

Sustainable Energy in the Mountains of Ukraine

There is nothing superfluous in nature.

Abstract. The present paper examines the different types of sustainable and renewable energy in the natural mountain system. Such sources are mountains ecosystem, sustainable energy, renewable sources, hydropower, wind power, solar power, and biogas. The analysis of the pros and cons of using certain sources, as well as a possible solution to problems that may arise in connection with the use of the above types is carried out. Moreover, the need to integrate into the sustainable development goals (SDGs) is indicated. The paper's topic is relevant due to the fact that sustainable energy sources in the mountains remain unused or underutilized. In addition to energy potential, the development of sustainable energy solutions can bring numerous benefits for energy potential, human health, the mountain environment and the global climate.

Keyword. Mountain's ecosystem; Sustainable energy; Renewable sources; Hydropower; Wind power; Solar power; Biogas.

Introduction

Energy sources existing today are divided into traditional and alternative ones. The traditional ones include minerals - oil, gas, coal. Their biggest drawback is that they are non-renewable resources. This is the first factor that motivates to recognize the need to use other energy sources.

Sooner or later, even the richest deposits will exhaust themselves, so the search for new options for obtaining energy becomes more relevant every year. The second factor, and perhaps the first in importance, is the impact on the ecology of the planet. Greenhouse gas emissions from burning minerals disrupt the climate balance. The effects of climate change have become more and more tangible over the past decade. Heavy rains and hurricanes, snow in the middle of spring, periods of prolonged droughts, floods, tornadoes, and other natural phenomena occur more and more often and we cannot control them. The only way for people to reduce the rate of climate change is transition to more environmentally friendly energy sources, which include renewable or alternative: sun, wind, water, biogas and others.

The production of electricity from renewable sources has taken an important place in the complex of energy reforms in Ukraine and today is fully supported and

stimulated by the state. According to the government's plan, by 2020 the share of renewable energy in Ukraine should be 11%, by 2035 - 25%¹.

Depending on climatic conditions, landscapes, temperature regime, ecological and natural systems of a particular territory, there are different available sources for creating electric energy. Wind power may be an alternative where hydropower development is limited by environmental, natural, and socio-economic factors. The peaks and ridges of the Ukrainian Carpathians have a very high potential for wind energy and are one of the most promising regions for the development of this type of energy in Ukraine. In Transcarpathia, where the potential for the development of wind energy is much lower, there are opportunities for active development of solar power plants, the use of geothermal energy. Everywhere in the Carpathians, there are great opportunities for the use of the most common local fuel - biomass, which today is simply emitted in the form of chips and sawdust.

This resource with skillful use (processing, such as fuel chips, pellets, briquettes) is able to provide basic local energy needs.

Recently, the use of alternative energy sources is associated not only with flattering reviews but also gives rise to many different myths and legends on this topic. We will try to determine how the use of wind energy affects people and the environment, as well as analyze how wind structures affect the ecosystem of the mountains. How solar panels work and in what environment they are most potentially developed. Just how controversial, in the opinion of various ecologists, experts, and ordinary residents, the construction of small hydroelectric stations can be. And why biogas on the territory of Ukraine can become one of the most profitable ecological and economic types of energy.

1. Solar energy

Ukraine has the necessary natural conditions to develop the direction of solar energy. In terms of climatic conditions, Ukraine belongs to the regions with an average intensity of solar radiation. The amount of solar energy supplied per unit area during the year is 1000-1350 kWh/m². If we look at the map of solar activity in Europe, we will see that in Ukraine the average annual solar radiation is the same as in France, Austria, or in the northern regions of Italy.²

¹ 'Energy Strategy of Ukraine for the Period up to 2035 "Safety, Energy Efficiency, Competitiveness" Ministry of Energy of Ukraine 18 August 2017, № 605-р https://mepr.gov.ua/files/images/news_2020/21012020/Енергетична%20стратегія%20України%20на%20період%20до%202035%20року.pdf accessed 24 August 2021.

² Wciślik S., Kotrys-Działak D. 'The Energy, Economic and Environmental Efficiency of a PV Installation Cooperating with a Heat Pump in the Central Part of Europe. Case study.' (Preprints 2020)

Solar power plants and solar collectors use the energy of the luminous flux, which naturally enters the photocells and turns into electrical energy, or thermal energy, to heat a liquid (water). The main plus is environmental friendliness and the complete absence of harmful emissions into the atmosphere. The main disadvantage is uneven power received during the day or other time periods. At night, in cloudy or rainy weather, power generation stops. On clear weather days, the amount of electricity produced exceeds the needs of energy consumers, so there is a need for batteries. Their price significantly increases the cost of produced kW/h.

