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TABLE OF CONTENTS

SECTION 1. SMART ENERGY, POWER AND ENERGY ENGINEERING	12
Pavlo Shymaniuk, Igor Blinov and Volodymyr Miroshnyk	
<i>Short-term nodal electrical load forecasting with artificial neural networks</i>	13-16
Ihor Blinov, Ievgen Zaitsev, Viktoriia Berezhnychenko and Yevhen Parus	
<i>Analysis of the effectiveness fault indicators use for control overhead power lines</i>	17-20
Pylyp Hovorov, Anastasiia Kindinova, Vladlen Hovorov and Omer Abdelrhim	
<i>Control of modes of power supply and lighting systems of cities based on the concept of Smart-Grid</i>	21-25
Yevhen Parus, Ihor Blinov and Dmytro Olefir	
<i>Simulation model for assessing the feasibility of using the Energy Storage System for Regulation of Modes of Electric Networks</i>	26-30
Nickolai Bolotnyi and Evgen Bardyk	
<i>An Analysis of Uncertainty for Failure Risk Assessment of Power Transformer</i>	31-35
Valentyna Molokanova, Andriy Maliienko, Vitaliy Petrenko and Ivan Lutsenko	
<i>Problems and concept of electric vehicles energy networks</i>	36-41
Vladyslav Markov, Evhen Honcharov and Natalia Kriukova	
<i>Problems Of Induction Generators Using At Wind Power Plants And Their Computer Simulation</i>	42-47
Vladislav Kuchanskyy, Yuri Lykhovyd, Belik Milan and Olena Rubanenko	
<i>Phase Design and Wires Cross Section Justification of Extra High Voltage Line</i>	48-52
Nickolai Bolotnyi and Evgen Bardyk	
<i>Improved Power Transformer Condition Assessment under Uncertainty using Fuzzy Logic</i>	53-58
Viacheslav Bezruchko, Roman Buinyi, Vadim Bodunov, Andrii Krasnozhon and Oleksandr Miroshnyk	
<i>Choosing the Cross-section of Cable Core for Wind Power Electrical Collector Network taking into account the economic factor</i>	59-62
Milan Belik, Vladislav Kuchanskyy, Yuri Lykhovyd and Olena Rubanenko	
<i>Optimal Value Determining Method of Parameters Compensating Devices of Bulk Electric Networks</i>	63-68
Mykhailo Artemenko, Yurii Kutafin, Ivan Shapoval, Vasyl Chopyk, Valerii Mykhalskyi and Serhii Polishchuk	
<i>Identification of unbalanced power in a three-phase three-wire power system under linear loading</i>	69-72
Mykola Grebchenko, Mykhailo Sopel, Yurii Pylypenko and Dmytro Voitov	
<i>Quasi-bilateral method for determining the distance to the ground fault of unilateral power lines</i>	73-77

Sergii Saukh and Andriy Borysenko

Representation of Power System Load Control Instruments in the Unit Commitment Model with Cyclic Horizon of Forecasting **78-84**

Oleksandr Burykin, Petro Lezhniuk, Artur Sytnyk, Yuliia Malogulko and Volodymyr Kulyk

Method of estimating the share of electricity consumption of a given consumer, which is provided from renewable energy sources **85-88**

Dmitry Tugay, Olexandr Shkorpela, Yana Forkun, Valentyn Akymov, Denis Bystrov and Radul Makoviei

Monitoring of loss power components in three-phase low-voltage power supply systems **89-94**

Vladimir Popov, Vadim Tkachenko, Vasyl Kostiuk, Olena Yarmoliuk and Ivan Frolov

Optimal Distribution Networks Sectionalizing to Comply Reliability Indexes Regulations **95-100**

SECTION 2. RENEWABLE ENERGY SYSTEMS AND DISTRIBUTED GENERATION 101**Mykhailo Abdulin, Oleksandr Siryi and Tetiana Sheleshei**

