144. First results of a BIPV Project in Romania

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Abstract

The paper is based on a research national project (under work) focused on the promotion of new architectural concepts which include active solar systems (PV generators) and passive solar systems (lighting systems). The advantages of using the distributed solar architecture are more conspicuous in the case of large network-connected PV systems, such as the PV systems in the urban area, installed on the buildings façades or roofs. The major purpose of the project is to demonstrate the efficiency of integrating various PV elements in buildings, to test them and to make them known so that they can be used on a large scale.

To demonstrate this purpose, the new products will be installed on three pilot buildings (two in Bucharest and one in Timisoara) and the PV modules will be integrated in consonance with their architecture. One of them will be a historical building and the other two will be new buildings; they will have different typologies and they will be located in different areas. The estimated installed power for each building will be of approximately 1.000Wp, including some technologies with PV modules integrated in the architecture of the buildings.

Keywords: building integrated PV, distributed solar architecture, pilot buildings.

1. Introduction

The future large-scale utilization of renewable energies is a world-wide priority, which can not be neglected by anyone. Currently, the world photovoltaic market approaches maturity, being in a continuous process of expansion reaching an annual increase of over 30% after 2003. The main actors on the market are Japan with roughly 48%, EU with 25% and the USA with 13%. The second position of the EU is primarily due to the fact that it massively financed specific programmes for the development of this area. Germany, for instance, launched in January 1999 the programme for the installation of 100,000 PV roofs before 2004 with an installed power of 300 MW, the users being granted excellent incentives (Report of the European Commission: Energy End – Use Efficiency and Electricity Biomass, Wind and Photovoltaics in the European Union –EUR21297EN). In the Report “Status of Photovoltaics in the Newly Associates States” (2004) elaborated based on the European project *PV-EC-NET* continued with *PV-NAS-NET* (FP6), it is stipulated that “the promotion of renewable energy sources” is an absolute priority of the EU. This is based on the Kyoto Protocol referring to the reduction of carbon dioxide emissions into the atmosphere and on the policy of security in the energy area.” The EU goal is to reach a production of energy from renewable sources of 21% of the electric energy consumption in 2010, compared with only 6% in 1998.

It is well known that the necessity to harmonise Romanian standards to the European ones, with precise goals regarding environmental degradation prevention (the Kyoto Protocol was ratified by the Parliament of Romania, Law no. 3/2001) and to promote sustainable development has determined the Government of Romania to qualify the importance of the promotion of renewable energy sources as “national objective” (art. 3, Government Decision (GD) no. 443/10.04.2003). The general objectives of the Strategy for the Utilisation of Renewable Energy Sources are stipulated by GD no. 1535/18.12.2003 and include the integration of renewable energy sources into the public energy system and the attenuation of the technical-functional and psycho-social barriers related to the use of such energies; the identification of cost and energy efficiency elements; the promotion of private investments on the renewable energy market. The integration of PV systems into building façades and roofs determining a new form of electric power plant, i.e. the distributed electric power plant, is the market segment with the highest rise worldwide, considered as the most attractive for the future, [2-8].

„*BIPV Architecture***”** is a general term which implies the integration of photovoltaic system into classical building design. The key concept here is represented by the photovoltaic modules, which substitute some façade or roof components. For the design and construction of solar/PV systems it is necessary to have information about the solar energy collectable on tilted surfaces. In Romania, the meteorological stations have no such databases and do not perform such measurements. This means that the application of numerical methods is limited because of the lack of data resulted from specific meteorological-climate observation. Although in Romania the building market is rapidly developing, the building contractors do not promote PV technologies and new materials used for high performance day lighting, either because of their ignorance or their conservativeness, or the high costs related to importing such systems from the European market. Though during the last years more private companies in Romania offered to merchandise and install PV systems, one can not discuss of a proper PV market. Thus, in contrast to other EU states, in Romania there is no photovoltaic building construction branch, the limited number of isolated cases being not enough to argue the start if a photovoltaic market in the building industry.

