Aspects of the use solar energy valorification for industrial and public lighten area

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Abstract. The paper presents a viable success alternative for solar energy valorification to generate electricity for industrial lighten system and city streets lighting system in Baia Sprie town. Electricity provided by solar power plants since 2016 and used for lighting the industrial area, urban parking, street lighting, partially replacing conventional energy. Within the Romanian Regional Sustainable Development Strategy there are several measures meant to obtain electricity from renewable energy sources which do not produce negative effects for the environment, which means that the expansion of the photovoltaic plant is desirable. In accordance with the Development Strategy of the town of Baia Sprie, the increase of the plant’s productions capacity through the extension of the plant surface for can be used by private consumers in different industries (woodworking, insulating windows, tinsmithing, conservation of forest fruits etc.).

1. Some considerations on solar energy

Conventional energy sources based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time damaging to the environment and to human health, especially by increasing the atmospheric levels of CO₂ even bellow 50µg/m³. So all over the world they search for alternative and renewable energy resources for electricity production.

The potential of alternative resources such as biomass, wind, solar, hydropower, and geothermal is enormous, and can provide sustainable energy services. It is becoming clear that future growth in the energy sector depends on the renewable energy [1], [2].

One of the renewable energy sources this paper refers to is solar energy used for the production of electricity. Solar energy represents the radiant energy produced by the Sun as a result of nuclear fusion, sent to Earth through space as energy quantum (photons) which interact with the atmosphere and the Earth’s surface, i.e. energy produced directly through the transfer of radiant energy from the Sun. This energy can be captured and used as heat in thermo-solar applications or can be transformed into electricity by means of the photovoltaic cells.

Solar energy could account for 8-15% of global electricity in 2050, depending on factors such as market demand, energy policy, manufacturing costs and technological advances. It may also play a role in providing power to the roughly 1.6 billion people worldwide without access to the electricity grid [3].
Solar cells, also called photovoltaic (PV) cells, convert sunlight directly into electricity, which is called the *PV effect*, discovered in 1954, when scientists at Bell Telephone discovered that silicon (an element found in sand) created an electric charge when exposed to sunlight [4].

Traditional solar cells are made from silicon, are usually flat-plate, and generally are the most efficient. Second-generation solar cells are called thin-film solar cells because they are made from amorphous silicon or non-silicon materials such as cadmium telluride. Thin film solar cells use layers of semiconductor materials only a few micrometers thick. Because of their flexibility, thin film solar cells can double as rooftop shingles and tiles, building facades, or the glazing for skylights.

Third-generation solar cells are made from a variety of new materials besides silicon, including solar inks using conventional printing press technologies, solar dyes, and conductive plastics. Some new solar cells use plastic lenses or mirrors to concentrate sunlight onto a very small piece of high efficiency PV material.

Because the lenses must be pointed at the sun, the use of concentrating collectors is limited to the sunniest parts of the country.

The cost of electricity produced from PV systems is quite higher than from most other competing technologies, but these costs are expected to continue to decline steadily improving in efficiency and increasing rapidly in sales. These potential reductions in cost, combined with the simplicity, versatility, reliability, and low environmental impact of PV systems, should help them become increasingly important sources of economical premium-quality power over the next 20 to 30 years.

Despite the fact that solar energy is renewable and easy to produce, the main problem is that the Sun does not offer constant energy anywhere on the Earth. Moreover, due to the Earth’s revolution around its own axis, and thus of the day-night alternance, solar energy can be used for generating electricity only for a limited amount of time during the day. Another limitation of this type of energy is in relation to weather, viz. during cloudy days the potential of capturing the solar energy decreases noticeably due to the screening of the Sun, thus limiting the applications of this form of renewable energy.

Europe holds a leading position in the production of power produced from solar energy, yet not sufficient enough to reach the objective listed under the European Climate Change Programme, which provisions that by 2020, 20% of the power required for consumption in Europe should be from renewable sources.

