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SOLAR ENERGY POLICY DEVELOPMENTS IN EUROPE

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Abstract
Solar energy is one of the most important renewable energy sources in Europe offering new possibilities to generate electricity and heat. In this context, the study provides accurate information about researches that characterize the solar resource and investigates the potential of solar energy in European countries. The analysis is also focused on the current status of market development including photovoltaic capacity, electricity production from solar photovoltaic power, solar thermal capacity and concentrated solar power plants in operation. The final part of the paper covers the support schemes and programmes on solar energy used in Europe.
Keywords: solar thermal heating and cooling, solar photovoltaic market, solar thermal power plants, solar technologies support schemes.

1. INTRODUCTION

Solar energy could be considered one of the most abundant sources of energy. Solar energy is emitted by the sun to the Earth's surface in the form of radiation at a relatively steady pace, 365 days per year. According to Bailey et all. (1997) the intensity of solar radiation when penetrating the atmosphere is accepted to be 1367 W/m², but it reduces to 1000 W/m² at the earth surface. However, the power of solar radiation reaching the surface of absorption varies depending on geographical location, weather conditions, environmental pollution and building density. Although not all countries get the same amount of solar energy, each of them can contribute significantly to the energy mix.

Solar energy can be converted into different forms of energy with a broad range of applications meeting the need of peoples for access to modern energy services (Zamfir, 2014). Solar radiation can be captured and used in three distinct ways: thermal energy produced with the aid of collectors made of materials that absorb heat; photovoltaic electricity, solar radiation being captured by a system of photovoltaic cells and converted directly into electricity. The electricity is either used directly or stored in special batteries or introduced into the national grid. In fact, there are four main concentrating solar power (CSP) technologies, which consists in large systems for capturing solar energy, such as parabolic solar collectors or central receiver towers, Dish Stirling and Fresnel (EREC, 2012). In general, they use a complex system of mirrors for overheating a liquid (special oils) in order to produce steams which put in place a turbine thereby generating electricity.

The shape, type and size of the equipment/devices for converting solar energy depend on the energy generated, as well as the policies developed by governments while performance goals vary depending on the technology used. Solar technologies can be used for a wide variety of applications especially focused on thermal processes and photovoltaic applications:

- *heating and cooling purposes* - solar thermal can deliver domestic hot water in low latitude areas, below 40 degrees, heating or cooling in buildings, industrial processes and swimming pools, etc;
- *electricity* produced with photovoltaic cells or concentrating solar power plant;
- *cooking* using special containers and tools - mini-furnaces from special materials, panels and reflective panels, etc;
- *chemical processes* in order to create chemical reactions as well as *solar vehicles*.

There are other emerging solar technologies that will provide hydrogen or hydrocarbon fuels, known as solar fuels.

Both solar technologies connected to the traditional grid (grid applications) and those that are not connected (off-grid applications) generate opportunities. The energy connected to the grid can be extremely valuable at peak times when the network is overloaded or during the summer due to air conditioning use. At the same time, the production of solar energy is variable, showing some degree of unpredictability which requires the development of new transmission infrastructure. Off grid applications also offer excelent opportunities for economic development of villaged located in isolated areas without electricity.

Solar technologies have positive environmental, social and economical impact to every nation and their environmental burden is small. Except for reduced emissions of carbon dioxide produced by conversion devices, the use of toxic materials in photovoltaic manufacturing companies and water usage for concentrating solar power, solar technologies are usually beneficial, replacing non-renewable fuels, contributing to the reduction of green house gas emissions and improving populations' health and livelihood in areas without access to electricity. Other areas of concern regard noise impact during the construction stage and negative visual impact caused by technologies' installation which could be minimized by choosing areas where population's density is not high or integrating technologies into

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buildings' design. (Edenhofer et al, 2012; Tsilingiridis et al., 2004). From an economic perspective solar energy could help create new jobs and encourage the development of micro-industries and mini industrial zones.

