

UTILIZATION OF SOLAR ENERGY AS A EUROPEAN ENERGY TREND

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Abstract

The problem developed in the paper is very specific, important and current due to the fact that it treats various energy sources, and in this context the research is mainly based on carefully selected and processed data on the participation of various sources in electricity production and its production from renewable energy sources (RES), especially from solar energy. Investing in the specific case of the production of electricity from solar energy has a significant role and direct impact in approaching, achieving and fulfilling the specific goal of each country separately by 2020 within the European Union, i.e., the fulfillment of the European Directive 20/20/20.

The paper is of special importance and aims to point out the impressive development and implementation of photovoltaic systems, which are favorites by investors and incomparable from an economic point of view, not to mention the range of environmental causes in air and environmental pollution, as opposed to operation of existing fossil and nuclear systems. Hence, in the future, such energy projects will be motivated, promoted and supported by various European financial funds, with great security in the investment and without a doubt in the profitability of these systems. This is until a complete transformation of electricity production from fossil and nuclear fuels with RES production is achieved within the EU-28 and non-EU-28 countries.

Keywords: Electricity production, renewable energy sources, photovoltaic systems, solar energy market, European energy trend.

1 Introduction

Today, electricity generation is an important and significant economic activity within the EU-28 and the countries individually. Hence, the issue that has been developed is very topical due to the fact that it treats and gives a clear picture of the percentage share of various energy sources, conventional, nuclear and renewable in electricity production on the one hand, and the European energy trend of solar energy use, through construction of photovoltaic systems for electricity on the other hand.

It is very important to switch to sustainable energy sources, instead of continuing to rely on unsustainable and expensive systems. The most important advantage that the photovoltaic system offers is that it is very economical and with the fastest return on the investor's investment.

Having in mind the above, the analysis in this paper is focused and aims to address and show that it is entirely possible to achieve 100% energy replacement of fossil and nuclear fuels with RES, for electricity production. This renewable electricity by 2050 will appear as the main carrier of energy in future energy systems.

In the context of what has been said, the analysis in the paper is summarized in three parts, as follows: The first part of the paper is dedicated to the share of different energy sources in the production of electricity in the EU-28. The second part continues with the European solar PV installed capacity. The third part points out the European solar PV capacity prospects and finally, the paper ends with a conclusion.

2 Share of different energy sources in the production of electricity in the EU-28

Regarding the structure of electricity production in 2018 (Table 1), the production of conventional thermal electricity decreased by 8.3 % in the EU-28 in 2018 and accounted for 45.9 % of the total production, while the production of electricity by nuclear power plants decreased (-0.3 %) and accounted for 25.5 % of the total. The electricity production in the EU-28 by wind increased by 5.0 % and represented 12.2 % of the total production, while the production by hydro which includes pumped hydro (not necessarily of renewable origin) increased by 11.4 % and represented 11.8 % of the total production. The electricity production by solar increased by 3.9 % and represented 4.0 % of the total production.

Table 1. Electricity statistics EU-28, 2016-2018 (GWh) (Source: Eurostat (*nrg_ind_peh*), (*nrg_cb_e*), (*nrg_105m*))

	EU-28				
	2016	2017	2018	17/16	18/17
1. Total net production	3 108 542	3 137 973	3 070 057	0.9%	-2.2%
of which:					
Conventional thermal	1 515 894	1 538 379	1 410 491	1.5%	-8.3%
Nuclear	795 629	785 916	783 936	-1.2%	-0.3%
Hydro	375 034	326 015	363 309	-13.1%	11.4%
of which: Pumped hydro power	29 529	29 931	45 515	1.4%	52.1%
Wind	300 219	358 003	375 929	19.2%	5.0%
Solar	110 386	118 295	122 908	7.2%	3.9%
Geothermal	6 272	6 292	6 168	0.3%	-2.0%
Other	4 613	4 554	7 316	-1.3%	60.6%
2. Imports	382 541	384 736	395 611	0.6%	2.8%
3. Exports	364 151	374 537	367 478	2.9%	-1.9%
4. Energy absorbed by pumping	41 130	42 617	38 788	3.6%	-9.0%
5. Energy supplied	3 085 801	3 105 555	3 059 402	0.6%	-1.5%
	Contribution of the sources to the production in %				
	EU-28				
	2016	2017	2018		
	Conventional thermal	48.8	49.0	45.9	
	Nuclear	25.6	25.0	25.5	
	Hydro	12.1	10.4	11.8	
	Wind	9.7	11.4	12.2	
	Solar	3.6	3.8	4.0	
	Geothermal	0.2	0.2	0.2	
	Other	0.1	0.1	0.2	

