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Solar Energy: Trends and Enabling Technologies

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Abstract
The global demand for energy is currently growing beyond the limits of installable generation capacity.To meet future energy demands efficiently, energy security and reliability must be improved and alternative energy sources must be investigated aggressively. An effective energy solution should be able to address long-term issues by utilizing alternative and renewable energy sources. Of the many available renewable sources of energy, solar energy is clearly a promising option as it is extensively available. Solar power, especially as it reaches more competitive levels with other energy sources in terms of cost, may serve to sustain the lives of millions of underprivileged people in developing countries. Furthermore, solar energy devices can benefit the environment and economy of developing countries. This paper illustrates the need for the utilization of alternative energy sources, evaluates the global scenario of installed generation systems, reviews technologies underlying various solar powered devices, and discusses several applications and challenges in this area. In addition, this paper addresses the costs of deployment, maintenance, and operation, as well as economic policies that promote installation of solar energy systems.

Key Words: efficiently, Enabling Technologies, generation capability, non-electrified areas, renewable energy technologies, concentrated solar power (CSP), concentrated photovoltaic's (CVT) and Building-integrated photo-voltaic (BIPVs).

1. Introduction

Preventing an energy crisis is one of the most essential issues of the this century. In the past, there has been a constant attempt to find an alternate way to satisfy the growing energy needs of the global population – the huge majority still living in poverty – without preying the resources that will be needed by future generations, polluting our ecosystems, and putting undue pressure on the energy-rich regions of the world. In achieving this, the main problem faced is the blast in demand due to both, the quick increase in population and the efforts of the most strongly populated regions of the world to develop their economies. In just one generation, the global population has increased by approx. 2 billion, with a most important contribution from developing countries. Also, it is a known fact that energy demand raises at a rate that is proportional to economic growth. On this basis, the International Energy Agency (IEA) estimates that developing countries will require to double their present generation capability in order to meet the increasing demand for power by the year 2020. In the International Energy Outlook (IEO) 2009 [1], the total world utilization of marketed energy is projected to raise by 44% from 2006 to 2030, as shown in following Fig. (1). In spite of several policies, and investments for increasing generation capacity, the number of non-electrified areas in developing countries has not changed significantly. need of access to electricity continues to be one of the major reasons that citizens of non-electrified communities are still poor [2]. So, it is significantly important to create the required infra- structure and establish the needed distributed energy generation resources to satisfy global energy needs.

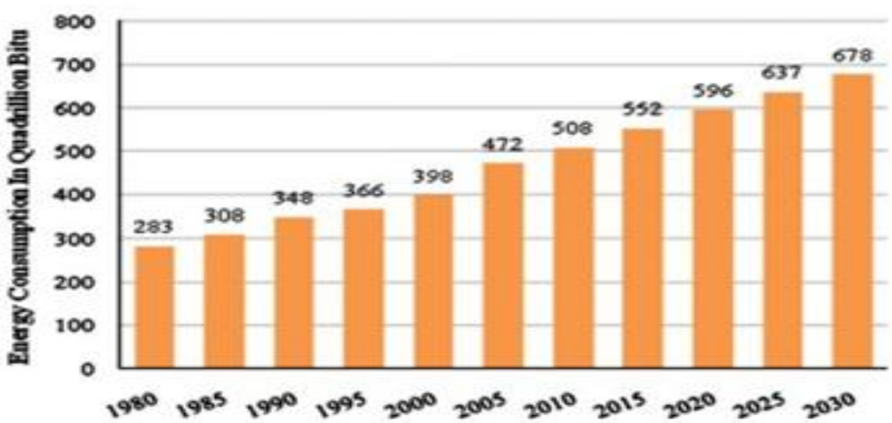

Fig.1

Renewable energy is not a new concept, but it continues to quickly emerge as an alternative to fossil fuels and other delete-ious energy sources. The potential of renewable energy sources is huge as they can produce many times the world's total energy demand. Such as some studies have indicated that approx. 1000 times the global energy requirement can be fulfilled by using solar energy; however, only 0.02% of solar energy is currently utilized [3]. Renewable energy
Sources For example: hydropower, geothermal energy, wind energy, biomass and solar energy, resources. A change to renewable energy systems is increasingly likely as their costs continue to decrease while the cost of fossil fuels continues to increase. In the past 30 years, solar system and wind power system have continued to get better their performance characteristics and have experienced quick sales growth. The main and generation costs associated with these type of systems have also been compact significantly. Because of these developments, market opportunities now exist to both innovate and take advantage of promising markets in order to encourage renewable energy technologies, mainly with additional assistance of governmental and popular reaction. The development and use of renewable energy sources can improve