The solar plant is designed to meet the growing demand for clean energy in the region while using the land efficiently. Innovative technologies for hybrid solar and wind power generation improve the reliability of power supply at a reduced cost.

The solar power plant is designed for the industrial generation of electricity by converting solar energy into environmentally friendly electricity in solar photovoltaic modules with its subsequent transformation into external electrical networks of the Transcarpathian region.³ Large on-grid solar power plants are designed to generate energy under an industrial green tariff. The main elements of an industrial solar system are photo panels and string or central industrial grid inverters. Photo panels are connected to inverters, which convert direct current from the photo panels into alternating current to generate electricity into the grid. The connection of the inverter to the mains is done through a transformer.⁴

The interesting fact is that solar stations in the mountains generate 1.5 times more “green” energy - the results were obtained in the course of research carried out by the team of the Swiss energy company Romande Energie. The solar stations in the mountains of the Valais canton are located at an altitude of 1.8 km above sea level. They consist of over thirty floating barges and over 2000 sq. m of solar panels.⁵

Annually, this SPP produces about 800,000 kW/hour of electricity - this amount is quite enough to cover the needs of almost 230 households for electricity. The energy generation efficiency of such a high-altitude installation is 1.5 times higher than those located at lower levels. This is because at the higher altitude, the radiation of the solar flux is more powerful. In addition, the snow covering the peaks of the mountains is an additional emitter - effectively repels the sun's rays falling on it onto nearby panels. So why don't we repeat this experience in our mountain system?

<https://www.preprints.org/manuscript/202011.0155/v1>

accessed 24 August 2021.

³ Fedosenko N., 'Three solar power plants were built in Transcarpathia' (Eco Town, 31 October 2021) <https://ecotown.com.ua/news/Na-Zakarpatti-zbuduvaly-try-sonyachni-elektrostantsiyi/> accessed 24 August 2021.

⁴ 'Schemes of organization of solar power plants' (Atmosfera, 13 June 2017) <https://www.atmosfera.ua/uk/sonyachni-elektrostantsii/sxemi-organizacii-sonyachnix-elektrostantsij/> accessed 24 August 2021.

⁵ Katanich D., 'Extraordinary views: This is the world's first mountainous solar farm' (Euronews.green, 14 May 2021) <https://www.euronews.com/green/2021/05/14/extraordinary-views-from-the-world-s-first-mountainous-solar-farm> accessed 24 August 2021.

For example, Ukraine has a large number of solar installations. In the Uzhgorod district of the Transcarpathian region in 2016, a solar power plant “Guta-2” with a capacity of 3.5 MW was installed and put into operation. According to the agency, a feature of the station is its location. The area of 5.73 hectares is located between the mountains and has a large slope to the north, which is not very “convenient” for the orientation of solar panels in the sun. To solve this problem in the construction of the station used a mounting system SMS-211, the design of which allowed to design and mount inseparable tables up to 300 m long for the use of all free space on the site.⁶

In August 2012, the company “Solar Energy Plus” built and put into operation a solar power plant with a capacity of 5.4 MW, located in the Uzhgorod district of the Transcarpathian region. Photovoltaic panels will produce about 4,800,000 kWh of electricity annually, sufficient to supply more than 1.3 thousand kWh of electricity households with monthly consumption of 300 kWh.

Another solar power plant with a capacity of 6,237 MW was erected near the village Shalanki of Vinogradovsky district of the Transcarpathian region. The project was implemented by Solar Light LLC using its own and credit funds. SPP consists of more than 22 thousand panels and occupies an area of about 10 hectares.

In agriculture, especially in backyard and greenhouse industries, solar panels could provide water with pumps and watering plants, and in livestock in arid regions, water for animals.

Solar battery systems with chemical accumulators are practically the only economically suitable for powering equipment in the absence of a central power supply network; in the mountainous regions of the Carpathians and Crimea, in field camps, pastures, etc., that is, in conditions when it is unprofitable to create and use a central power supply network, it is dangerous to human health.

This problem cannot be solved by the traditional method of building a fixed network due to its high cost. In addition, photo batteries are now in great demand in the world and could be exported, especially to our country. Thus, the use of alternative energy sources in Ukraine, primarily solar energy, will undoubtedly be beneficial. On the other hand, the Ukrainian economy has the appropriate capacities for the production of the necessary components and the creation of the infrastructure for such energy.

