Emerging & Reawakening Markets: The low cost of solar energy is attracting European countries that haven't been very active in the field in the past, especially in central Europe. European solar pioneers are turning to low-cost solar energy again, such as Spain who have recently abolished their "sun tax" laws (see section 3.4.2 for more information)
- Corporate sourcing: Some European markets are now starting to see direct bilateral Power Purchase Agreements (PPA) with solar energy increasingly competing with wholesale power markets. This development will be seen primarily in those European countries with the widest spreads between solar energy and wholesale power prices. While there has been talk about pure PPA based projects for a while in Spain, in 2018 the first are being built (EU PVSEC, 2018). The pipeline for these projects has grown to over 30 GW.
- Regulation: The European Commission and national governments have been developing a more flexible renewable energy system to overcome barriers that have inhibited solar energy growth possibilities in recent years.

This helps explain why the speed of current solar energy developments have had a significant growth and uptake. In 2016, Europe reached the significant figure of 100 GW grid-connected solar energy capacity. Just one year later, in 2017, almost 100 GW of solar energy had been added across the globe (Global Market Outlook, 2018).

2017 was also an important year as, globally, solar energy deployed almost twice as much capacity as wind. Solar energy installations also out-performed traditional energy generation technologies, with almost three times as much solar as gas and coal, and 9 times more than nuclear additions. Solar energy alone installed more generation capacity than all fossil fuels and nuclear together (Zalk, 2018).

Some of the reasons for the growth in uptake of solar energy are noted above but a key factor is that it is now increasingly the lowest-cost power generation technology and manufacture. Researchers and industry have been reducing solar energy costs significantly in recent years.

1.4 POTENTIAL ISSUES OF SLOWED GROWTH PATTERNS OF SOLAR ENERGY

However, despite this global growth, across the current 27 members of the European Union, there was negligible growth in 2017: the EU-27 added 5.91 GW in 2017, compared to 5.89 GW in 2016. This appears partly due to the UK's 'solar exit' in 2016 (Global Market Outlook, 2018), which halved new installations in 2017. Although 21 of the 27 EU markets added more solar energy installations than the year before, the overall market performance was still slow.

Solar Power Europe, in their introduction to their Global Outlook report 2018 state that policy makers now need to embrace the solar opportunity created by cost reductions and technology advances, by "*quickly creating the right regulatory frameworks for solar and storage, and other relevant technologies, to help speedily accomplish the energy transition*".

The European Union responded, although encouraging renewable energy in general rather than specifically solar energy, by agreeing in June 2018, a 32% 2030 renewables target. This also empowered citizens, companies and communities with the right to produce, consume, store and sell power without being subject to punitive taxes or excessive red tape. This indicates that solar has a vibrant future in Europe.

2 Incentives and Policy Instruments

2.1 ENERGY POLICY AND INCENTIVES IN EU-27

The following timeline highlights the policies, directives and frameworks that have been agreed or adapted in the past decade in the European Union in reference to energy.

Jan 2008: Climate and Energy Package

- Efforts for 20% RES in final energy consumption among member states
- 10% RES-T target made compulsory

2009: Directive 2009/28/EC Renewable Energy Directive (RED)

- Amended and repealed both RES-T and RES-E
- Established a framework in electricity sector, transport and heating and cooling for promoting RES
- EU RES mix 20% by 2020
- 10% RES for all member states in transport sector
- Priority access to grid for RES electricity
- RES-E imports from third countries
- All RES contributes to the 10% share in transport

2010: The UK bring in FiTs, a decade later than Germany.

May 2010: Directives 2010/30/EU and 2010/31/EU

- 2010/30/EU established a framework for the harmonisation of national end-user information
- 2010/31/EU promoted better energy performance conditions, accounting for outdoor climatic and local conditions as well as indoor climate requirements for cost-effectiveness

2011 Durban Agreement: begins negotiations on a new global regime to replace defunct Kyoto Protocol and to be concluded at Paris UN Conference 2015

- RES support schemes criticised in the rapid decline and mass production of PV
- President of DG Environment and Climate Commissioner Hedegaard in favour of keeping established framework based on the general but ambitious EU target combined with national binding objectives- Had the support of EP and environmental groups

- Economics in DG Climate Action and Energy Commissioner Oettinger supported the UK's request for a single GHG reduction target to be achieved through a reformed emissions trading scheme in cost effective manners

2011: COM 2011

- Guidelines for trans-Europe infrastructure is proposed
- Smart-grids are put into spotlight
- The Energy Roadmap 2050 was established

October 2012: Directive 2012/27/EU

- Amended previous energy efficiency directives of 2009 and 2010
- Promotes smart cities and communities
- Features renewable energy as the major player in the EU energy market

Jan 2014: European Commission proposal for post 2020 climate and energy framework

- 40% GHG reduction by 2030
- "at least" 27% RES target (slightly above business as usual scenario)
- no mandatory objectives at national level

Oct 2014: 2030 Climate and Energy Framework agreed on

- UK and France behind on targets and looking to control their own energy mix
- Central EU countries needed max flexibility and financial assistance in modernising their energy mix
- 40% GHG emission reduction with some concessionary points such as free allowances for less wealthy states
- 27% RES maintained but not legally binding
- 27% energy efficiency

February 2015: Energy Union Strategy is launched by the European Commission

December 2015: The Paris Agreement

- Concluded the COP21 with an agreement to keep the maximum global average temperature rise as close to 1.5°C

2016: UK Energy Act, 2016 established

- Provisions on the future and abandonment of offshore oil and gas installations
- Provisions on wind power

November 2016: Paris Agreement came into force

November 2017: COM 2017/2010

- Amended regulation in the energy statistics

December 2018: COP24 Katowice 2018

- Establishes stricter regulations to meet the current requirements of energy targets from the 2015 Paris Agreement

2.2 SOLAR ENERGY SPECIFIC POLICY AND INCENTIVES

Due to different energy policies, regulations and public support programmes for renewable energies in various EU-27 member states, market conditions for solar energy differ substantially. This section highlights some member states and gives more detail on their policy and incentives for solar uptake.

2.2.1 Germany

The German market growth is directly correlated to the introduction of the Renewable Sources Act (2000) (EEG). This law introduced a guaranteed feed-in-tariff (FiT) for electricity generated from solar energy PV systems over 20 years. This law already had a fixed built-in annual reduction which adjusted to reflect growth in markets and reduction in costs. This law only estimated installed capacity until 2008 and so in 2009 a plant registrar was introduced.

Since May 2012, the FiT has been adjusted on a monthly basis based on previous quarter installation figures. The EEG was revised in 2014 which introduced a system capacity of less than 10kWp are excluded from a new self-consumption levy. For larger than 10kWp systems, the levy on each self-consumed kWh increased to 40% in January 2015 (Jäger-Waldau, 2018b).

The low FiT for large ground mounted systems led to a decrease in installation numbers (Projektträger Jülich, 2016). In 2015, the government started tenders for ground mounted systems to push this sector to a more market driven competition. From September 2015, owners of new ground mounted PV systems have to apply and be awarded an auction from the Federal Network Agency which is determined by political decisions to limit this market.

As of January 2016, solar energy systems smaller than 100kWp are eligible for FiT. Any larger than 100kWp have to market their electricity. Since 2017, a programme was introduced to support the self-consumption in multi apartment buildings but as of May 2018, there has been little uptake to this support with only 160 PV systems of 4MW cumulative installed (Bundenetzagentur, 2018).

However, there is a concern at the levelling of solar energy installations in Germany. Installed capacity is growing, although 2016 saw a reduction in energy generated as shown in figure 2 below.