Energy and ecological assessment of gas burning boiler equipment **102-107**

Ryszard Strzelecki, Mykola Lukianov and Ievgen Verbytskyi

Feature of Solar Radiation Forecast Services Use for Solar Plants **108-111**

Serhii Denysiuk, Halyna Bielokha and Marina Kolomiichuk

Optimization of consumption of primary fuel in local electricity systems using diesel generators **112-115**

Ihor Sinchuk, Oleksii Mykhailenko, Andrey Kupin, Oleksandr Ilchenko, Kyrylo Budnikov and Vladyslav Baranovskyi

Developing the algorithm for the smart control system of distributed power generation of water drainage complexes at iron ore underground mines **116-122**

Igor Blinov, Volodymyr Miroshnyk and Stepan Loskutov

Comparison of widely-used models for multifactoral short-term photovoltaic generation forecast **123-126**

Sergii Boichenko and Oksana Tarasiuk

World Practicies and Prospects of Using Hydrogen As a Motor Fuel **127-132**

Oleksandr Plakhtiy, Volodymyr Nerubatskyi and Denys Hordiienko

Research of Operating Modes and Features of Integration of Renewable Energy Sources into the Electric Power System **133-138**

Olexandr Shkorpela, Dmitry Tugay and Serhii Korneliuk

Prospects of Implementation of a Synchronous Reluctance Machine in Low Power Wind Plants **139-143**

Petro Vasko, Andriy Verbovij and Serhii Pazych

Simulation modeling of the dynamics of the process of charging the pumped hydro storage station from wind turbine installation **144-148**

Oleksandr Popovych, Ivan Golovan, Stepan Shevchuk and Leonid Listovshchuk	
<i>Means of Complex Design of the Electromechanical System of the Gravity Energy Storage of the WindPower Plant</i>	149-152
Andrii Kondratiev, Oleksii Vambol, Maryna Shevtsova, Anton Tsaritsynskyi and Tetyana Nabokina	
<i>Influence of Technological and Design Factors on the Temperature Distribution in a Composite Being Moulded</i>	153-158
Mykola Ostroverkhov, Vadim Chumack, Mykhailo Kovalenko and Yevhen Ihnatiuk	
<i>Magnetoelectric Generator with Magnetic Flux Shunting for Electric Power Complexes</i>	159-164
Serhii Denysiuk, Halyna Bielokha, Denys Derevianko and Vadym Bronytskyi	
<i>Design and modeling PV converter with hysteresis control</i>	165-168
Mykola Ostroverkhov, Vadim Chumack, Mykhailo Kovalenko and Maxim Falchenko	
<i>Voltage Control of the Magnetoelectric Generator Based on the Change of the Magnetic Resistance of the Auxiliary Flux Circuits</i>	169-174
Viktor Denisov	
<i>Integrated Power System multi-node model, taking into account the nondispatchable of renewable energy sources</i>	175-179
Oleksii Karmazin, Volodymyr Lytvynchuk, Mykola Kaplin and Nickolai Bolotnyi	
<i>Analysis of the Probable Decrease of Load Shedding Reserve in Power System of Ukraine at Installed Capacity of Renewable Energy Sources</i>	180-183
Olexandr Shavolkin, Iryna Shvedchykova, Michal Kolcun and Dušan Medved'	
<i>Variant of Implementation of a Grid-Tied Solar-Wind System with a Storage Battery for Self-Consumption of Local Object</i>	184-189
SECTION 3. SMART CITIES AND BUILDINGS	190
Borys Basok, Borys Davydenko, Svitlana Goncharuk, Anatoliy Pavlenko, Oksana Lysenko and Volodymyr Novikov	
<i>Features of heat transfer through a window with electric heating</i>	191-194
Borys Basok, Borys Davydenko, Oksana Lysenko, Goncharuk Svitlana, Yurii Veremiichuk and Maryna Moroz	
<i>Intelligent management of the building's heat consumption when using individual heat points</i>	195-198
Oleksii Bychkov, Kateryna Merkulova and Yelyzaveta Zhabska	
<i>Improvement of Information Technology for Person Identification for Usage in Energy Smart Systems</i>	199-203
Svetlana Golubieva, Maryna Morneva and Iryna Deuschle	
<i>Increase in the efficiency of controlling marine electric engines by optimizing their control systems</i>	204-207
Svitlana Bevez, Viktoriia Voitko, Sergii Burbelo and Pavlo Stavytskyi	
<i>Approaches to developing an audio system as part of a smart house</i>	208-211

