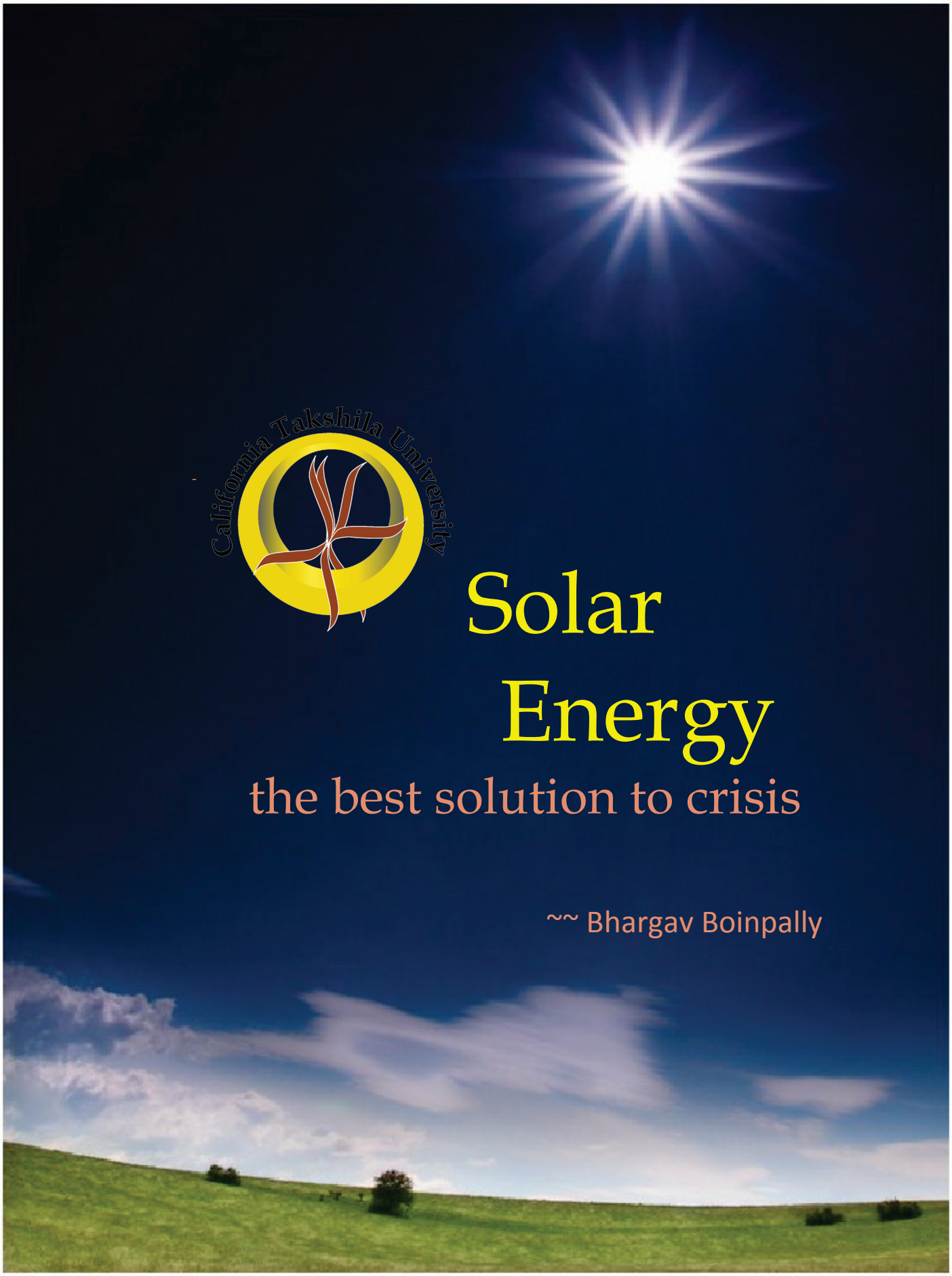



# Solar Energy

## the best solution to crisis

~~ Bhargav Boinpally

Rig Veda 1.164.13

"Sun moves in its orbit which itself is moving. Earth and other bodies move around sun due to force of attraction, because sun is heavier than them .

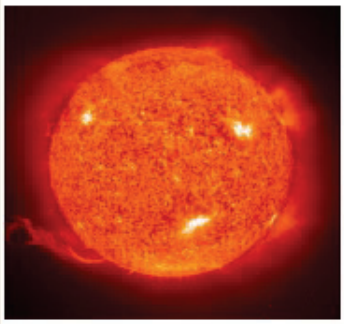


Image by NASA

Sun is a normal main-sequence G2 star [1] one of more than 100 billion stars in our galaxy.

| | |
|---|---|
| Diameter | :1,390,000 km. |
| Mass | :1.989e30 kg |
| Temperature | :5800 K (surface) |
| | 15,600,000 K (core) |

The Sun is by far the largest object in the solar system. It contains more than 99.8% of the total mass of the Solar System. The Sun is, at present about 70% hydrogen and 28% helium by mass everything else ("metals") amounts to less than 2%. This changes slowly over time as the Sun converts hydrogen to helium in its core.

All that exists today is from sun.

In India people say sun as god and chant mantras and offer pujas, Very famous is —surya namaskar|| [2] it is a form of offering prayers to sun god and it is coming from ancient Vedic ages. We can observe in Rig-Veda explaining the motion of sun and how other planets attracts to sun. The Sun God in Hinduism is an ancient and revered deity. History say that, In Ramayana Lord Rama belongs to surya-vansh. In Mahabharata , Karna is son of Sun god. Worshipping Sun is also can seen in ancient Egyptian religion. In Buddhism Sun is the bodhisattva of the Sun is known as Ri Gong Ri Guang Pu Sa.

1
stars given a designation consisting of a letter and number according to the nature of their spectral lines which corresponds roughly to surface temperature.
The classes are : O,B,A,F,G,K & M
O stars are the hottest
M stars are the coolest
The numbers are simply subdivisions of the major classes.
The classes are oddly sequenced because they were assigned long ago before we under stood their relationship to temperature.
O,B stars are rare but very bright.
M stars are numerous but dim
The sun is G2 star.

2
The Sun Salutation Pose, also known as Salute to the Sun and Surya Namaskar, is a series of 12 poses which help improve strength and flexibility of the muscles and spinal column.

At the Sun's core (approximately the inner 25% of its radius) the temperatures are extreme. The temperature is 15.6 million Kelvin[3] and the pressure is 250 billion atmospheres[4]. At the center of the core the Sun's density is more than 150 times that of water.

The Sun's power (about 386 billion billion megaWatts) is produced by nuclear fusion reactions. Each-second about 700,000,000 tons of hydrogen are converted to about 695,000,000 tons of helium and 5,000,000 tons (=3.86e33 ergs) of energy in the form of gamma rays. As it travels out toward the surface, the energy is continuously absorbed and re-emitted at lower and lower temperatures so that by the time it reaches the surface, it is primarily visible light. For the last 20% of the way to the surface the energy is carried more by convection than by radiation.

Almost all the energy on Earth comes from the Sun. It is very hard to dream what is the earth with out sun? and the answer is ICE and No Life.
Plants grow because it get energy from the Sun, the wind blows, and even fossil fuel are just energy stored from the Sun over millions of years.

But how much energy is actually coming from the Sun, and how much of it makes it all the way to the Earth , and how much we are utilizing?

As you probably know, in the core of the Sun, the temperatures and pressures are so high that hydrogen atoms are being fused into helium atoms at a rate of 600 million tons per second. According to reports, 89000 terawatts actually pass through the atmosphere and reach the surface. But total energy used by a;; human beings in equal to 15 terawatts. Means, more than 5930 terawatts still need to harness.

---

3

Kelvin is a unit of measurement for temperature . Symbol : K .

1 kelvin = -272.15 degrees Celsius

4

Atmosphere is a unit of pressure designed to equal the average pressure of the Earth's atmosphere at sea level. In other pressure units, one atmosphere equals exactly 1013.2 millibars (mb) or 101.325 kilopascals (kPa).