Combining solar power with other renewable energy sources could reduce carbon dioxide emissions to zero and increase the amount of energy provided especially in areas with low levels of solar radiation. On one hand, in areas with large amounts of biomass, *increasing* trends in *cloud cover and precipitation*, the combination of both types of renewable sources could reduce the cost of biomass transport, ensure *security* and *provide stable energy supply*. On the other hand, the combination of wind and solar energy could be the solution to the *fluctuations* in the *power generation* capacity and errors in prediction, **optimising the balance** between production and consumption (Arvizu at al, 2011). Therefore, only a rational exploitation could ensure the security of energy supply (Păceșilă, 2013).

In the last 30 years the cost of solar technologies has significantly reduced due to governments policies and support. The costs of electricity and thermal energy produced by collecting sunlight vary depending on the type of conversion technology used, the available solar radiation and the specific issues relating to the calculation of the discounts rate (Edenhofer et al, 2012). Reducing the cost of this type of energy could continue if the technology is constantly improving, productions as well as investments in research and development expand and access to capital is facilitated (Arvizu at al, 2011).

The variability and the cyclical nature of the Sun's energy output limit its applications: the sun does not provide constant power in any place on Earth; due to the Earth's rotation on its axis, and thus the alternation of day and night, the sunlight could be used to generate electricity only for a limited amount of time each day; the potential for capturing the solar energy decreases noticeably due to sun-shielding on cloudy days. In these circumstances, systems which stores excess energy have been developed.

2. THE POTENTIAL OF SOLAR ENERGY IN THE EUROPEAN COUNTRIES

In Europe, a large proportion of regions are characterized by a high potential for developing electricity and thermal energy. The regions with the main potential for electricity production are located on the periphery, namely in the countries of south and eastern Europe where the average annual solar radiation varies between between 2000 KWh/m² and 2300 KWh/m² in Cyprus and Malta, 1400 KWh/m² and 2300 KWh/m² in Portugal, Spain and Greece, 900 KWh/m² and 2200 KWh/m² in Italy, 1200 KWh/m².

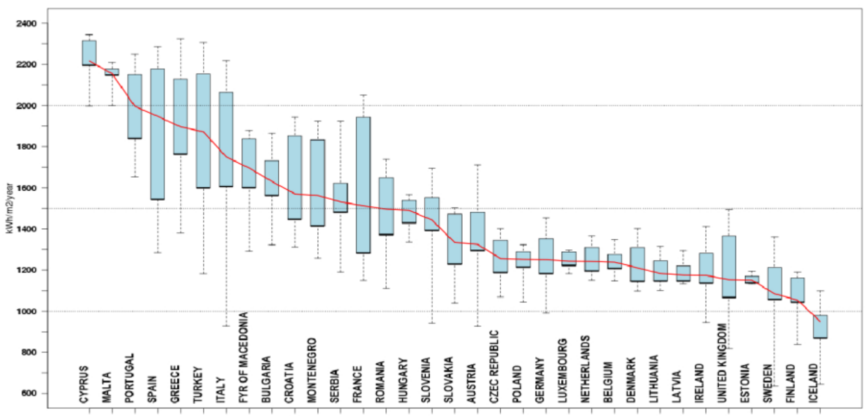

FIGURE 1 - COMPARISON OF IRRADIATION IN URBAN AREAS PER COUNTRY
Source: European Commission, Joint Research Centre, Institute For Energy and Transport, 2012

In northern Europe the score remains low, the average annual solar radiation varying between 600 KWh/m² and 800 KWh/m² in Iceland and Norway, 600 KWh/m² and 1300 KWh/m² in Sweden. The core area of Europe is characterized by a higher score which is between 1000 KWh/m² and 1400 KWh/m² in Germany, 1100KWh/m² and 1300 KWh/m² in Poland and Romania, 900 KWh/m² and 1700 KWh/m² in Austria and Slovenia, 1200 KWh/m² and 2000 KWh/m² in France.

