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Energy Management in the Smart Home

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Abstract

The issues of energy supply of a smart home (building) are considered, taking into account alternative power sources. The components of the energy supply system and the life support subsystem of a smart building, the functions assigned to the energy management system are analyzed, the feasibility of developing such a system to save electricity and solar in the building is shown. The structure of the building automation system is proposed, taking into account the characteristics of alternative power sources and possible restrictions on their use. Approaches to energy management in a smart building using the theory of fuzzy sets and features of such intelligent control are shown.

Keywords: smart home, alternative power sources, solar power plant, fuzzy logic

Introduction

A smart home or a smart building is a complex of special and household equipment that ensures the vital activity of people living or working in this house. At the time, automating the life support processes of a smart home involves the development and implementation of subsystems for monitoring and controlling all equipment and security alarms, which naturally requires the presence of a power supply subsystem, the functions of which are to provide energy to the entire complex and optimize energy management in order to save energy.

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There are a number of concepts for constructing an energy supply subsystem (Danilov et al., 2006), which differ in the use of energy from alternative power sources, mainly solar energy and wind energy. The use of the energy of thermal waters has a number of limitations due to the location of the object - of the smart home. Each of the concepts has the right to exist on the basis of economic, and in some cases special - strategic considerations.

Currently, due to the crisis in the fuel and energy sector, the increase in energy prices around the world, alternative power sources are increasingly being introduced (Stychinsky & Voropai 2016). Solar power plants for individual homes and individual buildings are widely used. In the latter, in addition to roofs, they also try to use facades, which increases the effective area of solar panels. However, with the development of alternative power sources and, in particular, solar energy, the problem of economical consumption of the collected energy, optimization of the operation of the entire smart building complex urgently arises. This problem has a number of particularities.

In individual separate smart houses, the problem is solved relatively easily, based on the peculiarities of using a smart house and on the preferences of its owner. Things are different in smart buildings, due to the nature of the work of different tenants, if the building is intended for business. Given these circumstances, the approach to developing a power supply subsystem with an optimal structure and advanced functions depends on the configuration of the solar power plant system and the devices and equipment used in it. It should be noted that for the purpose of universality or unification, energy management or energy management in such a smart building should cover all possible power sources connected to the power supply system: a solar power plant, a diesel generator, a wind power plant, backup batteries, as well as a solar collector that provides water heating, and finally, all the equipment and systems in the building.

Based on this, the structure of the smart home automation system can be represented as shown in Figure 1.