diversity in energy supply markets, contribute to securing long term sustainable energy supplies, help reduce local and global atmospheric emissions, and provide commercially striking options to meet specific energy service needs. The use of renewable energy is also becoming increasingly important to slow the effects of climate change. Solar technologies are an extremely promising renewable resource considering their ever-increasing output efficiencies and capacity to be utilized in a variety of locations. The inherent qualities of solar energy make it a beneficial utility, especially for developing countries, for many reasons:

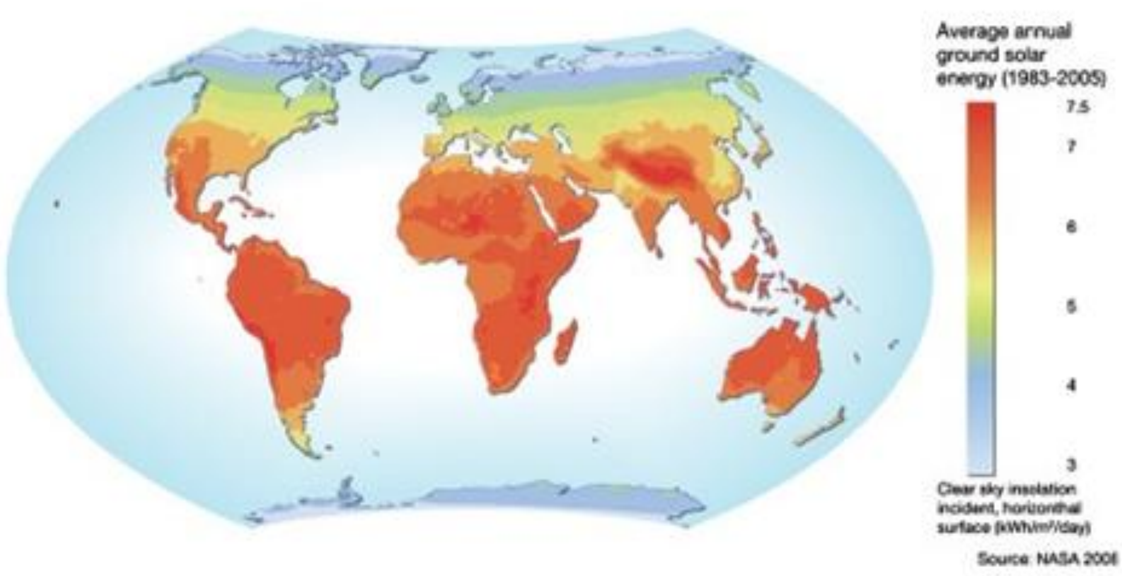

Fig.2

Most developing countries are located in regions with optimal access to the sun's rays. This is shown above in Fig. 2 For example, India's solar power reception is about 5.4 x 10^{15} kWh per year. and the average radiation in steamy and sub-steamy regions located in developing countries can be compared to that of annual global radiation of about 1600–2200 kWh/m2 [4].

1. Most of the available fossil fuel and energy resources can only be used by exploiting the ecosystem, which leads to social decline.
2. Increasing global independence of fossil fuels quickens the need for solar technology, rises enhancement of required research, and thereby lowers related costs.
3. Solar systems are relatively affordable and applicable to bothhouses and villages, as households of industrialized nations are using more solar power than ever before.
4. Within solar technologies, inert solar designs shine when considering renewable energy for buildings, and can be coupled with solar panels to achieve maximum comfort and sustainability.

2. Solar Technologies

Solar energy can be transformed into electrical energy using various technologies such as photovoltaic (PV) panels, concentrated solar power (CSP), and concentrated photovoltaic's (CVT) [5]. The following sub-sections explain these currently available technologies.

