The Wholesale Electricity Market in Wartime.
Implications of the Russian invasion and the ways toward revitalization.

Unjustified Russian invasion of Ukraine had severe impact on the wholesale electricity market. Since the beginning of the war, there has been a 35% decline in electricity consumption and about 65% in payments. A number of Ukrainian enterprises have stopped functioning. More than 5 million Ukrainians have left their homes and fled abroad. Households were allowed to postpone payments for the utilities which has caused a working capital deficit for the generating enterprises. The energy infrastructure was heavily damaged.

It will take time for Ukraine to restore the energy sector. Accurate data about the actual damage can be obtained through technical audits. Rehabilitation of energy infrastructure will require enormous efforts and investments, yet, there is an opportunity to reshape Ukraine's energy sector in line with European standards.

This article addresses the wholesale electricity market since the beginning of the unprovoked war against Ukraine and elaborates on the possible options for its restoration.

Energy Market Deficit

According to Energy Ministry, the liquidity deficit in the energy market of Ukraine amounts to about €250 million per month.
Since the start of the war electricity consumption fell by 34%, including industrial consumption by 32%. The nuclear power plants (NPP) production decreased by 34%, thermal power plants (TPP) production – by 28%, and electricity generation from renewable energy sources (RES) – by 72%.
The deficit can be overcome by obtaining financial assistance from partners, and/or by extending the exports of Ukrainian electricity to Europe.

Support for Ukraine to revitalize energy sector

Ukrainian authorities are called to maintain the achievements of energy market reform and to continue integration into the EU single market. Thus, the energy sector of Ukraine will be able to recover faster and overcome liquidity problems. Several initiatives, have been launched to support Ukraine's energy sector.

The Energy Community has decided to establish an Energy Support Fund for Ukraine[1] to counter the effects of the Russian invasion. It is expected that the donors of the Fund will be mainly EU member states, as well as international companies and corporations. Energy Community Secretariat will be acting as fiduciary[2] of the Ukraine Energy Support Fund.

[1] Energy Community Secretariat Ukraine support activities, https://www.energy-community.org/regionalinitiatives/Ukraine.html

2 Energy Community Secretariat to act as fiduciary of the Ukraine Energy Support Fund, https://www.energy-community.org/news/Energy-Community-News/2022/04/05.html

At the same time, the procedure for selecting suppliers will be implemented by international procurement agencies with experience in the energy sector.

Preference in procurement will be given to Ukrainian manufacturers who will offer the best value for money, as well as be able to fulfill orders in the shortest possible time.

It is an option for the countries that want to contribute, the practical or logistical ability to donate to the fund. The funds will be used for the energy supplies, repair damaged energy infrastructure and inject liquidity in the struggling energy sector.

Also, the European Commission published a Strategy for an EU external energy engagement in a changing world[3], which is part of the REPowerEU plan.

The Strategy recognizes the role of the European Community in supporting Ukraine, including the purchase of urgent goods through the Energy Support Fund of Ukraine and support for reforms for the future full integration of Ukraine's energy market with the EU.

The recent $750 billion Ukraine Recovery Plan[4] has been laid out in Lugano, Switzerland. The energy block emphasizes the nuclear, renewable and hydropower, hydrogen and biofuel production, projects to increase the flexibility of the energy system and construction of maneuvering capacities, development of power grids and energy infrastructure, gas production and transportation, development of oil transport and oil refining infrastructure as the main areas for investments in the energy sector of Ukraine.

The energy independence and the green transition of Ukraine is estimated at $130 billion. Construction of 1.5–2 GW peak capacities and 0.7–1 GW capacity batteries, localization of production of RES equipment, testing and development of transport of hydrogen infrastructure, construction of about 15 GW of electrolysis capacity, 3.5 GW of hydroelectric power plants and pumped hydroelectric power plants, more than 30 GW of RES for hydrogen production, development of biofuel production from agricultural products, residues and waste.

Green transition and impact of Russian military assault

The war in Ukraine has affected the Carbon Neutrality and Renewable Energy Policies. While the REPowerEU [5] is a longer-term commitment to phase out fossil fuels and boosting renewables, there are signs that some European states are slowing down their carbon phase-out strategies to prevent the risk of supply shortfalls.

