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ANALYSIS

DISTRIBUTED GREEN ENERGY FOR REBUILDING THE LIBERATED TERRITORIES AFTER THE WAR: AZERBAIJAN AND UKRAINE

Summary

Green energy is clean energy that, unlike fossil fuels, is non-polluting that comes from hundred percent renewable sources. Use of green energy by different countries varies depending on location as well as regional characteristics. Azerbaijan and Ukraine are countries suffered from war destruction, and consequently the territories de-occupied after the war in Azerbaijan and Ukraine need sustainable development based on a green decentralized energy system. After the 44-Day war Azerbaijan started the full restoration work in Karabakh region. Many infrastructure and energy projects had been completed and several new ones were stared.

It should be underlined that energy sector plays an important role for both countries. COVID-19 outbreak and the ongoing war between Ukraine and Russia harmed also the global energy sector. However, driven by its natural resources – crude oil and natural gas, Azerbaijan ensures its own energy security, and at the same time, supports energy security of Europe. Azerbaijan has also huge potential to develop green energy in the country. After the liberation of Karabakh, on 3 May 2021, the President of the Republic of Azerbaijan Ilham Aliyev signed an order on measures to establish a "green energy" zone in the liberated territories. It is worth noting that within the framework of the implementation of the instruction on the establishment of the" Green Energy Zone", investigations are being carried out to study the solar, wind, biomass, thermal, geothermal and other renewable energy potential of the liberated regions, to determine the coordinates of the territories, as well as to provide energy supply by building wind and solar power stations, as well as hydropower plants on reservoirs, lake and small rivers.[1]

[1] https://minenergy.gov.az/en/alternativ-ve-berpa-olunan-enerji/azerbaycanda-berpa-olunan-enerji-menbelerinden-istifade

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Renewable energy in Ukraine: development and destruction

In 2019, Ukraine was in the TOP-10 countries in the world in terms of the pace of green energy development, and in 2020 - in the TOP-5 European countries in terms of the pace of development of solar energy. The total capacity of green energy facilities at the beginning of 2022 reached 9,656 MW. However, Russia's invasion not only stopped the development of the industry, but caused devastating losses, and companies stopped on the verge of bankruptcy[2] .

Solar energy:

The total installed capacity of industrial solar power plants in Ukraine is 6,226.9 MW. About 60% of industrial solar power plants are concentrated in the southern and south-eastern regions of Ukraine, where active hostilities are taking place, amounting to about 3,700 MW. During the fighting, 30-40% of solar power plants in the regions affected by the Russian invasion have already been damaged - 1,120 - 1,500 MW of installed capacity. The most affected are industrial solar power plants, which are located in the Mykolayiv power hub[3].

Wind energy:

In Ukraine, the total capacity of installed wind farms is 1673 MW. Wind farms in Ukraine are concentrated in Zaporizhia, Mykolaiv, Odesa, and Lviv regions. Significant occasions were recognized by objects of renewable energy, including in the wake of their mass expansion near the coasts of Kherson, Mykolaiv, and Zaporizhia regions, which were paid off from the first day of the attack. About 70% of the wind stations stuck [4]. Following the words of the head of the Ukrainian Wind Energy Association (UWEA) Andriy Konechenkov, it was known about the five-megawatt wind turbines at the stations of the companies "Sivashenergoprom" and "Windcraft Ukraine" in Kherson region[5].

Bioenergy:

Enterprises that generate electricity and heat from biomass in Ukraine have an installed capacity of 224.5 MW (of which biomass - 119.1 MW, biogas - 105.4 MW). Bioenergy facilities are scattered throughout Ukraine and tend to settlements and large

[2] https://ecolog-ua.com/news/zruynovana-viynoyu-galuz-zelenoyi-energetyky-v-ukrayini-znahodytsya-na-grani-bankrutstva-shcho
[3] https://ecolog-ua.com/news/zruynovana-viynoyu-galuz-zelenoyi-energetyky-v-ukrayini-znahodytsya-na-grani-bankrutstva-shcho
[4] https://ua-energy.org/uk/posts/zelenyi-kurs-naipershi-neobkhidni-kroky-vid-ekspertiv-dlia-vidbudovy-ukrainy?fbclid=IwAR2KI5SCXsWz2kQH6gmKopWI4ts_bAZuDPyxhCgOV_FmnnBO8fV_uWkrjU8
[5]

agricultural enterprises.