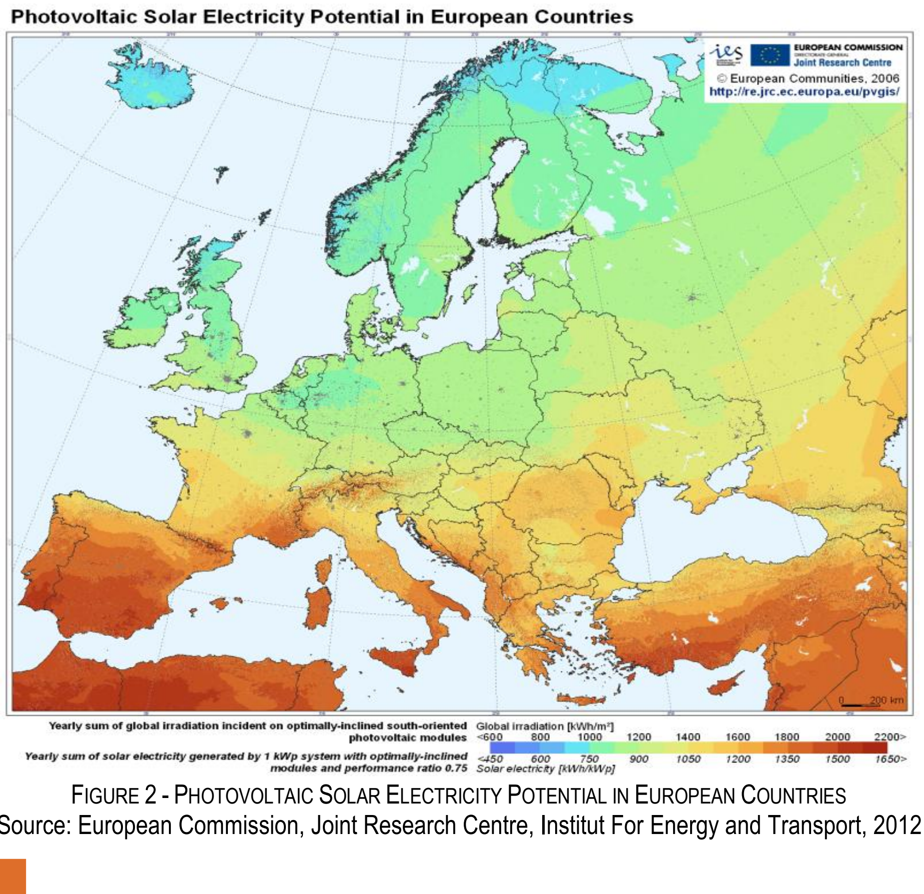

FIGURE 2 - PHOTOVOLTAIC SOLAR ELECTRICITY POTENTIAL IN EUROPEAN COUNTRIES
Source: European Commission, Joint Research Centre, Institut For Energy and Transport, 2012

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As regards solar thermal power plants, only the countries from the Mediterranean region are economically feasible, because their average annual solar radiation is above 2000 KWh/m²: Spain, Portugal, Greece, Italy, Malta and Cyprus (Frenzel, 2011).

3. OVERVIEW OF THE SOLAR ENERGY MARKET

3.1. Solar photovoltaics market and industry

The solar photovoltaic market witnessed a significant growth in Europe, with an important contribution to energy generation, especially in countries like Germany, Spain and Italy. In 2012, the market was not as sensitive as it was expected. France and Greece have survived despite high prices, Danish and Dutch markets have boomed due to the success of metering, as well as the Austrian market due to new financing programs. Once again Germany has broken the record of installed capacity, becoming a world leader. Worldwide, Europe is the leader as regards the solar photovoltaic per inhabitant: Germany, Italy, the Czech Republic, Belgium, and Spain.

