## **ENERGY SECURITY PARADIGM**

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Abstract: The article presents the main problems of energy security and global environmental problems (climate change, excessive environmental pollution, etc.). The relevance and modernity of the use of alternative energy sources is substantiated using the example of the development and use of environmentally friendly fuel hydrogen, the specific gravity of which in the fuel and energy balance is comparable to the specific gravity of organic fuel. An autonomous technical complex is proposed for the production of environmentally friendly hydrogen with its subsequent use as an energy source for the flight of unmanned aerial vehicles. The power supply of the autonomous technical complex is entirely based on a hybrid solar-wind power plant, which operates in areas without infrastructure [1].

**Keywords:** hydrogen, climate change, global warming, renewable energy, energy carrier, hybrid solar-wind power plant, hydrogen generator, application of hydrogen, autonomous technical complex, unmanned aerial vehicles.

Overcoming the old model of a resource-intensive economy, which leads to increased costs and decreased productivity, and increased negative impact on the environment, is one of the most pressing problems of our time. Today, many countries around the world are intensifying their environmental policies with the aim of transitioning from the traditional development model, where environmental protection is considered a burden on the economy, to a model in which the environment is recognized as the engine of development, that is, to a "green" economy.

The proclamation of a new global green course is one of the development paths that can restore stability to the global economic and financial systems and ensure stable growth in Human development.

In a simplified sense, a "green" economy is an economy with efficient use of natural resources, widespread use of renewable, resource-saving, non- and low-waste technologies, with low greenhouse gas emissions, with a significant reduction in environmental risks.

That is why the President of Uzbekistan Sh.M. Mirziyoyev on May 30, 2021, at the second international summit "Partnership for Green Growth and

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Global Goals - 2030" proposed a number of key decisions on green transformation.

Indeed, in conditions of intense climate change, scarcity and pollution of water resources, deterioration in the quality of drinking water, a decrease in the area of glaciers in the Pamirs and Tien Shan, where a significant part of the region's drainage is formed, land pollution and degradation, a sharp decrease in biodiversity, deterioration in the health and gene pool of the population The proposals of the head of our state are vital.

At the same time, the development of a "green" economy, including in the context of reducing the negative consequences of the Aral crisis and the socioeconomic and environmental rehabilitation of the Aral Sea region, is of current importance not only for Uzbekistan, but also for the whole of Central Asia.

Under these conditions, within the framework of the consistent and phased implementation of reforms in Uzbekistan in the field of state and social construction, tasks aimed at accelerating the process of our republic's transition to a "green" economy and effectively achieving sustainable development goals are brought to the fore. Moreover, this becomes a key issue in the context of the struggle with climate change.

Meanwhile, due to the drying of the Aral Sea, climate changes in the Aral basin are occurring much more severely than in other regions, twice as intense as the world average (0.290C versus 0.140C, respectively), the daily temperature range has increased, and relative air humidity has decreased, especially in warm period of the year, the number of days with air temperatures above 400C increased.

In this regard, Uzbekistan is taking the following measures:

- on the implementation of political decisions in the field of strengthening regional cooperation;

- to improve the regulatory framework in the field of environmental protection;

- on the development and adoption of development programs and strategies;

- for the implementation of investment projects:

- on organizing scientific and practical forums with the participation of leading experts in the field of ecology.

It should be noted that today in the Aral Sea region unparalleled largescale work is being carried out to improve the economic, social and environmental situation. On the dry bottom of the Aral Sea, only from December 2018 to March 2023, about 1 million 800 thousand hectares were sown with saxaul seeds (including with the help of aviation).

Planting desert-resistant plants at the bottom of the Aral Sea simultaneously solves several important problems.

1. Conditions are created to mitigate the state of the environment and prevent further degradation of natural resources.

2. The maximum volume of sand retention on the drained bottom of the Aral Sea is ensured.

3. A favorable ecosystem is formed for the spread and reproduction of different types of fauna.

4. Increasing the area of desert forests and biodiversity will create conditions for climate mitigation in this region.

Among the promising areas for introducing a "green" economy into the agricultural sector of the republic is the development of the production of environmentally friendly agricultural products.

Another initiative of Uzbekistan was the development and the adoption of the Concept of interaction in the field of "smart" agriculture and the introduction of agricultural innovations that will help solve food security problems in the region, which are aggravated by population growth and depletion of land and water resources.