Some countries are reconsidering their decision to shut down their nuclear plants (Germany) and gas fields (Netherlands), the others are contemplating a slower-than-planned phase-out of

3 Strategy for an EU external energy engagement, https://energy.ec.europa.eu/topics/energy-strategy/strategy-eu-external-energy-engagement_en

4 Ukraine recovery plan, https://recovery.gov.ua

[5] REPowerEU https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

coal-powered energy (Great Britain, Germany). Simultaneously, the EU member states are boosting the solar and wind energy projects (Germany, Denmark).

Joining the European Network of transmission system operators for electricity (ENTSO-E)

One of the unprecedented events of this year is that the electricity grids of Ukraine and Moldova have been successfully synchronized with the Continental European Grid.

The technical assessment of the test was carried out between 24-27 February 2022. Ukraine has got all political support from its western allies. On February 28, the energy ministers of the EU countries voted for Ukraine's accession, and on February 30, ENTSO-E already made a statement considering the synchronization application.

Despite the ongoing war, on 16 March 2022, the Transmission system operators **(**TSOs) of Continental Europe started the trial synchronization of the Continental European Power System with the power systems of Ukraine and Moldova. This was accomplished ahead of schedule and greatly contributed to energy independence thus, allowing energy supply in case of disruption to the Ukrainian power system (UPS).

Although Ukraine and Moldova were jointly synchronized with the European power system with the 50 Hz frequency, the flows with neighboring EU countries - Hungary, Slovakia, and Romania were still technical. The potential transmission capacity at the western borders is about 2,000 MW.

The exports to Poland constituted 200 MW/day. Nowadays, Ukraine and Poland plan to restore and implement the high-voltage power line Khmelnytskyi NPP-Rzeszow[6] with its conversion to 440 kV by the end of 2022.This transmission line can increase Ukraine's export potential by 25-30 per cent.

Less than two months after synchronizing with the European power grid (on12 May, 2022) Ukraine has begun exporting electricity to neighboring Moldova. Ukrhydroenergo has booked a power transmission capacity of 80-150 MW/h to deliver electricity to Energocom, the Moldovan state wholesale company.

Notably, Ukrenergo, Ukrainian energy company, has become an Observer Member[7] within the European electricity TSO members of ENTSO-E. This would enable Ukrainian TSO to participate in the meetings of the ENTSO-E Regional Group to elaborate on the issues of electricity market development, balancing, ancillary services, electronic data exchange, development of cyber security in the electricity sector, integration of renewable energy sources and more.

[6] Memorandum was signed at ministerial level. Volumes of electricity exports from Ukraine to Poland can potentially increase to 1 GW, - Herman Galushchenko, https://www.kmu.gov.ua/news/obsyagi-eksportu-elektroenergiyi-z-ukrayini-do-polshchi-potencijno-mozhut-zrosti-do-1-gvt-german-galushchenko

[7] ENTSO-E welcomes Ukrenergo as Observer Member
https://www.entsoe.eu/news/2022/04/26/entso-e-welcomes-ukrenergo-as-observer-member/

On 7 June, 2022, Continental Europe TSOs confirmed the key conditions[8] that would enable a gradual opening of the electricity trade with Ukraine. The full implementation of these technical conditions is necessary to guarantee the security and stability of the extended power system.

In particular, 6 technical requirements were fulfilled by Ukrenergo, and TSOs of neighboring countries for the start of trade. Remarkably, Ukrenergo[9] has integrated into the mechanism of financial settlement of cross-border unintentional deviations of technical flows (FSkar mechanism); and also has connected to the "Special Alarm System" for real-time monitoring of electricity flows along cross-border lines and exchange of this data with other European TSOs.

The commercial electricity exchanges with the Ukraine/Moldova power system has started on 30 June on the interconnection between Ukraine and Romania to be followed by the electricity trading on the other interconnections Ukraine-Slovakia, Ukraine-Hungary, and Moldova-Romania. The total trade capacity was initially set to 100 MW in the first phase, later on a gradual increase in the trade capacity would be regularly assessed based on power system stability and security considerations.

The price in Ukraine is currently about €70/MWh, and in neighboring Hungary - more than €300/MWh.

The European Union has provided for the possibility of joining up to 15% in 2030[10] of the installed capacity of the ENTSO-E neighboring country.
Ukraine has to follow the same target, it should invest in interconnections that allow for at least 15 per cent of the electricity produced on its territory to be transported across its borders to Poland, Romania, Slovakia, and Hungary.

