HYBRID PHOTOVOLTAIC EQUIPMENT IN URBAN AREAS

Ivan KOPECKÝ[1]* – Danka RAKÚSOVÁ - Monika PILKOVÁ[3]

[1] *Dipl. Eng. Ivan Kopecký, PhD., Faculty of Special Technology, Alexander Dubček University of Trenčín, Pri parku, Trenčín 91105, Slovakia*

[2] *Dipl. Eng. Danka Rakúsová, CSc., Faculty of Special Technology, Alexander Dubček University of Trenčín, Pri parku, Trenčín 91105, Slovakia.*

[3] *Dipl. Eng. Monika Pilková. PhD., Faculty of Special Technology, Alexander Dubček University of Trenčín, Pri parku, Trenčín 91105,Slovakia.*

**Corresponding author E-mail address: *[1] ivan.kopecky@tnuni.sk*

Abstract

Decreasing reserves of fossil fuels, an increase of a world-wide population and demands of individuals for energy in the whole world, a deepening dependence of a present civilization on a reliable provision of energy, a threat to biosphere, where a power economy has been created, including transportation as well as unstableness of sources and fuel consumption form an environment, that will significantly differ from a trouble free situation that the citizens of industrial developed countries of the 20th century had got accustomed to when fueling and using the energy.

Key words: Photovoltaic cell, renewable source, energy, solar sensor, power plant.

1Introduction

Current situation and direction of development suggest a probability of irreversible effects on a global economy as well as on global warming.

Demands for energy will permanently grow; they will put a strain on limited reserves of fossil sources of energy being at the same time a raw stock for chemical industry.

In general, the consumption of energy in all its user forms is still rising.

For example, in 2010 the consumption of energy increased in the world by 5, 5 % comparing with consumption before a crisis in 2009. This increasing trend was recorded in all G20 countries. Such increase of consumption of energy has been caused by two decisive facts.

After a decrement in 2009 the economic activities of OECD countries have been retrieved, an energy consumption increased by 6,7% in Japan, in Europe by 4% and in the USA by 3,7%,

Demand for energies has increased in China and India (an increase by more than 6%); China has strengthened its position of the greatest consumer of energy (by 11% more than USA). [1]

The development trends in period from 1993 – 2020 are displayed in the next Fig. 1 (data are in Mtoe - Million Tons of Oil Equivalent).

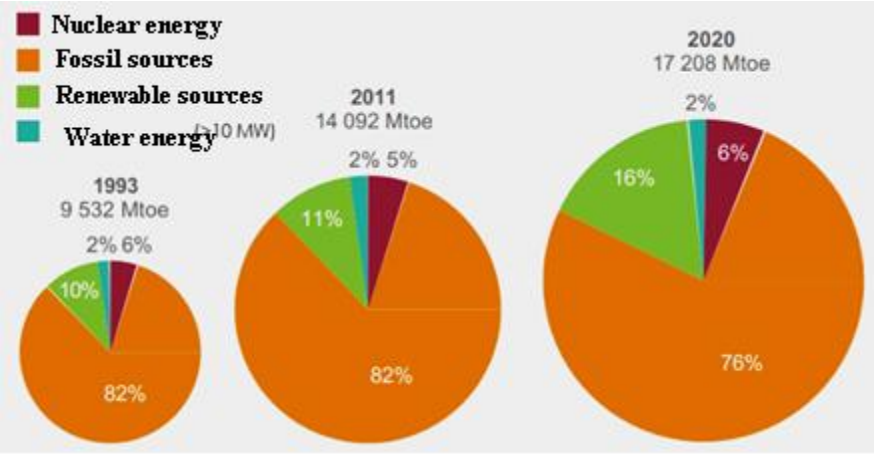

Fig. 1. *A scenario of development of a global energy [2]*

Most of European countries are dependent form import of fossil fuels, even though their power security is very high thanks to a sufficient source diversification and recently also to a transformation of economy towards renewable sources of energy, that bring not only positives but negatives as well.

Development in Slovakia leads in the next years to an increase of power effectiveness, to a more efficient use of renewable sources of energy, to a production decentralization and application of new Technologies in area of scrap material processing.

A political framework will be still affected by the European regulation policy, by removing the inconsequent acts and by limiting a subvention of redemption prices from renewable sources and other technologies that have been proving for a long time, that they have deformed a power environment.