I. Solar Photovoltaic's

Solar photovoltaic's (PV) modules are solid-state semiconductor devices that change sunlight into direct-current (DC) electricity. Materials used on Photovoltaic (PV) panels are silicon (monocrystalline, polycrystalline and micro- crystalline), cadmium telluride and copper indium selenide [6]. Photovoltaic (PV) production has been doubling every 2 years, increasing by an average of approx. 48% each year from last 10 years, making it the world's fastest-growing energy technology [7]. approx.90% of the current generating capacity from PV consists of grid-tied electrical systems. Such installations may be ground-mounted or built on the roof or walls of a building, hence called building integrated photovoltaics (BIPV). Modern Solar Photovoltaic (PV) power stations have capacities ranging from 10 to 60 MW although proposed solar Photovoltaic(PV) power stations will have a capacity of 150 MW or more [8]. A typical Photovoltaic (PV) panel can now operate for up to 10 years at 90% of its rated power capacity and for up to 25 years at 80% of its rated power capacity. Fig. 3 shows the total installed solar energy nameplate capacity and generation.

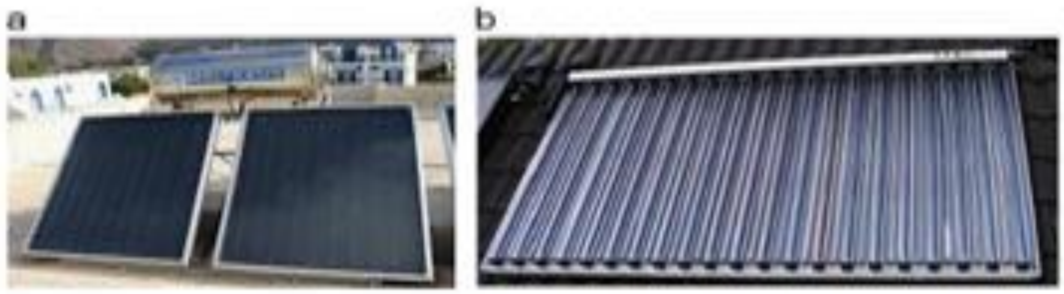

Fig3.

II. Concentrated solar power systems

Photovoltaic (PV) panels can sometimes be inefficient in capturing all available energy from sunlight due to their shape and variation in solar intensity throughout the day. An alternative way to efficiently capture maximum solar energy is with the help of concentrated solar power (CSP) systems. In Concentrated solar power (CSP) systems lenses or mirrors are use to focus sunlight covered over a large area into a small area to produce electrical energy. Solar concentrators are mounted on the solar tracker to remain track of the position of the sun. As long as the temperature is at an optimum point for a junction of cells, the solar cells will operate with high efficiency. If these systems are installed at a large solar plant, then they can be used to make sure that the harnessed energy is more effectively changed to heat. Parabolic trough solar thermal systems are the only Concentrated solar power (CSP) systems which are available commercially. Concentrated solar power (CSP) systems use parabolic, trough-shaped mirrors to focus sunlight on thermally efficient receiver tubes that hold a heat transfer fluid. This heat transfer fluid is heated to approx. 3900^0C (7341^0F) and pumped through a series of heat exchangers to make superheated steam that powers a conventional turbine generator to produce electricity.

3. Cost of electricity generated from solar systems

Due to advancement in technology and enhancement in manufacturing scale and sophistication, the cost of Photovoltaic (PV) cells has decreased steadily since the first solar cells were manufactured [9]. Although the cost of electricity produced from Photovoltaic (PV) systems is still higher than the other competing technologies, this cost is expected to continue to decrease steadily. The cost of Photovoltaic (PV) installation was Rs.105 per unit of generating capacity in 2009 which came-down to about Rs.76 in 2011. According to industry analysis, this price is slated to reach Rs.57 per unit of generating capacity by 2013. These potential reductions in cost, combined with the reliability, simplicity, versatility, and low environmental impact of

Photovoltaic (PV) systems, should help Photovoltaic (PV) systems to become highly utilized sources of economical, premium-quality power over the next 20-30 years.
Now a day in India, the minimum cost of energy from Solar Photovoltaic (PV) is Rs 12.00/kWh and from Concentrated solar power (CSP) systems is Rs.19.00/kWh [10]. Solar electric prices today are at approximately Rs.17.00/kWh, or near about 2–5 times the installation location and local electric rates. This is because of the high installation costs involved.. Demand for solar powered systems is very high in countries with high electricity tariffs.