At the same time, there is an urgent need for scientific and innovative developments in such areas as organic farming, personalized and "smart" agriculture, the creation of genotypes of crops with high yields and resistance to harsh soil and climatic conditions. In addition, about 90 percent of the Central Asian region's total water resources are used in agriculture, with still inefficient irrigation methods. In these conditions, the issue of exchanging experience between countries in the development and implementation of modern environmentally friendly resource- and water-saving technologies in agriculture is becoming urgent.

## Hydrogen is the Main Energy Carrier of the XXI Century

The development of renewable energy sources plays a special role in the process of transition of the energy sector of Uzbekistan to a "Green Economy".

In modern conditions, the issue of ensuring energy security is becoming one of the most important priorities of any state. Currently, fossil fuels - coal, oil, natural gas and uranium - are the basis of the world's energy balance, although their reserves are declining every year as they are developed and used. Today, the volume of fossil fuels burned annually in the world is approximately equivalent to 13 billion tons of oil, or about two tons of oil equivalent for every person on the planet. Over the past 40 years, the volume of fossil fuels produced in the world has exceeded the volume of its production in the entire previous history of mankind.

Despite the fact that there is now a trend in the world market to reduce the consumption of liquid hydrocarbons, at the current level of energy consumption, the world's oil reserves will barely last for several decades. Taking into account the further development of the economy, population growth and the established traditional method of energy supply, energy consumption will increase accordingly. At the same time, in recent decades, due to the massive use of traditional hydrocarbon resources, global environmental problems have arisen on the planet. Among them are climate change, destruction of the ozone layer, etc. According to available estimates, the annual industrial emissions of carbon dioxide into the atmosphere alone exceed 7 billion tons, and carbon monoxide - hundreds of millions of tons. In the world, the volume of harmful emissions has increased 3.7 times compared to the 50s and has a steady upward trend.

In the context of depletion of the world's hydrocarbon reserves and worsening global environmental problems, the development of alternative energy with the expansion of the use of renewable energy sources is becoming increasingly important. The development and use of renewable energy sources in the world is becoming an unconditional factor in innovative development. In particular, it leads to the formation of a new technological base for the generation of electricity and heat, increases the energy efficiency of the electric power industry, creates new jobs, improves the quality of life of people: environmental conditions are improved, and the threat of man-made disasters is reduced.

In this regard, in the developed economic development strategies, leading countries set the goal of achieving by 2030 up to 30-40 percent or more of the share of renewable energy sources in the total volume of electricity generated. For these purposes, today, in countries such as the USA and Japan, the total area of solar collectors has increased by an order of magnitude. Israel has more than one million solar energy installations, providing 75 percent of the country's total hot water supply. In Europe, the annual growth in the use of renewable energy

sources is approximately 40-45 percent. The use of wind energy is also developing rapidly.

The experience of using renewable energy sources shows that they generally pay for themselves, despite the high costs of their acquisition and use in the initial period of operation. For example, in Germany, by 2040 it is planned to increase the share of renewable energy sources to 50 percent in the country's overall energy balance.

Uzbekistan, with the current volumes of production and consumption of thermal energy resources, will be provided with energy resources for several years. In the structure of primary fuel and energy resources of the Republic of Uzbekistan, 95 percent is occupied by oil and gas. At the same time, the factor of resource limitation of hydrocarbon energy sources, the scale and rate of their depletion encourages us to take the necessary measures to become one of the leading countries developing alternative energy. The introduction of renewable energy sources is one of the most important priorities in the transition of the country's economy to innovation and environmentally friendly technologies [2].

According to expert estimates, the possibilities of using renewable energy sources in our country are equivalent to the equivalent of 51 billion tons of oil. Existing technologies today make it possible to obtain energy equivalent to 179 million tons of oil, which is almost three times the volume of fuel produced in the republic, and also to prevent emissions of 447 million tons of carbon dioxide, sulfur compounds, nitrogen oxide and other pollutants.

In order to create a legal framework, systematically consolidate priority areas and a set of government policy measures in the field of use of renewable energy sources, increase energy efficiency in sectors of the economy, the social sphere and the level of diversification of the fuel and energy balance, financial incentives for renewable energy producers, as well as strengthening the country's energy security in 2019, the Law of the Republic of Uzbekistan "On the use of renewable energy sources" was declared.

One of the important aspects of Uzbekistan's transition to a "green" economy is the development of environmentally friendly transport.

The structure of vehicles used in the republic is dominated by automobiles, the total number of which is more than 3.5 million units. Despite the relative efficiency and cost-effectiveness, motor transport is the second largest consumer of energy resources and, along with the industrial sector, is one of the main polluters of the environment. In general, the share of pollutant emissions into the atmosphere from vehicles currently reaches 63 percent in the country, and in large cities such as Tashkent it exceeds 80 percent.