TABLE 1 - CUMULATIVE PHOTOVOLTAIC CAPACITY: THE TOP COUNTRIES IN THE EUROPEAN UNION (27) AT THE END OF 2011 AND 2012 (MWP)

Country	2011			2012		
	On grid	Off Grid	Total	On grid	Off Grid	Total
Germany	25039.0	55.0	25094.0	32643.0	55.0	32698.0
Italy	12773.0	10.0	12783.0	16350.0	11.0	16361.0
Spain	4298.9	23.3	4322.2	4492.0	24.6	4516.6
France	2924.0	24.6	2948.6	4003.0	24.6	4027.6
Belgium	2050.5	0.1	2050.6	2649.9	0.1	2650
Czech Republic	1913.0	0.4	1913.4	2022.0	0.4	2022.4
United Kingdom	976.0	2.3	978.3	1655.0	2.3	1657.3
Greece	624.3	7.0	631.3	1536.3	7.0	1543.3
Bulgaria	211.5	0.7	212.2	932.5	0.7	933.2
Slovakia	487.2	0.1	487.3	517.2	0.1	517.3
Austria	182.7	4.5	187.2	417.2	4.5	421.7
Denmark	15.0	1.7	16.7	390.0	1.7	391.7
Netherlands	141.0	5.0	146.0	316.0	5.0	321.0
Portugal	157.7	3.2	160.9	225.5	3.3	228.8
Slovenia	100.3	0.1	100.4	217.3	0.1	217.4

Source: Photovoltaic barometer, 2012

The new photovoltaic capacity installed in 2011 and 2012 in Germany and Italy allowed the EU to dominate the global PV market with a total sum of 68647.2 GW. Almost one third of this total (22019.4 GW) accounting for nearly three-quarters (74%) of photovoltaic installed capacity all over the world was connected in 2011 and a quarter (16519.9) in 2012. However, after the euphoria of the 2011 EU PV market has experienced a lower growth rate and in Italy the installed solar capacity in 2012 is long way from the one installed in 2011 (EurObserv'ER, 2012).

TABLE 2 - PHOTOVOLTAIC CAPACITY CONNECTED: THE TOP COUNTRIES IN THE EUROPEAN UNION (27) DURING THE YEARS 2011 AND 2012 (MWP)

Country	2011			2012		
	On grid	Off Grid	Total	On grid	Off Grid	Total
Germany	7485.0	5.0	7490.0	7604.0	0.0	7604.0
Italy	9303.0	0.0	9303.0	3577.0	1.0	3578.0
France	1755.4	0.5	1755.9	1079.0	0.0	1079.0
Greece	425.8	0.1	425,9	912.0	0.0	912.0
Bulgaria	179.5	0.4	179.9	721.0	0.0	721.0
United Kingdom	899.0	0.3	899.3	679.0	0.0	679.0
Belgium	995.6	0.0	995.6	599.3	0.0	599.3
Denmark	8.6	1.0	9.6	375.0	0.0	375.0
Austria	91.0	0.7	91.7	234.5	0.0	234.5
Spain	377,9	1.0	378.9	193.1	1.3	194.4
Netherlands	58.0	0.0	58.0	175.0	0.0	175.0
Slovenia	54.9	0.0	54.9	116.9	0.0	116.9
Czech Republic	0.0	0.0	0.0	109.0	0.0	109.0
Portugal	34.8	0.1	34.9	67.8	0.1	67.9
Slovakia	313.0	0.1	313.2	30.0	0.0	30.0

Source: Photovoltaic barometer, 2012

In 2011 and 2012, the electricity generated by photovoltaic installations accounted for almost half of EU electricity generation. In the most active countries, the share of solar electricity is logically much higher: about 3.6% in Italy, 3.1% in Germany, 2.6% in Spain.