Yuriy Varetsky	212-215
<i>PV Reactive Power Impact on MV Distribution Grid Operating Conditions – Case Study</i>	
Volodymyr Shaleva, Fedir Matiko, Hanna Krykh and Vitalii Roman	216-220
<i>Smart system for monitoring technological process parameters and energy equipment protection</i>	
Vitalii Opryshko, Serhii Denysiuk, Oksana Lysenko, Dmytro Biriukov and Borys Basok	221-225
<i>Demand Response as a possible new service in after-war Ukrainian power system</i>	
Borys Pleskach and Victor Samoylov	226-229
<i>Smart assessment of hidden energy losses at a thermal power plant</i>	
Danylo Filyanin, Anatolii Voloshko, Vasyl Kalinchyk, Olexandr Meita, Andrii Zhuravlow and Vitalii Pobigaylo	230-232
<i>The monitoring of additional heating of the cable</i>	
Olga Chernousenko, Vitalii Peshko, Dmitro Rindyuk and Inna Bednarska	233-238
<i>Effect of Start-up Operating Modes on the Cyclic Damage of Thermal Power Plant Units</i>	
Iryna Shvedchykova, Julia Romanchenko, Inna Melkonova, Hryhoriy Melkonov and Andrii Pisotskii	239-242
<i>Possibilities of Electricity Generation Using Small Wind Generators in Eastern Ukraine</i>	
Stanislav Popov, Mykola Ishchenko, Oleksandr Savytskyi, Liudmyla Ishchenko and Danil Veselovsky	243-247
<i>Mathematical model for prediction of characteristics of power supply in large industrial regions</i>	
SECTION 4. SMART INDUSTRIAL APPLICATIONS AND CONSUMERS	248
Mykola Pechenik, Serhii Burian, Ihor Khudia, Pushkar Mykola and Vitalii Teryaev	249-252
<i>Operation Modes Investigation of Cascade Pump Unit Using Refining Hydraulic Network Model</i>	
Nina Filimonenko, Kostiantyn Filimonenko and Hryhoriy Melkonov	253-257
<i>Peculiarities of the Reconstruction of the Relay Protection of a Transformer Substation</i>	
Joaquim Monteiro, Vitor Pires, Fernando Silva and Sonia Pinto	258-263
<i>A Model Predictive Controller for a Buck-Boost Rectifier of an Electric Vehicle Integrated Battery Charger with a Dual-Inverter Drive</i>	
Yevhen Pistun, Halyna Matiko and Hanna Krykh	264-268
<i>Algorithmization of designing gas-hydrodynamic measuring transducers using structural and parametric optimization</i>	
Mykhailo Seheda, Petro Gogolyuk and Yurii Blyznak	269-272
<i>Mathematical model of analysis of wave electromagnetic transients in three-winding transformers</i>	