Solar energy is the Earth's most available source of energy, easily capable of providing many times that total current energy demand. In present world for any country, it is impossible to give electricity for free for ever. But the sun is giving to earth his energy for free , we need to take some important decisions and steps to solve the problem of energy crisis. We need to understand and develop the equipment's and technics to capture the sun energy in max. way. It must be a collective effort of all departments, from Electrical to Space engineering scientists from computers to material science engineers from scholars to pundits. Then whole globe will be safe and happy.

Solar energy is an inexhaustible resource. The sun produces vast amounts of renewable solar energy that can be collected and converted into heat and electricity.

Solar energy produces clean and virtually unlimited power. Facing the continuously increasing demand and the gradual depletion of the available fossil fuel reserve, it provides an attractive solution to the future energy needs.

Solar technology is not a new technology , it is being practicing from very old ages to till today .
History says that from the 4th million Century B.C. to today we are using and developing new ways in Solar technology.

Here you can learn more about the milestones in the historical development of solar technology, century by century, and year by year. You can also glimpse the future.

4th Million Century B.C.

First known use of Tools in East Africa[5].

10,000 B.C

Use of Solar Cooker (Akshaya Patra[6]) by draupadi as written in Mahabharata .

---

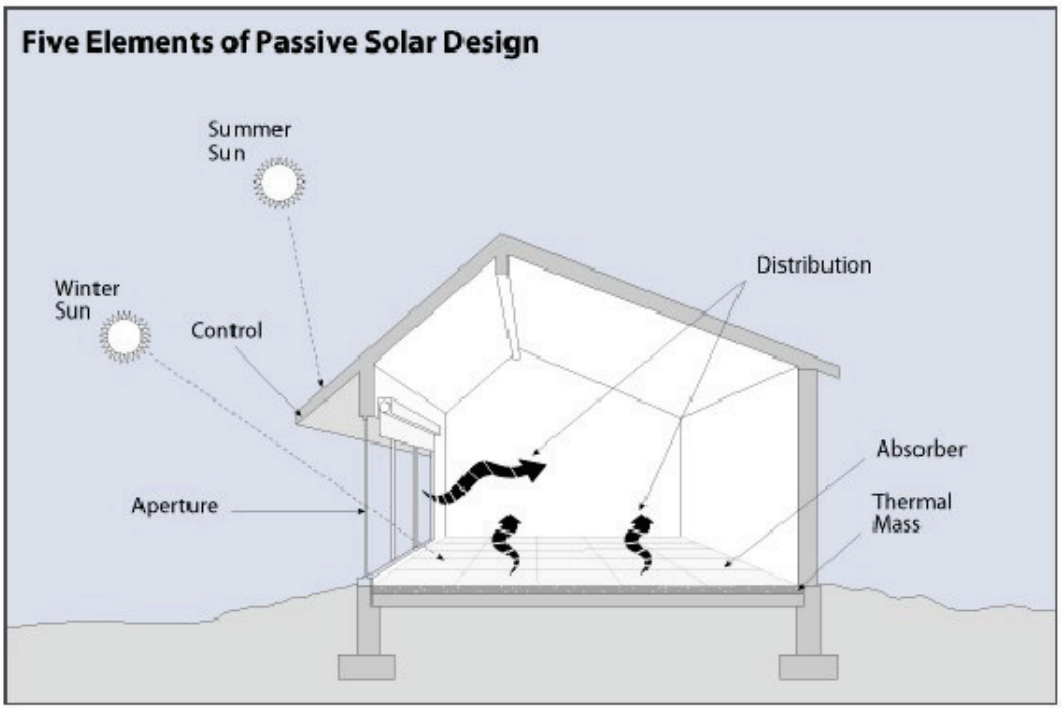
5
Presently, east African countries are Burundi , Djibouti , Eritrea , Ethiopia , Kenya , Rwanda , Somalia , Sudan , Tanzania , Uganda.

6
Using the Akshaya-paatra, Draupadii devi used to serve the Atithi-abhyaagatas first, then following Pativrataa-dharmam used to serve Paandavas and then eat aahaaram provided by the Akshaya-paatra. It was a wonderful vessel given to yudishtira by the Lord surya which held a never-failing supply of food to the pandavas every day.

1500 B.C.

Fire starting kits carried in Europe.

500 B.C.

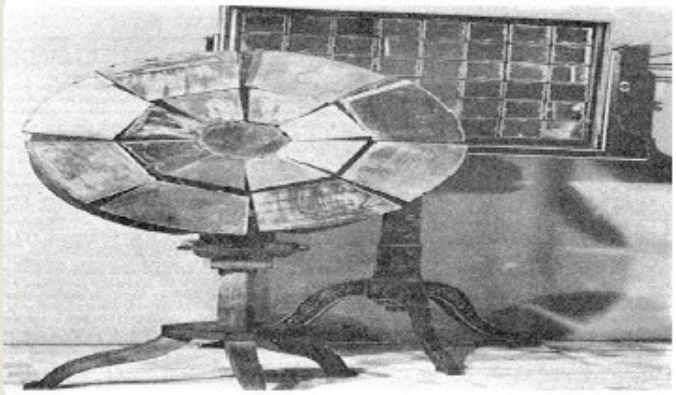



Passive solar energy use in Greek homes.

7th Century B.C.

Magnifying glass used to concentrate sun's rays to make fire and to burn ants.

3rd Century B.C.



Greeks and Romans use burning mirrors to light torches for religious purposes.

## 2nd Century B.C.

As early as 212 BC, the Greek scientist, Archimedes, used the reflective Properties of bronze shields to focus sunlight and to set fire to wooden ships from the Roman Empire which were besieging Syracuse.

## 20 A.D.

Chinese document use of burning mirrors to light torches for religious purposes.

## 1st to 4th Century A.D.

The famous Roman bathhouses in the first to fourth centuries A.D. had large south facing windows to let in the sun's warmth.

## 1200s A.D.

Ancestors of Pueblo people called Anasazi in North America live in south-facing Cliff dwellings that cap ture the winter sun.

## 13th century

In North America, the ancestors of Pueblo people known as Anasazi build south facing cliff dwellings that capture the warmth of the winter sun.

## 1767

Swiss scientist Horace de Saussure was credited with building the world's first solar collector, later used by Sir John Herschel to cook food during his South Africa expedition in the 1830s.

## 1816

Image : Robert Sterling

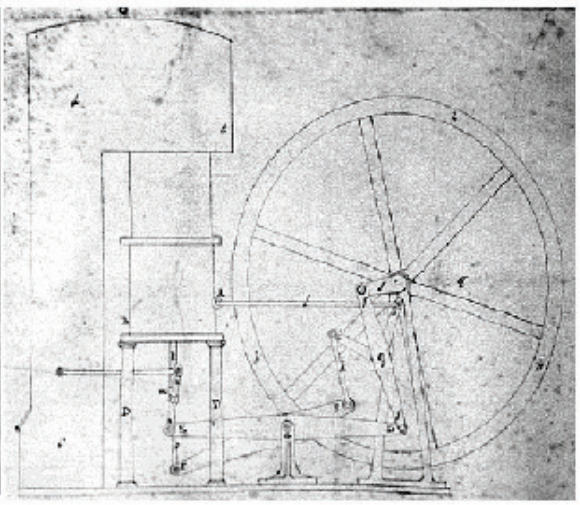


Image: model of Sterling system

Robert Sterling ,built heat engines in his home workshop. This engine was later used in the dish/Sterling system, a solar thermal electric technology that concentrates the sun's thermal energy in order to produce power.

