An Example of the Importance of Reason and Science:

WHO SUCCEEDED CONVERTING SUNLIGHT TO ELECTRICITY?

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How did french Alexandre Edmond Becquerel's invention, which began in 1839,when he was just 19 years old, begin with his first observationin his father's physicslaboratory?

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The sun has been radiating its massive energy for billions of years, and it is estimated that it will last 'about 4 billion years'. In the 1700s, when they asked Newton, the world-renowned physicist – how does sunlight appear in the sun, how do you explain the source of light in physics?" **He said: I do not know, it is the work of God !!** Today, we know that the sun's rays formed during the fusion of light atomic nuclei in the sun, such as hydrogen, deuterium, tritium, helium, under very high temperature and pressure as a result of what we call FUSION.
The slight use of solar energy by humans is not new, but begins with people wandering the earth. Their proper use of solar energy goes back to 7th Century B.C. People were initially cooking either in places under the sun or with magnifying glasses, mirrors, focusing the sun's rays and lighting fires, and making rooms heated by the sun's rays /1/. In the 3rd century B.C., Greeks and Romans lit sacred torches in religious ceremonies with 'burning mirrors'. The story of The Greek Archimedes, in the 3rd century BC, when the Romans burned a wooden warship with the sun's rays projected through bronze mirrors, and the Roman soldiers were unable to land, is told. Although this cannot be proved to be true, it is afact that the Greek navy burned a wooden test ship in 1970 from a distance of50 meterswith the sun's rays projected in bronze mirrors, indicating that the old story may be true /1/.

When the sun's rays hit a metal surface, it is observed for the first time in the 19th Century that it generates electricity. French physicist Alexandre Edmond Becquerel (1820-1891)was working on batteries in the laboratory of his father Antoine Cesar Becquerel, a professor of physics, and conducting some experiments. In electrolysis experiments, it concludes that the current intensity between the platinum anode and the cathode is slightly greaterinthelight laboratory than in the dark, when light increases the electric currentin electrolysis, when it is only 19 years old. This is later called a photovoltaic event. However, with the wave theory of light or electromagnetic radiation, which until then was known in classical physics, the basis of this event cannot be explained by Becquerel and later researchers. Edmond Becquerel (**) meanwhile finds short wavy purple rays in the sunlight spectrum.

After this observation by A.E.Becquerel in 1839, in 1873, Willoughby Smith found that Selenium was a good photoiletken. Three years later, in 1876, William Grylls Adams and his student Richard Evans Day applied the photovoltaic method to Selenium, provingthat selenium actually increases the electric current in the light. Since it was not clear in those days how the photovoltaic event occurred, Fritts relates to Werner von Siemens, a well-known expert, and Siemens confirms that Fritts' solar cell works through experiments.
Since the basis on which the photovoltaic event is basedis not understood in physics until the early 1900s, there is not much progress in the technology of obtaining electricity from the sun's rays.

Einstein explains in his scientific paper in1905that light consists of cut energy packages (particles, quantas or photons) proportional to its frequency, and when rays hit a metal surface, photons transfer these energies toelectrons,removing them from atoms andreleasing themas a**'photoelectric event'.**

