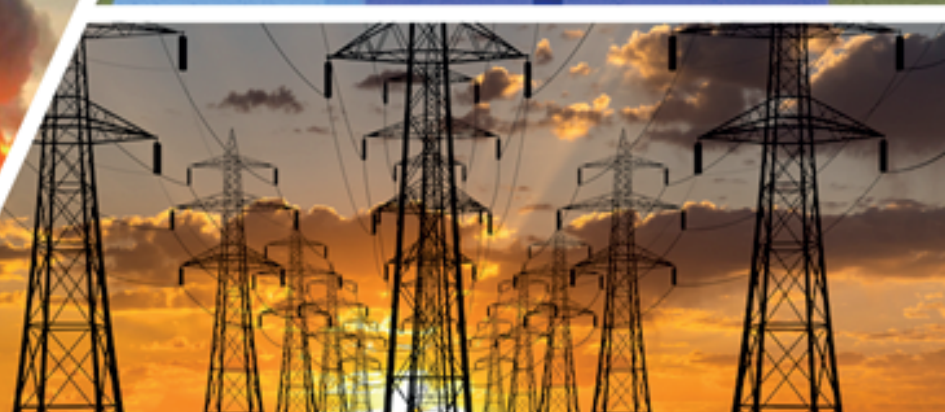


RUSSIAN TACTICS TARGETING UKRAINIAN CRITICAL ENERGY INFRASTRUCTURE



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Disclaimer:

This study used solely information from open mass media sources and social media, as well as some discussions and interviews conducted under Chatham House rules.

Conclusions, made in the study, are solely of the Centre’s experts and do not reflect the position of state authorities of Ukraine, energy network operators, NATO or any member state institutions.

The study also includes materials from the Centre’s archives of the last 10 years.

Chapter 4, marked with (*), is additional research, conducted by the Centre’s experts above the scope of the project, as a logical supplementation due to further dynamics of events around the energy infrastructure.

The views expressed in this report do not necessarily reflect those of NATO or its member nations.



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REASSESSING THE ROLE OF HYBRID TACTICS TARGETING UKRAINE'S AND MOLDOVA'S ENERGY SUPPLIES IN THE CONTEXT OF RUSSIA'S FULL-SCALE INVASION OF UKRAINE

The supply of energy resources (oil, petroleum products, natural gas, nuclear fuel, electricity) was and remains one of the basic elements of Russia's hybrid strategy and tactics for establishing control over the economy and politics of third countries. To succeed, a set of tools is used, which is determined by the level of economic development and influence on political forces, as well as the degree of dependence on the supply of Russian energy resources. Among the most popular tools are political negotiations behind closed doors at the level of the highest government officials, corrupting the negotiators, usually, through the organization of non-transparent schemes for obtaining financial benefits from trade with Russian energy resources on local markets, political blackmail, etc.

Main instruments of Russian hybrid impact on Ukraine and Moldova utilizing energy relations, before Russian aggression against Ukraine in 2024, included:

- creation of "gas debts" through opaque supply and transit conditions, as well as inherited from Soviet-era high gas intensity and import dependency of Ukraine's and Moldova's economies;
- blocking of projects to diversify the supply of energy resources from non-Russian sources;
- blackmail and bribery of political and government officials with the aim of concluding agreements for the supply of energy with asymmetric rights and obligations;
- use of offshore jurisdictions for non-transparent distribution of profits, including in a favour of a circle of designated persons among decision-makers and political figures.

In the period between 2014 and 2022, Russia exerted influence on the central authorities of Ukraine and Moldova, using the "puppet regimes" on the occupied and uncontrolled territories (the so-called DPR and LPR in Ukraine and TMR in Moldova), financing them largely through opaque energy business schemes that kept Kyiv and Chisinau dependent on Moscow (*more in details please see in Annexes 1 and 2*).

1.1. Hybrid tactics of energy dependence leverage before and after the full-scale invasion

On the eve of the full-scale invasion, Russian influence on the energy sectors of Ukraine and Moldova was at a high level. First of all, the energy systems of both countries worked in synchronization with the much more powerful Russian United Energy System and remained dependent on **frequency and voltage regulation**. Factors of import of energy resources had a strong influence:

A. Electricity – from Russia-controlled Belarus to [Ukraine](#) [1] and from Russia-controlled Transnistria to [Moldova](#) [2] (~80% of domestic consumption of the latter), with devastating pressure on local electricity producers and the internal market.

B. Petroleum products from Russia and Belarus, with substantial market share and tendencies of further increases (diesel, gasoline, LPG). For instance, in January 2022, Ukraine's [diesel import](#) [3] from Belarus increased by 21% to 245.5 thousand tons. Diesel imports from Russia increased twofold in comparison to January 2021 – 171 thousand tons. Since February 7, 2022, Belarus has [blocked](#) [4] railway transit of

petroleum products from Lithuania, ensuring further increase of its share.

C. Coal remained an important energy source for Ukraine's thermal power stations. In 2021, around [62% of coal imports](#) [5] (12 million tons) came from Russia, with perspectives to grow up. In November 2021, Russia banned anthracite supply for Ukraine's thermal power stations and blocked the transit of Kazakh coal.

D. Natural gas imports before the Russian full-scale invasion remain a critical dependency only for Moldova. Ukraine has successfully diversified gas imports and refused to buy gas from Russia in 2025. However, Ukraine preserved gas transit, used to keep pressure in pipelines and provide conditions for certain operations with European gas traders (virtual reverse).

1.2. Beginning of the full-scale invasion

1.2.1. Ukraine

Ukraine's TSO Ukrenergo has officially informed about testing [isolated mode of United Energy System functioning](#) [6] (UES) during February 24-26, 2022. It is possible that this fact became one of the arguments in favour of the Russian invasion date, as it technically separated the UES of Ukraine from the Russian and Belarusian ones and deprived it of the opportunity to receive emergency assistance and support in frequency and voltage regulation. At the same time, Russia could count on the chaos of the first hours of the invasion as a prerequisite for the collapse of the Ukrainian UES. Faced with the threat of a humanitarian catastrophe, Ukraine, according to the Kremlin, could abandon armed resistance to save the population in the middle of the heating season.

However, Ukraine and the UES withstood the first massive missile attacks and in a matter of hours adapted to work under wartime conditions. Previous three-year preparation for synchronization with the ENTSO-E of the European Union, technical re-equipment of generating capacities, which increased the possibilities for frequency and voltage regulation, as well as the preparation of personnel and their previous readiness to pass the test period in isolated mode became important elements for keeping stability of the UES, contrary to what aggressor expected.

The robust [cyber-protection system](#) [7] for dispatching centers, UES regional control centers, key substations and generation facilities became another key tool, which helped the energy sector withstand massive Russian cyber-attacks before and in the first days after the invasion.

One of the biggest Ukrainian energy companies – DTEK, emphasized the importance of a very timely decision to establish at the beginning of February 2022 a reserve control center in the western part of Ukraine, where it managed to complete a substantial part of work to [communication and IT infrastructure](#) [8].

The rapid seizure of energy facilities took place primarily in the south of Ukraine, where Russian troops did not meet organized resistance. For instance, [on February 24, 2022](#), [9] Russian troops seized Kakhovska HPP with the dam and the main gateway of the North Crimean Canal, which gave Russian troops access to the right bank of the Dnieper and made it possible to unblock the water supply to Crimea, which was occupied in 2014.

On February 24-25, 2022, Russian troops invaded through the territory of Belarus Chornobyl Zone and seized [Chornobyl NPP](#). [10] This opened one of the shortest routes in the direction of Kyiv, as well as created a base for the accumulation of equipment and weapons, personnel rotation after the beginning of intense fighting in the Kyiv region. On March 4, 2022, Russian troops shelled and seized [Zaporizhzhia NPP](#) [11] to use it further as the base for deployment of troops, storage of weapons and political blackmailing of Ukraine and Europe. After occupation of Enerhodar city, invaders also established control over Zaporizhzhia TPP. Coal supply was interrupted and the thermal power plant was shut down. Brave resistance of the Armed Forces of Ukraine prevented the seizure of [South-Ukrainian NPP](#) [12] that forms together with HPP and pumped hydro storage power plant on the Dniester River the South-Ukrainian energy complex.

