Study of the new innovations in solar energy and the possibility of developing them in Ahvaz metropolis

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Abstract

The light from the Sun is a non-vanishing renewable source of energy which is free from environmental pollution and noise. It can easily compensate the energy drawn from the non-renewable sources of energy such as fossil fuels and petroleum deposits inside the earth. Solar energy is the cleanest and most abundant renewable energy source in the world. It's also the earth's oldest energy form. Throughout the last couple of decades, cutting-edge technology has changed the way we're able to harness this energy for uses that run the gamut from providing light to generating electricity. This paper suggests a new concept of solar collection that prints the solar cells directly onto a spherical surface and shows if it is possible to use the spherical reflector for systems requiring process heat and make possible substantial utilization of solar energy and considerable save a relative to fossil energy in Ahvaz metropolis.

Keywords: spherical reflector, Solar Energy, Spherical Surface Collector, Solar Balloon, Renewable Energy

Introduction

The increasing demand for energy, the continuous reduction in existing sources of fossil fuels and the growing concern regarding environment pollution, have pushed mankind to explore new technologies for the production of electrical energy using clean, renewable sources, such as solar energy, wind energy, etc. Among the non-conventional, renewable energy sources, solar energy affords great potential for conversion into electric power, able to ensure an important part of the electrical energy needs of the planet.[1]

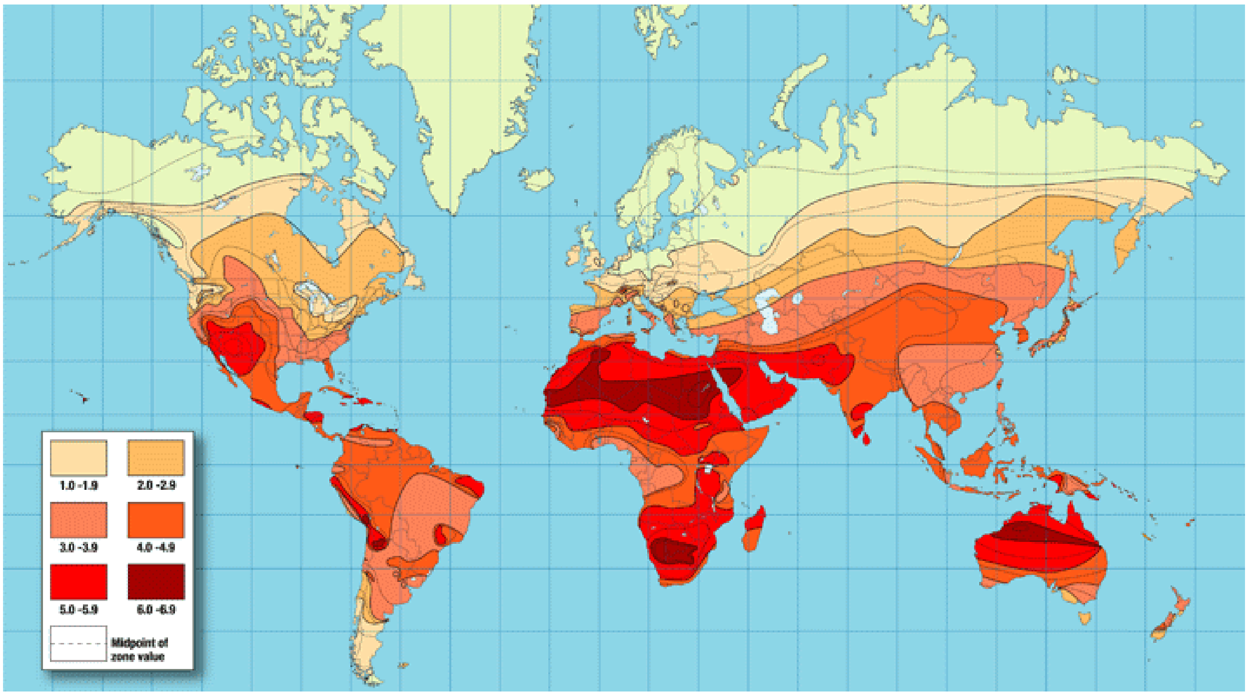
In 1990, the world demand for power exceeded 10 terrawatts (10X1012 Watts) thermal, with about 30% of the thermal energy being used to produce electricity [2]. In 1990, the nations of the Organization for Economic Cooperation and Development (OECD) used more than two-thirds of the world's total electrical power of >10.5 terrawatt-hours [3]. However, beginning in 2015, the DOE has forecast that the non-OECD countries' share of electric power usage will exceed fifty percent and will continue to rise [3]. Energy demand is estimated to increase by more than 60% from the present 382 Quads (1999) to 612 Quads in 2020 and electricity, with an annual growth rate of 2.7% between 1999 and 2020 will outpace growth of other energy use, reaching more than 22.4 terrawatt-hours [3].

The conversion of solar light into electrical energy represents one of the most promising and challenging energetic technologies, in continuous development, being clean, silent and reliable, with very low maintenance costs and minimal ecological impact. Solar energy is free, practically inexhaustible, and involves no polluting residues or greenhouse gases emissions. [1]

Currently, conventional solar cells with planar light reception surface are made of highly purified silicon crystals, which imply very high costs and complex production processes. The recent shortage of high-grade silicon has generated interest in developing alternative photovoltaic technologies. For instance, spherical solar cells (SPVC) have drawn attention due to their relative low costs (using less silicon), flexibility (adaptability of the solar modules to a variety of applications), and conversion efficiency: spherical reception surface can intercept sunlight in all directions, thus increasing its power generation capacity; it can minimize output fluctuations even under direct sunlight,and even the angle of reflected incident light changes [4].