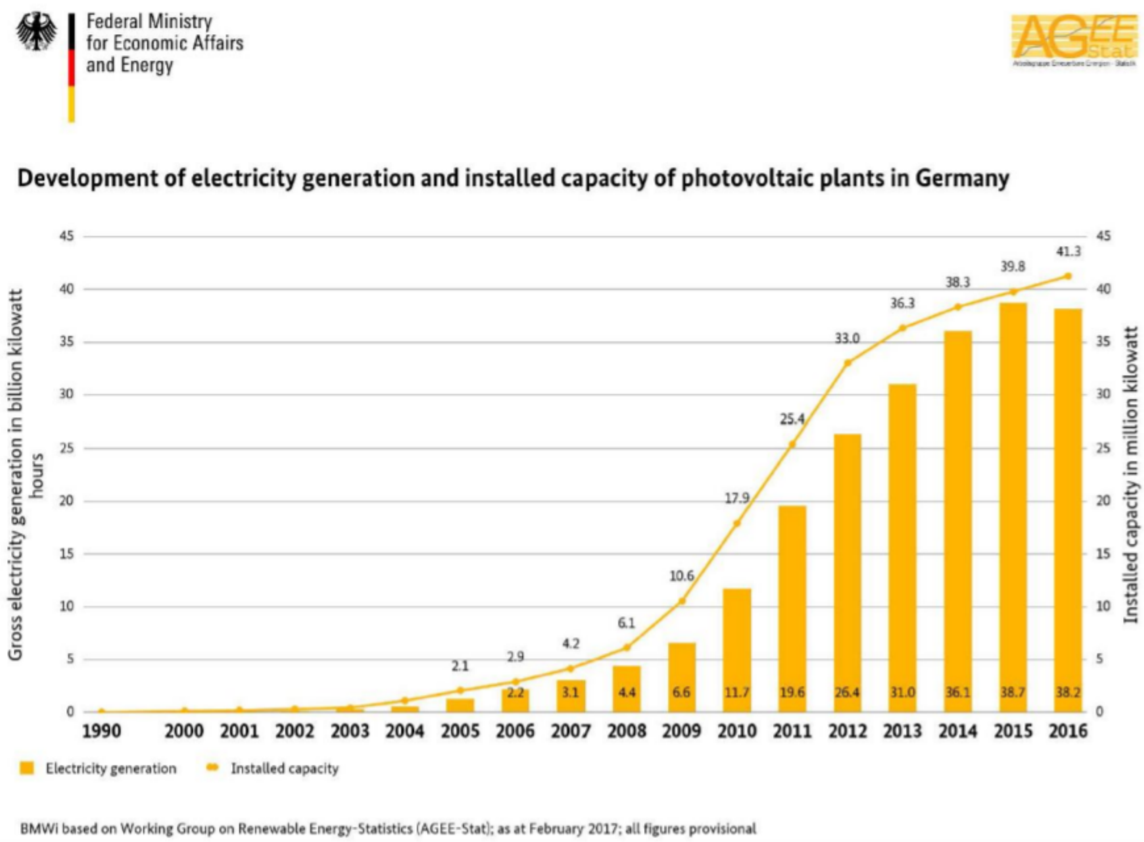

Figure 2 Development of electricity generation and installed capacity

The “Energiewende”, the transformation of the energy system is a core task for Germany’s environmental and economic policy. The overall objective is an environmental friendly, reliable and economically feasible energy supply. The German Federal Government announced the German Energy Concept in autumn 2010 with the Federal Ministry for Economic Affairs and Energy (BMWi) defining an energy agenda comprising 10 key projects to approach this goal of the energy transition during 2013-2017 (BMWi 2013). The goals will be achieved through energy use and the use of renewable energy. The German Energy Concept aims to reach 18 % of the total gross energy consumption in 2020 (in 2015, the figure had reached 14.8%(Erneuerbare-energien 2015). Further targets are 35% in 2020, 40-45% in 2025 and 80% in 2050. With respect to the electricity supply, the share for renewable energies has reached approx. 31.7% of the gross electricity consumption of Germany in 2016. This is already close to the first target for 2020 of the Energy Concept. Solar energy recorded a share of 6.4% of gross electricity consumption, a growth that is attributed to the Renewable Energy Sources Act (EEG 2014) and a noticeable decrease of system prices.

	On-going measures residential	Measures that commenced during 2016 - residential	On-going measures Commercial + industrial	Measures that commenced during 2016 – commercial + industrial	On-going measures Ground-mounted	Measures that commenced during 2016 – ground mounted
Feed-in tariffs	yes	-	yes	-	-	Only after a tender
Feed-in premium (above market price)	yes	-	yes	-	yes	-
Self-consumption	yes	-	yes	-	yes	-
Net-metering	-	-	-	-	-	-
Net-billing	-	-	-	-	-	-
Sustainable building requirements		-		-		-
BIPV incentives	-	-	-	-	-	-

Figure 3 Summary of Solar Energy Support Measures (Projektträger Jülich 2016)

Since 2013 the KfW has been running a market stimulation program to boost the installation of local stationary storage systems in conjunction with small PV systems < 30 kWp. The funding is two-fold: A loan and a grant on the repayment. The first phase ended in 2015 and was limited to a total of 25 MEUR of grants. A second phase has been active since 2016[1] with a funding volume of 10 MEUR (grants) per year. During 2016, 6,468 storage systems were financially supported (800 for existing and 5,668 for newly installed PV systems), with the total volume of loans reaching 105 MEUR. During the first phase (2013-2015), more than 17,000 storage systems were funded (ZSW, 2015).

2.2.2 Sweden

Between 2006 and 2015, the Swedish Government offered a direct capital subsidy for the installation of grid-connected solar PV systems, which covered 35% - 70% of the installation cost of certain systems (IEA-PVPS, 2018). Sweden also has a green electricity certificate system and shares a joint certificate market with Norway.

[1] Note: this may change in 2019

The Swedish Energy Commission was set up in March 2015 with the purpose of coming to a general political consensus on the future of Swedish electricity system beyond 2025, and which agreed a goal that Sweden would have 100 % renewable generation by 2040, while still planning to be a net exporter of power. This would phase out the Swedish nuclear reactors, continue investment in transmission capacity, demand flexibility and energy efficiency, and extend the Swedish green electricity certificate system from 2020 to 2030. Significant legislation changes are likely to spring from this political agreement, and the Swedish PV market will most likely benefit from this (National Survey Report 2016). The agreement that was first communicated in June 2016 was only a framework, but in 2017 this framework has been filled with more concrete measures. The agreement also states that the existing regulations should be adapted to new products and services in energy efficiency, energy storage and sale of micro produced electricity (Energikommissionen 2016[2]).

In 2006 a direct capital subsidy program was introduced to stimulate investment in energy efficiency and conversion to renewable energy sources for public buildings. Through this solar energy systems were eligible for 70 % of the installation costs covered if they were built on a public building. One impact of this move was to stimulate the grid-connected solar energy market in Sweden. Prior to this most solar energy was off grid, associated with summer cottages and rural dwellings. This program ended in December 2008 and did not reopen until mid-2009, leading to a significant reduction in the installation rate in 2009. The subsidy program reopened and has had several extensions until, in an effort to meet the increased interest in solar energy in Sweden the Government greatly increased the annual budget for the years 2016–2019 rising from 235 to 390 million SEK.

[2] Note: the 2016 report was published late 2017. The updated 2017 report is expected imminently.

Table 3 indicates the support measures for solar energy installations as at 2016.

	On-going measures – Residential	Measures that commenced during 2016 – Residential	On-going measures – Commercial + industrial	Measures that commenced during 2016 – Commercial + industrial	On-going measures – Ground-mounted	Measures that commenced during 2016 – Ground mounted
Feed-in tariffs	-	-	-	-	-	-
Feed-in premium (above market price)	Yes	-	(Yes)[1]		-	-
Capital subsidies	Yes	-	Yes	-	Yes	-
Green certificates	Yes	-	Yes	-	Yes	-
Renewable portfolio standards (RPS)	-	-	-	-	-	-
Income tax credits	Yes[2]	-	(Yes)[2]			
Self-consumption	Yes	-	Yes	-	Yes	-
Net-metering	-	-	-	-	-	-
Net-billing	-	-	-	-	-	-
Commercial bank activities e.g. green mortgages promoting PV	-	-	-	-	-	-
Activities of electricity utility businesses	Yes	-	Yes	-	Yes	-
Sustainable building requirements	Yes	-	Yes	-	Yes	-
BIPV incentives	-	-	-	-	-	-

[1] Only small commercial system can benefit from the tax credit system.

[2] The feed in premium is compensated as income tax credits. It is the same system.

Table 3 PV support measures summary table (Swedish Energy Agency 2016)

There are indications that there is a growing trend where solar energy systems are being installed without having been granted direct capital subsidy. Possible reasons for this could be:

- Due to long waiting times, owners install their systems and hope to be granted direct capital subsidy afterwards.
- Private customers use the ROT tax deduction instead
- Customers find it sufficiently attractive to install solar energy without the direct capital subsidy.

