# SUSTAINABILITY OF SOLAR POWER MANAGEMENT ALONG WITH ITS APPLICATIONS AND ECONOMY

Ahmet CELEBI[1,2], Saim Özdemir[1], Bülent Şengörür[1,3], Namık AK[4]

[1]*Department of Environmental Engineering, Sakarya University, Turkey,* ahmetc@sakarya.edu.tr

[2]*Water Resources and Environmental Engineering Laboratory, Department of Process and Environmental Engineering, University of Oulu, Finland*

[3]*Kırklareli Unıv. Faculty of Engıneerıng, 39020, Kırklareli, Turkey,*

[4]*Adıyaman University, Faculty of Technology, Department of Energy Systems Engineering 02040, Adıyaman, Turkey*

## ABSTRACT

Many types of renewable energy resources, especially solar energy, are constantly refilled and will never over. Most renewable energy comes either directly or indirectly from the sun. Sunlight with its energy can be used directly for heating, lighting, life buildings, generating electricity, water heating, cooling and a variety of commercial and industrial uses. Solar energy technologies use only the Sun's energy. There have already many of technologies that still have been developing to take more efficient and advantage from the Sun. Main parameter is cost in the process. The purposes of the present study are reveal the how solar energy utilize and important for nature and local inhabitant especially in rural areas, economies, feasibilities and investigate to best management way with their trends and future perspective. Results show that solar energy is most usable energy source for many countries (majority of the human population in the world). Both directly, vital for local inhabitant and has huge potential in future and indirectly for our planet in many other way. Consequently, this topic yet needed more study and paid attention firstly in terms of management.

***Keywords:*** *Renewable energy, Sun, economy, best management*

## 1. INTRODUCTION

Solar power and its importance have been more popular and noteworthy. As a renewable and clean energy, solar energy is carbon-free, inexhaustible, sustainable, and practically unlimited. It is able to satisfy the power demand of mankind at present and in the future if some of the solar radiation radiating on the Earth's surface is utilized. Especially in last decades, how to turn the abundant solar energy into the energy that human can directly utilize has become a popular and difficult problem. Because of fossil fuels consumption and the exacerbation of greenhouse effect, many countries provide economic incentives and supports for the development of solar power plants, including non-returnable subsidies, soft loans, favorable tax policies and so on (Li et al., 2014).

Solar technologies are characterized as either passive or active depending on the way they capture, convert and distribute sunlight. Active solar techniques use photovoltaic panels, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favorable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun (Philibert, 2005).

One of the challenge is Prediction of solar radiation and power (Long et al., 2014). Numerous algorithms have been applied to predict solar radiation and power based on time-series and meteorological data. Time-series models predicted future solar power by computing the conditional expectation (Rizvi et al. 1996) based on its present and previous samples. Meteorological parameters including temperature, clearness, dust, and relative humidity were also frequently considered as inputs for predicting solar power (Turk and Onat, 1999).

Promising researches revealing recently. A team of European researchers (Savin et al. 2015) has just announced that they've set a new record by creating black silicon solar cells that can convert 22.1 percent of the Sun's light into electricity - an increase of almost four percent on their previous record. The team compared their new black silicon solar cells with traditional solar cells of the same efficiency, and showed that their cells increased daily energy production by 3 percent, thanks to their ability to suck up light even when the Sun was low in the sky. This is an advantage particularly in the north, where the sun shines from a low angle for a large part of the year. This means that we may soon see solar panels on the market that can create electricity no matter where the Sun is in the sky, and even on cloudy days.

Renewable energy and especially solar power energy issues still need so many research and steps for our earth’s future. Main purpose of the study is being attention of this topics importance and useful for all humankind, ecosystem and local people to utilize and take advantage more.

## 2. SUSTAINABLE MANAGEMENT, RISK ASSESSMENT AND ECONOMY

The annual collector yield of all water-based solar thermal systems in operation by the end of 2011 in the 56 recorded countries was 195.5 TWh/a (or 704.0 PJ/a). This corresponds to an energy savings equivalent to 20.9 million tons of oil per year and 64.1 million tons of $CO_2$ (IEA, 2013).

