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Small Green Energy: Implementation through Gamification of the Educational Process

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Abstract - Several new devices related to the field of small green energy, which have a social significance for countries such as the Republic of Kazakhstan, are proposed, particularly, a combined vehicle based on a dirigible with increased travel capability, as well as non-trivial focusing systems that significantly simplify pointing at the Sun. It is shown that at the first stages of the introduction of such devices, it is advisable to use them for the gamification of the educational process. This is justified, first, by the fact that the introduction of small green energy systems into widespread use is not only a technical, but also a social problem, respectively, any non-trivial innovations in this area are initially advisable to introduce in the form of children's games.

***Keywords*:** green energy, educational games, focusing systems, airships, transport network.

1. Introduction

At present, there is no doubt that the widespread dissemination of the ideas of green energy and, more broadly, the formation of an environment-friendly society is not only a technical, but also a social problem [1], [2]. Therefore, this issue is inseparable from environmental education, which main aim is transforming the collective conscience to the ecological one [3]–[5].

From this point of view, the concept of small green energy is very important, which is reflected, particularly, in the works of [6]. In accordance with this concept, main interest is to create a set of technologies, each of which individually provides a relatively small contribution to energy production, but it becomes significant because there are many such technologies.

The introduction of this concept into widespread use will face serious difficulties of an economic nature with the factor of the so-called "valley of death" [7], through which any innovation passes through. The cost of creating an industrial prototype that could have a potential interest of a serious investor is often beyond the capabilities of an individual research group, especially when it comes to innovations focused on a relatively narrow market.

The way out of this situation is clearly connected with the focus on creating children's educational games, since here the requirements for technical efficiency are significantly reduced; the main importance is the educational component [8]. Moreover, such games can be created by students as a completing their final work, i.e., at present, it is advisable to understand the gamification of the educational process in two ways. This is not only the actual games used in the educational process, but also the process of creating such games, which also becomes a component of learning. Among other things, this approach gives a significant space for the imagination of students and undergraduates, games-unlike products used in industry, can have limited sales, technical requirements for them are reduced, etc.

This understanding of the gamification of the educational process becomes especially important for the introduction of the concept of small green energy into widespread use, which, ultimately, is designed to radically change the consciousness of people in terms of their attitude to energy resources, which is especially relevant for the post-Soviet states, where the mass consciousness still considers energy resources almost free.

In this paper, we propose a few educational games aimed at introducing the concepts of small green energy first in the educational process, and then in the mass consciousness.

2. Solar-Powered Transport: Implementation Through Educational Games

For such countries as Kazakhstan, it is critically important to saturate the territory with transport communications. The large territory, most of which is occupied by the steppe, and the low population density raises this issue of a geopolitical level. It is obvious that in such conditions, the creation of a classical transport network will require not only significant costs, but such costs, the payback of which will be in question for more than a long time.

The obvious solution is to create alternative types of transport – vehicles of increased travel capacity, minimally dependent on the supply of fuel. The latter are often critical, for example, for farms, especially those located in remote areas.

Below we consider one of the possible options for creating an alternative transport, which with a certain degree of metaphor can be called a "steppe sailboat". Specifically, we are talking about creating a wheeled transport on wind power. Such projects were previously proposed in the literature more than once [9], but their implementation in practice did not take place, which, obviously, is due to economic reasons, international competition, and mass consciousness focused on road transport, etc. The "valley of death" factor, which was mentioned above, also played a significant role here, and which becomes the more significant the more non-trivial the innovation is.

The simplest design of the "steppe sailboat", suitable for use in the educational process in the game mode, is an analog of the airship, combined with a ground gondola (Fig.1). The main feature of the design is that the shell, filled with a gas lighter than air, does not have the opportunity to go into free flight due to the fact that it is connected to the ground gondola. The design of the which can also be extremely simplified, to the point that contact with the earth's surface can be provided by a single wheel or even a ball, which provides increased travel capability design.

It is these features of the design of the "steppe sailboat" that leave a significant scope for technical creativity of students. In particular, depending on the degree of rigidity of the connections between the ground gondola and the shell filled with lighter-than-air gas, the slings can accommodate both aerodrivers powered by solar panels that complete the shell, and additional sails, which actually make the proposed design a "steppe sailboat".

Figure 1: Concept of a variant of the construction underlying the "steppe sailboat".

The functional diagram of the basic construction is shown in Fig. 2. We emphasize that this design was originally developed as a children's game, i.e., it is not a "steppe sailboat" in itself, but it can be converted into it by placing additional nodes, which were mentioned above.