At the same time, the annual volume of pollutant emissions due to the use of gasoline and diesel fuel in vehicles is more than 1.5 million tons.

One of the most effective and environmentally friendly is the conversion of internal combustion engines to cryogenic hydrogen or gasoline-hydrogen composite fuel. Many countries around the world are developing technology to switch to hydrogen fuel.

At the same time, the advantages of hydrogen as a fuel are not only related to

the fact that its combustion produces environmentally friendly water vapor,

but also compared to organic fuel, it has a large reserve of energy: when burning a ton of hydrogen, so much

the same heat as when burning 3.5 tons of organic fuel.

Due to the depletion of hydrocarbon reserves around the world, intensive work is underway to search for alternative energy sources and energy carriers. Today, it is relevant to convert internal combustion engines to hydrogen or gasoline-hydrogen composite fuel. At the same time, many countries around the world are independently, unfortunately, separately, developing technologies for the transition to hydrogen fuel. The main focus on the development of hydrogen energy was formulated in the mid-70s of the 20th century at the height of the first wave of the energy crisis. It was based on the idea of hydrogen as an alternative environmentally friendly fuel, the specific gravity of which in the fuel and energy complex was assumed to be commensurate with the specific gravity of organic fuel. At the global level, many scientific events dedicated to hydrogen were organized and held, where all participants expressed the opinion that the widespread use of hydrogen in energy "provides humanity with a unique chance to survive in a world free from environmental and social disasters" [3, 4, 5].

However, today this issue is more acute and tough. On the pages of information and analytical publications, reports systematically appear on the use of hydrogen in various installations, including in aircraft engines. Naturally, data is provided on the environmental, technological, economic and mechanical aspects of the raw materials and technology used. It should be noted that today the world is very close to the widespread implementation of the transition to hydrogen and/or gasoline-hydrogen composite fuel mixtures for use in internal combustion engines.

Currently, more than 1,300 gas stations that refuel with compressed (liquid) hydrogen fuel are already operating in the United States and European countries.

The relevance of using environmentally friendly fuel lies in the fact that in recent decades, global environmental problems have arisen on the planet (climate change, excessive environmental pollution, etc.). It is estimated that the annual emission of carbon dioxide into the atmosphere exceeds 33 gigatons, and the volume of greenhouse gases amounted to approximately 42 billion tons. In the world, the volume of harmful emissions has increased almost 4 times compared to the 50s and has a steady upward trend.

The current warming, according to scientists, is also due to an increase in greenhouse gases in the atmosphere. But now the reason is different - human activity, which in terms of its impact on the climate is comparable to the most powerful natural processes. In addition, this effect is much faster. Atmospheric carbon dioxide has risen from 280 ppm (parts per million) in the 1700s to approximately 415 ppm today, and continues to rise rapidly [6, 7].

The advantages of hydrogen as a fuel are associated not only with the fact that its combustion produces "environmentally friendly" water vapor. Compared to organic fuel, it has a large "energy reserve": the combustion of 1 ton of hydrogen releases the same amount of heat as the combustion of 3.5 tons of organic fuel. In addition, hydrogen, unlike hydrocarbon fuels, is capable of catalytic oxidation at low temperatures with direct conversion of chemical oxidation energy into electrical energy, which may be a decisive argument for the use of hydrogen in the energy sector.

Devices that allow this unique feature to be realized, the so-called fuel cells or electrochemical energy generators, are characterized by very high efficiency. - 70 - 80%, that is, 2 - 2.5 times higher than efficiency. heat engines. It is obvious that for the widespread use of any type of fuel in economic sectors, at least two conditions must be met:

firstly, this fuel must be available and relatively inexpensive;

secondly, the optimal technology for its production must be developed and industrial devices created for its implementation.

All stages of its implementation are related to the fact that there is no hydrogen in a free state on Earth, and to obtain it you need available chemical raw materials and primary energy sources. In other words, hydrogen is not a fuel, but an energy carrier.

Among hydrogen consumers, the following main groups are usually distinguished:

1) consumers of liquid hydrogen - for their service, as a rule, specialized vehicles and containers are used;

2) consumers of high-pressure hydrogen (in cylinders) - mainly highpurity gas is used for their service - this is hydrogen obtained by electrolysis of water;

3) consumers of low pressure hydrogen - this group includes the main consumers to whom gas is delivered, as a rule, by pipeline transport - local lines of the hydrogen supply system.