As a result of the Russian invasion, 10-15% of the installed capacity was affected. This primarily applies to cities whose infrastructure has been bombed, and regions of active hostilities: north and east of Kharkiv region, Sumy and Chernihiv regions, Mykolaiv district, the city of Zhytomyr. In particular, the boiler house, which provided up to 30% of heat supply in Zhytomyr, Bio TPP on the district road of Mykolaiv, was destroyed, the infrastructure of the first energy efficient village of Ukraine Vesele (currently under temporary occupation) was completely destroyed[6].

Hydropower:

Ukrainian Hydroenergo continues to provide coverage of peak loads, frequency, and power regulation, as well as a mobile emergency reserve in the United Power System of Ukraine. HPPs and PSPs, which are part of the company, operate regularly according to schedule and follow the teams of dispatchers. Full-time operational staff are on duty[7].

De-occupied territories in Ukraine

The land area of de-occupied territories is around 30000 km, but isn`t constant, because the fighting continues. Moreover, on the territories de-occupied in the North part of Ukraine in Kyiv, Chernihiv, and Sumy regions the reconstruction of infrastructure and road and the railway network was completed as a whole. Many cities were destroyed as a result of fighting and enterprises were destroyed or relocated. This way, expedient planning of new territorial sustainable development of de-occupied territories based on a green decentralized network.

Distributed green energy systems

The cornerstone green decentralized network is distributed green energy which includes:

- decentralized energy systems;
- renewable energy development in particular Bioenergy;
- safety nuclear energy;
- artificial intelligence in the energy sector;
- green hydrogen energy;
- internet Energy (IoE).

[6] https://ecolog-ua.com/news/zruynovana-viynoyu-galuz-zelenoyi-energetyky-v-ukrayini-znahodytsya-na-grani-bankrutstva-shcho
[7] http://mpe.kmu.gov.ua/minugol/control/publish/article?art_id=245656073

- An important limitation in the distribution of electricity has been that electrical energy cannot be stored and must be generated as needed.

Local decentralized renewable energy models offer an opportunity to circumvent regional barriers, provide affordable electricity, and reduce reliance on imported fossil fuels. These models entail the implementation of renewable energy technologies on-premise, such as rooftop solar power systems or solar microgrids that can power entire communities. These systems can run on- or off-grid with energy storage or in hybrid mode coupled to the existing diesel generators or stationary electrical networks [8].

Distributed renewable energy generation would enhance security and economic indicators through reduced dependence on fuel imports, lower outflows of foreign currencies, and improved business competitiveness. Decentralized system models reduce the overall costs through the reduction of grid and flexibility costs and required investments. A decentralized system, particularly through the use of isolated, off-grid units and mini-grids, is suitable in rural areas where the population density is low. Often much more economically feasible than central grid build-outs, decentralized approaches can achieve rural electrification faster[9].

Smart grid technologies facilitate the management of decentralized energy systems. Linking distributed generation resources through a grid system increases their reliability, particularly when using renewable resources.

Local distributed grid generation will be useful for rural electrification. Off-grid distributed generation can reduce the need for expensive transmission and distribution network expansion. Lower losses through the lengthy transmission of electricity increase eco-efficiency of project for rebuilding. Decentralized siting of energy generation facilities requires decentralized businesses to construct, operate and maintain the facilities, creating opportunities for local business and job creation[10].

Green rebuilt of the distributed green energy system in Ukraine and

EU plan "RebuildUkraine"

18th May 2022 was created the international coordination platform, the 'Ukraine reconstruction platform', co-led by the Commission representing the European Union and

[8] https://www.csis.org/analysis/failure-power-need-decentralized-renewable-energy-models
[9] https://www.forbes.com/sites/mitsubishiheavyindustries/2021/09/27/decentralized-renewable-energy-could-meet-africas-vast-needs-and-make-an-important-leap-in-decarbonization/?sh=1074da761791
[10] https://www.unescap.org/sites/default/files/14.%20FS-Decentralized-energy-system.pdf

by the Ukrainian government, would work as an overarching strategic governance body.[11]

The 'RebuildUkraine' reconstruction plan endorsed by the platform, based on a needs assessment, would become the basis for the European Union and the other partners to determine the priority areas selected for financing and the specific projects. The platform would coordinate the financing sources and their destination to optimize their use, as well as monitor progress in the implementation of the plan.[12]

One of four major pillars of reconstruction is supporting the recovery of Ukraine's economy and society by promoting sustainable and inclusive economic competitiveness, sustainable trade, and private sector development, while contributing to the green and digital transition of the country[13].

Distributed green energy for rebuilt of deoccupied territories after war will be part of energy security system. Conservation of energy supply capacity of decentralized energy, as local energy sources using, such as wind, solar and hydropower, agro- and forest biomass energy can secure the promotion of energy security. It is important to give the ability to change the focus on climate change and reduce the economic effect.