In order to implement market coupling the following has to be accomplished:

- Using mechanisms already working in the European market, in particular, SDAC (Single Day-Ahead Coupling) and SDIC (Single Intraday Coupling), which enable continuous cross-border trading across Europe. Applications from different countries are collected, sent to one global center and results are generated using the EUPHEMIA algorithm.
- Joining the JAO single trading platform where cross-border transmission capacity rights are auctioned. It also provides accounting (clearing and settlement), contracting, reporting, project support and IT services.
- Confirming the status of the Nominated Electricity Market Operator (NEMO) - an entity designated by the competent authority to perform tasks related to single day-ahead or single intraday market coupling.

[8] Continental Europe TSOs confirm the technical pre-conditions for the gradual opening of electricity trade with Ukraine, https://www.entsoe.eu/news/2022/06/08/continental-europe-tsos-confirm-the-technical-pre-conditions-for-the-gradual-opening-of-electricity-trade-with-ukraine/

Ukrenergo official website, https://ua.energy

[10] Electricity interconnection targets, https://energy.ec.europa.eu/topics/infrastructure/electricity-interconnection-targets_en

Advantages of UPS synchronization with the Continental European Grid

- Increasing reliability of UPS, toughening competition in the Ukrainian electricity market.
- Better investment opportunity and incentive to operate within the European energy space in conformity to the rules and standards that are clear to investors.
- Stability of the grid and new opportunities for the development of renewable energy provide the necessary balancing capacity.

The electricity exports will benefit both Ukraine and the EU: in the context of the current energy crisis due to the war with Russia, Ukrainian electricity for the EU is to strengthen energy security, diversify markets, and the ability to obtain carbon-neutral energy cheaper.

For Ukraine and Moldova, this means complete independence of electricity from Belarus and Russia and becoming a part of the European energy space. For Europe, this would mean changing the energy landscape in the region and getting a new player in the energy system - Ukraine, which will become a powerful and reliable source of electricity supply.

Heating season

Similar to many European countries Ukraine has been moving steadily to low carbon energy, although would probably rely on coal this coming heating season.

Military actions pose a huge challenge for the upcoming heating season. Many occupied territories (settlements) turned out to be near the combat zones or where the critical infrastructure has been severely damaged.

The Government reported that Russian troops destroyed more than 200 boiler houses and severely damaged the Kremenchuk, Chernihiv, Okhtyrka, Luhansk, and Severodonetsk CHPs. Hundreds of power lines and transformer substations were destroyed. Energy infrastructure and energy losses have already reached tens of billions of UAH. Add to this the loss of the Vuglehirskaya TPP and the long-term forced operation of the Zmiivskaya TPP on gas.

The special headquarters set up by the Government on June 7, 2022 has been assigned with the task to balance the country's energy system, carry out repairs, etc. One of the Government's most important tasks is to accumulate 19 bcm gas[11] in Underground Storage Facilities (USFs) and up to 3 million tons of coal in warehouses by winter.

According to the Energy Ministry, Ukraine has completed the previous heating season with 9 bcm gas in UFSs and this year's gas production is estimated at 16-19 bcm and consumption - at 21-24 bcm. As for coal, the reserves in TPP warehouses amount to 1.5 million tons as of July. At some of the stations, the supply of coal is blocked due to the threat of shelling and logistical problems, and destruction. Coal production in state-owned mines fell by about a third due to the occupation of some facilities.

As for gas, it might be the inner production only provided the demand remains on the same level without imports from the other countries. To this end, on June 13, the Cabinet of Ministers

[11] CMU Regulation No. 691 dated 17 June 2022, https://www.kmu.gov.ua/npas/pro-vnesennya-zmini-do-punktu-2-po-a691

has banned[12] the export of liquid fuel (fuel oil), coal (except coking coal), and gas of Ukrainian origin. The moratorium will be in force during the martial law and within six months from the moment of its termination or cancellation.

The Ministry of Energy will determine the procedure for the use and payment of coal from the strategic reserve, and it is highly likely that the main recipient will be Centrenergo, the state company. It still operates on an extremely expensive coal mix, using significant volumes of expensive imported coal. At the same time, for the last 4 months it has been working, on the surplus (and therefore cheap) market, not covering its cost price with the sale of electricity.

The Government warns about extremely difficult and unpredictable heating season.