TABLE 3 - ELECTRICITY PRODUCTION FROM SOLAR PHOTOVOLTAIC POWER: THE TOP COUNTRIES IN THE EUROPEAN UNION (27) IN 2011 AND 2012 (MWP)

Country	2011	2012
Germany	19340.0	28000.0
Italy	10795.7	18800.0
Spain	7360.0	8169.0
France	2400.0	4000.0
Czech Republic	2182.0	2173.0
Belgium	1169.6	2115.0
United Kingdom	252.0	1327.0
Greece	610.0	1239.4
Bulgaria	120.0	534.0
Slovakia	397.0	500.0
Portugal	277.0	360.0
Austria	174.1	300.0
Netherlands	100.0	200.0
Slovenia	65.7	121.4
Denmark	15.0	114.0

Source: Photovoltaic barometer, 2012

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As regards solar photovoltaics industry, the Europe's share in global production dropped to 14% in 2010. The decline continued in 2011 and 2012, the situation being extremely tense, many companies and midsize companies filing for bankruptcy, closing branches or withdrawing from the market in order to limit losses. For example, in 2012 Germany's Q-Cells has declared insolvency, and First Solar announced withdrawal from the European market (REN21, 2012).

3.2. Solar thermal heating/cooling market and industry

Compared to other continents, the European market covers a wide range of solar thermal applications such as hot water preparation, family homes and hotels heating, numerous systems for air conditioning and cooling, large plants for district heating.

The most advanced solar thermal markets are Germany, Spain and Austria which uses almost all the applications mentioned. Solar water heaters gain ground in Cyprus and Greece, covering a significant amount of thermal energy for residential sector (Edenhofer, 2012) and the number of solar cooling installation increase from one year to the next. As regards solar heat installed capacity, Germany is the largest installer across the Europe even though the market has seen a significant drop in 2010 by almost 29%. In 2011 Germany, Denmark and Portugal have made progresses in this field, while Greece and Austria recorded slight fall. In 2012 Hungary, Belgium, Slovenia, the Netherlands and Denmark have shown tremendous growth, while Ireland, Portugal and Sweden were on the opposites side.

In 2010 Cyprus was the world leader in solar heating (575 kWth per 1000 inhabitants), while Austria (337 kWth per 1000 inhabitants) ranks first in continental Europe, followed by Greece (266 kWth per 1,000 inhabitants) and Germany (112 kWth per 1,000 inhabitants).

In recent years Europe has also focused on hybrid solar installations, several projects being implemented in the Mediterranean region. Another trend of the European market consists in using combined systems, for example domestic hot water and space heating, which represents 50% of the systems installed in Germany and Austria and are more and more used in Southern and Northern Europe.

The least developed solar thermal technology remains solar heat and steam which is used in different industrial purposes such as food production, beverages, textiles (a sheep wool manufacturer in Slovenia), pulp industry and other fields (a concrete plant in Austria).

In terms of solar thermal capacity and collector area, the European leaders are Germany, Greece and Austria, but in these countries the number of homes using solar thermal energy still remains small.

TABLE 4 - MARKET SIZE IN TERMS OF SOLAR THERMAL CAPACITY (KWTH) AND IN TERMS OF COLLECTOR AREA (M2): THE TOP COUNTRIES IN THE EUROPEAN UNION (27) AND SWITZERLAND