In Ukraine, it will be clear that the European Bank for Reconstruction and Development and other credit institutions of the European Union will become donors of life and infrastructure. In order to finance the life of life from zero energy savings, the provision of energy supply and heat supply with low levels of CO2 in accordance with EU standards, calling for goiter, Ukraine will become climate neutral until 2060 [14].

DiXi Group experts believe that the goal of rebuilding Ukraine should not be a return to the pre-war state, but full development and integration into the European community, based on sustainable development and taking into account the European Green Course (EPC), which is also a requirement of Copenhagen criteria EU[15].

Conceptual approaches to network distributed green energy in the de-occupied territories of Ukraine

The concept of using network distributed green energy is based on the general

[11] https://www.eeas.europa.eu/delegations/ukraine/ukraine-commission-presents-plans-unions-immediate-response-address-ukraines_en?s=232
[12] https://www.eeas.europa.eu/delegations/ukraine/ukraine-commission-presents-plans-unions-immediate-response-address-ukraines_en?s=232
[13] https://ec.europa.eu/info/sites/default/files/ukraine-relief-reconstruction_en.pdf
[14] https://ua-energy.org/uk/posts/zelenyi-kurs-naipershi-neobkhidni-kroky-vid-ekspertiv-dlia-vidbudovy-ukrainy?fbclid=IwAR3XIYe6ilgJrszrONrZwivyvLXRAscC0KRrbFArFjFSa1NPSRr60RyU4Yk
[15] https://ua-energy.org/uk/posts/zelenyi-kurs-naipershi-neobkhidni-kroky-vid-ekspertiv-dlia-vidbudovy-ukrainy?fbclid=IwAR3XIYe6ilgJrszrONrZwivyvLXRAscC0KRrbFArFjFSa1NPSRr60RyU4Yk

nature of the consequences in the territories that were under occupation and where the hostilities took place.

From these territories, most of the population moved to other regions of the country, and a significant part of the dwellings was destroyed or not suitable for habitation. Bridges and other objects of transport infrastructure were also destroyed, which are gradually being restored, often with temporary structures. Most of the industrial enterprises were destroyed or closed, some enterprises relocated to other regions of the country. Energy networks are damaged or destroyed, electrical substations are disabled, and traditional power generation capacities are disabled. In the context of rising prices for traditional energy resources, such as natural gas, oil, and coal, as well as the rupture of economic relations with the Russian Federation and Belarus, it is advisable to develop a network of distributed green energy as a source of traditional energy sources in the territories affected by hostilities.

Since both industrial and domestic energy consumption in the territories affected by the hostilities has significantly decreased, and the population has decreased compared to the pre-war level, it is advisable to re-design new distributed power generation networks.

Significant areas of de-occupied territories are located in the north of the country in Zhytomyr, Kyiv, Chernihiv, and Sumy regions. Most of the territory is occupied by pine forests, wetlands, and separate sections of agricultural landscapes. Settlements are located on these territories, primarily villages with 100-200 households and cities with a population of up to 10,000 people. Now the population has more than halved. Therefore, it is advisable to develop bioenergy in these territories as a local generation of electricity and heat for individual settlements or individual facilities, such as forestry, farms, agricultural processing enterprises, as well as for communal facilities, and housing. It is advisable to initially plan artificial intelligence and energy storage networks for territorial communities or territorial community unions. Part of this network will be the rehabilitation of communal facilities such as schools and hospitals based on passive house technology. This technology is also possible for the construction of new housing, instead of the destroyed one. Is expedient, creating a local distribution within a network of a territorial community for a dozen villages and a small city based on bioenergy generators operating on waste forestry and agricultural products, supplemented with domestic or small industrial solar power plants with several local energy storage facilities controlled by artificial intelligence will provide many advantages. It will reduce the volume of primary investments, reduce construction time, significantly increase energy security, and reduce the negative impact on the environment and climate. And most importantly, this approach will make it possible to attract international, primarily European, credit and grant resources.

De-occupied territories in Azerbaijan and development of green energy

The Republic of Azerbaijan is rich in natural resources, and the country's oil and natural gas production meets all domestic energy needs. In 2016, Azerbaijan signed the Paris Agreement on climate change, and the country aims to reduce greenhouse gas emissions by up to 35 percent by 2030.[16] Azerbaijan has already started to develop its renewable energy capacity, and one of the country's primary goals is to support a sustainable energy future. The promotion of green energy is one of the main priorities of the state's energy policy direction. To date, Azerbaijan's energy policy is aimed at modernizing the energy sector, adapting policy instruments and the regulatory framework to rapidly changing energy market. In this regard, the main aim of Azerbaijan's energy strategy is to optimize the energy sector and provide a reliable energy supply system.

