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Sustainable Energy Systems: The Role of Solar Energy

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Abstract

Energy is an important and crucial issue to reach sustainable development. Nowadays economies are still mainly based on fossil fuels, which imply the depletion of non renewable resources and environmental problems such as air pollution and climate change. In addition markets and prices present some instability and there is a need to increase security of supply. Renewable energy sources are one of the pillars that can support new and more sustainable energy systems, which includes undoubtedly solar energy: a cleaner, available and renewable energy.

Keywords: RES; Solar energy; Sustainable energy systems

Abreviations: RES: Renewable energy sources; EU: European Union; PV: photovoltaic solar cells; CSP: concentrating solar thermal power; CPV-T: concentrating photovoltaic–thermal; SCWH: solar collectors for water heating

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Renewable energy sources (RES) are a key factor to face existing challenges. Providing clean energy to populations at an affordable price is also a goal that contributes to improve quality of life and to sustainable development. In fact sustainable development relies on renewable energy sources and solar energy is recognized as being very important for many countries. These concerns about energy are common to most countries from Europe, America, Asia, etc. and solar energy systems can be implemented with success in most of them [1]. European Union (EU), for example, has clearly defined a commitment concerning RES to achieve a low carbon economy [2]. The pathway to full de carbonisation is described in the report From Roadmap to Reality, indicating how the current EU energy framework can be improved through measures concerning the demand side and by regionalizing system operation and enhancing investments in low carbon assets [3]. Mechanisms to support RES were and are being implemented worldwide and they have led to the development and deployment of technologies such as photovoltaic solar cells (PV) and wind power. However further investment is necessary to enhance technology development, implementation and deployment.

There are several technological solutions that can be implemented depending on the goals (electricity production or heat generation), the location's characteristics and other requirements. For electricity production photovoltaic solar cells (PV), concentrating solar thermal power (CSP) and concentrating photovoltaic–thermal (CPV-T) can be used. CPV-T systems combine photovoltaic technology with solar thermal technology Heat generation can be done with solar collectors for water heating (SCWH) and concentrating photovoltaic–thermal (CPV-T). The first generation PV systems are the wafer-based crystalline silicon (mono and multi), second generation uses the thin film technology (e.g. amorphous silicon, micromorph silicon, etc.) and the following generations uses emerging technologies such as dye-sensitized, organic/polymer, etc. Besides the advantage of reducing the amount of materials used, thin film technology can be easily used in buildings (Building integrated PV, BIPV) [4].

Solar energy systems have evolved positively in the last years. In 2014 total PV capacity was 177 GW [5] and by the end of 2016 was 303 GW mainly due to Asia. During 2016, at least 75 GW of PV capacity was added which is equivalent to the installation of more than 31,000 solar panels every hour. This is due to the increasing competitiveness of solar PV, the potential of PV to tackle key aspects such as pollution, CO2 emissions and energy dependency. However government incentives and regulations are still very important in this market [6].

The top five countries for total capacity in 2014 for the Solar PV were Germany, China, Japan, Italy and United States and in 2016 were China, Japan, Germany, United States and Italy,

which shows that China and Japan are now occupying the first two places and that Asia is a major player in this sector [5,6]. However considering PV capacity per inhabitant Germany sill remains at the fist position followed by Japan, Italy, Belgium and Australia/Greece. In Europe, Germany and Italy form a cluster where the share of electricity from PV systems is higher than 20% and energy production from PV systems is higher than 20 TWh in 2014 [7]. The European Union (EU) was the first region to pass the 100 GW in 2016 but was rapidly surpassed by Asia. Solar thermal energy is also used worldwide to provide hot water, to heat and cool spaces, etc. In 2016 it increased 37 GWth, reaching 472 GWth (glazed and unglazed collectors) by the end of the year. China also occupies the first position in this kind of systems followed by United States, Turkey, Germany and Brasil. Spain is still the leader in existing CSP capacity with 2.3 GW (2016) followed by the United States. These two countries account for 80% of total capacity of this kind of solar energy systems. In this case the increase due to new installations was very small [6].

Another emerging problem in the solar energy sector is the amount of wastes related to solar panels. Soon there will be a large amount of this kind of wastes, since lifespan of photovoltaic panels is 20-30 years. The panels have resources that are not abundant and for that reason their recovery is very important. EU has already fix rules about the end of life of photovoltaic panels, which are consider electric and electronic waste (WEEE) [8]. Since the beginning of 2014, photovoltaic panels' recycling is mandatory. End-of-life disposal is very important because it can assure that solar energy remains a cleaner technology, from cradle to grave. However future sustainable energy systems will not rely only in solar energy, they will be complemented by the energy produced by using other RES such as wind, hydro, geothermal, ocean and wave and biomass energy depending on location characteristics. Biofuels will also play an important role because the transport sector, for example, has a significant weight in the energy consumption of developed and developing countries. The future countries' energy mix will be hopefully based on the natural, available and renewable resources of each region taking advantage of its own characteristics, assuring energy supply, affordable prices and reducing environmental impacts. Some technical problems and energy management issues can be overcome by energy storage (batteries, power to gas, etc.), self-consumption and other demand side measures, etc.

This shift to renewable energy systems will not be easy to implement because besides the technical problems that should be solved by, for example, technology innovation and development, there will be resistance by conventional utilities that will either struggle for participating or maintaining their position in the market. Solar energy has a great potential for solving today's and future energy problems. PV has become cost competitive and there is an increasing awareness about its use to overcome crucial problems such increasing energy demand, pollution problems, climate change issues, etc. In some regions (Europe) the market is already changing and important measures such as the use of solar PV for self-consumption in residential, commercial and industrial sectors are being implemented. For achieving 100% renewable energy systems it seems inevitable to consider solar energy (electricity production and/or heat generation) as a very important contribution to the energy portfolio. This is even true for countries where the locations' characteristics seem to be not so adequate. Germany in Europe is a proof of this fact, where energy production from PV systems is higher than 20 TWh, with irradiations values that are not the highest in EU. Energy policies are being launch for achieving low carbon economies, through pathways that seem to be sunnier and more sustainable.

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