Solar Constant

The solar constant is the amount of incoming solar electromagnetic radiation per unit area, measured on the outer surface of Earth's atmosphere on a plane perpendicular to the rays. The solar constant includes all types of solar radiation, not just the visible light. It is estimated to be roughly 1,366 watts per square meter (W/m2) according to satellite measurements, though this fluctuates by about 6.9 % during a year (from 1,412 W/m2 in early January to 1,321 W/m2 in early July) due to Earth's varying distance from the Sun.For the entire planet, the power is 1.740×10^{17} W, plus or minus 3.5 %. The solar constant does not remain constant over long periods of time. The average value cited, 1,366 W/m2, is equivalent to 1.96 calories per minute per square centimeter, or 1.96 langleys (Ly) per minute. figure 2 below shows solar



insolation level on the world map. [5]

figure 2: The map shows the amount of solar energy in hours, received each day on an optimally tilted surface during the worst month of the year. (Based on accumulated worldwide solar insolation data). Source: www.altestore.com

According to the map Iran is a country that has 300 hundred sunny days in two thirds of it and has an average radiation of 4,5-5,5 KWh per square meters per day therefor Iran is a country with high potential for solar energy. Some specialist in the solar energy field have even gone further and said in an idealistic view that if Irans desserts are equipped with solar energy facilities, Iran will be able to provide the energy needs for many of the countries in the area. Ahvaz is capital of Khuzestan province and 8th metropolitan of Iran which is located at 21 degrees and 20 minutes north latitude and 48 degrees 40 minutes east longitude is located. This city is mostly plan and is 18 meters above sea level. The total area of Ahvaz is 20477 hectares of which 6923 ha of are urban areas. A large part of Khuzestan province is located in plain and Ahvaz is located in this plain section. Unfortunately, pollution in Ahvaz increasing rapidly and the situation is aggravating by time. Karun River is the largest and most probes derived from the Bakhtiari Mountains and passes of Ahvaz city.

This metropolis is in hottest regions of Iran and 10 most polluted cities in the world. Therefore, the city required to take serious actions to prevent further air pollution and environment contamination.
Ahvaz metropolis located in Iran country is located in the area with 6.0-6.9 range of mount of solar energy in hours is one of the best cities for using the dollar power energies and this source can be used as a serious source of energy there. in this article we introduced and analyzed one of the new meths of using solar energy and efficiency analyses of using this system in Ahvaz metropolis.

Advantages and Limitations of Solar Energy

Renewable energy sources in general, and Solar Energy source in particular, has the potential to provide energy services with zero or almost zero emission. The solar energy is abundant and no other source in renewable energy is like solar energy. Every technology has its own advantages and disadvantages. As the solar insolation and atmospheric conditions vary significantly from place to place, efficiency of solar energy also differs accordingly. [6]

Advantages

- It is an abundant Renewable Energy
- This technology is Omnipresent and it can be captured for conversion on a daily basis
- It is a Non-polluting technology, which means that it does not release green house gases
- It is a Noiseless technology as there are no moving parts involved in energy generation
- This technology requires Low-maintenance because of lack of moving parts
- It can be installed on modular basis and expanded over a period of time
- Most viable alternative for providing electricity in remote rural areas as it can be installed where the energy demand is high and can be expanded on modular basis.

Limitations

- As the technology is in an evolving stage, the efficiency levels of conversion from light to electricity is in the range of 10 to 17%, depending on the technology used.

- The initial investment cost of this technology is high. At present the technology is basically surviving because of subsidy schemes available by the government.

- Solar energy is available only during daytime. Most load profiles indicate peak load in the evening/night time. This necessitates expensive storage devices like battery, which need to be replaced every 3 to 5 years. Generally, the cost of the Battery is 30 to 40% of the system cost.

- As the efficiency levels are low, the space required is relatively high. For instance, with the existing levels of technologies, the land required for putting up a 1 MW solar PV power plant is between 6 to 9 acres. However, research is going on to increase the efficiency levels of the cell.

- Solar energy is heavily dependent on atmospheric conditions.

- Solar insolation varies from location to location, so there are certain geographic limitations in generating solar power.

- With the existing module and inverter manufacturing technologies, it may not be worthwhile in terms of costs to deploy solar energy for certain loads which require very high starting power (e.g. air conditioners).

There are three major categories of solar technology:

- 1. Photovoltaic systems (PV) directly convert sunlight to electricity. They generate electricity using naturally-conductive, light-absorbing materials such as silicon. Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid.

- 2. Solar heating and cooling systems (SHC) absorb sunlight to generate heat, which they use to provide hot water, space heating, and cooling.

- 3. Concentrating solar power (CSP) technologies use mirrors to concentrate the energy from the sun to drive traditional steam turbines or engines that create electricity. [7]

Principles of Operation of Solar Energy

Solar energy is available in abundance in most parts of the world. The amount of solar energy incident on the earth's surface is approximately1.5 x 10^{18} kWh/year, which is about 10,000 times the current annual energy consumption of the entire world. The density of power radiated from the sun (referred to as solar energy constant) is 1.373 kW/m^2. Solar cell is a device which converts photons in Solar rays to direct-current (DC) and voltage. The associated technology is called Solar Photovoltaic (SPV). A typical silicon PV cell is a thin wafer consisting of a very thin layer of phosphorous-doped (N-type) silicon on top of a thicker layer of boron-doped (P-type) silicon. An electrical field is created near the top surface of the cell where these two materials are in contact (the P-N junction). When the sunlight hits the semiconductor surface, an electron springs up and is attracted towards the N-type semiconductor material. This will cause more negatives in the n-type and more positives in the P-type semiconductors, generating a higher flow of electricity. This is known as Photovoltaic effect.figure shows the working mechanism of a silicon solar cell. [8]