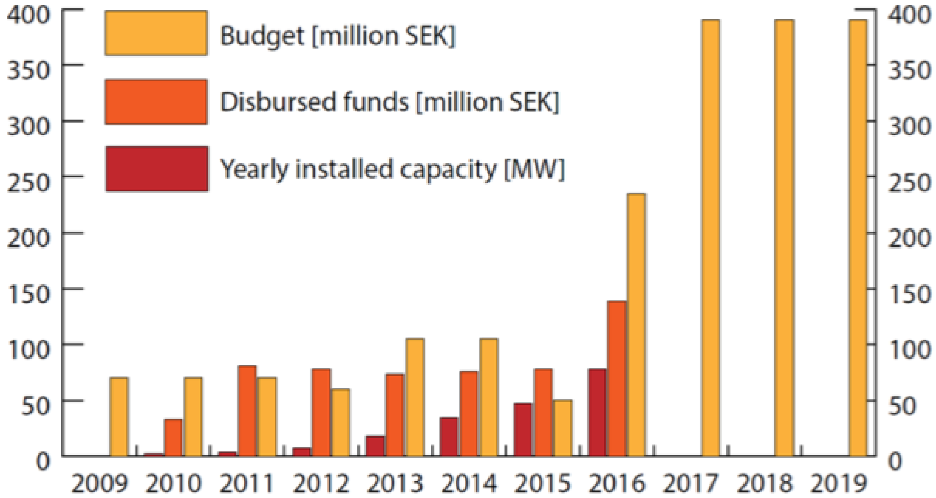

Figure 2 The budget and disbursed funds of the direct capital subsidy along with the annual grid connected Swedish PV market. (Swedish Energy Agency 2016)

The Green Electricity Certificate System has also had a positive impact on the increased installation of solar energy in Sweden. The basic principle is that producers of renewable electricity receive one certificate from the Government for each MWh produced. Certain electricity stakeholders are obliged to purchase certificates representing a specific share of the electricity they sell or use, the so-called quota obligation. The sale of certificates gives producers an extra income in addition to the revenues from electricity sales. Ultimately it is the electricity consumers that pay for the expansion of renewable electricity production as the cost of the certificates is a part of the end consumers' electricity price. The energy sources that are entitled to receive certificates are wind power, some small hydro, some biofuels, solar, geothermal, wave and peat in power generation, and each production facility can receive green electricity certificates for a maximum of 15 years. With broad political agreement the Swedish Government stated in 2017 that the electricity certificate system will be extended to 2030.

It has ben noted by the Swedish Energy Agency in their annual report that not all solar energy installations take up the green energy certificates. This could be due to a combination of administrative and technical issues, with suggestions that the system is not particularly user friendly.

In 2015 an amendment to the Income Tax Act provided for a tax credit of 0.60 SEK/kWh for renewable electricity fed into the grid. The tax credit is received in addition to other compensations for the excess electricity, such as compensation offered by electricity retailer utility companies, the grid benefit compensation and revenues for selling green electricity certificates.

In late 2017 the Government launched an investigation that aims to simplify this tax credit and expand it to also include shared-owned renewable electricity to make it possible for those who live in apartments to also invest in solar energy.

To help increase individual customers possibility to store their own produced electricity the Swedish Government has introduced a direct capital subsidy for energy storage for households. The subsidy is given for energy storage that is:

- connected to an electricity production system for self-consumption of renewable electricity
- connected to the grid
- helps to store electricity for use at a time other than the time of production
- which increases the annual share of self-produced electricity used within the property to enhance electricity consumption.

The state aid is not given to installations of storage that has received the ROT tax deduction or any other public support (Sveriges Riksblad 2016). Eligible costs are the costs of installing electrical energy storage systems, such as battery, cabling, control systems, smart energy hubs and work time. The subsidy is only granted to private persons at a maximum of 60% of the eligible costs, and a maximum of 50 000 SEK. The state aid for storage program was introduced in November 2016, but all storage installations that meet the criteria's that were installed in 2016 are entitled to apply for the subsidy. The budget for the storage subsidy program is 50 million per year for 2017 through 2019.

3 Financing

While use of fossil fuels is decreasing throughout the EU, there is still concern over their incentivised use compared to incentivised renewables. Fossil fuels have in the past benefited from significant public subsidies, with the EU and its member governments handing out over 112billion Euros a year to the industry. Renewables have also benefited from incentives in the form of feed in tariffs and other subsidies, but the renewable sector receives 35% less incentivised funding than the fossil fuel sector. On a positive note, this suggests the opportunity to is there to reduce public expenditure due to the declining demand from fossil fuels.

The below figure (Figure 3) from Connolly et al, 2015 compares the "Business as Usual" scenario to the 100% Renewable Energy scenario from Roadmap 2050 and depicts that in basic terms, there is not a significant price difference between the scenarios.

3.1 LEVELISED COST OF ELECTRICITY (LCOE)

Agora Energiewende (2015) conducted a levelised costs of electricity analysis to compare and calculate system prices for future solar systems based on a variety of scenarios. Levelised costs of electricity are the net present value of the unit-cost of electricity (ct/kWh in this report) over the lifetime of a generating asset (such as a solar panel or solar array). Agora Energiewende (2015) calculated that in the three locations they analysed (Southern Germany, Southern France and Southern Spain), the LCOE for utility scale PV systems range between 5.4 and 8.4ct/kWh. This was further calculated to predict the price of LCOE for this system in 2050 of between 1.8 and 4.4ct/kWh.

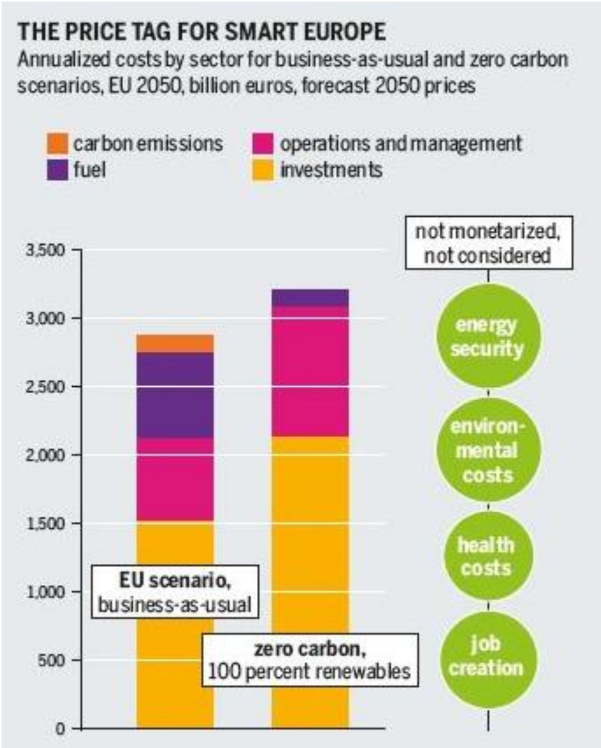

Figure 3: Comparison graph of Roadmap scenarios in renewable energy sector *(Source: Energy Atlas, 2018 & Connolly et al, 2015)*

In 2017, solar energy attracted 58% of all new renewable energy investments (EUR 140 billion). The worldwide investment stock of solar is estimated for 2040 to be EUR 2.2trillion (BNEF, 2018). Between the end of 2009 and the first half of 2018, Levelized Cost of Electricity (LCOE) from PV dropped by 75%. This is mainly due to the decrease in module prices by 85% from high demand market production in China and Japan (Jäger-Waldau, 2018b).

3.2 FINANCIAL DIP AND SURGE OF SOLAR ENERGY

Some aspects, such as the economic recession of 2008 caused a steady decrease in PV, followed by a sudden price dip in 2009 where the shortage of polysilicon prevented effective pricing competition (Jäger-Waldau, 2018b). According to BENF (2013), there was a significant price drop in solar energy between 2005 and 2011 due to the ambitious investments and huge overcapacities. Since then, the PV market accelerated again in 2015, slowly reducing on trend as of today.

3.3 AFFORDABILITY OF SOLAR ENERGY BASED ON INTEREST RATES PER EU-27 STATE

Taking information from the PV Status Report 2018 (Jäger-Waldau, 2018b) the PV system prices in the EU are compared (Figure *2* & Figure *3*). The competitiveness of PV generated electricity from LCOE is highlighted when interest rates on investment finance is taken into account. Where those EU member states have a significant investment and technological advancement in solar energy generation (Germany, Denmark, Italy), solar energy is cheaper than grid in residential situations, regardless of whether interest rates (at an assumed level of 3%) are applied or not. Those countries where solar is not yet as established, either due to political or seasonal variations, the interest rates applied to an unsubsidised solar energy system with a 20-year lifetime has a significant effect on the costs of residential electricity. In these member states, such as Sweden and Slovakia, the applied interest rates (3%) mean that electricity is cheaper bought from the grid than procured from solar energy systems.

Electricity production from residential Solar energy systems can be cheaper than from the grid, dependent on the localised climate, solar irradiance and, as shown in the above figures, interest rates (Huld et al, 2014).