From a technical point of view, the largest problem will be an implementation of smart networks and solution of problems connected with a decentralized production and electro mobility.

Cooperation with foreign countries will be crucial for the Slovak Republic for future especially in area of building a gas interconnection and reinforcement of cross-border pipe lining aiming to increase a power security and competitiveness of an energy market. Slovakia is very vulnerable in this sense, as it was proved by a gas crisis in 2009 year and with regard to a global political situation the issue of power safety has been much more significant. [3]

Even though Slovakia has undertaken to gradually increase the ratio of electricity being produced from renewable sources, it happens only very slowly. The water power plants fall behind due to drought and solar business is inhibited by a government.

The most electricity by us is still produced by nuclear power plants.

Hydrogen is considered as a fuel of future. Also the energy gases (e.g. propane and butane) will be used more. Research of fuel cells and biological transfer of energy using microorganisms for a production of methane and hydrogen is developing promisingly.

A natural priority is a provision of a power security of a country through looking for new sustainable ways of production of electricity, preferably from renewable sources, including unquestionably photovoltaic power equipment. [4]

2 Photovoltaic power equipment

Electric energy obtained by a direct transformation of a solar radiation has been known since the 19th century. Development of photovoltaic applications has been still dependent on a technical level and knowledge first of all in area of semiconductor physics. The photovoltaic systems themselves represent a connection of photovoltaic parts into a chain that is terminated with electric appliances.

The basic element of photovoltaic equipment is a photovoltaic cell. Such cells transfer a solar energy into an electric one. The basic material of a solar cell is silicium in:

- A polycrystalline form,
- Monocrystalline form,
- Amorphous form.

The development of modern technologies has managed to bring an efficiency of a multi-crystalline silicium cells significantly closer to an efficiency of monocrystalline silicium. (effectiveness of particular types of photovoltaic cells is shown in the table:

Table 1 *Effectiveness of particular types of photovoltaic cells*

Type of a solar cell	**Typical effectiveness of cells under common conditions (%)**	**Maximum cell effectiveness measured under common conditions (%)**	**Maximum cell effectiveness measured in laboratory conditions (%)**
Monocrystalline silicium	12 - 16	22	25
Multicrystalline silicium	11 - 14	16	20
Amorphous silicium	5 - 7	10	13
Cadmium telluride	10	12	16

The whole photovoltaic equipment consists of following parts:

- Solar module,
- charging controller,
- batteries (12V, DC),

- voltage inverter (230V, 50Hz, AC),
- appliances,
- mounting supports.

3 Autonomous and hybrid systems

Autonomous systems (or also so called Grid-off systems) are used generally on places, where there are no mains available.

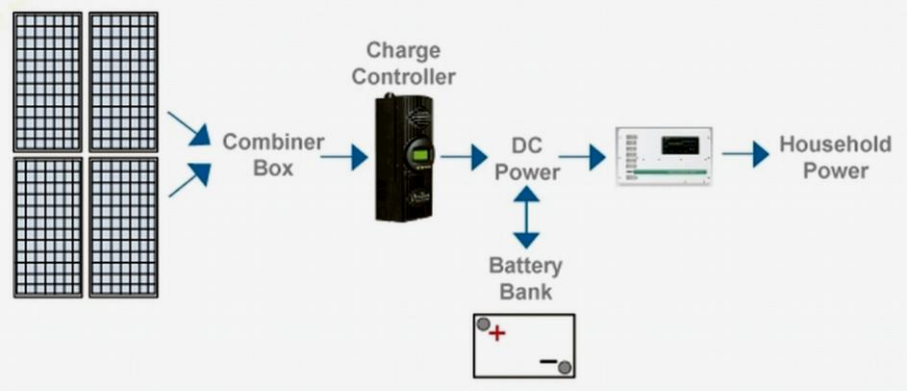

Fig. 2 *Grid-off system flow chart*

Hybrid photovoltaic system is basically a combination of a standard mains power plant (Grid-on) and an insular system (Grid-off).

Advantage of hybrid photovoltaic systems is a maximum use of a produced energy on spot of production, either in a form of an electric energy, or for heating, to heat warm utility water, for air-conditioning, watering, and operation of a swimming pool or other defined appliances, whereby the mains would be provided only needed quantity of energy.