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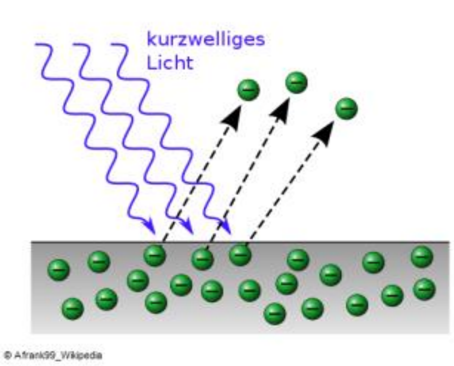
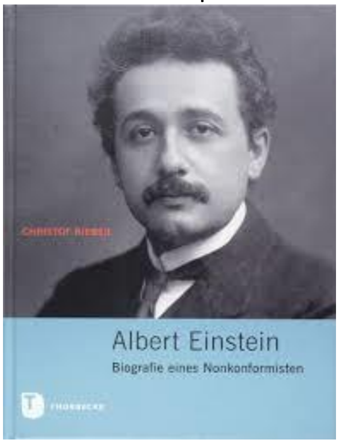
(*) Up to 5 000 trillion kWh (see end   of article forvolume .).
Einstein's explanation was confirmed in1916 by   Rober Millikan of the UnitedStates. Einstein was awardedthe Nobel Prize in1921 not because of the well-known invention of Relativity/ Relativity, but because of this explanation he brought to 'Photoelectric Olay'.
The photovoltaic eventis basically based on the photoelectric event,but there is some difference between them.
In the photoelectric event, electrons that receive energy above a certain threshold of energy depending on the type of conductive material from the sun's rays or electromagnetic radiation are released (when they are not oriented to form an electric current), **in the photovoltaic event,**electrons are directed inside the semiconductor material, thereby converting the energy of the solar rays into electrical energy. Itis also understood why it is not appropriateto use metals in solar cells.

Figure 1 a**:** In the photoelectric event, which is the basis of the photovoltaic event, short wavy light photons remove electrons from the metal surface.

Alexandre Edmond Becquerel



(1820 – 1891)(1879 – 1954)



***Şekil 1** b: Daryl Chapin (1906 – 1995) ve Gerald Pearson (1905 – 1987), Calvin Fuller (1902 – 1994))*
In 1954, they contributed greatly to the development of research in technology that transformed solar energy into direct electricity by performing semiconductor silicon solar cells together (ATT Bell Labs)

Many physicists contribute to the emergence and development of solar cells /1/. A.Edmond Becquerel provides the curtain on the photovoltaic event, while Charles E. Fritts (1850-1903) pioneers the emergence of solarcells. Einstein's aforementioned work then revolutionizes the character of light, enabling the development of photovoltaic technology. In 1941, immediately after the discovery of transist ducks, Russel Ohl made the first solar cell that could be used. In 1954 (Daryl

Chapin, Calvin Fuller and Gerald Pearson),three researchers at the Bell laboratory made solar cells of semiconductor silisium (1,2/.

Where were the first solar cells used?

Photovoltaic solar cells with a diameter of 16 cm were first used on the Vanguard 1 Satellite in 1958, and for 7 yearsthe satellite's data flow to earthwas ensured.

The oil crisis of 1973, the 1979 U.S. Harrisburg TMI and the 1986 Chernobyl nuclear power plant accidents ledto the acceleration of electricity generation from the sun's rays by photovoltaic method, and the development of this technology by allocating large sums of money in thisregard.

With each passing year, electricity generation from the sun's rays by photovoltaic method is increasing all over the world. In 2019, the total installed power of solar power in the world increased to the installed electricpower of 500 GigaWatts or100 large nuclear power plants (sincesolar plants work with a maximum efficiency of20%, the electricity they produce annually is only about 1/5).