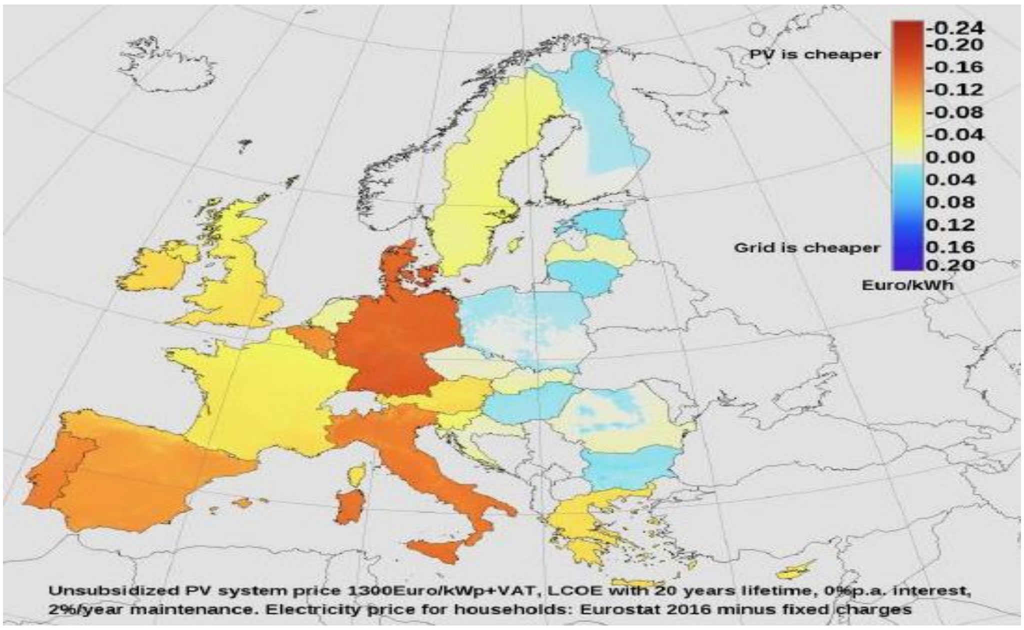

Figure 2: PV System price with no interest *(Source: Jäger-Waldau, 2018b)*

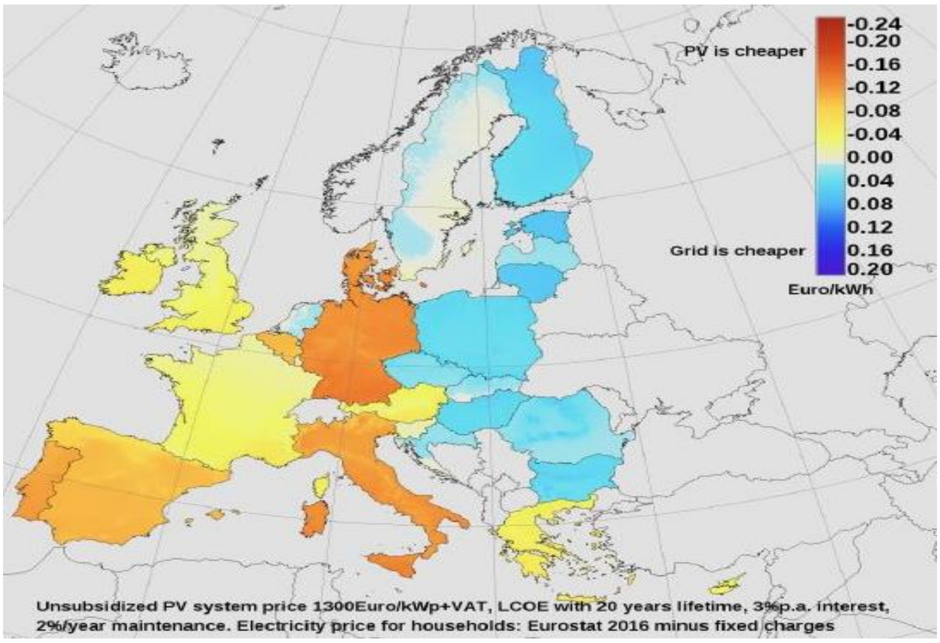

Figure 3: PV System price with 3% interest applied *(Source: Jäger-Waldau, 2018b)*

3.4 FINANCIAL GAIN/LOSS FROM INCENTIVES

Solar energy has seen a significant impact in EU-27-member states when private and public consumers are offered incentivised returns on their solar energy procurement. The following section highlights Germany, Spain and Greece in the positive and negative effects policy and incentives had on the solar energy market.

3.4.1 Germany

In an effort to achieve Germany's renewable energy goals of 55-60% of electricity consumption by 2035, the government introduced feed-in tariffs (FiTs). Designed to accelerate investment in such technologies and overcome the insecurity often associated with renewable energy, FiTs have proven effective in Germany as uptake of Solar energy has risen in correlation with the implementation of such policy mechanisms.

Germany's feed-in tariffs for solar energy, alongside rising surcharges for more traditional electricity taken from the grid, render renewable energy an attractive alternative (Sternkopf, 2017). Despite the growing uptake of solar energy causing FiTs to decrease in response, such renewable energies prove to be proliferating across Germany. This suggests that engaging feed-in tariffs during the initial stages renewable energy implementation proves effective at increasing wide-spread adoption.

3.4.2 Spain

In spite of the high proportion of daylight hours experienced in Spain, the uptake of solar energy remains limited. Contrary to Germany, feed-in tariffs for these countries proved inconsistent during the initial stages of solar energy implementation which may explain the lack of uptake.

In Spain, financial support schemes for renewable energy were withdrawn at the beginning of 2012 leaving a period of two years before the implementation of subsequent support strategies. Following this, renewable plant operators were offered a choice of either a guaranteed FiT or bonus (Jimeno, 2017). However, such changes to the financial incentives offered creates a potential for insecurity, ultimately resulting in residents' wariness of adopting renewable technologies such as solar energy.

Moreover, the Spanish government's implementation of the 'sun tax' in 2015 served to further detract residents from solar energy uptake (Tsagas, 2015). Taxing self-consumption Solar PV owners for both their personal consumption and for the sale of excess electricity to the grid increases the costs associated with such PV systems. Detracting future investors from installing PV systems, this tax justifies residents' wariness of PV and consequently the decrease in uptake of such solar systems in Spain.

Additionally, for solar energy installations up to 100kW the 'sun tax' prevents the sale of electricity to the grid (Tsagas, 2015). Instead, such system owners are obliged to donate the excess electricity produced. Whilst this is not a problem shared by larger systems proprietors - those exceeding 100kW- a process of registration is required to allow for the sale of excess electricity to the grid. However, whilst such limiting factors undoubtedly effect solar energy uptake, the implementation of new laws also work retroactively. Thus, all PV systems are affected as they must comply with such modern constraints.

3.4.3 Greece

Greece, like Spain, is a country with significant solar energy potential. Geopolitical hindrances in Greece have meant that solar uptake is not as significant as its potential.

The strong correlation between feed-in tariffs and the uptake of solar energy is exemplified in the case of Greece between 2006 and 2009. However, the FiT policy mechanism caused a deficit in the electricity market resulting in the withdrawal of such financial incentives from solar energy. Making feed-in tariffs applicable only in specific cases caused insecurity and ultimately limited the uptake of such renewable technologies.

4 Good and Bad Practices for Solar Implementation

There are, perhaps inevitably, examples of good and bad solar implementation in the EU-27-member states. This section considers some of the EU-27-member states, highlighting good and bad practices to increase solar energy uptake.

4.1 GERMANY: COMMUNITY INVOLVEMENT

Germany has always been the forerunners in solar energy implementation. In 1999, they implemented the 100,000 roofs programme which supported the installation of PV systems larger than 1kW. Low interest loans were offered with a ten-year repayment period. This supported the expansion of current installations (as well as new) in order to increase the solar capacity in Germany. The Programme ended in 2003, having supported 55,000 installation and 261MW additional capacity (IEA, 2012).

Figure *4* from Energy Atlas, 2018 and Eurostat, 2018 shows Germany as a good case of solar PV uptake. Germany is the EU leader in PV installations and a significant part of this success has been down to public participation in solar projects. As the below figure depicts, solar energy has 50% of installations by community energy participants and less than 5% of the installations from large, traditional power generating companies.

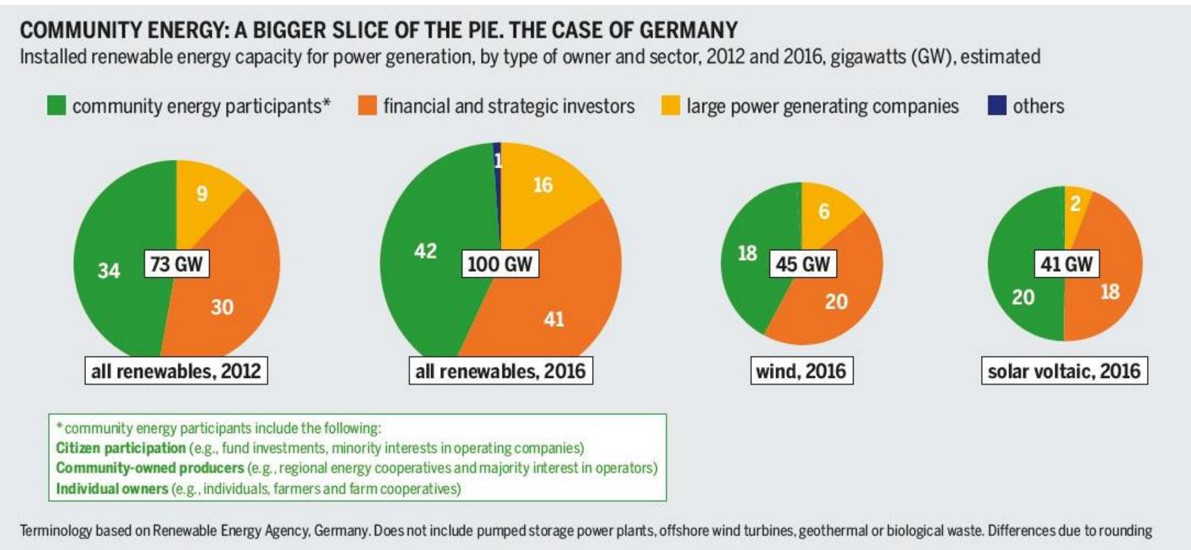

Figure 4: Installed renewable energy capacity for power generation in Germany *(Source: Energy Atlas, 2018 & Eurostat, 2018)*

4.2 SPAIN: MISSED POTENTIALS

Spain represents an example of missed growth opportunities. After an initial surge of investment in solar energy, the hinderances of the government's energy policy has slowed solar energy growth. Compared to the wind power contributions in Spain of nearly 40% generated electricity, Solar energy produced just 3%.