On the Fig. 1 showing the mean annual direct normal irradiation for the region of interest, derived from the created data set. One can see in the figure that the annual direct normal irradiation at offshore regions is higher than at most European land regions. The annual direct normal irradiation of this data set was compared with data from HelioClim-3 (Rigoiller, 2004). The results match well for the region of interest. Influence of sea wave excitation on the performance of floating offshore solar power plants was investigated. As its results the avoidance of platform motion is essential for an economic platform design, as the efficiency of solar concentrator’s decreases significantly for even small misalignments (Diendorfer et al., 2012). Therefore a platform design should be developed, which reduces the platform response to wave excitation to minimum.

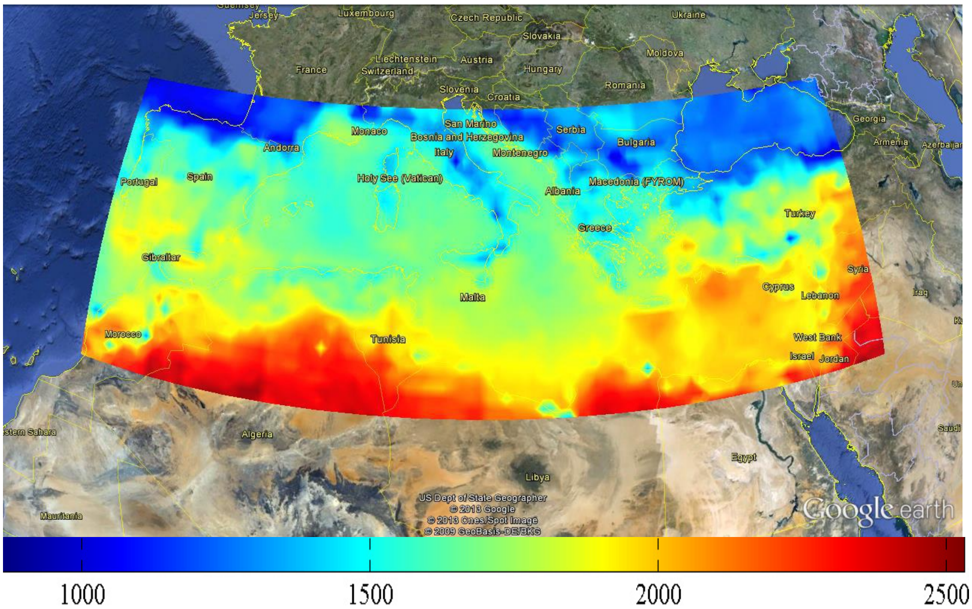



Fig. 1  Direct normal irradiance in kWh/m2a for the Mediterranean region (Diendorfer et al., 2014)