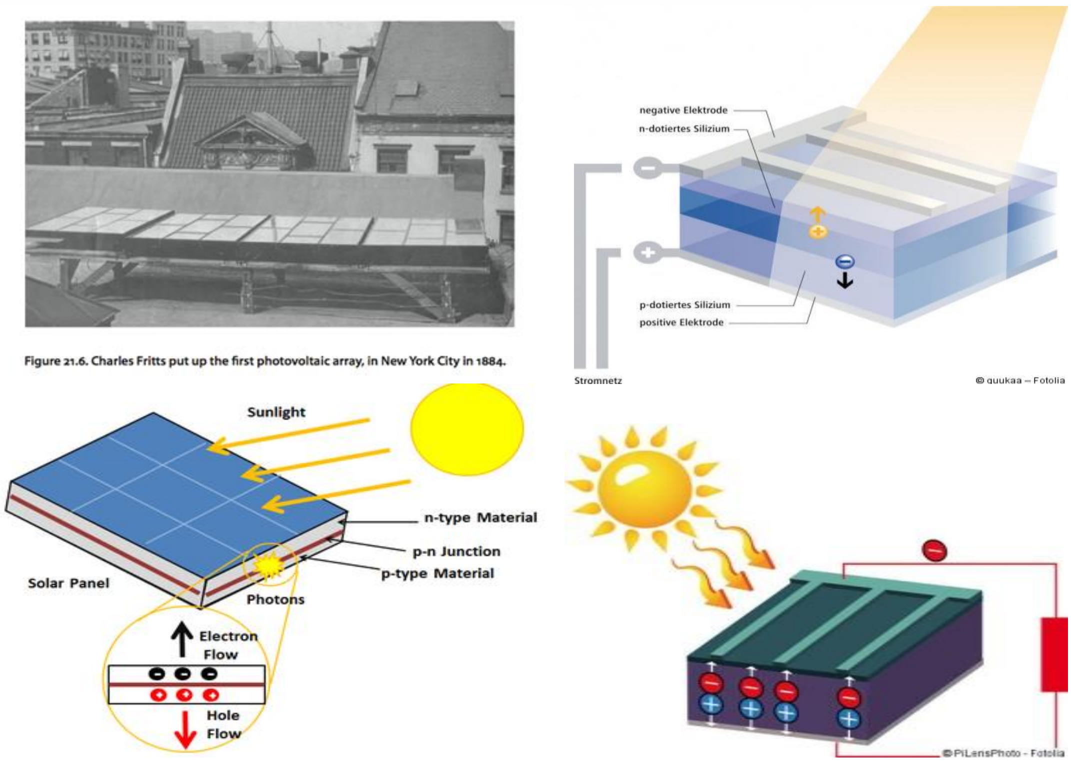


Figure 2: *a. Above left. Charles Frıtts' first photovoltaic panel in New York in 1884,*

Figure 2 *b. Lower left. 9 solar rays that hit a panel with solar cells produce electric current by generating voltage as a result of the electric field between the plus and minus charged Silicon (semiconductor) layers.*

Figure 2 *c. and d. Up* and down the *right: schematic pictures of a semiconductor, for example, a silicon solar panel show the feeding of electric current to the electrical circuit.*

How to obtain electricity from light by photovoltaic method (Figure 2):

1. Light is dropped on top of semiconductor matter ('Silicon solar cell')
2. Electrons in semiconductor atoms absorb some of the energy of ray particles (photons)
3. With the energy they cool, the electrons break off from the atoms and head towards the anode of the semiconductor solar cell.
4. How much the electrical field in the p-n joint of the semiconductordirects the electrons to the collection wire

5. Thus, the electrons transfer electrical energy to the desired place in case of electric current from the wire.

Structure and operation of solar cells (batteries)

More than 90% of the solar cells used in the world today are made of quark sand (silicon). Silicon is the most commonly found substance in the earth's crust. In order to use silica in solar cells, quark sand must first be washed and crystallized. Then it needs to be cut into slices, free of foreign substances and equipped with conductive channels (wires) to transmit the electric current. Single crystalline silicon cells are made of a thoroughly cleaned semiconductor material. Melted silicon is made into rods and then cut into 0.25 mm thick. Thus, the efficiency of the solar cell can be increased from 14% to 16% /3,4/.

When light falls on such a layer of silicon, the electrons are released. In order to direct these electrons and create an electric current, different foreign substances such as Boron and Phosphorus are joined to the upper and lower surfaces of each solar cell, allowing electrons to be collected on one surface and protons on atoms of these foreign substances on the other surface. Thus, as with a battery, plus and minus two poles are created. If the upper and lower faces of the solar cell are connected to one wire (Figure 2b) and a light bulb is inserted, for example, it is seen that the electric current generated by the cell held in the sun's rays lights up the lamp. Solar cells can generate a little bit of electric current even in closed weather. As the intensity of the sun's rays increases, so does the electric current intensity (Amperage) produced by the solar cell. During the very sunny summer months, the electric power of solar cells (Watt= Volt x Current intensity) is also increasing. The voltage of the solar cell is approximately 0.5 Volts, and the current intensity varies according to the size of the cell. A silicon cell usually made of 16 cm x 16 cm produces an average current intensity of 5.5 amps and can reach 2.75 Watts (= 0.5 Volts x 5.5 Amps) of electric power in strong sun. The maximum power of solar plants consisting of solar panels is given at the 'peak' (p), which is the highest value that can be reached in summer. For example, konya Karatay Solar Power Plant has electric power: 18 MWp

