Modeling the energy storage system from photoelectric conversion in the phase-change materials accumulator

Due to the need to reduce greenhouse gas emission and the need to increase the energy independence of countries as well as considering the progressive depletion of fossil fuel resources, renewable energy sources, such as solar energy, have been used increasingly. Given the cyclical nature of the availability of solar energy, its efficient usage depends on the use of efficient and effective energy storage systems. Storage of energy using specific heat and latent heat allows the use of batteries with variable phases and it can be used in a very wide range of capacities and temperatures. Energy storage currently seems deliberate and justified not only in the power industry, but also in agricultural production, e.g. for drying processes, preparation of process water, or for heating e.g. greenhouse facilities.

In connection with the above, the essence of the doctoral dissertation was the research and analysis of modeling the energy storage system from photoelectric conversion in the phase change battery.

The work covers three areas of issues. The first of them consisted of an analysis of a current state of knowledge on the existing methods of energy storage including the energy coming from photoelectric conversion. The possibilities of energy storage are presented and the methods of modeling the energy storage system are mentioned.

The second area included gathering, ordering and analyzing data recorded by a computerized measurement system from the photovoltaic plant under test and a phase change battery. The second stage also presents the methodology for the construction of four models:

1. Electricity yield from solar radiation conversion for the tested types of photovoltaic cells.
2. Energy storage in the PCM battery.
3. Heat loss in the PCM battery.
4. Gathering energy from photoelectric conversion in the PCM battery.

For their construction, selected modeling methods were used, such as: artificial neural networks (SSN), random forest (RF), boosting regression trees (BRT), multivariate adaptive regression splines (MARS), standard multiple regression (SMR), classification and regression trees C&RT (CRT), chi-squared automatic interaction detection (CHAID). For their construction, selected modeling methods were chosen, such as artificial neural networks (SSN), random forest (RF), reinforced regression trees (BRT), MARSplines (MARS), standard multiple regression (SMR), standard C & RT regression trees (CRT), exhaustive CHAID for regression (CHAID). The choice of methods was made on the basis of literature review and previous analyses. Then, the quality of selected models was evaluated using:

1. Absolute forecast error (APE).
2. Mean Absolute Percentage Error (MAPE).
3. Share of balance differences with respect to the sum of actual values (ΔESRt).
4. Mean Squared Error (MSE).

The implementation of the main purpose of the work was preceded by the DSC technique of properties used in the R58 paraffin storage reservoir, which was necessary to model the process of energy storage while charging the PCM accumulator.

The last area of the issues was the presentation and discussion of the obtained research results. Failure values were determined and interpreted, and the impact of input data on the quality of the analyzed models was evaluated and then the model with the lowest error values was selected.

On the basis of the results obtained, the research hypothesis put in the work was positively verified. The final result of this doctoral dissertation is the construction of such a model that will enable selection of the type and size of the solar power plant for energy storage system from photoelectric conversion.

The collected research material and analyses will allow agricultural producers involved in growing plants under covers to use the presented method of energy storage from photoelectric conversion in the phase change battery.