With this in mind, the priority task for cities where the centralized heat supply was destroyed, the modular boiler houses with the possibility of alternative energy sources use would be a solution. The transition to individual heating using the electric systems, renewable pellet systems, wood-fired boilers, autonomous boilers should be determined at the local authority level.
At the same time, the Cabinet of Ministers attempted to settle the issue of not raising tariffs for housing and utilities during the war [13] by recommending that the bodies authorized to set tariffs for heat, supply of thermal energy, hot water, centralized water supply, and sewerage, stick to the current prices for the households during martial law in Ukraine.

RES sector

In Ukraine the renewable energy sector has also faced serious challenges. Until recently, this industry was developing quite dynamically. As of mid-2021, it had reached a total capacity of about 9 gigawatts (GW). This amounted to about 15 per cent of the total balance of the UPS of Ukraine.

All in all, the RES sector was responsible for 8 per cent of power production, however, the scale of the destruction is enormous as the most of the facilities were built in the southern regions: Kherson, Mykolaiv, Zaporizhzhya, Odesa, and Dnipro. According to experts' estimates, since the beginning of the war, the work of 70 per cent of wind farms, more than half of solar power plants, and 10% of biomass and biogas plants have been stopped or significantly limited.

According to some estimates, around 30 to 40 per cent of Ukraine's industrial solar generation facilities (1120 to 1500 megawatts (MW) were affected by the Russian invasion. At the same time, the Ukrainian Wind Energy Association claims that more than two-thirds of all the country's wind farms (1673 MW) have been shut down. The energy companies operating these facilities many of which have substantial loan obligations now could find themselves on the brink of bankruptcy.

[12] CMU Resolution No. 1424 dated 29.12.2021, On the approval of lists of goods, the export and import of which are subject to licensing, and quotas for 2022, https://zakon.rada.gov.ua/laws/show/1424-2021-п#Text

[13] CMU Resolution No. 502 of April 29, 2022 "Some issues of regulation of activities in the field of public utilities due to imposing of martial law in Ukraine".
https://zakon.rada.gov.ua/laws/show/502-2022-п#Text

The RES sector payments.

In the wake of the hostilities Ministry of Energy has obligated Guaranteed Buyer to make all its payments[14] exclusively to repay the debt to Energoatom.

This was followed by the new procedure[15] for payments for electricity from RES for the period of martial law that has unblocked the "green" tariff payments and imposed certain restrictions.

Under the new procedure, producers could be reimbursed for the incomplete cost of electricity, which is determined by the percentage of the "green" tariff for various energy sources (energy facilities): 15% - for the sun (SES), 16% - for wind (WPP), 35% - for hydro (HPP), 40% - for biogas (biogas energy complexes), 60% - for biomass (CHP).

The Ministry of Energy[16] has slightly increased interest rates for some sectors. According to Order No. 206, payments have increase to 18% for SPPs and WPPs, and up to 75% for bio.

These payments were insufficient given the current credit obligations, where the source of return on investment in newly built facilities is income from the sale of electricity at a "green" rate.

Curtailments are still applied to RES generating companies by TSO. Solar power plants are instructed to reduce generation at those hours of the day when the optimal amount of electricity can be generated, thus, affecting their productivity. In addition, there is a problem with forecasting, because some stations are located in the occupied territories, some in the war zone.

It is not explicitly prohibited by legislation for the RES producers to sell electricity in different market segments on generally accepted terms. Although, there are risks to forecasting the volume of electricity and not having the procedure of returning to the existing practice of selling green electricity to Guaranteed Buyer at the green tariff.

Revitalization of the renewables sector would depend on a few joining European markets would contribute to resolving the RES sector problems in Ukraine.

Exports are extremely important for renewable electricity producers, which are currently virtually non-existent due to constant dispatch disconnections due to falling consumption.
The green aspiration of Ukraine should not become less ambitious, thus RES sector is vital to pursuing a green transition.

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[14] Energy Ministry Order No. 03 dated 04.03.2022, https://zakon.rada.gov.ua/rada/show/v0104922-22#Text

[16] Energy Ministry Order No. 206, https://www.kmu.gov.ua/news/minenergo-zbilshilo-rozmir-viplat-virobnikam-elektroenergiyi-za-zelenim-tarifom

Promoting the concept of the "green" transition for Ukraine. The revitalization of the energy sector and economy using the new technologies.

It is worth noting about the importance of rooftop stations. According to the State Energy Efficiency and Energy Saving Agency, the number of households that have installed solar stations in 2021 increased to 44.88 thousand, almost 15 thousand of which were added in 2021.