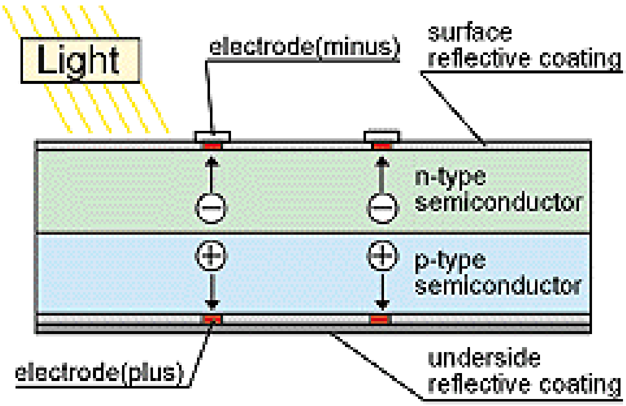


figure 1:Silicon Solar Cell and its working mechanism (Source: global.kyocera.com)

The amount of current generated by a PV cell depends on its efficiency, its size (surface area) and the intensity of sunlight striking the surface. For example, under peak sunlight conditions a typical commercial PV cell with a surface area of about 25 square inches will produce about 2 watts peak power.[9]

Photovoltaic cells (pv)

Photovoltaic cells convert solar light photons into electricity. The PV effect was observed as early as 1839 by Alexandre Edmund Becquerel, and in 1954 Bell Labs introduced the first solar PV device that produced a useable amount of electricity. Today the conductor layer of most commercial solar cells is made from a refined silicon crystal similar to the material in computer chips, and typically the efficiency ratio of these cells for converting sunlight to usable power is about 20 percent. The familiar rigid solar panel consists of multiple solar cells in an integrated group, all oriented in one plane.

Most PV cell research aims to lower the cost of solar cells or achieve cost savings by increasing their efficiency. Scarcity or availability of components is a consideration, too, and is related not only to cost, but also to practical implementation. Innovations that expect to come into common use must employ commonly available materials. [10]

Another research consideration is improving safety: toxic or flammable materials need to be avoided or reduced wherever possible.[11] Silicon-based solar PV production involves use of many of the same materials as the microelectronics industry and therefore presents many of the same hazards. Commonly used perovskite solar cells contain the well- known toxin lead--methylammonium lead iodide is the material of choice for such solar cells. There is a very small amount in a solar cell and a slim chance it would leak, but nevertheless the European Union-funded FutureNanoNeeds project is now investigating the health risks and dangers of lead-based perovskite materials.[12]

PV modules contain substances such as glass, aluminum and semiconductor materials that can be successfully recovered and reused, and recycling of thin-film and silicon modules is already taking place. In the United States, First Solar has developed a process for recycling thin-film modules under the company’s pre-funded module collection and recycling program.[13]

For the use of continual solar power, there are 3 ways that are listed below:

1. The use of solar cells (PV): turning solar power into DC voltage using solar cells

2. The use of solar thermal energy (SCP): focusing the solar power and using its thermal power to put turbines into motion to create electricity.

3. Solar cooling and solar heating (SHC): systems that use direct solar power , without turning it into electricity, to create heat and cold(Like solar water heaters)

The use of solar energy in buildings

Solar cooling systems:

The heating and cooling of buildings using solar energy was an idea mentioned in the 1930s and reached remarkable progress in less than a decade, as for heating water and air can be used as energy carrier fluids by the use of solar heaters. Also By adding a solar system to absorption refrigeration system in addition to hot water and heating, these systems are used in buildings for the use of cooling. Annual energy consumption in the country indicates that the maximum amount of energy consumption occurs in warm months. The main reason for such an increase is the high energy of cooling systems. The study indicates that in these seasons with such increased usage, Solar energy is available with high performance .It seems that the replacement of available solar energy resources in these seasons is a way to reduce the amount of maximum energy consumption. In order to produce cooling using Absorption and compression refrigeration cycles are common. According to the survey, the use of absorption cooling system with recycling cycles is very affordable. In contrast, if the system is used without the recovery cycles more energy will be used in comparison to compression systems.

It should be noted that the use of absorption cooling systems rather than compression system will not only be examined from the perspective of energy consumption But also in terms of environmental pollutants it imposes less pollution to the environment compared to vapor compression cooling systems but providing the thermal energy needed for an absorption cooling system using two solar and fossil sources in parallel form is a Good practice which, due to weather conditions and high radiation intensity in the summer sun, it is recommended.

At this state The hot water boiler is required to power the chiller In the hours that solar energy is not directly accountable for the needs of the system.

Generally a solar collector is a heat exchanger that converts solar energy into heat,In conventional converters, power transmission takes place via a fluid to another But in solar collectors the energy is transmitted to the fluid by radiation.

Flat collectors can produce heat up to 100 C and they obtain this temperature by receiving direct and diffused solar radiation generally for these collectors tracing mechanisms are not considered and they are set permanently in the right direction Flat collectors generally include on or more protective layers with an air gap in between them, an original format and an absorbent. At low cooling loads (less than 100 tons of refrigeration) the use of solar cooling system is more economical.

In these systems based on the fact that absorption chiller needs less heat, the amount of collectors and its surface is reduced.

Absorption chillers work at low temperatures (between 60C- 90C) so they are better for cooling solar.

Domestic heaters:

Pump water heaters and thermosyphone water heaters are used in domestic systems.