Policy changes in Spain have stalled the initial positive growth in renewable generation which grew from 8.3% to 14.3% between 2004 and 2012 (EnergyAtlas, 2018). Spain fell short of its interim renewable target by 1% in 2015 and experts doubt Spain will reach the remaining 4% of their energy target by 2020.

Spain put in place examples of good practise with previous strong growth from FiTs. The surge in investment, however led to overcapacity and demand stalled due to the economic crisis. Additionally, unlike many other EU-27-member states, Spain had not retired their conventional energy plants to make way for renewables- reaffirming the lack of enthusiasm and support for solar energy.

Overall, the poorly designed electricity tariff system is the root of the problem. The government compensates energy firms if generation costs are higher than the amount the firms are allowed to charge their customers.

Government policy changes between 2012 and 2015 reduced future support for solar energy implementation and increased the price consumers are charged for power. The "sun tax" described in section 3.4.2 created further uncertainty into the potential of Spain's solar energy uptake and their ability to hit energy targets. These policy changes resulted in more than 80,000 jobs being lost across the renewable sector (EnergyAtlas, 2018).

4.2.1 Future hope for Solar Energy in Spain

There is an increasing media storm for sustainable societies and the public energy debate in Spain has become a hot topic in the need for change. The worldwide push for developing sustainable energy, self-generation and democratisation of the model gives Spanish citizens the push for national energy policy. The geographical conditions in Spain give great potential to be leaders in solar energy procurement but so far, renewables and specifically solar energy has faced strict regulatory and political environments.

A revised EU Renewable Energy Directive could push Spain in the right direction to extrapolate their solar potential and regain the legal and investment security needed to bring this energy transition.

4.3 GREECE: FINANICIAL CRASH

Greece has one of the largest solar potentials in Europe, and surprisingly, only taps into a small fraction of it. By comparison, Germany has installed more than double the solar PV capacity than Greece, emphasising the underutilisation of the Greek renewable sector.

Greece has seen an increase in its renewable uptake due to favourable FiTs leading to an increase from 9MW in 2007 to 2,611MW in 2016. The 2009 European Commission Directive on energy also pushed this increase in solar energy. This directive triggered a national law promoting renewables into Greece's total electricity mix. A second contributor to the rise in solar energy in Greece was the decrease in installation prices for solar panels between 2007 and 2014. This saw PV module prices fall by 79% (EnergyAtlas, 2018).

However, the 2014 financial crisis in Greece stunted the growth for any more renewable implementation. PV FiTs were significantly cut to deal with the government debts and producers of solar energy were burdened with high costs with little tariff incentives.

Due to the nature of the banking and economic crisis in Greece, the investments in renewables have been stunted and there is growing concern as to whether the national goal of 40% share of electricity consumption by renewables will be reached in the next ten years, let alone by 2020.

4.3.1 Future hope for Solar Energy in Greece

Not all hope is lost for the economic future of renewables in Greece, however. A draft law for energy communities, slated for 2018 will recognise citizens' rights to produce, store, sell and consume their own energy. This encourages local organisations to be the vehicle for solar energy growth and utilise the energy transition in Greece.

This law will also provide assurance for energy security to the many islands not connected to the mainland grid. The Greek islands mostly rely on fossil fuels for their energy source and will need encouragement to switch to green power; smart energy management and support schemes.

Feed-in-tariffs have not benefitted Greece like they do in many other EU-27-member states and therefore the future for solar implementation highlights the need for favouring electricity auctions. They will need to come to terms with replacing the heavily dependent fossil fuels for renewables and storage systems. Inter-island connections are key for solar trade in Greece and government support needs to back this in association with the European Emission Trading Scheme offering funding.

5 Grid Issues

Implications for the EU power systems of 2030 gives rise to the concern of power system flexibility in the ability to deal with the increased variability of generation. Common concerns to the Grid in the uptake of high renewables are: curtailment, congestion and cross border interconnection. In particular, the high seasonal variances of solar across the EU-27 can cause unreliability to the meet the electricity demands. The stochastic nature of solar makes it hard to predict the energy output. The predicted the amount of solar irradiance across a full year to meet annual demands. EU-27-member states differ drastically in their solar energy abilities. For example, Spain can get 320 days of sunshine a year but was hindered by its "sun tax" while Sweden is immersed in darkness for much of winter but has great potential in summer during midnight sun times when energy would be considered cheaper.

5.1 CURTAILMENT

When there is an excess supply of wind and solar energy that cannot be consumed within a market or exported to neighbouring markets, this is regarded as "curtailment". High levels of curtailment are indicative of an instability in the grid, where it not able to handle large amounts of stochastic energy. Curtailment is to be avoided due to the risks it poses as a barrier for deployment for project developers, which in turn increases the difficulties in making projects economically viable.

Figure *5* details countries in EU member states which are predicted to have a significant proportion of curtailment by 2030, these are Malta, Croatia and Denmark with 12.2%, 4.7% and 3.8%, respectively (IRENA, 2018).

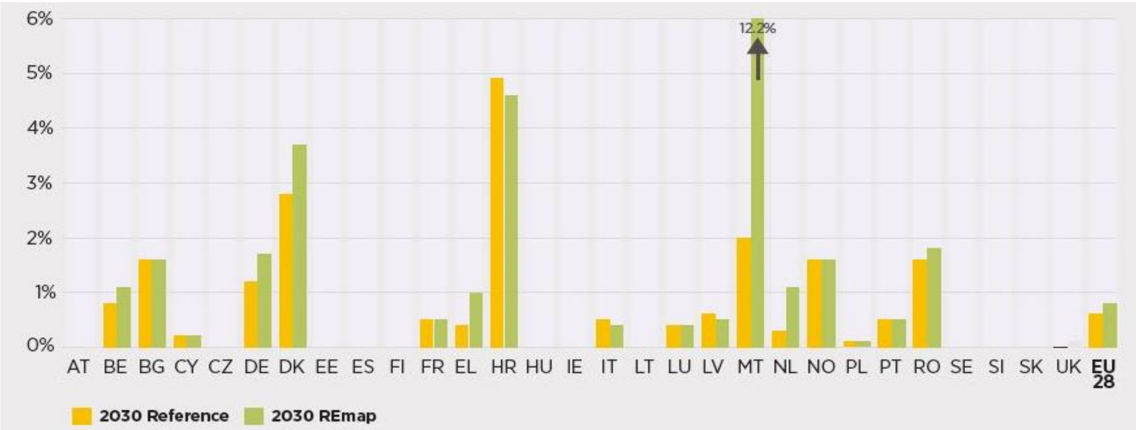

Figure 5: Renewable energy curtailment rate by EU Member State in 2030 *(Source: IRENA, 2018)*

Curtailment levels could increase because of high renewable share in the transmission lines causing congestion to the grid. By 2030, there needs to be effective levels of deployment to minimise curtailment such as storage, demand side response and infrastructure of connection advancement (IRENA, 2018). While it is essential to minimise curtailment, it can in some cases be used cost effectively as a method of system flexibility.

5.2 VEHICLE TO GRID (V2G)

In the past three years, the concept of Vehicle- to-Grid (V2G) has adapted to give consumers control on their energy and balance the grid. V2G is the technology in which energy is stored in electric vehicles (EV) and fed back to the grid to help supply energy during peak demand times. This technological advancement, as well as smart charging and demand side response are aimed at changing the way individuals and businesses use energy now and, in the future, to satisfy demand. The electric car technology is advancing in a way that EV owners can utilise the storage capacity of the battery and redirect the load, creating a somewhat mini power plant for consumer control. V2G technology could support the grid by making the charging and discharging of the batteries smart and optimal and as such making the electricity network more reliable and more responsive in filling in the gaps from conventional to stochastic energy changes.

