Alternative Energy Sources in Resolving Environmental Problems and Providing Safety of Single-Industry Towns

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Abstract. Environmental protection and reasonable use of natural resources stipulates for shaping consumer culture correcting the way of life of a modern society in compliance with the environmental requirements of modern life. It is necessary to introduce the measures efficiently regulating economic activity and orienting it towards environmentally correct forms. It is generally known that the key factor of the further civilization development is an efficient use of energy sources. In this connection, a reasonable way of developing national economy is the replacement of traditional “non-renewable” energy sources by alternative ones. The way of the economic development is the search for new ways of providing the national economy with a sufficient amount of energy with a corresponding reduction of the general volume of its use.

1. Introduction

Many states in the world strive for a reasonable and environmentally correct use of energy resources. For example, the energy capacity of the gross domestic product in Europe for 10 years of a new millennium from 252 kg/1000 $ (in 2000) reduced to 179 $ (in 2010) [1]. In Great Britain some companies successfully apply the system of target energy monitoring while in the European Union there are the following market mechanisms in place: system of “green certificates” (encouraging companies to use renewable energy sources) and the system of “white certificates” (encouraging the reduction of energy sources consumption and greenhouse gas emission) [2].

Energy sources are traditionally divided into non-renewable (traditional) and renewable (non-traditional, alternative). Non-renewable sources include: coal, oil, gas and atomic energy. Non-traditional (alternative) and renewable sources are: biomass, wind, ocean, sun, water motion, geothermal energy, secondary energy sources.

According to preliminary estimates, the potential capacity of non-renewable resources in Russia is as follows: mineral coal – 86 %, oil – 2 %, gas – 2.5 %, nuclear fuel – 8.5 %. Renewable resources have the following potential capacity: hydroenergy – 57 %, solar energy – 7.5 %, wind energy – 18 %, biomass – 17.5 % [3].

2. Rationale

As of today traditional energy sources are generally used, such as: oil, coal, natural gas. However, the growth of global economy can be limited because of the lack of energy sources and continuously growing prices for them [4]. “The environmental consequences of traditional energy sources use cause an urgent problem”. The planet population and energy consumption keep growing. “The general
energy consumption for the following 15 years is going to grow more than 1.5 times”. In future the use of traditional energy sources (mostly heat-electric generation plants), hazardous substances emissions can reach disaster proportions [5].

The energy capacity of the gross national product in Russia is 2-4 times higher than the one in the USA and Western Europe, the efficiency of use of electric and heat energy is lower, correspondingly, by 2-6 times. Energy saving is the way to natural energy preservation. In the modern world the term “energy efficiency” is being increasingly used to denote a type of cost efficient activity directed at reasonable use of fuel and energy resources with the “upgrade of existing technologies and compliance with the requirements set to environment protection”. Today the companies successfully apply such energy sources as solar batteries, biological gas units, mini-hydroelectric plants, wind generators. “People strive to use alternative energy sources to gain the maximum possible amount of energy from renewable resources” [6]. The critical point in renewable energy use was reached in 2015 in the USA. There the cost of electric power energy kW manufacture from solar electric plants and wind electric plants (taking into account subsidy assistance) was equal to the level of electric power production at burning of fossil fuel types. However, even without public subsidies the cost of a kWh of solar electric plants would be equal to 7.2 cents, wind electric plants – 3.7 cents, comparing with 6.1 cents at gas energy and 6.6 cents - coal energy [7]. Today the share of renewable energy sources in the world is equal to 9.3 % while the largest share is taken by hydroelectric plants – 6.8 % of global energy. The other shares account for solar energy, wind energy, geothermal energy and biological fuel. The most developed countries in the area of renewable power generation: Germany, China, Japan, USA and Italy. More than a half of all global energy generated by solar power plants are divided these 5 countries [7]. The European Union sets a task to increase the electrical energy generation by means of renewable energy sources up to 30 % of general energy consumption. In this view solar energy is considered to be the most profitable. The solar energy peculiarity is the possibility to generate heat and solar energy during a whole year round [8]. Solar electric plants are virtually noiseless and do not emit any substances in the atmosphere [5; 9].

3. Research objective
To consider the possibility of applying alternative energy sources in resolving environmental problems and providing safety of single-industry towns.

4. The theoretical part
A single-industry town is a populated area depending on one or several crucial companies. The exceptions can include: town - transport nodes, museum towns, science cities, resort cities/towns which can also have a status of single-industry towns without large industrial companies located there [10]. It is a common situation when Russian single-industry towns directly depend on crucial companies in these towns. The strategy of economic development, energy provision, development of social infrastructure, territory environmental state - all these factors, as a rule, result from the activity of such crucial company.