⁶ ‘A solar power plant has started operating in the mountains in Transcarpathia’ (Focus, 11 January 2017) <https://focus.ua/politics/364299> accessed 24 August 2021.

2. Wind power

In regions with a high wind speed, in coastal zones, and at facilities where the solar power plant “cannot cope” in winter, wind power plants are used for autonomous power supply. Wind speed and the absence of turbulence should be critical when choosing a site for a wind turbine. For these reasons, among other locations, the top of a mountain or hill is also ideal.

Wind power is now considered one of the cheapest in terms of electricity generation. Wind farms have exceeded fossil fuels in many developed and emerging markets since 2018, according to the Global Wind Energy Council (GWEC).

For example, there are two modern wind power plants in Ukraine. The Stry Sambir-1⁷ and Stry Sambir-2⁸ wind farms are located in the lowlands of Prykarpattia near the upper reaches of the Dniester River. In the Carpathian region, the winds are quite strong, the average annual wind speed is 6.5 - 7.5 m/sec. This territory has a special relief, contributing to the emergence of powerful winds along the Dniester River. The annual production of electricity is about 56 million kW / h, which is enough to provide ecologically clean electricity for two and a half districts of the region. This wind potential makes it possible to build cost-effective high-capacity industrial wind farms. The stations were opened in 2015 and 2016. The height of one wind turbine is 119 m, the length is 56 m, and the warranty period is 20 years. The total cost of the project is EUR 20.5 million.

A wind farm consists of several wind generators connected into one network. A wind generator is an installation that converts wind energy into electrical energy. According to Wind Europe, the average capacity of one wind turbine ranges from 2 to 3.6 megawatts. On average, wind energy from one turn of the blades of a wind generator is enough to light one apartment all day.⁹

There is also an alternative option for maximum consumption of energy resources of the mountains - placement of solar panels, which can consume the energy of the sun during the day, and installation of wind turbines to obtain a high level of energy both at night and in the cold season. Depending on the localities, the winds can reach their greatest strength during the abovementioned times. This option is most beneficial when sunlight either is completely absent or can be generated in a smaller amount.

⁷ Kuts T., ‘The most powerful wind station in the Carpathians “Old Sambor-1” (Nature Energy, 21 October 2016) <https://alternative-energy.com.ua/moshhnejshaya-v-karpatah-vetrovaya-stancziya-stryj-sambor-1/> accessed 24 August 2021.

⁸ ‘A large wind farm has been launched in western Ukraine’ (Delo.ua, 27 October 2017) <https://delo.ua/business/na-zapadnoj-ukraine-zapustili-krupnuju-vetroelektrostantsiju-335845/> accessed 24 August 2021.

⁹ ‘Correct location of the wind turbine’ (Helios House, 19 January 2018) <https://www.helios-house.ru/pravilnoe-raspolozhenie-vetrogeneratora.html> accessed 24 August 2021.

In addition to all the advantages of using alternative energy sources - wind farms, there are some aspects that can lead to negative consequences for the environment. There are conflicting approaches and opinions on this issue. Is this so, the author understands below.

For example, on the website of the British newspaper Telegraph, Alex Singleton writes about their health threat: “Wind turbines can cause heart problems, tinnitus, dizziness, panic attacks, migraines, and sleep disturbances, according to the latest scientific reports from an American scientist. Incredible. We already know that wind turbines are ugly, killing birds and cheating taxpayers, so now we have every excuse to stop them.”¹⁰ But we will try to dispel these myths.

The first, and probably the most basic cause of concern for people, is the noise generated by wind turbines. Noise is defined as any harsh, loud, or simply unwanted sound.¹¹ But even if, according to the norms, the noise produced is within the permissible limits, there are people who are more sensitive to noise. This is because different noise affects people in different ways. For example, most people enjoy listening to the sound of waves on the seashore, but we are angry at the sounds of renovation from a neighbor’s apartment. And this is despite the fact that the actual noise level from the surf can be much higher than the sounds of repairs coming from afar. Sea waves emit random “white” noise, while repair sounds have some systematic content that our brains cannot ignore, distinguish and analyze. The situation is roughly the same with wind turbines. This kind of noise is called unwanted sound.

Modern turbines are planned in such a way as to minimize the noise from the mechanical elements of the wind turbine. Thus, almost all audible noise is the noise of the wind interacting with the rotating turbine blade. There is not much noise at a distance of 300 meters from the wind farm. Modern wind turbines are quieter than most power generation equipment. And even in those areas where the population density is low and there is practically no noise from human activity, there is still more noise from the breezes of the wind itself than from the rotation of a wind turbine.

