INFLUENCE OF PHOTOVOLTAIC POWER SYSTEM ON ENVIRONMENT IN THE CZECH REPUBLIC

Lenka Raková, Jan Škorpil

ABSTRACT

This paper describes the potential impacts of photovoltaic power plants on environment in the Czech Republic. In the first part is evaluated an analysis of a life cycle of photovoltaic modules by means of CLM method's. Next there are describes effect on landscape character, built up area and impact of photovoltaic power plants on the environmental during their operation. The finish part deals with the recycling method and with the influence of semiconductor on people.

Keywords

Photovoltaic power plant, environment, life cycle assessment, built-up area, recycling

1. INTRODUCTION

The Sun and its rays are a primary source of almost all the energy needed for the existence and development of the human population on the Earth. The rest of energy has an origin from energy contained in the atomic nucleus. Influence of renewable and non-renewable energy sources on environment is conditioned by more factors than only by their origin. The aim of this work is description of impact of photovoltaic power plants on environment. Photovoltaic power station belongs to the renewable energy sources. Some sources of information indicate wrongly their zero impact on environment. This argument is absurd, because every source of energy has some environmental impact and it is decisive just its level. Today a total installed capacity of photovoltaic power plants is about 1 964 MW in the Czech Republic (Figure 1).

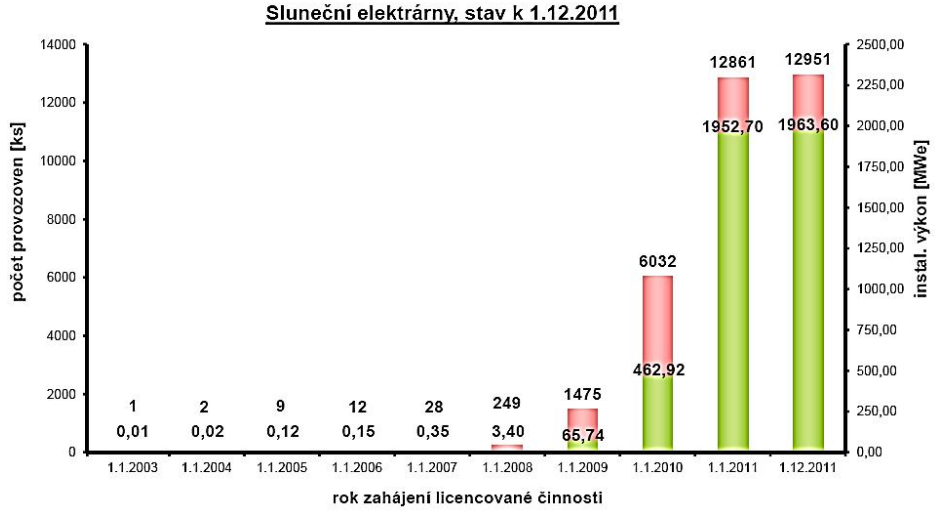

Figure 1 – Total installed capacity PVE [8]

2. LIFE CYCLE ASSESSMENT

The environmental impact of photovoltaic power system is possible to assess on basis of an analysis of life cycle (LCA - Life Cycle Assessment). Impacts are divided into [1]:

- Directly – built-up agricultural land, emissions from of extraction of primary raw material, consumption of water during of production, emissions of chemical substances, etc.
- Indirectly – emissions from production of electricity and from transport.

The most frequently used method for to evaluate the environmental impact is CLM method's that is based on a comparison of impact activities on environment. This method is defined several categories such as [2]:

- Abiotic depletion: resource depletion in kg Sb-eq.
- Global warming: the amount of CO2 produced in kg equ.
- Damage to the ozone layer: depletion of the ozone layer in kg CFC equ.
- Human toxicity: human toxicity in kg 1,4-DB equ.
- Photochemical oxidation: near-ground ozone in kg C_2H_4 equ.
- Acidification: the amount of SO_2 in kg equ.
- Eutrophication: eutrophication in kg PO_4 equ.