Consumers of the first group do not yet constitute the main part among the operators, but the prospect of this part is inevitable, since cryogenic technology everywhere shows the need to implement it in life in a way that today there is no technology that is more environmentally and economically beneficial, so many scientific centers are working on these problems world. For example, it is no coincidence that the international organization "Refrigeration", headquartered in Paris, pays special attention to the development of developments for the production and use of liquefied hydrogen in economic sectors.

Over the past 30 years, global hydrogen production has increased significantly. According to forecasts, by 2025 there will be a further increase in its production, ensuring the development of the chemical industry and energy.

For example, in the USA alone there are currently dozens of enterprises of varying capacities specialized in hydrogen production.

There are two main industrial methods for its production. One of them, truly environmentally friendly, is based on electrolysis or electrochemical decomposition of water or water vapor. In this case, the primary source of energy is an electric current generator.

The advantage of electrolysis hydrogen is that the methods of its additional purification (to an impurity content of less than 10"1 vol. %) are economical and technologically simple. That is why electrolysis hydrogen is used to obtain pure and high-purity hydrogen. At the same time, classically, the most promising and not only environmentally friendly, but also in the future the most economical will be the production of hydrogen by electrolysis of water, that is, its decomposition under the influence of electric current. One of the

obstacles to the large-scale use of the electrolytic method until today has been the high consumption of electrical energy. The use of renewable and environmentally friendly methods for producing electrical energy energy that will be used for the electrolysis of water is a truly environmentally friendly integrated technology. If we switch to hydrogen energy, then some emissions (NOx and CO) will be significantly reduced, and some (SO<sub>2</sub> and particulate matter) will not exist at all.

It should be noted that in the total volume of hydrogen production, the share of electrochemical methods still does not exceed 2–4%, although in some countries, for example, Canada, Norway, the USA, and China, it is significantly higher. The prospects for the development of these methods and the cost or "availability" of electrolytic green hydrogen largely depend on the availability of "cheap" or "expensive" electricity. However, the development of science and technology is now confidently establishing renewable energy sources in this role - mainly solar (helio), wind and hybrid solar-wind energy [8, 9, 10].

Additional opportunities to reduce the cost of electrolysis hydrogen are associated with improving methods of electrolysis of water (water vapor). In this regard, the use of hydrogen energy as a heat source for sand heat accumulators, which can reserve heat for heating apartment buildings for a long time from several weeks to a month, is also promising [11].

The tasks of scientists and specialists in the development of hydrogen energy, in our opinion, are the following:

- search and research of new promising materials and processes in the field of hydrogen energy;

- research on the rational and effective use of integrated, environmentally friendly and independent of natural reserves technologies aimed at producing hydrogen by electrolytic method, using local potential of renewable energy sources;

- organize scientific support for industrial developments in hydrogen technology from all interested research institutes and development organizations;

- development of forecasts for the development of hydrogen energy in the world and in the country.

Currently, studies conducted in the republic, taking into account existing local conditions, show that hydrogen remains practically the only environmentally friendly fuel for road transport, and, in a broader sense, for any autonomous energy facilities of the future. Over the past few years, our scientists have been working to create an experimental pilot plant for producing hydrogen in an environmentally friendly way. It uses electrical energy generated using photoconverters and a wind generator to decompose water molecules. To date, encouraging results have been achieved on the viability of the chosen technology, since the cost of electrical energy generated by photoconverters and a wind generator is practically on the same level as electrical energy generated using traditional technology.

In recent years, a number of Decrees, Presidential resolutions and decisions of the Government of the Republic of Uzbekistan have been adopted to accelerate and expand research and introduce such energy sources. Government agencies have been given specific tasks to significantly reduce energy consumption by up to 30% through the use of automated systems, solar and wind installations.

In this regard, the following priority areas of work are currently being put forward in Uzbekistan:

a) development of technology for the production of hydrogen by electrolysis of water using an autonomous hybrid solar-wind power plant with the subsequent creation of fuel cells for the domestic and foreign markets;

b) development of complexes for the production, purification, accumulation, storage and transportation of hydrogen;

c) creation of highly efficient power plants and wide-class electrochemical generators based on fuel cells, including for use in household electronic devices;

d) development of hydrogen energy infrastructure elements;

e) introduction of technologically safe and environmentally friendly methods of storing and transporting hydrogen, etc.

In general, the use of hydrogen plants and power systems makes it possible to obtain the required power ratings at relatively low specific costs for electrical energy sources compared to traditional energy sources.