1839

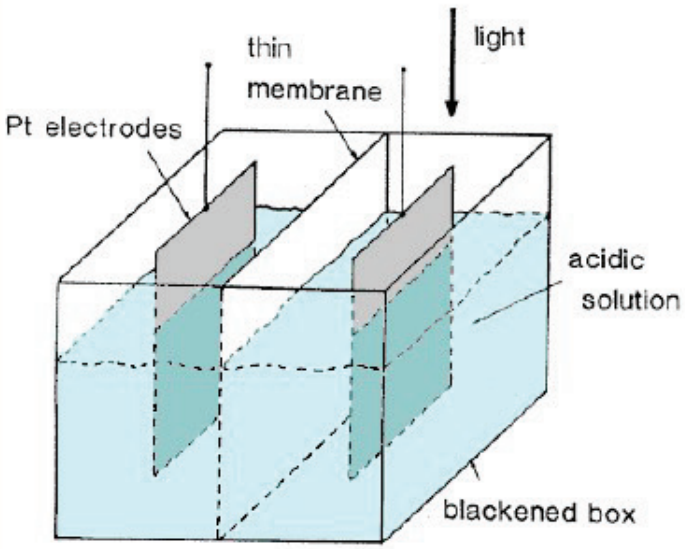



Diagram of apparatus described by Becquerel (1839)

French scientist Edmond Becquerel discovers the photovoltaic effect while experimenting with an electrolytic cell made up of two metal electrodes placed in an electricity-conducting solution

electricity-generation increased when exposed to light

1854

Hermann von Helmholtz calculates that sun is 25 million years old.

1860

John Ericsson of USA did the first realistic application of solar energy using parabolic solar reflector to drive caloric engine on steam boiler.

1873

Willoughby Smith discovered the photoconductivity of selenium.

1876

William Grylls Adams and Richard Evans Day proved that it is possible to convert solar energy into electricity directly, without any moving parts or heat. They found that a photocurrent could be produced in a sample of selenium when contacted by 2 heated platinum contacts.

1878

Augustin Mouchot demonstrated the art of cooking in a solar oven at the World Exhibition in Paris in 1878.

1880

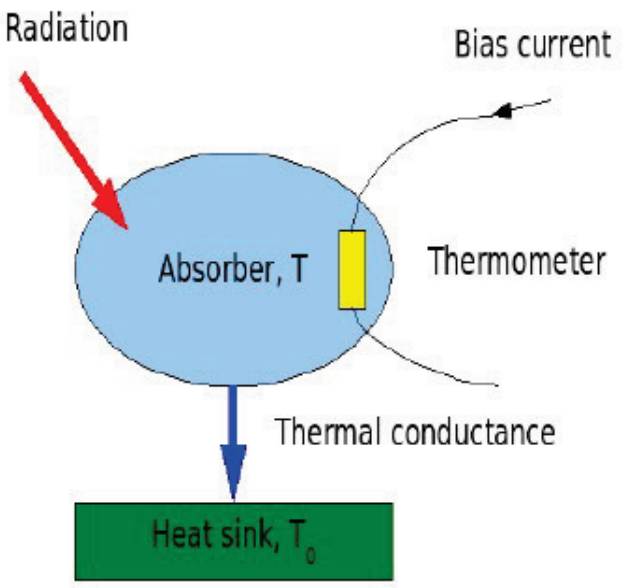



Image shows the basic principle of bolometer .

Samuel Pierpont Langley, invents the bolometer[7].

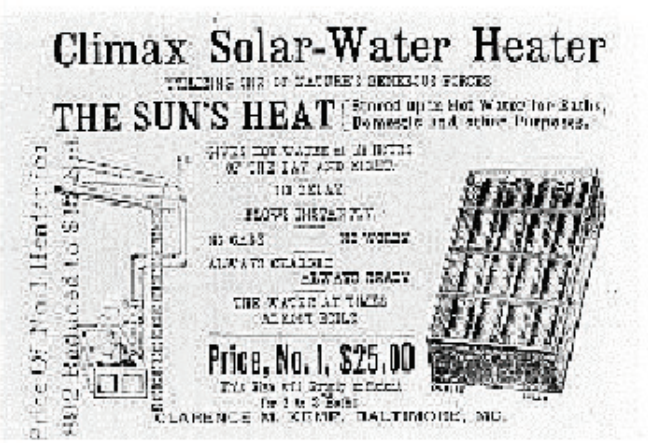
1883

Charles Fritts, given description on the first solar cells prepared by pressing a layer of selenium between gold and other metal.

1887

Heinrich Hertz discovered that ultraviolet light altered the lowest voltage capable of causing a spark to jump between two metal electrodes.

1891




Advertisement for the Climax Solar-Water Heater, the world's first commercial solar water heater, patented in 1891.

Baltimore inventor Clarence Kemp patented the first commercial solar water heater.

7 A bolometer is a device for measuring the energy of incident of electromagnetic radiation. It was first used in telescope to measure infrared radiation.

1904

Albert Einstein published his paper on the photoelectric effect[8].

1904

Wilhelm Ludwig Franz Hallwachs, discovered that a combination of copper and cuprous oxide was photo-sensitive.

1908

William J. Bailey of the Carnegie Steel Company invents a solar collector with copper coils and an insulated box and that became the predecessor of the many latest solar collectors.

1914

Goldman and Brodsky noted that it existed a barrier layer in photovoltaic devices.

1916

Robert Millikan , a physicist provided experimental proof of the photoelectric effect.

1918

Polish scientist Jan Czochralski developed a way to grow single-crystal silicon.

---

8 When radiations with certain minimum frequency strike the surface of a metal, the electrons are ejected from the surface of the metal. This phenomenon is called photoelectric effect and the electrons emitted are called photo-electrons.

Maximum kinetic energy of the ejected electron = absorbed energy – threshold energy

$1/2\ mv_{2max} = hv - hv_0 = hc\ [1/\lambda - 1/\lambda_0]$

Where, $v_0$ and $\lambda_0$ are threshold frequency and threshold wavelength.

Planck'sConstant-> $h = 6.63 \times 10^{-34}$ J s = $4.14 \times 10^{-15}$ eV s

$hc = 1.99 \times 10^{-25}$ J m = 1240 eV nm

W is the Work function

$1/2mv_2$ is the maximum kinetic energy of the ejected electrons.

,

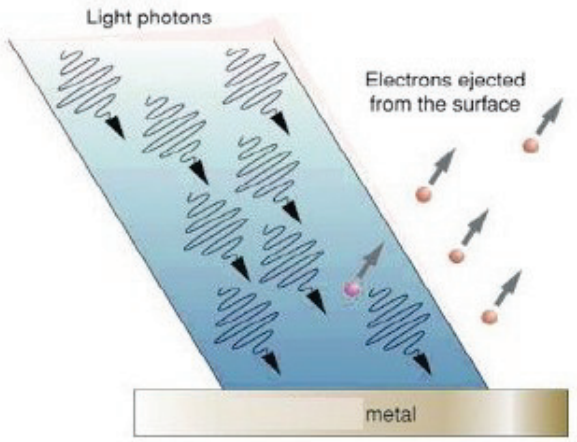
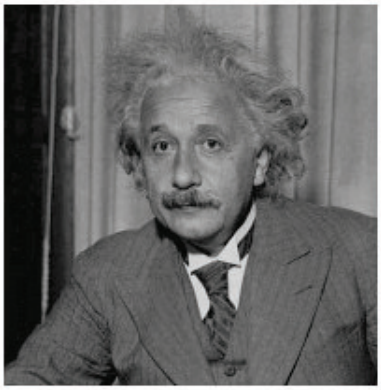



Image : Principle of photoelectric effect

1921



Albert Einstein wins the Nobel Prize for his theories (1904 research and technical paper) explaining the photoelectric effect.

1923

Robert Andrews Millikan receives Nobel Prize for explaining the measurement of the charge on the electron and for his work on the photoelectric effect.

1930s

Most housing in florida is using solar energy to heat the water.

1932

Audobert and Stora discover the photovoltaic effect[9] in cadmium sulfide (CdS).

1940s

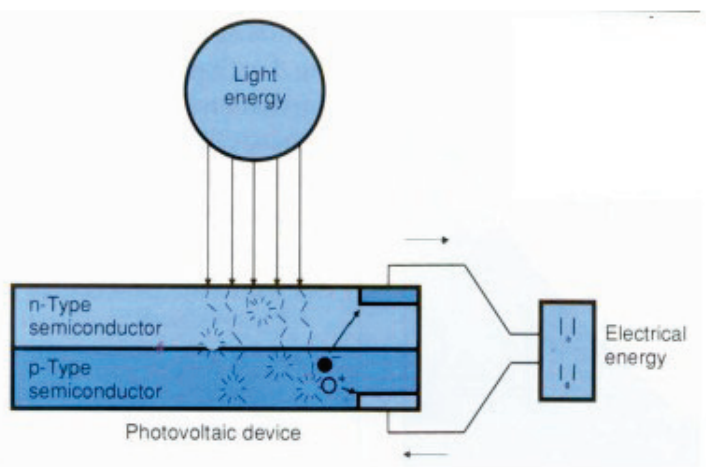
In late 1940's the demand for solar homes became so great that a large number of housing developments across the united states were built with both active and passive solar applications.