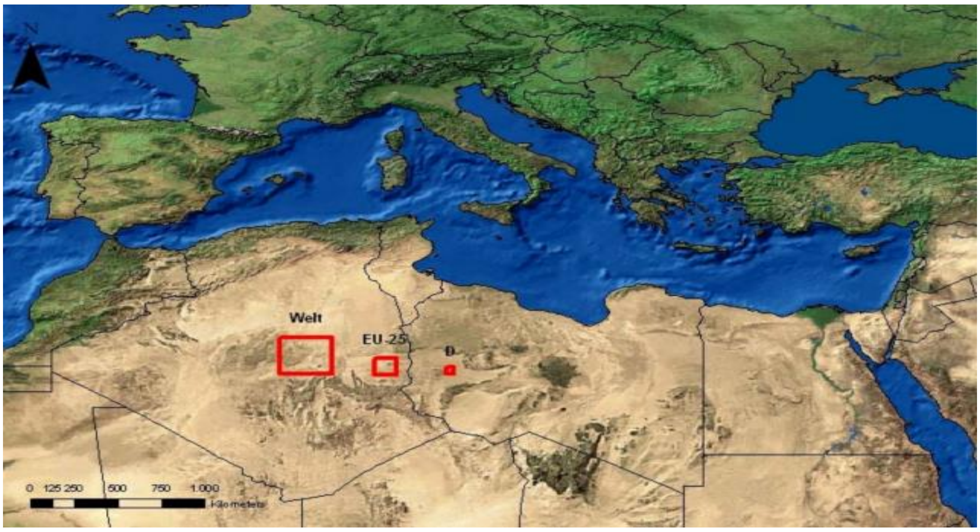
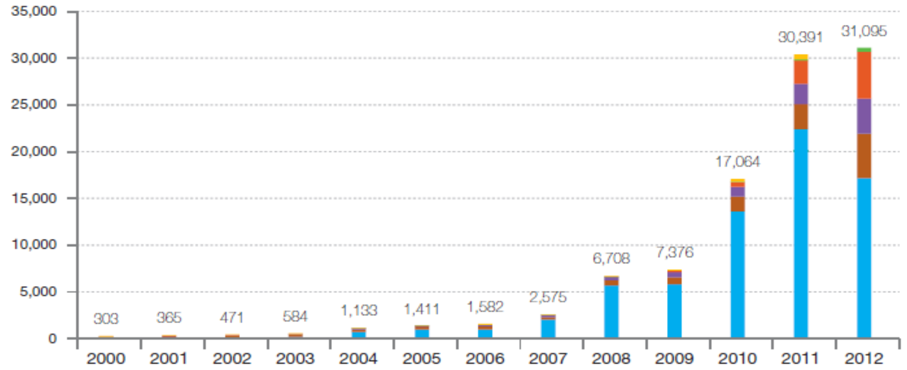



Fig. 2: Theoretical space requirement to meet the electricity demand of the world, Europe (EU-25) and Germany (May, 2005)

In 2009, the total global electricity consumption was 20,279,640 GWh. The sun creates more energy than that in one hour. The tricky part is collecting that energy and converting it into useful electricity with solar panels. How much area would need to be covered with solar panels in order to capture enough energy to meet global demand? Actually, it's not as much as you'd think. The image above has three red boxes showing what area would need to be covered for Germany (De), Europe (EU-25), and the entire World (May, 2005).

**Location**; Land (topography) and water resource are the two important indicators to assess the potential locations for Solar Power systems. Firstly, the selected land should be far from housing, farming, protected nature reserves, sensitive ecosystems and natural landscape, and require a large area with low terrain slope in the solar field of the systems (Fluri, 2009). Land capability is then can be determined by using the satellite data. After further excluding the geomorphological features like sand dunes, rock outcrops, salt flats, and glaciers, as well as the areas with slope greater than 3% and population density above 150 persons per $km^2$ (Li et al., 2014).

**Hybrid models**; the PV/wind hybrid power system has great development potential all over the world, but to develop the large-capacity hybrid system, the site selection of PV/wind hybrid power station is a big problem. The issue of site selection of the hybrid power plants have researched sparsely yet (Jun et al., 2014). Show that depending on plant concept and energy source combination, the cost of hybrids can be up to 50% lower than for standalone plants. Also Solar Power hybrids can lower the cost of other renewable energy sources, such as geothermal, by significantly increasing cycle efficiency. These benefits paired with the potential to realize small Solar Power installations, rather than several hundred million or even billion dollar projects, allow financiers and operators to understand the different Solar Power technologies better and finance larger hybrid and standalone systems in the future (Juergen et al. 2014).




| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ROW | 88 | 56 | 80 | 77 | 29 | 10 | 105 | 42 | 76 | 80 | 284 | 508 | -* |
| MEA | n/a | n/a | n/a | n/a | 1 | n/a | n/a | 1 | 1 | 22 | 46 | 121 | 410 |
| China | 19 | 5 | 19 | 10 | 10 | 8 | 10 | 20 | 40 | 160 | 500 | 2,500 | 5,000 |
| Americas | 24 | 32 | 47 | 66 | 104 | 106 | 150 | 213 | 346 | 543 | 1,029 | 2,179 | 3,758 |
| APAC | 117 | 140 | 191 | 230 | 282 | 303 | 324 | 271 | 535 | 742 | 1,583 | 2,672 | 4,769 |
| Europe | 56 | 133 | 135 | 202 | 707 | 984 | 992 | 2,028 | 5,710 | 5,830 | 13,622 | 22,411 | 17,159 |
| **Total** | **303** | **365** | **471** | **584** | **1,133** | **1,411** | **1,582** | **2,575** | **6,708** | **7,376** | **17,064** | **30,391** | **31,095** |

* From 2012 onwards, these figures are directly integrated into those of the relevant regions.