From the perspective of solar energy, Romania falls under the European zone B (the first class, class A, contains countries such as Spain, Portugal, Greece, or Italy). In Romania, there are 4 sunny areas that can be defined, from a maximum of 1600 kWh/m$^2$ in the south of the country, i.e. in Dobrogea, to 1250 kWh/m$^2$ in the northern part of the country, figure 1.

![Romanian solar map](image)

**Figure 1.** Romanian solar map [4]

Romania’s geographical position is favourable for the use of solar energy from March to November.
2. The use of solar energy in the NW part of Romania, in the town of Baia Sprie

The areas in the north and north-west of Romania are not the most favourable ones as regards the use of solar energy as renewable energy source, yet mounting certain solar panels or smaller solar energy stations in sunny areas may somewhat contribute to the reduction of the power consumption from primary energy resources, and more specifically to the reduction of pollution generated by thermal power stations.

This option of using solar energy as renewable resource was chosen by a small town in the NW of Romania, i.e. the town of Baia Sprie.

2.1. General aspects regarding the geographical location, the climate and the town administration

Located in the North-Western Development Region of Romania, Maramureş County, the town of Baia Sprie is situated about 9 km from the county capital city Baia Mare. The town lies at the southern base of the mountainous plateau Oaş, Gutâi, Țibles, at an altitude of 380m. [6]

Through its positioning, at the south-eastern foot of the Gutâi Mountain, Baia Sprie is considered a developed town in the contact area of two important relief units between the wide hill depression of Transylvania and the Oriental Carpathians. The town was one of the most important mining centres for non-ferrous metals and gold in the north-western part of Romania.

The climate is specific for the sub-mountainous areas, with an annual average temperature of 9-11°C, abundant rainfall which creates a dense hydrographical network.

The town has an administrative surface of 9602 ha and a population of 17,076 inhabitants [7], including the neighbouring towns of Chiuzaia, Satu Nou de Sus and Tăuţii de Sus.

2.2. The public lighting system and the main power consumers

The public lighting system in Baia Sprie is made up of: switch-on points, distribution boards, junction boxes, subterranean or aerial low tension electric lines, foundations, lampposts, grounding installations, consoles, street lamps, accessories, conductors, insulators, clamps, coatings, command equipment, automation and measurement equipment used for public lighting.

The public lighting network of the town of Baia Sprie is 55 km long. Due to the fact that the town stretches over an extended area, it was required to have a dense network of roads, which make up 178 km all together. Along this system of public roads, public lighting requires great consumption of electricity, leading to major expenses from the local public budget [8].

A detailed analysis of the public electricity consumers in Baia Sprie over the period 2008-2009 highlighted the main consumers, as well as the recorded consumption values (table 1).

| Year  | Public lighting | Schools, kindergartens | Town hall | Culture House | Hostel | Sports hall | Hospital | Total |
|-------|----------------|------------------------|----------|---------------|--------|-------------|---------|-------|
| 2009KW/h | 775.938 | 104.922 | 26.469 | 9.498 | 12.407 | 4096 | 49.119 | 982.449 |
| 2008KW/h | 837.745 | 111.792 | 25490 | 9.088 | 10.868 | 5120 | 42.258 | 1.042.361 |

Of this detailed analysis one can conclude that the main consumer of electricity in Baia Sprie is the public lighting system, whose annual recorded consumption is approximately 80% of the total consumption for the recorded year of the entire town. The entire quantity of conventional electricity is used from the National Electricity System (NES), Romania’s national system of producing and
distributing electricity, without any extra support of energy produced from renewable resources: geothermal, solar or wind energy.

2.3. Solutions regarding the reduction of electricity consumption

The high expenses incurred with the public lighting electricity consumption required certain solutions regarding the considerable reduction of this consumption and thus of the expenses from the local budget. At a first stage, along 2010, a series of measures were taken with governmental support. These measures were aimed at replacing the 2347 streetlights with 483 LED lights and 27 energy-efficient light bulbs, modernising all command and switch-on stations, extending the network with about 400 new appliances, and 4000 metres of network cable. The result of this approach was the reduction of the annual consumption by 20%, yet the solution was not a true success due to the limitations of the support from the local budget [6].