5.3 ENERGY TRADE

For a fully integrated EU renewable power market, there needs to be the ability to trade power across Member States. This ability will highlight a flexible power system which will enable the integration of larger volumes of renewable by reducing the stochastic nature into larger power systems in potential neighbouring Member States.

Trade between EU-27 Member State borders is expected to contribute to 16% of the final electricity consumption by 2030. For this to be achievable, the EU has set a 10% electricity interconnection target for 2020 which will test the limitations to the current infrastructure and highlight the areas needing for expansion (European Commission, 2017). Figure *6* shows the import and exports of power in EU Member States predicted for 2030, based on Renewable Energy Map by IRENA, 2018.

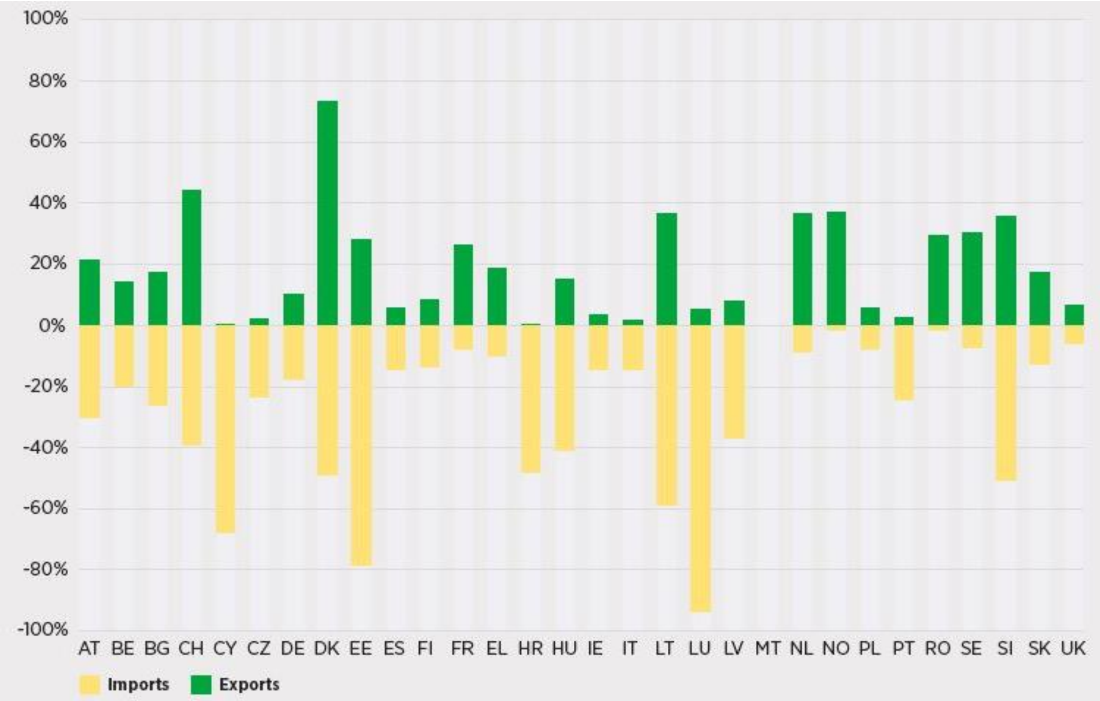

Figure 6: Power imports and exports by EU Member Stat in 2030 *(Source: IRENA, 2018)*

5.4 INFRASTRUCTURE

Additional interconnection and better grid infrastructure are essential in order to reduce transmission congestion. Congestion occurs when an interconnector is operating at maximum capacity. For EU-27 to meet the requirements of renewable penetration by 2030, the European interconnectors are expected to be operating in high levels of congestion 39% of the time (IRENA, 2018).

While it is crucial for the interconnectors around the EU-27 Member States to be advanced and improve infrastructure to reduce the pressures on the voltage networks, there is an ever-growing need for better solutions of storage. Storage will elevate these pressures, can in some cases act in a demand side response manner and reduce curtailment issues which gives better promise to financing new technologies in solar utilisation.

6 Storage

There are, in principle, two methods to increase direct consumption of solar PV energy. One method would be to have intelligent control systems which utilise solar energy and turn on appliances when PV is high, but demand would be low. The second option would be to store the energy, either as electricity or heat storage. Storage gives the additional flexibility to residents and network operators to manage loads profitably

While solar energy covers around 5% of the European Union's electricity demand today, its contribution could easily increase up to 15% by 2030; it would only take around 20 GW of newly installed PV capacity per year. A major trend linked to the deployment of solar PV is its co-location with battery storage. Storage adds flexibility and allows increasing system integration of solar PV. European examples can be found in the UK, where the first subsidy free utility solar & storage installations are being developed. Or in Germany, where around 50% of all residential solar PV installations in 2016/2017 were coupled to battery storage.

7 Socio Economic Factors

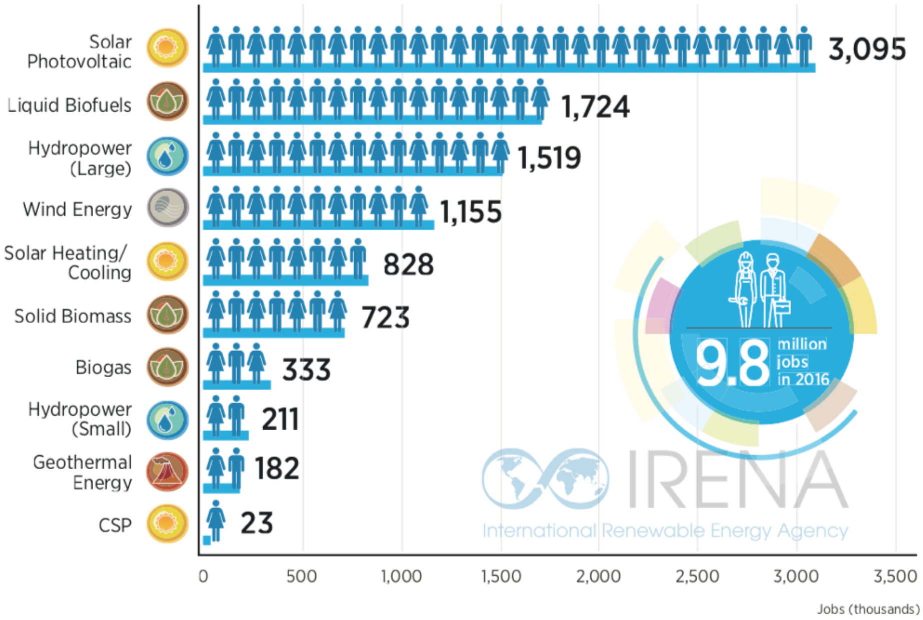

Figure 7: Renewable Energy Employment by technology *(Source: IRENA, 2017)*

There are a number of forces which define the socio-economic impacts within the PV industry. EY, 2018 estimate that much of the significant impacts on both job creation and gross value added (GVA) in solar are: annual installed capacity, efficiency gains in manufacturing and services and the decline of incentive schemes for installations in Europe.

According to EnergyAtlas (2018), renewables have created 8.3 million jobs worldwide and 1.1 million in EU. In Germany alone 370,000 people are employed in renewable energy fields with this figure set to increase as implementation of solar PV rises.

In addition, solar & storage bring economic advantages: Storing solar electricity when prices are high and using it when prices are low allows stabilising energy prices to reduce future grid upgrades and expansion cost.

The four key social benefits that solar energy and storage produces are:

- local job creation;
- avoided CO2 emissions;
- true consumer empowerment, especially relating to community run schemes.
- Lower energy costs, with some potential to reduce costs for those living in energy poverty

To capture the full potential of solar & storage in the future, politics must set the right conditions now. SolarPower, Europe's Solar & Storage Task force, is calling on EU institutions to ensure that the following policy asks are strengthened and fully reflected in the new Market Design Directive (whereas these points need to be addressed similarly anywhere in the world for solar energy & storage to thrive).

Recent evidence from the UK indicates that reducing FiTs can have an immediate and direct economic consequence. When the FiTs were dramatically reduced at the end of 2015, surveys by PWC and the UK Solar Trade Association estimated 12,500 jobs were lost in the UK. (Cleantechia 2016). Other estimates suggest the figure could be as high as 18,000. It is also worth noting that solar jobs are not geographically linked to any resource or material and can generally be located in areas of high unemployment. Whether manufacturing of panels or equipment, sales, admin, installation, maintenance or research, most of the jobs are located either at the point of installation or can be generated in an unemployment blackspot, reducing disproportionately positive socio-economic benefits.

Other reports indicate the employment potential associated with renewable energy in general. With a RES target of 35% in the Renewable Energy Directive, instead of the current 27%, job provision would increase by 56% in the solar industry alone (EY, 2017).