In general, the design of such buildings one should pursue the optimization of the processes of dimensioning and orienting the surfaces on which the components collecting solar energy are to be placed in order to obtain a maximum of collected energy, satisfying at the same time the quality with regard to destination of the building, the designing and aesthetics rules. Therefore, the data regarding the solar energy collectable on tilted surfaces represent a vital prerequisite for architects and engineers who have to size the PV or thermosolar systems, for the specialists who have to elaborate feasibility studies associated to the implementation of solar installations.

Compared with other European countries, Romania has an above-average solar irradiation in the summer (Fig. 1), comparable to the one of Greece, country in which the solar/photovoltaic technology is highly developed.

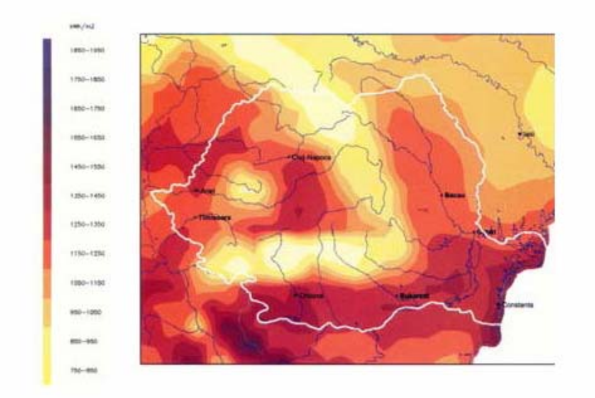

Fig. 1. Global Solar Radiation Map for Romania

Stand-alone private PV systems and the ones supplying energy also into the grid can be an attractive investment solution. A key element for the promotion of these renewable energy sources is the education for the sustainable development of the economic and social life of the population, especially young people, future inhabitants of houses designed and built using the new concepts of solar architecture. The effort to carry out a project of such a span requires human resources highly qualified in different areas of study such as urban architecture, the physics of photovoltaic devices, the physics of atmosphere (solar radiation), applied electronics (electrical measurement methods), data transmission, informatics, database administration.

2. Project objectives

In September 2007, a research Romanian institute (IPA SA) and four Romanian universities (WUT, PUB, TUT and UAUIM) started a research project on "Promotion of Solar Architecture in Romania" (PASOR), [1]. The project will be concluded in September 2010.

The main issue proposed to be solved by the project refers to the opening of a solar building market. The methods proposed are focussed on the two target groups:

- raising the public awareness of the environmental degradation, especially now when it was proved that the effects of human action upon nature have devastating consequences on the one hand and on the other one when the European energy market had suffered another shock through the increase in the price of natural gases; information regarding how to use renewable energy sources, pointing out the economical advantages deriving from them;
- offering tools and training to experts by elaboration of concrete solar architecture solutions.

To fulfil these goals, the following specific objectives were proposed:

- Initiation of a network for monitoring the solar energy on tilted surfaces, including: design, practical achievement and calibration of the measuring instrumentation;
- setting up of two measurement centres for meteorological parameters and data acquisitions in Bucharest and Timisoara;
- development of a software program for the estimation with an acceptable accuracy of the solar energy collectable in other locations than those selected within the project;
- creation of a web-site allowing on-line access to the data base

The data base developed at the first specific objective represents the main source of information in dimensioning the photovoltaic systems. As such, we want to develop interactive software to facilitate the process of designing grid-connected or stand-alone PV systems, with on-line access on the website of the project.

Elaboration of technical solutions for PV systems integrated into façade and roof elements - private or public buildings: schools, libraries.

Installation of three demo PV systems, and their monitoring, through measurements for an entire year, at three public buildings visited both by experts and by the public, in Bucharest (terrace covering at UAUIM and window of BIPV Laboratory at PUB) and Timisoara (roof of WUT).

