The Analysis of Computer Software for Selection of the Optimal System of Effective Electricity Supply for Ukraine Autonomous Agricultural Objects

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The issues of substantiation of the expediency of using computer programs to ensure the optimal selection of parameters of renewable energy sources of autonomous agricultural facilities of Ukraine considers in the article. It is noted that the available software packages available for Ukraine do not sufficiently take into account the necessary factors in creating a combined energy supply system. There are given the characteristics of each type of programs and their analysis and comparison. The presented results of research on definition of optimum software complexes show advantages and lacks of each complex and prospects of their application in agrarian branch.

Computer programs, renewable energy sources, hybrid renewable energy sources, mathematical model of optimization.

Introduction

Nuclear, thermal, hydropower, solar, wind and biogas power plants are used in Ukraine at present.

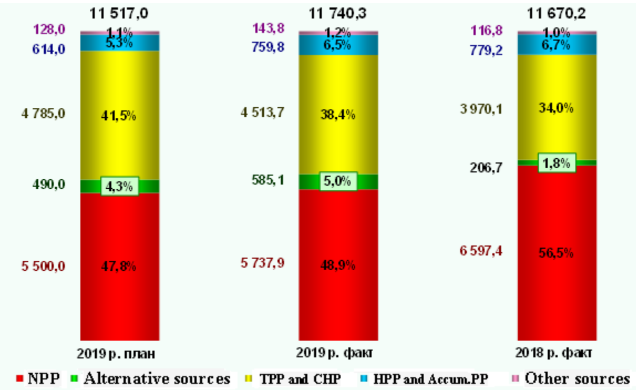

Fig. 1. Structure and volumes of electricity production in the UES of Ukraine in June 2018, 2019 (Information…, 2019)

This structure (Fig. 1) shows that the largest amount of energy from 2019 (and till now too) produced by nuclear (48.9%) and thermal (38.4%) power plants.

68 out of 75 TPP power units have exhausted their design resource and are in operation beyond the park service life, 2 – over the service life limit and 5 – over the park service life, in 2018, what we can see in the NERC annual report (Fig. 2) (Report…, 2018).

As of January 1, 2018, Ukrenergo's maintenance crews were servicing 137 110-750 kV substations (substations) with a total installed capacity of over 78,700 MVA, as well as 21,300 km of 220-800 kV main and interstate power transmission lines (PL).

Ensuring the supply of electricity in remote agricultural areas is a complex task that requires comprehensive consideration and solution.

It is necessary to consider the need to create an alternative and reliable measures to ensure independent power sources (Дурас, 2017) in the agricultural sector and the country as a whole, considering the condition of nuclear reactors and the need for constant repairs for them.

Ukraine choose the course of development of alternative energy sources, that follows Based on the above and considering the obligations imposed on the state by the Paris Agreement and penalties for emissions into the atmosphere of more than permissible CO2. "Energy Strategy of Ukraine for the period up to 2035", where intensive attraction of investments in RES sector is planned on stage 2 up to 2025, contributes to the same (Energy…, 2017). It is planned to increase them in the structure of WPPE up to 25%, by 2035.

Figure 1 shows that Ukraine used nearly 5% of renewable energy sources at 2019 and it is not much bigger now .

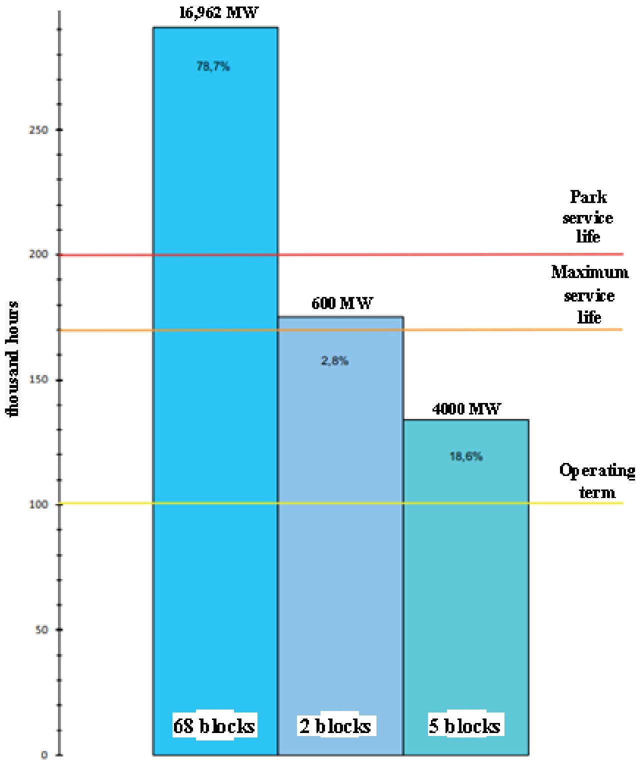

Fig.2. Technical condition of power units of power generating companies of thermal power plants in Ukraine by service life as of 01.01.2019.