The total net electricity production in 2018 at the EU-28 level is mostly produced from conventional thermal and nuclear energy, 71.4%, while the rest of 28.6% of RES.

Regarding the electricity production from various energy sources in different countries, we will observe the EU-28 countries, including Republic of North Macedonia and eight other countries. After an increase of 0.9 % in 2017, the total net electricity production in 2018, at the level of EU-28, amounts to 3070057 GWh, which is a decrease in production by 2.2% compared to 2017 (Electricity generation statistics – first results, 2019).

After the increase of 0.9% in 2017, the total net electricity production in 2018 at the EU-28 level, reaches a value of 3,070,057 GWh, which is a decrease in production by 2.2% compared to 2017.

Electricity from conventional thermal energy sources is produced in all countries, however the highest share between the EU-28 member states was observed in Estonia (93.9%), Cyprus (91.4%), Malta (90.9%),

Poland (90.2%), Holland (83.9%), Greece (68.6%), Ireland (68.3%), Italy (66.0%) and the lowest was observed in Sweden (9.4%). Outside of the EU-28, Turkey had a share of 67.5% (Table 2).

Table 2. Distribution of electricity production by source, 2018 (%), in EU-28 countries and outside the EU-28 (Source: Eurostat (nrg_105m))

2018	Conventional thermal	Nuclear	Hydro	Wind	Solar	Geothermal & others	Total
Countries	%	%	%	%	%	%	%
EU-28	45.9	25.5	11.8	12.2	4.0	0.4	100
EA-19	43.6	27.0	11.9	12.2	4.7	0.6	100
EE	93.9	0.0	0.2	6.0	0.0	0.0	100
CY	91.4	0.0	0.0	4.6	4.0	0.0	100
MT	90.9	0.0	0.0	0.0	0.0	9.1	100
PL	90.2	0.0	1.5	8.1	0.2	0.0	100
NL	83.9	2.9	0.1	10.9	2.2	0.0	100
EL	68.6	0.0	11.4	12.4	7.5	0.0	100
IE	68.3	0.0	3.2	28.6	0.0	0.0	100
IT	66.0	0.0	17.6	6.2	8.2	2.0	100
LV	61.0	0.0	37.2	1.8	0.0	0.0	100
CZ	58.6	34.5	3.2	0.7	2.8	0.1	100
UK	57.0	18.6	2.4	17.9	4.1	0.0	100
DE	56.0	12.6	3.5	19.6	8.1	0.1	100
PT	53.2	0.0	23.2	21.6	1.7	0.4	100
DK	48.6	0.0	0.1	48.0	3.3	0.0	100
BG	46.4	36.7	11.2	3.2	2.5	0.1	100
HU	45.3	49.9	0.7	2.0	2.0	0.0	100
BE	43.5	39.0	1.8	10.4	5.0	0.3	100
ES	42.2	20.4	13.8	19.0	4.6	0.0	100
FI	39.2	32.5	19.5	8.7	0.1	0.0	100
RO	38.5	17.8	30.1	10.7	3.0	0.0	100
HR	31.3	0.0	57.9	10.2	0.5	0.0	100
SI	30.8	35.9	31.6	0.0	1.7	0.0	100
LT	25.2	0.0	29.6	35.7	2.5	7.0	100
AT	24.9	0.0	56.7	8.9	0.0	9.4	100
SK	22.9	58.2	16.2	0.0	2.5	0.2	100
LU	21.4	0.0	61.3	12.2	5.2	0.0	100
FR	9.8	71.3	12.5	4.7	1.7	0.0	100
SE	9.4	41.6	38.5	10.5	0.0	0.0	100
NO	2.4	0.0	95.0	2.6	0.0	0.0	100
TR	67.5	0.0	20.7	6.9	2.6	2.4	100
RS	67.0	0.0	32.5	0.4	0.0	0.0	100
MK	63.6	0.0	34.1	1.9	0.4	0.0	100
ME	38.6	0.0	57.1	4.3	0.0	0.0	100
AL	0.0	0.0	100.0	0.0	0.0	0.0	100
BA	53.4	0.0	46.3	0.3	0.0	0.0	100
UA	38.2	53.1	7.5	0.7	0.5	0.0	100
GE	17.4	0.0	81.9	0.7	0.0	0.0	100