An exception may be turbines, which are located in hilly terrain. The noise generated by wind turbines in hilly terrain can be amplified by sudden changes in altitude in the mountains. In this case, the type of landscape plays the main role.

The second problem that can affect human health is flickering shadow. Wind turbines, like other tall buildings, cast a shadow over nearby houses. If you live near such a turbine, then you may be annoyed by the flickering shadow that appears when

¹⁰ Eschner K., ‘Two Myths and One Truth About Wind Turbines’ (Smithsonian Magazine, 15 June 2017) <https://www.smithsonianmag.com/smart-news/two-myths-and-one-truth-about-wind-turbines-180963626/> accessed 24 August 2021.

¹¹ Omelchenko A., ‘Wind energy. Facts and conjectures’ (Atmosfera, 27 July 2021) <https://www.atmosfera.ua/ru/stati-o-vetrogeneratorax/energiya-vetra-fakty-i-domysly/> accessed 24 August 2021.

the rotor (blade) rotates. The rotor rips apart the even sunlight, creating a flickering effect.

This problem is absolutely solvable. One has only to retreat from the houses at a distance equal to the sum of 7-10 rotor diameters (this is about 300-800 meters), at which a person is not exposed to the influence of shadow flashes. The second solution is to build turbines behind the houses in relation to the movement of the Sun.

The same situation has developed with infrasound, which seems to be emitted by wind turbines and this negatively affects human health. Infrasound surrounds us all the time. This is also the result of traffic, airplanes, trains. And even in our homes, we have sources of such sounds - these are our household appliances. Infrasound also occurs during thunderstorms, earthquakes, and hurricanes. Infrasound is a sound at low frequencies, it is not captured by human senses, but certain low frequencies can cause perceptible anxiety in a person, anxiety, and even mental disorders (sound waves with a frequency of less than 20 hertz).¹² Scientists all over the world categorically reject the information that there is a harmful effect of infrasound from wind installations. And numerous tests and experiments on wind farms only confirm their words.

The myth is that turbines kill many birds. According to statistics, less than one bird's deaths in 10,000 are due to a wind turbine. Most of the premature death of birds occurs due to high-voltage wires, high-speed traffic on the roads, and even due to the activities of ordinary domestic cats, which out of these ten thousand catches about one thousand.

The last argument of opponents of alternative wind power is its high cost. But with the rates of growth in the cost of electricity that are now observed in our country, in a year or two, this type of business may turn out to be much more profitable than at the moment.

3. Hydropower

Hydropower is a combination of natural and artificial systems designed to convert energy-water flow into electricity. In other words, these are the hydroelectric power plants where takes place electricity generation by use water flow energy, as well as natural and artificial objects - rivers, dams, reservoirs, inlet canals, and pipelines, etc.

Up to 10 small hydroelectric power plants are running in the Transcarpathian region today. And in addition, at different stages of planning, design, and production

¹² Leventhall Geoff 'What is infrasound?' (2007) 93 Progress in Biophysics and Molecular Biology 130 <https://www.sciencedirect.com/science/article/pii/S0079610706000848#!> accessed 24 August 2021.

of permits in the Carpathian region of Ukraine there are more than 500 small hydroelectric power plants, including 360 small hydroelectric power plants in the Transcarpathian region, more than 100 small hydroelectric power plants in Ivano-Frankivsk region and several dozen in Lviv and Chernivtsi regions.¹³

For various reasons, the ecological condition of the rivers of the Ukrainian Carpathians until recently was slightly better than the condition of plain rivers in other regions of Ukraine. This was facilitated by the mountainous nature of their watercourses, and ten times higher water content in the Carpathian regions, and lower population density, industrial facilities, lower intensity of agriculture.

Most of the proposed projects involve the construction of small hydroelectric power plants of the derivation type in the Carpathians. In these hydroelectric power plants, water is taken into a pipe, transported down a certain distance (usually several kilometers), and then discharged to a turbine for energy production, after which it returns to the river.¹⁴ Investors consider water energy and this type of station to be the most profitable for the western regions. Small hydropower plants have a real service life of more than half a century at relatively low operating costs, and their load is more stable and guaranteed. In addition, unlike wind and solar, hydropower does not need additional regulating capacities.