Russian troops conducted massive shelling on February 21, 2022 on [Lugansk TPP](#) [13] in Schastia city, causing much damages to the plant and shortages in electricity supply of the city. Later, the TPP was seized and remains on the temporary occupied territory. On March 3, 2022, Russian troops conducted a strike with the [vacuum bomb](#) [14] and totally destroyed Okhtyrka combined heat and power (CHP). This strike could be conducted as an act of revenge for the successful defense of the city against Russian troops and inflicted significant losses. Russians used similar tactics in attacks against Chernihiv CHP to damage it during the hostilities around the city in February and March 2022. Sumy CHP was also under shelling during the active phase of fighting in the suburbs. For instance, [on March 3, 2022](#), [15] the city was partially without electricity and heat after the next round of shelling. Destroyed equipment was exchanged, generation of electricity and heat was promptly restored. On April 2022, another critical energy infrastructure object – [Kremenchuk CHP](#). [16] became a target for missile attack. The strike could aim to destroy the energy supply of several important industrial enterprises in the city, namely automobile, car-building and oil-refining plants. Since the full-scale invasion, Russia has conducted strikes with bombs and missiles against infrastructure for petroleum products storages and later on – against oil refineries (see [Fig. 1](#)) [17].



Massive shelling on this infrastructure began already at the end of February 2022, after the failure of the «Russian blitzkrieg» and the start of the total resistance of the Defense Forces in all directions of the enemy's offensive.

Combined with the cut-off of Russian and Belarusian petroleum products supply from the first days of the invasion, this Russian tactic was aimed at creating a transport collapse in Ukraine and depriving the Defense Forces of the ability to use heavy equipment in maneuverable defense.

1.2.2. Moldova

Focusing its main efforts on hostilities in Ukraine, Russia has not used hybrid methods of influence against Moldova in the first half of 2022 utilizing its energy import dependence. However, already in October Russia began to limit the supply of natural gas, in violation of the supply agreement provisions, including on the territory of Transnistria occupied by them. Such a hybrid tactics could be aimed at creating a significant shortage of electricity in the right-bank part of Moldova, a jump in social tension and increased pressure on the government to revise its pro-European course. The restriction of Russian gas supply by approximately 30% led to an imbalance in the work of the Cuciurgan TPP and a reduction in the supply of electricity to the right bank of Moldova. Since Ukraine has also suspended the supply of electricity from November 2022 due to the large-scale damages of the UES because of Russian missile attacks, Moldova has fallen into a real energy crisis. On some days, there were partial blackouts on the territory of the country. The expansion of cooperation between the Romanian company Hidroelectrica and the Moldovan Energocom, as well as a 250 million Euro package of financial assistance from the EU helped to minimize the negative consequences for Moldova. In [December 2022](#), [18] Moldova terminated Russian gas imports to the right bank and started active preparations for suspending electricity imports from Cuciurgan TPP, while enhancing network connections with Romania.

1.3. Conclusions about the first phase of the invasion

In the first days of the full-scale invasion, Russia tried to exploit Ukraine's fuel dependence though the cessation of supplies of all types of petroleum products from Russia and Belarus, which created a shortage of fuel on the market.

Disconnection of the UES of Ukraine and Moldova from Russia and Belarus energy systems on the day of the full-scale Russian invasion, its successful functioning in the isolated mode and respective synchronization with the ENTSO-E energy system prevented implementation of Russian plans to create a black-out in the UES of Ukraine.

After the collapse of the blitzkrieg and the activation of large-scale Ukrainian resistance, Russian invaders carried out numerous missile and bomb attacks on petroleum products storage bases with the aim of paralyzing transport links and the mobility of the Defense Forces of Ukraine.

Moldova activated projects to diversify electricity and gas supply to the country, taking into consideration Ukraine's negative experience with fuel dependence on the aggressor and positive results in overcoming gas and electricity shortages through diversification.

ANALYSIS OF THE PATTERNS OF RUSSIA'S TARGETING AND OCCUPYING OF CRITICAL ENERGY INFRASTRUCTURE (POWER PLANTS, PRODUCTION FACILITIES, PIPELINES, GRIDS, ETC.) AND THEIR PURPOSE AS PART OF RUSSIA'S ILLEGAL WAR

According to the Russian blitzkrieg plan (to seize Kyiv in three days), since February 24, 2022, Russian troops avoided striking on fuel infrastructure during the first days of the invasion. They might be prohibited from striking fuel deposits because of estimations that Kyiv would “fall in three days” and guarantee Ukraine`s capitulation. Therefore, energy infrastructure should be preserved from destruction.

This approach was changed after the blitzkrieg collapse. Successful seizure of the biggest in Ukraine and Europe Zaporizhzhia NPP has stimulated the aggressor to continue the offense towards the South-Ukrainian energy complex – South-Ukrainian NPP (3 GW) and Tashlyk pumped hydro storage power plant (1,9 GW).



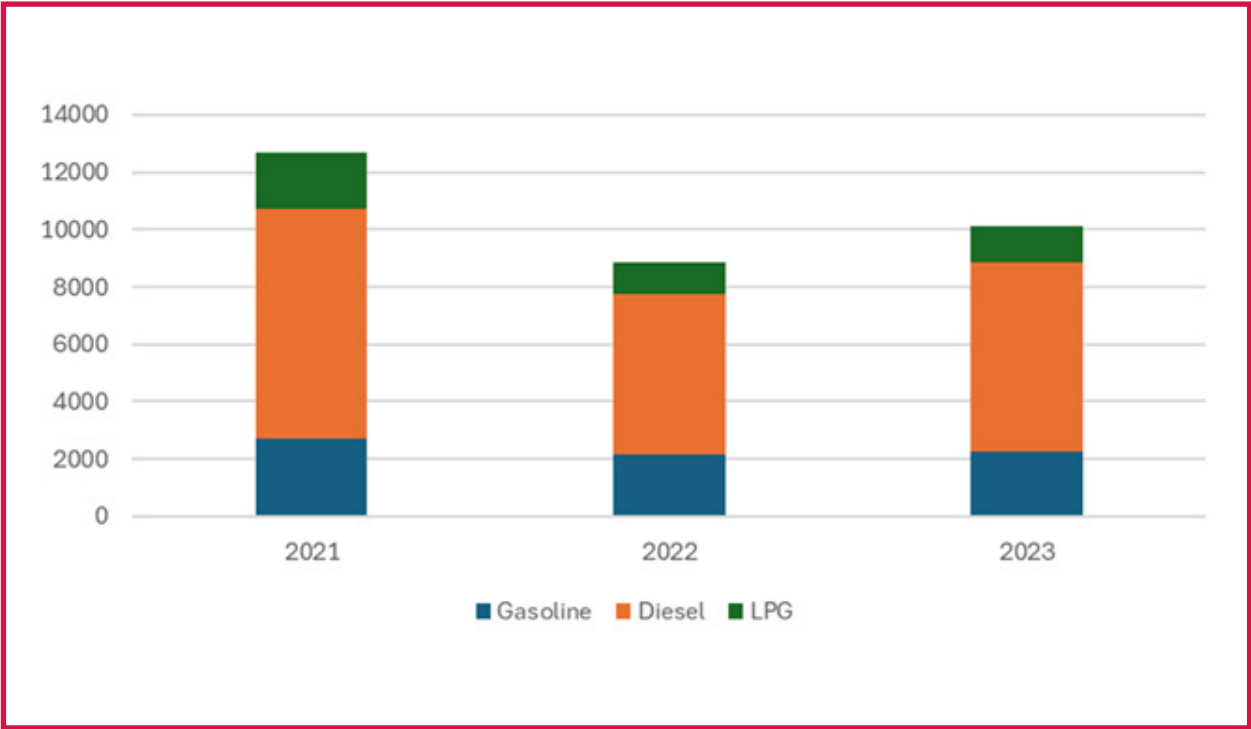
Panorama of the Tashlyk pumped hydro storage power plant, which forms an energy complex with the South-Ukrainian NPP

Under this scenario, 9 of 15 existing nuclear reactors (65% nuclear generation) should have fallen under Russian control together with the electricity supply of southern regions of Ukraine – Mykolaiv, Kherson, and Odesa regions. On the eastern front, Russia aimed at seizing Kharkiv region, the main gas-producing region of Ukraine – with around 45% of the whole Ukrainian domestic gas production located there. One of the biggest Zmiivska TPP of the state-owned Centerenergo was also located in the Kharkiv region (*latter, Zmiivska TPP was completely destroyed in an attack on March 22, 2024*). If some of those regions will be seized, Ukraine would feel a substantial deficit of natural gas and electricity.