Numerous reports have commented on the cost per job with subsidised schemes, noting that subsidies for solar provide a greater number of jobs than subsidies for fossil fuel powered schemes. However, politics does not always agree, and certain Governments do not provide financial support for solar schemes. The Czech Republic for example does not support FiT schemes. Although the economic, social and environmental case for supporting solar energy is strong, there is still a requirement to develop the political response in some of the EU27.

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11 Country Codes

Country	Code
Austria	AT
Belgium	BE
Bulgaria	BG
Croatia	HR
Cyprus	CY
Czech Republic	CZ
Denmark	Dk
Estonia	EE
Finland	FI
Germany	DE
Greece	EL
Hungary	HU
Ireland	IE
Italy	IT
Latvia	LV
Lithuania	LT
Luxemburg	LU
Malta	MT
Netherlands	NL
Poland	PL
Portugal	PT
Romania	RO
Slovakia	SK
Slovenia	SI
Spain	ES
Sweden	SE
United Kingdom	UK

12 Appendix 1: Selected EU Countries

Information in the Appendix is taken directly from the PV status report 2018

12.1 AUSTRIA

In 2017, Austria installed about 150 MW of new solar PV systems and increased the cumulative capacity to 1.25 GW. The Ökostrom-Einspeisetarifverordnung 2012 (Eco-Electricity Act) is the regulation which sets the prices for the purchase of electricity generated by green power plants. In addition, there is a federal investment subsidy programme for PV systems with different sizes. For each of these categories a limited budget is available. 14

The investment can be supported with a maximum of EUR 275/kWp for add-on and ground-mounted systems and EUR 375/kWp for building-integrated systems. In addition to these federal programmes, five federal states have their own PV programmes and six states have programmes to support the installation of electricity storage.

In June 2017 the Eco-Electricity Act was changed. For 2018 and 2019 an additional budget of EUR 15 million each year to support PV systems and electricity storage was agreed (BGB, 2017).

At the end of May 2018, the Austrian Government approved the new Climate and Energy Strategy – "mission 2030" – for Austria (GoA, 2018). The main issues concerning photo-voltaics are:

- Increase the share of renewables in final energy consumption to 45-50% by 2030. This corresponds to about 80 TWh of electricity or 30 TWH more than today from hydro, solar and wind.
- In 2030 renewable electricity production should cover 100% of electricity consumption.
- Investment support programme for "100,000 rooftops with local storage".
- Removal of all taxation on self-generation, currently exempted up to 25MWh.
- Change incentives to a combination of feed-in premiums, auctions and investment incentives.

According to a study by the Energy Economics Group of the Technical University of Vienna, the installed PV capacity to realise "mission 2030" should be in the range of 14 to 15 GW by 2030, a more than 10fold increase compared to 2017 (Haa, 2017).

12.2 BELGIUM

The three Belgian regions (Brussels, Flanders and Wallonia) have individual support schemes for PV, but one electricity market. Therefore, some regulations are regional and others are national. A common denominator is the fact that all three regions selected an renewable portfolio standard (RPS) system with quotas for RES. A net-metering scheme exists for systems up to 5 kWp Brussels or 10 kWp (Flanders and Wallonia) as long as the electricity generated does not exceed the consumer's own electricity demand.

In 2011, Belgian installations peaked with over 1 GW of new systems, before starting to decline in 2012. At the end of 2017, cumulative installed capacity was over 3.8 GW with about 290 MW installed in that year (IEA, 2018b). Over 9.3 % of Belgian households are al-ready generating their own solar PV electricity, and PV power supplied 2.89 TWh or 3.6 % of the country's net electricity production in 2017.

The proposal of the Belgium Parliament for a new Energy Pact 2050 was published in January 2018 (BKV, 2018). The main issues concerning photovoltaics are:

- Gradual phase-out of Belgium's 6 GW of nuclear capacity between 2022 and 2025 and increase of renewables in the power supply to 40% by 2030 (8 GW of PV, 4.2 GW onshore wind and 4 GW offshore wind).
- Increase of renewables in the power supply to 100% by 2050.
- 2 GW of large-scale storage and 3 GW of distributed small-scale storage.

The Belgian grid operator Elia published three scenarios for the Belgian electricity supply indicating that total solar PV power could be in the range of 5 to 11.6 GW by 2030 and in the highest scenario could go up to 18 GW by 2040 (Eli, 2017). To reach the 2030 targets of the Energy Pact, the present market size of about 300 MW only has to increase slightly over the next 12 years.

12.3 DENMARK

The combination of a net-metering system and high electricity prices of EUR 0.295/kWh resulted in 378 MW of PV systems being installed in Denmark in 2012. Due to this rapid development, the regime was already changed in November 2012 [GoD 2012].

The so called 60/40 programme, which went into effect on 11 June 2013 was suspended with immediate effect on 3 May 2016. Under the scheme PV power systems were eligible for a maximum reimbursement (bonus plus market price) of DKK 0.60/kWh (EUR5) 0.081/kWh) during the first 10 years of operation, and DKK 0.40/kWh (EUR 0.054/kWh) being applicable for a further 10 years.

The reason for this decision by the Danish Parliament was the fact that the transmission system operator (TSO) Energinet.dk received application for 4.5 GW in March and April 2016. All applications, which had not been processed and approved before 3 May 2016 were declared not eligible for the scheme.

At the end of November 2016, the German Bundesnetzagentur announced the results of the first cross boarder auction with Denmark: five bids, all of them from Denmark and to be built there, totalling 50 MW won at a price of 5.38 cents per kilowatt hour (EURct/kWh) [Bna 2016]. The results of the first Danish cross border auction in Decem-ber 2016 revealed even lower prices. The 9 winning tenders will get a fixed premium of 12.89 Danish øre per kWh (EUR 17.32/MWh) for 20 years on top of the Danish spot mar-ket price, which is fluctuating in the range of EUR 30 to 40/MWh [Ene 2016].

In 2017, the Danish government decided to have a tender for PV systems smaller than 1 MW in 2018 and a joint tender for solar and wind power in 2018 and 2019 [Ene 2018a]. The support scheme was approved by the European Commission in August 2018 [EC 2018a].

In 2017 about 60 MW were installed increasing the total capacity to over 900 MW. PV systems generated 2.3% of the Danish electricity in 2017.

12.4 FRANCE

In 2017, 887 MW of new PV systems were connected to the grid in France [Rte 2018]. Total cumulative installed capacity increased to over 8.06 GW, including about 400 MW in the French Overseas Departments [Sta 2018]. Electricity production (continental France and Corsica) from PV systems was 9.2 TWh or 1.7 % of the national electricity generation [Rte 2018].

On 22 July 2015, France's National Assembly adopted the Energy Transition for Green Growth Act. The legislation aims to reduce France's reliance on nuclear to 50 % of power generation by 2025 and increase the share of renewable energies in the final gross energy consumption to 23 % in 2020 and 32 % in 2030 [MEE 2016].

The targets for PV to achieve the 2023 goal are 10.2 GW installed PV power by 2018 and between 18.2 and 20.2 GW by 2023. Under the new support mechanism, feed-in tariffs are only available for systems below 100 kW capacity and tenders for systems above. However, there is still a difference for the larger systems: Systems between 100 and 500 kW bid for fixed tariffs, larger systems for a market premium. In the first half of 2018 PV systems with a capacity of 479 MW were connected to the grid [Sta 2018]. The capacity of projects in the planning stage increased to 6 GW, of which 2.5 GW already had a signed connection agreement.

In 2016, the mandatory introduction of smart meters started and should be completed by 2021. This measure provides an indirect support measure for small self-consumption systems, because it removes the grid connection costs. These costs were in general more than 12% of the price of a 3 kW system.

12.5 GERMANY

Compared to 2016, new PV system installations in Germany saw a slight increase to 1.75 GW, with about 440 MW free-field systems as a result of previous auctions [Bun 2018]. For the first 7 months of 2018 the Bundesnetzagentur reported the registration of PV projects with 1.65 GW out of which about 480 MW free-field systems as a result of previous auctions.

The German market growth is directly correlated to the introduction of the Renewable Energy Sources Act (Erneuerbare Energien Gesetz EEG) in 2000 [EEG 2000]. This law introduced a guaranteed feed-in tariff (FiT) for electricity generated from solar PV systems for 20 years and already had a fixed built-in annual reduction which was adjusted over time to reflect the rapid growth of the market and corresponding price cuts. However, the rapid market growth required additional adjustments. Until 2008, only estimates of installed capacity existed, so a plant registrar was introduced on 1 January 2009.

Since May 2012, the FiT has been adjusted on a monthly basis depending on the actual installation of the previous quarter. The revision of the EEG in 2014 changed the system size for new systems eligible for a feed in tariff and introduced levels of levies on self-consumption [EEG 2014]. So far systems with a capacity of less than 10 kWp are excepted form the levy. For all other systems, the levy on each self-consumed kWh increased to 40% on 1 January 2017.