Electricity from nuclear sources is produced in 14 countries and the highest share between the EU-28 member states was observed in France (71.3%), Slovakia (58.2%), Hungary (49.9), Sweden (41.6), Belgium (39.0%), Bulgaria (36.7%), Slovenia (35.9%), Czech Republic (34.5%), Finland (32.5%), whereas in Holland it was 2.9%, while outside of the EU-28 countries Ukraine is with a share of 53.1%. In Germany, where it was decided to close down their nuclear power plants by the year 2022, the share of electricity produced by nuclear power is 12.6 % of the total.

Electricity from hydro power sources is produced in almost all countries and the highest share between the EU-28 member states was observed in Luxemburg (61.3%), Croatia (57.9%), Latvia (59.3%), Austria (56.7%), Sweden (38.5%), Latvia (37.2%), Slovenia (31.6%), Romania (30.1%), Lithuania (29.6%),

Portugal (23.2%), Finland (19.5%) and with 0.1% in Holland and Denmark, while outside of the EU-28 countries Albania is with a share of 100.0%.

Electricity from wind power sources is produced in almost all countries and the highest share between the EU-28 member states was observed in Denmark (48.0%), Lithuania (35.7%), Ireland (28.6%), Portugal (21.6%), Germany (19.6%), Spain (19.0%), Great Britain (17.9%), Greece (12.4%), Luxembourg (12.2%), Holland (10.9%), and finally Czech Republic with 0.7%, while outside of the EU-28 countries Turkey is with a share of 6.9%.

Electricity from solar energy sources is produced in almost all countries and the highest share between the EU-28 member states was observed in Italy (8.2%), Germany (6.9%), Greece (7.5%), Luxemburg (5.2%), Belgium (5.0%), Spain (4.6%), Great Britain (4.1%), Cyprus (4.0%), Denmark (3.3%), Romania (3.0%) and finally Poland with 0.2%, while outside of the EU-28 countries Turkey is with a share of 2.6%.

Solar energy can be used directly to generate electricity using a more sophisticated technology called solar photovoltaic-PV (Everett. B. et al, 2013, 8, 603). The term "photovoltaic" is derived by combining the Greek word for light, photos, with volts, the name of a unit of potential difference (i.e. voltage) in an electrical circuit (Boyle G., 2014, 14-76). Photovoltaic systems are made in a wide range of sizes and functions. Two basic qualifications of photovoltaic systems are stand-alone and grid-connected (Hodge B. K., 2013, 225-241).

Electricity from geothermal and other energy, the highest share between the EU-28 member states was observed in Austria (9.4%), in Malta (9.1%) and in Lithuania (7.0%), whereas, outside of the EU-28 countries Turkey is with a share of 2.4%.