After blitzkrieg collapse and massive strong resistance of the Armed Forces of Ukraine, since February 27, 2022, the aggressor has started numerous strikes against fuel storage bases with the aim to limit fuel supply for aviation, armoured and transport vehicles of the Armed Forces of Ukraine. Since September 11, 2022, Russia has conducted many attacks against the electricity infrastructure of Ukraine, with the massive strikes in the period from October 10, 2022 to March 9, 2023. In the end of March 2024, Russia renewed massive attacks, which had the most devastating effect on critical energy infrastructure.

2.1. The fuel market of Ukraine before the Russian full-scale invasion.

The fuel market of Ukraine before the full-scale invasion of Russia had a disproportion in the supply of petroleum products. In 2021, its total volume was more than 12 million tons. Consumption of diesel fuel was more than 8.0 million tons, gasoline – 2.7 million tons, and almost 2 million tons of LPG (see data in *Diagram 1*).



*Diagram 1. Petroleum products market of Ukraine, 2021-2023.
 Blu – gasoline, orange – diesel, green – LPG
 Source: Data of Group A-95.*

Ukraine oil refining covered only 20% of the domestic market demand. About 70% of demand was supplied mainly from Belarus, as well as from Russia. A little more than 8.0% came from Lithuania, from the Mazeikiu Nafta refinery, owned by Poland’s PKN Orlen. In 2021, imports from Lithuania accounted for 9% of diesel fuel (690 thousand tons), 11% of gasoline (265 thousand tons), and 16% of jet fuel (57 thousand tons) supply. After the beginning of the Russian invasion, foreign supplies were cut off. The naval blockade by the aggressor made it impossible to import petroleum products through the Black Sea ports.

2.2. Initial Attacks: Fuel Storage Facilities

In February 2022, Russia launched missile attacks against first two big fuel storage depots near Kyiv and Lviv. On February 28, Russia conducted an air strike with bombs against a fuel storage depot in Okhtyrka near its border. On March 3, Russians bombed a fuel storage depot in Chernihiv, on March 7 – in Zhytomyr. First of all, Russians tried to destroy fuel storage facilities, used by the Armed Forces of Ukraine in regions, where they resisted Russian troops' offense towards Kyiv from the north (from Belarus) and from the east (from Russia). However, at the end of March, Russia conducted missile strikes against other fuel storage facilities, located in the west of Ukraine, in Dubno, Lviv, Lutsk and Rivne, as well as in Dnipro.

2.3. Refining

At the early stage of hostilities, the Russians did not attack oil refineries. Obviously, they still assumed that in a short time – a few weeks – they would be able to capture, at least, the eastern (left-bank) part of Ukraine, and therefore they might need the two working refineries in Kremenchuk and Shebelynka to supply fuel to the occupation forces. However, it did not last long. Already on April 2, a missile attack was carried out on the Kremenchuk Refinery, the largest in Ukraine and one of the largest in Europe. On April 3, cruise missiles attacked the Odesa Refinery, which had not been operating since 2014.

Kremenchuk Refinery has a total capacity of 18.6 million tons of crude oil per year. It stopped to use Russian oil 10 years ago and switched entirely to Ukrainian Light and imports of Azeri Light. In 2021, it refined 3.2 million tons of oil. Kremenchuk Refinery provided 38% of gasoline, 14% of diesel and 6% of LPG on Ukrainian fuel market.

Since the plant has a large territory and significant reserve capacity, the strikes continued. In general, during 2022-2024, the refinery and the nearby Kremenchuk thermal power plant were damaged throughout 7 massive strikes by approximately 40 cruise and ballistic missiles (Iskander-K, X-22) and UAVs of the Shahed-131/136 type. In 2022: April 24, May 12, and June 18, in 2023: September 20 and November 1st, in 2024: January 28.

On June 18, 2022, an attack was conducted on the Shebelynska refinery, although it has not been functioning since February 26, as it is located near the war zone in the Kharkiv region. The strike was made from the Grad multiple rocket launcher. Also, the Lysychansk refinery, which had not been operating since 2012 and did not store fuel, was also fired upon by MLRS Grad. On February 16, 2023, an old refinery in the west of Ukraine in Drohobych, which had been inactive since 2009, but whose tank park was used by a private company to store petroleum products for market needs, was hit by a missile attack.

2.4. Oil transportation system

The oil transportation system of Ukraine was not a target for Russian attacks at least until April 1, 2024 (*see Annex 7. Map 1. Oil Pipeline System of Ukraine*). The supply of Russian oil to Hungary, Slovakia, and the Czech Republic went and continues to go through the main oil pipeline «Druzhba» on the territory of Ukraine. These supplies go to refineries owned by Hungarian MOL (refineries in Százhalombatta and Bratislava) and Polish Orlen (Litvinov refinery in the Czech Republic).

It should be noted that the system of oil TSO Ukrtransnafta also includes the PrykarpattZakhidTrans petroleum product pipeline (PZT) with a capacity of 2 million tons per year. During the Cold War, it was part of the fuel supply system of the Southern Group of Soviet troops in Hungary, and as part of the so-called socialist cooperation within the Council of Mutual Economic Assistance, it was used to supply diesel to the Hungarian petrochemical industry. This petroleum product pipeline retained its functionality after the collapse of the USSR. In recent years, it has been used to import diesel from Belarus. Through it, 65% of its imports to Ukraine were provided.

2.5. Changes in the fuel market under war conditions

After the Russian full-scale invasion, Ukraine faced a very severe situation that no NATO and EU countries experienced. The consequence of the interruption of petroleum products` import and intensive strikes by cruise missiles on fuel storage facilities resulted in a fuel shortage for 4 months. The priority of providing fuel from the State Reserve in conditions of shortage was for the Armed Forces, Ukrzaliznytsia (Ukrainian Railways) and freight transport, which provided the logistics of the Armed Forces.

However, already by July 2022, the deficit disappeared. Ukraine introduced free market prices for fuel. It stimulated the rapid establishment of new logistics chains for the supply of fuel. The fuel logistics system has radically changed. Previously, fuel was mainly supplied by rail and sea. Now more than 40% of deliveries are road transport. These are thousands of tanker trucks. If there were no more than 1,500 tanker trucks in Ukraine before the full-scale Russian invasion, by the end of 2022 there would be 4,155 of them. Practically all available tanker trucks were bought in Europe. In 2023, their fleet has increased even further and now has about 6,500 units. You can bomb an oil depot, or an oil refinery, or target a railway station, which are stationary objects, but it is impossible to destroy thousands of moving tanker trucks.

There was a sharp increase in the number of importers: if in 2021 there were about 130, then at the peak in December 2022 - more than 400. The purchase of the terminal of the Polish Baltchem SA Zakłady Chemiczne in Szczecin by one of the largest Ukrainian trading companies UPG was of great importance.

It should be noted that Ukraine's government introduced quick and correct actions at the beginning of the Russian full-scale invasion – the excise tax on petroleum products was abolished, and the VAT was reduced from 20 to 7%, with the simultaneous suspension of fuel price regulation. This made it possible for traders to quickly bring in fuel from abroad and replenish their stocks. If in March 2022 Ukraine imported only 58.8 thousand tons of fuel, then in August - 709.5 thousand tons. Import volumes increased almost 12 times in six months.

The overall balance of the main types of fuel (gasoline, diesel, LPG) consumed on the market of Ukraine during 2021-2023 is presented in *Diagram 1* above.