Solar plants are usually not close to where electricity will be used. Therefore, in order to reduce cable losses to remote locations, these are planned to have high voltages and lower current intensities. The voltage of each solar cell is approximately 0.5 Volts. For example, a 96-cell panel can provide a potential of up to 50 Volts. For a rough calculation, the electrical power of a paneled panel of 1 m 2 can be up to 200 Watts, since the efficiency of the solar cell is usually taken no more than**20%** and the power of the sun's raysis 1000 Watts /m 2.

When generating electricity by photovoltaic method, their efficiency decreases if the panels get too warm in the summer days. This is because a large number of electrons, which are over-heated in the sun, lower the voltage that will occur. **In the photovoltaic method, it is not the heat energy of the sun, but the frequency of the sun's rays or the energy of the photons.** The most yield is achieved in cool, windy, open or less humid but sunny weather. The wind sweeps away the layer of moisture and hot air accumulated on the panels, making the rays more effective in generating electricity.

Comparison of The Efficiency of Solar Power Plants with other electricalsedentaries

The electricity power of solar plants, given above as MWp, is peak or maximum values that can be reached on the hottest days of the year and cannot be directly compared to the MW power of coal, natural gas and nuclear power plants. For example, the electricity efficiency that a 1000 MWp solar power plant can produce per year (the ratio of installed electric power to 20%is only 200 MW compared to other plants.

From here, for example, the world's largest solar power plant of 1547 MW
Tengger Desert Solar Park, China – if we calculate the electricity it will generateannually:
1547 MW x 14.8% Yield x 8760 h/year= **2005 GWh.**

However, the coal plant of the samepower:
1547 MW x %60 x 8760 h/y **-8,130 GWh**
Nuclear Power Plant:
1547 x %80 x 8760h/y'l ' **10 840 GWh**

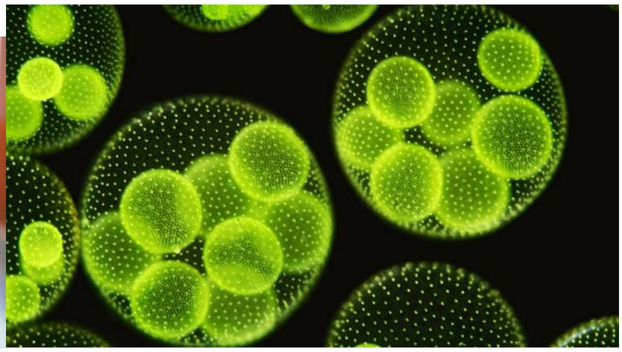
Turkey can provide the most of its electricity from the sun in the future and how many solar plants of **an average of 100 MWp** may **be required** for this **and how much space do they** take **up?** **(Y-scolding y**a**calculatedcalculation)**
Turkey produceda total of 305 TWh of electrical energy in 2018. Up to 2.6% or 7.9 TWh of this was generated from solar energy with a total installed power of 5 000 MW (See./9/.
Yieldfrom: 7.9 TWh/ 5 GWx8760h/year= 18%.
Total installed solar power in 2018 ahead (2040?) If it is tripled or added2 times to the one in 2018 :2 x 5 000 MW= 10 000 MW. This will require 100 100 MW installed power plants and additional electrical power to be produced :10 000 MW x 0.18 x 8 760h/year= 15.77 TWh.

Future electricity generation will be2 times (= 15.77/ 7.9= 2) of solar power generation in2018. Or total productionin solar energy will increase to only 7.8% of total production in 2018 : (7.9 + 15.77) / 305= 7.8%. In addition, since total electricity generation will increase in the future (due topopulation growth, more comfortable and extravagant life), the share of solar power will be reduced further and the share of solar plants with 100 MW (or larger, with a total of 10 000 MW) will be reduced to 5%. In this case, if the share of solar power generation is to be increased in our country, it is clearthat much more solar plants will be needed. In addition, a new electrical network will be required to ensure their smooth operation (maintenance, repair, safety).
In a research study, it is calculated that the total electricity installed power available in 2030 will be 8500 MW and its production will be 12.75 TWh with the addition of 500 MWp installed power eachyear with solar energy /10/.

