ET3034Tux - 1.4 – History of solar energy

In this block I will give a quick overview of the development of solar energy technology.

Note, that this overview will be far from complete.

If you are interested in a more detailed overview, I advise you to search on the internet, where you will find many good historic overviews.

As early as the 7th century before Christ, humans have used the first solar technology.

They used magnifying glasses to make fire.

Later, the Romans and Greeks used concentrating mirrors for the same purpose as well.

In the 18th century Horace de Saussure built heat traps, which are a kind of miniature green houses.

He constructed hot boxes, consisting of a glass box, within another bigger glass box, up to even five boxes.

When exposed to direct solar irradiation, the temperature in the inner bottom box rose up to 108 degrees Celsius, warm enough to boil water and cook food.

These boxes can be considered as the world's first solar collectors.

In 1839, the scientist Edmond Becquerel, at an age of 19 years, discovered the photovoltaic effect.

The photovoltaic effect is the generation of voltage or current in a material when exposed to light.

He observed this effect in an electrolytic cell.

The cell was made out of two platinum electrodes, placed in an electrolyte.

An electrolyte is an electrically conducting solution, and in this case he used silver chloride placed in an acidic solution.

By shining light on it, he observed that the current in the cell was enhanced.

In the sixties and seventies of the 19th century the French physicist Augustin Mouchot was developing solar powered steam engines.

He believed that the coal resources were limited.

He developed the first parabolic trough solar collector.

As coal became cheaper, the French government decided that solar energy was too expensive and stopped funding Mouchot's research.

William Grylls Adams and Richard Evans Day demonstrated in 1876 that a junction based on platinum and the semiconductor selenium shows the photovoltaic effect.

However, the performance of the device was too poor.

Seven years later, Charles Fritts managed to make a PV-device based on a gold-selenium junction with a light-to-electricity conversion efficiency of 1%.

In 1887 Hertz discovered the photoelectric effect, which is the effect that some charged objects when exposed to ultraviolet light lose their charge faster.

In 1905 Albert Einstein published a paper in which he explained the photoelectric effect with assuming that light energy is being carried with quantized package of energy.

Nowadays, we call these packages photons, which we will discuss later this week in great detail.

For this paper Einstein received the Nobel Prize in 1921.

In 1918 the Polish scientist Jan Czochralski developed a way to grow single crystal silicon a technique of great importance for the solar cell technology based on c-Si wafers, which has been developed in the second half of the 20th century.

In week 4, we will come back to this processing method.

In 1932 the photovoltaic effect was discovered in the II-VI semiconductor material: cadmium sulfide by Audobert and Stora.

In week 5 we will come back to solar cells based on II-VI materials.

It took up to 1953 for the potential performance of solar cells made of various materials with various band gaps to be estimated.

Dr.

Dan Trivich of the Wayne State University performed theoretical calculations in reference to the solar spectrum.

In week 3 of this course we will come back to such estimations.

The real development of modern photovoltaic devices, as we know them today, started at Bell Labs.

In 1954 Bell Telephone Laboratories produced a silicon solar cell with a light-to-electricity conversion efficiency of 4% , and they later achieved 11%.

In the mid and late fifties various companies and labs among US, Signal Corps Laboratories, RCA Lab and Hoffman Electronics developed silicon based solar cells to power orbiting earth satellites.

From 1958 and in the sixties, the progress in PV technology was driven by the energy demand of space technology.

Various satellites in the series Vanguard, Explorer and Sputnik were launched with PV powered systems on board.

In 1962 Bell Telephone Laboratories launched the first solar powered telecommunications satellite, whereas in 1966 NASA launched the first Orbiting Astronomical Observatory powered by a 1 kW photovoltaic solar array.

In 1968, Professor Giovanni Francia built the first concentrated solar power plant near Genoa in Italy.

The plant was able to produce 1 MW with superheated steam at 100 bar and 500 degrees Celsius.

Note that these pictures do not reflect the plant in Italy.

In 1970 in the USSR Zhores Alferov develops the high-efficiency solar cell based on gallium arsenide heterojunction solar cells.

This is the first demonstrator of a solar cell based on III-V semiconductor materials.

We will discuss this technology in week 5.

At RCA Laboratories, Dave Carlson and Chris Wronski develop in 1976 the first thin-film photovoltaic devices based on amorphous silicon (a-Si).

In 1978 in Japan, SHARP and Tokyo Electronic Applications Laboratory bring the first solar powered calculators on the market.

In the seventies, due to the oil crisis, and the increasing oil prices, the public interest in photovoltaic technology for terrestrial application is increasing.

PV technology is not only a niche technology for space applications anymore.

In the late 70s and 80s many companies start to develop PV modules and systems for terrestrial applications.

In 1980 the first thin-film solar cells based on copper sulfide or cadmium sulfide with conversion efficiencies above 10% were demonstrated at the University of Delaware.

In 1985, at the University of New South Wales in Australia, crystalline silicon (c-Si) solar cells with efficiencies above 20% were demonstrated.

In week 4, the background and current status of high-efficient c-Si PV devices will be discussed.

In 1984 up to 1991 the largest solar thermal energy generating facility in the world was built.

These 9 solar plants built in the Mojave Desert in California, have a combined capacity of 354 MW.

In 1991 the first high-efficiency dye-sensitized solar cell was published by the École Polytechnique Fédérale de Lausanne (EPFL) in Switzerland by Michael Grëtzel and co-workers.

The dye-sensitized solar cell is a kind of photoelectrochemical system, in which a semiconductor material based on molecular sensitizers, is placed between a photoanode and an electrolyte.

We will discuss this technology in week 6.

In 1994, National Renewable Energy Laboratory (NREL) in the US developed the concentrator solar cells, based on III-V semiconductor material.

The cell based on a GaInP/GaAs based two terminal concentrator solar cell exceeded the 30% conversion limit.

The concentrator PV technology will be discussed in weeks 5 and 6.

And at the end of the nineties, the total worldwide installed photovoltaic power reached 1 GW in 1999.

From 2000, solar energy entered the era in which environmental issues and economic issues renewed the public interest in solar energy.

It is the era in which the solar market has transformed from a local market to a global market.

In the new millennium Germany took the lead with their progressive feed-in tariffs policy, leading to a large national solar market and industry.

In 2010, 43% of the worldwide installed PV systems were installed in Germany.

From 2008, the Chinese government has heavily invested in the local solar industry and has become, in a few years, the dominant PV module manufacturer.

In 2012 the worldwide solar energy capacity surpassed the magic barrier of 100 GW installed power.

This is 100 times more than the installed capacity 13 years earlier in 1999.

This means the solar market has been annually growing with on average 40% for the last 13 years.

Since 2008, installed PV power has shown an unprecedented growth, and shows the potential of solar energy to soon become the largest energy source that is not based on fossil fuels.

In the coming weeks it will be my pleasure to introduce you to the energy technology of the future: solar energy.

In this block I have given you a quick journey through the history of solar energy technology.

In the next block we will look at its future.