Intense dissemination activities: promotion of the idea of PV architecture through the organisation of a workshop, inviting representatives of potential promoters: companies from the architecture, building and energy fields of activity as well as specialists from the National Institute for Meteorology and Hydrology;

Measurable objectives:

- Promoting the increase in the percent of renewable energies in the energy balance of Romania. Promoting efficient installations and building them at lower cost price, would aid Romania's rapid integration in the EU structure, which established as one of its priorities the development and use of renewable energies. Furthermore a decrease in the import of raw materials such as crude oil, natural gas and coal would be registered.
- Education of potential users through the presentation of the advantages in using those installations, which could aid environmental protection and decreasing greenhouse effect.

As specified, the project objectives are focused on the main objective of the programme, aiming at the acceleration of the process of harmonisation with EU standards and requirements in the building construction area. Considering that the use of renewable energy is a priority both for the European Commission and for Romania's Government, the proposed project relates correctly to the priorities and specific objectives of the European Research Area. The objectives aim to introduce a new concept in urban development by promoting a new science, the photovoltaic architecture, and to initiate R&D activities in this area. All of these stress the complex interdisciplinary character of the thematic approached in this project.

3. Project description

The *PV architecture* is a new concept for Romania**.** Consequently, the project aims to achieve demonstrative designs of ecological solar buildings containing in their structure photovoltaic elements, passive solar elements, and modern systems for day lighting. These will be available on-line on the web-site of the project and, additionally, will be presented to building contractors and to the public. In this section of the project we have in view the practical construction of three BIPV (building integrated PV) systems to be integrated in the structure of buildings. The three systems will be equipped with monitoring systems and the necessary infrastructure for transmitting the data to the web-site. A computer-based displaying system placed in public domain will permit real-time visualisation of the parameters of the installation and, additionally, will transmit technical and economical information referring to the solar/photovoltaic architecture to the large public.

A holistic analysis of the building has to be done before to introduce a BIPV system. The main criteria of such analysis would be as follows:

- opportunity of the BIPV utilisation;
- involvements of the built environment (urban, rural, industrial) towards the building;
- involvements of the BIPV placement towards the building itself (these criteria are linked with volumetric analysis, style, general and particular look of the building envelope);
- specific requirements of the building envelope based on the type of selected BIPV;
- optimum action type and place (analysis of the BIPV systems corresponding with the envelope parts where it would be intended to act);
- technical and operational involvements on the envelope components;
- efficiency of the agreed system;
- financial and payback period involvements of the investment;
- type and way of the produced electrical energy management.

The main activities developed by the project partners are as follows:

Project coordinator (IPA SA):

- elaboration of technical solutions for PV systems integrated into façade and roof elements, including sizing and preparation of the technical documentation for the design of the PV systems to be used in the three demo projects;
- elaboration of the technical information and data support for the development of a data acquisition and processing software;
- software development for sizing building-integrated PV systems;
- design of the PV systems for all real and demo applications within the project.

West University of Timisoara (WUT):

- development of a software for solar radiation estimation (based on the models which can be deduced taking into account the new database);
- achievement of a PV system located at the WUT.
- development in Timisoara of the centre for measuring solar radiation on tilted surfaces.

Polytechnic University of Bucharest (PUB):

- development of a BIPV Laboratory at Physics Department (together with IPA);
- elaboration of IT solutions for the development of a specific website for the performance of all project activities (database administration, online courses, partner's communication, setting up of a solar architecture library, etc.). The website will be structured on two levels: public and private;
- elaboration of market surveys and of a strategy for the implementation of BIPV systems on the Romanian market;
- drawing up of a guide on building-integrated PV systems;

Polytechnic University of Timisoara (PUT):

- research related to the achievement of the measuring and data centralising instrumentation (electronic data acquisition and processing equipment);
- development of a FIELDBUS type measuring network, of programs associated to interfacing and real-time building of a database with online access;
- studies on the optimal use of solar radiation spectrum areas.