The new fuel supply system successfully passed a serious test in November and December 2022 after massive Russian missile strikes on the energy infrastructure of Ukraine, in particular, on thermal power plants. Then there was an almost 20

percent jump in the demand for gasoline and diesel fuel to ensure the operation of 354,000 generators imported to Ukraine. Their total power was more than 1000 MW, which is equal to the power of 1 nuclear power unit of the VVER-1000 type.

2.6. Estimated structure of fuel imports.

In 2022, Ukraine received 95% of imported gasoline and 72% of diesel fuel from EU countries: Poland, Lithuania, Slovakia, Romania, Bulgaria, and Greece. Supplies from Bulgaria were especially important in the first months of the Russian invasion, they accounted for up to 40% of the fuel needed for the Armed Forces.

In 2023, the fuel market of Ukraine was supplied mainly by imports. Diesel fuel consumption was 6.6 million tons, gasoline consumption was 2.2 million tons, and LPG consumption was 1.2 million tons, as can be seen from *Diagram 1* above. The structure of fuel imports by producing countries and main directions of supply is presented in *Diagrams 2 and 3* (gasoline and diesel fuel, respectively).

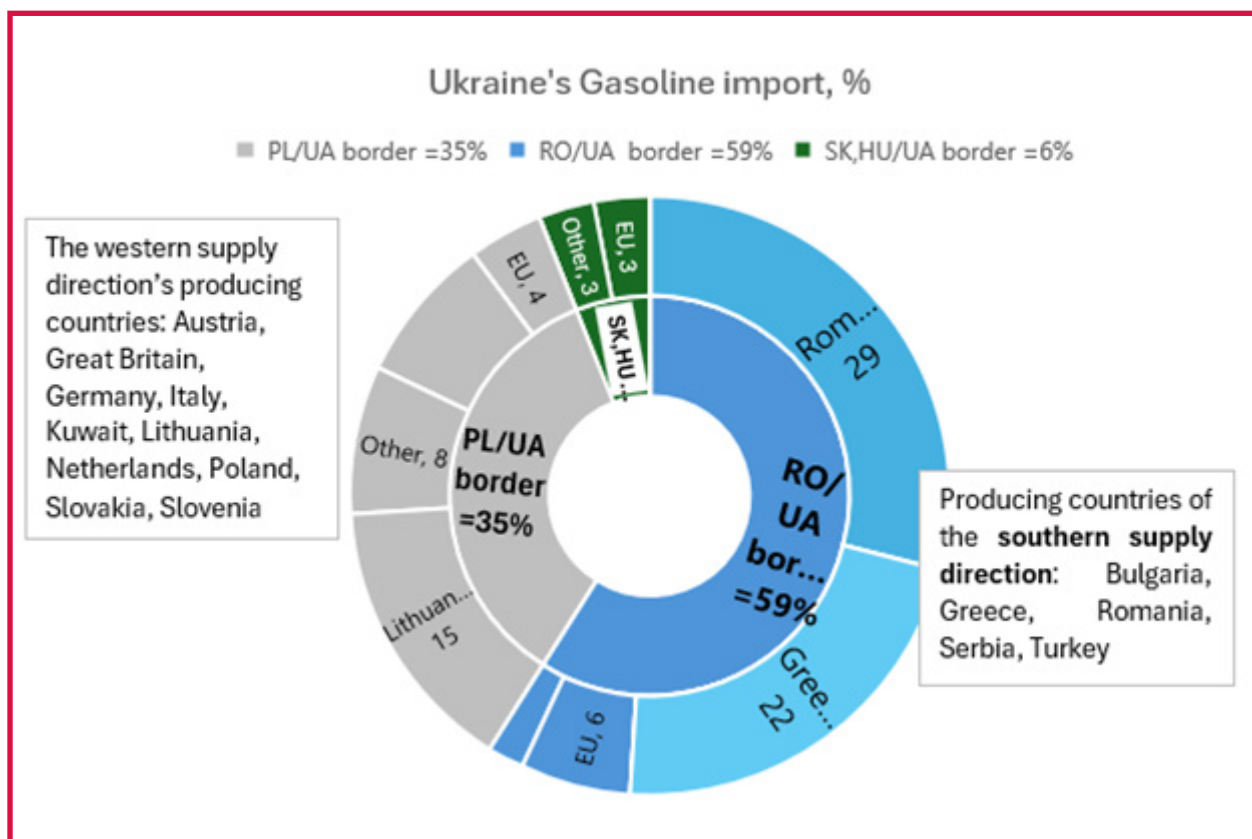


Diagram 2. Gasoline import. Source: Data of the Group A-95.

After the beginning of the Russian invasion, the PrykarpatzakhidTrans (PZT) petroleum product pipeline began to be used for reverse deliveries of diesel from the territory of Hungary to Ukraine. As far as it is known, these were mainly non-Hungarian supplies, and traders used the infrastructure in Hungary to pump the resources to Ukraine. This is a cheap, efficient, and reliable way to deliver diesel, however, it was used quite limitedly - only 114 thousand tons of diesel were pumped in 2022. In 2023, the pumped volume increased to 426,000 tons.

The sea imports are important for the Ukrainian fuel market. After the beginning of unfriendly blockades of the border by Polish and Slovak farmers/lorry drivers, the maritime direction of fuel import began to play an increasingly important role. The

main supplies go through the Romanian ports of Constanta and Galati, as well as the Moldovan Giurgiulesti.

The systematic actions of the Navy Forces of Ukraine, starting with the destruction of the flagship of the Russian fleet, the missile cruiser «Moskva» on April 14, 2022 and periodic attacks by naval drones of Russian ships, led to the escape of the remnants to the eastern sector of the Black Sea. This made it possible to resume the import of fuel by sea through the trade corridor from the ports of the Odesa region to the Bosphorus. The volume of imports amounted to 1.826 million tons in 2023.

The provision of fuel in the form of humanitarian aid was of great importance in 2022. For example, Ukraine received 25,000 tons of gasoline from the Polish reserve. Also, small volumes of diesel fuel, gasoline and motor oils are periodically delivered from NATO.

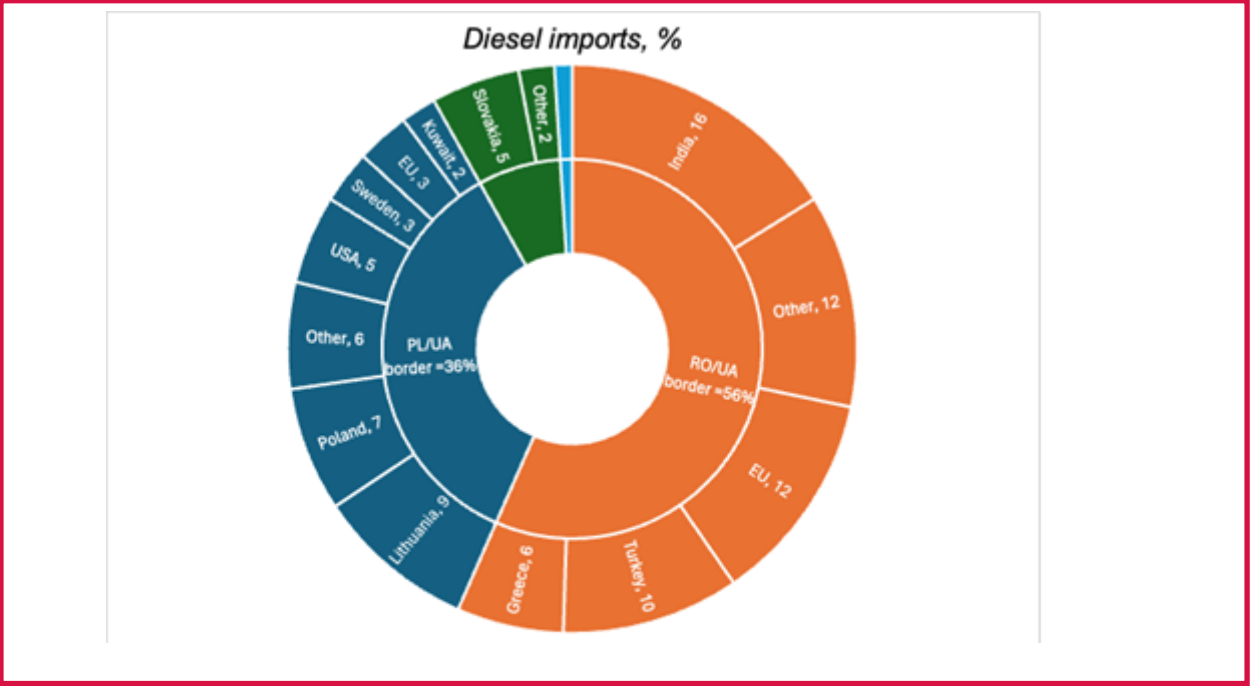


Diagram 3. Diesel imports. Source: Data of the Group A-95.