Consider a typical example of a Ural single-industry town – Magnitogorsk. The crucial Magnitogorsk company is MMK - Magnitogorsk Iron and Steel Works. The energy complex of MMK includes: a heat electric generation plant, central power plant and air-vapor electric plant. In addition, this complex includes a workshop of electric grids and substations, steam power and gas, water supply and energy workshop, the center of energy-saving technologies and electrotechnical laboratory. Energy from electric power plants provides 70% of in-house electric energy for MMK, and the “net cost of it is virtually two times lower in comparison with a purchased one, these plants fully meet the company’s demands in heat energy - heat and vapor, and also cover the city heat demands by 70 %” [11]. The main natural source of energy used by the company is coal. It should be mentioned that in Russia each second kWh is produced with the use of coal while in the European part 90 % of electric power is generated on the basis of gas [12]. The technology of coal burning applied by modern industrial plants, in particular, coal-dust firing and coal burning in the fluidized bed, has a number of
flaws. One of the main flaws are the presence of gold slag dumps and ash occurrence in the atmosphere. Such gold slag dumps contain: SiO₂, Al₂O₃, CaO and many other substances [13]. Polluted aerial environment conditions a large number of diseases: various types of dust diseases, bronchial asthma, various kinds of dust bronchitis and many others. “In the metallurgical industry pollution of the aerial environment at the work places is quite a critical problem”. Metal production is accompanied by “emission of various hazardous gases into the aerial environment” [14].

Modern directions of the environmental policy at industrial companies can be divided into: organizational (providing for a technological procedure, manufacturing discipline, management and control over resource losses); technological (industrial efficiency and re-organization which do not require large investments and made at the expense of current costs); investment (stipulation for a critical reconstruction of technologies requiring large investments). The investment direction of the environmental policy of companies stipulates for “long-term cost demanding measures, for example, introduction of new technologies (biogas, geothermal waters, solar energy, wind energy, heat pump use, etc.)” [15].

The problem of upgrading industrial processes of manufacturing companies are relevant for Russian single-industry towns. The point is not only in increasing the production quality and volumes. Here we speak about the development of the environmental aspect of industrial processes based upon the preservation of natural resources, environmental and industrial safety, human health preservation. Indeed, the application of renewable energy sources on industrial scale in a single-industry town is hardly achievable now. But it is possible to partially introduce the innovations into conventional economic areas. Today Magnitogorsk and its crucial company “MMK” taken as an example are fully provided with energy from non-renewable sources. The environmental pollution indicators are close to the critical limits. The great part of pollution is caused by production wastes. The application of renewable energy sources, such as solar energy, at manufacturing facilities located in the industrial area and adjacent territories will provide for partial “unloading” of the energy complex “MMK”. The application of solar batteries in the infrastructure facilities of the metallurgical plant can become the first step towards the plant upgrade.

5. The practical part
Solar energy can be obtained and applied by means of using solar batteries. As of today there are various kinds of solar batteries: mono-crystalline silicone-based batteries; poly-crystalline silicone-based batteries; belt silicone-based batteries; amorphic silicone-based batteries; film batteries; cadmium telluride batteries. Silicone-based poly-crystalline batteries MSK-200 with the dimensions of 805x1575x40 mm at much lower prices than the mono-crystalline silicone ones due to the content of many admixtures. The useful life of such batteries is approximately 30 years. The relevance of solar batteries use is largely owing to the environment situation and safety as the application of such type of energy obtaining allows one partially stop using non-renewable energy sources. Such transition has a positive impact not only on the environment situation but also on the scientific progress development, for example, a wide introduction of electromotive cars in daily use. Therefore, after some refining of this technology, it can become a fully functional energy source. Solar batteries have an advantage over common electric plants - the batteries can supply energy to adjacent facilities which eliminates the necessity of transporting energy from the power plant to its destination, consequently, the energy losses are minimum. Also, in case of unexpected emergencies the aftermath will not be so critical as in case of electric power plants because the electric power plant failure leaves the whole districts and even cities without energy. The risk of emergency situations at industrial facilities is high, the reliability of their element structures depends on multiple factors. If we consider metallurgical plants, there is always emergency risk [16; 17; 18; 19]. When we use solar batteries a comparatively small number of facilities will be left without energy in case of emergency. Therefore, at optimizing the technology of solar battery use one can obtain quite large energy volumes without significant economic expenditures.
Consider solar batteries in detail. A solar battery consists of several solar converters representing semi-conductors. They directly convert solar energy into electric current. Some of such elements combined in one device and represent a solar battery. The temperature rise has a bad impact on the operation of solar batteries decreasing their capacity. That is why at the installation of batteries on flat surfaces it is necessary to leave a free space at every side of the battery to provide air circulation and heat removal. In addition, for the purpose of decreasing the sensitivity towards the temperature drop at plate manufacture, various admixtures are used such as boron, copper, arsenic, cadmium and others. Snow has positive and negative impact on the operation of solar batteries. The negative impact is explained by the fact that it can become cluttered the space between the battery and surface to which it is fastened and thus prevents ventilation. The positive impact is that the battery absorbs light from all sides, consequently, it can absorb the light reflected by snow with its rear side which leads to the growth in performance. The angle of inclination is important for the efficient operation of solar batteries. The optimal angle depends on the land and varies from 15 to 90 degrees. As a rule, this angle is approximated to the land latitude. According to the solar atlas the southern angle of the sun in the Chelyabinsk region, where MMK is located, is 45° in summer and 9° in winter. That is why the installation of plates should be made under the angle of 30°, therefore, it can cover most of luminous flux for all seasons.