Better storage technologies for the better renewables' opportunities

The Ukrainian Parliament has adopted a law that defines the use of the energy storage[17] systems and regulates the licensing of the energy storage activities and the work of energy storage system operators - a new entity in the electricity market.
The new law on energy storage systems development would increase the stability of the electricity supply. It would help integrate the green generation energy facilities into the UES and ensure the reliability of the power supply schedule, equalizing the load schedule for both the power plants and electricity infrastructure.

Public Service Obligation (PSO)

The wholesale electricity market continues to be regulated. To provide an affordable electricity price for the households, the Public Service Obligation (PSO) mechanism has been extended by the Cabinet of Ministers' Resolution[18] until November 2022.
Since October 1, 2021, the households consuming up to 250 kWh per month, shall pay 1.44 UAH/kWh (including VAT), and the households consuming over this amount - 1.68 UAH/kWh.
Ukrinterenergo, the state enterprise of foreign economic activity, continues to serve as a supplier of "last resort" in the electricity market until the end of 2022. Also, the Regulator has reduced its tariff service for the 1st quarter of 2022 by 2.4 times - up to 516.85 UAH/MWh (excluding VAT).
This was due to amending the Methodology for setting the tariff for such a service (before the changes the tariff for the 1st quarter of 2022 would be fixed at the level of 856.93 UAH/MWh.

As the commercial exports to EU neighboring countries started, the Government has obligated the exporters to transfer 80% of the income from exports[19] to ensure the availability of electricity for household consumers. Thus, electricity exporters will transfer the cost of the "electricity supply security service" to the state company Guaranteed Buyer. This value will be calculated as 80% of the difference between the conditional income of the exporter and the costs of carrying out this export. The Guaranteed Buyer will further direct the received funds

[17] Law of Ukraine No.2046-IX dated February 15, 2022 "On amendments to some laws of Ukraine regarding the development of energy storage facilities", https://zakon.rada.gov.ua/laws/show/2046-IX#Text

[18] CMU Resolution No.453 dated 16.04.2022, https://www.kmu.gov.ua/npas/pro-vnesennya-zmin-do-postanovi-kabinetu-ministriv-ukrayini-vid-5-chervnya-2019-r-483-453

19 CMU Resolution No.775 dated 07 July 2022,
https://www.kmu.gov.ua/npas/pro-pokladennia-spetsialnykh-oboviazkiv-na-uchasnykiv-rynku-elektrychnoi-enerhii-s775-70722

to providers of universal services that deliver electricity to the population. Exporters who do not sign a contract with Guaranteed Buyer will not be admitted to Ukrenergo's electricity auctions. These changes are valid until the day martial law is terminated or abolished.

Attempts to return to old market model

Under the guise of war and martial law, a number of conditions and rules in force are violated.

The Ministry of Energy of Ukraine has issued a controversial Order "On stabilization of the electricity market" seeking to stabilize the situation in the electricity market, which is deteriorating sharply due to the war.
The was to force the participants of this market to buy in the DAM at least 10% of total decadal consumption.
According to the order, Ukrenergo, based on the results of each decade, on the third working day after its completion, must check the compliance of market participants with the requirements of the order.
In case the market participant does not purchase the specified amount on the DAM market, such market participant is obliged to purchase the appropriate amount of electricity on the DAM in the next decade, otherwise, such a market participant acquires the default status.

This order was cancelled[20], however, this was an attempt to return to old electricity model.

Safety for Ukraine's nuclear plants

Nuclear power plants were operating under the control of Ukrenergo carrying a total load of 6.2 GW. As of 7 June, 8 of the country's 15 reactors were operating: two at Zaporizhzhia (units 2&4), three at Rivne (units 2-4), one at Khmelnytskyi (unit 1), and two at South Ukraine (units 1&2). The other reactors are offline for regular maintenance or are being held in reserve. In July, 2022 two more unit were back to operation from temporary downtime.

The International Atomic Energy Agency[21] has raised the alarm over the safety of Ukraine's nuclear plants. Alarms went off around the world on 3 March, when a fight erupted just outside the biggest nuclear plant in Ukraine.

Russian troops captured the Zaporizhzhia nuclear power plant - six power units that together can generate about 6 GW of electricity. This station accounts for half of all nuclear power generated in Ukraine. The station operates at a minimum, mainly to provide its cooling system. It is still connected to UES, and the Russians are constantly threatening to connect ZNPP to the Russian network.