Until recently, the Carpathians were considered, first of all, as a region with priority development of nature protection, ecological tourism, provision of high-quality water resources, and support of the health of aquatic ecosystems of Ukraine. Currently, the region is key in terms of the flow of international rivers such as the Dniester and the Danube.

However, the attack on mountain rivers goes on a wide front: from intensive construction of riverbed valleys by residential, recreational, and industrial facilities with imperfect wastewater treatment systems or without them at all - to intensive deforestation on mountain slopes, from chemical pollution of lands and underground reservoirs as a result of modern agricultural and agro-industrial production - to planned mass construction of small and mini-hydropower plants (MHPP) of derivation type with water dams and dam hydroelectric power stations.¹⁵

For the last 10-15 years such phenomena are observed also, as pollution of river banks by thousands of tons of solid household waste (SHW). Small hydropower plants today are able to make a contribution to increasing electricity production in Ukraine. However, due to technological features, peculiarities of climatic conditions of Ukraine

¹³ Vovchak V., Teslenko O., Samchenko O., 'Small Hydropower of Ukraine' (Vol. 1 Institute of Ecology and Energy Saving Kyiv 2018) <https://energyukraine.org/wp-content/uploads/2018/05/Otchet-MGES1.pdf> accessed 24 August 2021.

¹⁴ Pavelko A., Prots B., Stankevych-Volosyanchuk O. 'Hydropower in the Carpathians: Myths and Reality' (World Wide Fund for Nature WWF, 2015) https://ucn.org.ua/wp-content/uploads/2019/02/wwf_hydropower_myths_reality.pdf accessed 24 August 2021.

¹⁵ Ibid

in general and the Ukrainian Carpathians in particular, the potential negative impact of small HPPs on the environment, as well as due to the non-competitive price of electricity purchased at small HPPs, the potential of small HPPs is extremely small in terms of their contribution to Ukraine's energy independence or energy self-sufficiency of its individual regions¹⁶.

What are the risks of the constructed power plants?

1. Risks are related to the impact on the geological environment: intensification of erosion processes, rise (above the dam) or fall (below the dam or in the area of influence of derivation structures) groundwater level, redistribution of sediments, landslides, etc.

2. Risks are associated with the impact of the geological environment on the buildings and structures of hydropower plants: complete or partial destruction due to mudslides, landslides, earthquakes.

3. Risks associated with changes in the hydrological regime: changes in oxygen, temperature, flow velocity, drying of rivers in the interstitial periods in some areas, etc.

4. Risks, associated with changes in wildlife: extinction of plants and animals, including rare and endangered. Death of aquatic animals as a result of construction works. Destruction of aquatic animals, including fish, due to the impact of hydroelectric turbines. Fragmentation of river ecosystems with the impossibility of further migration, exchange of genetic material, and maintenance of viable populations of fish and other aquatic animals. The death of aquatic and aquatic animals, including fish, due to changes in environmental conditions (stagnant regime in reservoirs, changes in temperature, oxygen content, direct destruction of forage areas, and areas of reproduction of aquatic living organisms).¹⁷

Also, as an example, we can describe water power plants that are located on the territory of the European Union, but a similar parallel cannot be carried out, since there are significant differences. The first one is that the EU has adopted a practice banning the construction of hydropower facilities within certain rivers or parts of them. These are the so-called especially valuable river areas, forbidden river areas ("no-go" areas). They are distinguished on the basis of different criteria, depending on the country.

These can be either certain categories of protected areas, or habitats of protected species of animals and plants, centers of biological diversity or rivers in a relatively unchanged natural state, and others. One of the leaders, Bavaria, has banned the construction of hydroelectric power plants on rivers that are free-flowing and have

¹⁶ Vasyluk A., 'Carpathians in dams' (Texty.org.ua, 14 March 2013) https://texty.org.ua/articles/44219/Karpaty_v_dambah_Girski_richky_mozhut_zabraty-44219/ accessed 24 August 2021.

¹⁷ Ibid

avoided construction in previous years¹⁸. In other countries, there are some rivers. In the United States, there are so-called “wild rivers”¹⁹, which are protected from any human interference that could affect their naturalness, including the construction of hydroelectric power plants.

Unfortunately, in Ukraine, HPP developers believe that there are no restrictions for them. In particular, there were attempts to build small hydropower plants within the Carpathian National Nature Park, the Carpathian Biosphere Reserve, the Chermosy National Nature Park, the Black Cheremosh Hydrological Reserve²⁰, and so on.