Yevgeniy Trotsenko, Volodymyr Brzhezitsky, Yaroslav Haran, Andrii Derzhuk and Mandar Dixit	273-276
<i>Ultimate Effect of Non-Identity of Resistive Elements of High-Voltage Arm on Amplitude-Frequency Characteristic of Voltage Divider (Numerical Results)</i>	
Kateryna Bratkovska, Pavlo Makhlin, Alexander Shram, Dmytro Kulagin and Denys Fedosha	277-281
<i>Estimation of Optimization Approaches of the Energy Intensive Equipment's Power-Time Diagrams of Industrial Enterprises</i>	
Victor Khilov, Natalija Glukhova, Ludmila Pesotskaya and Sergii Fedorov	282-287
<i>Using Fuzzy Control Principles to Improve the Electromagnetic Compatibility of Electrical Supply and Electromechanical Systems</i>	
Valentyn Glyva, Larysa Levchenko, Natalia Ausheva and Oksana Tykhenko	288-291
<i>The propagation of electromagnetic fields of energy facilities modeling in the context of energy saving and public safety</i>	
Sergei Peresada, Yevhen Nikonenko and Serhii Kovbasa	292-296
<i>Field-weakening methods for torque-flux direct field-oriented control of induction motors</i>	
Stefan Zaichenko, Serhii Denysiuk, Göktay Ediz, Umran Ercetin, Denys Derevianko and Volodymyr Dubovyk	297-301
<i>Comparison of energy efficiency of a synchronous electric generator with a spark ignition engine using liquefied petroleum gas and gasoline</i>	
Mykola Buryk, Mykola Ostroverkhov and Ivan Buryk	302-307
<i>Robust Vector Control of the Interior Permanent Magnet Synchronous Motor with a Strategy of Maximum Torque per Ampere</i>	
Vitalii Teriaiev, Anton Dovbyk and Vladislav Kornienko	308-312
<i>Combined Algorithm of Improved Frequency Control of Linear Induction Motors</i>	
Vladimir Voytenko, Vladimir Vodichev and Alexander Kalinin	313-318
<i>Optimization of the Stator Current Vector Control System of the Electric Vehicle Drive with Induction Motor</i>	
Santi Behera, Kishor Sasmal, Sasmita Behera, Nimay Chandra Giri, Olena Rubanenko and Mohit Bajaj	319-323
<i>Design and Control of 11-Level Modular Multilevel Converter with Dual Purpose Inverter for Grid Connected Photovoltaic System</i>	
Volodymyr Gritsyuk, Igor Nevliudov, Mykola Zablodskiy, Vasyl Shynkarenko, Yevhen Rudniev, Leonid Ivanov and Dmytro Yanushkevych	324-328
<i>Numerical Analysis of Thermal Processes in an Electromechanical Pump-Heat Generator</i>	
Kseniia Minakova, Roman Zaitsev and Mykhailo Kirichenko	329-334
<i>Control and cooling of the electronic load solution based on FET-transistor</i>	
Vitor Fernaldo Pires, Armado Pires, Daniel Foito, Miguel Chaves and Armando Cordeiro	335-340
<i>A Fault Tolerant Multilevel Converter Topology for an 8/6 SRM Drive Based on a Cross-Switched Configuration</i>	

Volodymyr Nerubatskyi, Oleksandr Plakhtii and Denys Hordiienko	341-346
<i>Adaptive Modulation Frequency Selection System in Power Active Filter</i>	
Marina Rezinkina	347-350
<i>Protective Coatings Providing Safety and Electromagnetic Durability of Electronics of the Smart Grids</i>	
Konstantin Nemchenko, Tatiana Vikhtinskaya and Valeria Kopyakova	351-352
<i>Using of search methods for effective three-phase feeder load balancing</i>	
Borys Kuznetsov, Ihor Bovdui, Nikitina Tetiana, Valerii Kolomiets and Borys Kobylanskyi	353-356
<i>Adjustment of Two Circuits System of Active Shielding of the Magnetic Field Generated by Overhead Power Lines</i>	
Andrii Dymereets, Alexey Gorodny, Roman Yershov, Anatoliy Revko and Serhii Stepenko	357-362
<i>Static Characteristics of Zero-Current-Switching Quasi-Resonant Boost Converter under Variation of Resonant Circuit and Load Parameters</i>	
SECTION 5. POLICIES, MARKETS AND CHALLENGES	363
Oleksandr Vatrenko and Mykola Iakymchuk	364-367
<i>Energy aspects of thin round elastic plates' stability loss</i>	
Elena Dzhyhun	368-371
<i>Study of the impact of climate change on the volume of electricity production at HPPs in Ukraine</i>	
Serhii Denysiuk, Denys Derevianko, Halyna Bielokha and Stefan Zaichenko	372-377
<i>Cost effective reliability improvement methods in power systems with renewables</i>	
Iryna Kameneva and Elena Dzhyhun	378-381
<i>Forecasting the state of water resources to balance loads and increase the stability of the energy sector</i>	
Andrii Antonov and Dmytro Bosiy	382-385
<i>Renewable electricity sources selection based on the economy applied approach</i>	
Oleksandr Zaporozhets, Larysa Levchenko, Valentyn Glyva and Nataliia Burdeina	386-389
<i>Environment impact assessment for new wind farm developments in Ukraine</i>	
Nickolai Bolotnyi, Oleksii Karmazin and Olexandr Ostapchuk	390-395
<i>Analysis of Prospects for Electrical Energy Storage Application in Power Supply Systems of Ukraine</i>	
Ihor Blinov, Volodymyr Miroshnyk and Viktoriia Sychova	396-399
<i>Comparison of models for short-term forecasting of electricity imbalances</i>	
Oleksandr Novoseltsev, Oleksandr Kovalko, Tatyana Eutukhova and Maria Yevtukhova	400-404
<i>Service-Oriented Logic of Using Information Technologies in the Circular Economy</i>	
Author Index	405-410

