PHOTOVOLTAIC PRINCIPLE AND ENERGY ACCUMULATION R&D IN THE CZECH REPUBLIC

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Introduction

Photovoltaic technology is one of the most progressive renewable energy source. Its growth and cost reduction potential is huge. All world deserts surfaces coverage at 1% with photovoltaic cells with 15% conversion efficiency will provide more energy than all power plants in the whole world. Photovoltaic system produces clear energy without greenhouse gases and waste emissions.

Solar cells are semiconductor devices that convert sunlight into direct current (DC) electricity. Groups of PV cells are electrically configured into modules and arrays, which can be used to charge batteries, operate motors, and to power any number of electrical loads. With the appropriate power conversion equipment, PV systems can produce alternating current (AC) compatible with any conventional appliances, and operate in parallel with and interconnected to the utility grid.

Principle

A typical silicon PV cell is composed of a thin wafer consisting of an ultra-thin layer of phosphorus-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, called the P-N junction. When sunlight strikes the surface of a PV cell, this electrical field provides momentum and direction to light-stimulated electrons, resulting in a flow of current when the solar cell is connected to an electrical load.

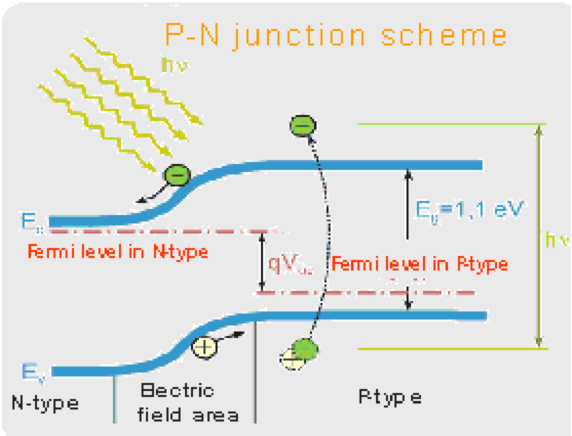

Fig. 1 *PN junction principle scheme.*

Regardless of size, a typical silicon PV cell produces about 0.5 – 0.6 volt DC under open-circuit, no-load conditions. The current (and power) output of a PV cell depends on its efficiency and size (surface area), and is proportional the intensity of sunlight striking the surface of the cell.

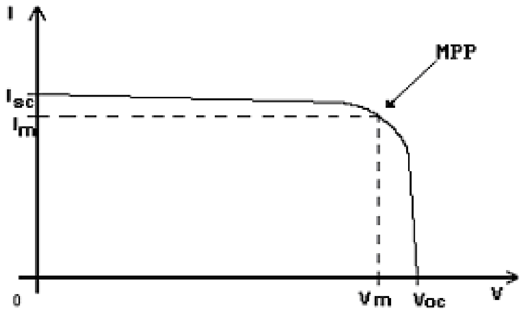

Fig. 2 *PV cell voltage-current curve.*

Spectral resolution

PV cells are not able to convert all incident irradiation into electricity. Every photon is carrier of the small energy quantity. There are a lot of unevenly distributed photons with specific energy in the solar radiation spectrum. Yellow incident light represents much more photons than the red one (see Fig. 3). On horizontal axis is wavelength in µm – if is wavelength shorter, photon energy is better.

Incident radiation at the PV cell must have sufficient energy, so that PV cell can produce energy. For silicon PV cells is minimal photon energy 1,12eV, which matches to approx. 1,1 µm wavelength. Photon energy, which exceeds limits, converts into thermal energy. Therefore, we can theoretically utilize only 50% of the incident radiation, in the PV cell. In industry processes is achieved PV cells efficiency about 15%. In laboratory produced PV cell is achieved efficiency about 30%.

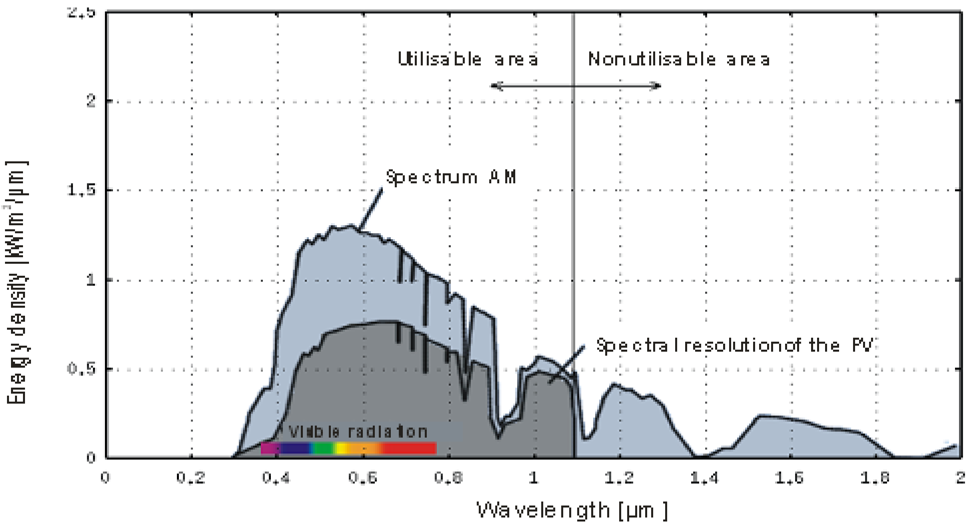

Fig. 3 *PV cell spectral resolution*

Applications

PV systems have a number of merits and unique advantages over conventional power generating technologies. It can be designed for a variety of applications and operational requirements. PV systems are modular, have no moving parts and are easily expandable. You can install PV system almost wherever you wish because is have not any specific demands. The only one requirement is south oriented never shadowed site. So that PV system can be installed on any surface which realizes requirements e.g. building roof, plain area, building façade and many others. PV has got a lot of architectonical friendly variations. You can integrate PV system into buildings, with coloured PV cells application, and make a company logo (see Fig. 4) Colour of the PV cell depends on thickness of the nitride layer (within the range of nanometres – e.g. 80 nm blue, 150 nm gold, 200 nm magenta).