1949

Professor Félix Trombe, constructed the world's first solar furnace in Mont-Louis, France.

1954

Daryl Chapin, Calvin Fuller, and Gerald Pearson invented silicon solar cell[10].




9 The photovoltaic effect is the physical process through which a PV cell converts sunlight into electricity . When photons strike a PV cell, they may be reflected or absorbed, or they may pass right through. The absorbed photons generate electricity.

10 A solar cell is a solid state device that converts the energy of sun-light directly into electricity by the photovoltaic effect.

1955

First commercial solar building, built by mechanical engineers Frank Bridgers and Don Paxton at 213 Truman N.E. in Albuquerque, New Mexico.

Image— First commercial solar building , New Mexico , USA.

1957

Hoffman Electronics achieved 8% efficient photovoltaic cells.

1958

T. Mandelkorn, U.S. Signal Corps Laboratories, fabricates n-on-p silicon photovoltaic cells (critically important for space cells; more resistant to radiation).

1958

Vanguard—I was the first satellite to be powered by solar power.

1959

On August 7, the Explorer VI satellite is launched with a photovoltaic array of 9600 cells (1 cm x 2 cm each). Then, on October 13, the Explorer VII satellite is launched.

1962

Bell Telephone Laboratories launches the first telecommunications satellite, the Telstar11(initial power 14 watts).

11 Telstar is the communication satellite which is powered by solar cells.

1963

Japan installs a 242watt, photovoltaic array on a lighthouse, the world's largest array at that time.

1964

NASA launches the first Nimbus spacecraft—a satellite powered by a 470-watt photovoltaic array.

Image by NASA

1965

Peter Edward Glaser conceives the idea of the satellite solar power station.

1966

NASA launches the first Orbiting Astronomical Observatory, powered by a 1-kilowatt photovoltaic array, to provide astronomical data in the ultraviolet and X-ray wavelengths filtered out by the earth's atmosphere.

1967

April 23rd , 1967—Soviet space program launched SOYUZ –1 spacecraft , Which is a first manned space craft and also it is powered by solar cells.

1967

The 1967 Arab-Israeli War produced a short-term resolution to Israel's fuel dependency, as Israel conquered several Egyptian oil fields, but with the return of Sinai as part of the Camp David Accords the need for more restrained fuel use resurfaced. To encourage energy efficiency, the Israeli government passed a law requiring installation of solar water heaters in newly constructed buildings. The requirement was successful. Today, 85% of Israel's 1,650,000 households use solar water heaters.

1970

Image : Solar furnace at Odeillo , France

The world's largest solar furnace 1000 kW ,constructed in Odeillo, France . This is an 8 story building.

1970s

Dr. Elliot Berman, with help from Exxon Corporation, designs a significantly less costly solar cell, bringing price down from $100 a watt to $20 a watt.

1972

The French install a cadmium sulfide (CdS) photovoltaic system to operate an educational television at a village school in Niger.

1972

The Institute of Energy Conversion is established at the University of Delaware to perform research and development on thin-film photovoltaic (PV) and solar thermal systems, becoming the world's first laboratory dedicated to PV research and development.

1973

The University of Delaware builds "Solar One," a PV/thermal hybrid system.

1976

The NASA Lewis Research Center starts installing 83 photovoltaic power systems on every continent except Australia. These systems provide such diverse applications as vaccine refrigeration, room lighting, medical clinic lighting, telecommunications, water pumping, grain milling, and classroom television. The Center completed the project in 1995, working on it from 1976-1985 and then again from 1992-1995.

1977

The U.S. Department of Energy launches the Solar Energy Research Institute todays ,—National Renewable Energy Laboratory‖, a federal facility dedicated to finding and improving ways to harness and use energy from the sun.

1978

1978 NASA's Lewis Research Center dedicates a 3.5-kilowatt photovoltaic (PV) system it installed on the Papago Indian Reservation located in southern Arizona—the world's first village PV system. The system is used to provide for water pumping and residential electricity in 15 homes until 1983, when grid power reached the village. The PV system was then dedicated to pumping water from a community well.

1980

ARCO Solar becomes the first company to produce more than 1 megawatt of photovoltaic modules in one year.

1980

University of Delaware, the first thin-film solar cell exceeds 10% efficiency; it's made of copper sulfide and cadmium sulfide.

1981

Paul MacCready builds the first solar-powered aircraft—the Solar Challenger—and flies it from France to England across the English Channel. The aircraft had over 16,000 solar cells mounted on its wings, which produced 3,000 watts of power.

Image : Solar Challenger

## 1982

Image: Solar Car

In 1981 Hans Tholstrup and Larry Perkins built a solar powered racecar. In 1982, the pair became the first to across a state in a solar car[12], from Perth to Sydney, Australia in 20 days. Tholstrup was the creator of the World Solar Challenge[13] in Australia.

12 The first solar car invented was a tiny 15-inch vehicle created by William G. Cobb of General Motors. Called the Sunmobile, Cobb showcased the first solar car at the Chicago Powerama convention on August 31, 1955 .

13 The World Solar Challenge is a solar-powered car race which covers 3021 km (1,877 miles) through the Australian Outback, from Darwin toAdelaide.

1983

ARCO Solar dedicates a 6-megawatt photovoltaic substation in central California. The 120-acre, unmanned facility , supplies Pacific Gas & Electric Company's utility grid with enough power for up to 2,500 homes

1984

The Sacramento Municipal Utility District commissions its first 1-megawatt photovoltaic electricity generating facility.

1985

Researchers at the University of South Wales break the 20% efficiency barrier for silicon solar cells under 1-sun conditions.

1986

The world's largest solar thermal facility is commissioned in Kramer Junction, California. The solar field contains rows of mirrors that concentrate the sun's energy onto a system of pipes circulating a heat transfer fluid. The heat transfer fluid is used to produce steam, which powers a conventional turbine to generate.

1986

ARCO Solar releases the G-4000 — the world's first commercial thin-film module.

1988

Dr. Alvin Marks receives patents for two solar power technologies: Lepcon[14] and Lumeloid[15].

1991

President George Bush announces that the U.S. Department of Energy's ―Solar Energy Research Institute‖ has been designated the ―National Renewable Energy Laboratory‖.

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14 Lepcon consists of glass panels covered with millions of aluminum or copper strips, each less than a thousandth of a millimeter wide. As sunlight hits the metal strips, light energy is transferred to electrons in the metal, which escape at one end in the form of electricity.

15 Lumeloid is similar but substitutes cheaper, film-like sheets of plastic for the glass panels and covers the plastic with conductive polymers.

1992

Researchers at the University of South Florida develop a 15.9% efficient thin-film photovoltaic cell made of cadmium telluride, breaking the 15% barrier in this technology.

1993

Pacific Gas & Electric installs the first grid-supported photovoltaic system in Kerman, California. The 500-kilowatt system is the first "distributed power" PV installation.

1994

The National Renewable Energy Laboratory develops a solar cell made of gallium indium phosphide and gallium arsenide; it's the first one of its kind to exceed 30% conversion efficiency.

1996

Image: Icare , a solar powered airplane

The world's most advanced solar-powered airplane, the Icare, flies over Germany.

1996

The U.S. Department of Energy and an industry consortium begin operating Solar Two — an upgrade of the Solar One.

1997

In 1997, CSR[16] completed its first major RE project in Auroville[17], installing a 36.3 kWp solar PV power plant. Built in a record 29 days, it was one of the first of its kind in India.

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16 CSR—Center for scientific research.