As part of research on the creation of new engineering and technological complexes in this area, a group of scientists consisting of A. Abdullaev, B. Alikhanov and R. Isaev with the participation of specialists V. Korolev, G. Gulyamkhadzhaev and Y. Mankovsky developed a new technical solution for the rational use of autonomous technical complex (ATC) based on hybrid sources of electrical energy powered by solar and wind energy in combination with hydrogen technology systems [1].

Features of ATC:

- no energy and communication infrastructure required;
- the presence of an autonomous power supply system based on hybrid technologies (solar and wind energy);
- production of hydrogen gas through electrolysis of water;
- the main raw material is ordinary distilled water obtained from atmospheric air;
- environmentally friendly and no polluting emissions.

Devices that allow this unique feature to be realized, the so-called fuel cells or electrochemical energy generators, are characterized by very high efficiency. - 70 - 80%, that is, 2 - 2.5 times higher than efficiency. heat engines.

Main components of ATC:

a) a hybrid installation for providing electricity based on photoconverters and a wind generator;

b) a water generator for obtaining water from the surrounding atmospheric air;

c) hydrogen filling station.

Figure 1 shows a block diagram of an autonomous technical complex based on hybrid energy sources and a hydrogen system.

Operating principle of ATC.

ATC consists of three modules:

the first module is an electrical energy generation module;

the second module is a water generator and a hydrogen generator;

the third module is the main consumers of hydrogen energy.

The first module is designed to generate electrical energy from renewable energy sources: photoconverters and a wind generator.



Fig. 1. Block diagram of an autonomous technical complex based on hybrid energy sources and a hydrogen system

The resulting electrical energy is transferred to the second module - a hydrogen generator and a generator for obtaining water from the atmosphere, as well as to the third module - consumers of hydrogen energy.

The hydrogen generator is designed to produce hydrogen gas, the raw material source of which is distilled water. Water is supplied to the hydrogen generator from a water generator, which produces water from atmospheric air.

The hydrogen generator electrolyzes clean water, extracts hydrogen gas and sends it to a built-in storage vessel, from where the hydrogen unit is refueled. All these elements make up a single hydrogen refueling station.

We currently have a hydrogen refueling station based on the ORCA type hydrogen generator, a new product based on energy saving and environmental protection technology. The hydrogen refueling station is used to refuel hydrogen cylinders of unmanned aerial vehicles (UAVs) and agricultural equipment equipped with hydrogen fuel cells.



Fig. 2. Functional diagram of an autonomous technical complex

The hydrogen refueling station is highly integrated and fully automated, it can generate hydrogen, it is easy to set up, and it uses natural water, it is very easy to operate. The station is not affected by atmospheric interference and is explosion-proof, and is also equipped with an alarm system.

Currently, work is underway on the use of ATC for irrigation of agricultural land using hybrid solar-wind power plants and hydrogen fuel for agricultural machinery and other consumers in areas without infrastructure, which consists of several modules combined into a single multifunctional system:

- module of renewable energy sources (photoconverters, wind generators);
- water supply module for irrigation of agricultural land (well and pump);
- water storage module (reservoir or waterproofed pool);
- drinking water module (atmospheric water generator);
- hydrogen fuel module (hydrogen generator, producing compressed hydrogen from water);
- agricultural equipment, UAVs and vehicles powered by hydrogen fuel.

From the above, it can be noted that the relevance of this area lies in the development of new technologies for the production of hydrogen from water using hybrid solar and wind energy.

Based on the results of constant monitoring of climate data of cities around the world (https://ru.climate-data.org/), it is known that Uzbekistan has an average of 3633.4 hours of sunshine per year. Considering that in recent years, many scientists have put forward scientific justifications for the feasibility of using solar energy even in cities where there are low rates of sunshine per year. For example, Murmansk (Russia) - 1715 hours of sunshine, Kiruna (Sweden) - 1680 hours, Cologne (Germany) - 1500 hours, Birmingham (UK) -1400 hours per year. In the conditions of our country, with such a potential for sunny days a year, it is simply unacceptable to ignore or neglect the use of renewable energy sources!

The application of the proposed technology will successfully serve to obtain electrical energy in an environmentally friendly way. In addition, it should be noted that the Republic of Uzbekistan is located in the arid zone of the middle zone of the globe, which necessitates and allows for the widespread use of hydrogen in various sectors of the economy: in the transport system, in industrial heat and power engineering, in the development (revitalization) of desert lands, etc.

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