Country	In operation*	Annual evolution of the market	In operation*	Annual evolution of the market	In operation*	Annual evolution of the market
	2010	2010/2009	2011	2011/2010	2012	2012/2011
	Total glazed	Total glazed	Total glazed	Total glazed	Total glazed	Total glazed
	kW(th)	%	%	%	%	%
Austria	2 685 556	-21.4%	2 791 662	-17.8%	2 875 837	2.7%
Belgium	229 703	-24.5%	226 298	7.1%	269 173	18.9%
Cyprus	500 515	-11.5%	499 351	-7.4%	495 443	-0.8%
Czech Republic	215 863	66.4%	264 647	-29.1%	299 129	12.8%
Denmark	367 602	6.6%	408 524	-3.5%	477 642	16.9%
France	1 101 730	-3.4%	1 277 430	-2.0%	1 452 080	13.7%
Germany	9 676 800	-28.8%	10 495 800	10.4%	11 234 300	7%
Greece	2 858 940	3.9%	2 861 040	7.5%	2 883 440	0.8%
Hungary	104 870	-4.5%	119 570	0.0%	153 870	29.4%
Ireland	92 042	-22.7%	110 900	8.4%	189 538	11,1%
Italy	1 870 211	3.2%	2 151 751	-15.3%	2 356 011	10,4%
Netherlands	332 217	-19.2%	332 217	-19.2%	356 346	7.3%
Poland	459 123	1.1%	636 573	73.7%	847 973	33.2%
Portugal	470 888	4.9%	546 906	-30.2%	599 807	9.7%
Spain	1 474 806	-13.9%	1 658 903	-20.7%	1 811 013	9.2%
Slovenia	122 710	-13.6%	122 710	9.1%	130 760	6.6%
Sweden	226 615	-2.95	235 915	0.5%	242 012	2.6%
Switzerland	626 844	-3.9%	716 589	-3.3%	801 802	12.1%
United Kingdom	401 254	18.1%	459 899	-12.8%	496 771	8.0%

* Capacity "in operation" refers to the solar thermal capacity built in the past and considered to be still in use.
Source: ESTIF, 2010,2011, 2012

Solar thermal industry has faced many problems in recent years due to the economic situation in Europe, particularly in the northern Mediterranean countries. Despite the merger between various players in the market, the production shrank many companies in Southern and Central Europe being forced to shut down production capacity and lay off employees. For example in 2011 Isofoton in Spain has left the industry.

Compared to other solar industries, the majority of companies in the field of solar thermal heating and cooling are large. The greatest producers of of flat-plate and vacuum tube collectors are: GreenOneTec (Austria), Bosch Thermotechnik (Germany), Ezinc (Turkey) and Viessmann Werke (Germany). The top exporting countries of solar water heating systems in Europe is Greece, followed by France. Most of the Greek exports are directed towards Cyprus and the area closed to the Mediterranean region while France exports are to other continents.

The installed system prices vary from country to country. Although in some countries such as Austria and Germany the installation costs have been reduced in recent years, the number of homeowners

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using such technologies have not increased, but even decreased. This could be explained by the fact that in some old buildings the installation is relatively expensive.

3.3. Concentrating Solar Thermal Power markets and industry

The capacity to cover a high energy demand prompted the authorities in the Mediterranean region, especially in Spain to support widespread implementation of these technologies. Currently, there are 11 plants in Europe connected to the grid that generate clean power and another 16 are under construction. There are also other 30 projects aimed at placing new plant (EREC, 2012). Spain is the world leader in the field, dominating the market in 2011 due to the legal framework and policy support.

In 2011 the market has recorded steady growth, mainly due to the investments in parabolic solar collectors as well as other technologies like Fresner plants which are under construction in Spain. This growth can be explained by the complicated economic situation which prompted the European companies to seek to consolidate their position. In Spain they have developed new technology or established joint ventures, especially with Japanese companies. Others have tried to create hybrid systems including CSP plants and gas-fired plants or other renewable energy technologies. For example, in Spain near Barcelona there is a project which integrates biomass along with CSP technologies. Instead, other firms like Solar Millennium in Germany have gone bankrupt.