In order that different activities can compare with each other they are related to an equivalent value. The graph (Figure 2) shows that the production photovoltaic cell has the most effect from all the factors. If the production of photovoltaic cells will reduced or technologically modified, the impact on the environment will reduce.

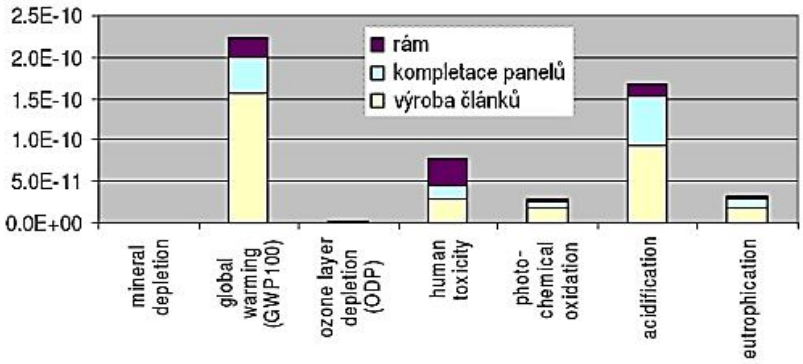

Figure 2 – CLM method's [1]

The energy consumption on the production of silicon is approximately 80% from the total consumption of electric energy for the production of photovoltaic panel. Therefore there are an attempts at more effective technology of production of photovoltaic cells with utilization more efficient melting equipment, reducing consumption of silicon and increase efficiency of cells (concentrators, Fresnel lenses, amorphous and tandems cells, cells based on nanostructures, etc.) and reduction of losses by cutting and recycling of photovoltaic panels.

The return on electrical energy used at production of first modules was not reached for their life. Now due to technical progress, mainly in terms of reducing consumption of silicon and increasing efficiency of silicon panels, is payback time around two to four years. [1, 4]

2.1. Effect on landscape character and built-up of agricultural area

Effect on the landscape character is assessed in dependence to the type design. The smaller systems located on the roofs or walls of buildings have not negative impact. Conversely nowadays they are produced photovoltaic modules with different colour’s modifications of the surface. These modules became architectural component.

The large photovoltaic power plants installed on the large lands are subject to assessment of the impact on the ambient landscape at the building proceedings within the EIA studies. Constructing is not permitted by legislation at the significant natural, cultural and historical localities in the cases of damage to their character. A crucial point of view is the built up area. [5]

A photovoltaic power plant has to be contained in the projects of lands before its construction. It is a temporary building that will be dismantled after the end their life. The grass area under the constructions can be use as a pasture for the sheep.

Built up area will be increased using with stands with one or two axes tracker of sun two to three times more than that photovoltaic power plant with the fixed stands. Produced electric power is higher from the stands with tracker. The figure number 3 shows an example of the produced electric power from the photovoltaic power systems with different kinds of a construction and with the installed power about 150 kWp. The plants are placed in the same locality near a town Plana at Marienbad. On the graph it sees a very few differences between a produced electric power from systems with one axis and two axes of trackers. This is given by climatic conditions in the Czech Republic. So if we take all aspects into account is the best a variant of fixed construction with manual adjustment of the tilt panels in according to seasonal operations in the Czech Republic. [6]