2.7. Strikes on enemy's territory.

For a long time, the Armed Forces of Ukraine have not attacked Russia's fuel bases, logistics hubs located in the border regions with Ukraine, from which fuel was supplied to Russian troops engaged in hostilities. In the same way, there were no strikes on the critical energy infrastructure on the territory of the Russian Federation, while the aggressor struck all over the territory of Ukraine.

The Armed Forces of Ukraine conducted the first strike against fuel objects in Russia only on April 1, 2022. Two attack helicopters Mi-24 passed at an ultra-low altitude on the territory of Russia and attacked an fuel depot in Belgorod. Later, missile attacks and drone attacks were carried out not only on several fuel storage depots in the occupied territories of Ukraine but also on fuel facilities, depots of the state enterprise «RosReserve» and refineries located in the range of weapons of the Armed Forces - from the Baltic to the Black Sea, especially starting from January 2024 – strikes on Russian oil refining.

Naval drone attacks on Russian warships of the Russian Federation, as well as on the Sig fuel tanker, which delivered diesel fuel to the occupation contingent of Russian troops in Ukraine and was hit on August 5, 2023, became unique operations of the Navy Forces and special units.

LESSONS LEARNT FOR UKRAINE AND NATO FROM UKRAINE'S RESISTANCE TO RUSSIA'S AIR STRIKE CAMPAIGN AGAINST ITS CRITICAL ENERGY INFRASTRUCTURE FOR BUILDING RESILIENCE

3.1. State of Ukrainian Air Defence before Russia's full-scale invasion

3.1.1. Retrospective

The air defense of Ukraine was developed based on the former regional air defense of the USSR. Its transformation into an autonomous air defense system of independent Ukraine took place quite easily. Air defense of the USSR was formed according to the object-zonal principle. Since the beginning of the 1960s, the south-western zone of the airspace of the USSR (Ukraine and Moldova) was protected by the 8th Separate Air Defense Army with headquarters in Kyiv. Thus, the functional management system of the former 8th Army of the USSR Armed Forces was quite easily transformed into the air defense management system of Ukraine as the newly independent state. Its units, except for the Chisinau anti-aircraft missile brigade, control of which was transferred to independent Moldova according to the territorial principle, formed the basis of the air defense forces of Ukraine. In the early 1990s, the [Air Defense Forces of Ukraine](#), [19] which at that time were not part of the Air Force, but represented a separate type of the Armed Forces, included anti-aircraft missile troops, fighter aircraft, radio engineering troops, as well as separate means of warning about a missile attack and countering threats from Earth orbit.

During the first decade, national Air Defense Forces were transformed to create a closed circle of the air defense system of Ukraine. From 1992 to 2004, the Air Defense Forces of Ukraine consisted of three corps: the 28th (headquarters - Lviv), the 49th (former Dnipropetrovsk) and the 60th (Odesa). The corps, in turn, included air defense fighter aviation regiments, anti-aircraft missile regiments (brigades) and radio engineering brigades - units designed to conduct radar reconnaissance to ensure timely detection of an enemy air attack and the issuance of radar information to the on-duty air defense forces. Fighter regiments were armed with Su-15TM, MiG-23MLD, MiG-25PD/PDS and MiG-29 interceptors. Anti-aircraft missile brigades were equipped with various air defense systems of medium and long-range: «Krug», «Kub», «Buk-M1», S-75, S-125, S-200, S-300P/PT. All this [Soviet equipment](#), [20] which is now technically and morally obsolete, was then still able to perform the tasks set before it.

As of 1992, Ukraine had 80 MiG-23, 15 MiG-25, 220 MiG-29, and 40 Su-27 aircraft. By 1997, the anti-aircraft missile forces had 160 divisions armed with various air defense systems and air defense missiles. The reduction in the number of anti-aircraft forces and means was mostly due to the withdrawal of some air defense systems (S-75, S-125, «Krug» and «Kub») from the combat inventory, as well as due to the addition of S-300P anti-aircraft missile regiments to the three-division units. S-200 long-range

mobile air defense systems with a range of 240-250 kilometres at medium and high altitudes were also gradually reduced, and then they were completely withdrawn from service. [The S-300PT and Buk-M1 air defense systems](#) [21] remained the basic anti-aircraft missile systems in Ukraine at the beginning of the large-scale invasion of Russia in 2022. [Of the fighter aircraft](#), [22] after reductions and decommissioning - in 1993, the MiG-25 was decommissioned, then the MiG-23, and by 1997 the Su-15 was also sent to storage bases - only the multi-purpose MiG-29 and Su-27 remained in service.

While reforming the Armed Forces of Ukraine, at least three attempts were made to merge the Air Defense Forces with the Air Forces. There were unsuccessful attempts in 1994 and 1996. Ultimately, in 2004-2005, the Air Defense Forces and the Air Forces were merged into one type - the Air Forces of the Armed Forces of Ukraine (AF of the Armed Forces of Ukraine).

3.1.2. The organizational structure of the [Ukrainian Air Defense Forces](#) [23] before the large-scale invasion of Russia

The Air Defense Forces of Ukraine were distributed among four commands of the Air Forces of the Armed Forces of Ukraine:

- Air Command «West» (headquarters - Lviv);
- Air command «Center» (Vasylkiv, Kyiv region);
- Air Command «East» (Dnipro);
- Air Command «South» (Odesa).

Each Air Command consisted of tactical aviation brigades, anti-aircraft missile brigades/regiments and a radio engineering brigade (*see Annex 3. The structure of the Air Forces Command of the Ukrainian Armed Forces and Annex 4. Structure, armament, deployment of air defense units of the Ukrainian Armed Forces as of 2021*).

According to the assessment of the Air Force Command of the Ukrainian Armed Forces, it was the air shield of Ukraine that became a deterrent to the further expansion of Russian aggression in 2014–2020. At the same time, as of 2020, the military potential inherited by the Air Force from the Soviet past was practically exhausted.

During the implementation of the first stage of the [«Vision of the Air Forces 2035»](#) [24] (from 2021/22 to 2025), the main efforts should be focused on the re-equipment of the ground air defense system of the Air Forces of the Armed Forces of Ukraine with a new medium-range missile complex with a distributed modular system. The priority in the re-equipment was devoted to a highly mobile, network-oriented medium-range air defense system of foreign production (NASAMS type or similar) in the amount of 36–40 units. By 2030-2035, to cover the most sensitive and critical objects of the state administration system, objects of the national economy and critical infrastructure, certain critical elements of the combat troops in operations, a limited number of medium- and long-range air defense systems with the possibility of anti-missile defense should be purchased - of the SAMP-T, Patriot type, or ZRK-S(V) D produced by the domestic defense industry in the amount of 9–12 units. At the same time, to ensure the re-equipment of tactical aviation in the second stage, in 2023-2025, the first limited batch should be purchased - up to 6-12 units of modern multi-purpose aircraft fighters.

The completion of the anti-aircraft missile forces re-equipment and the start of the planned re-equipment of tactical aviation was supposed to stop the degradation of the air defense capabilities of the Air Forces of the Armed Forces of Ukraine. By 2030, at least two tactical aviation brigades and four anti-aircraft missile regiments should be completely re-equipped with new aircraft and air defense systems and acquire full operational capabilities. However, plans to gradually build up Ukraine's air defense capabilities were thwarted by Russia's full-scale invasion. The concept of the air defense had to be changed «on the fly» in response to an existential challenge from the aggressor for the existence of Ukraine in general.