Day-Ahead Market (DAM) and Intraday market (IDM)

[20] Cancelled by Energy Ministry order No. 205 dated 15 June2022
http://search.ligazakon.ua/l_doc2.nsf/link1/RE38038.html

21 Nuclear safety and security in Ukraine, The International Atomic Energy Agency, https://www.iaea.org

The first three days of military conflict the Day-Ahead Market (DAM) and Intraday market (IDM) were unstable. Price volatility and a significant decrease in trading volumes were observed.

The peak fell on February 27 - the price index of base load electricity at DAM in the UPS fell to 988.76 UAH/MWh, and daily trading fell to a record low of 22 thousand MWh.

IDM trading volumes have declined significantly since the start of Russia's full-scale war against Ukraine, and during the first nine days of the war, the average daily IDM trading volume was 3,500 MWh.

In order to stabilize the situation on the spot market and support electricity producers in wartime, the Regulator decided to raise the minimum price caps on DAM and keep the current price caps on IDM.

From March 1, the Regulator set the minimum sales prices for electricity on the IDM in the UPS at 110% of the estimated price for DAM.

Also, the Regulator has on May 31 reduced the upper price cap on IDM from 110% to 102% of the DAM price to reduce prices in the IDM.

The National Regulator continued to operate under martial law and to monitor the energy situation, making decisions affecting the functioning of energy markets, the energy system, and the utility.
In particular, these changes include:
- easing the conditions for applying the default status[22] to electricity producers who provide services in the balancing electricity market; electricity suppliers that perform the functions of universal service providers; traders under certain conditions;
- requiring participants of the DAM and IDM to indicate the price of electricity is not less than 110% of the DAM price set by the operator market for each billing period of the relevant delivery day.

Within 5 months since the beginning of war 14 participants stopped their operations on DAM and IDM.

In the period of hostilities the DAM performs the function of an indicator, allowing for easy decision to be made with the consumer about the price.

The RES sector needs to review the electricity sales terms

One of the ways to improve the trading strategy is to introduce the Feed in Premium.

The respective draft bill provides for the introduction of a Feed-in-Premium or contracts for the difference, based on fixed payments at the "green" rate. The RES producers would operate

[22] NEURC Regulation No. 332 dated 25 February 2022
https://www.nerc.gov.ua/acts/pro-zabezpechennya-stabilnogo-funkcionuvannya-rinku-elektrichnoyi-energiyi-u-tomu-chisli-finansovogo-stanu-uchasnikiv-rinku-elektrichnoyi-energiyi-pid-chas-osoblivogo-periodu

in different market segments, and get compensated for the difference between the market price and the "green" tariff without leaving the balancing group of the Guaranteed Buyer.

Introduced Feed-in-Premium system or contracts for difference. It is important to allow manufacturers to trade in different market segments, with the right not to leave the balancing group of the Guaranteed Buyer.

The issue of compensation for the difference between the market price and the "green" tariff can be considered after the end of martial law.

Guaranteed Buyer continues to pay the RES producers.

TSO's tariff remains one of the major sources of payments to RES producers. On 11 February 2022 the Regulator approved the transmission tariff[23] for Ukrenergo beginning 1 April 2022. The suggested amount of increase is up to 20,8 %, fixing the transmission tariff for 417.17 UAH/MWh (12,93 EUR/MWh).

Earlier in December 2021, the NEURC approved the increase of the transmission tariff for Ukrenergo beginning 2022 for 17.6% as compared with the transmission tariff for 2021.

The Regulator's decision accounted for the lack of UAH 10.528 billion (EUR 326,374,496) in the state budget for 2022 to pay for "green" electricity from renewable sources in the amount of 20% of the forecast marketable output for the year. The state budget for 2022, adopted on 2 December 2021, suspended the 20% provision for 2022 and thus creating a significant risk of accumulating new debts for "green" electricity from renewable sources.

It is worth noting that the volume of transmission, on the basis of which the Ukrenergo tariff was calculated, fell by more than 30%. On the other hand, a large number of RES producers were forced to stop due to hostilities, some of them generally damaged. That is, we have two factors that significantly affect the balance of Ukrenergo's tariff capabilities.

However, it is obvious that a significant reduction in electricity consumption in the country as a whole, and as a consequence of its transmission, is crucial.