Regarding the production of electricity of over 50% of RES (hydropower, wind energy, solar energy and geothermal and other energy sources) is achieved in five EU-28 countries: Luxembourg with 78.7%, Austria with 75.0%, Lithuania with 74.8%, and Croatia with 68.6% and Denmark with 51.4%. While the countries outside the EU-28 are the following: Albania with 100.0%, Norway with 97.6%, and Germany with 82.6% and Montenegro with 61.4%.

RES can be defined as: energy flows that are renewed at the same rate as they are "used" (Sorensen, 2000).

3 European solar PV installed capacity

2018 was a great year for solar in Europe. The continent added 11.3 GW in 2018, a 21% rise over the 9.3 GW installed the year before (see Fig. 1). In the European Union, demand even soared by 37% to 8.2 GW, up from 6.0 GW deployed in 2017. Europe's comparatively lower growth results primarily from the solar market contraction of Turkey, the continent's number one in 2017. On the other hand, the EU-28's switch from 'no growth' to two-digit growth, to a large extent, stems from the national binding 2020 renewable targets that many member states yet have to meet.

The growth of the European/EU solar market in 2018 was impressive, although a little below expectations in last year's GMO-Global Market Outlook (34% for Europe, 45% for EU). There was also a surprising shortage for high-efficiency modules in Europe combined with a price hike towards the end of the year, as Chinese demand was unexpectedly high in the fourth quarter.

Germany was Europe's top solar PV Market in 2018. Four years after it lost its title to the United Kingdom in 2014, Germany took back the scepter from previous market leader Turkey. At 2.95 GW, the German market grew 67% year-on-year, after it added 1.76 GW in 2017 and almost the same capacity in the two years before-1.52 GW in 2016 and 1.45 GW in 2015. This is the first time Germany met its 2.5 GW target since 2013.

The second largest solar market in Europe was Turkey, which fully disappointed last year. After a short and very high flight in 2017, when the market rose nearly 4.5 times to 2.6 GW, compared to 584 MW the previous year, Turkey was hit by a financial crisis in 2018. It installed only 1.64 GW, a year-on-year decrease of 37%.