4. Applications

I. General applications

Building-integrated photovoltaic:
Building-integrated photovoltaic's are a promising option for households in remote, mountainous, and rural areas with no access to the electric grid, as arrays of Photovoltaic(PV) panels are mounted on the roof or the external walls of buildings . Zero energy solar houses, where energy required by the household appliances is generated by the solar panels at the same location, could be another option. In case the energy generated at this type of houses increases the total household energy consumption, the remaining energy can be fed back to the utility grid [11].

Crop and grain drying: The use of solar dryers in agriculture can prove to be tremendously efficient due to the low manufacturing and operating cost. Solar dryers are able to protect grain and fruits. Solar dryers, dry faster and more homogeneously, and create a better quality product than older methods.

Greenhouse heating: Solar greenhouses use solar energy for both heating and lighting. A solar greenhouse prepared with thermal mass can be used for collecting and storing solar heat energy. The greenhouse can also be insulated to retain this heat for use during the night and on cloudy days. This will greatly decrease the need to use fossil fuels for heating. A gas or oil heater may provide as a backup heater or to increase carbon dioxide (CO_2) levels inside the greenhouse in order to decrease higher plant growth.

Heating and cooling: Technologies like flat plate and evacuated tube solar heating and cooling are currently being used in various applications. These include solar water heating systems for commercial and residential use, the heating of swimming pools, and solar air heating systems.

II. Approaches to integrated energy solution

In addition to solar energy, there are various other well-known macro-level renewable energy sources like bio-energy, wind energy, hydropower and geothermal energy which can be integrated on a grid- level. However, for smaller meso-scale or off-grid energy generation, options for non-solar power generation are limited. Small wind energy converters ranging in size from 20 W to 100 kW are available in many parts of the world, annual average wind speeds of 15-20 Km/h can be sufficient for these small wind generators. With power outputs between 5- 100 kW, micro-hydro generators are used to power small communities usually in remote mountainous regions [12]. Pico-hydro power generation systems have outputs below 5 kW and are generally used for one to three residences. Regularly these can be integrated with biodiesel generators or wood stoves to develop an integrated meso-scale solution.

For embedded applications, it is obvious that solar energy is not available. Other micro-renewal energy sources have greater potential for various indoor, embedded, or isolated environments, including magnetic, vibration, thermal, and kinetic energy harvesting. Mechanical vibrations and air flow are the other alternatives [13]. Vibrational energy harvesters may utilize electromagnetic, magnetostrictive, electrostatic, or piezoelectric technology. As piezoelectric-based technologies have proven to be a high volume manufacturing success, a National Science Foundation (NSF) workshop considered these harvesters mature and adequate. And they have the highest probability and impact of success, as shown by their opportunity analysis in Fig. 4 [14].

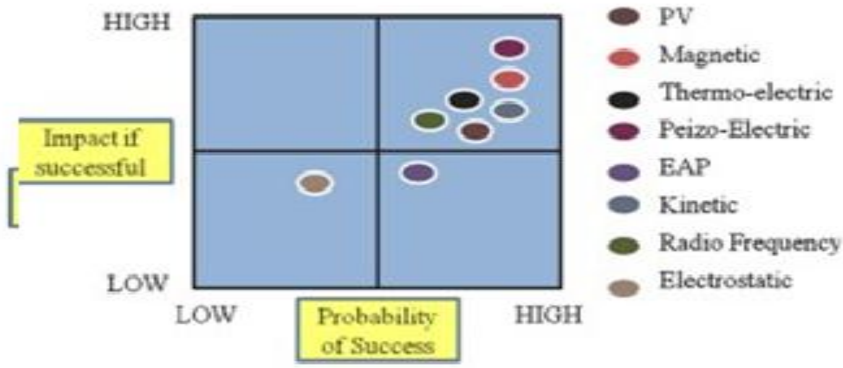

Fig.4

These harvesters are being evaluated for the powering of sensor nodes for wireless sensor networks, data processors, controllers, data loggers, transmitters, and possibly cell phones and LED lighting. Fig. 5 explains that these harvesters are addressing the convergence of technology and market trends towards wireless, ‘‘smart’’ sensing, controlling, and operations.