A certain percentage of payments for RES was secured thanks to the March resumption of auctions for the sale of "green" electricity. In six months of 2022, 51 auctions were held. In general, 2.04 million MWh were sold in January through May 2022, which is 20% more than

Guarantees of origin. Integration into the European energy system as a significant opportunity to intensify the production of renewable electricity through its exports. And one of the key tools for strengthening the generation of green electricity and ensuring its actual exports is the mechanism of guarantees of origin.

The main tool for tracking electricity is the guarantee of origin (RED II Directive 2018/2001, Article 19).

"Green" electricity must be confirmed by a guarantee of origin. According to Article 19 of the EU RED II Directive, to conform to final consumers the share or amount of energy from

[23] Resolution No.2454 dated 1 December 2021: On setting the tariff for electric energy transmission services of Ukrenergo NPC, for 2022, https://zakon.rada.gov.ua/rada/show/v2454874-21#Text

renewable sources, the state must guarantee the origin of such energy by objective, transparent and non-discriminatory criteria.

As of 16 July the debt of Ukrenergo before the Guaranteed Buyer, for servicing RES, amounts to 10 billion UAH. The TSO has also accrued around 1 billion debts before Centerenergo of the balancing market.

Renewable energy goals are a big part of this development.

And these goals are quite ambitious and are a challenge, given the capacity of the Ukrainian energy system itself. We aim to achieve 25% of “green” energy in electricity production by 2035, as set out in the Energy Strategy to 2035. At the same time, the National Economic Strategy until 2030 sets an even more ambitious goal - 25% of electricity generation from renewable sources in 2030.The State Agency for Energy Efficiency, in turn, has developed a draft National Action Plan for Renewable Energy until 2030, which identifies guidelines for the development of the industry and specific ways to achieve 25% of renewable electricity in the energy balance. And this National Action Plan is on the way to being submitted to the Government. The recent Lugano Conference revealed new ambition in the presented Ukraine Recovery Plan. It envisages the construction of 30 GW of green energy capacity over the next 10 years.

Of course, the goals need to be revised after the war, but they should not be less ambitious, given the growing importance of energy security and energy independence from Russian fossil fuels.

Renovation of the buildings based on efficiency measures.

Energy efficiency is not just about protecting the climate or saving households. It is also a matter of energy independence, a key component of the state's energy security and sustainable innovation development.

It is estimated that as the total losses of Ukraine's economy due to the war, taking into account both direct and indirect losses (GDP decline, investment cessation, the outflow of labor, additional defense and social support costs, etc.) fluctuate from $ 564 billion to $ 600 billion.

The war also destroyed, damaged, or seized 35.2 million square meters of housing, at least 208 businesses, 580 health facilities, 562 kindergartens, 156 warehouses, 102 religious buildings, 83 administrative buildings, 27 oil depots, and 12 civilian airports.

Energy efficiency must become an integral component of Ukraine's recovery, State Agency on Energy Efficiency and Energy saving of Ukraine.

The implementation of energy efficiency policies, renewable energy development, including the use of hydrogen and biomethane, and decarbonization are mandatory components of the European integration process and identified by the European Commission in the REPowerEU plan as priority steps to overcome dependence on Russian fossil fuels.

Conclusions

It will take time for Ukraine to restore the energy sector. Accurate information about the actual damage can be obtained only from the results of technical audits of the energy facilities after the liberation of the territories.

The post-war reconstruction of various facilities and infrastructure must take into account the criteria of sustainable development, which focuses on the efficient use of energy resources and innovative technologies.