Partner University of Architecture and Urbanism in Bucharest "Ion Mincu" (UAUIM):

- analysis of types of civil buildings in the existing stock and evaluation of possibilities of intervention upon these ones by introducing PV panels;
- proposals of interventions in existing civil buildings by integrating the panels within the building envelope;
- experiments related to possibilities of intervention on the covering – terrace of a building of the "Ion Mincu" University and on the framework of the same building (the old building of the School of Architecture), and monitoring of subsequent behaviour;
- participation at the elaboration of market surveys and of a strategy for the implementation of building-integrated PV systems on the Romanian market.

4. Expected project results

Quantitative results:

- Centres for measuring the solar energy that can be collected from tilted surfaces (unique in Romania);
- Modernization and installation, by applying the project's energy concepts, at the terrace of West University of Timisoara, and at a terrace of the University of Architecture and Urban Planning "Ion Mincu" - Bucharest; Solar windows in The BIPV Laboratory from Polytechnic University of Bucharest
- Project website, containing: software and guide, accessible online, for: estimation of the solar energy that can be collected from tilted surfaces; PV system design; architectural solutions;
- Database containing measurements of solar energy collectable from tilted surfaces;
- Submission to the authorities of the legal requirements related to the authorisation of the operation of distributed electric power sources;
- Organisation of a thematic competition („Solar house") for students;
- Organisation of workshop for discussing the results of the project with representatives of the target groups;

- Brochures, guidelines, bibliographies for the different target groups
- Estimated profits and profitableness:
- Development of specialisation, in the solar architecture with great opportunities within EU market;
- Achievement of important steps in the development of the photovoltaic industry in Romania;
- Possibility of capitalization on the results obtained by the project in Romania's neighbouring countries;
- Achievement of important steps in fulfilling Romania's commitments as future member of the EU, as regards Chapters Environment and Energy.

Dissemination plan:

Logical Diagram of the project dissemination activities is presented in Fig. 2. Main points of this dissemination plan are considered to be the following:

- Organisation the visiting of the demo PV installations for interested public;
- Promoting the idea of solar architecture to the specialists, both through the web-site and through roundtables, conferences and colloquiums addressed to both local authorities and the large public. Editing a Newsletter for presenting the results of the project and elaboration of brochures for dissemination to the large public;
- Creation and administration of a specialised website dedicated to all project activities. The website will include two sections, one public (including users form the EU states) and one for the partners' use;
- Organisation of a workshop on aspects related to solar radiation measuring on tilted surfaces;
- Organisation of a competition of projects/models of "Solar houses" for students of architecture and engineering universities;
- Elaboration of a guide on BIPV systems and on the new technologies, for architects, and of materials for building daylighting as well as a bibliography for specialists;
- Presentation of the results of the project at national and European scientific events;
- Participation (by models and posters) to national exhibitions specialized in building construction: Constructexpo and Windoor.