The second difference is the different approaches to hydropower planning on rivers that are not included in the list of those where the construction of hydropower plants is prohibited. In particular, the issue of planning is considered first. Planning is not a hydroelectric power plant, but the entire territory, which may include the construction of hydroelectric power plants and the allocation of relevant areas for such construction. Next, the plan must pass a strategic environmental assessment, i.e. an assessment of whether how all the measures envisaged will affect the environment and whether such impact is permissible.

Proponents of installing hydropower plants say that small hydropower plants will protect against floods and inundations. In fact, small hydropower plants are virtually incapable of protecting people and the economy from floods. The main reasons are:

1. For small hydropower plants do not create large enough reservoirs capable of accumulating any significant volumes of floodwater. The dam of a small hydroelectric power station is a simple dam in the path of floodwaters, through which they either simply flow, either descend directly through the locks or bypass it (the last case, in particular, was observed at the Sniatyn HPP during the catastrophic floods of 2008).

2. In fact, flood defenses and MHPPs are considered to be functionally incompatible, which is clearly stated in the international document “Integrated Water Basin Management Plan of the Tisza River”, which is approved by the governments of 5 countries, including and Ukraine in 2012. After all, in order to effectively accumulate excess water, it is necessary to keep the appropriate flood tanks dry. At the same time, the features of stable operation of hydropower plants require that reservoirs be filled with water.²¹

¹⁸ ‘Hydroelectric Power Plants as a Source of Renewable Energy: Legal and Ecological Aspects’ (Federal Environmental Agency (Umweltbundesamt) Berlin, November 2003) <https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/2544.pdf> accessed 24 August 2021.

¹⁹ ‘Wild Rivers System: St. Croix Waterway. Hearings, Eighty-ninth Congress, First Session’ (U.S. Government Printing Office, 1965) p.536 [https://books.google.lt/books?id=dm1zIXLU0NEC&dq=United+States,+there+are+so-called+\"wild+rivers\".&hl=ru&authuser=1&source=gb_s_navlinks_s](https://books.google.lt/books?id=dm1zIXLU0NEC&dq=United+States,+there+are+so-called+\) accessed 24 August 2021.

²⁰ Dorosh S., Popovich Z., ‘Why do the peasants of Transcarpathia oppose the construction of small hydropower plants?’ (BBC News, 31 July 2017) <https://www.bbc.com/ukrainian/features-40641403> accessed 24 August 2021.

²¹ Ibid, ‘Hydroelectric Power Plants’.

It is possible to install hydropower plants at the outlet of dry flood tanks, but their attractiveness for business is low because they will work for a very short period of the year - during the discharge of accumulated floodwaters. In the case of particularly devastating floods, which are likely to occur more frequently as a result of global warming, there is a possibility of destruction of hydroelectric dams with the corresponding formation of flood waves, which will only add destructive force to the water flow. In such a scenario, the wave, having destroyed one dam in the upper reaches, will descend with increasing force, destroying the dams.

One of the arguments in favor of small hydropower plants is that their work is not accompanied by greenhouse gas emissions, and therefore such electricity production is clean and helps prevent climate change. In fact, not everything is so simple. Small hydropower plants do generate electricity without burning fossil fuels. This prevents the release of carbon dioxide into the atmosphere.

Compared to the huge emissions from thermal energy, hydropower plants have a really small impact on the climate. However, during the construction of hydropower plants, the negative impact on the climate can still be. If the HPP requires the creation of a reservoir, then at the time of its filling, emissions of another greenhouse gas - methane, which has a greenhouse potential more than 20 times higher than carbon dioxide²². This increase is due to the decomposition of organic matter contained in residues, such as plants, under conditions of flooding of the reservoir. In addition, the operation of hydropower plants in Ukraine does not mean that there is a real reduction in greenhouse gas emissions.

After all, in order to achieve a real reduction, it is necessary to decommission the relevant capacities at thermal power plants (TPPs) when starting hydroelectric power plants.

In order to preserve the natural fund of the Carpathian Mountains, the following restrictions and principles for the installation of hydroelectric power plants can be proposed.

Allocation of especially valuable river areas with legislative enshrinement of environmental status and a ban on the construction of hydropower plants in such areas and other types of environmentally destructive activities. Allocation of valuable river areas, where the construction of only the least environmentally harmful hydropower plants is possible - for example, dam-less natural hydropower plants, as well as a ban on the complete blocking of riverbeds by any dams or walls.

Carrying out a qualitative environmental impact assessment of HPP projects, including consideration of the refusal to build HPPs as an alternative, based on the data of comprehensive research.

