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Intellectual Hybrid Renewable Energy Systems

It is considered a new approach to the creation of Intellectual Hybrid Renewable Energy Systems. It is shown that for the solution of this problem it is necessary to use genetic algorithms. The new genetic algorithm is proposed and its features are given.

Actuality. Nowadays, renewable energy sources have probable potential to contribute to fulfill partially to the energy increasing demands worldwide as such sources are reliable and inexhaustible to a great extent.

The most studied solution to improve the sustainability of the power generation infrastructure is the implementation of stand-alone decentralized Hybrid Renewable Energy Systems (HRES). The main objective is to exploit the available renewable resources in order to improve the overall efficiency and cost-effectiveness of the system. Several optimization methods have been developed to find the optimal hybrid energy configuration. Hybrid renewable energy systems have been widely used for electricity supply in remote and isolated locations far from the electricity public distribution network. These systems provide a relatively reliable source of electricity generation and operate in an unattended manner for extended periods of time if they are properly sized, designed and maintained. However, these systems do suffer from the natural fluctuating attributes solar and wind energy sources.

Optimization of Hybrid Renewable Energy Systems.

The cost of the individual system is a function of its power size. Thus, the optimal sizing of a hybrid system is a far important aspect of system efficient functionality.

Several factors, such as climatic data, system’s component costs, and the temporal distribution of the electric load have to be taken into consideration in the hybrid system design. The optimal design for HRES is dependent and closely related to place of application.

The main objective of the present study is to determine the optimum renewable energy subsystems of HRES that can provide the electricity needs of for example, typical residential buildings.

The system sizing and costing optimization is carried out based on the on-site measured data of renewable sources energy characteristics included into HRES.

The optimization methods used to analyze HRES are focused on three problems: (1) to find the optimal HRES configuration, (2) to design strategies for optimal dispatch, or (3) to address both problems concurrently.

In particular, the first problem has been tackled using several optimization methods, including linear programming [1 – 3], dynamic programming [4], genetic algorithms [5 – 7], and simulated annealing [8, 9].

The following list contains the parameters used in this study to model each type of energy technology:

- diesel generator: fuel consumption at 100% load, fuel consumption at 50% load, rated power, minimum load, installed cost, maintenance cost, replacement cost, and lifetime;

- Wind turbine: power curve, rated power, hub height, installed cost, and maintenance cost;

- PV cell: efficiency, rated power, area, installed cost, maintenance cost, replacement cost, and lifetime;

- Hydraulic turbine: turbine efficiency, generator efficiency, maximum flow, minimum flow, rated power, installed cost, maintenance cost, replacement cost, and lifetime.

- Fuel Cell: fuel curve slope, rated power, installed cost, maintenance cost, replacement cost, and lifetime.

- Electrolyzer: rated power, minimum load, rated hydrogen production, installed cost, maintenance cost, replacement cost, and lifetime.

- Battery: cycles to failure (80% depth of discharge), nominal capacity, capacity ratio, rate constant, round trip efficiency, lifetime throughput, nominal voltage, maximum charge rate, maximum charge current, and installed cost.

- Hydrogen Tank: rated capacity, installed cost, maintenance cost, replacement cost, and lifetime.

A two-level optimization method has been developed to select the optimal subset of energy components and define its optimal dispatch policy. This multilevel optimization approach combines state-of-the-art methods for solving each subproblem (i.e., hybrid system design and dispatch policy), and its objective is to minimize the Net Present Value (NPV) of the system. The optimal subset of energy technologies is determined by the top-level optimization using an in-house implementation of Genetic Algorithms (GA).

Features of the developed algorithm:

– transition from constraints to additional criteria;

– use the concept of Pareto optimality, dominance and density computing solutions for adaptation decisions;

– adaptive determination of the probability of crossing and mutation;

– use of a special type of crossover – neighborhood crossover;

– support of an external set of individuals (archives) for the implementation of elitism;

– clustering to eliminate clots points and increasing the solution representativeness ;

– "chromosomal treatment" in the area of initial limitations to refine the decisions.

A Hybrid Renewable of PV Solar PV/wind Energy System was developed at the National Aviation University, which is located on the roof of the educational building No. 5 (Fig. 1). Hybrid Renewable Energy System consists of a wind energy system with a combined vertically-axial rotor type Darrie- Savonius, PV Solar Energy subsystem, energy storage battery and control system.

The HRES is completely autonomous, does not require constant control during operation and maintenance. Overall dimensions are 2 m high and 2.4 m wide wingspan. Rotor wind turbine is made of fiberglass and aluminum.

Fig. 1. Hybrid Renewable Energy System “VS-1.1”

The wind energy system itself is made according to the direct drive rotor-generator circuit, which provides high reliability and simplicity of construction. The combined rotor ensures the operation of the system on small winds (at a wind speed of 2 m/s).

Table 1.

Specification

Characteristic	Unit of measurement	Value
Rated power	W	2000
Maximum power	W	2200
Maximum output voltage of the generator	B	~60
Working wind speed	m/s	6-14
Start wind speed	m/s	2
Working range of wind speeds	m/s	4-30
Weight	kg	90
Lifetime	years	20

The graph of the dependence of wind energy system power with a combined vertically-axial rotor on the wind speed is shown in Fig. 2.

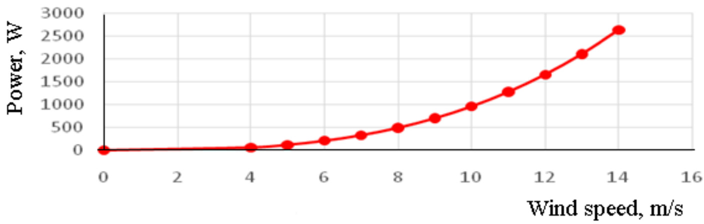

Fig. 2. Graph of the dependence of wind energy system power with a combined vertically-axial rotor from the wind speed

At the moment, the HRES fully provides illumination of the educational building No. 5 at the National Aviation University at night.

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