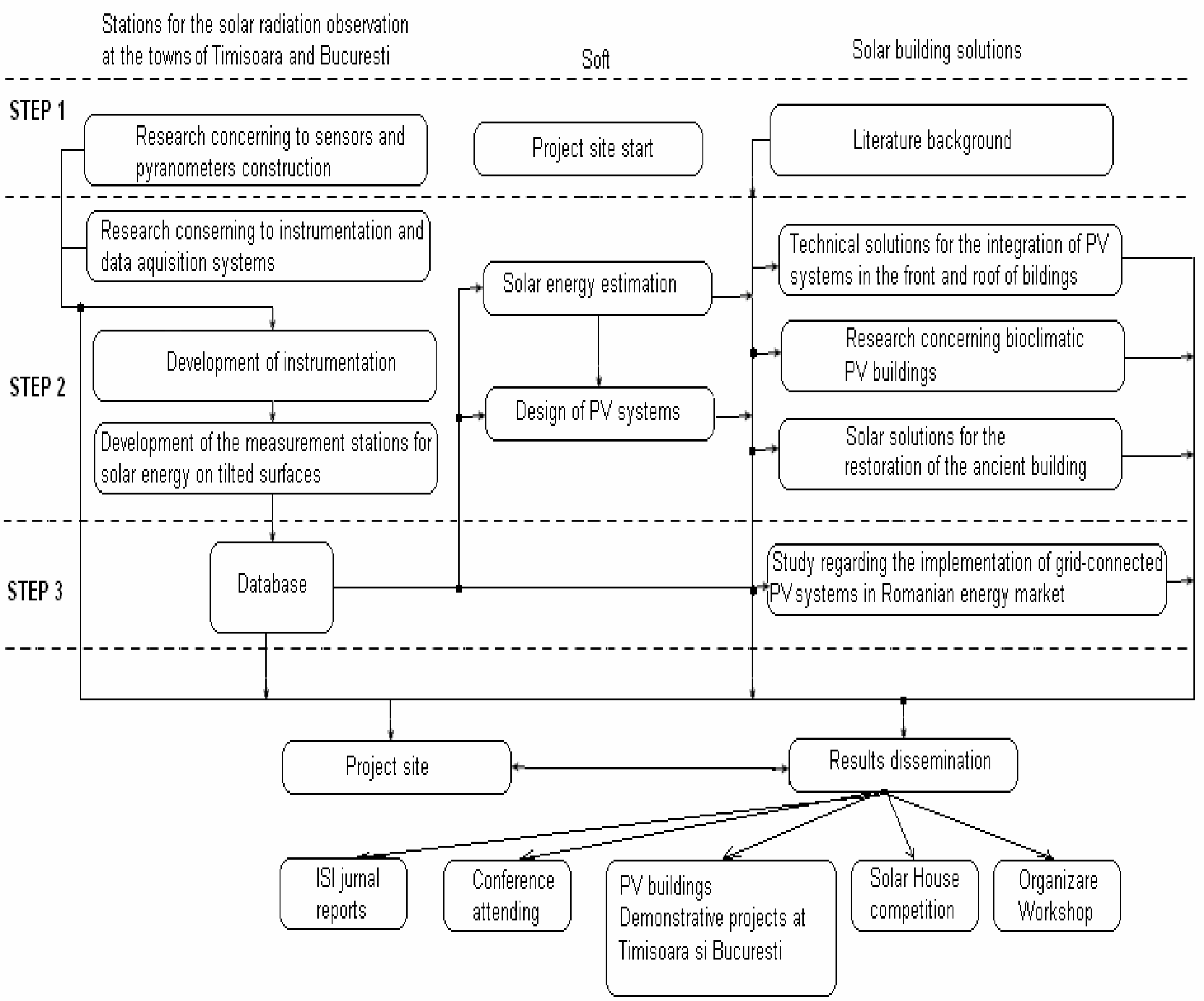

Fig. 2. Logical diagram of the project development -dissemination activities

5. Technical, economical and social impact

Technical impact

- development of the first BIPV Laboratory in Bucharest, Romania;
- first-time achievement in Romania of a systematic demo projects for building-integrated PV systems, having as support and model similar achievements at European and world level, anticipating a high impact on building contractors and end-users for the promotion of solar architecture integrating ecological energy sources in facades or roofs.

Economical and social impact

- creation of new jobs in the companies interested in extending their activities to include building-integrated PV systems and in those open to developing and investing in this field of activity;
- education and training of the young generation (specialists in architecture and in technical areas, students and even pupils) for the purpose of creating the human support able to carry on the long-term development of this field in the future;
- increase of the share of renewable energy (for any application, however small, designed to provide fully or partially the energy necessary for a certain purpose) compared with the energy obtained from conventional sources, contributing thus directly to CO_2 emission reduction and greenhouse effect mitigation – all these leading to environmental protection and conservation and to the decrease of noxious effects on people's health as well as reduction of diseases caused by pollution;
- these solutions can be adopted in time in rural tourism, creating opportunities of development of this sector in isolated tourist areas, too;
- the rehabilitation of old buildings in the historical centres of certain towns by using solar technologies would introduce in Romania the concept of "sustainable city" ("solar city"), a concept which is usually in the EU.