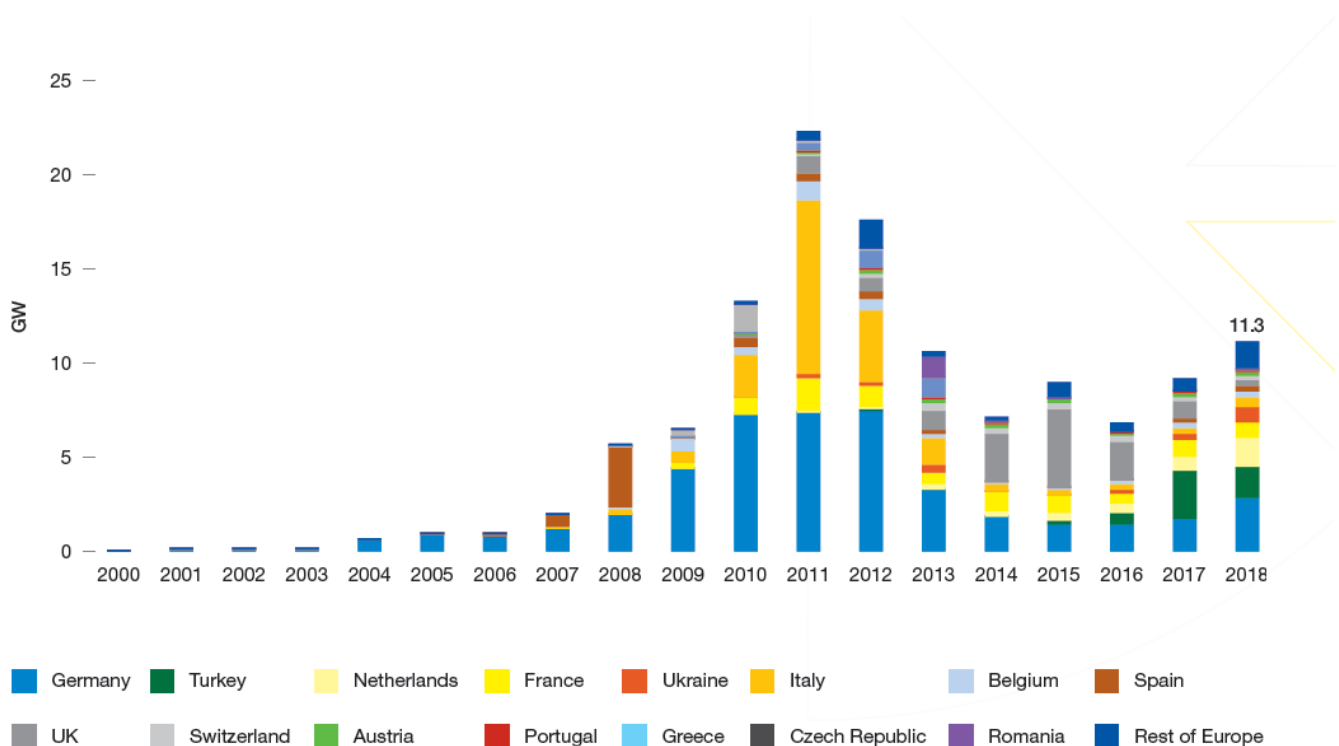


Figure 1. European annual solar PV installed capacity 2000-2018 (Source: *Global Market Outlook for Solar Power*, 2019, p.80)

Solar needed to become cost-competitive with other technologies for the Netherlands to develop from a medium-sized market to one of Europe's leaders. Last year was the first time the Dutch solar market reached the GW-scale, one of three European markets in that group. The Netherlands installed 1.5 GW in 2018, almost doubling from the 770 MW it added in 2017, when it had already grown by over 50% over the previous year.

The French solar market disappointed again in 2018. It still did not reach the GW-scale, but much worse, unlike most of the other European solar markets, it even contracted slightly by 4% to 873 MW. France missed its 10 GW cumulative solar target in 2018 by over 1 GW.

A very generous feed-in tariff of 15 euro cents/kWh for large-scale PV systems has catapulted Ukraine into the top 5 European solar markets in 2018. A total of 803 MW was installed, 228% higher than the 245 MW connected to the grid in 2017.

To sum up, the solar in the European Union and Europe as a whole is on the upswing. From the 28 EU member states, 22 connected more solar to the grid than the year before; for the entire continent, less than a dozen countries experienced lower demand for solar power technology.

The picture of European total solar installed capacities in 2018 is very similar to 2017 (see Fig. 2). Germany remains Europe's largest solar power plant operator with 45.9 GW of total installed capacity, followed by Italy with 19.9 GW. Again, Germany (36.5%) and Italy (15.8%) were home to over half of Europe's solar power generation capacities. Therefore, they decreased their share slightly 52.3% vs. 54.7% compared to the previous year. The only other European market having more than 10 GW installed was the UK, but as it installed only 286 MW, adding up to a 13 GW total, its share decreased by 1% point to 10.3%. Next to

the three European 2-digit level solar markets, 12 countries had solar capacities in the 1-digit GW-level (France, Spain, Turkey, Netherlands, Belgium, Greece, Switzerland, Czech Republic, Ukraine, Austria, Romania, Bulgaria), while most countries on the continent operated less than 1 GW of total solar power (Global Market Outlook for Solar Power, 2019, 79-88).