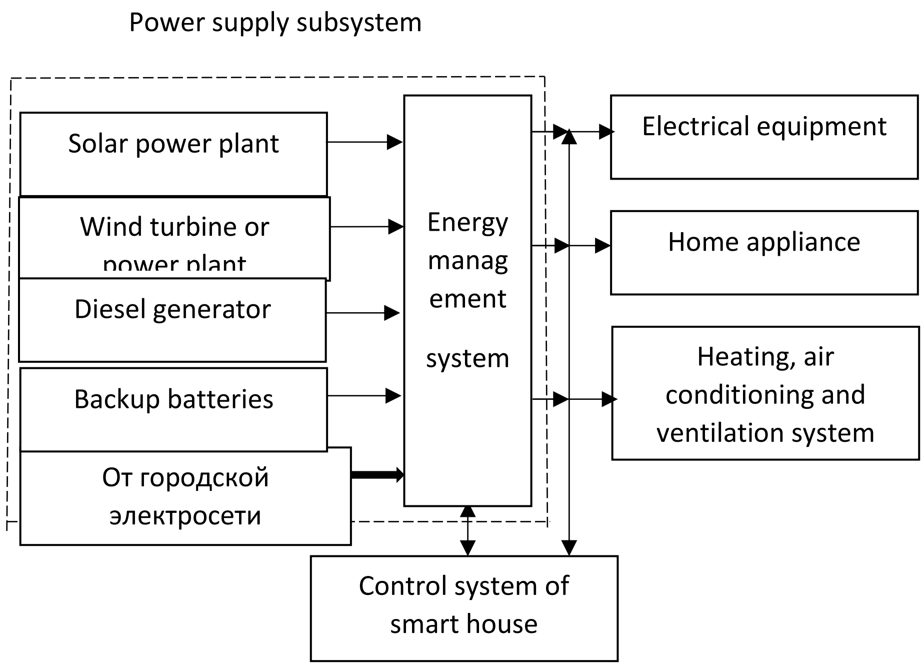

Figure1. The structure of a smart home automation system

The energy management system, together with the smart building control system, ensures timely switching on and off of power supplies and equipment, regulation of the main energy-intensive processes in the building, software shutdown of loads and shutdown of high-power equipment if necessary and in emergency cases (Dyakonov, et al., 2008). In addition, this system controls the mode of transmitting of excess energy into the city network during the hours set for this mode, which increases the efficiency of the solar power plant and the smart building automation system itself.

As the experience of operating solar power plants on photovoltaic solar panels shows, in order to increase the efficiency of a solar power plant, it is necessary to solve the issues of choosing the solar panels themselves and the corresponding equipment, optimizing the power take-off from solar panels depending on the time of day and weather, optimizing charge and discharge control of batteries.

The principle of directing a battery of solar panels to the sun is given in (Arzhanov et al., 2014), which sets out the basic conditions and limitations for automatic control of a solar power plant. In (Dontsov et al., 2015), two algorithms for the solar battery controller are proposed, according to which the controller operates in the modes of charging and searching for extreme power. In (Zubova & Rudykh 2018), the problem of choosing the membership functions of fuzzy sets for optimizing the control systems of a wind turbine is considered.

An analysis of existing systems and control algorithms allows us to conclude that the most appropriate approach to managing the energy of a solar power plant as part of a smart building power supply system is the use of fuzzy logic, both in the control and management system of the station, and in smart building energy management.

Thus, for fuzzy energy management algorithms when using a solar electric system, linguistic variables to be controlled and managed and their corresponding membership functions should be selected. As such values, we choose the power of solar panels and load, the range of charge and discharge of the battery, the limits for changing the coordinates of the solar battery, the limits for changing the temperature of air and panels, the duration of operation of various equipment in a smart building, etc. For each of the selected values, fuzzy rules of the type “if ..., then ...” and the corresponding linguistic terms such as “very small”, “small”, “medium”, “large”, “very large” or “very low”, “low”, “very low”, “low average”, “average”, “very average”, “high”, “high”, very high”, etc. should be develop.

Obviously, to use the developed rules for each of the processes, the well-known scheme of fuzzyfication, logical inference and knowledge base, defuzzyfication, is used, which is given, for example, in (Shtovba, 2003), which also describes the modeling of certain processes using the Simulink package of the MatLAB program (Dontsov et al., 2015). The regulation of the main process parameters is carried out on the basis of a PID controller with fuzzy settings. Modeling and solving problems of this type can also be performed in the Fuzzy Toolbox in MatLAB. As the practice of using fuzzy logic shows, in order to successfully solve the problem, it is necessary to correctly choose the membership functions of each value and the fuzzy model to identify the process under consideration.

Conclusions

The efficiency of a smart building automation system depends on many factors, one of which is the availability of high-quality electrical energy. This circumstance urgently requires the development and implementation of an energy supply subsystem, the operation of which, together with the control system and other subsystems of a smart building, will allow solving the issues of energy management and saving solar, electric and thermal energy at a higher level.

The widespread introduction of alternative and renewable power sources, especially solar panels for powering smart buildings and houses, also allows reducing hydrocarbon emissions in the long term, thereby improving the environment.

The use of fuzzy set theory and fuzzy logic to manage and control various processes in a smart building improves the quality of management of all processes, including the power supply subsystem, by developing an adequate model of processes that in most cases cannot be identified by deterministic models.

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