²² Ibid, 'Hydropower in the Carpathians: Myths and Reality'.

Creating opportunities for the restoration of natural river ecosystems. Preferring environmentally friendly technologies for the development of hydropower potential of rivers (for example, non-dam natural hydropower plants), which do not have a negative impact on the environment, inherent in the described derivation and dam small hydropower plants;

By the way, the struggle continues not only in Ukraine: in the United States (Washington state), two dams 33 and 64 meters high were recently demolished on the Elwha River, which blocked the river and fish migration routes for 102 years. This demolition, which is the largest demolition of the dam for environmental reasons in history, was due to the struggle of local residents and environmentalists - the defenders of rivers. The health of the river and the fish turned out to be more important for both the local community and the state.²³

4. Biogas

Biofuel is understood as any type of fuel obtained from plant raw materials, animal waste, organic waste from industry, and human life. Ordinary firewood is also biofuel, a renewable source of thermal energy. Truth, it will take several decades to restore its reserves.

In the industrial production of biofuels as an alternative form of energy, both specially grown crops and agricultural waste are used. The types of biofuels known today include fuel pellets and briquettes; bioethanol, bio-gasoline, and biodiesel; biogas.

For the production of solid biofuels, waste from the woodworking industry is used, and raw materials - energy wood - are specially grown. The advantage, in this case, is the relative cheapness of the resulting product, the disadvantage is the rather long recovery/growth period of the raw material.

The production of liquid biofuels is based on the processing of crops and animal fats. Different countries use different types of vegetation: sugarcane, rapeseed, soybeans, corn, and the like.

Alternative energy is actively developing in Ukraine based on the processing of agricultural waste. Biogas is obtained from the fermentation of plant materials. It is no different in composition from natural methane and is used for thermal and power plants.²⁴

²³ 'Elwha River Restoration Project' (ISGS, 4 November 2020) https://www.usgs.gov/centers/pemsc/science/usgs-science-supporting-elwha-river-restoration-project?qt-science_center_objects=0#qt-science_center_objects accessed 24 August 2021.

²⁴ 'Alternative energy sources' (Ecodevelop, 9 October 2019) <https://ecodevelop.ua/ru/alternativni-dzherela-energiyi/> accessed 24 August 2021.

Biogas is one of the most promising alternative fuels. Its production not only does not require growing or other preparation of the source material but also allows you to get rid of waste, thereby reducing the environmental load on the environment.

In Ukraine, obtaining fuel in biogas plants is becoming a trend. In terms of market volume, this area ranks third after solar and wind energy. Biogas can be used as natural gas: accumulate, pump, generate electricity from it, use it as fuel for internal combustion engines.

As a result of many years of research, mankind has come to the conclusion that biogas can be produced artificially in special installations, who produce it from organic raw materials by anaerobic fermentation and at the same time receive biofertilizers

The schematic diagram of a biogas system includes primary storage of raw materials, a pumping station, a reactor, and a cogeneration unit operating in a single technological chain. The raw material for biogas production can be products and waste of plant growing, animal husbandry, food, and processing industries.²⁵

Better deal with the production of biogas in China, which has 28 million biogas plants and produces 18 billion cubic meters. m of biogas per year, India - 3,8 million biogas plants, Germany - 8 thousand, hundreds of them in Holland, Canada, Russia, Belarus, Kyrgyzstan, Kazakhstan. There are only 11 biogas plants in Ukraine.²⁶

Ilya Klimchuk, a leading engineer at the Institute of Renewable Energy at the National Academy of Sciences of Ukraine, is convinced that the combination of solar energy and biogas is the best fit in Ukraine for residential or office buildings in remote areas with undeveloped infrastructure, for example, in Polesie and the Carpathians.

For example, up to 4.7 million tons - about the same amount of dung “produced” per year by poultry farms in Ukraine. Poultry farms often dispose of large volumes of manure, dumping it into compost pits or storing it in open soil areas, thereby contaminating adjacent water bodies and groundwater, because chicken manure is particularly rich in phosphates and ammonium nitrogen.²⁷

And the high content of methane in piles of droppings, if stored improperly, leads to the so-called greenhouse effect.

The mountainous region of the Carpathians has a large number of agricultural land, as well as farms. Many settlements are located in remote areas of the mountains, so livestock and plant growth are integral activities. Also, the climatic conditions of such an area allow you to create farms and keep cows, buffaloes, goats, horses, pigs, etc. Animals produce large amounts of waste every day that can provide energy

²⁵ ‘Schematic of a Biogas Plant’ (Biteco, 9 December 2019) <https://biteco-energy.com/help/1575899636/id39/> accessed 24 August 2021.