3.1.3. Air defense of the Ground Forces of the Ukrainian Armed Forces and its role in the protection of critical energy infrastructure

Referring to the «pre-war» state of the air defense system of Ukraine in the context of the lessons from the Russian air strikes campaign against the critical energy infrastructure in 2022-2023, it is worth considering the forces and means of air defense of the Ground Forces of the Armed Forces of Ukraine (Air Defense Forces of the Ground Forces of the Armed Forces of Ukraine). After the start of massive strikes with unmanned aerial vehicles Shahed-136/131 (Geran-2) on objects in the strategic depth of Ukraine, a significant burden on their repulsion fell precisely on anti-aircraft missile and artillery systems of short and medium range.

The main purpose of the Air Defense Forces of the Ground Forces of the Ukrainian Armed Forces is to cover units from enemy air strikes in all types of combat operations while regrouping and deploying them in place. Until 2022, the Air Defense Forces deployed anti-aircraft missile and anti-aircraft artillery systems and complexes of Soviet time, which however were characterized by high rate of fire, survivability, maneuverability, and the ability to operate in various combat conditions. The anti-aircraft missile systems and complexes of the divisional level of the Air Defense of the Ground Forces include the Osa-AKM, Tor-M air defense systems, of the regimental level - Strila-10, anti-aircraft gun-missile and self-propelled gun installations 2C6 «Tunguska» and ZSU-23-4M «Shylka», portable anti-aircraft missile complexes (MANPADS) «Strila-2M» and «Igla», anti-aircraft artillery installations ZU-23-2.

Air Defense Forces of the Ground Forces of Ukraine are organizationally a part of the combined military formations and units. They consist of anti-aircraft missile, anti-aircraft missile and artillery, anti-aircraft artillery, radio engineering units – usually divisions as part of combined-arms brigades and batteries as part of battalions (*see Annex 5. Air defense troops of the Ground Forces of the Ukrainian Armed Forces*).

Combined Russian missile and drone strikes against critical energy infrastructure of Ukraine made evident that the Air Defense Forces of the Ground Forces of Ukraine are both an important element on the combat field, and a necessary instrument to defend infrastructure objects. The Air Defense Forces of the Ground Forces of Ukraine are deployed together with Territorial Defense units and in close cooperation with the air defense and fighter aircraft of the Air Forces of the Armed Forces of Ukraine. Together, the above capacities make it possible to withstand quite effective Russian attacks with unmanned aerial vehicles, subsonic cruise missiles, helicopters, and airplanes.

Lessons learned by Ukraine since the beginning of the full-scale invasion of Russia show that although the command of the Armed Forces of Ukraine realistically assessed the state of its Air Defense System and started preparations for its radical renewal in the future, it did not expect such a rapid and large-scale attack, similar to a full-scale invasion of the Armed Forces of Russia in February 2022.

3.1.4. Air defense capacities' enhancement during the war

Since the first months of the invasion, Ukraine, together with its partners in the Ramstein Group, has been actively working to strengthen anti-aircraft cover and repulse (in cooperation with aviation) of important critical energy infrastructure and telecommunications facilities against enemy air strikes. **The war “presses time” and forces to act twofold quicker, sometimes through probes and mistakes.**

The main efforts are directed at the modernization of the existing air defense and Radio-technical forces, their unification with the received highly mobile, network-oriented, geographically distributed medium-range anti-aircraft missile systems of foreign production, and their unification among themselves. Military-technical assistance from partners contributes to the saturation of the object-by-object anti-aircraft defense with modern means. Air Defense of Ukraine, created during the war, is unique – no one in the world has such a diverse set of systems. And this is another challenge in troop management, logistics, combat operations.

In the spring of 2023, a limited number of powerful Patriot air defense systems appeared in Ukraine's arsenal. It helps the Armed Forces of Ukraine to intercept Russian Kinzhal aeroballistic missiles. Later, according to information from Ukrainian and foreign sources, as of August 2023, further air defense systems of various ranges were transferred to Ukraine.

The USA, Germany and the Netherlands delivered one Patriot battery to Ukraine each. Another anti-aircraft missile system that has proven itself very well is the Norwegian NASAMS complex with an American radar. The USA handed over eight NASAMS batteries to Ukraine, Norway – four, Lithuania – two, and Canada – one. More than two dozen high-performance IRIS-T SLM air defense systems were handed over to Ukraine by Germany and Sweden. The USA also handed over 20 Avenger self-propelled air defense systems to Ukraine. Britain - six Stormer HVM2 air defense systems with Starstreak missiles. Italy and France delivered SAMP/T, Crotale, Skyguard air defense systems to Ukraine. Soviet air defense systems - S-300, Osa-AK, S-125, «Kub», «Strila-10» - were transferred to Ukraine by the Czech Republic, Poland, and Slovakia. Also, the air defense of the Armed Forces of Ukraine has already received or will soon receive the American short-range MIM-23 Hawk air defense systems (Spain, USA, Sweden), the German Gepard air defense systems, the American Stinger MANPADS, the British Starstreak MANPADS, the French Mistral MANPADS, the Polish Grom and Piorun MANPADS.

Saturation of the air defense system with surface-to-air anti-aircraft artillery and anti-aircraft missile means is yielding results. The Air Defense Forces of the Air Forces of Ukraine demonstrated the unique capabilities of destroying not only the supersonic Kinzhal aeroballistic missiles but also the newest hypersonic Zircons. However, it is

impossible to “close the sky» for 100% on such a territory as Ukraine with ground-based air defense systems. According to the approaches generally accepted in NATO countries, fighter aircraft play the main role in air defense. Ukraine has at its disposal only a limited fleet of outdated MiG-29 and Su-27, which are significantly inferior to Russian generation 4++ aircraft in terms of tactical and technical characteristics.

Therefore, to close Ukraine’s sky for Russian aircraft, the Air Forces of Ukraine need western fighter aircraft. F-16 and JAS-39 Gripen are an urgent need, and, among other things, should reduce the risks of damage to the critical energy infrastructure of Ukraine.

3.2. How can countries better prepare, e.g. by improving contingency planning or training

To be ready on a national level for war threats, one should have:

- air defense/anti-missile defense umbrellas in the area of critical energy facilities, especially in the area of hydroelectric power stations with high dams;
- cyber-security systems for telecommunication assets which ensure critical energy infrastructure functioning;
- anti-sabotage protection, especially for countries with maritime critical infrastructure;
- reliably protected strategic fuel reserves (in underground caverns), inaccessible to damage by conventional means;
- part of the strategic reserves, located abroad with the possibility of its prompt receipt in an emergency situation;
- distributed mobile fuel reserves for operational needs to support the armed forces and transport;
- pre-developed schemes for eliminating electricity shortages due to distributed backup generation and/or receiving emergency assistance from partner countries in the event of damage to generation facilities;
- rapid response repair teams in network operators to restore energy supply in case of damage to critical energy infrastructure facilities;
- spare parts and reserve equipment for substations and generation units.

It is important to simulate scenarios of possible enemy`s strikes to damage energy networks, determine the vulnerabilities of networks, and develop mechanisms for neutralizing negative consequences in the event of critical energy infrastructure damage. Based on this, it is important to organize and conduct regular command and staff exercises with the involvement of network operators, civil authorities, armed forces, etc.

Lessons learned by Ukraine make evident, that the quick introduction of distributed mobile facilities for transportation and storage of fuel in cases of targeted attacks against petroleum product bases helps to avoid shortages and ensure uninterrupted supply for armed forces and transport. Ukraine purchases for this purpose all available tanker trucks in Europe. Within months over 40% of fuel imports switched to automobile transport, totally absent even at the beginning of 2022. In turn, nearly 100% of railway fuel transportation dropped to 40–45%.

Countries with Soviet/Russian nuclear reactors should take efforts to stop cooperation with Rosatom and its subsidiaries on their NPPs.

Countries around the North, Baltic, and Black seas should pay special attention to the protection of marine critical infrastructure - underwater gas pipelines, oil pipelines, offshore production platforms, fibre optic communication lines, and power cables. It is important to increase the awareness/qualification of the TSO staff on cyber security issues.

