ENERGY EFFICIENCY AND THERMAL COMFORT IN BUILDING-INTEGRATED PHOTOVOLTAIC - CASE STUDY

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Abstract

Today the photovoltaic cells are used in different and complex domains. Buildings constitute a significant share in energy consumption in recent years the question of energy efficiency through reduced consumption of energy and ensure environmental comfort conditions. Photovoltaic cells replace the conventional materials in building domain and are used on building envelope (e.g. facades, roofs). The term for these photovoltaic cells is "Building-integrated photovoltaics" and in this paper is described one case and the photovoltaic cells used for this integrated system.

Keywords: Energy, building-integrated photovoltaics, performance, monitoring

1. INTRODUCTION

Indoor environments should safeguard and enhance occupant 's health, comfort and productivity, because people spend about 90% in indoor spaces [1]. The demand in our world is to provide a comfortable and healthy indoor environment and to find the best possible balance between an efficient use of energy in buildings. The quality of the indoor environment is in dependence with many factors. In figure 1 are described these factors, whom could be categorised into: outdoor conditions, building, building services and people & their activities [2], [3].

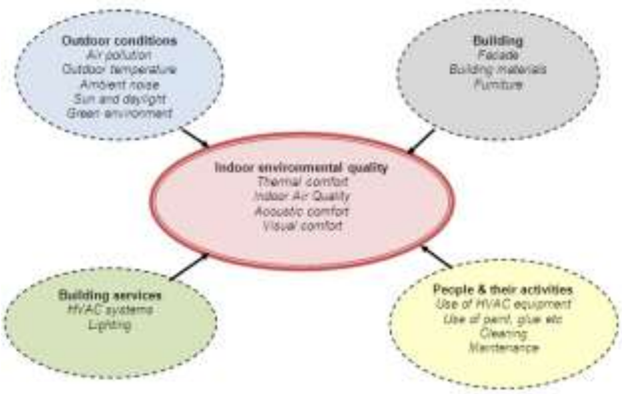

Fig.1. Factors wich influence the Indoor Environmental Quality [1], [2]

An important factor wich has an important role in indoor environmental quality is represented by buildings, that means: facades, building materials, furniture. Because the world is focused on renewable energy and non-polluting materials, zero-energy and zero emissions buildings experienced a real interest. Building integrated photovoltaic systems replace components of the conventional building materials and systems in the climate envelope of buildings. These systems are considered as a functional part in a building structure. Also, they are architecturally integrated into the building's design [4]. For this, the building integrated photovoltaic systems serve in the same time as a building envelope material and power generator [5].

Photovoltaic cells market has become more and more important over the last years and they have an important role on the energy map in a lot of country. Today are many technologies based on solar conversion and this is shows in figure 2. Are included in this map crystalline Si, thin-film, single- junction GaAs, collected from solar companies, multijunction and emerging technologies, universities and national laboratories [6].

