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# SOLAR ENERGY APPLICATION FOR FARM ENTERPRISES ELECTRICAL MAINTENANCE

*Features of livestock houses designing for rural (farm) enterprises with observance of sanitary standards have been described; expensiveness of the design phases, construction and installation works and electricity generation equipment in such buildings is emphasized. Foreign experience in solar cell batteries application has been analyzed. Advantages and disadvantages of the renewable power sources setting up have been determined, particularly concerning the first few years of operation. The dynamics of the energy-intensive equipment installation at farm enterprises of Ukraine has been analyzed, a trend of implementing innovative technologies as an autonomous, maximally independent energy supply source, has been detected. The environmental safety of such energy supply solution and its installation efficiency in any region is emphasized. The possibility is considered for alternative energy supply sources application and energy supply independence of cooperated livestock houses at farm enterprises, particularly under the conditions of persistent reduction in prices for photo-electric modules and persistent growth of gas and electricity rates.*

***Keywords:*** *livestock house, farm enterprise, natural energy sources, solar cell batteries.*

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# ВИКОРИСТАННЯ СОНЯЧНОЇ ЕНЕРГІЇ ДЛЯ ОБСЛУГОВУВАННЯ ФЕРМЕРСЬКИХ ГОСПОДАРСТВ

*Відмічено особливість проектування тваринницьких будівель селянських (фермерських) господарств з дотриманням санітарних вимог; відзначено дорожнечу етапів проектування, будівельно-монтажних робіт та технічної експлуатації електроустановок у таких будівлях. Проаналізовано закордонний досвід використання сонячних батарей. Визначено переваги та недоліки встановлення відновлювальних джерел енергії, особливо в перші роки використання. Проаналізовано динаміку встановлення енергоємного обладнання у фермерських господарствах в Україні, виявлено тенденцію до запровадження новітніх технологій автономного, максимально незалежного джерела енергопостачання. Відмічено екологічність такого рішення з енергозабезпечення, ефективність установлення для будь-якого регіону. Розглянуто можливість застосування альтернативних джерел енергозабезпечення й енергонезалежності в кооперованих тваринницьких будівлях фермерських господарств, особливо в умовах постійного зниження цін на фотоелектричні модулі та постійного підвищення тарифів на газ і світло.*

***Ключові слова:*** *тваринницька будівля, фермерське господарство, природні джерела енергії, сонячні батареї.*

**Introduction.** Until quite recently, in Ukraine, solar energy was only discussed in the academic circles, and it was considered that solar power stations construction and solar cell batteries installation is a costly affair and low efficient in our climes. However, permanent gas and electricity prices growing has caused the interest of common Ukrainians in the alternative electric and energy independence sources [1].

**Analysis of the latest research sources and publications.** Basing upon the analysis of space-planning and constructive decisions of small-space livestock houses, taking into account microclimate parameters, availability of different animal species in a cooperated building for farm enterprises of the Poltava region, the design proposals of cooperated livestock houses [2] have been developed, where the basic performance specifications, requirements concerning space-planning and constructive decisions of cooperated livestock houses, design proposals with applying current technological systems are considered.

Substantiation of space-planning decisions of cooperated livestock houses is presented. New types of houses have been suggested on the basis of the developed cooperated livestock houses nomenclature, matrix of possibilities for cooperating and blocking small-space cooperated livestock houses with different animal species [3]. To calculate the parameters of production premises in a cooperated and blocked building, the algorithm for calculating the livestock house's total area and the production area [4] as well as a block diagram of the calculation program have been developed [5].

**Highlighting the earlier unsolved issues of the general problem.** At present, many solar power stations have been built in Ukraine, both large and small ones. Solar energy projects are popular among the companies and investors, whose primary activity is agro-business. Farm enterprises' owners in the present day environment, having calculated their possible losses and the investments' costs, more frequently decide to install solar power stations.