Possible additional measures:

- Oil transportation system operators can use some pipelines which are out of operation, after appropriate cleaning and preparation, for fuel storage;
- petroleum product facilities should be protected by air defense systems, and radio-electronic warfare means, and mobile groups with small arms should protect against UAVs and subsonic cruise missiles;
- it is important by all means to prevent enemy superiority over sea and marine logistics. To do this, it is necessary to create a reliable defense system: coastal anti-ship complexes, maritime strike drones, air defense, mine barriers, anti-sabotage defense;
- temporary storage of operational fuel reserves near the combat zone must be dispersed and covered;
- immediate strikes should be directed both against fuel logistics of enemy troops on the battlefield and fuel infrastructure as well as refineries in its strategic depth, as well as fuel depots of "RosReserve";

3.3. How Ukraine managed to quickly restore service after disruption, including related to decision-making, public-private sector cooperation, equipment and spare parts as well as personnel

3.3.1. Russian strategic plan against Ukraine's critical energy infrastructure

Russian large-scale strikes against the critical energy infrastructure of Ukraine were redirected from regional petroleum product bases after their damage on the United Energy System of Ukraine (UES of Ukraine). The final aim was to collapse the centralized electricity supply for consumers in Ukraine. However, despite massive combined missile and drone attacks during autumn-winter 2022-2023 (from October 10, 2022, to March 23, 2023), the aggressor failed to achieve its goal. There was only one blackout in the UES of Ukraine so far – on November 23, 2022. The UES of Ukraine restored synchronized operation during a short period – approximately 12 hours.

Russia concentrated all efforts on damaging Ukraine's energy infrastructure, because:

- Electricity is today the key energy source to ensure the life of citizens and the functioning of industries in developed countries;
- Strikes against gas and oil transportation systems of Ukraine could threaten Russian energy transit to the EU, which was not in the Russian interests at that time;
- Electricity shortages on railways, which are nearly all electrified in Ukraine, resulted in substantial logistics problems to deliver coal to the TPPs and import petroleum products from Europe.

Russian main goal was however to provoke in Ukraine large-scale social unrest and protests because of the absence of electricity and heat during the cold winter period and to direct such protests into anti-war trend and the search for «compromises» with Russia (actually - capitulation) to end the war.

3.3.2. Outcomes of massive strikes against facilities of the United Energy System of Ukraine

During the period from October 10, 2022 to March 9, 2023, Ukraine's UES facilities were hit 243 times by cruise and ballistic missiles, as well as drones. Affected:

- 20 thermal power plants – 112 hits;
- 84 critical transformer substations – 122 hits.

With the aim to achieve the UES collapse and its physical rupture, the enemy decided to use the imbalance of generation and consumption on both banks of the Dnieper. After seizure of Zaporizhzhia NPP (6 power units) and the Dniprovsk TPP, the largest in Ukraine, both located on the Left Bank (Enerhodar) and their subsequent disconnection from the UES of Ukraine, an imbalance in the energy system arose. On the Right Bank of Ukraine, where the main generating capacities are located (9 out of 15 power units of the type VVER-1000 and VVER-440 at three out of 4 NPPs, 5 powerful TPPs), but fewer industrial consumers, the surplus increased, while on the Left Bank, the deficit grew rapidly. The enemy's main plan was to split Ukraine's energy system in half along the Dnieper River, and by disrupting the flow of electricity between the Right Bank and the Left Bank, causing the collapse of the UES.

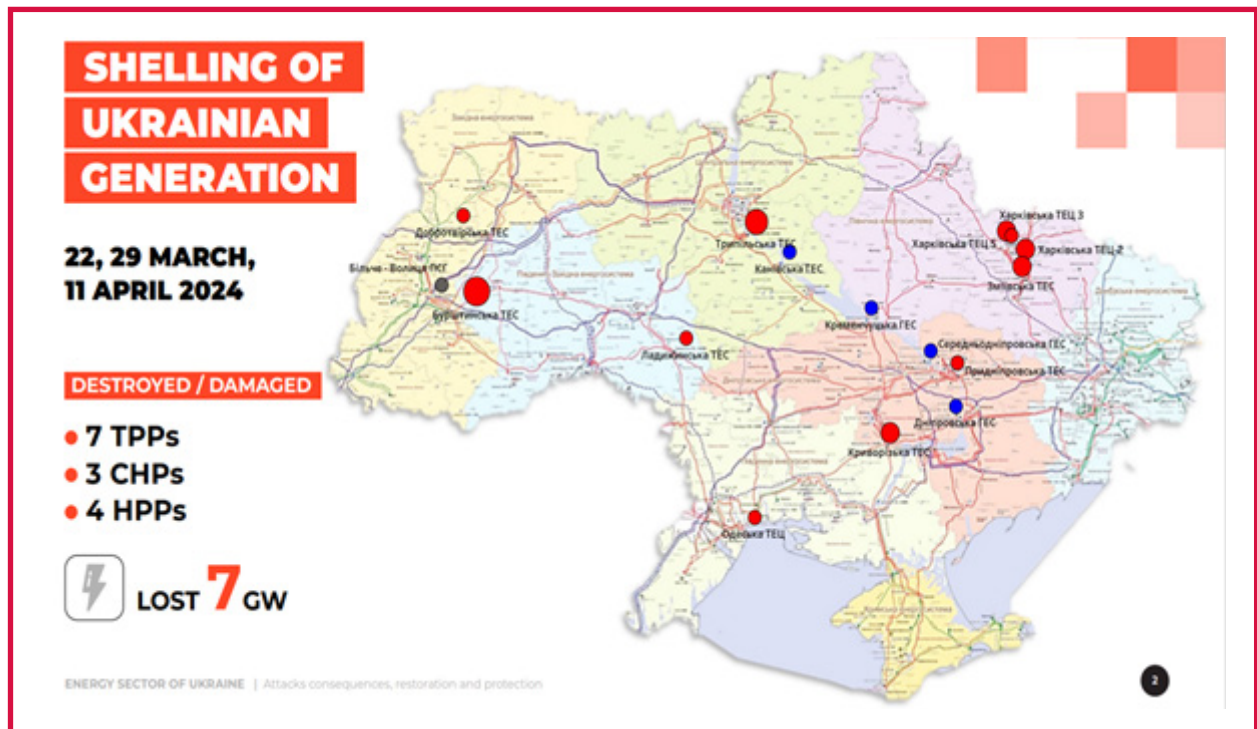
On November 23, 2022, the aggressor achieved its goal - because of numerous strikes in October-November, half of the transformer capacity was destroyed. The UES suffered a short blackout. Energy flows were disrupted. However, the TSO Ukrenergo managed to quickly repair the equipment and restore flows. The dispatch centre of Ukrenergo has learned how to balance the power system in conditions of its complete imbalance. The UES managed to be balanced at the expense of energy flows from hydroelectric power plants and pumped storage hydroelectric power plants. Electricity imported from the EU was not enough to cover the deficit in the power system – instead of the possible maximum capacity of 1,200 MW, only a maximum of 609 MW was available for import in certain hours.

The viability of the UES is ensured by the surplus of transformer capacity, which plays a key role in the transmission of electricity from generating capacities (nuclear power plants, thermal power plants, hydroelectric power plants, etc.) to consumers, and which amounted to 46.3 GW by October 2022. As of the end of February 2024, this capacity, considering the restoration of a number of affected but repairable facilities, was 31-34 GW. Peak consumption in the winter season of 2023-2024 was 18 GW. This situation meant that before the strikes of March-April 2024, the operator Ukrenergo should have had a certain surplus of transmission capacities for the next winter season of 2024-2025 since peak consumption in Ukraine for many years until 2022 did not exceed 25 GW of capacity. However, the problem is the exhaustion of technical possibilities in the transfer of excess electricity from the Right bank to the Left. Usually, no more than 1.5 GW of power was transferred from the Right Bank to the Left Bank, now this flow has increased to 5 GW and this is the limit. In the event of further damage to energy facilities on the Left Bank and an increase in the energy deficit there, it will not be technically possible to direct additional energy flows from the Right Bank.