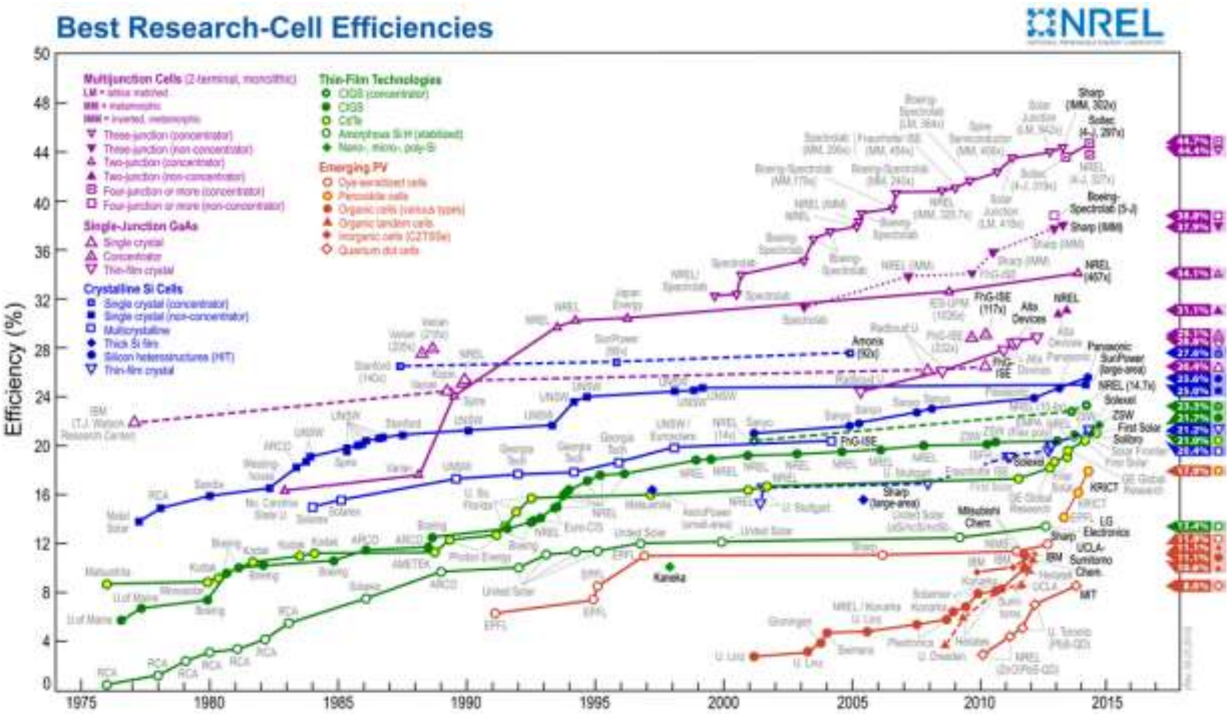

Fig.2. Best Research-Cell Efficiencies [6]

Building integrated photovoltaic systems contains integrated photovoltaic cells on windows, glass or tiled facades and roofs. Photovoltaic cells have different colours and transparencies. To improve indoor environmental comfort the photovoltaic cells provide daylight and serve as water and sun protection [4].

For the buildings sector, according to the first National Action Plan regarding the Energy Efficiency 2008 – 2012, transmitted by our country to the European Commission, according to the provisions of Directive 2006/32/CE, it is forecasted that by applying the measures of thermal refurbishment of buildings included in the Multiannual National Plan foreseen by the Government Urgence Order no. 18/2009, to achieve energy savings of approximately 25% in regard to the existing situation, respectively the realization of energy saving for the period 2008 – 2010 of approximately 36.000 MWh/year. The objectives included in the Romanian Government Programme for 2009 – 2015 are:

- to increase of financial resources from the state budget for implementing national developing programmes of infrastructure for the local interest;
- to increase the energy performance of apartment buildings and public buildings;
- to implement the new investment programmes and continuing the existent programmes in the public interest infrastucture in order to attain in an accelerated rhythm the housing conditions according to the european requirements in order to increase the life quality [1], [3].

2. EXPERIMENTAL PROCEDURE

This experiment is focused for building facade and is made using photovoltaic cells integrated in building. Building-integrated photovoltaic are electric power systems wich not only produce electricity, they are also part of the building. These systems are parts from the study of solar panels optimal dimensions, to adapt them to the facade of the building [6].

This study is conducted in Timisoara, Romania. First step in this study is to found the best solution where to be installed photovoltaic cells.

Building integrated photovoltaic systems has at base photovoltaic cells [7]. In figure 3 are presented types of photovoltaic cells used for building integrated systems and also the characteristics of each one. It is seen that monocrystalline cells are more efficient than polycrystalline cells.