Renewable electricity sources selection based on the economy applied approach

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Abstract— The aim of the work is to develop an economically justified approach to the selection of renewable sources of electricity. This aim is achieved by construction an automated algorithm that takes into account a set of restrictions for creating the optimal structure of a photovoltaic station. The work confirms the influence of such factors on project implementation as: electricity consumption schedule, built-up area, photovoltaic station mounting system type, allocated amount of money for project implementation, fixed and variable costs for maintenance of photovoltaic station, cost of electricity. The results of an economically justified approach to the selection of renewable sources of electricity at a real photovoltaic station are given. Indicators such as pay-back period and cash flow were calculated, which show the feasibility of the proposed approach.

Keywords— *renewable, energy, photovoltaic, electricity, station, pay-back period, cash flow*

I. INTRODUCTION

In modern conditions, the share of electricity in the unit cost of production is quite significant and with the increase in electricity tariffs, it becomes even more significant.

It is possible to achieve the minimization of electricity consumption in production, increase environmental standards and profitability of production by introducing renewable energy facilities into existing technological processes [1, 2].

The above is in line with the aim set by 2030 to make all sectors of the European Union's (EU) economy climate neutral [3, 4, 5].

At the same time, the widespread use of renewable energy facilities significantly reduces dependence on hydrocarbons, which in 2022 has become a means of energy blackmail.

The development of renewable energy creates new opportunities for [6, 7]:

- development of science and technology;
- attraction of investments;
- creation of new jobs;
- reduction of energy dependence;
- improvement of health and well-being;
- transition to ecological mobility.

The European Green Deal opens up great opportunities for European industry and the industries of those countries that are integrating into the European Union [8].

New technologies annually make it possible to make renewable energy facilities more flexible and functional. This

allows you to influence entire value-added chains: energy, transport, production, agriculture and construction [9, 10].

II. THE MAIN MATERIAL

Photovoltaic (PV) stations are the most effective, cheap and simple source of electricity. Which are scalable systems, the functioning of which can be carried out both in autonomous, hybrid and fully synchronized with the power system mode.

Of course, the use of PV stations as autonomous power supply systems is quite complicated and expensive, due to the need to store the produced electricity in batteries and the variability of generation of electricity.

Therefore, the most flexible and effective way of using PV stations is to use them for partial compensation of one's own electricity needs. The investment climate of such an event significantly increases when the legislation on Net Metering or Net Billing is in force in the country [11].

At the same time, the appearance of a large number of players in the electricity market will create a supply that will lead to a decrease in the cost of electricity. At this stage, hydrogen energy becomes relevant as a means of storing cheap energy for use at times of peak consumption [12].