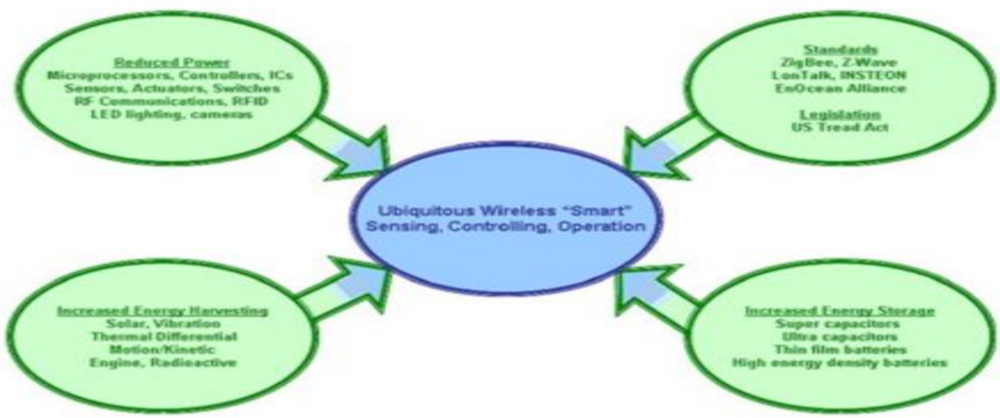

Fig.5

III. Wireless sensors for improved performance

Operation of a solar power plant depends upon a number of factors, including electrical such as photovoltaic (PV) efficiency, output power, temperature etc, environmental such as intensity of sunlight, rain, direction, temperature and air etc and mechanical like size of the panels, incline angle, position, etc. The environmental factors play a very crucial role in determining the output from a solar power plant. Like, the direction and orientation of photovoltaic (PV) panels must be perfect in order to achieve the maximum power output. There is also a need to develop models which will serve as a tool to help identify design barriers and quantify the cost and mass impact of design changes on various components of the solar panels. Using advanced wireless sensors to collect data on photovoltaic (PV) installations and performing analysis to further enhance system design can be highly attractive to design engineers and researchers (Fig. 6)

Fig. 6

A wireless sensor network enables the sensors to be placed all over a structure. Such a wireless system could be combined with electrical, mechanical and environmental monitoring sensors to be a part of a remote, multi-panel, centralized plant monitoring, and control system. Data from the sensors are transmitted via wireless technology to a central monitoring station using satellite Internet as shown in Fig. 7. At the central monitoring station, data is analyzed and a relationship between different sensed parameters is established for improving the efficiency of the whole system. S uch as various performance monitoring systems consisting of sensors and other photo-operated devices such as op-amp 741 circuitry, photo-transistors, photo sensors, etc.can be

Fig.7

Integrated into the photovoltaic (PV) module to enable automatic orientation of the photovoltaic (PV) module to the sun's direction, making troubleshooting and maintenance more efficient. Efficient energy conversion is possible if the photovoltaic (PV) modules are equipped with advanced tracking and optical systems Like Fresnel lens.

IV. Integration into the smart grid: The present electric grid is becoming congested due to a lack of its ability for expansion and continued growth in electricity demand. The present electricity grid is non-uniform and unintelligent as the demand side cannot communicate with the supply side. Compatibility of the grid with distributed power supplies would bring down costs for connecting renewable energy sources to the grid. Getting the electricity from the renewable energy sources located in isolated areas involves more than just building more power lines. The electric grid should be able to handle greater and faster changes to load flow caused by intermittent generation and should plan for standby store capacity to supplement blinking generation. Effective grid management can be achieved by improving data collection, using efficient communication protocols and network monitoring systems which provide operators with up-to-date information about the status of grid. The smart grid helps to identify faults in the grid and deal with them before they are serious [15]. A smart grid applies state of the art technologies and techniques to make the grid more efficient and provides advanced energy management techniques and approaches for integrating solar power into the grid. The grid's software uses stochastic prediction algorithms for renewable energy forecasting, and these predictions may be used to switch on or switch off the loads. Smart grids will integrate weather reports, real-time output monitoring, and grid-load balancing to respond to this inconsistency pro-actively [16].