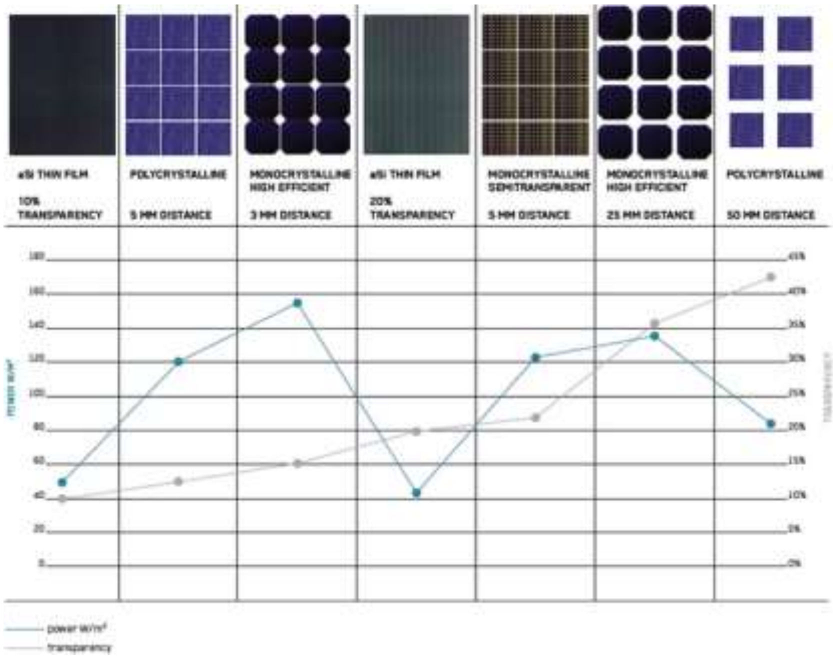

Fig.3. Different types of photovoltaic cells used for buildings integrated photovoltaic systems, [7]

The building integrated photovoltaic cells system consists of nine photovoltaic monocrystalline cells serial mounted, wich has the output power equalwith 37.62W under Standard Test Conditions. The Current-Voltage curve for mono crystalline photovoltaic cells used in this study is presented in figure 4 [3].

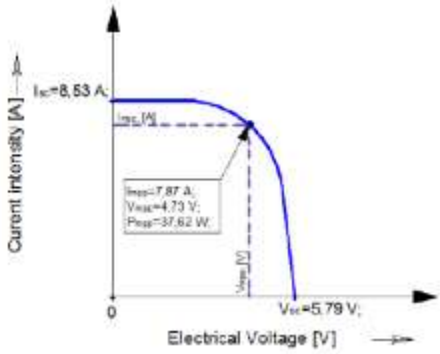

Fig.4. Current-Voltage curve of monocystalline photovoltaic cells used in this study [3]

This structure combine serial monocrystalline photovoltaic cells with dimensions 156x156 mm, the gross area of the entire structure is 0.53 m2. This systems has below dimensions: 1778x300x13.52 mm. Cells distance are 5mm width and 5 mm length, and maximum edge distance is 167 mm.

This study describes the solar radiance and power provided by this system.

3. RESULTS AND DISCUSSIONS

The efficiency of this system is influenced solar irradiation of photovoltaic cells. The best solution is when this solar system is mounted verticaly on the south facade, because the others three facades have a low efficiency of solar energy. The variation of solar irradiance on this system is presented in figure 5.

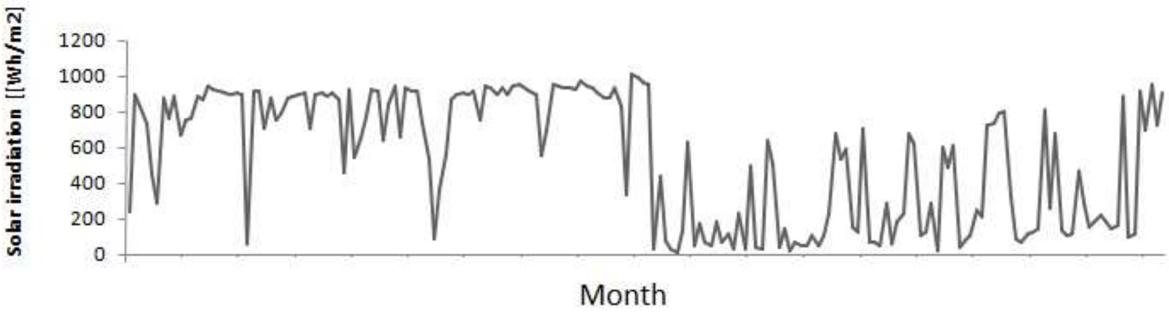

Fig.5. Variation of total solar irradiation on a South facade in 2013

If the performance of this system is monitored, means that is measured the power provided by these cells considering the same conditions of temperature and solar irradiation. The power provided during year 2013 is shows in below figure.