Another viable option, in agreement with the European tendencies regarding the harnessing of renewable energy, has become a priority. Thus, a series of studies regarding the solar potential of the area around the town of Baia Sprie has been carried out. Moreover, a series of scenarios regarding the factors which influence the production of electricity from solar energy, the optimal tilt angle of the photovoltaic panels, their type and number, the surface they cover, the right positioning, the size of the electricity production capacity etc. have also been analysed.

All these aspects were aimed at achieving an optimal production of electricity by harnessing solar energy in order to ensure sustainable energy for the public consumers in the town of Baia Sprie, whose energy consumption is soaring.

2.4. Baia Sprie Solar power plant

When calculating the energy the photovoltaic system would be required to produce, it was considered that the development of the town would lead to the increase of electricity consumption reaching a value of 1,250,000 KW/h (1250 MWh), and when estimating the electricity production capacity, this projected consumption was considered.

The studies lead to the design and implementation of a solar power plat (figure 2) in Baia Sprie in the autumn of 2015, with the following technical specifications:

- 896 photovoltaic panels with monoaxial solar orientation (figure 3);
- the length of use of these panels can be 25-30 years;
- 4 power inverters with a power of 60 kW each (figure 4);
- 250 kVA power converter station to which the inverters are connected (figure 5);
- the annual electrical output is 265 MW;

The solar power plant activity is monitored in real-time on the Internet. The solar power plant functions 24/7, 365 days/year, except during the night.

The solar panels transform the captured solar energy into continuous current, then, with the help of the power inverters, it is transformed into alternative tree-phase electric power and transported to the power converter station. All the electricity produced is uploaded into the national electricity system (NES), from where it goes to the public consumers that are connected to it.

Figure 2. The solar power plant [9]  
Figure 3. Photovoltaic panels [9]
The monthly variation of energy produced in 2016, as compared to the projected energy, is represented in figure 6.

The greatest difference between the projected electricity and the generated electricity were recorded in January, February, March, October, November and December, when the meteorological conditions were unfavourable for capturing solar energy (cloudy sky, abundant snowfall, invisible sky due to fog, glaze, and heavier rainfall than the multiannual average). These differences vary from a minimum of 2.2 MWh, in February, to a maximum of 6.7 MWh.

In December, April, May, August and September, due to favourable meteorological conditions, the generated electricity recorded significantly higher values as compared to the projection for those months.

For 2016, the projected quantity of energy was 265.1 MWh, and the energy produced by the solar power plant was 253.1 MWh, i.e. 12 MWh less. This difference was determined by a series of technical problems (5 in total in 2016) which occurred in the operation of the grid of the National Electricity System, which made it impossible to insert the electricity generated by the solar plant.

At the same electricity generating capacity, over the year 2017, without December having finished, estimating the generated electricity identical to the one from the previous year, i.e. of 4.1 MWh, the solar plant produced 265.92 MWh, exceeding the annual projected value by 265 MWh. The data are centralized in figure 7.
3. Conclusions
The Baia Sprie solar power plant is the first of its kind in Maramures. The presented solar power plant generates enough electric energy for covering the total electric consumption of the industrial and public lighting system in Baia Sprie, between May and October, but for the period between November and April it can cover only 20.24% of the electric consumption necessity. During the aforementioned period, the day is shorter, and the weather is not quite favourable for solar power use, so the electrical production decreases.

Within the Romanian Regional Sustainable Development Strategy there are several measures meant to obtain electricity from renewable energy sources which do not produce negative effects for the environment, which means that the expansion of the photovoltaic plant is desirable.

In accordance with the Development Strategy of the town of Baia Sprie, the increase of the plant’s productions capacity through the extension of the plant surface for can be used by private consumers in different industries (woodworking, insulating windows, tinsmithing, conservation of forest fruits, etc.).

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