Domestic systems provide heated water for the use of 4 to 7 people per day.

Domestic systems can be either thermosyphone or pump.

Termosython domestic water heaters:

With horizontal tank structure and function of this class of solar water heaters is relatively simple. The water heater consists of a tank and some collector whose performance depends heavily on the circumstances of time and place (geographical area)

Collector page surfaces absorb solar radiation and convert them into heat. Riser pipe connected to the heat absorbed in these pages.

In case the system is indirect, the warm fluid will be stored in the reservoir (consisting of a two-layered reservoir). The warm fluid (a solution of water and antifreeze liquid) will enter the outer layer and the consumed water will become warmer. To increase the performance of water heaters, the absorbent surfaces are placed inside a frame which will be covered from the bottom with a suitable insulator to decrease heat loss. Moreover, in order to prevent heat loss from the upper surface of the absorbent surfaces, the surface of the frame will be covered by one or two glass layers (or other transparent material). The radiation properties of the surfaces are highly effective in the performance of a solar water heater. For better performance, it is necessary that the surfaces have absorption coefficient, and, vice versa, they are required to have a low emissivity so that their heat loss is low. Surfaces with such properties are known as Selective Surfaces.

Domestic Pump Water Heaters

This system consists of a reservoir, two collectors and a pump. Explanation regarding the reservoir collectors of this system is exactly similar to the explanations mentioned for the thermosiphone system. The difference is that the reservoir of this system can be placed in any place of the building. Therefore, it can be placed apart from the collector and nearest to the place of consumption. This system can also be used as a complementary system or as a pre-heater. The addition of this circulation pump to the circuit leads to increased output power and efficiency.

Solar Air Heater

A solar air heater is a device which, while absorbing the thermal energy from the sun, warms the incoming fresh air to the building. In this case, while using green and clean energy, there is no limit to the amount of provided fresh air, and this system can provide, partially or entirely, the thermal load of a building.

Solar Drier

Understanding solar energy and using it for different purposes dates back to prehistoric times. Drying is the process of acquiring a portion of the water of edibles or other products which leads to an increase in product life and prevents the growth of bacteria. In solar driers, solar energy is used directly or indirectly for drying purposes, and wind flows, either naturally or obligatory, which accelerates the drying process of the product. Solar driers are designed and created in different shapes and sizes for various products and usages.

Different type of solar energy

Virtually any one in the world has knowledge about solar energy but the fact is not only general people but the engineers of this knowledge yet haven't enough about it. The majority of presence information that are related to solar energy are summarized into water purification and photoelectric cells but it is very huge and engineers find more cheap way for apply it and this energy as a clean and pollution energy is a good subtitle for other fuels. Its main problem is deserve if it in clean days. But the is that better approaches and methods would be available for man through increasing sciences development that cover a good respond to present concerns. We in this part, refer to some forms of catching solar energy. Although this has various forms, we refer to different forms of generating energy at energy sites as following:

Turbo generator energy sites: Water or other liquid is changed into vapor in this energy sites, and through rotating turbine connected to the generator, power energy is generated which by some of them the daily thermal energy is reserved at high consuming hours in capacities. At present three main Helium energy sites have been established with central tower CRS, try type and solar pond which at solar energy system, water warmth presented at bottom of natural or fabricated ponds of salt water is used to pressure liquid like Freon. At solar pond system, beginning expenses are low, system complexity is little, and there would be possibility in reserving at rights and for few cloudy days. But the other two systems have high expenses and there wouldn't possibility in reserving comparing with mirror systems, so we have no alternative but using fossilized solar compound systems.

Power towers: They are referred as cold and warm. The warm system is consisted of a very big greenhouse without lateral walls and a tall central chimney in which there are fans connected to the generator. By sun shining and declining the amount of air under greenhouse, the chimney operates then the air moves up quickly and cause rotating fan and generating electricity. Amongst the most important features of this design we can point out the high simplicity of the system, simple tools, low expenses, long lifetime as well as independency to water, by the way we can generate thermal course through burning fossil fuel inside contrived spaces at nights then it causes to generate electricity.

At the cold system, the general form of power site is like above but this one courses through spraying water, heavy dry air and very slow spread two and downside then they causes rotating fans and generating electricity of main feature is it's activity at all night. By the way one can work on the fields 6 K.M away from the power site. But the considerable deficit is providing water on hot and dry regions.

Photoelectric power site: It's the one with big plates of a photoelectric cell which transforms directly the solar energy into electricity. This system is not proper enough for big power sites. It's just used for points from main network as well as for small equipment.

The power site with Straling engine: It's a sort of out-burning engine which provides conditions for transforming thermal energy into electricity one when exposing warmth resulting from centralizing reflex mirrors. This engine is of cost innovations that we expect it will play an important role for better using solar energy.

Hydrogen production: In power sites with Straling engine and photoelectric, we can electrolyzed water through producing electricity, preserve the final Hydrogen and use it when needed, by the way carrying big tanks of Hydrogen is a good way for transferring energy from full-shining to low-shining points of the world. Second feature of this system is that it can generate electricity through burning Hydrogen at nights by help of Straling engines. One of the methods, studying is to use Hydrogen of some proper metals (MG) which their reactions produce high temperature (warmth) and during the day separate Hydrogen by sun shining on the tanks containing (MG CH) and preserve it as well as during nights, blending Hydrogen and my leads to producing warmth. Generally speaking, sciences hope, by accomplished studies as well as New technology of PV cells, batteries, solar transmission and CSP, in 2015achieving technology of burning Hydrogen without difficulty in large and small scales and even home usage that Hydrogen would be as future fuel. It seems that production, preserving and transportation this material to solar energy will be possible in near future.