Additional unquestionable advantage of a hybrid photovoltaic system is an already integrated function aiming to use a surplus energy during power peaks, when a smart hybrid converter can redirect a surplus energy in a real time or with a controlled delay into pre-assigned power demanding appliances.

Fig. 3 *Hybrid photovoltaic system*

The systems with an output ranging from 1 – 10 kWp are usually installed on dwelling houses. (kWp is a unit of a peak output of a photovoltaic power plant)

4 The systems connected to mains (Grid-on)

The advantage of Grid-on systems is a fact, that all produced electric energy is processed in contrast to the Grid-off systems. These systems usually consist of a larger amount of photovoltaic modules, voltage invertors, devices for measurement and regulation of mains protection. Connection of photovoltaic systems into mains can be performed in two basic versions. [5]

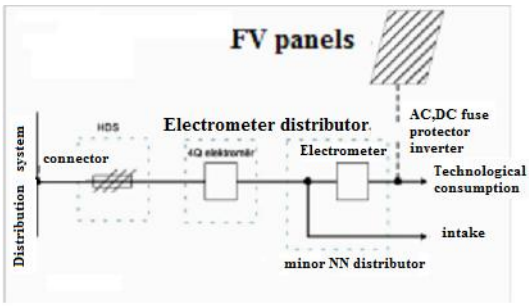

Fig. 4 *System connection for own consumption*

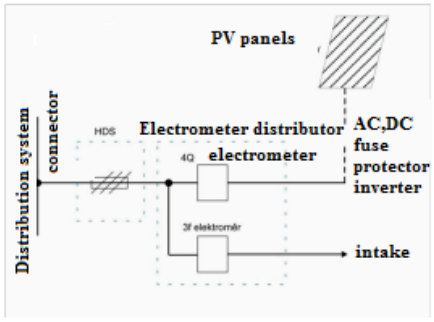

Fig. 5 *System connection for delivery into mains*

5 Hybrid photovoltaic equipment in urban area

Building of photovoltaic power plants is suppressed and use of Grid-off and hybrid systems become a modern trend in provision of electric energy for retail customers. Trend in placing the photovoltaic collectors on suitable areas in urban areas finds more and more applications in practice.

Imagine your future, when you can use Instruments in a household fed by electricity delivered by window blinds. Such future might seems to be by the head and ears, however it is fully feasible.

Alternative energies become more and more important, especially a solar energy that the owners of private and commercial real estates are focused on.

Solar energy is a smart and a fascinating power technology of future. This technology needs no movable parts or high temperatures. Solar rays are led through solar panels that are thin enough and flexible so they can be in such products as window blinds or backpacks or are mounted on a car roof.

There are available two versions in practice:

- systems for public mains supply Fig. 5 ,
- separate solutions Fig. 4.

In the first option, the surplus current is taken away into public mains for remuneration. In separate solutions the electricity is produced for individually supplied week-end houses, floating vessels or camping cars.

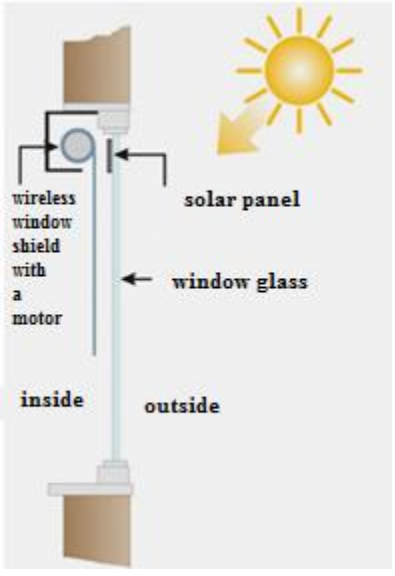

Fig. 6 An example of power effective alternative to drive the window shields with a motor

6 Photovoltaic window blinds (PVVB)

Photovoltaic blinds are identical with common blinds, except for a grid shield, that is covered with photovoltaics – with solar cells.

Horizontal blinds will produce energy also in an open position, in a closed position, or something in between.

Vertical blinds must be oriented towards the sun.