The main purpose of the above stations construction is the necessity of providing the uninterrupted service of equipment under the condition of interruptible energy supply from electric power networks; additionally, there is a possibility of energy accumulation in the batteries for using it at night or during the low light periods. Besides, farmers can gain profits from selling the electric energy according to «green» tariff.

**The aim of the study** is to disclose the possibility of solar cell batteries application for electrification, hot water supply and heating livestock houses of farm enterprises.

**Basic material and study results.** The peculiarity of livestock houses planning is mandatory compliance with the requirements to the rural (farm) enterprises location. According to [6], the length of sanitary protection zones from various small-space livestock houses to the nearest residential building must make from 15 to 400 m. That means remoteness from energy supply sources, which, in its turn, influences growing prices of the design phases, construction and installation works and technical operation of electric plants.

The greatest advantage of the solar energy application is its availability, because even in winter, sunlight is shining outside, thus, it can generate at least the minimal necessary amount of energy. Additionally, solar cell batteries do possess a long term of operation, so consequently they are perfectly repaid. If you divide the cost of solar batteries installation by the number of years they can be operated, savings will become vivid.

An autonomous solar cell battery can generate the sufficient amount of energy to meet the every-day needs (Fig.1). Besides, the solar cell battery provides the complete independence of the electric power system in future. Additionally, a solar collector does not need careful maintenance: the only thing needed is a periodic cleaning. Moreover, there is no need to pay the electricity bills, and the invested money will be repaid within the 5 years term.

One more solar systems' advantage is that they are easily scaled. That means, that one can buy a small installation with a few panels, and later on one can buy some more. Therefore, if a family budget is limited, transfer to the solar energy is quite possible, though partial.

**Figure 1 – Solar cell batteries at a private enterprise**

First solar batteries able to transform solar energy into the mechanical one were constructed in France. Late in the XIX century, at the World's Fair in Paris, P. Muse, an inventor, demonstrated an insolator, an apparatus focusing sun rays on the steam boiler by means of a mirror. The boiler drove a typing machine, which typed 500 printed copies per hour.

Solar energy was also used late in the XXth century in the USA: a solar battery supplied energy to the American satellite vehicle «Venguard».

The first industrial solar power station was constructed in the Crimea, in 1985, not far from the town of Shcholkine. Its peak capacity made 5 MW. It equaled the capacity of the first nuclear reactor. It has only generated 2 mln kW/hours of electricity for the 10 years period, however, the cost of its electricity was high enough, and the station was closed in the middle 90ies. It was the very time, that analogous works were activated in the USA, where Loose Industries Company launched an 80 MW solar-gas power station in 1989. Over the 5 years period, only in California, there had been built several stations of the sort, with the capacity of 480 MW; the cost of one solar-gas kW/hour was brought to 7 – 8 cent against 15 cent for a kW/hour: that is the cost o f electricity generated by an atomic power station (APS).

Nowadays, the world's leader in using solar installations is China, where solar heat collectors occupy 80% of the market.

In general, all the developed countries of Europe and Asia, as well as the USA, possess the experience of using alternative sources of energy. In Japan, for instance, the total capacity of solar power stations makes directly 3 GW. The most ecologically safe city in the world has been constructed in Japan.

All buildings in it are using solar energy, water consumption is reduced by 30%, and instead of public transport bicycles and electric cars are used. Gasoline service stations are replaced with the electric car service stations.

It seemed that there was too much sunlight in Japan, and it seemed difficult to match the Japanese. However, Germany, which is located more northward than Ukraine, has already installed nearly 9GW of solar panels. Last year, in July, 2015, first in the German history, solar batteries, installed throughout the country, produced the same amount of electric energy as APS: the both generated 5.18 TW (terawatt) hours (it is proved by the calculations made at the Fraunhofer Institute for Solar Energy Systems (ISE), Freiburg, Germany).