Usage of solar energy

Main merit of using solar energy comparing with other sources is that:

1) - It's a neat energy sources and lack of pollution.

2) - It's a free source except expenses related to establishments.

3) - It's a tested technology.

4) - It's free from risk of thermal unbalance.

5) - It's achievement at night by means of operating sun shining plans through special reflectors.

Although the sun is the main sources of energy, its energy output isn't equal on the earth, since it's lighting not only arrives at different surfaces alternatively, but also its amount changes at any place in summer and winter, so it's hard to predicate. Therefore, evaluating its amount, regarding long term average of data, can be achieved and based on it, establishment projects are applicable.

Spherical sun power generator

German Architect Andre Broessel believes he has a solution that can “squeeze more juice out of the sun”, even during the night hours and in low-light regions. His company Rawlemon has created a spherical sun power generator prototype called the beta.ray and his technology combines spherical geometry principles with dual axis tracking system allowing twice the yield of a conventional solar panel in a much smaller surface area. The futuristic design is fully rotational and is suitable for inclined surfaces, walls of buildings, and anywhere with access to the sky. It can even be used as an electric car charging station.[14]“The beta.ray comes with a hybrid collector to convert daily electricity and thermal energy at the same time. While reducing the silicon cell area to 25% with the equivalent power output by using our ultra transmission Ball Lens point focusing concentrator, it operates at efficiency levels of nearly 57% in hybrid mode. At night time the Ball Lens can transform into a high-power lamp to illuminate your location, simply by using a few LED’s. The station is designed for off grid conditions as well as to supplement buildings’ consumption of electricity and thermal circuits like hot water.” [15]In figure 3 it’s shown how this new technology works and how it can generate power.

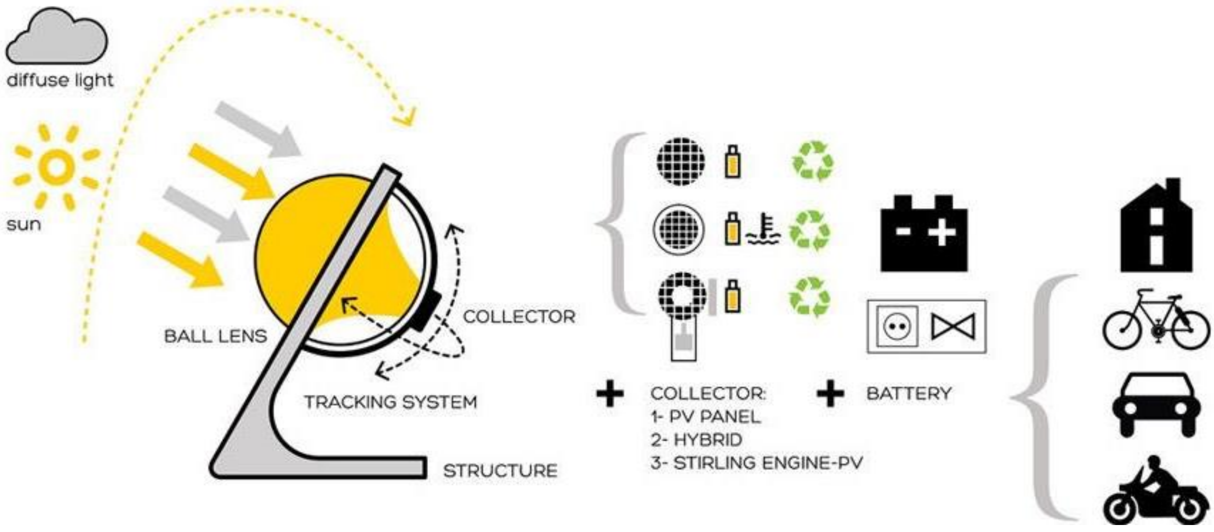


figure3: the function of the Spherical sun power generator

A spherical sun power generator prototype with trade name Beta.ray will produce twice the yield of a conventional solar panel in a much smaller surface area. It comes with a hybrid collector to convert to daily electricity and thermal energy at the same time. Developed by German architect Andre Broessel for his company Rawlemon, the modular collector system charges and stores energy during daylight hours and can even collect energy from the moon at night. The Rawlemon website asserts, “ [16]

Multi-junction cells made from multiple materials will respond to multiple light wavelengths and some of the energy that would otherwise be lost can be captured and converted. Multi-junction cells can only function with concentrator systems. in figure 4 its shown how this technology collects the rays.

figure 4: capturing multiple light with different angles (it was done in night and by artificial light to show the light rays)

Improved polymer solar cells

Polymers are a familiar technology seen in such products as polystyrene plastic. When heated, thermoplastic polymer softens and can be converted into semi-finished products like films and sheets. Polymer solar cells have the desirable features of lighter weight and flexibility, but they need extra processing steps and coating technologies that are a technical challenge. Researchers at Iowa State University and Ames Laboratory took flexible, lightweight polymers and added a textured substrate pattern that provided a thin, uniform light-absorbing layer. This textured substrate pattern remains uniformly thin when going up and down the flat-topped ridges, which are less than a millionth of a meter high. With this layer, efficiency improved by 20 percent. The technology is being patented by Iowa State University Research Foundation Inc. Once the technology is patented, it will be licensed to solar cells manufacturers.[17]

Ultra-short pulse laser scribing

Flexible thin-film solar cells that can be used as rooftop shingles and tiles, building facades, or the glazing for skylights are a rapidly expanding portion of the solar cell market. Ultra-thin film- type solar cells have now been manufactured which are quite malleable and appropriate for corners and curvilinear structures. The films when assembled into an array are only as efficient as the “microchannels” on the films which help convert the sunlight to electrons needed for power generation. Until now the scribing of the microchannels has been done with the help of a mechanical stylus—an expensive process that results in inexact grooves of uneven depth. Using the ultra-short pulse laser in a process called “cold ablation” (laser beams flashed for only quadrillionths of a second), a team from Purdue University very rapidly inscribed microchannels with exact depths and well-defined outlines without causing any damage to the ultra-thin-film solar cells. The research, funded by National Science Foundation, aims to increase efficiency while significantly reducing cost.