It should be noted that one of the key elements of Azerbaijan's energy reforms is also the development of green energy. In recent years, the country has started sustainable development in the energy sector through the creation of green energy zones and the gradual process of decarbonization. It is worth noting that renewable energy production in Azerbaijan aims to support a sustainable energy future by producing more electricity from renewable energy sources. This process will be an important target to decrease the use of natural gas in electricity production.

Talking about green energy in the country it is worth noting that key sources of renewable energy in Azerbaijan are hydropower, wind, solar, biomass, and geothermal energy. The potential for solar and wind power generation is especially significant. The possibilities for wind-power development are very strong, especially on the Absheron Peninsula, the Caspian seashore, and islands in the northwest of the Caspian basin.

The government is focusing on the development of a long-term energy strategy. This strategy will cover the period until 2050 and will reflect important areas such as electricity and natural gas supply, energy efficiency, and the use of renewables.[17] As is clear from the strategy, the government intends to support a "twin-pillar" approach to promote sustainable energy for achieving its long-term goals. This process will help the country produce electricity using renewable energy sources while decreasing the use of natural gas for electricity production.

It should be highlighted that the total power generation capacity of Azerbaijan is 7542.2 MW, the capacity of the power plants on renewable energy sources, including large HPPs is 1304.5 MW, which is 17.3 % of the total capacity. Hydropower capacity is 1154.8 MW (30 stations, 20 of which is SHPP), wind power capacity 66.1 MW (7 stations, 2 of which is hybrid), bioenergy capacity 37.7 MW (2 stations, 1 of which is hybrid), solar energy

[16] https://eu4climate.eu/azerbaijan/
[17] https://report.az/ru/energetika/dolgosrochnaya-energeticheskaya-strategiya-azerbajdzhana-na-stadii-razrabotki/

capacity 45.9 MW (12 stations, 2 of which is hybrid). One hybrid power plant (Gobustan) is equipped based on wind-2.7 MW, solar-3 MW and bioenergy-0.7 MW. In Nakhvhivan AR 4 SPPs with a total capacity of 33 MW are commissioned. Installed capacity on renewable energy sources excluding large hydropower plants, was 194 MW in 2021 and it made up 2.5 % of total electricity generation capacity.

In 2021, electricity production in the Republic amounted to 27,8 billion kWh. During the reporting period, electricity generation at TPPs amounted to 26.2 bln kWh, at HPPs to 1277.3 mln kWh, and at other sources (WPP, SPP and Solid household waste plant) to 339.9 mln kWh in comparison. 91.5 mln kWh of electricity was generated at WPPs, 55.2 mln kWh at SPPs, and 193.2 mln kWh at the solid household waste incineration plant. Electricity generated from renewable energy sources made up 5.8 % of total production. [18]

As it was mentioned above, the country has initiated sustainable development in the energy sector through the creation of green energy zones and the gradual process of decarbonization. The key aim is to attract international investment in the green energy sector by providing a high level of protection of foreign investment. In this regard, the country is actively working on plans to develop “green energy zones” in Karabakh. After the liberation of Karabakh following the 44-Day war, President Ilham Aliyev declared Karabakh and East Zangezur economic regions a green energy zone. These regions have great potential for renewable energy, especially hydro-energy. It should be noted that about 25% of Azerbaijan's internal water resources falls to the share of the liberated territories, which is approximately 2.56 bcm annually. In particular, it should be noted that there is a favorable potential for the implementation of solar energy projects in the liberated territories. Thus, Zangilan, Jabrayil, Gubadli and Fuzuli regions are the second most favorable regions in the country followed by Nakhchivan AR according to the solar radiation observed. As a result of the initial observations, the relevant areas with favorable solar radiation were identified. The potential of solar energy in the liberated territories is estimated at more than 7200 MW. The territory of Jabrayil and Zangilan districts was considered expedient on the basis of preliminary studies, topography for solar power projects, climatic conditions, proximity to the network, energy production potential, transport infrastructure and comparative analysis of other technical factors. The presence of favorable wind potential in the liberated territories, especially in the mountainous parts of Lachin and Kalbajar, was determined according to preliminary researches. The analysis shows that the wind power potential in these areas is around 2000 MW. In previous years, relevant scientific research has been carried out on the existence of geothermal energy sources in the liberated territories. Preliminary analysis shows that there are geothermal sources in the mountainous part of the Lesser Caucasus (4000-5000 cubic meter per day (30-74°C)). Based on preliminary observations, it is more expedient to use this potential for

[18] https://minenergy.gov.az/en/alternativ-ve-berpa-olunan-enerji/azerbaycanda-berpa-olunan-enerji-menbelerinden-istifade

heat supply and balneological purpose, respectively.[19] The renewable-energy potential of these regions will allow the generation of electricity from these sources to supply the "smart cities and villages" that Azerbaijan is building in its liberated territories. All the above-mentioned show that Azerbaijan targets to create the backbone of its energy supply system. This will also increase the electricity export potential of the country in the future, as Azerbaijan aims to export electricity to Europe through the "Green Energy Corridor".