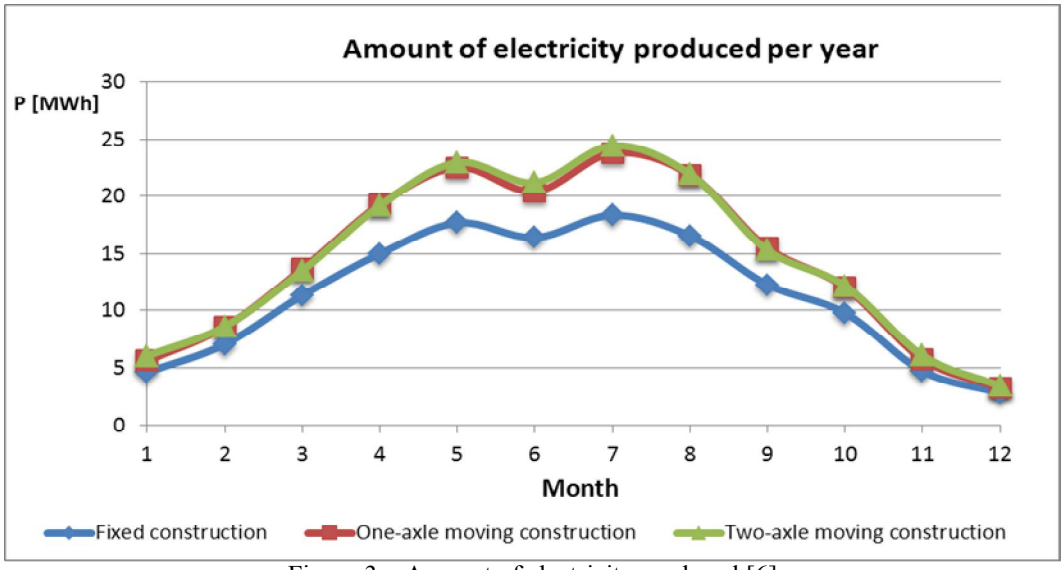

Figure 3 – Amount of electricity produced [6]

2.2. Operation of power plant

During operation of photovoltaic power plants produce no gaseous emissions or no emissions of particulate. In the large power station there is danger only from potential spills of oil from transformers or damage resulting fire. This risk is same for all transformers in the electricity system.

Large number of photovoltaic power plants working in grid-on system has an indirectly impact on environment because they are power supplies that we can not regulate. Support services are activated to keep the balance of power in the network. Today support services are mainly composed of fossil fuel power plants. Therefore by the power regulation of PVE there is generated indirect impacts on environment. Solution is for example the accumulation of electrical energy or smart grid.

3. RECYCLING

Currently the installed modules are the most frequently monocrystalline or polycrystalline silicon, but due the further development of this technology will be used thin film modules 3rd and 4th generations. Recycle method’s are different and are developed with the structure and the type of the photovoltaic panels.

The lifetime of photovoltaic power plant is about 20 years. After this period they will be dismantled and recycled. The steel stands will be able to use on other construction. Inverters, cables and other electrical and electronic controls equipment will be removed by the company on a liquidation of the electrical waste. Undamaged and functional components or materials will be used

again or recycled under the Act No. 185/2001 Coll., About Wastes, as amended. Uninstalled modules are recycled. PV CYCLE Association was instituted in the Europe in the 2007. This association removes and recycles modules from their members. This project is financed by the manufacturers and suppliers of photovoltaic panels. The first principle of recycling of the monocrystalline panels was based on the manual disassembly of the panel. Photovoltaic cells are cleaned chemically and at the end they are compiled again. The base of recycling of panels with the monocrystalline cells is removing an aluminium frame and glass. Currently methods of recycling are:

2) Thermal treatment

The most significant representative of this method is the company Deutsche Solar AG. After removing glass and frame, an EVA’s film is burnt in an incineration oven at the temperature of 600°C. The gases are burned and the combustion gases are cleaned before their release into the air. The remaining materials such as photovoltaic cells, glass and metals are separated manually for further using. Cells are re-etched to the wafer. This method is suitable for monocrystalline or polycrystalline cells.

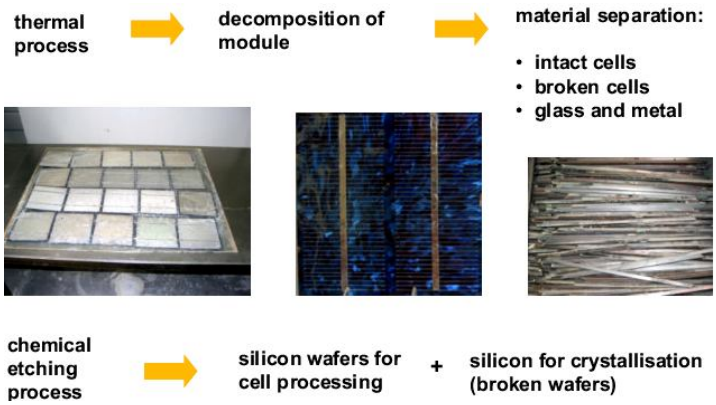

Figure 4 –Thermal recycling [2]