Figure 3 - Evolution of global PhotoVoltaic annual installations 2000-2012 (MW) (EPIA, 2013).

Environmental sides of the plant changes significantly when it is operated in hybrid model (12% electricity from Natural Gas): climate change 124 kg $CO_2$ eq/MWh; human toxicity 12.4 kg 1,4-DB eq/MWh; terrestrial acidification 215 g $SO_2$; freshwater eutrophication 9.46 g P eq/Mwh; marine eco toxicity 266 g 1,4-DB eq/Mwh; natural land transformation, 0.02 $m^2$/MWh; water depletion 6.24m3/MWh; fossil depletion 48.4 kg oil eq/MWh. In the hybrid mode operation, most of the environmental damage is associated with the consumption of Natural Gas. Hence, the most impacting phase is Operation and Management of the Solar Power plant. The incorporation to operate the installation in hybrid mode has a negligible effect on the environmental performance of the plant (Miguel and Corona, 2014).

Three operation models, the full solar model, the full geothermal model and the geothermal–solar combined model are compared in typical summer and winter days and throughout the year. Due to the ambient-dependent geothermal water outlet temperature, introducing the geothermal water makes greater contribution in winter days than in summer days, in the night than in the daytime. And, introducing high temperature and mass flow rate geothermal water can doubled and redoubled improve the power capacity (Cao et al. 2014).

Europe's market has progressed rapidly over the past decade: from an annual market of less than 1 GW in 2003 to a market of over 13.6 GW in 2010 and 22.4 GW in 2011 – even in the face of difficult economic circumstances and varying levels of opposition to PV in some countries. But the record performance of 2011, driven by the fast expansion of PV in Italy and again a high level of installations in Germany, was not repeatable in 2012 and the market went down to 17.2 GW. For the first time in the last 12 years, the PV market in Europe decreased in terms of new connected capacity. Even so, in 2012 the PV market in Europe again exceeded all expectations. However, due to variable delays in connecting PV systems to the grid depending on the country, some installations from 2010 were not connected until 2011 and this repeated again in 2012. This has an impact on market perception. Seventh time in the last 13 years, Germany was the world's top PV market, with 7.6 GW of newly connected systems; China was second with an assumed 5 GW, followed closely by Italy (3.4 GW), the USA (3.3 GW) and Japan with an estimated 2 GW. But under even the most pessimistic scenario, PV will continue to increase its share of the energy mix in Europe and around the world, becoming a reliable source of clean, safe and infinitely renewable energy for all (EPIA, 2012).

Table 1 : Investment cost variation in relation to the base scenario (Million US$) (Malagueta et al. 2014).

| Year | NG | Hydro | CSP 12h | CSP 6h | Hybrid | Simple | Total |
|---|---|---|---|---|---|---|---|
| 2015 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2020 | -222 | 0 | 0 | 0 | 6,436 | 0 | 6,213 |
| 2025 | -773 | 0 | 0 | 3,781 | 12,449 | 2,016 | 17,472 |
| 2030 | -773 | -3,124 | 7,633 | 7,561 | 15,697 | 2,016 | 29,010 |
| 2035 | -773 | -6,027 | 15,267 | 11,342 | 18,471 | 2,016 | 40,296 |
| 2040 | -513 | -9,395 | 15,267 | 22,684 | 21,473 | 2,016 | 51,532 |
| | | | | | **Total Cost** | | **144,523** |

Concentrated Solar Power (CSP) potential in Brazil and evaluates the impact caused by a large-scale integration of this alternative into the Brazilian electricity system in the long term (horizon 2040). With regard to costs, the alternative scenario would be about 144 billion dollars dearer that the base scenario, as presented in Table 1, which shows the costs avoided by the non-installation of thermoelectric and hydroelectric plants, and the additional costs of each type of CSP plant analyzed (Malagueta et al., 2014).