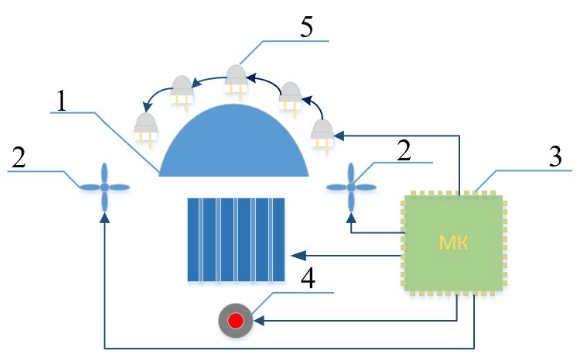

Figure 2: Functional scheme of the basic construction designed to implement the idea of a "steppe sailboat".

The proposed device contains a cylinder filled with a lighter-than-air gas (1), a wheel or other rotating element that provides contact with the earth's surface (2), attached to the platform (5) by fasteners (4) through the axis on which the wheel rotates. The balloon (1) is attached to the platform (5) by rigid spokes (3), two propellers are located on the platform to ensure the movement of this structure. The platform (5) can have a different configuration. Its geometry may be provided for the use of an analog of football game, etc.

The lifting force generated by the lighter-than-air gas filling the cylinder (1) keeps the structure in question in an upright position, so that its direction of movement can be set only by two propellers, and not by four, as it is in the case for quadcopters. The dimensions of this structure are determined by the lifting force sufficient to keep this structure in an upright position. Additionally, the cylinders are equipped with light-guide elements (7), which are hollow tubes made of a translucent colored polymer material. These LED elements are designed to mark the actions of the participants in the game.

We emphasize that the possibility of using this device as a real vehicle, is debatable, however, at this stage, it is not one of the tasks.

We are talking about creating a basic design that can be used as simply as possible in the game mode and further improved, based on a clearly formulated goal. As an example, the creation of a "steppe sailboat", and the appearance of a wide range of designs using the proposed version as a base is easy to predict, starting from historical analogies.

Indeed, at the turn of the XIX and XX centuries, when the design of even such a relatively simple device as a bicycle was not yet fully developed, a huge number of its various modifications appeared, many of which today cause even bewilderment or a smile.

However, if we think in terms of the history and philosophy of science, it is precisely this variability of primary designs that has led to the emergence of relevant industries that focus on the most effective models. Moreover, the key to the emergence of these industries was a clearly formulated focus on solving a very specific applied problem – replacing horse-drawn transport with an alternative (it is appropriate to recall that the largest Russian chemist D. I. Mendeleev seriously discussed the problem of catastrophic pollution of cities with horse manure).

In relation to modern conditions, there is again the question of creating alternative vehicles that should not just abandon the use of classic fuel, but also the use of third-party sources of electricity (its receipt, obviously, cannot but have a direct or indirect impact on the environment).

It is significant that for such countries as Kazakhstan, the solution of this problem is of interest not only from the point of view of solving global problems, but also from the point of view of microeconomics. Specifically, the use of such systems as "steppe sailboats" will ensure the overcoming of significant economic dependence on large suppliers, financial institutions, etc.

The direct implementation of any technical systems that provide additional degrees of freedom to Kazakh farmers will obviously encounter significant resistance from the relevant structures. Therefore, there is no other option but to ensure implementation in other ways through the educational process.

An important factor here is the possibility of organizing spectacular (competitive, sports, etc.) events, which are based on the use of "steppe sailboats" or structures approaching them.

Note also that an additional possibility (due to the mechanical connection with the ground gondola) for improving the proposed design is the transition to the use of "solar airships", i.e., shells filled with air at high temperatures. Interest in such systems is currently quite high [10], [11], both because of obvious environmental considerations and because of the opportunities for fuel economy.

The design of solar airships is most closely related to the development of non-trivial focusing systems, which are discussed in the next section.

3. Non-trivial focusing systems: their use for gamification of the educational process

Despite the success in the development of photoelectric panels, the question of improving solar concentrators does not lose its relevance [12]–[14]. There is a significant amount of works that discusses the problems of pointing concentrators of various configurations (mainly spherical and parabolic).

The literature also describes numerous attempts to create large-size parabolic concentrators [15], firstly the creation of appropriate rotary mechanisms. This problem is partly solved using film polymer coatings [16], which are naturally interfaced with the design of solar airships. In this case, the same metallized polymer coating can serve as both the shell of the airship and a mirror that concentrates the sun's rays on the working element of the structure (for example, a steam generator can act as such).

Particularly, a modification of mirror focusing systems is known, in which the mirror surface is formed when the shell is filled with gas under excessive pressure, for example, inflatable solar radiation capacitors, which allow to collect radiation energy from a large area [17].