Since 1 September 2015, owners of new ground mounted systems have to participate and win an auction of the Federal Network Agency. The total amount of capacities auctioned is determined by political decisions and limits this market segment.

Starting on 1 January 2016 only systems smaller than 100 kWp are eligible for a feed in tariff and since then also larger rooftop systems have to market their electricity directly or take part in auctions. The relevant feed-in-tariffs are regularly published by the Bundesnetzagentur.

The fact that the tariff for residential PV systems smaller than 10 kWp (September 2018: EUR 0.1230/kWh) is now well below the average variable electricity rate consumers are paying (EUR 0.235- 0.275/kWh) and the fact that they are still exempt from the EEG levy makes self-consumption attractive and is opening up new possibilities for the introduction of local storage. Since July 2017 a programme to support the self-consumptions for tenants of multi apartment buildings exists, but until May 2018 only about 160 PV systems with 4 MW cumulative power were installed [Bna 2018].

Since 1 May 2013, the Kreditanstalt für Wiederaufbau (KfW) has been offering low interest loans with a single repayment bonus of up to 30 % and a maximum of EUR 600/kW of storage for PV systems up to 30 kWp [KfW 2013]. The support was gradually reduced over time and the programme will now terminate at the end of 2018 [KfW 2016].

12.6 GREECE

In 2009, Greece introduced a FiT scheme which started slowly until the market accelerated from 2011 until 2013, when 425 MW, 930 MW and more than 1 GW of new PV system capacity was installed respectively. This boom ended on 10 May 2013, when the Greek Ministry of Environment, Energy and Climate Change (YPEKA) announced retroactive changes in the FiT for systems larger than 100 kWp and new tariffs for all systems from 1 June 2013. During the first five months of 2013 almost 900 MW were installed and increased the total cumulative capacity to over 2.5 GW. About 2.4 GW were installed in the Greek mainland and the rest on the islands. Since the only a few tens of MW have been installed.

The Greek Operator of the Electricity Market (ADMIE) reported about 2 094 MW of installed grid-connected PV systems over 10 kW and 351 MW of rooftop PV systems up to 10 kW at the end of March 2018 [Adm 2018]. These figures are the same as last year and do not include the installed capacity of non-interconnected Greek islands, which — according to the Hellenic Electricity Distribution Network Operator SA — was 170 MW in April 2018 [Hed 2018].

After the European Commission approved the new auction scheme on 4 January 2018 [EC 2018b], the first renewables auction in Greece was held on 2 July 2018. The auction was held by the Regulatory Authority for Energy (RAE) and had three categories:

- PV plants of 0.5 to 1 MW (83 projects with 53.48 MW of capacity were awarded with a weighted price of EUR 78.42 per MWh)
- PV plants between 1 and 20 MW (8 projects with 52.92 MW of capacity were awarded with a weighted price of EUR 63.81 per MWh)
- Wind power plants between 3 and 50 MW (170.92 MW of capacity was awarded with a weighted price of EUR 69.53 per MWh). The lowest bid was achieved in the second category with EUR 62.97 per MWh. A second auction is planned for the end of 2018.

12.7 HUNGARY

The Hungarian National Renewable Action Plan required by the EU Renewable Energy Directive (2009/28/EC) foresees to reach a renewable energy share of 14.65% of its gross energy consumption by 2020. As a consequence of not meeting the trajectory set out in the NREAP a new supporting scheme for electricity generation from RES was adopted in June 2016.

The existing mandatory take-off system, guaranteeing a fixed price per kWh generated, was passed out on 31 December 2016. However, all project owners, which had submitted their application before this deadline, were still eligible for this scheme.

In July 2017 the European Commission approved the new renewable support scheme (METÁR) [EC 2017]. For systems with a capacity below 500 kW a feed in tariff (FiT) and for systems between 500 kW and 1 MW a feed-in premium (FiP) will be set at the beginning of each year. The approved internal rate of return (IRR) used to calculate the level of the FiT and FiP and the duration of support is 6,94 %. Systems above 1 MW are eligible for a competitive FiP determined by a bidding procedure.

In the first half of 2018, METAR, which finally came into force last October, already had some turbulences, when the government unexpectedly brought forward the application deadline for projects of 50 - 500kW to April 26, whereas in the original government decree no deadline was foreseen. No date for a bidding for larger systems has been set yet.

In 2017, Hungary connected about 90 MW of PV systems, increasing cumulative installed capacity to 380 MW by the end of 2017.

12.8 ITALY

In 2017, Italy connected 415 MW of PV systems, increasing cumulative installed capacity to 19.7 GW by the end of 2017 according to the annual report of the Gestore dei Servizi Energetici (GSE) [Gse 2018]. After the Quinto Conto Energia (Fifth Energy Bill) ended in July 2013, the only support mechanisms are now via the Scambio sul Posto (self-consumption) scheme and a tax break for the system investment costs.
According to the Italian national grid operator TERNA, electricity from PV systems provided 24.81 TWh or 7.7 % of the total electricity sold in 2017 [Ter 2018]. Solar photovoltaic power generation was 11.41 TWh or 7.2 % of the total electricity during the first six months of 2018. The highest monthly coverage was in April 2018, when PV electricity supplied 10.1 % of the Italian energy demand.
In March 2018, ENEL announced that it started the production of bi-facial silicon heterojunction modules at its 3SUN factory in Catania, Sicily, and aims to increase the production volume to 240 MW by 2019 [Ene 2018b].

12.9 THE NETHERLANDS

According to the Dutch Statistical Office, PV systems with a capacity of 815 MW have been installed in 2017 bringing the total installed PV power to 2 864 MW at the end of the year [Cbs 2018]. The total generated solar electricity was 2.15 TWh or 1.85 % of the net electricity generation.

Since 2011, the main incentive has been a net-metering scheme for small residential systems up to 15 kW and a maximum of 5 000 kWh/year. Systems larger than 15 kW can apply for the programme to stimulate sustainable energy production (SED+), for a max-imum of 950 full load hours per year, which is open for all renewable energy technologies [RVO 2018]. Over 3 700 PV projects with a combined capacity of 1.7 GW were selected in the first round of the 2018 SDE+. This brings the total approved capacity of PV systems for the two 2017 and the first 2018 allocations to 5.9 GW.

12.10 POLAND

The Polish National Renewable Action Plan required by the EU Renewable Energy Di-rective (2009/28/EC) foresees to reach a renewable energy share of 15.5% in the gross final energy consumption. Renewable electricity should reach 19.13% of the final energy supply by 2020.

The Renewable Energy Act of 2015 went into force in July 2016 and replaces the previous green certificate system with an auction scheme [GoP 2016]. The first auction for sys-tems smaller than 1 MW took place on 30th of December 2016 and the second on 29/30 June 2017. A total of 360 MW was awarded to 436 projects, out of which 40 systems with about 27 MW were installed until the end of May 2018 [Ieo 2018].

In 2017, Poland connected about 80 MW of PV systems, increasing cumulative installed capacity to 280 GW [Ieo 2018]. About half of the capacity was installed under the old green certificate system, the other half are residential small systems.

12.11 SPAIN

Spain takes the fifth place in Europe with regard to the total cumulative installed capaci-ty, at 5.6 GW6. Most of this capacity was installed in 2008 when the country was the largest market, with over 3.3 GW [IEA 2014]. As a consequence, the Spanish Govern-ment started to introduce a number of regulations in order to limit the growth of the sec-tor already in 2008 and suspended the remuneration pre-assignment procedures for new renewable energy power capacity in January 2012. The justification given for this move was that, until then, Spain's energy system had amassed a EUR 24-billion power-tariff deficit. The government argued that the special regime for renewable energy was the main reason for this. However, this argument was more than questionable as the deficit already amounted to almost EUR 9 billion in 2007, a time when payments under the spe-cial regime for renewable energy were still limited. After peaking in 2013 with EUR 28.8 billion the deficit had decreased to EUR 23 billion at the end of 2016 [CNM 2017]. According to press reports, Moody's estimates that the deficit will decrease by over 9% from the EUR 21 billion at the end of 2017 to about EUR 19 billion at the end of 2018 [Eur 2018].

A more detailed description of the development of the Spanish market can be found in earlier PV Status Reports [Jäg 2016].

In 2017, new PV systems were installed with a capacity of roughly 150 MW. In the same year, electricity generated from grid connected PV systems contributed 8.4 TWh or 3.2 % of the Spanish electricity generation.

After five years of very little new PV power additions, the next three years will bring some change. In July 2017, the Spanish Ministry for Energy and Tourism announced the winners of the second renewable energy auction in 2017 and solar photovoltaic power projects had won 3.9 GWAC in this auction [MET 2017]. The winning consortia have to connect the systems before the 1st January 2020.

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