How much space does it **take for** new **solar plants?**
If 200 Watt solar panels are usedat each plant with 100 MWp installed power : **500 000 panels (= 100** million Watts/ 200 **Watts)** for the **100 MW power plant** and on average **100 watts** for each panel If 4 m2 space is required, **2 Million** m**²** (= **200 Hectares) will** be **required for 500 000 panels** of a **100 MW power plant (1** 400 m x 1 400 m edged square area). For 100 solar plants with a power of 100 MWp, a total area of : 100 x 2 km^2= 200 km**²** or **20 000 Hectares** is required.
Undoubtedly solar plants will be larger and smaller than 100 MWp , but this calculation is an approach for the number of panels required for the additional 15.77 TWh of power generation that can be provided by solar power plants and the space to be installed (**Note:** Each panel is about 2m x 1m. However, an average of 4 m 2 was taken in our above calculations for a panel with distance between panels, cable connections, roads and other facilities. Some businesses even predict 10 m 2 for each panel whenselecting space for the solar plant).

Types and future of solar cells: Generating Electricity from Algae!
Other types of solar cells include multi-crystalline, amorphous silicon, Copper-indium-Gallium (CIGS) –Cell, Gallium Arsenide Solar Cell (GaAS-Cells). Of these, the yield of the amorphous silicon is quite low 8%. Solar cells are also being made with organic matter and some color materials. There is a lot of research on various solar cells.
These include plastic color substances (Graetzel solar cells), genetically modified organic substances and even algae /4-6/. As is known, these impulses convertsunlight, water and CO2 into photosynthesis-rich energy carbon hydrates and oxygen. Today, scientists all over the world are trying to use electricity by photovoltaic method, for example by altering the genes of algae, pulling

some of the electrons used in photosynthesis fromtheplant/6,7/. Biological solar cells, which today have very low yields, are viewed as the electric energy source of the future.

Result
Today, by photovoltaic method, electricity generation from the sun's rays continues to spread all over the world. Although there is a great improvement in this regard in Turkey, as seen from the calculations we have made above, in this way electricity generation will only be able to reach 7.9 + 15.77 = 24 TWh in the future (2040?) even if it is doubled to the present amount, which will be8% of the total electricity production in 2018. Moreover, since the total electricity generation will increase by then, the share of solar energy will be reduced even more. In addition, for the 100 solar plants that can be made new, as we have given in the example above, 200 hectares (2 million m$^{2)}$ each (1400mx1400m) mustbe located in 100 different parts of our country, in a way that does not disturb the nature. On the other hand, this amount ofelectrical energy of 24 TWh in the future will be only half the amount produced by Germany from the sun's rays today.

Note: Considering the recommendations in our previous article on the reduction of harmful chemicals in solar panels, it can be useful to take the necessary measures and we hope that after 25-30 years many parts of our country can be prevented from turning into thousands of old panel dumps /8/.

(*) 1 Watt: Electrical power unit olup indicates 'Energy**transfer speed' (not energy, not**energy!). **Power (W)= Ws/s**
Energy unit: WattsSeconds (Ws) = Power (Watts) x Seconds (s).
1 kWh = 1000 Wh, 1 MWh= 1 Milyon Wh, 1 GWh= 1 Billion Wh, 1 TWh= 1 Trilyon Wh= 1 Billion kWh
For example, it will take 1 billion kWh of energy to burn a 1 billion 100 Watt light bulb for 10 hours.
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(**) Antoine Henri Becquerel, son of Alexandre Edmond Becquelerl, together with Marie and Pierre Curie, explained radioactivity by demonstrating that uranium is radioactive and they were awarded the Nobel Prize for their invention. From grandparents to grandchildren, the Becquerels worked as professors and contributed to science.

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