In case we have several windows with photovoltaics, the electricity can be combined from all Windows through a centre for management and distribution of solar PVVB energy. The created direct current will be transformed into an alternating current and outer equipment such mobile phones, printers, lights can be connected to a distribution centre in order to use the energy.

When photovoltaic is mounted, it replaces standard blinds, so the costs for PVVB are partially reimbursed. Additional costs are marginal, as they can be gained back, when the electricity is sold back into public mains. As the solar energy is a renewable source of energy, in case of suitable legal conditions, the claims for tax-relief can be raised.

Fig. 7 *Photovoltaic panels on window*

Fig.8 *Movable blinds with manual control with a motor*

Photovoltaic panels on window blinds are a new limit of a renewable energy in households or offices. A thin and flexible photovoltaics, is able to conform to various shapes and is placed on thin blind listels. The listels can be made of metal or wood with a double set of wires on the sides or through a centre to set a tilting.

Present-day offered blinds are produced so they conform to any decoration and they are so discrete, that in a view from inside they do not differ from standard ones that make them especially suitable for buildings in historical centres, where some architectural restrictions may exist.

They can be mounted either on a single window or outside so they shield a frontal or an inner varnish of a window frame and so to prevent from gathering of dust on the surface. Some of them can be used as a thermal isolation and a protection from thievery.

And suggested output, amount of energy that can be produced? As they are able to adjust their position towards a direction of sun rays, their efficiency is maximal. In particular, the panel used for a medium on blinds is able to produce 0,35 kWh. To be demonstrative, it is amount of energy, needed for an operation of a laptop. [6]

7 Autonomous movable ID2 blinds

The blinds belong to those product delivered to the market by the Bubendorff company. The blinds are equipped with individual radio remote control, ID2 are completely autonomous with an option to control them also through a group remote control.

An output of an autonomous ID2 solar sensor and battery output enable the blinds to provide optimal operation during 15 years.

Autonomous ID2 is made so it works as minimum on 21 000 cycles, it is equal to 60 years of operation, because of an everyday opening and closing cycles.

Movable photovoltaic blinds are the most reliable and durable with a designed battery with a lifelong warranty for 15 years. [7]

Fig. 9 ID 2 autonomous movable blinds operating with solar energy,
100% sun – 100 % independence [8]

An intense growth of a commercial employment of power technologies using renewable sources recently has moved on this power alternative into a centre of economic and political consideration. There is a proposed hybrid set of sources of electric energy, suitable for a large application by combining external mains and a complementing source by a photovoltaic system placed on blinds, on window boards, balconies, loggias of buildings on residential areas, on family houses, on official buildings etc.
The important thing is, that it is one of options how to provide a sufficient amount of energy for future generations with no negative impact on environment.

Acknowledgements
This publication was created in the frame of the project Research of a technological base for draft of application of renewable sources of energy in practice, ITMS code 26220220083, of the Operational Program Research and Development funded from the European Fundof Regional Development.

References:

[1] MASTNÝ, P., DRÁPELA, J., MIŠÁK, S., MACHÁČEK, J., PTÁČEK, M.,RADIL, L., BARTOŠÍK, T., PAVELKA, T.: Obnovitelné zdroje elektrické energie, České vysoké učení technické v Praze, Praha 2011, ISBN 978-80-01-04937-2

[2] WEC (World Energy Council): World Energy Resources: 2013 Survey, London. 2013. ISBN 978 0 946 121 29 8, Dostupné na internete: <www.worldenergy.org/publications/2013>.

[3] JANÍČEK, F., CERMAN, A., KUBICA, J.: Riešenia globálnych a regionálnych problémov v energetike, Slovenská technická univerzita Fakulta elektrotechniky a informatiky

[4] WEC (World Energy Council): World Energy Trilemma: Time to get real - the agenda for change, London. 2013. ISBN: 778 0 946 121 24 3. Dostupné na internete: <www.worldenergy.org/publications/2013>.

[5] ÁČ, V., KOPECKÝ, I., JUS, M., TIMÁR, Š.: VID Mobile power device from renewable resourses of electric energy , 2013 TnUAD Trenčín,

[6] http://www.dailyenmoveme.com/en/tags/solar-blinds

[7] http://solarstrom-tag-und-nacht.de/der-solarstromspeicher/das-system-wechselrichter/

[8] http://www.dailyenmoveme.com/en/parole-chiave/pv