1. As a result of hostilities, a significant part of the energy infrastructure and power grid are critically damaged. Ukraine will have to rebuild a significant part of the power grid in different areas as well as the infrastructure for the electricity generation, transmission and distribution. The revitalization has to be based on innovations and development of smart grids.
2. Ukraine's post-war reconstruction of the energy sector should be based on renewable energy sources. Ukraine has made significant progress in renewable energy sector in recent years. By the end of 2021, the share of RES in national electricity production was over 8%. Currently, all projects that were already in the development and construction phase have been put on hold. With Ukraine obtaining EU candidacy status it will contribute to achieving renewable energy target which has recently been raised to 25% by 2030 in the National Economic Strategy. The payment terms for the renewables' sector should be reviewed. Exports are extremely important for renewable electricity producers, which are currently virtually non-existent due to constant dispatch disconnections due to falling consumption.
3. With Ukraine's joining the European electricity grid there is the window of opportunity to increase the volume of exports to Europe. Ukraine has to increase a number of interconnections. The European Union has provided for the possibility of joining up to 15% in 2030 of the installed capacity of the ENTSO-E neighboring country The installed capacity of international intersections (interconnectors) with EU countries is much lower than expected. Ukraine is connected to Moldova by a 0.7 GW interconnector, and the UPS to the EU by 0.9 GW. Also, Ukrenergo uses intersections, in addition to trade, for technological balancing of the network. The full use of the physical power of the intersections is limited by the optimization strategies of the auctioneers' trade for the use of the interconnector. These indicators are the result of two factors of limited Ukrainian competition in Europe: the first - technological (lack of physical capacity of interconnectors), and the second - commercial (lack of business practice in international trade in EU markets).
4. Joining ENTSO-E would help balance the system, making it easier to manage variable renewables. The electricity exports will benefit both Ukraine and the EU. In the context of the current energy crisis due to the war with Russia, Ukrainian electricity for the EU is to strengthen energy security, diversify markets, and the ability to obtain carbon-neutral energy cheaper.
5. The architecture of trading electricity to Europe has to be organized according to the EU rules under the transparent competitive auctions, in which companies will purchase the access to interstate power lines, which, in fact, are exported or imported. The bids should be held in a transparent way and those offering the highest price for access will receive it and, accordingly, the opportunity to export electricity.
6. Improving market model is important for post-war renovation in line with joining the European market that would contribute to the transparency of the price formation.

However, the wholesale electricity prices are restricted with caps and the European prices are much higher, thus, cancellation of price caps and joining the ENTSO-E may not lower the prices for Ukraine significantly.

7. Due to the recent problems connected to the upcoming heating season, Ukraine will have to rely on electrification. Large share of nuclear power in Ukrainian energy mix that would provide for the energy security. Ukraine's energy mix – where nuclear power plays a significant role – has the potential to sell electricity to the EU, making a positive contribution to EU efforts to decarbonize its energy consumption.
8. The wholesale electricity market is far from being liberalized. Public electricity generators are obligated under PSO mechanism to sell electricity below its production cost accruing debts. When the war is over, the huge investment is needed in generation, transmission and distribution. The regulations should ensure market competition and prices, free choice of suppliers, non- discrimination and transparency of market operations. The effective performance would provide incentives for foreign investors to develop the after war modernized electricity sector.
9. Continue to elaborate legislation following the EU standards and the latest energy law advancements including Electricity Directive and Electricity Regulation to promote sustainable growth.
10. Ukraine will be given the security assistance tailored to meet critical Ukrainian needs. Ukrainian authorities are called to maintain the achievements of energy market reform and to continue integration into the EU single market. Thus, the energy sector of Ukraine will be able to recover faster and overcome liquidity problems. Several initiatives, have been launched to support Ukraine's energy sector.
11. Affordability of the electricity is a societal and political challenge. The government will have to try hard to protect suppliers from the price increase. There will be a huge burden on the budget as the authorities have committed to non-increase of the tariffs. Addressing the energy poverty issues and low-income consumers should not distort the market. The true cost of electricity provides for the stable functioning and incentive for the investments. At the same time, Ukraine electricity prices are among the lowest in Europe and joining ENTSO-E would not mean the lowering the electricity process at the first stage.
12. Households should be encouraged to produce electricity to the national grid. The number of rooftop solar panels has significantly increased before the war. This would also be a future target in line with European REPowerE initiative aimed at boosting renewables, including biomethane and renewable hydrogen, heat pumps, and rooftop solar panels.
13. The saving energy issue should become everyone's contribution to solving the current crisis. The recent Ukraine recovery plan envisages the reconstruction of the residential areas and infrastructure. Investment in the housing has to be associated with the highest energy efficiency standards to improve heating system, insulation and lower CO2 emissions during the buildings life cycle.
14. Green transition was one of Ukraine's energy priorities before the war, but Russian aggression has made this approach even more urgent. Ukraine's energy transition will be based on a strong nuclear sector, an increase in wind and solar energy, and in hydropower production.
15. While making efforts to restore the energy sector one should thoroughly consider the environmental consequences of the war. In the post-war period, their strengthening should be avoided due to the additional impact of energy and industry on the environment and human health.