Dry cooled plants have more benefit in terms of water amount. Less amount of water is required and is estimated to about 60,000 $m^3$/a. For comparison, wet cooled similar CSP plant requires 751,617 $m^3$/a. In other words, 92% of water saving could be reached by using the dry cooling system in the CSP power plant. In monetary terms, the water costs for dry cooling are about 29,995.58 €/a (assuming the cost of water 0.5 €/$m^3$), whereas, the costs for the wet cooled plant are around 375,808.83 € per year. Several studies showed that dry cooling could save more than 90% of water consumption (Turchi et al., 2010). CSP power plants require huge initial investments. While any additional costs are undesired and would threaten securing project finance. In this context a trade-off between all options should be made for each specific site to know whether to use dry cooling or not. For many locations, dry cooling is the only affordable option and therefore must be considered (Liqreina and Qoaider, 2014).

## 3. WAYS OF SOLAR ENERGY UTILIZATION AND ITS POTENTIAL

Solar energy technologies are the most promising renewable sources for the future world energy, Main types are photovoltaic, which is direct conversion from light energy into electricity, and concentrating solar thermal power called also concentrating solar power (CSP) are the two common technology types utilize solar energy to generate power (Liqreina and Qoaider, 2014).

Solar Chimney Power plant (SCPP) is another trend for utilize the Sun to energy. The working principle of SCPPs is simple: A huge chimney in an arid area with sufficiently high solar irradiation is surrounded by a large glass roof, the collector. The warm air collected under the roof flows towards the chimney. There, on its way, it drives turbines connected to generators which create electric power (Chikere et al. 2011). SCPP design and parts are shown in the figure 4 and table 2.

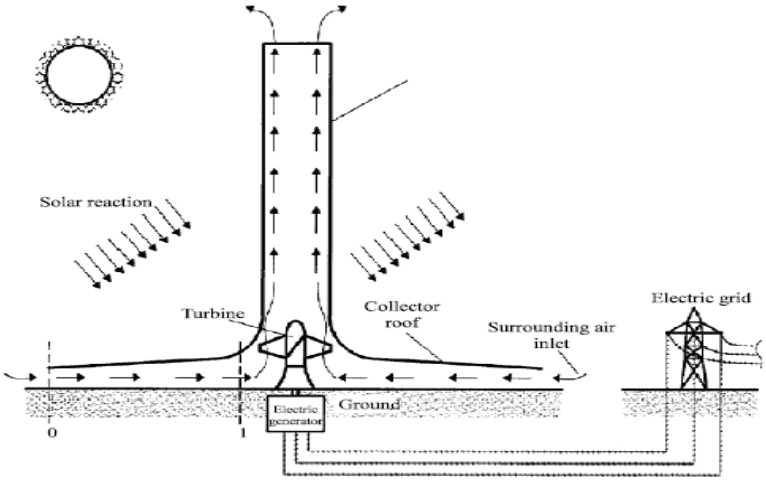



Fig. 4 : Solar Chimney Power Plant diagram

Table 2 : Electricity production, system efficiency and emission reduction at different chimney heights.

| Chimney height (m) | System efficiency (%) | Electricity production (GW h/yr) | Emission reduction in tonnes | | |
|---|---|---|---|---|---|
| | | | $CO_2$ | $SO_x$ | $NO_x$ |
| 300 | 0.51 | 37.80 | 9936 | 55.53 | 28.07 |
| 400 | 0.69 | 50.40 | 13,248 | 74.05 | 37.43 |
| 500 | 0.86 | 63.00 | 16,560 | 92.56 | 46.78 |
| 600 | 1.03 | 75.60 | 19,872 | 111.10 | 56.14 |
| 700 | 1.20 | 88.20 | 23,184 | 129.60 | 65.5 |
| 750 | 1.29 | 94.50 | 24,840 | 138.80 | 70.17 |
| 800 | 1.37 | 100.70 | 26,496 | 148.10 | 74.84 |
| 900 | 1.54 | 113.30 | 29,808 | 166.60 | 84.21 |
| 1000 | 1.71 | 125.90 | 33,119 | 185.10 | 93.57 |

Solar hot water systems use sunlight to heat water. In low geographical latitudes (below 40 degrees) from 60 to 70% of the domestic hot water use with temperatures up to 60 °C can be provided by solar heating systems. The most common types of solar water heaters are evacuated tube collectors (44%) and glazed flat plate collectors (34%) generally used for domestic hot water; and unglazed plastic collectors (21%) used mainly to heat swimming pools (IEA, 2007; Weiss et al. 2005).

