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Simple technological guidelines for the implementation of the Romanian National Strategy on PV systems

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ABSTRACT

This paper provides guidelines which may be useful for the implementation of the Romanian PV system Strategy. Four solutions for PV module orientation were analyzed: (1) fixed optimum tilt angle, (2) single-axis azimuth orientation; (3) single-axis elevation orientation and (4) two-axis orientation. The fixed module at optimum tilt angle collects 14–17% more solar energy than a horizontal module. The optimum tilt angle ranges between 32° in the South and 40° in the North of the country. The difference between the performance of the two single-axis orientation systems (2) and (3) is small. Both systems provide 23–25% more electric energy than fixed modules. Two axes orientation generates 27–30% more electric energy than fixed modules. Modules based on the four types of cells have been considered for a PV plant of given installed power: (1) Poly Si; (2) Mono Si; (3) CdTe and (4) CuInSe. The smallest and largest collection surface areas correspond to Mono Si and CdTe, respectively. The energy generated by all types of modules is comparable, with the highest and lowest values being associated to CdTe and CuInSe cells, respectively. The limited transport capacity of the existing electric grid in South-East Romania puts an upper bound on the number of PV systems to be carried out in the near future.

Introduction

Solar energy is a clean energy source whose potential is largely unexploited. There is a tendency, however, to increase the implementation rate of PV systems. Their main advantages are silent operation and reduced maintenance (Agnolucci, 2007; Ruiz et al., 2008). The price of PV systems continuously decreased since 1970. It is now around 6 USD per installed Watt. For bigger systems it is lower (Markvart, 2002). The cost of the electrical energy provided by PV systems ranges between 0.25 and 0.5 USD/kWh (Bostan et al., 2007). PV electricity is already economically attractive for small isolated users, whose connection to the electrical grid would require large investments. The developing countries used PV systems in 2007 for rural electricity (66%), health sector (16%) and water pumping (16%) while the developed countries used them in the public and residential building sectors (60%) and for grid-connected PV plants (40%) (Bostan et al., 2007).

The electric energy produced in 2010 in Romania originated mainly from hydraulic energy (35.7%), coal (33.8%), nuclear energy (19.4%), natural gas (10.2%) and fuel oil (0.9%) (ANRE, 2010). The contribution of the renewable energy sources, including solar energy, is less than 1%.

The target stated by the Romanian Energy Strategy for the PV systems is 260 MW installed power by 2020 (MECMA, 2007). Considering the weak present-day implementation, this is a chalenging objective. It will succeed only if the future legislation will find appropriate ways to support investments in the PV sector. In a previous paper we have analyzed the potential of the local administration to act as the driving force for the implementation of the Romanian PV system Strategy (Iacobescu and Badescu, 2012). Also, the potential of four types of potential investors were analyzed in (Badescu and Iacobescu, submitted for publication). It has been shown that the PV projects are not yet economically profitable. In practice the PV sector receives governmental and European subsidies. However, the subsidies are different for local administration, small and medium enterprises (SMEs) and national companies, respectively. The best legislation strategy is to stimulate investments in the PV sector by local administration. The strategy supporting investments by SMEs is the second best (Badescu and Iacobescu, submitted for publication).

The PV sector is rich in design solutions. Making the right choice may have significant beneficial consequences. Easy to understand solutions are needed for common problems such as choosing the PV cell type or PV module's orientation system. This paper provides guidelines which may be useful for the implementation of the Romanian PV system Strategy. Numerical results are shown for the case of a specific type of investor (i.e. the local administration). However, the present findings are, to a large extent, independent of the investor type.

PV system utilization in Romania

About thirty small (1–5 kW) PV systems were gradually implemented in remote Romanian geographical areas or places lacking easy access to the electrical grid. The installed PV power was less than 120 kW in

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2009. In March 2011, this power was 1940 kW, of which 1330 kW consisted in grid-connected systems (Teodoreanu, 2011). The owners of the largest PV systems are universities, research institutes and local authorities (county councils and city halls, see Table 1 of Iacobescu and Badescu (2012).

Now, the tendency is to implement larger grid-connected PV systems. Such systems need electrical transformers and connection points to the national electrical grid (presently owned by Transelectrica SA). Table 1 shows the list of PV investors (dated November 2010) who asked connection to the grid. The approval depends on the availability of connection points (Transelectrica, 2011).

Technical documentation exists for the implementation of about 60 MW (see Table 1). Since the target for the year 2020 is 260 MW, there is an extra need of 200 MW PV systems to be installed. This is the objective of the present study.

Basic method of PV strategy implementation

Eighty Romanian localities covering the territory of the country are considered here (Table 2). According to the standard C 107/1-2005 (MLPAT, 2005) these localities are representative for all regions and topoclimates of the country. The list contains the largest towns, the capitals of the forty counties and other smaller localities.

Standard PV plant description

A standard PV plant is considered in this study. A brief description follows. The basic component is the solar cell. PV cells connected in series and parallel constitute a PV module. Fixed PV modules are considered here (Olariu, 2011; Teodoreanu, 2011). The modules are interconnected.