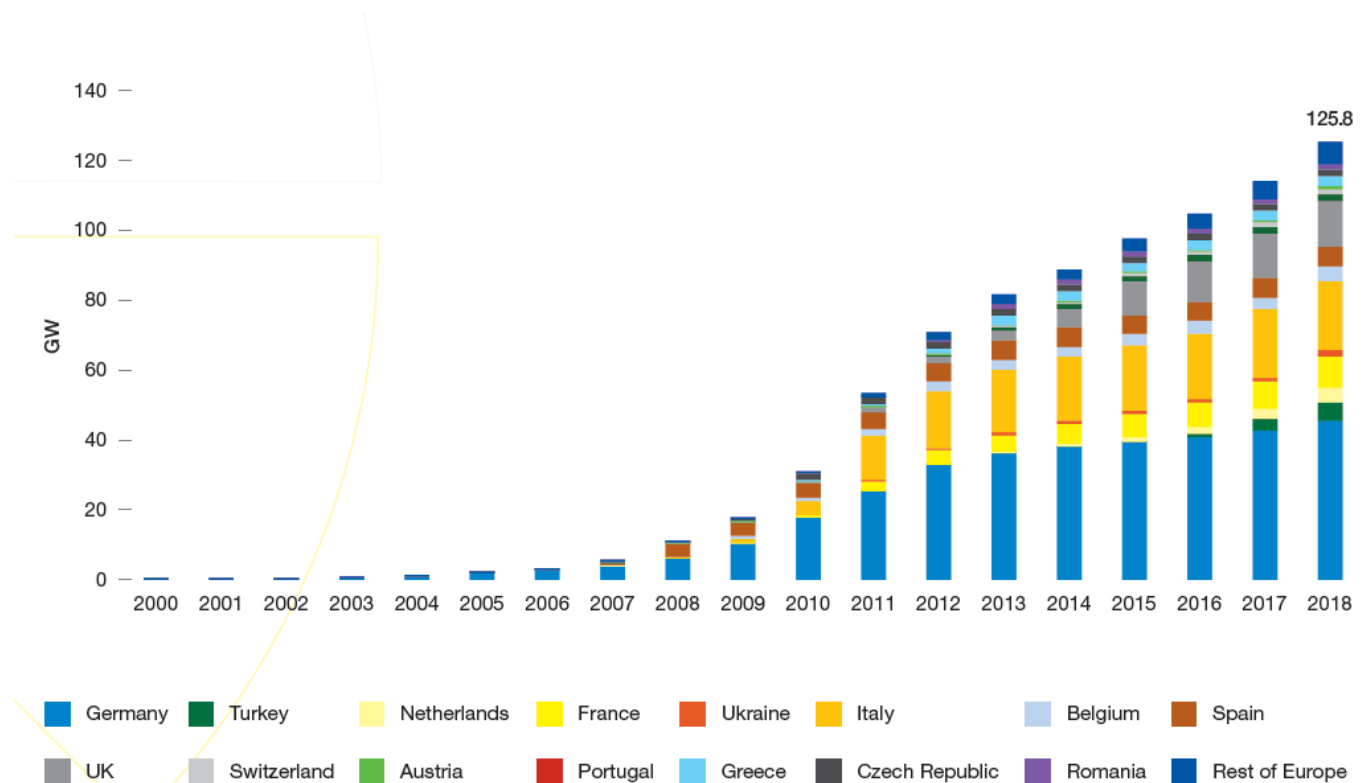


Figure 2. European total solar PV installed capacity 2000-2018 (Source: *Global Market Outlook for Solar Power*, 2019, p.81)

4 European solar PV capacity prospects

Annual ‘weather forecast’ is mostly bright and sunny for the entire European continent. Putting the Top 15 European solar PV markets prospects 2019 – 2023 under the microscope, the prospects are upbeat on 12 of these countries, for only two countries the political support prospects are considered cloudy (UK and Russia), while we see a rainy outlook for just one – Turkey (see Table 3).