In the Republic of Korea 274 MW of solar panels capacity were installed in 2008. It can be compared with the Vladivostok TPP's (thermal power plant) capacity in the same year. In Italy solar power stations with the total capacity of 900 MW were only implemented in 2009, in the USA – that of 475 MW, in Czech Republic – 411 MW, in Belgium – 292 MW, in France – 195 MW.

Current models are so efficient that they successfully collect energy not only in our climes, but even in Yakutia. The largest solar power station above the Arctic Circle has been recently built there; its capacity makes 1 MW, it is also designed to operate in the conditions of frosts up to minus 50°C. The station is expected to save nearly 5 tank wagons of diesel oil for the population next winter; before now, only generators were used, since it was practically impossible to install trunk transmission line at such a long distance.

The first currently known farmer, who has undertaken risks of using renewable power sources in the Subarctic, was Artem Andronaki [7]. In his farm keeping of such animals and birds as ostriches, reindeers, quails, goats, rabbits, various chicken breeds, turkeys, guinea fowls, a peacock and even a sea-eagle is cooperated. All animals and birds are kept by the farmer due to sales of meat and quail eggs, goat milk, ostrich chicken and eggs, live rabbits, as well as at the expense of tourists.

«I'm pleased very much with the solar cell batteries operation in our north conditions! Many people consider that they constantly need direct sunlight. But it is not so! They need ultraviolet light, which penetrates through clouds. My solar panel produces nearly 700 W in overcast days, and 1 kW in sunny days. Thus, the difference is small…», – the farmer thought. The decisive factor for solar cell batteries installation has been a high cost of electric transmission lines repair and the electricity price itself. However, installation itself requires sufficient expenses, and it is the technology's expensiveness is the main reason of the alternative energy sources' slow spreading in the agricultural sector.

In 2015 – 2016, almost 20% of farm enterprises in Ukraine are going to install a solar power station with the capacity starting from 0.5 MW. It is proved by the data of the public opinion poll performed by the Farmers' and Private Land Owners Association of Ukraine.

Taking into account the number of farm enterprises, which made 39563 as of 1, July, 2015, and solar power stations' prices, making about €1300 per 1 kW capacity, in the nearest six months Ukrainian agrarians can buy 8.000 solar power plants with the total cost of €5.2 bln, – experts say, mentioning, that only objects with the capacity of 0.5 MW are spoken about. A solar power plant with the capacity of 0.5 – 1.5 MW will permit complete providing of an average farm enterprise with electric energy.

The above forecast is proved by the dynamics of the energy- intensive equipment installation for the latest year and a half. Thus, while before now, the only one efficient «farm» solar power station with the capacity of 1.3 MW was working in Ukraine (in the village of Ivanivka, Kirovograd region), at present, about 15 such stations with the capacities of 0.5 0 1.5 MW have appeared.

As a result of the last year rotating power cuts, numerous farm manufacturers suffered losses. This year, a lack of coal is observed at thermal power plants, producing nearly 40% of all the electricity in the country. Thus, as of 21, August, 2015, the coal reserves in the Ukrainian TPP made less than 1.3 t, while the norm was 2.7 mln t. At present, five TPP are on the brink of ruin, they are: Kryvorizka, Prydniprovska, Slov'yanska, Zmiyivska and Kurakhovska thermal power plants. According to the data of Minenergovugillya, in 2015 the current monthly electric energy deficiency is estimated to be 250-300 mln kW a year. It is covered due to imports from Russia.

Taking into consideration the region's climate conditions, dimensions, installation, build-up factor and regeneration technology simplification, the solar cell batteries structure is being permanently improved. American physicists have developed a new technology, which provides

raising the solar cell batteries' efficiency by 30% (Fig. 2). The batteries' efficiency is approximately relevant to that of the new generators, having batteries driven by a mechanic motor. Applying the technologies based on the Japanese art of kirigami permits not only obtaining cheaper «green» energy, but just as well reducing the solar cell batteries' manufacturing costs [8].

