Scientific activity in the problems of technical and economic modeling of solar stations. An example of unstable climatic conditions

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Abstract. Bibliographic analysis of the dynamics of scientific publications by the software used were carried out. In the scientific and educational field, HOMER and RETScreen programs are the most popular, and in the engineering and applied fields - TRNSYS and PVSyst. To demonstrate a typical “local” type of modelling, the HOMER program have been used for the Leningrad Region, Pushkino, a region with unstable climatic conditions.

1 Introduction

The exceptional growth of alternative energy [1] is an important factor in social development. For example 171 gigawatts were installed in 2018, of which 84% are solar and wind. In our work [2], the four directions of the development have been analyzed:

- Production of equipment and power plants.
- Installation and maintenance of power plants.
- State regulation and interaction with financial institutions.
- Science and education.

The first two direction are associated with a huge cash--flow, high risks, and a very high cost of making erroneous decisions [3]. To describe the interaction with government and financial institutions, a special analysis is required, which is not considered in this paper. The study of the problems of alternative energy in science and education enjoys avalanche-like growth. Since the beginning of this year, over 19,000 articles have already been published devoted to the study of the technical and economic aspects of solar energy. Note, that most of the authors of these works do not have the resources, technologies, and practical experience to create real-life systems. However, the pressure from government and university management requires activity. Computer modeling is, for them, in fact, the only feasible way. Published articles can be divided into the following areas:

- Study of the local balance of generation / consumption for various geographies.

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• Studying the global balance of generation / consumption at the country / region level.
• Modeling a single photovoltaic cell and solar power plant.
• Integration of geographic data with technical and economic models, improving the data for GIS systems.
• The impact of alternative energy on society, the environment. Some authors consider the “green” movement as a kind of cult philosophy.

2 An example of unstable climatic conditions

We carried out [2] a bibliographic analysis of the dynamics of scientific publications by the software used. In the scientific and educational field, HOMER and RETScreen programs are the most popular, and in the engineering and applied fields - TRNSYS and PVSyst. Computer modelling is the easiest way to “join” alternative energy field for the beginners, and for professionals - a good method of preliminary assessment of functionality and risks.

To demonstrate a typical “local” type of modelling, the HOMER program have been used for the Leningrad Region, Pushkino, a region with unstable climatic conditions. Any solar modelling program requires input data of different types and is typically integrated with a GIS (Geographic Information System) such as NASA databases. In Fig. 1 annual changes in solar radiation with long periods of variable cloud cover are shown.

![Fig. 1. NASA data of the solar radiation intensity for a horizontal surface with coordinates (59.709303,30.440056) IAEP, Pushkin, from 13.10. 2015 to 10/13/2019.](image)

In Fig. 2 the results of calculations (volumes of electricity generation, purchase and sale depending on the time of day) for a solar station with a capacity of 36 kW, approximately corresponding to the needs of a small agricultural farm are shown. In the NASA database also available: humidity, temperature, wind at different heights and others. The ease of integration and the availability of a wide variety of visual formats makes NASA Power the
main source of data for solar modelling, however it often can be used only for a preliminary analysis of solar-wind energy installations. Depending on the power of the station, the amount of energy consumed and the time of year, it is possible to optimize the conditions of its operation in advance. In Fig. 2 shows that with a shortage of electricity, which can be caused by adverse weather conditions or increased demand for electricity, there is an additional consumption of energy from the grid (blue color). Brown indicates the amount of solar electricity. Depending on the mode of consumption, surplus electricity can be transferred to the network (green). For more accurate technical and economic simulations, in addition to GIS data described above, additional forecast parameters are required: dynamics of consumption, discount rates, inflation, degree of risk, degradation of equipment parameters, etc. They cannot be obtained from standard databases.

Fig. 2. The result of the HOMER program for generating electricity from a 36 kW solar station and associated cash flows.

3 Conclusions

Thus, the success or failure of a specific installation of a solar power installation depends both on the flexibility of the analysis tools, and on the quality of the description and assessment of the specific situation, the forecast becomes difficult for regions with unstable climatic conditions. To obtain a long-term forecast of cash flow, associated with a solar power station, a number of parameters must be taken into account: the power of solar cells, the amount of energy consumed, the potential increase in the cost of buying and selling energy, the seasonal decrease in solar insolation, and its instability. The listed parameters that
affect the output indicators can be taken into account when drawing up the graphs of the cost estimation of the plant life cycle, shown in Fig. 3.

Fig. 3. The result of the prognostic assessment of the aggregate nominal cash flow (in $). The blue color indicates the most favorable situation; the gray color indicates the basic, not optimized situation.

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