A BP Solar MSX 240 fixed module based on polycrystalline silicon PV cells is the building block of the PV plant considered here. The module consists of 144 PV cells. Other characteristics: surface area 2.15 m^2, installed power 240 W and nominal conversion efficiency 11.1%. The maximum power and open circuit voltage (electric current) were 68.4 V (3.5 A) and 85.2 V (3.8 A), respectively. The cost is 592 USD per module. Other details may be found in POSHARP (2011) and Retscreen (2011). The modules' optimum fixed tilt angle depends on location (Oancea et al., 1981).

PV modules generate continuous electric current (CC). Most user devices in Romania are using alternate current (CA) at 50 Hz frequency. An invertor is needed to convert CC to CA. The (common) invertor efficiency is 90%. Electric tranformers are installed between the invertors and the electric grid (Bostan et al., 2007, chaps. 3.5.2, 3.5.4).

Analysis tool

The RETScreen Clean Energy Project Analysis software (Retscreen, 2011) has been used to perform energy production analysis, financial analysis, and greenhouse gases (GHG) emission analysis. RETScreen software takes into account the energy resource available at project site, equipment performance, initial project costs, "base case" credits, on-going and periodic project costs, avoided cost of energy, financing, taxes on equipment and income (or savings), environmental characteristics of energy displaced and environmental credits and/or subsidies.

Table 1
PV plants to be installed in Romania in the near future (list dated November 2010) (Transelectrica, 2011). The investor type is also shown (LA — local administration; SME — small/medium enterprise; NGO — non-governmental organization).

Investor	Investor type	Locality	County	Installed power (MW)	Medium/high voltage transformer station (kV)
Solar energy Srl	SME	Costinesti	Constanta	1.5	20
Consiliul Local Vidra	LA	Cretesti	Ilfov	1.066	20
Sc Imsaproiect Srl	SME	Magiresti	Bucuresti	0.00648	0.4
Primaria Municipiului Giurgiu	LA	Giurgiu	Giurgiu	0.95	20
SC GCIT Gestiune Si Consultanta IT SRL	SME	Balotesti	Ilfov	0.1821	0.4
Comuna Luncavita	LA	Luncavita	Caras-Severin	0.252	20
Asociatia De Dezvoltare Intercomunitara Santamaria Orlea-Rau De Mori	NGO	Tustea	Hunedoara	0.75	20
Primaria Orasului Bocsa	LA	Bocsa	Caras-Severin	0.5	20
Comuna Buces	LA	Stanija	Hunedoara	1.5	20
im Eurosei Srl	SME	Lovrin	Timis	2.808	20
Instal Niva Srl	SME	Lovrin	Timis	2.808	20
Municipiul Caransebes	LA	Caransebes	Caras-Severin	3.234	20
Primaria Otelu Rosu	LA	Otelu Rosu	Caras-Severin	0.918	20
Sc Corvin Fotovoltaic Srl	SME	Ghelari	Hunedoara	6.4	20
Sc Maxagro Srl	SME	GATAIA	Timis	8	110
Sc Megaconstruct Srl	SME	GATAIA	Timis	8	110
Sc Iosca & Erjica Srl	SME	GATAIA	Timis	8	110
Sc Maxcenter Srl	SME	GATAIA	Timis	8	110
Sc Montana Energy Rom Srl	SME	Stanesti	Giurgiu	5.5	20
Primaria Vanatorii Mici	LA	Vinatorii Mici	Giurgiu	0.1	20
Primaria Gogosari	LA	Gogosari	Giurgiu	0.17	20
Sc Energy Green Biomasse Srl Giurgiu	SME	Adunatii Copaceni	Giurgiu	2	20
Consiliul Judetean Giurgiu	LA	Slobozia	Giurgiu	1	20
Sc Turbo Consult Srl	SME	Vidra	Ilfov	0.25	20
Parc Solar Tm Srl	SME	Sacosul Turcesc	Timis	2.9	20
Primaria Socodor	LA	Socodor	Arad	0.111	20
Primaria Graniceri	LA	Siclau	Arad	0.097	20
Primaria Herculane	LA	Herculane	Caras-Severin	0.53	20
Primaria Firdea	LA	Firdea	Timis	0.25	20
Primaria Vinga	LA	Vinga	Arad	0.45	20
Primaria Prigor	LA	Prigor	Caras-Severin	0.1	20
Eurocons Expert Srl Deva	SME	Ulies	Hunedoara	0.99	20
Joint Systems Srl	SME	Ulies	Hunedoara	0.99	20
Primaria Dumbrava	LA	Dumbrava	Timis	0.25	20
Primaria Dumbravita	LA	Dumbravita	Timis	0.31	20
Banattika Srl	SME	Iecea Mare	Timis	1	20
Primaria Semlac	LA	Semlac	Arad	0.3	20
Ferart Srl	SME	Ulies	Hunedoara	0.99	20