Touching upon green energy future in the country, it is also worth mentioning that recently, two important renewable energy projects were signed with Saudi Arabia's ACWA Power and United Arab Emirates (UAE) Masdar energy companies. An agreement on a solar power plant project with a capacity of 230 MW has been signed with Masdar. According to Minister of Energy Parviz Shahbazov, "by signing these contracts for a solar power plant worth about $200 million, we are one step closer to our goals for the renewable energy and carbon emissions. The solar power plant to be built in Baku and Absheron district will produce about 500 million kWh of electricity annually, save 110 million cubic meters of natural gas, reduce carbon emissions by 200,000 tons, create new jobs, and attract other investors to new projects."[20]

Another important project, the 240-MW Khizi-Absheron Wind Power Plant, will be built by ACWA Power. Total investment for both projects is $400 million, and this overseas investment is economically significant as it will create many jobs and save natural gas. The Khizi-Absheron project, implemented through the attraction of foreign investment, will be the largest wind farm in the country. These investments will also stimulate future investment pathways. Azerbaijan has proved itself a reliable partner, and the economic and energy policies being implemented in the country create a favorable investment climate for foreign investors. Most importantly, the Khizi-Absheron wind power project "will prevent the release of over 400,000 tons of carbon dioxide into the atmosphere and save 200 million cubic meters of gas per year. At the same time, it will help the country increase the share of renewable energy sources in the country's energy system to 30 percent by 2030." [21]

Also, the Ministry of Energy of the Republic of Azerbaijan and bp have signed an Addendum to the Implementation Agreement that they had previously signed in June 2021 committing them to work together to take the next steps towards joint implementation of a 240MW solar power plant in the liberated Jabrayil. According to the document, it is the parties' plan to achieve an effective technical and commercial solution to the project implementation through piloting a commercial structure called a "Virtual Power Transfer

[19] https://minenergy.gov.az/en/alternativ-ve-berpa-olunan-enerji/azerbaycanda-berpa-olunan-enerji-menbelerinden-istifade
[20] https://minenergy.gov.az/en/foto-qalereya/masdar-sirketi-ile-qoyulus-gucu-230-mvt-olan-gunes-elektrik-stansiyasi-layihesi-uzre-muqavileler-imzalanib
[21] https://report.az/en/energy/what-is-the-significance-of-khizi-absheron-wind-farm-for-azerbaijan/

Arrangement". This will enable the project to produce solar power in Jabrayil and sell it in another part of the country to either public or private off-takers.[22]

It should be noted that before the occupation, more than 30 HPSs used to operate in Karabakh and most of them were destroyed. Azerbaijan has started immediately the reconstruction process after liberation, and as a result, hydroelectric power station with a capacity of 8 MW, located in the village of Gulabird, Sugovushan-1 and Sugovushan-2 stations have already been reconstructed and put into operation. The government plans also to reconstruct small hydroelectric power plants with a total capacity of about 130 MW in the amount of 11 units in Kalbajar District and 12 units in Lachin District.[23] Taking into account that around 25 percent of the country's local water resources originate in this region, it is beneficial to use local rivers for the construction of hydropower stations (HPS).

Last but not least, all analysis show that Azerbaijan has started important reforms in its energy sector to meet challenges and support a sustainable energy future. The government already considers development of renewable energy as one of the key objectives of the state energy policy. It collaborates with the European Commission, UNDP, IRENA World Bank, Asian Development Bank etc. to promote the development of sustainable energy in Azerbaijan. Supporting renewable energy sources, Azerbaijan will balance successfully the use of natural gas and renewables in electricity production. This will create new opportunities for electricity production and export. Karabakh region has great potential for the development of green energy, and the main aim of the government is not only to develop renewables in this region but also use the most efficient ways in the transmission and distribution of green energy.

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[22] https://azertag.az/en/xeber/Ministry_of_Energy_bp_agree_on_next_steps_in_solar_project_in_south_west_of_Azerbaijan-2164874

[23] https://report.az/en/energy/plans-for-restoration-of-karabakh-power-system-announced/