17 Auroville , Auroville Universal Township, founded on a vision for human unity, has been growing into a place of peace and stewardship since its beginnings in 1968. Located 10 km North of Pondicherry and 160 km South of Chennai, in the South Indian State of Tamil Nadu.

1998


Image shows Pathfinder , by NASA

On August 6, a remote-controlled solar-powered aircraft, "Pathfinder," sets an altitude record of 80,000 feet on its 39th consecutive flight in Monrovia, California — higher than any propeller-driven aircraft to date.

1998

Subhendu Guha, a scientist noted for pioneering work in amorphous silicon, leads the invention of flexible solar shingles[18], a roofing material and state-of-the-art technology for converting sunlight to electricity on buildings.

1999

4 Time Square in New York City completed its construction in 1999, The building has used BIPV[19] panels from 37th floor to 43rd floor.

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18 Solar shingles are photovoltaic cells, capturing sunlight and transforming it into energy.

19 BIPV—Building Integrated Photovoltaic Panels , is a type of solar electric panel that uses silicon as a semiconductor and acts like a part of your roof. They're also known as solar roof shingles. BIPV can be done on new or existing roofs.

1999

Spectrolab, Inc. and the National Renewable Energy Laboratory develop a photovoltaic solar cell that converts 32.3 percent of the sunlight that hits it into electricity.

1999

Cumulative worldwide installed photovoltaic capacity reaches 1000 megawatts.

2000

Solar Industry researchers develop a new inverter[20] for solar electric systems, that increases safety during power outages.

2000

The 12-kilowatt solar electric system of a Morrison, Colorado, family is the largest residential installation in the United States to be registered with the U.S. Department of Energy's Million Solar Roofs program.

2000

CSR embarked on another major demonstration project, the Solar Bowl, installed at Auroville's collective kitchen, the Solar Kitchen.

2000

At the International Space Station, astronauts begin installing solar panels on what will be the largest solar power array deployed in space. Each wing of the array consists of 32,800 solar cells.

2000

Morrison , Colorado is the largest residential family to be registered in Million solar roof program with US department of energy. The program has provided electricity for 8 homes each 6,000sqfoot. The total installation is 12kw.

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20 Inverter : The inverter converts direct current ( DC) to Alternating Current. This is standard for household wiring and also same for power lines to homes.

2001

NASDA[21] announces plans to develop a satellite based solar power system , that beams energy back to earth.

2002

Two Tests of a solar powered remote controlled aircraft called pathfinder plus were conducted successfully.

2002

Rail yard in Nebraska has installed 350 blue signal rail yard lanterns, which has energy saving light emitting diode technology.

2003

STMicroelectronis , a major European chip maker said it has discovered new ways to produce solar cells which will generate electricity twenty times cheaper than most of the today's solar panels.

2004

A team of Scientists in University of South Wales , Australia has developed a new way to produce of energy , ―solar hydrogen process‖ which produces energy from water. Using special titanium oxide ceramics that harvest sunlight and split water to produce hydrogen fuel.

2005

NJIT university, has installed a 50kw solar power on the roof of its campus , It has installs an array of 160 panels on its roof.

2006

Major in this year is, it is the year of IPO[21] boom in solar industry. It is the beginning of many serious financial resources coming into this industry, which has allowed the industry to continue its work and growth.

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21 IPO : Initial Public Offering.

2007

Boeing Spectrolab and National Renewable energy Laboratory has developed HEMM[22] solar cell , which achieves highest efficiency in photovoltaic device to date. The HEMM solar cell broke the 40% efficiency barrier.

2009

July 2009, India Unveils a US $19billion , to produce 20GW solar power by 2020.

2010

Nano-pillars were developed by LBNL[23] with 99% light absorption.

And many more inventions and development currently going on .. In all developed and most of the developing countries. In future much more interesting invention and developments are to be seen……

According to my view, on of the theme in the developing countries should be get awareness in the public and in the investors. Solar energy is environment friendly.

There is a huge scope of growing market in developing countries like India , Brazil , countries in Africa continent etc .. for the power producing technologies. Number of projects have already initiated and currently being developed.

In addition to main power companies, independent power producers are in the early stages of design and development for potential parabolic trough power projects in India , Greece , Spain and many more countries around the world. If these handled projects went success , it could open door for many more additional projects opportunities in other developing countries.

In the following context you can see the solar maps of some of the developing countries , estimated and created by NERL.

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22 HEMM: High efficiency Metamorphic Multi junction

