

Energy storage device as a part of electric energy production system based on renewable energy sources

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1. Introduction

This work deals with an energy storage device as a part of electric energy production system based on renewable energy sources. The system supplies given load with known load diagram. Operational diagrams of individual units in the system are determined in an optimization procedure. The optimization goal is to supply given load with minimal use of conventional energy delivered from electric grid. Optimization is performed by a stochastic search algorithm called Differential Evolution [1] for the system consisting of a solar power plant, wind turbine unit, flow battery (VRB unit), load and the electric grid. Individual elements are described in [2]-[7]. The optimization input data are given weather forecasting and forecasted load diagram.

2. Models

Models of all units in the discussed system are needed in the optimization procedure together with the calculation of solar irradiation and wind power [2]. In general, they can be given in the form mathematical expressions or in the form of look-up tables. In the given case, the models or better input-output relations of individual units in the system are applied in the optimization procedure in the form of look-up tables.

3. Differential Evolution

In the given case, the operational diagram of VRB unit [7] is to be determined by the optimization for 24 hours long interval of observation. The goal of optimization is to minimize value of the objective function q , which is defined by (1).

$$q = \mathbf{e}^T \mathbf{e} \quad (1)$$

The objective function represents the sum of squared differences between consumption and production of electric energy \mathbf{e} . \mathbf{e} is defined by (2):

$$\mathbf{e} = (\mathbf{P}_{SOLAR} + \mathbf{P}_{WIND} - \mathbf{P}_{VRB} - \mathbf{P}_{LOAD}) \frac{1}{\mathbf{P}_{inst}} \quad (2)$$

where P_{inst} is the total installed power of photovoltaic unit, wind turbine unit and VRB unit. Vectors P_{SOLAR}

and P_{WIND} represent power produced in the solar cells power plant and wind turbines power plant, respectively.

4. Results

Figs. 1 and 2 show optimized operational diagrams of individual units in the discussed systems determined for two different cases. Fig. 1 shows results for the case when electric energy produced from renewable sources is in the same range as consumption while Fig. 2 shows results for the case when consumption is higher than production of electric energy from renewable energy sources.

5. Conclusion

This work deals with the system of devices for production of electric energy from renewable energy sources installed at the University of Maribor. The system consists of photovoltaic unit, a wind turbine unit, VRB based energy storage system and load. The goal of this work is to determine operational diagrams of individual units in the system by optimization in order to minimize use of electric energy from the grid.

References

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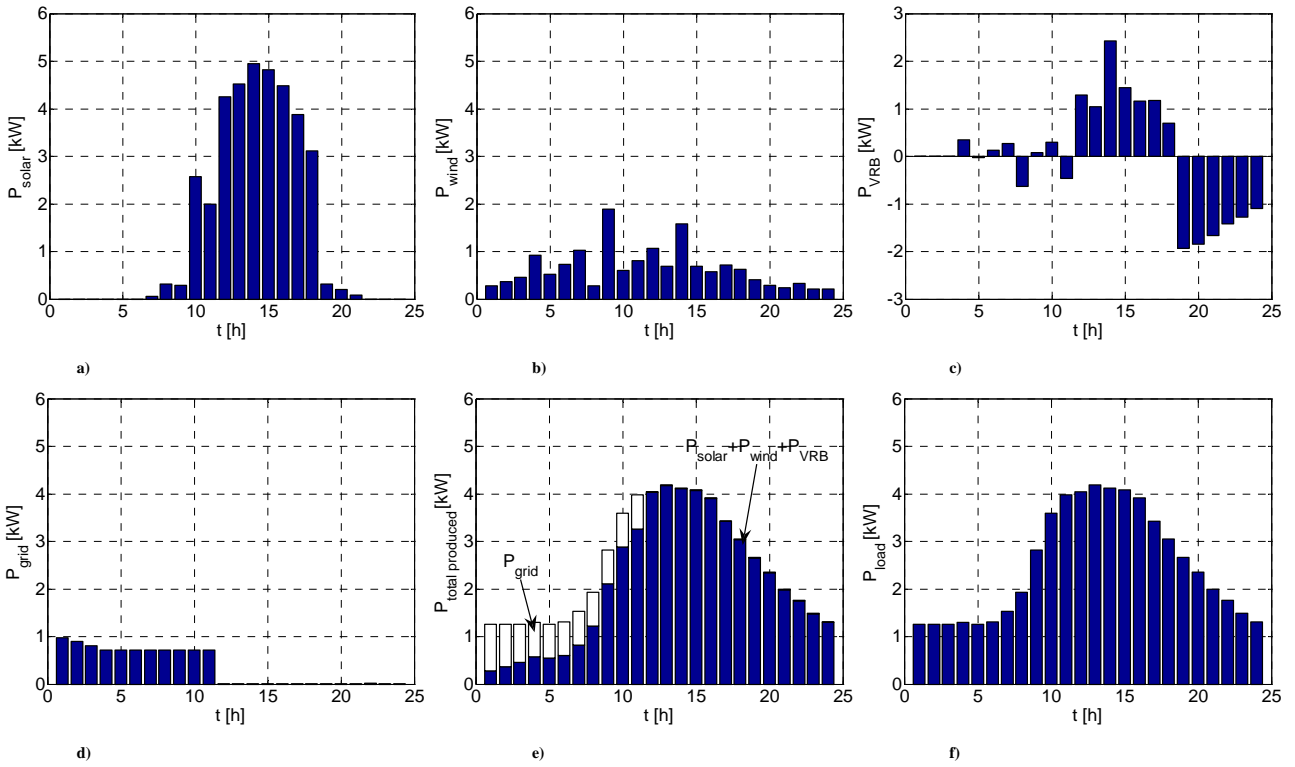