Of course, for the political leadership, the departure from carbon energy is difficult and even dangerous, from the point of view of the structure of some countries' economy. But the rate of spread of renewable sources of electrical energy will in any case encourage the development of green hydrogen [13].

Building close relationships and clear coordination of actions between the energy sector and other sectors of the economy will ensure the greatest efficiency from the use of energy from renewable sources.

Such a structure will have a positive impact not only on the development of industry, but also on the improvement of the situation on the labor market, social protection of the population and the training of qualified personnel at all stages of training in educational institutions.

The construction of a PV station to compensate for one's own needs is an investment project designed to solve several problems at once:

- compensation of electricity consumption;
- increasing energy independence;
- reducing the impact on the environment during production;
- improvement of the quality indicators of electricity in the power system;

- making a positive impact on the electricity market;
- stimulating the development of green energy in general.

Accordingly, for each such project, it is necessary to carry out a technical and economic justification, which should show its attractiveness.

Thus, the main indicators for assessing the rate of return on investment of such a project are the investment payback period (PBP) and CASH FLOW.

It is possible to achieve the optimization of which by taking into account all the factors that affect the efficiency of the photovoltaic plant in question.

The PBP can be calculated using the formula:

$$PBP = \frac{CAPEX}{EBITDA} \quad (1)$$

where CAPEX – investment amount, €.

EBITDA – Earnings before Interest, Taxes, Depreciation and Amortization, €.

At the same time, the EBITDA can be presented as follows:

$$EBITDA = SP \cdot P_{SPP} \cdot RC \cdot EP - OPEX \quad (2)$$

where SP – Specific Production, kWh/kWp/year, this parameter depends on the type of Mounting System type (MS_{type}), Coverage Area (CA), and the location of the PV station: $SP = f(MS_{type}, CA, Location)$.

OPEX – Operating Expenses, €, are defined as the sum of Fixed Costs (FC) and variable costs (VC);

RC – Restriction Coefficient ($RC = 1$);

EP – Electricity Price, €.

P_{SPP} – installed capacity of solar power plant, kW.

Installed capacity of solar power plant is directly dependent on the Estimated Power Consumption (EPC), MS_{type} and CA: $P_{SPP} = f(EPC, MS_{type}, CA)$.

In this case, credit funds and payment of taxes on profit are not considered, so CASH FLOW will be defined as the difference between CAPEX and EBITDA.

Based on the above, the following can be formulated. For an average PV station, there are a number of parameters that set limits for its construction and evaluation of the efficiency of operation:

- electricity consumption schedule;
- coverage area;
- mounting system type;
- allocated amount of money for the implementation of the project;
- constant and variable costs for maintenance of the photovoltaic installation;

- electricity price.

Accordingly, taking into account these restrictions, such a renewable energy facility as a PV station will bring the most benefit to the owner.

Summarizing the given statements and based on many years of experience, an approach to solving the problems of implementing PV stations has been formed.

It is presented in the form of an algorithm (Fig. 1) and the above formulas. They combine both technical and economic factors that affect the implementation of the project of building a PV station.

Taking them into account makes it possible to achieve the selection of optimal solutions that will satisfy the needs of the customer.

As an example, let's consider the results of this approach at one of the facilities, which was implemented by SOLAR STEELCONSTRUCTION LLC in 2022.

This is a small public facility that operates during daylight hours and provides services to citizens.