²⁶ Chernyavsky S., Khalak V., Stadnytska O., Ferents L., ‘Biogas Systems and Their Use in Agricultural Production’ (Agribusiness today, 30 November 2016) <http://agro-business.com.ua/agro/idei-trendy/item/8389-biohazovi-systemy-ta-ikh-vykorystannia-u-silhospyrobnystvi.html> accessed 24 August 2021.

²⁷ Panasiuk S., Logvynenko B., ‘Turning Chicken Manure into Fertiliser and a Source of Energy’ (Ukrainer, 12 March 2021) <https://ukrainer.net/integro-sd-en/> accessed 24 August 2021.

benefits. Therefore, all animal and poultry waste needs to be properly disposed of. Storing waste without proper decontamination will not only damage the soil with highly concentrated substances but also can promote the spread of pathogens, weed seeds, eggs, and parasite larvae in the soil.

Conclusion

1. Wind energy is energy-efficient, since its use in no way affects the Earth's atmosphere, does not cause harmful emissions. And the resources of wind energy are 50 times more than human needs in general. The main disadvantage of wind turbines is their high price. In addition, wind turbines generate high-frequency noise and require more or less constant wind speeds, open areas, and heights.

2. The energy of the Sun is also safe for the environment. It can be produced as long as the sun is shining. And the solar-powered stations (solar stations) are generally silent. But there are also disadvantages: they take up large areas, and the energy output is variable. They can be located on the territory of the mountains of Ukraine, where there is a lot of sun and open spaces.

3. Hydropower does not need fossil resources and, like those mentioned above, does not pollute the atmosphere. However, as a result of the construction of hydropower facilities, vast tracts of land are flooded, rare fish species disappear, flora and fauna are destroyed, and fertile soils are lost. Hydropower accounts for 8% of the country's total energy balance, but new facilities could potentially be located in any region of the Carpathians that has small or large rivers. These three sources account for almost 99% of all energy produced from renewable sources.

4. At the same time, biomass has great potential as an alternative energy source, which is very widely used in the world. The use of biomass and fuels from it allows, first of all, to take a step towards energy independence from traditional fuels. Now the leading positions in wood (firewood, briquettes, pellets). Since energy plants are grown specifically for these purposes in Ivano-Frankivsk, Lviv, Ternopil, Volyn, and Carpathian mountain regions can also act as biomass. Recently, cereal straw and animal waste has been increasingly used as an important source of alternative energy. It is the use of this energy source that would be expedient and most promising in the Carpathian region, known for its agricultural lands. The combustion of biomass is not completely environmentally friendly. But, somewhat losing in environmental friendliness to natural gas, biomass is more environmentally friendly than coal. The general toxicity of its combustion products is 2 times less than that of coal. When burning biomass in boiler houses, it is necessary to use efficient gas cleaning equipment. It allows

achieving high-quality cleaning of flue gas emissions and reducing the environmental burden on the environment.

The introduction of alternative sources not only in mountainous natural areas, but throughout the country has a clearly established procedure. And according to Ukrainian legislation, this process has a number of restrictions. So, one piece of land will not be allocated for the construction of solar, wind power plants and other facilities for the production and processing of biomass as fuel, without the obligatory expert opinion of the Sanitary and Epidemiological Service regarding the correctness of determining the size of the production area and sanitary protection zones for such facilities, as well as no public comment. And the composition of the project documentation must include the “Project of Environmental Impact Assessment (EIA)”.

The procedure for making a decision on the construction of bioenergy facilities is as follows: (1) first, information about the intentions of construction and the characteristics of emissions is published in the media; (2) then public hearings are held (they take into account written and other appeals of citizens regarding such construction); (3) the customer and the executor of the EIA provide for the consideration of the local population and public organizations a list of questions and comments of citizens, give substantiated answers to them; (4) the decision on the taken into account part of the public proposals and the justification for the part that was not taken into account shall be generalized; (5) finally, make a decision of the public examination (if it was carried out). Public discussion of objects posing an increased environmental hazard should last at least 30 days and no more than 3 months from the date of publication of the announcement of the state environmental expertise.

Therefore, such decisions, important for cities and the state, depend not only on officials but also on society. An example of this is the aforementioned complex process of creating hydroelectric power plants.

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Global horizontal irradiation

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