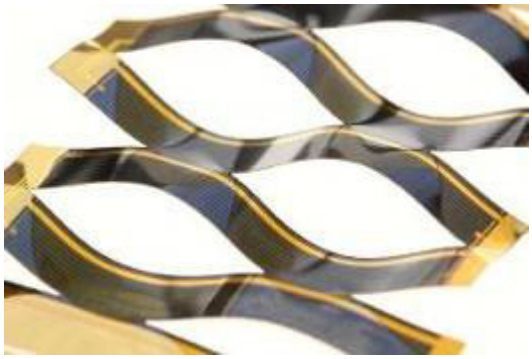

**Figure 2 – Volume elements of the innovative technologies for solar cell batteries manufacturing**

However, what structure solar cell batteries may have, the basic technology of electric energy collection in the livestock house remains unchanged (Fig. 3).

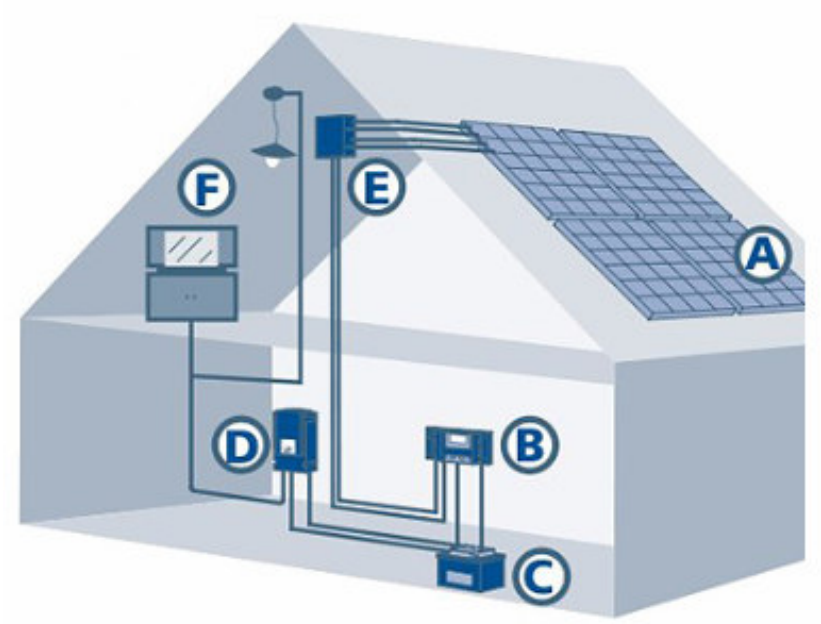


**Figure 3 – An example of a typical network photoelectric system installation in the livestock house:**
A – generator; B – solar panel charging controller; C – accumulator;
D – inverter; E – contact box; F – consumer

**Conclusions.** Energy independence, provided to the farm enterprises owners by solar cell batteries application, is getting closer to reality. More and more frequently solar cell batteries are used as an autonomous, maximally independent energy source. Ecological safety of the above energy supply decision is vivid, as energy is obtained from the renewable source, that is the Sun. There are no limitations on the consumed energy amount. If the total energy consumed was multiplied thirtyfold, even then it only would make 0.001% of the Sun's energy reaching the Earth.

Experts are sure that in the nearest years the demand for solar power stations will remain, particularly under the conditions of the photoelectric modules prices decline. According to the studies of Fraunhofer Institute (ISE), since early 2012, the European modules have got cheaper by 32% up to € 0.73 per 1W, and those of China got cheaper b y 27% up to € 0.58 per 1W. Savings from payments for energy products, centralized energy consumption while using solar cell batteries, are also very significant. Their application is an ideal decision in cases, when the cost of the limits committed by the local heat and power authorities, is excessively high, and in a number of cases it even exceeds the cost of the solar cell batteries installation.

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