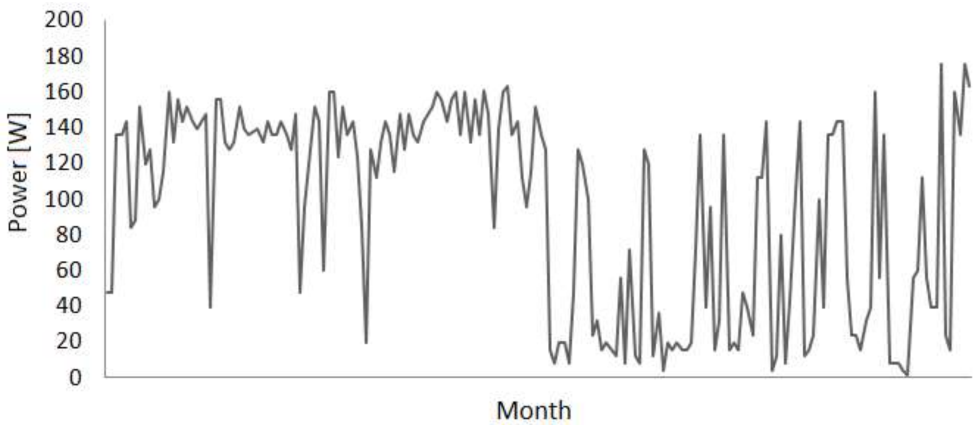

Fig.6. Variation of power provided by building integrated photovoltaic system in 2013

Monitoring the total solar irradiance on a South facade and the power collected during these experiments from this system integrated in facade was performed during one year and the results are presented in figure 5 and 6. With this experiment it is shown that photovoltaic systems are useful for society. The systems with photovoltaic cells offers a lot of advantages: simplicity of operation, low maintenance costs and lower environmental impact.

CONCLUSIONS

This paper provide information about building integrated system with photovoltaic cells and characteristics of them. Also is described the roll of renewable energy, in this case as indoor comfort and efficiency for energetic system. In this case is explain a situation, when is monitored a photovoltaic system to see the photovoltaic electricity on a surface of 0.53 m^2. Building integrated photovoltaic systems provide an economical, technical and aesthetic solution to integrate photovoltaic cells to increase electricity production.

LITERATURE

[1] Retezan A. , Dobosi I. S., Retezan R. – The healts of constructions necessity, possibilities, achivements, Kosice, 2002;

[2] Bellia L., Boerstra A., Dijken F. van, Ianniello E., Lopardo G., Minichiello F., Romagnoni P., Gameiro da Silva M. C., 2010. Indoor Environment and Energy Efficiency in Schools (d'Ambrosio F.R. ed). REHVA Guidebook no.6 Brussels: REHVA;

[3] PĂCURAR Cristian, PĂCURAR Ana Talida, RETEZAN Adrian, energy efficiency and thermal comfort in schools after renovation using photovoltaic cells, NANOCON 2012 - 4th International Conference on Nanomaterials - Research & Application;

[4] C. Peng, Y. Huang, Z. Wu, "Building-integrated photovoltaics (BIPV) in architectural design in China", Energy and Buildings, 43, 3592-3598, 2011;

[5] Strong, Building Integrated Photovoltaics (BIPV), Whole Building Design Guide, <http://www.wbdg.org/resources/bipv.php >, June 9, 2010, (accessed September 14, 2014);

[6] National Renewable Energy Laboratory (NREL), Best Research-Cell Efficiencies, Rev. 11-11-2013, http://www.nrel.gov/ncpv/images/efficiency_chart.jpg, (accessed September 14, 2014);

[7] Sapa Building Systems, http://www.sapagroup.com/en/sapa-building-system-tr/page-1/bipv-fotovotaik-sistemler/ , (accessed September 14, 2014);