TABLE 5 - CONCENTRATED SOLAR POWER PLANTS IN OPERATION

Country	CSP in Europe (MW_{peak})		
	2010	**2011**	**2012**
Spain	632.4 (Parabolic solar collectors, Central receiver towers, Linear Fresnel)	1151.4 (Parabolic solar collectors, Central receiver towers, Linear Fresnel)	1953.9 (Parabolic solar collectors, Central receiver towers, Linear Fresnel)
Italy	5 (Parabolic solar collectors)	5 (Parabolic solar collectors)	5 (Parabolic solar collectors)
France	1	0.75 (Linear Fresnel)	0.75 (Linear Fresnel)

Source Solar thermal and concentrated solar power barometer, 2013

4. REVIEW OF SUPPORT SCHEMES AND PROGRAMMES ON SOLAR ENERGY

There are different solar technologies support schemes operating in Europe. They are established in accordance with the priorities set at national level. The main instruments to support investments in solar energy technologies are investments subsidies or grant subsidies and fiscal instruments (tax incentives). Other instruments that directly stimulate the energy production refer to feed-in tariffs and the green pricing, as well as the renewable obligation and certificates and guarantees of electricity origin. Green certificates are included in both groups of instruments.

The support schemes for photovoltaic investments used in the majority of the European countries are: investment grants for PV system installation or grid-connected PV system (Austria, Belgia, Bulgaria, Cyprus, Czech Republic, France, Germany, Greece, Hungary, Italy, Netherlands, Turkey etc.), fiscal incentives (Czech Republic, Demark, France, Germany, Greece, Itay, Poland, Turkey), VAT reduction (Bulgaria, Czech republic, France, Italy). The support schemes in the electricity sector are dominated by feed in tariff for building mounted installations (Austria, Bulgaria), ground mounted installations (Austria, Bulgaria, Germany, Slovenia), PV installations (Cyprus), rooftop installation (Germany, Greece, Portugal, Slovenia), green certificates (Belgium, Poland, Sweden), feed in tariff or green bonus (Czech Republic, Netherlands). Other countries use feed in tariff in combination with self consumption for micro generation PV systems and support for electricity injected into the network (Ireland) or in combination with self consumption for PV system and support for grid connected installations (Italy) (European Photovoltaic Industry Association, 2013). In many countris mos of these support programmes are available since 2012 or 2013.

Tax Incentives and investments grants are mainly used in Malta and Ireland, while other countries use them as additional support for certain projects (Copenhagen Resource Institute, 2012). In Latvia there are not support measures for photovoltaic because feed in tariff was cancelled. Other countries have only measures for stimulating the production of electricity: green certificates for building mounted installations in Romania, feed in tariff for PV installations (Slovakia). Spain is at the opposite site having only several investment grants at regional level, because the moratorium established in 2012 closed the feed in tariff program. Due to European Bank for Reconstruction and Development soft loans for PV installations could be obtained in Bulgaria.

There are also different types of incentive schemes for solar thermal and renewable heat in Europe: investments grants (Poland, Czech Republic, Slovakia, Ireland), tax reduction (Italy, France), VAT reduction (France), feed in tariff (United Kingdom), green certificates (Sweden, France), low or zero interest rates loan (France, Poland, Germany) (Noyon, 2010).

As regards concentrating solar power industry, the most important government support is the feed in tariff in Spain as well as Italy. There are no specific support mechanism for CSP in France (CSP fit guide, 2011).

5. CONCLUSIONS

Characteristics and potential of solar energy as well as the market development in European countries is investigated in this paper which offers relevant information, accurate data and country analyses about

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photovoltaic capacity, electricity production from solar photovoltaic power, solar thermal capacity and concentrated solar power plants in operation.

Based on the idea raised in the paper, one can conclude that solar energy has a great potential in Europe and could be considered a major source of renewable energy. If this resource is exploited properly, its contribution to reducing carbon dioxide emissions could be significant. Furthermore, a great contribution to solving other challenges the world faces today, such as energy security and access to modern energy services, would become obvious.

However, solar energy is not able to compete with non-renewable sources in generating electricity and heat without certain incentives. In this context, the schemes and programs supporting a large portfolio of solar energy technologies should be extended to other sunny regions of Europe in the future, especially if they are characterized by economic growth and population explosion. If this were the case, solar energy could turn into a competitive energy source used in many applications in European countries in the coming decades.

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