Solar power is an blinking source of energy, meaning that it may not always be able to meet peak load requirements. As a result, solar energy has to rely upon other expensive energy storage technologies Such as compressed air, batteries, pumped hydro, etc. The solution of this problem is to combine plug-in hybrid electric vehicles (PHEVs), smart grids and solar power. A plug-in hybrid electric vehicles (PHEVs) can be considered as a complimentary resource to provide energy storage during the day. As a result of integrating plug-in hybrid electric vehicles (PHEVs), into the smart grid, the plug-in hybrid electric vehicles (PHEVs), owners benefit by selling energy to the grid during the day when the demand is higher and buying back the energy during the night when the cost is less if a variable-cost electric power system is available. Thus, the solar energy systems and plug-in hybrid electric vehicles (PHEVs), s result in better economic and environmental benefits when used in conjunction

5. Economic policies to promote solar energy:

The PV market is currently being driven by subsidies, tax exemptions, and other financial incentives. Micro-finance Institutions, which are the most likely funding sources in rural areas, are being supported by bigger government funding agencies. Recently in the India, the Department of Energy uses a systems driven approach for the management of research activities of solar energy system (SES). This approach uses market analysis, testing, modeling, and prioritizing to resolve the research needs and assess progress [17]. In India, Jawaharlal Nehru National Solar Mission has been established to make the necessary changes to government policies in order to promote and develop solar technologies. Changes in policy include making the utilization of solar heaters mandatory, ensuring certification for manufacturers of solar powered appliances, supporting promotion of the solar energy system (SES).through local agencies and power utilities, and supporting technological upgrades to achieve high efficiency and cost reduction [18].

The ability to promote a clean power source and improve basic living standards is the major attraction for international funding of solar energy in developing countries. Developmental aid funding from several bi-lateral and multi-lateral aid agencies specifically include solar activities, which has benefited the market [19].Since the initial costs of installing a photovoltaic(PV) system are very high, and despite lifetime economic advantages, micro-finance is becoming more of a focus in improving its affordability.

6. Challenges to solar energy:

Fundamental challenges faced by solar energy system (SES). Are the cost, manufacturing procedure, and waste products.In order to implement solar energy system (SES) at a large scale, technology needs to be cost effective compared to fossil fuels or nuclear energy based generation systems. In addition, educating customers about the advantages and marketing the solar energy products can be costly and difficult in rural areas, due to low literacy rates. Impractical political promises or plans for rural electrification can also be a barrier for market expansion [20]. Power generation using solar energy system (SES) is weather-dependent and the trend of generation cannot be fully predicted. Due to the intermittency in power generation, solar energy system (SES) might not be a good choice for a continuous load requirement, and raises reliability and power quality issues. Because of this, solar energy system (SES) has to beoperated in conjunction with the utility grid or some kind of energy storage in order to achieve required continuity in power supply. The grid-connected operation leads to other set of issues related to voltage stability, reactive power demand, etc. Another problem associated with using solar energy system (SES) is that the energy generated by the solar energy systems (SES) is DC, that has to bechanged to AC before utilizing it for home appliances or before feeding it back to the utility grid. Solar energy devices produce no air or water pollution and no greenhouse gases, but do have someindirect impacts on the environment. Like there are some toxic materials and chemicals, and different solvents and alcohols which are used in the manufacturing process of phoovoltai cells. In addition, large solar thermal power plants can harm ecosystems if not properly managed. Such as birds and insects can be killed if they fly into a concentrated beam of sunlight, such as that created by a ‘‘solar power tower.’’ CSPs also use potentially hazardous fluids (to transfer heat) that require proper handling and disposal. The use of CSP on a large scale could also lead to water pollution, since water is required for regular cleaning of the concentrators and receivers and for cooling the turbine-generator.

7. Solar in developing countries

The main role of all types of solar power in developing countries is twofold: easing the burden of energy production for everyday tasks and lessening the carbon emissions of developing economies. Pursuing these goals will aid in reducing poverty and increasing the general well-being of individuals in these countries. For example, 30–40% of energy is typically spent on water heating that is done by burning wood or other fossil fuels [21]. The addition of a solar powered water heating system would lead to enlarged freedom from this burden (leading to opportunities to pursue other ventures) and increased hygiene due to installed plumbing. Due to these obvious benefits of solar installations in developing countries, much work has been completed regarding general policy and viability while also heavily investigating individual locations [22]. While this work is extensive, it can be summarized in by considering a few main issues: (1) the use of solar in developing countries is highly beneficial in terms of independence, health, and economic growth, governments need toput policies in place that attract investment and encourage development of this sector, and solar, in general, is an excellent option for developing countries due to their access to high levels of sunlight.