Unlike in the previous two editions of the GMO, the top 3 prospects in Europe have changed this time. Germany is still considered to add the largest solar volume in the coming five years (even though the 52 GW FIT premium cap will be reached in 2020/21, an issue that is believed will be fixed). But the following ones are no longer France and Turkey – now it’s Spain and the Netherlands. Recent solar developments in these two countries-strong political backing, current high installation activity, and large pipeline-are providing a solid foundation to assume that demand will be very strong until 2023: is anticipated Spain to add 19.5 GW and the Netherlands to grid-connect 15.9 GW. GMO 2019’s Medium Scenario anticipates the 15 fastest growing European markets to install at least 2 GW each in the 5-year forecast period (up from at least 1.3 GW in GMO 2018), with the range stretching from Germany, adding the largest volume of 26.7 GW (up from 20.3 GW), to 2.1 GW in Switzerland, while being much smaller and growing at a higher average rate, installing the lowest volume.

In total, is expected the European countries to add 129.2 GW (up from 92.8 GW) in the 5-year forecast period. That’s roughly as much as the total installed capacity in Europe.

Table 3. Top European Solar PV Capacity Prospects (Source: Global Market Outlook for Solar Power, 2019, p.86)

	2018 Total Capacity (MW)	2023 Total Capacity Medium Scenario by 2023 (MW)	2019-2023 New Capacity (MW)	2019-2023 Compound Annual Growth Rate (%)	Political support prospects
Germany	45,920	72,611	26,692	10%	sunny
Spain	5,915	25,367	19,452	34%	sunny
Netherlands	4,181	20,059	15,878	37%	sunny
France	8,920	22,259	13,339	20%	sunny
Italy	19,877	29,498	9,621	8%	sunny
Ukraine	2,004	7,963	5,959	32%	sunny
Turkey	5,062	10,562	5,500	16%	rainy
Portugal	660	4,525	3,865	47%	sunny
Hungary	797	3,580	2,783	35%	sunny
United Kingdom	12,962	15,674	2,711	4%	cloudy
Poland	464	3,139	2,675	47%	sunny
Ireland	50	2,667	2,617	121%	sunny
Belgium	4,075	6,367	2,292	9%	sunny
Russia	518	2,770	2,252	40%	cloudy
Switzerland	2,205	4,292	2,087	14%	sunny

5 Conclusions

From the detailed and practical processing of the selected data and their analysis, regarding the percentage share of the various energy sources, conventional, nuclear and renewable in the production of electricity, within the EU-28 and outside the EU-28 in general, and solar photovoltaic capacities for electricity generation as well as their perspective in particular, we can conclude as follows:

- For the most part, electricity production in 2018 is still based on conventional thermal sources, with 45.9% and nuclear sources with 25.5%. RES participate with 28.6% of the production.
- Regarding the structure of electricity generation in the EU-28 in 2018, conventionally thermal electricity from nuclear power plants is reduced, while electricity production from RES has increased.
- Also, the production of electricity from solar energy is increasing from year to year and in 2018 represents 4.0% of total production.
- As for the production of electricity, however in most EU-28 countries it over 50% is produced from conventional thermal and nuclear sources, while in only five EU-28 countries over 50% of RES.
- Many EU 28 member states need to reduce or replace electricity generation from conventional thermal and nuclear sources with RES, thus meeting the European quantified target for RES participation in gross final energy consumption.
- The same goal was achieved by the countries that mainly have the largest production of electricity from RES.
- The increased share of RES in the production of electricity is of great importance in terms of reducing greenhouse gas emissions, and thus protection and preservation of the environment, in general and human life in particular.
- The construction of new photovoltaic power plants in Europe is growing from year to year and in 2018 this growth reaches a value of 21% compared to the previous 2017.
- The total solar capacity built at the level of Europe, from year to year is growing significantly and becoming more and more attractive. Germany, Italy and the United Kingdom have the largest share in these facilities in 2018, with double-digit levels of GW, i.e. 45.9 GW, 19.9 GW and 13 GW, respectively.

- The latest global analysis compares leveled energy costs for the latest generation of USD / MWh-based technologies and shows that it is cheaper to build new solar power plants than to modernize existing thermal power plants.
- A new report by Solar Power Europe and LUT University shows that it is entirely possible to achieve a 100% renewable energy scenario in which Europe will meet its goal of climate neutrality by 2050.

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