Benefits of a BIPV Solar Roofing System

Some key features of a Solar Integrated BIPV roofing system include:

- Easy to install

Our attractive, flexible solar roof panel literally rolls right on. We will manufacture the solar roofing systems in easy to handle modular rolls to allow for rapid installation at our customer's sites. We will employ experienced roofing professionals to install our products, with no disruption to your business.

- Light weight

The chosen solar panel weighs only about 4 kg/m^2 allowing installation on existing facilities without exceeding roof loading limitations.

- Powerful

The amorphous silicon panels enable maximum kilowatt-hour output, producing electricity using a wider spectrum of light than traditional crystalline technology. This feature enables the panels to produce electricity all day long, even when it is cloudy.

- Rugged and durable

Durability to cope with challenging weather conditions, and stability to handle changing light and shade conditions, have been built into all our roofing products. In addition, our roof is sealed and bonded, providing a weather-tight, long-lasting roof that has no penetrations. All our roofs are backed by a 20 year guarantee and an operations & maintenance program.

- Attractive appearance

Our unique electrical engineering integrates the solar array within the roofing assembly providing a neat and uncluttered roof surface.

6. Conclusions and next steps

There is growing interest in highly glazed building facades, driven by a variety of architectural, aesthetic, business and environmental rationales. The environmental rationale appears plausible only if conventional glazing systems are replaced by a new generation of high performance, interactive, intelligent façade systems, that meet the comfort and performance needs of occupants while satisfying owner economic needs and broader societal environmental concerns. The challenge is that new technology, better systems integration using more capable design tools, and smarter building operation are all necessary to meet these goals. The opportunity is to create a new class of buildings that are both environmentally responsible at a regional or global level while providing the amenities and working environments that owners and occupants seek.

BIPV systems could be applied both for existing buildings, and for new ones. They could be introduced on roof coverings, as façades and as skylights/shading devices.

An important requirement for operation at optimum parameters would be that the PV panels were not shadowed.

The BIPV systems could represent for Romania, as well as for developed EU countries a very good solution to be considered in the buildings industry. Although it is not cheap, it could be adopted in the future based on corresponding public education and on legal support granted by specific fiscal facilities.

In June 2008, a BIPV Laboratory developed at Physics Department of PUB and IPA SA was put in operation. It contains: a BIPV system, a monitoring station for measurement of weather parameters and an installation for monitoring of main BIPV physical quantities (see Fig. 3 (a), (b), (c)).

Other two BIPV demonstrative systems must be installed on two pilot buildings: in Bucharest (it will integrate an historical building) and in Timisoara (a new building will be considered). They will have different typologies and we will consider new technologies for PV modules integrated in the architecture of the selected buildings.

Fig. 3. BIPV Laboratory Polytechnic University of Bucharest (PUB)
(a) outside view of the BIPV window installed at Physics Department, PUB
(b) Meteorological Station installed at BIPV Laboratory, PUB
(c) inside view of the BIPV system including the inverter and the monitoring station for PV parameters

References

IPA SA (coordinator), WUT, PUB, TUT, UAUIM, *Promotion of Solar Architecture in Romania* (PASOR), Project No. 21039/2007, Research Romania's Partnership Programme

Nordmann T., July-august 2005, Built-in-future – integration, technical and market issues for PV, **Renewable Energy World**, **8**, no.4.

.

Harvey D., 2006, *Low-Energy buildings and District-Energy Systems*, 384 pages, James & James Ltd.

Prasad D. and Snow M., 2005, A Source Book for Building Integrated Photovoltaics (BIPV), 256 pages, EarthScan

http://buildingsolar.com/technology.asp

http://www.terrasolar.com/bipv. html

www.domainnames.com.

www.pvnord.org