FDT light-harvesting film

Some of the most promising solar cells today use light-harvesting films made from perovskites, a group of materials with the same type of crystal structure as calcium titanium oxide (CaTiO3). Perovskite-based solar cells use expensive "hole-transporting" materials, whose function is to move the positive charges that are generated when light hits the perovskite film. Publishing in Nature Energy, scientists at École Polytechnique Fédérale de Lausanne have now made a molecularly engineered hole-transporting material called FDT. Lead researcher Mohammad Nazeeruddin reports, "By comparison, FDT is easy to synthesize and purify, and its cost is estimated to be a fifth of that for existing materials.” FDT is able to keep the efficiency of the solar cell above 20%.

Tandem perovskite-silicon cells

A number of chemical researchers believe perovskites open the door to a new era of high- efficiency, low-cost solar cells. Perovskites are easily synthesized, and their [18]

Ability to absorb light in the blue region of the spectrum complements silicon, which absorbs long-wavelength red and near-infrared light. A new tandem solar cell featuring monolithic perovskite and silicon has been reported to produce electricity with efficiency of 18 percent, according to scientists at Helmholtz-Zentrum Berlin and École Polytechnique Fédérale de Lausanne, Switzerland. While this is not the highest solar cell efficiency rating, Professor Bernd Rech of Helmholtz-Zentrum Berlin believes industry will be interested in the potential. He says, “There are many established production facilities for silicon cells. The perovskite layers could considerably increase the efficiency level. To achieve this, the fabrication techniques only need to be supplemented with a few more production steps.”[19]

3D-Printed Solar Energy Trees

Researchers at the VTT Technical Research Centre of Finland have developed some very decorative prototypes of what they are calling "energy harvesting trees," thanks to advancing solar and 3D printing technologies. The tiny leaves store solar energy and can be used to power small appliances and mobile devices. They flourish indoors and outdoors and can also harvest kinetic energy from wind and temperature changes in the surrounding environment.The tree's leaves are flexible organic solar cells, each with a separate power converter. The trunks are 3D-printed using wood-based bio-composites. They are mass producible.[20] figure 5 shows a 3D printed solar energy tree.

figure 5 : 3D printed solar trees

Ceria for solar fuel production

Because ceria or cerium oxide—the most commonly-found rare-earth metal—has a natural propensity to alternately exhale and inhale oxygen as it heats up or cools down, it is under exploration for use as a means to create fuel. A new prototype formulated by Swiss and US researchers uses a quartz window to focus sunlight through a small cavity on a ceria-filled cylinder. When water and/or carbon dioxide are pumped into the vessel, hydrogen and/or carbon monoxide are created. Hydrogen by itself is used in hydrogen cells, and by mixing hydrogen and carbon monoxide, a synthetic fuel (syngas) can be produced. The resulting fuels are portable and can be used at any time. Researchers expect improved insulation and smaller apertures can increase efficiency to some 19% and make it a commercially workable option. [21]

Batteries and storage

The greatest technical challenge with producing electricity from renewable sources is their intermittency. Photovoltaic cells can generate power from sunlight, but they must be partnered with some kind of storage mechanism for power to be available at night or in cloudy weather. Grid-connected users of PV-generated power can receive power from the grid when the sun isn't shining, whether from renewable or non-renewable energy sources. Off-grid users need to store their own surplus power for those times , and utilities require grid-sized batteries or another large-capacity storage medium.

Until recently, batteries for energy storage have been based on lead-acid chemistry that pollutes, has a short life span, and may be unreliable. Lithium was an attractive alternative to lead, since it is the lightest of all metals and has great electrochemical potential. Due to its inherent instability, however, especially during charging, research shifted to a non-metallic lithium battery using lithium ions.[22] Lithium ion is the advanced technology that has been brought into commercial level production at this time, but a variety of battery chemistries are near that stage. As Ellen Williams, director of the US Advanced Research Projects Agency-Energy (ARPA-E) said in February 2016 of work by that agency, battery storage systems are on the verge of transforming America's electrical grid.[23]

The objective of all this development is to produce cheaper, safer storage for renewable sources with longer operational capacity. Progress continues, including the arrival on the retail market of the first mass-produced, affordable solar home batteries.