23 LBNL: Lawrence Berkeley National Laboratory

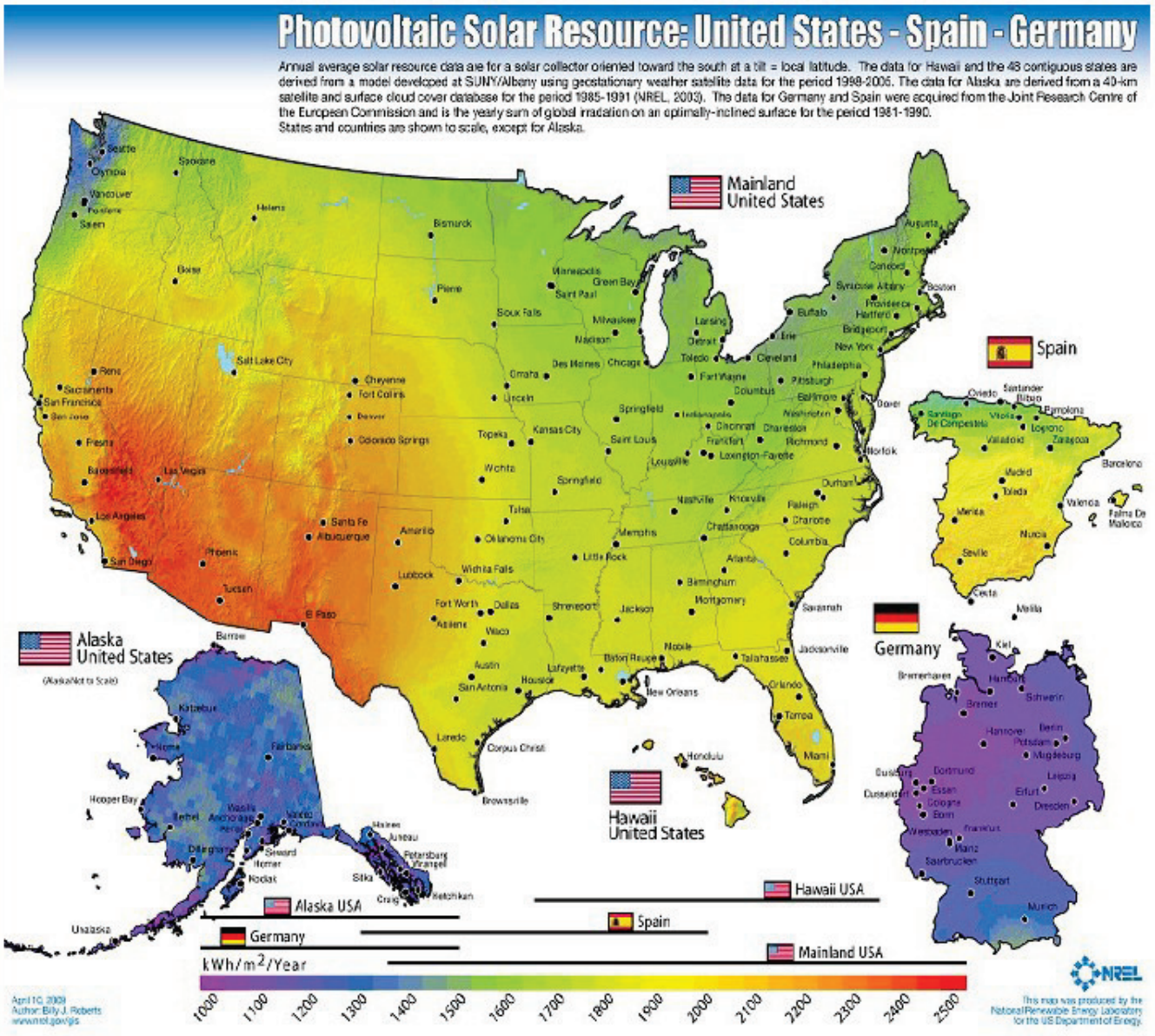
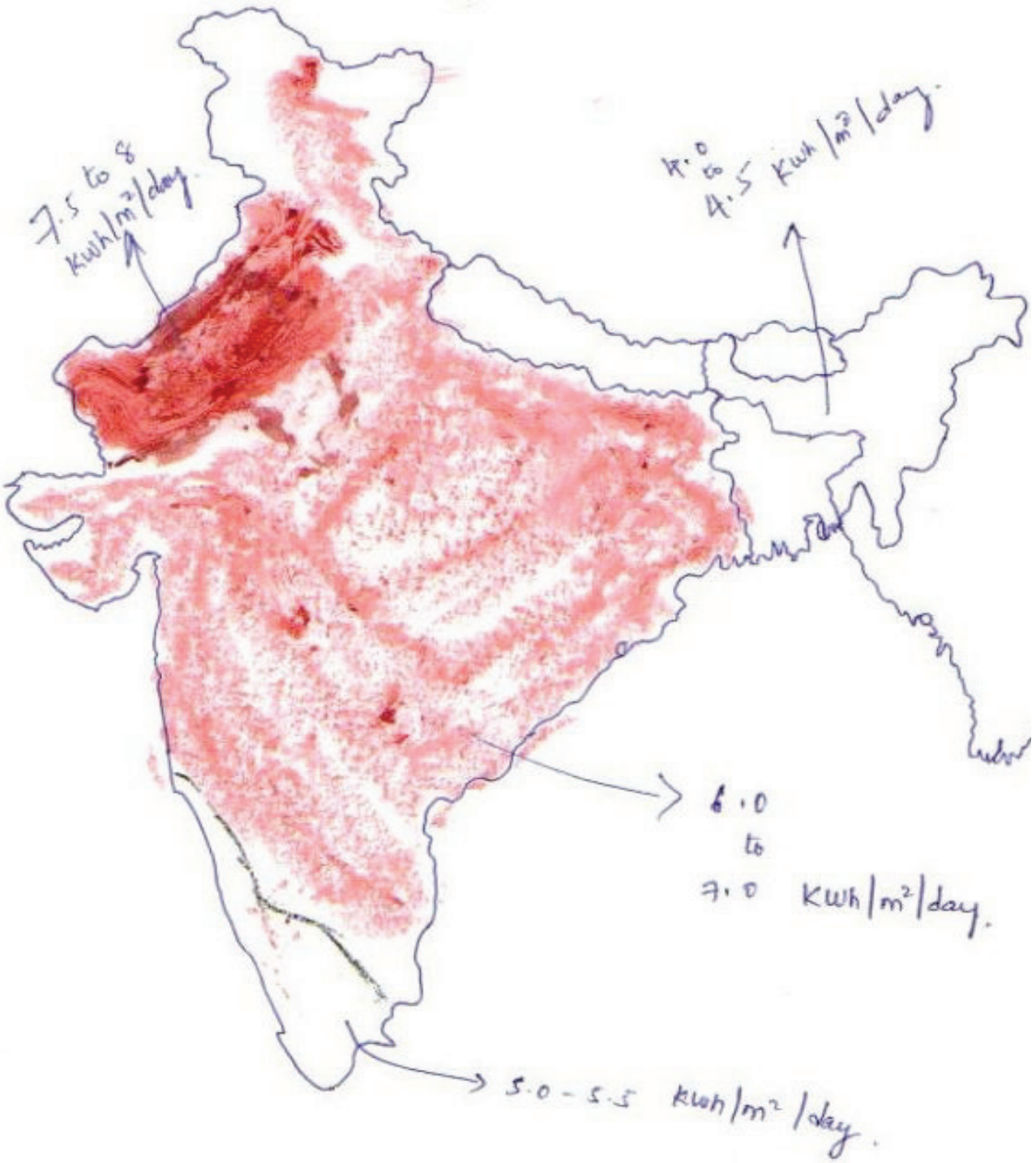