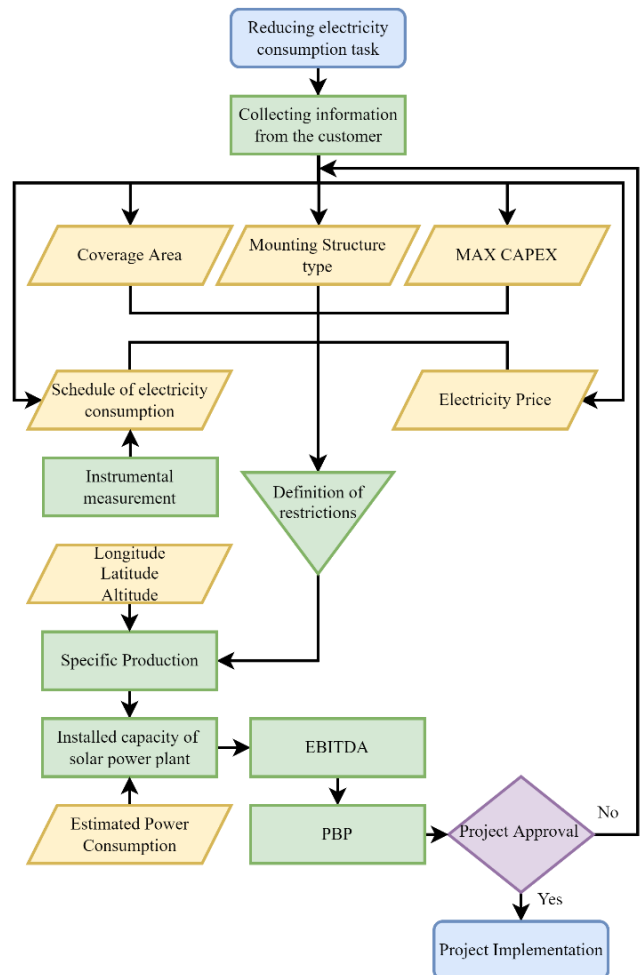


Fig. 1. Algorithm of an economically justified approach to the selection of renewable sources of electricity

The first limitation for this object was the schedule of electric energy consumption, which is built on the basis of the results of instrumental measurement, Fig. 2.

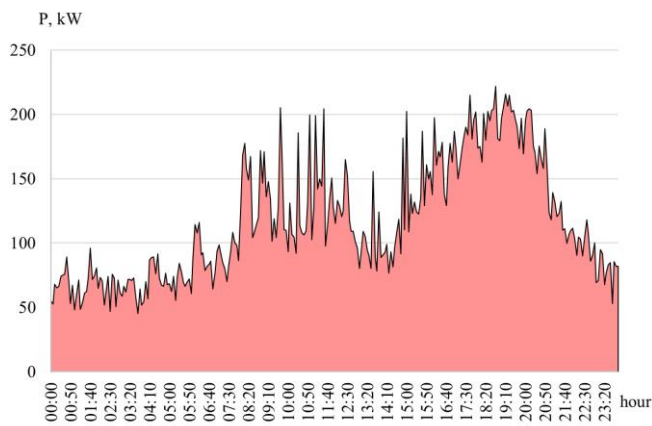


Fig. 2. Schedule of electricity consumption during the day

In the course of a staff survey and analysis of available information on annual electricity consumption, it was established that the constructed consumption schedule is typical for the entire year. There is a slight decrease in electricity consumption on weekends.

The second limitation was the available roofs area of the object, which is 750 m² of usable area.

The third limitation was the use of modular mounting system SRS-EW type from SOLARsk, which allow for the most efficient use available roofs area of the object, Fig. 3 (a) SRS-EW type sample, b) photo of the built station).



Fig. 3. Modular mounting system SRS-EW type from SOLARsk

As a result, 140.8 kW of the installed power of photo modules was placed on the roof of the building, on which various equipment was located.

Funding was not a constraint in this case.

As a result, after conducting engineering research, the equipment was selected and calculations were made to forecast the generation of electricity during the year. The calculations took into account the influence of all meteorological factors and losses. The following results were obtained, Fig. 4.