The development of renewable sources must be implemented by broader methods and technologies. Therefore, it is necessary to involve software products that would facilitate the use of RES in various combinations. The aim of the article is to analyze the combination of the software products.

Methods

Methodologically, the study will be conducted by analyzing the dormant types of software packages available on the Ukrainian market. The existing and available for Ukraine programs should be analyzed, to determine the best version of the program. The criteria should be: the availability of the trial version, the cost of the program, the availability of the language equivalent and instructions for use, the interface of the program, the functionality of the program (the coverage of the necessary instruments and sources), the mathematical apparatus.

Each software product has its own characteristics that are used and available in the work. This paper discusses the main aspects used in the work of programs.

Software products have their own mathematical approaches, their own design interface, various input parameters, data sources for analysis, various output functions. Each of the product is decomposed into components and analyzed in comparison with others for a wide range of possibilities, in the study.

Results and Discussion

Some scientists consider the application of hybrid energy complexes based on RES in their works. For example, a monograph "Hybrid-Renewable Energy Systems in Microgrids: Integration, Developments and Control" was published (Hina, 2018) in 2018 and every year the topic of HES is gaining a wide mass (Zohuri, 2018), (Djamila, 2020).

Most systems are considered as a combination of solar and wind plants, theoretically (Ramirez Camargo et al., 2019), (Sajid et al., 2019), (Zahedi, 2014), (Tripanagnostopoulos et al., 2010), (Григораш et al., 2016), (Motaz et al., 2013) and practically (Кундас et al., 2012), (Дайчман, 2016), (Люкайтис et al., 2019), (Lawan et al., 2020), analyzing the peculiarities of the application of already established systems.

The most commonly used systems are those that combine solar photovoltaic panels and wind farms, at present. Systems are being developed that will use the most optimal sources of electricity (Weitemeyer et al., 2016), since RES consists of a larger list than SES and WES (Zohuri, 2018).

There are a sufficient number of programs in the world, with the help of which it is possible to select the optimal combination of renewable energy sources according to various parameters. There are also software packages for the calculation of a separate type of alternative energy sources without considering their combination with other sources.

TRNSYS (Transient system simulation program) is developed jointly in the United States, France, Germany – a system, one of the functions of which is the selection of the optimal combination of solar panels.

There are also applications that are used as online calculators. One such example is the solar power plant calculator on the website of Atmosfera.

The use of "HOMER" (Hybrid optimization modeling software), developed in the USA, is impossible (blocked by the company) because of sanctions to Russia and Crimea.

LEAP program (Long-range Energy Alternatives Planning System), Sweden (Stockholm Environment University) – available after registration in the system. It allows you to select and analyze the optimal power plants to reduce harmful emissions of the whole country, taking into account the harmful effects of motor vehicles, and takes into account the financial costs and the specifics of international tax obligations, considering different scenarios. The program can be the basis for selecting the current energy direction of a country, taking into account financial costs, environmental and other components. But she has a rather specific direction that is not useful for more local purposes while using by an individual consumer.

"Hybrid 2" can be found and downloaded from the website of Massachusetts Amherst University, but the drawback is that it cannot be installed on all operating systems that came out later than Windows XP, which is quite inconvenient and makes it impossible to work with the program. In addition, the program description itself already states that the code does not take into account short-term system fluctuations caused by system dynamics or component transients. It is also not possible to take into account HPPs, bio-gas plants, GeoPPs, and sea-wave and tidal systems.

The Canadian program RETScreen Expert allows you to calculate not only renewable energy sources, but also other objects: industrial, commercial, residential, agricultural. The application receives weather data from an integrated online database, using more than 20 sources. The user himself sets the alternative sources he proposes to install and the data of the financial costs he will incur in installation and operation. The program basically calculates the total amount of energy that the consumer will receive over a given period of operation and the reduction of emissions that will be generated as a result of implementing renewable energy sources. The advantage is a small amount of input data, the availability of free access to the Internet and the availability of versions of the program in Ukrainian and Russian. The disadvantages include a large number of factors not taken into account: the variable nature of the wind, the presence or absence of heliostat. The main disadvantage can be considered that the program calculates the entered data without offering options or scenarios for the combination of RES. The appearance of the program interface is shown in Figures 4,5. Its mathematical basis for calculating financial analyses uses formulas from Brealey and Myers (1991) or Garrison et al. (1990), and the risk analysis model is based on "Monte Carlo simulation".

IHOGA, Spain (University of Zaragoza), (Improved Hybrid Optimization by Genetic Algorithms) is a program developed in C++ to help select optimal combinations of RES. The program uses genetic algorithms developed by Dr. Rodolfo Dufo Lopez and others in its basis. Advantage is possibility to set priorities: mono-objective – if optimization is calculated financially (based on Monte Carlo simulation rule), or multi-objective – if optimization by several selected parameters, besides financial optimization, also CO2 emissions into atmosphere, creation of work places during installation and maintenance of plants, etc. (based on Pareto algorithm).