Image by NREL

# INDIA SOLAR RESOURCE.



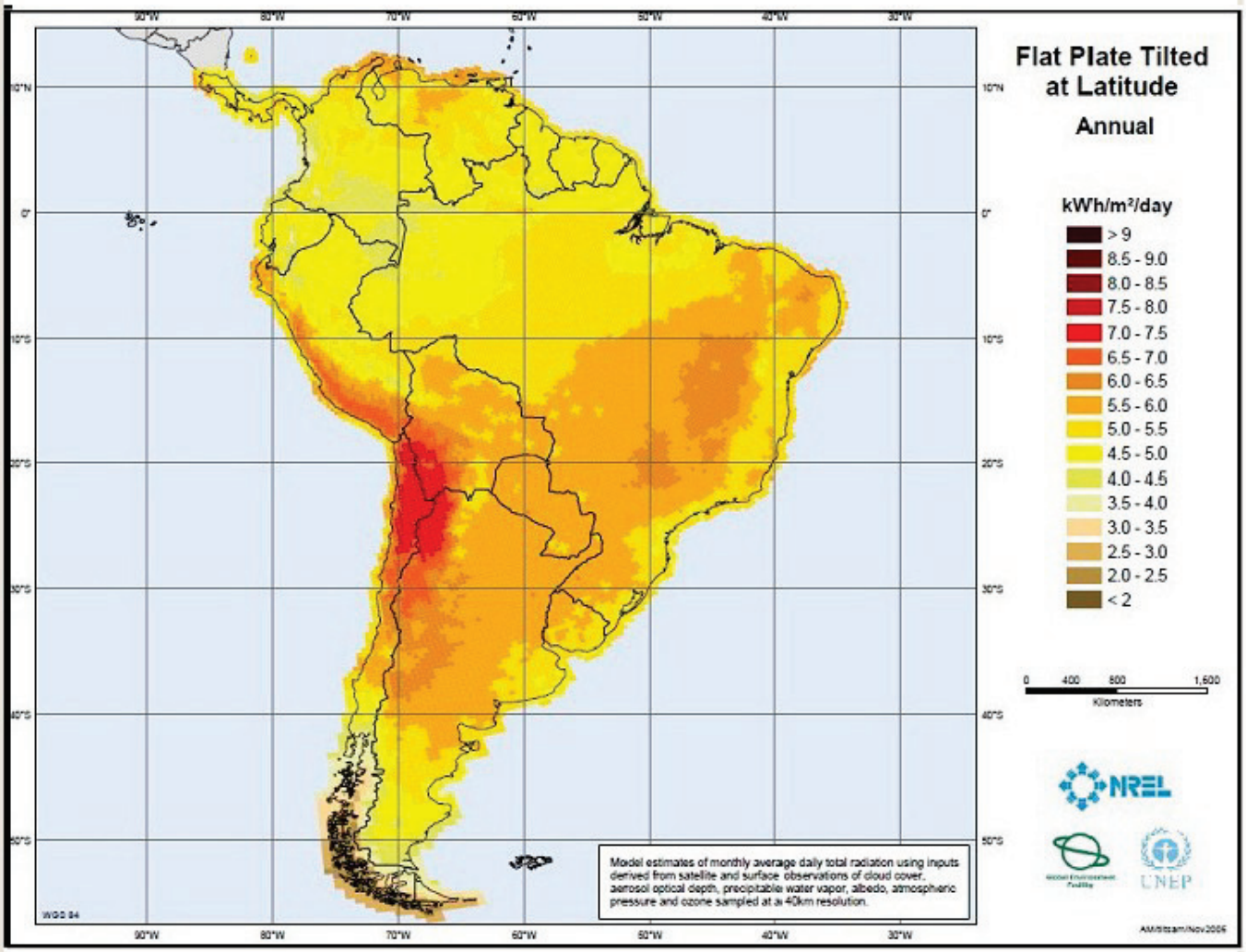



Image by NREL : South America

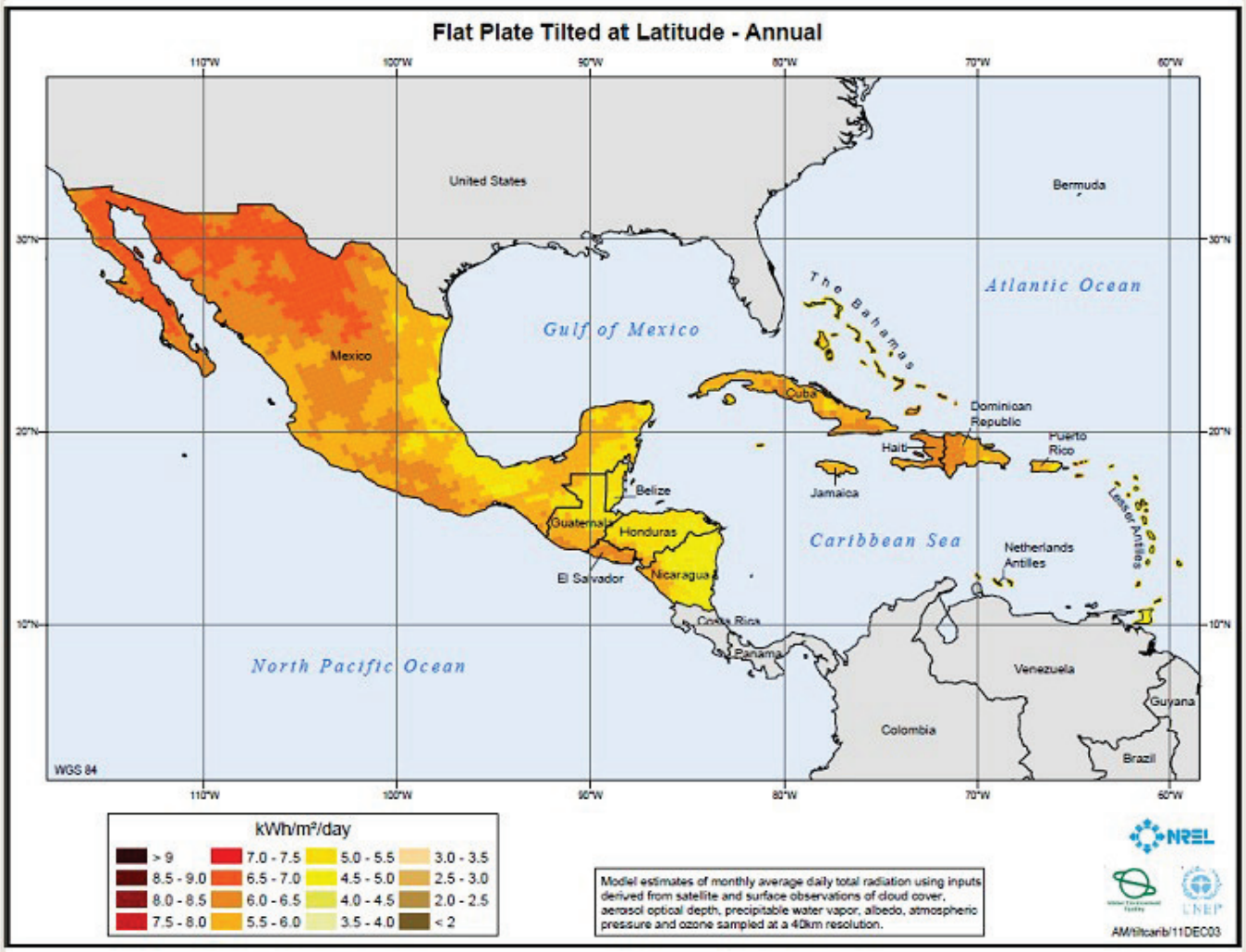



Image by NREL : Mexico

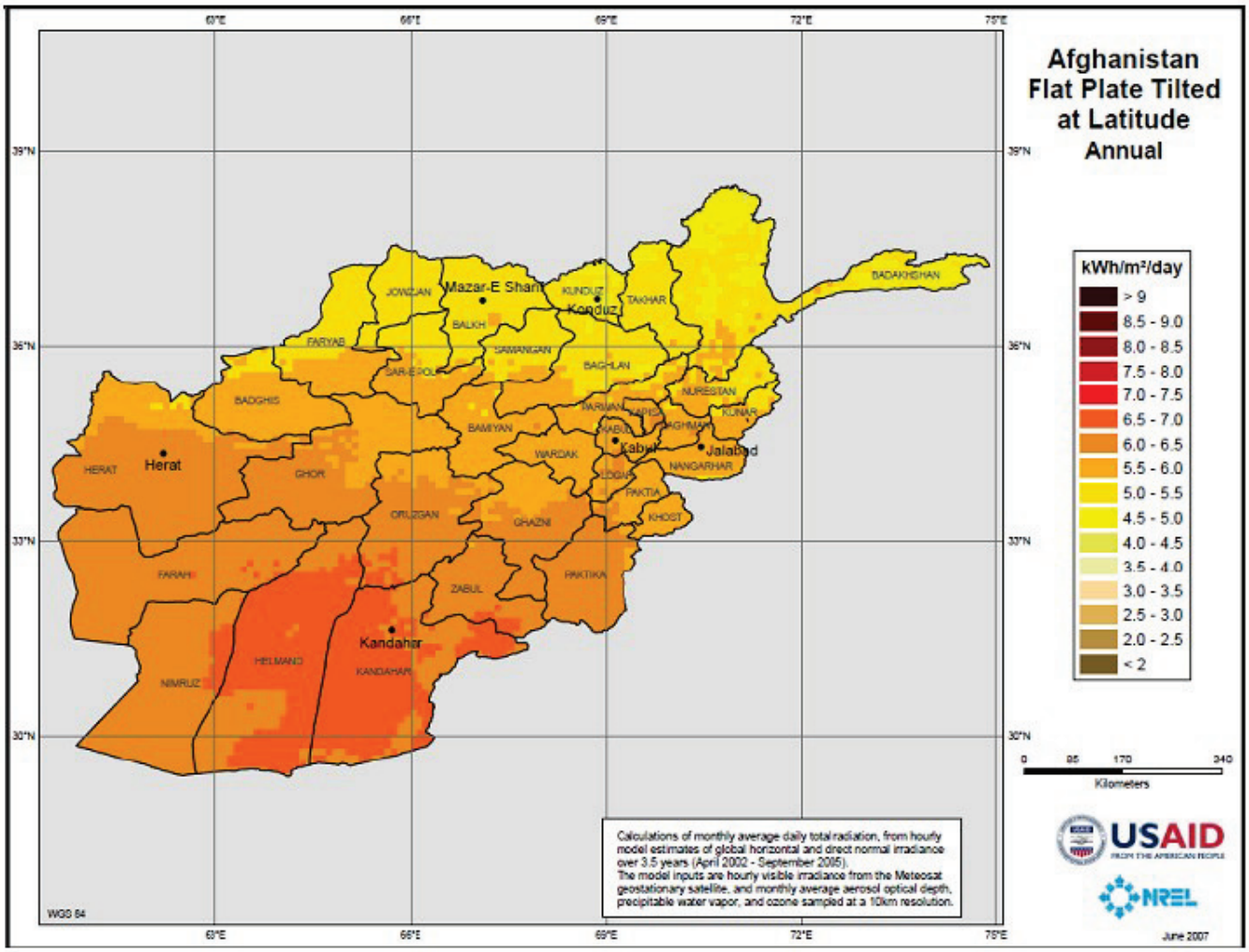



Image by NREL : country-Afghanistan

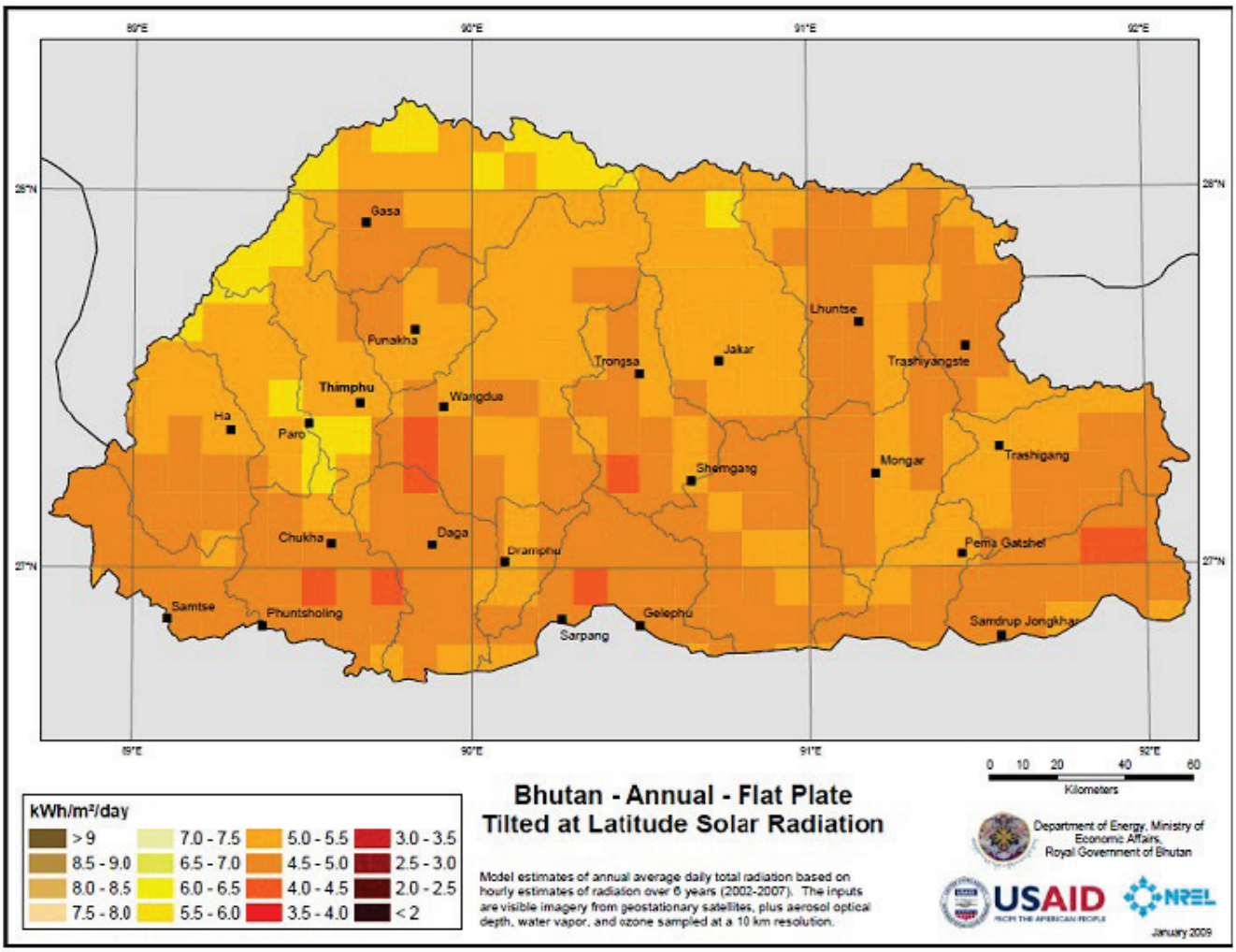
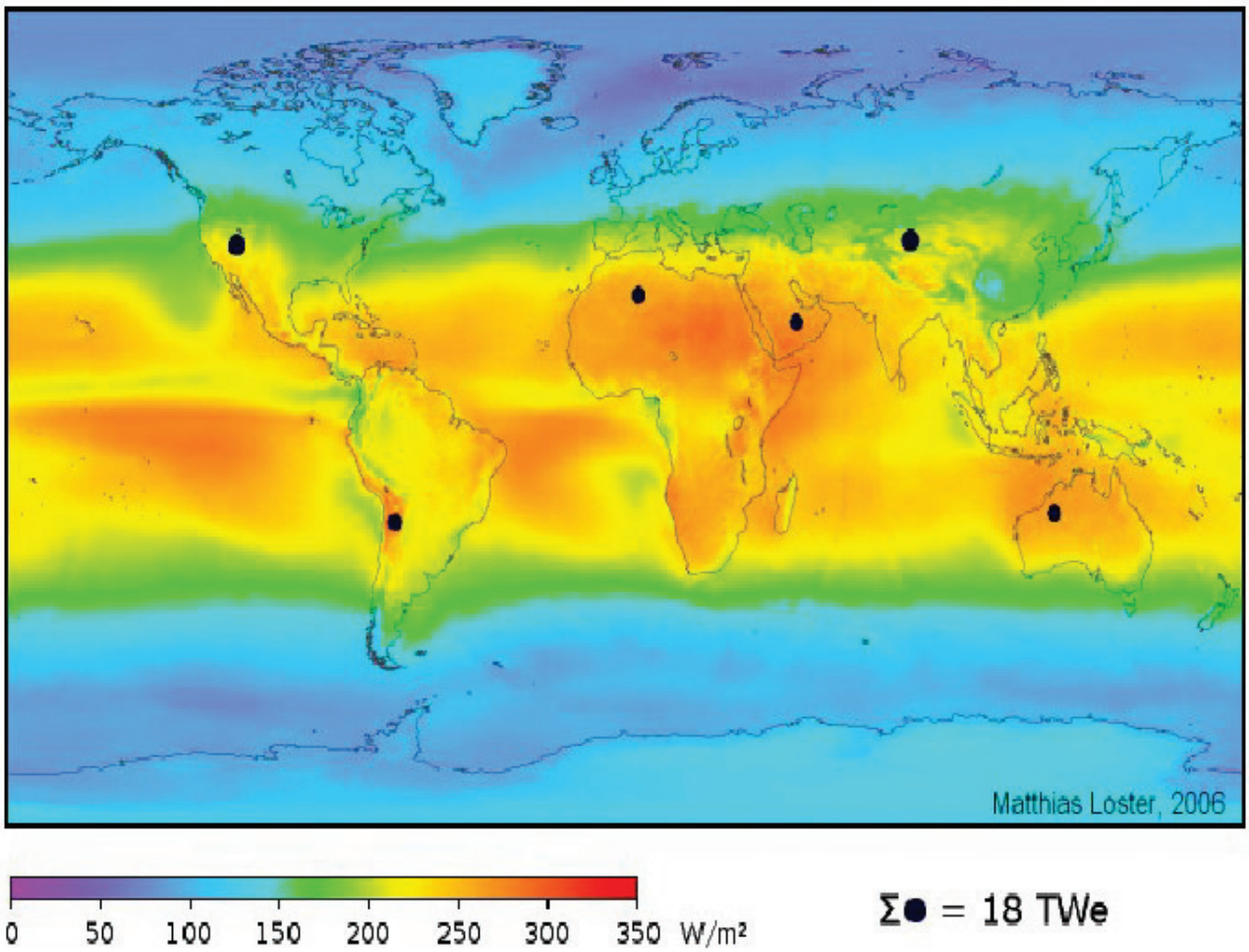



Image by NREL , Country –Bhutan




Source by Wikipedia , world map –solar land area

In my view,

Prospective ways to improve the efficiency of the solar energy are:

1) Photons enhanced thermionic emission could double efficiency of solar cells.

2) Combining 2 or more non-conventional energy sources with solar may be improved the output efficiency.

3) Increase the velocity of the captured electrons in the tube after the sunlight hits the solar panels.

4) Can add a concentrator to the solar panels which helps increasing the amount of light the solar panel absorbs.

**Conclusion:**

Implementation of Latest technologies to develop the efficient solar energy requires involvement of both the political and economic players. Large outgoing research technologies effort aims to overcome these barriers. All the technologies faces the challenges related to the steps involved in the conversion of photon energy into electricity; photon absorption , charge carrier generation , charge separation , and charge transport. Both fundamental research and technical development are critical requirements for these technologies to become more efficient , stable , and reliable. Solar energy had the large potential and is going to be one of the main source of energy in the future which is environment friendly , but technologies advances and break through are necessary to overcome low conversion efficiency and make the power available to common man for the affordable cost.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