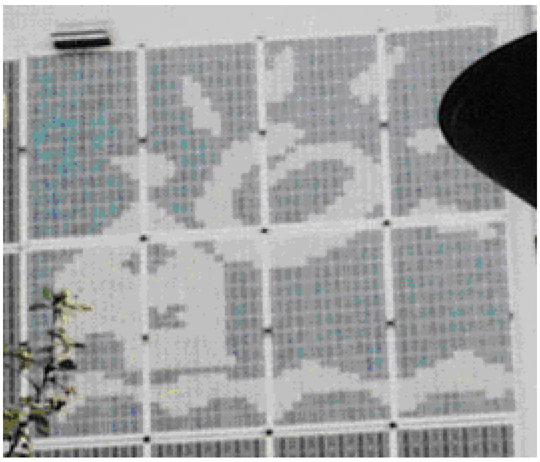

Fig. 4 *Coloured PV logo*

Financing Issue

At present, the high cost of PV modules and equipment (as compared to conventional energy sources) is the primary limiting factor for the technology. Consequently, the economic value of PV systems is realized over many years.
The theory of the learning curve shows that every doubling of photovoltaic output leads to a 20% fall in price. This has also been confirmed in Germany: since 1990 the price of photovoltaic systems has fallen over 60% from EUR 13,500 to about EUR 5,000 today. Between 1999 and 2003, the fall in price was 25% in the 100,000-roofs scheme.

By the August 2005 come into operation Law No. 180/2005 Coll. "Act on Promotion of Use of Renewable Sources)", which regulates, in accordance with the legislation of the European Communities (European Directive No. 2001/77/EC), the method of promoting the production of electricity from renewable energy sources. The most important is Article 6, where you can find order to state RES electricity prices in a way 15 year guarantee of the playback time (PBT).

For PV system was stated price **13,20 CZK/kWh**. This electricity price is almost high enough to reach statutory 15 year PBT. At present PV system prices and for real 15 year PBT is essential increasing of the PV electricity cost min. up to German feed in tariff levels, which takes into account PV system type (façade, building roof, open land) and feed (see Table 1) tariff guarantee is for 20 years.

Table 1 *Feed in tariff in Germany for PV systems installed in 2005:*

Feed-in tariff per kWh	Up to 30 kWp	30-100 kWp	From 100 kWp
On buildings and noise protection walls	54,53c	51,87c	51,30c
Façade integrated	54,58c	51,92c	51,35c
Open land		43,42c	

If you wish to reach PV system acceptable payback time, you need to acquire the financial support. Photovoltaic system financial support is in the Czech Republic quite complicated. There is no direct PV support and you have to find your own subsidy solution. There are three main possibilities:

1) You are individual person – maximum subsidy value is **50 thousands CZK** (with 50% support) from State programme for energy savings support and RES using, Annex II. Programme No. 1.A.

2) You are working in your own business (Enterprise) – maximum support from "Operational Programme Industry and Enterprise 2004-2006" is **46%**. There is a condition about annual 60 tons CO_2 reduction, which means minimal installed power ca. 52 kWp.

3) You are public organisation (school, city, NGO etc.) – maximum support from new Operational Programme of Environmental 2007 – 2013 is **85%**. This is really good way to secure financing of your PV system.

Electrochemical accumulation

Renewable energy sources (wind, photovoltaic) got improper character concerning great power generating changes. While are PV and wind systems operating in small scales there is no problem with utility grid regulation, but in large scales there can be problems with power regulation in the frame of utility grid. As we see, there is no possibility to force RES to produce with continual output power, but if we use an accumulation device, problem is solved. Similar problem are resolving off-grid PV installations, where the accumulation subsystem is very important system part.

At present exist a lot of accumulation types (pumped hydro, electrochemical storage, pumped air storage, flywheel storage etc.). The most flexibility with maintenance less operation disposes electrochemical storage systems. Their lifetime and storage capacity have, if compared with other systems, very good performance ratio. R&D works which handle electrochemical systems are reaching up good results.

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Conclusion

Photovoltaic is relatively new technology which done very big improving progress during its lifetime. Cost comparison with other renewable energy sources is not so good, at this time. Nevertheless, its potential is incredible. PV becomes in the very near future one of the most significant renewable electricity production source. The new cheap technologies will help to achieve better efficiency and significant cost reduction. So, the PV shall become available to wide users spectre.

At present PV electricity prices is necessary to acquire suitable financial subsidy. Without support you can’t obtain 15 year PBT (defined by Act. No. 180/2005 Coll.), but R&D results are promising additional interesting cost reduction in very near future.

Energy accumulation R&D activities in the frame of VaV SN/3/171/05 are running well and we can expect attractive results.

Acknowledgements

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