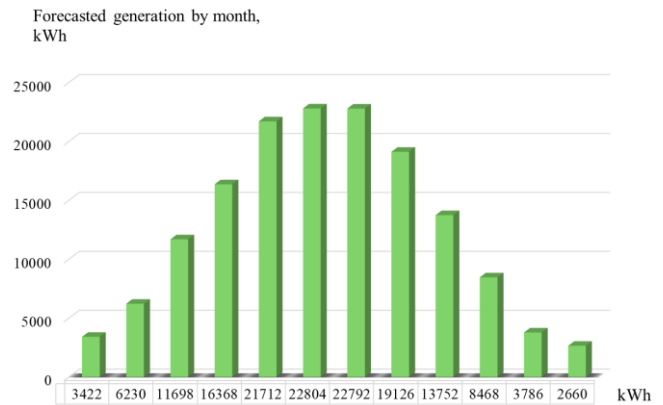


Fig. 4. Forecasted monthly generation of electricity by a PV station

The forecasted electricity generation schedule given is the initial information for conversion into a monetary unit and calculation of monthly EBITDA and CASH FLOW.

Accordingly, taking into account the available information about the company's electricity consumption and project generation, we built a diagram that reflects the CASH FLOW by years, Fig. 5.

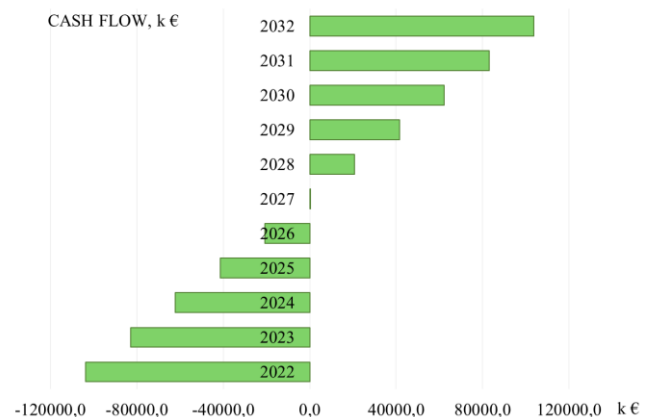


Fig. 5. CASH FLOW for 10 years of PV station operation

The information on the CASH FLOW which presented graphically, clearly shows the rate of return on investments and PBP.

Since this object is built, it is possible to assess how exactly this PV station functions. We present the results of the operation of the PV station on a sunny summer day, Fig. 6.

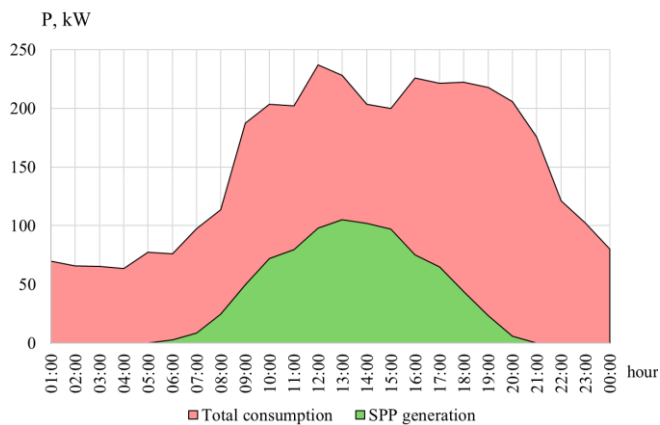


Fig. 6. The results of the electricity producing by PV station during sunny summer day

III. CONCLUSIONS

The presented results show that the generated electricity is consumed in full, while it can be noted that the power of the PV station isn't enough to cover the electricity consumption of this object. This is determined by the existing limitation on the roof area.

Of course, not all objects have a schedule of electricity consumption that is related to daylight hours, but for each case, a separate solution can be found.

Taking into account all the restrictions for this object made it possible to select the most optimal PV station from both a technical and an economic point of view

This article confirmed the greatest impact on the implementation of the project of such factors as: schedule of electricity consumption, coverage area, mounting system type, allocated amount of money for the implementation of the project, fixed and variable costs for maintenance of the photovoltaic installation, cost of electricity.

The correctness and expediency of the formed economically justified approach to the selection of renewable sources of electricity is confirmed by the relevant indicators of the rate of return on investment – PBP and CASH FLOW, as well as the physical implementation of this project.

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