Figure 1: Power from the photovoltaic unit a), power from the aero generator b), power from the VRB unit c), power from the grid d), total power produced in the system e), and load diagram f).

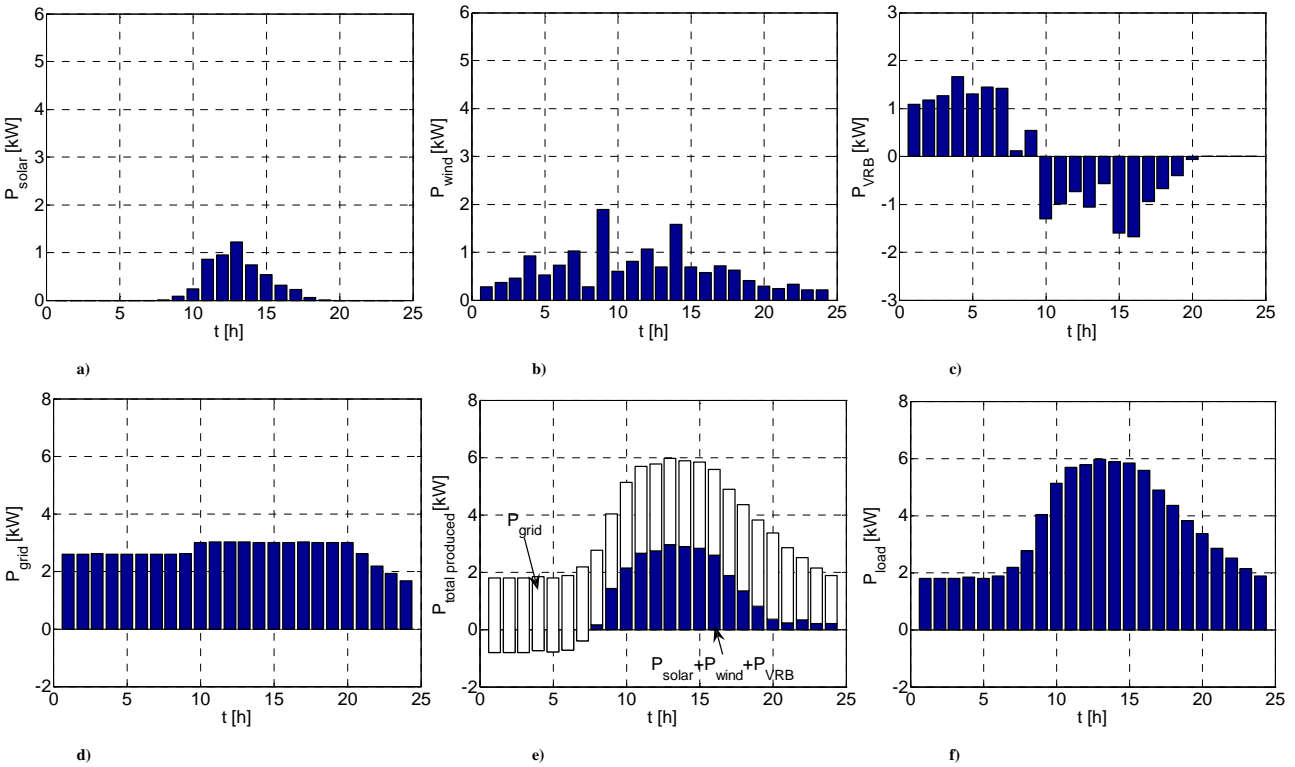


Figure 2: Power from the photovoltaic unit a), power from the aero generator b), power from the VRB unit c), power from the grid d), total power produced in the system e), and load diagram f).