Tesla: Lithium ion

At its massive factory near a lithium mine in Nevada, Tesla has started producing its lithium-ion Powerwall battery. Powerwall is a home battery that partners with solar panels to provide stored-up power for use at night or during outages. With the battery, a home can achieve a net-zero energy rating; that is, it can produce as much energy as it consumes while still connected to the utility grid for periods of high demand. Each Powerwall has a 7kWh energy storage capacity, and multiple batteries may be installed together to meet greater energy needs. A 10kWh version is also available. Tesla offered its first demonstration home system batteries in 2015, and in 2016 Tesla is busy filling orders from the long waiting list. The selling price to installers is $3,750 for 10kWh and $3,000 for 7kWh, excluding inverter and installation.[24] Tesla is also offering a 100kWh battery for utility scale use. According to Tesla they can scale to any size—10,000 Powerpacks would generate 1Gw of electricity. The CEO of Tesla said that 160 million Powerpacks could enable the entire US to transition to renewable energy and 900 million Powerpacks would enable the whole world to make the transition. [25]

Sonnenbatterie: lithium ion

A German company, Sonnenbatterie, also entered the US market in 2015. Sonnenbatterie employs Sony Fortelion lithium-ion batteries for its storage systems and claims they can be used for up to 10,000 charge cycles. The German manufacturer has opened facilities in Los Angeles and Atlanta.[26]

Aquion Energy: aqueous sodium ion

The world's first battery with Cradle-to-Cradle Material Health certification works on saltwater and other commonly available materials and stores enough solar or wind energy to power a single-family home for eight hours. The size of a dishwasher or small refrigerator, the Aqueous Hybrid Ion (AHI) battery can fit off-grid and microgrid locations. Aquion Energy has fully scaled manufacturing with global distribution channels and installations in many locations including Australia, California, Germany, Hawaii, Malaysia, and the Philippines.[27]

Ambri: liquid-metal

The Ambri battery combines two metals that have different weights and melting points, separated with a salt layer. Electric currents heat the metals to as much as 700 degrees Celsius (1,292 degrees Fahrenheit) to pass electrons through the molten salt. In September 2015 Ambri revealed disappointing test results that pushed back commercial deployment indefinitely. The problem is the seals that keep the liquid electrodes enclosed— steel cans that must be hermetically sealed with materials that hold up for many years. Ambri's manufacturing facility in Cambridge, Massachusetts, is still seeking a solution to its sealant problem. [28]

Seeo: dry lithium

Silicon Valley start-up Seeo is developing a battery using a solid dry polymer for its electrolyte, which is far less flammable than a liquid one. The second-generation version of the battery utilizes lithium for the anode, and a new material that can store more energy for the cathode. Although it has yet to sell its batteries commercially, Seeo has been making batteries on its pilot production line for test purposes for some time. In August 2015 the company was purchased by German auto parts giant Bosch. [29.30]

Concentrating Solar power (CSP)

Utility-scale solar plants utilize mirrors to collect sunlight, and they store the collected energy as heat. Like natural gas, coal, and nuclear plants, many CSP systems require access to water for cooling. All require small amounts of water to wash collection and mirror surfaces, but some plants can utilize wet, dry, and hybrid cooling techniques to maximize water conservation. Finally, CSP plants must have access to a power grid to distribute the garnered power. The first phase of what will become the largest concentrated solar power (CSP) plant in the world went live in late 2015. [31]The Moroccan city of Ouarzazate is the site for a complex of four linked solar mega-plants that, alongside hydro and wind, will help provide nearly half of Morocco's electricity from renewables by 2020. The project is a major step in the country's ambitions to use its deserts to become energy-independent. When construction is complete, the plant will have capacity to generate 580MW of electricity, enough to power a million homes. The first phase, Noor 1, has a generating capacity of 160MW and utilizes 500,000 crescent-shaped solar mirrors in 800 rows. Each parabolic mirror is 12 meters high and focused on a steel pipeline carrying a synthetic thermal oil heat transfer solution that is warmed to 393 degrees C as it snakes along the trough before coiling into a heat engine. There it is mixed with water to create steam that turns energy-generating turbines. The heat tank contains molten sands that can store heat energy for three hours. The US$9 billion project is justified as cost-effective, since Morocco has been importing 94% of its energy as fossil fuels from abroad. [32]

Solar energy in Iran

Iran is located on the Sun Belt which means it receives-and therefore has the capacity to utilize- a high level of sun radiation. Iran has an average annual sunshine duration of about 2800 hours and receives an average solar radiation of about 4.5-5.5 kWh per square meter per day, both indicating the high potential of solar energy in this country. Solar energy experts who have done extensive studies on the Iranian desert expanses believe that development of solar energy utilization systems in these regions will lead to provision of a significant portion of regional electricity needs, and the produced electricity may be abundant enough to be exported to other areas. Studies conducted by DLR Co. (Germany) on Iran have shown that more than 60,000 megawatts of solar thermal power plant can be installed over an area of more than 2000 kilometers.[42,43]Fig 6 shows Iran's solar radiation atlas, where solar radiation potential is classified into a number of regions. As this figure shows, the provinces of Yazd, Fars, Kerman, which receive the highest

amount of radiation are in the lower middle black frame.

Many researches and feasibility studies, which have estimated and analyzed the solar radiation for Iran's different areas, will provide the necessary groundwork for development of clean energy facilities, and especially solar power plant [45.46].

Geography of the study area

Ahvaz is the capital of Khuzestan province and one of Iran's metropolises. This city is located in the central region of Ahvaz County, on 31 degrees and 20 minutes north latitude and 48 degrees and 40 minutes east longitude, and on the floodplains of Khuzestan at 18 meters above sea level. According to the latest official statistics, 32 percent of population of Khuzestan province live within the boundaries of Ahvaz metropolis.

Fig 6. The diagram of horizontal radiation pertaining to Ahvaz solar energy potential[44]

35 percent of this population live in suburbs, making Ahvaz Iran's second most suburbanized city after Mashhad. 51% of oil produced by National Iranian South Oil Company is currently produced in this city and it also houses some of largest Iranian companies. Ahwaz have an area of 31,800 hectares, which make it Iran's third largest city after Tehran and Mashhad. Karun, which is Iran's largest river in terms of discharge and originates from Bakhtiari Mountains, crosses the middle of Ahvaz, dividing this city into eastern and western parts. Cities around Ahwaz are: Masjed Soleiman, Dezful, Andimeshk, Shushtar and shush in the north, Ra□mhormoz, Haftkel, Ize, Baghmalek in the east, Behbahan, Mahshahr, Shadegan

and Khorramshahr in the south and Susangerd, Hoveize, and Bastan in the West [47, 48].Fig 7 shows the position of Ahvaz on the map of Iran. Ahvaz is one of the Southern cities in Iran.