In 2007, the total installed capacity of solar hot water systems is approximately 154 GW. China is the world leader in their deployment with 70 GW installed as of 2006 and a long term goal of 210 GW by 2020. Israel and Cyprus are the leaders in the use of solar hot water systems with over 90% of homes using them. In the United States, Canada and Australia heating swimming pools is the dominant application of solar hot water with an installed capacity of 18 GW as of 2005 (REN21, 2008; Chiaro et al. 2007; Philibert, 2005).

Development of a solar-powered car has been an engineering goal since the 1980s. in The World Solar Challenge has a biannual solar-powered car race, where teams from universities and enterprises compete over 3,021 kilometres (1,877 mi) across central Australia from Darwin to Adelaide. In 1987, when it was founded, the winner's average speed was 67 kilometres per hour (42 mph) and by 2007 the winner's average speed had improved to 90.87 kilometres per hour (56.46 mph) (ANZSES, 2007). Besides, some vehicles use solar panels just for auxiliary power, such as for air conditioning in order to reducing fuel consumption.

Solar distillation can be used to make saline or brackish water potable. The first recorded instance of this was by 16th-century Arab alchemists. A large-scale solar distillation project was first constructed in 1872 in the Chilean mining town of Las Salinas. The plant, which had solar collection area of 4,700 $m^2$, could produce up to 22,700 L per day and operated for 40 years. Individual still designs include single-slope, double-slope (or greenhouse type), vertical, conical, inverted absorber, multi-wick, and multiple effect. These stills can operate in passive, active, or hybrid modes. Double-slope stills are the most economical for decentralized domestic purposes, while active multiple effect units are more suitable for large-scale applications (Tiwari, 2003 ; Shilton et al. 2008 ; Tadesse et al. 2003).

Solar water disinfection (SODIS) involves exposing water-filled plastic polyethylene terephthalate (PET) bottles to sunlight for several hours. Exposure times vary depending on weather and climate from a minimum of six hours to two days during fully overcast conditions. It is recommended by the WHO (World Health Organization) as a viable method for household water treatment and safe storage. Over two million people in developing countries use this method for their daily drinking water (McGuigan et al. 2012).

Solar energy may be used in a water stabilization pond to treat waste water without chemicals or electricity. A further environmental advantage is that algae grow in such ponds and consume carbon dioxide in photosynthesis, although algae may produce toxic chemicals that make the water unusable (Shilton et al. 2008; Tadess et al. 2003).

Fig. 5. Solar water disinfection in Indonesia Small scale solar powered sewerage treatment plant.

Solarization effects on bacterial inactivation in sewage sludge was studied using thermotolerant coliforms, enterococci and *Escherichia coli* (*E. coli*) as the indicator organisms. Solarization significantly increased the sludge temperature fastly. The results suggest that the temperature regime produced by solarization was sufficient to reduce bacterial indicators to an acceptable level, meeting the pathogen regulation limit, in two weeks. Solarization appears to be an effective method to inactivate sludge indicator microorganism (Ozdemir et al. 2013)

## 4. CONCLUSION

As a renewable energy, solar energy cost still more than conventional way today. In another side renewable energy issues needed more attention to research & development. Using and utilization of the solar energy have been improving, developing very fast especially in last decade. Benefit of Solar energy is not limited with production of power only. In addition, such as Stabilization, sterilization, treatment of water and soil etc. could be done using by solar energy. Solar energy is one of the promising and important factors of global warming issues as well. Researches showed that especially hybrid solutions is more important and valuable and should be considered different kind hybrid solutions according to location and must be paid more attention and investment for the earth and humankind future.

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