The application of solar batteries at the facilities located in the MMK territory is the idea requiring its development. As of today there is already a project of a multilevel parking in the area of the 5th control post of Magnitogorsk Iron and Steel Works developed by Nosov Magnitogorsk State Technical University.

Consider advantages and disadvantages of solar batteries installation. The advantages include that it is necessary only to install batteries properly, they need no fuel. Automatic regulation and noiseless operation can be also referred to the advantages. Solar batteries do not require turning on and off. Electricity is reserved in special accumulators and thus, energy is available day and night. The battery can occupy a large area of the roof surface making it practical and useful. The advantage of such battery is also a long useful life (not less than 20 years). After 20 years its capacity and amount of processed energy decrease by 70-80%. As the batteries do not have complex mechanisms and moving parts, they are not subject to break and wear. In addition, the advantages include its continuity (stability) and universal access as sun is virtually everything and its light is free in contrast to fuel. Sunlight is a reliable energy source. The battery will generate electric power every day until the dusk even at gloomy weather (although the amount of energy will be less).

Apparently, this system is not ideal and also has its disadvantages:

- need of quite intense light. The batteries will generate energy in any case, but it is more efficient to locate them at the sites with lots of sunshine (non-shaded areas and on the southern side, if possible);
- in winter the efficiency of batteries decreases;
- quite a large area required for their installation;
- quite a high cost as of today.

One of the most critical disadvantages of solar batteries is that the largest amount of energy is generated at daytime while the highest demand for its energy falls on the evening. This disadvantage is offset by the use of accumulators allowing for preserving energy stores and its use any time.

Using an alternative energy source as the main one for providing the infrastructure object of a metallurgical plant with energy is a new and prospective idea. The students demonstrated a creative approach to the project suggesting the installation of a range of solar batteries on the roof of a future multilevel parking in the MMK territory. These batteries will be able to provide power for the whole facility.

The project of the car parking complex stipulates for the installation of solar panels MSK-200, 805*1575*40. They are installed in a row at the angle of 30 degrees with the working surface oriented towards the south. The panels are located in special fastening stands from stainless steel at the height of 500 mm from the roof surface. It is stipulated to prevent panel covering with snow and for a good
operation in winter. The rows of solar batteries are located at the distance of 3,000 mm from each other, it is necessary for panel ventilation, preventing the shadowing of some rows because of the close positioning of others and for the convenience of snow cleaning from the roof.

It is assumed that the generated energy will be used for:
- car parking lightning inside and outside;
- ramp heating in winter;
- electrical device power supply in the territory.

Under the project the modules of solar batteries are fully functional:
- within a temperature range -50°C to +75°C;
- within the range of atmospheric pressure up to 85-107 kPa;
- within the range of relative humidity 0-100 %;
- at maximum rain intensity up to 5mm/min;
- at maximum load snow+wind up to 2,000 Pa.

6. Conclusions

The application of solar batteries at infrastructure facilities of an industrial plant allows gradual upgrade of industrial processes and the economic organization orienting the vector of its development towards a modern and relevant direction. The use of alternative energy sources facilitates shaping of consumer culture correcting the way of life of modern society in compliance with the environmental requirements of the time.

The application of new technologies and materials in construction and reconstruction of the infrastructure facilities of industrial companies will probably set the problem of searching for architectural & designer solutions which, in their turn, can encourage young architects to generate creative ideas. Using alternative sources as design elements of the architectural environment will be supported for the application of additive construction technologies. In any case all the aforementioned will contribute to the development of the architectural environment of single-industry towns modifying them and making them modern and more attractive for the youth [20; 21; 22; 23]. Searching for the options of applying alternative energy sources will facilitate the process of solving environmental problems and safety issues of industrial companies as well as the development of single-industry towns in compliance with modern requirements.

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