Complex Mobile Independent Power Station for Urban Areas

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Abstract. A new type of a complex mobile independent power station developed in the Department of Engineering Communications and Life-Support Systems of Irkutsk National Research Technical University, is presented in this article. This station contains only solar panel, wind turbine, accumulator, diesel generator and microbial fuel cell for to produce electric energy, heat pump and solar collector to generate heat energy and also wastewater treatment plant and new complex control system. The complex mobile independent power station is intended for full power supply of a different kind of consumers located even in remote areas thus reducing their dependence from centralized energy supply systems, decrease the fossil fuel consumption, improve the environment of urban areas and solve the problems of the purification of industrial and municipal wastewater.

1. Introduction
Energy supply systems play a huge role in the life of every modern person. Electric energy and heat supply energy usually obtained by burning fuel recourses. The annual coal consumption in the world is about 3 billion tons. One large Thermal power station burns an average of about 2 million tons of coal per year.

There is not a secret that traditional power engineering have a disadvantages, such as:
- Ecological consequences from processing of fuel for energy supply system [1,2].
- Decrease of fuel reserves and increase of energy consumption [2].
- Increase of fuel price.
- Impossibility of the remote areas energy supply.

Because of such disadvantages the development of renewable energy sources like solar energy, hydro energy, wind energy, ground heat and etc. are so actual [3-9].

Alternative energy has a number of advantages:
- Inexhaustible energy sources [10];
- Accessibility [11];
- Mobility and autonomy [12];
- Environmentally friendly energy production [13-14].

Development and reconstruction of urban infrastructure is impossible without the reconstruction and modernization of life support systems, even based on renewable energy sources. At the same time, the reconstruction and technical re-equipment of building energy and water supply systems, as well as facilities for the purification of industrial and municipal wastewater, is one of the most difficult
engineering tasks. For energy supply and sewage treatment of villages, cottage settlements and even separate buildings it is necessary to build additional energy and sewage treatment plants, with associated complex design work. In most cases, after deterioration or obsolescence of these stations, it is necessary to carry out major repairs and reconstruction or conservation, followed by the construction of a new stations. It is also impossible to move them with reusing in case of a decrease in the number of subscribers of these stations or their complete disappearance for some circumstances.

The complex mobile independent power stations, described in this article, will allow to solve these problems.

2. Purpose of the mobile independent power station
The mobile independent power station is intended for full power supply the residential and production buildings, which do not have the central power supply. This station are suitable for almost any types of buildings and do not require additional design and construction works. It can be used as main energy source so as secondary or temporary energy source. The mobile station can be easy moved from one subscriber to another and integrated to existing energy supply systems of a building.

There are exist the similar stations, like Power container (Research and Production Company "EWA") (Figure 1) [15] or EcosPowerCube (Ecosphere Technologies, Inc) (Figure 2) [16], but most them contain only solar panel, wind turbine, accumulator and, sometimes, diesel generator to produce only an electric energy. There are some modifications which contains heat pumps for heating and hot water supply [17].

![Figure 1. Power container (EWA). Technical features: Mass of 8,5 tons; cost is from 62 thousand Euros; dimensions 6,1 x 2,5 x 2,8 meters.](image1)

![Figure 2. EcosPowerCube. Technical features: Mass of 10 tons; cost is about 96 thousands Euros; dimensions 12 x 4,8 x 3,0 meters.](image2)

3. Development of a new type of complex mobile independent power station
Development of a new type of complex mobile independent power station is carried out by engineers of department of engineering communications and life-support systems in the Irkutsk National Research Technical University (INRTU). Main feature of this station is ability not only to produce electrical and thermal energy, but also to purify wastewater.

For thermal energy generation this complex mobile station contains heat pump, which will take low-potential heat from the ground or the nearest pond.

Also this station contains flat liquid solar collector, named Solar UNit 1 (SUN 1) (Figure 3 and Figure 4) [18]. It is also constructed by engineers of department of engineering communications and life-support systems in INRTU. It has a simple design and improved heat-insulating properties due to increased layer of rear heat insulation and double frontal glass, this will allow to use the solar collector with a lower outside temperature. Spline tubing form allows to obtain a higher outlet temperature and consequently increase the efficiency of solar collector. Also it has a repair ability, that eliminates the
need for a complete replacement of the collector in case of mechanical damage, and a relatively low market price. The SUN 1 model is patented by INRTU [19].

Figure 3. Assembled prototype of solar collector SUN 1.

Also a new type of complex mobile independent power station contains the indirect boiler, which equipped with an additional electric heater.

For electric power generation a new type of complex mobile independent power station contains a standard for such stations equipment, such as solar panel, wind turbine, accumulator, inverter and diesel generator. A part of electric energy, produced by the station, is spent on its own pumps and control system.

Figure 5. Microbial fuel cell.

Figure 6. Pneumatic-hydraulic jet aerator.

For to produce more electric energy this station contains a microbial fuel cell (Figure 5) [20], which takes microbial medium from a wastewater treatment plant (Figure 7) [21], which is also a part of developed station. The plant uses a new pneumatic-hydraulic jet aerator (Figure 6), which is constructed and patented by engineers of INRTU [22]. It has a various productivity on a gas phase and obtaining sizes of gas bubbles from 0,2 to 5,0 mm. It has a simple design and it is easy in operation. Also this aerator is reliable for working in usual and corrosive medium. There is a possibility of rotary model of the aerator with maintenance the reacting mixes in suspension state. Treated water can be used for a technical needs, such as irrigation systems, washing systems, fire-fighting systems and etc.

The station has a new control system, which is also developed in INRTU. It has such advantages as complex control of all power station systems; possibility of saving operational data of the station;
possibility of data transmission on the remote server by means of the GSM module. A control unit operates all mobile station systems and checks all parameters. The power station draft is presented on Figure 8.

![Figure 7. Wastewater treatment plant: 1 – percolator; 2 - settling trench; 3 - anaerobic zone of fermentation; 4 - inert bacteria carrier; 5 - thin layer blocks; 6 – filter; 7 - airlift pump; 8 - pneumatic-hydraulic jet aerators; 9 - catalyst chamber; 10 - ultra-violet water treatment block; 11 – sediment; 12 - thermal insulation; 13 – aeration equipment block.]

![Figure 8. The power station draft: SP – solar panel; WT – wind turbine; IN – inverter; DG – diesel generator; MFC – microbial fuel cell; WTP – wastewater treatment plant; UVWT – ultra-violet water treatment; HP – heat pump; IB – indirect boiler; EH – electric heater; P – pump; TV – thermostatic valve; HE – heat exchanger; SC – solar collector; TS – temperature sender.]

4. Conclusion
In this article were presented a results of development of the new complex mobile independent power station for life support systems using energy-saving technologies based on developments of the INRTU engineers. The power station draft were developed and presented in this article.

This station increases the reliability of uninterrupted power and heat supply from the central energy systems residential, industrial, military and other facilities, reduces the fuel consumption of the diesel generator to 80% of the cost of its operation in the system and also it has the ability to move depending on the specific situation. Availability of water treatment plant allows to expand the functionality of the station. New type of control system will allow a full operation of all station parameters and equipment, increasing the systems coefficient of efficiency.

The new type of integrated mobile autonomous power plant has a relatively small estimated cost which is approximately 39-48 thousands of euro.
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