8. Conclusions:

Solar power is proving to be an attractive opportunity in terms of both business and power generation. Significant improvements have already been accomplished by numerous international, governmental, and non-governmental organizations including the funding and development of projects involving renewable energy systems for various developed as well as developing nations. This progress is transforming rundown conditions into quality living spaces and providing new luxuries to those who were once lacking. Ecosystems, developing societies, and the solar energy market will only benefit from an increase in solar photovoltaic (PV) solar energy system (SES) System installations. Funding for these systems, however, is a challenging aspect when considering the extensive demand. Luckily, as more and more organizations helper their financial, professional and technical services, solar energy is becoming more cost effective. While progress has been slow but steady over the last two decades, the current efforts of industry leaders and researchers have greatly reduced costs and improved efficiencies', thus increasing the demand for solar energy system (SES).

References

1. US Department of Energy. International energy outlook 2009. Technical report DOE/EIA-0484; US Department of Energy; 2009 http://www.eia.doe. gov/oiaf/ieo/pdf/0484(2009).pdf.
2. Khatib H. Renewable energy in developing countries. In: Proceedings of the international conference on renewable energy—clean power, London, UK; 1993. p. 1–6.
3. Xia X, Xia J. Evaluation of potential for developing renewable sources of energy to facilitate development in developing countries. In: Proceedings of the Asia-Pacific power and energy engineering conference, Chengdu, China; 2010. p. 1–3.
4. US Energy Information Administration. World map of solar resources; 2011
5. Solar updraft tower; 2010 /http://www.renewable-energy-info.com/solar/updraft-tower.htmlS.
6. Razykov T, Ferekides C, Morel D, Stefanakos E, Ullal H, Upadhyaya H. Solar photovoltaic electricity: current status and future prospects. Solar Energy 2011;85(8):1580–608.
7. Kropp R. Solar expected to maintain its status as the world's fastest-growing energy technology /http://www.socialfunds.com/news/article.cgi/2639.htmlS; 2009.
8. Jacobson M. Review of solutions to global warming, air pollution, and energy security. Technical report. Stanford; 2008.
9. Swanson R. Photovoltaics power up. Science Magazine 2009;324:891–2.
10. Levelized cost of new generation resources in the annual energy outlook 2011; 2010 /http://www.eia.gov/oiaf/aeo/electricity_generation.htmlS.
11. Candanedo J, Athienitis A. A systematic approach for energy design of advanced solar houses. In: IEEE electrical power & energy conference, Montreal, Canada; 2009. p. 1–6.
12. Khennas S, Barnett A. Best practices for sustainable development of micro hydro power in developing countries. Technical report. Department for International Development, UK; 2000.
13. Wang X, Shi J. Piezoelectric nanogenerators for self-powered nanodevices. In: Ciofani G, Menciassi A, editors. Piezoelectric nanomaterials for biomedical applications. nanomedicine and nanotoxicology. Berlin, Heidelberg: Springer; 2012. p. 135–72.
14. Frost & Sullivan Research Service. Advances in energy harvesting technolo gies. Technical report. Frost & Sullivan Research Service; 2007.
15. Gonzalez J, Moll F, Rubio A. A prospect on the use of piezoelectric effect to supply power to wearable electronic devices. ICMR 2001;1:202–7.
16. McGrail M. Big winds and gentle breezes merge into a promising outlook for wind power technology. Technical report. Brodeur Partners and Beaupre; 2012.
17. Frye W. Smart grid transforming the electricity system to meet future demand and reduce greenhouse gas emissions. Technical report. Cisco Internet Business Solutions Group; 2008.
18. Cameron C, Cornelius C. A systems-driven approach to solar energy R&D. In:IEEE international conference on system of systems engineering. San Antonio,TX; 2007. p. 1–6.
19. Jawaharlal Nehru National Solar Mission towards building solar India; 2012 /http://mnre.gov.in/pdf/mission-document-JNNSM.pdfS.
20. Renewable energy market share; 2012 /http://www.solarbuzz.com/Stats Marketshare.htmS.
21. Martinot E, Chaurey A, Lew D, Moreira J, Wamukonya N. Renewable energy markets in developing countries. Annual Review of Environment andResources 2002;27:309–48.
22. Holm D, Arch D. Renewable energy future for the developing world. Technical report. International Solar Energy Society; 2005.