3) Chemical - Mechanical treatment

This method was developed by the First Solar Company and it is used for thin film modules, for example for CdTe cells. The modules are pulverized on the elements with size about 4 to 5 mm in the shredder and in the hammer mill. Elements are transported to the slow rotating drum. The semiconductor films are physically removed by addition of a sulphuric acid and hydrogen peroxide into the drum. Then the glass and EVA is separated from the liquid. The crushed material is transported into a vibrating screen to separate the glass from the EVA. The metals will be precipitated from the liquid in the three stages by an increasing pH and an addition of sodium hydroxide.

4) Construction adjustment

Structural modifications have to simplify of separation of the components by using the encapsulation of cells without lamination or by using the materials with low adhesion. [1, 2, 4, 7]

4. INFLUENCE OF SEMICONDUCTOR ON THE ENVIRONMENT

Monocrystals on the basis of germanium and silicon are not toxic or dangerous to health.

- Phosphorus – red phosphorus is not toxic, but during a melt it is transferred to highly toxic white phosphorus that it causes the severe burns. When cutting is danger of phosphine PH_3 (severe lungs irritation, cardiac dysfunction, renal damage, coma and even death).
- Arsenic – as a metal is no toxic. Arsenic and many of its compounds are highly toxic.

- Cadmium – it is a cumulative toxin that causes damage of the kidney and the liver, osteoporosis, anemia and cancer. Due of the great toxicity of cadmium is expected to stop of the production CdTe cells in the EU.
- Selenium – all compounds. But selenium is for the human body necessary because it acts as an antioxidant. The recommended daily dose is 55 to 70 μg. [3]

5. CONCLUSION

In view of production and recycling we can assume impact of photovoltaic power plants on the environment similar to impact of relevant energy or industrial devices. During these processes it is important to observe strictly technological practices to reduce of the escape of dangerous substance.

During the operation there are not generated gaseous emissions, emissions of solid pollutants, water pollution or soil pollution. And there is not provable effect on a fauna and a flora. The main disadvantage is the degradation of landscape and built-up area. In the case that power plant will be installed and operated in accordance with legislation and generally accepted of requirements of these works, they have not almost effect on environment.

The question is how much these resources are ecological in the dependence on their high power consumption during production and liquidation. These sources connected to the electricity grid are necessary to regulate by other sources and it means the more electrical energy, technical demands and financial cost. However, photovoltaic power plants have a minimal influence on the environment in comparison with conventional coal-fired power stations.

REFERENCES

[1] Bechník B., Bařinka R., Čech P.: Analýza životního cyklu fotovoltaických systémů: http://www.czrea.org/cs/druhy-oze/fotovoltaika/ziv-cyklus
[2] Knut Sander a col.: Study on the development of a take back and recovery system for photovol-taic products, 2007
[3] Kučerová, E.: Elektrotechnické materiály, ZČU, Plzeň, 2002
[4] Libra, M., Poulek, V.: Fotovoltaika, ILSA, Praha, vydání 1., 2009.
[5] Ministerstvo životního prostředí, Metodický návod: Vyhodnocení možností umístění větrných a fotovoltaických elektráren z hlediska ochrany přírody a krajiny, (dostupné z www.mzp.cz)
[6] Raková, L.: Porovnání různých druhů fotovoltaických elektráren, diplomová práce, ZČU, 2010
[7] http://www.pvcycle.org
[8] http://www.eru.cz

ACKNOWLEDGEMENT

This work was supported and granted by project no. SGS-2012-047.

Authors:

Ing. Lenka Raková
University of West Bohemia
Department of Electrical Power Engineering and Environmental Engineering
Univerzitní 8, 306 14 Plzeň, Czech Republic
E-mail: lencar@kee.zcu.cz

Prof. Ing. Jan Škorpil, CSc.
University of West Bohemia
Department of Electrical Power Engineering and Environmental Engineering
Univerzitní 8, 306 14 Plzeň, Czech Republic
E-mail: skorpil@kee.zcu.cz