Fig 5. Position of Ahvaz on the map of Iran

Solar energy and sustainable development of Khuzestan province

Referring to statistics and global graphs indicates that whole Europe (except a small portion of its north) more than 75 percent of American continent, about 33 percent of Africa, more than a half of Oceania, most portion of east and south-west Asia are located in a limitation which has sun shine less 2400 hours in the year and of course it is less than 1600 hours at most portions during the year, indeed, most portions of country (except narrow type in the north) are in points with yearly sunshine amount less than 2400 hours and nearly 3600 hours or even more. So Iran is considered strategic point in field of solar energy potential along with a part of middle Asian countries, central countries and west countries to south American which Iran neighborhood to central and north Europe multiplies the importance of the given region of the greatest consumption markets.

The province it not only located in hot and dry line of the earth but also it has enough capabilities in order to be transformed to a pole of solar energy production as a result one should study that solar energy has what relation to different aspects of sustainable development in the area as well as why it is considered one of the development lines in this province. No doubt studying this field with various and cheap and proper technology from this recursive energy replies all aspects and tools for sustainable development. Since it, other than compatible with the geographical conditions of the area is a inner method, so regarding to be about to end fossil fuels especially oil, that has an important role in economy provides a sort of continuation in economy it has no effect on the environment and it gives the neatest energy to people living in the area. Next energy will be solar one and Iran is one of the best regions in this field. Economy of Iran depends on oil. Although launching to increase non-oil exports is required, this couldn't take the place of oil perfectly. In one hand, because of specific conditions mentioned before. Iran has capabilities to produce much more energy, so it can export the solar energy to other countries and this province (Khuzestan province) is considerable in this field.

It is predicted that taking into account the geographical conditions of Iran the producers of the technology of solar energy have paid significant attention to Iran and have considered Iran as a strategic area obviously technology production domestically would be much better than being dependent as seen in fossil fuels. It spite of attempts made by Iran, still much dependence is seen on developed countries in production and processing and petro chemically there are not enough facilities for producing most of products. Therefore, attainting technology of solar energy both provides the availability of the preliminaries of energy production in our country and makes possible the lowering of price of energy in Iran as well as exporting energy and technology. This would be a great thing during the reduction of fossil fuels and the rise in price of energy during the country toward independence and finding a good economic position. In terms of the region as great steps have been taken industrially commercially and in tourism in Khuzestan province in producing some agricultural products for export, it is essential that this province pay attention to solar energy to meet its needs (due to the impossibility of other kinds of energy including electricity made by water, etc) and provide the bed for exploitation in other parts of the country and even in neighboring nations. In fact Khuzestan province as an axis of development is able to meet the needs of the area and makes possible the export of solar energy and its technology. Selling services besides employment brings profits for the area. If this happens, there would be positive bio-environmental and air pollution would fall as one big trouble of industrial areas. Accordingly, precious works and places in this area would be protected against air pollution.

Conclusions

Future energy scenarios depend on many factors. Government leaders, scientists, and energy investors don’t always agree on the best path. At the present time it takes fossil fuel energy to make solar applications, and if we or fail to apply the remaining supplies of oil and gas to their development, generations from now humans may be back where we were before the industrial revolution—living by direct or crudely amplified sunlight.

Given what was explained and through the study of of each innovation , and by taking into account the climatic properties of Ahvaz which has high variety, the following points are proposed:

Solar energy is received in Ahwaz at all times throughout the year, and it has symmetry on different surfaces in western and eastern directions. Ahwaz is a city with one of the highest potentials for using solar energy. According to the results, Ahwaz has unsuitable conditions (very hot) in 43.9% of the entire year and is in need of using cooling equipment. Given the lack of cold weather in this city throughout the year, use of solar heating devices seems unnecessary. Therefore, using solar cooling devices in this region is considered an economical solution with a high level of performance in the long run.

Estimation of solar radiation is a very important step in the design of different types of solar power generation systems and can have a significant impact on the overall manner and method of constructing these power plants; so obviously a more careful and accurate estimation of this parameter will ultimately lead to much better results. The importance of solar radiation estimation is not limited to electricity generation systems, since it is also among the important parameters of geological and ecological studies and among main factors of many hydrological and meteorological models. Iran has many solar radiation monitoring stations but they are still not enough to provide a solar radiation monitoring network adequate to this country's large area. In this paper, we conducted a technical-economic analysis on solar energy potential of Ahvaz by using meteorological data and technical-economic feasibility study performed with the help of Homer software. The diagram of horizontal radiation of Ahvaz showed that the highest level of solar radiation, which is 5.520 kWh per square meter, can be received in July and the lowest level, which is 0.930 kWh per square meter, can be received in December. The annual electricity to be generated by solar panels in Ahvaz was calculated to 26123 kWh per year. This analysis also showed that this project will need an initial investment of 25,902 $ and will have an annual revenue of 5224.6 $, which result in a payback period of about 5 years. This result points to the need for further attention to Ahvaz solar energy potential and indicates the necessity of further scientific studies on all parts of Iran in order to fully map its solar energy generation potential. Overall, these results show that investments on Ahvaz solar energy sector will be economically justified.

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