However, the use of such structures currently faces distinct difficulties, and not as much technical as economic in nature. They can also be solved by using non-trivial focusing systems in the educational process, and in the context mentioned above.

Specifically, we are talking about the fact that in the course of, for example, a master's thesis, designs can be created (in the order of performing the qualification work) that have limited practical application – up to single copies.

An example of such an application is the implementation of various types of different entertainment events, etc. Also, we need to note that the commercial success of many educational institutions focused on the training of designers and other professions related to applied art is largely recovered by the fact that the results of the final work are actually used even in single copies, for example, this applies to the design of cafes, restaurants, etc. [18].

Below we consider a non-trivial focusing system, the distinctive feature of which is the possibility of its application in water shows and attractions of various kinds.

This focusing system (Fig.3) overcomes the basic disadvantages of existing types of solar radiation concentrators, which, first of all, the need to use bulky support structures, increased wind resistance, as well as significant additional energy costs when pointing the focusing system at the Sun.

The underwater dome (1) and the surface shell (2), which are made of optically transparent material, are attached to the body (3), which provides the flotation of the focusing system under consideration. The lower reflecting shell (6) is also attached to it.

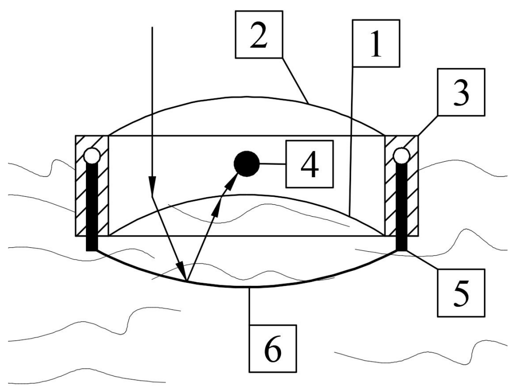

Figure 3: Functional diagram of a partially submerged focusing system;
1 – The upper underwater dome, 2-the surface transparent shell that maintains the compensating pressure; 3 – the body of the floating system; 4-an element for collecting solar energy, such as a hydraulic system connected to a heated water pool; 5-mounting rods; the lower underwater reflecting dome.

Between the underwater dome (1) and the surface shell (2), atmospheric air is pumped at a pressure that compensates for the water pressure on the dome (1). In this case, the underwater dome (1) can have both a spherical shape and the shape of a smoothed parabolic cylinder. In the latter case, the orientation to the Sun is provided by turning all the systems in the water (Fig. 4).

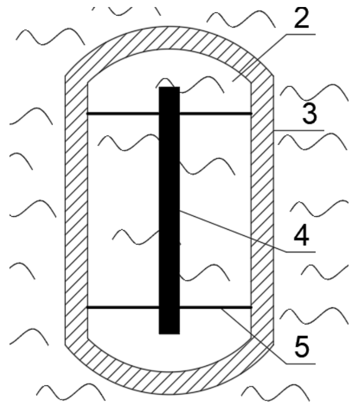

Figure 4: Using a partially submerged focusing system in cylindrical focusing mode.

An element for collecting solar energy (4) is attached to the body from the underwater side (3), using rods (5), which is, for example, part of a hydraulic system connected to a heated water pool. Element (4) may also be part of a water jet system, if this focusing system is used as an energy source for a solar-powered vessel.

The flotating of the system, in particular the weight of the hull (3), is selected so that the dome (1) on the lower side is completely filled with water, i.e., it is located below the water surface at a depth that excludes the impact of waves on the operation of the system. This, among other things, allows you to significantly reduce wind resistance compared to ground-based inflatable focusing systems, since the air-filled shell is located under water, protecting it from direct wind exposure.

The sun's rays pass through the surface shell (2) without being refracted, since it is made of a material of uniform thickness. Refraction occurs at the interface of the media defined by the underwater dome (1), since it separates the media with different refractive indices (air and water).

As a result, the system as a whole is an analog of a lens that focuses radiation on the element (4), with the difference that its material is actually water filling the dome (1) from below.

Devices of this kind can be used in water performances of various kinds, entertaining events, etc. An important advantage of the proposed design is also its variability, i.e., the creation of its various modifications can be used in the educational process, and even at the level of attracting students to research activities.

4. Conclusion

The materials of this work show that it is possible to offer a number of different devices that simultaneously meet both the concept of small green energy and new approaches to the modernization of the educational process, an important part of which is its gamification.

The proposed constructions, however, are nothing more than an example of how the concept of small green energy can be implemented in the educational process (through the development and following use of systems belonging to the class of green technologies by students).

The most significant thing here is the fact that when creating new systems of this type, they can be created and operated even in single copies, which eliminates the numerous economic problems that arise when creating structures focused on mass use.

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