The EnergyPRO program (Denmark) has a number of advantages and disadvantages. There is a wide range of languages available. There are English, German, Danish and with rare updates Polish and Lithuanian. And the demo version has only English, Danish and German.The cost of the license depends on the modules connected by the customer, as well as the period for which the updates. The climatic data are selected from the CFSR – it is an abbreviation of the climatic forecast of the reanalysis system. To calculate the data, the main object needed is a time series of data. This can be weather data, electricity prices, etc. From the data on the site and personal correspondence, the user has the right to purchase a software license permanently or for one year.

Table 1. Comparison of available software products

№	Comparison parameter	RETScreen	IHOGA	EnergyPRO
1	Variety of alternative sources that can be calculated	WPP, SPP, GeoPP, cogeneration plant from biogas plants, HPP, wave energy, tidal energy, ocean wave energy, fuel cell, solar collectors	SPP, WPP, HPP, Hydrogen plants	Cogeneration plant at biogas plants, SPP, Solar Collector, WPP.
2	Availability of free trial version	+	+	+
3	Availability of Ukrainian language	+	-	-
4	Necessity of instruction for studying		+	+
5	Possibility to add another type of alternative sources	+	-	-
6	No types of unconventional energy sources	Hydrogen plant	Cogeneration plant from biogas plants, wave energy, tidal energy, ocean wave energy, fuel cell, solar collectors	Hydropower plants, Hydrogen plants, Geopower plants, Wave energy, Tidal energy, Ocean wave energy, Fuel cell, Solar collectors

The software modules must be paid for in order to work. The remaining modules depend on the needs of the users.

Based on the above – the most available three main programs RETScreen, IHOGA and EnergyPRO, between which a comparative analysis was conducted. Table 1 shows a comparison of the three programs available in Ukraine according to different characteristics.

Table 2. Availability of coefficients used for optimization

№	Comparison coefficients	RETScreen	IHOGA	Energy PRO
1	C_{CO2} = gravimetric penalty for CO2 emissions	+	+	+
2	C_{av} = average generation cost	-	-	+
3	AE – annual return	+	-	+
4	NPC– total system cost	+	+	-
5	LPSP- probability of power loss	-	+	-
6	LCOE – present value cost per unit of energy supplied to customer	+	+	-

Each program has its own mathematical model of optimization. Optimization is carried out taking into account different aspects, so Table 2 shows the coefficients taken into account in the mathematical models of programs.

Consequently, among the above programs RETScreen has technical advantages of use, but there are disadvantages that are not considered: the variable nature of the wind, the presence or absence of heliostat; there is a need to translate the instructions for use. The purpose of the program is only to calculate the data input. No RES options or scenarios are offered. RETScreen facilitates financial accounts, but is not a key software product for selecting a profitable combination of sources.

The IHOGA and EnergyPRO programs have a modern algorithm and broad functionality, but there are elemental and mathematical limitations.

Conclusion

There are programs which by different parameters and characteristics offer the optimal selection of the combination of renewable energy sources to ensure the selection of the optimal system of efficient power supply for autonomous agricultural facilities in Ukraine, but the available programs do not meet the criteria of the greatest optimality and coverage of the existing range of renewable sources. Each of the programs has its own shortcomings. Therefore, in further research it is appropriate to consider options for improvement and functional features of the programs. The mathematical apparatus needs to be improved by covering more criteria expressed through mathematical optimization coefficients. The complex should take into account the majority of RES or be able to add different types of sources, while it is necessary to consider different parameters of installations, which can be designed and installed in small farms of Polessky region and Ukraine as a whole.

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Kompiuterinės programinės įrangos, skirtos optimaliai efektyvaus elektros energijos tiekimo Ukrainos autonominiams žemės ūkio objektams parinkti, analizė

Santrauka

Straipsnyje aptariami kompiuterinių programų naudojimo tikslingumo klausimai, siekiant užtikrinti optimalų Ukrainos autonominių žemės ūkio įrenginių atsinaujinančių energijos išteklių parametrų pasirinkimą. Dėmesys atkreiptinas, jog Ukrainoje turimuose programinės įrangos paketuose nepakankamai atsižvelgiama į būtinus veiksnius kuriant kombinuotą energijos tiekimo sistemą. Pateikiamos kiekvieno tipo programų charakteristikos ir jų analizė bei palyginimas. Pateikti optimalių programinės įrangos kompleksų apibrėžimo tyrimų rezultatai rodo kiekvieno komplekso privalumus ir trūkumus bei jų taikymo agrarinėje šakoje

Kompiuterinės programos, atsinaujinantys energijos šaltiniai, hibridiniai atsinaujinantys energijos šaltiniai, matematinis optimizavimo modelis

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