The attack on the critical energy infrastructure of Ukraine **on March 22, 2024** was the largest during the entire period of the full-scale invasion of Russia. The total volley was 151 units - successively waves of drones, cruise and ballistic missiles. Although the UES of Ukraine maintained its functionality and no blackout occurred, at the same

time, during the combined attack, important generation facilities (thermal power plant, hydroelectric power station) and transformer substations (PS330 kV and PS750 kV) were affected. In the following days, attacks on energy facilities continued. In particular, substations were targeted, located in the west of Ukraine, so that their damage would lead to the disintegration of the UES of Ukraine with the European ENTSO-E network. The main plan of the enemy was to make it impossible for the UES of Ukraine to receive emergency assistance with electricity supplies from European operators.

The generation of Ukraine - TPPs, CHPs and HPPs suffered serious damage as a result of three massive and combined Russian attacks. In total, 7 GW of capacity was lost (see diagram below)



Source: Ministry of Energy of Ukraine

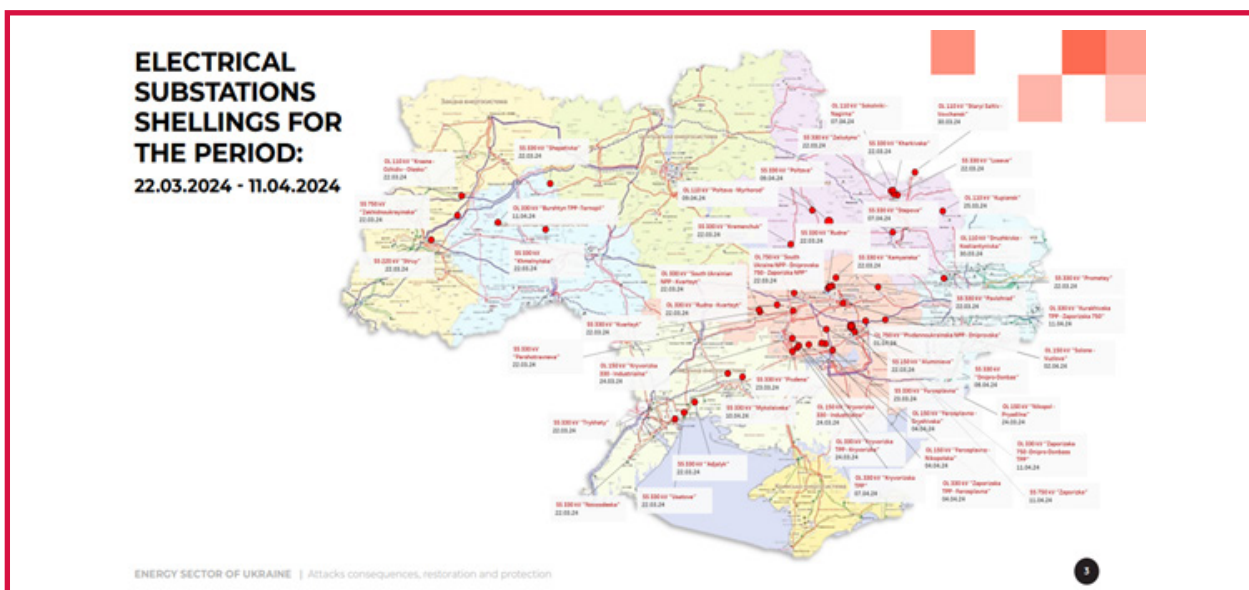
Attacks on hydroelectric power stations are aimed at depriving Ukraine's UES of maneuvering capacity. As a result, the UES should have expected to experience a blackout with its fragmentation into regional «energy islands».

Russian attacks led to the complete destruction of the generating capacity of the second largest city in Ukraine – Kharkiv. CHP-5, which was a subject to the first attacks on September 11, 2022, and after repairs continued to provide the city with heat and electricity for two winters of 2022/23 and 2023/24, was completely destroyed by a massive strike of ballistic missiles from the S-300 air defense system and X-22 air-launched cruise missiles. The largest hydroelectric power station in Ukraine - DniproHES and transformer substations in Zaporizhzhia were also fatally damaged (8 hits by cruise and ballistic missiles). Critical energy infrastructure facilities in the Odesa region were seriously damaged. The enemy plans to de-energize the port infrastructure of the region so that Ukraine does not have the opportunity to carry out export-import operations through the main trade ports of Odesa, Pivdenny, Chornomorsk, Ismail, and Reni.

From March 22 to April 11, 2024, a number of important transformer substations of the TSO Ukrenergo also suffered additional damage. As one can see from the Map-Scheme below, the strikes were concentrated on substations of industrial agglomerations in the central part of Ukraine, where the main facilities of the defense industry and railway hubs are located.



Source: NV.ua, data of Ukrenergo as of April 2024



Source: Ministry of Energy of Ukraine

The massive attacks on March 22 and 29, and April 11, 2024, cumulatively resulted in:

- critical reduction of shunting generation (TPPs + HPPs) in the UES of Ukraine;
- increasing imbalance between the Left Bank (deficit) and the Right Bank;
- growing risk of disconnection of the UES of Ukraine from the European ENTSO-E network;
- increased risk of the UES collapse during subsequent attacks;
- the maximum probability of the UES breaking up into energy islands at the summer or winter peak of energy consumption.

A change in the enemy's tactics of mass strikes was [noticed](#) [25] in TSO Ukrenergo: the number of missiles used during the winter attack [in 2022-2023] for the whole territory of Ukraine is now aimed at five to six energy sites in one region.

3.3.3. The reasons for the failure of the aggressor's plan in 2022-2023

There were several reasons for the failure of the aggressor's plans to destroy the centralized electricity supply system of Ukraine. First of all, it is necessary to note the peculiarities of the territorial and generation structure of the UES of Ukraine, its operation, and the high level of professionalism of the operational dispatching, maintenance and repair personnel of energy companies. The state authorities managed to organize sufficiently fast obtaining assistance to the energy sector from foreign partners of Ukraine. Along with this, certain amounts of assistance were also received by energy companies from foreign counterparts based on direct contacts.

Among the peculiarities of the territorial and generation structure of the UES, which are important in the context of the high stability of the UES of Ukraine in the conditions of Russian aggression, is the branching of the power transmission lines network (*see Annex 8. Map 2. United Energy System of Ukraine*). It was gradually built up during the second half of the 20th century. The UES network ensured the transmission and distribution of 298 billion kWh produced in 1990 with a high level of reliability of electricity supply. In 2021, total electricity generation fell to 156.6 billion kWh, reflecting market demand.

As Russia started the aggression, the UES of Ukraine had a significant surplus of the network's capacity, consumers were sufficiently well reserved in terms of the possibility of receiving electricity based on various supply schemes - using various substations and transmission lines.

The equipment exchanged during maintenance and repairs, was stored as a reserve for spare parts. The same approach was used regarding transformers, which were also stored as a reserve after modernization and exchange on modern units.

Generation capacities of the UES of Ukraine also had a certain surplus. Thus, the total installed capacity of power stations in the UES of Ukraine as of December 31, 2021 (excluding power-generating facilities of the Crimean electric power system and the temporarily uncontrolled territory of the Donetsk and Luhansk regions) was 56,247 GW, of which:

- 28 GW accounted for thermal power plants (in particular, thermal power plants, combined heat and power plants, block-type thermal power stations);
- 13,835 GW – for nuclear power plants;
- 6.3 GW – for hydro- and pumped storage hydro power plants;
- 8.15 GW – for wind, solar and biomass power plants.

The above-installed capacity was more than 2 times higher than the maximum demand in the UES of Ukraine, which in recent years was at the level of less than 25 GW.

Given seizure, damage, and destruction of many objects of the UES of Ukraine, it was in principle impossible to ensure sustainable centralized electricity supply to all consumers. **During the 2022-2023 heating season, households did not have access to electricity for an average of 35 days.** Therefore, the controlled disconnection of certain groups of consumers for a set time, with sufficiently high discipline in the execution of disconnection schedules was very necessary in those conditions and showed a good result. Minimum disconnection periods from the power supply of critical infrastructure facilities ensured the avoidance of catastrophic consequences for the population.

Despite the massive strikes directly on the generation and power output systems of power plants, the seizure of the Zaporizhzhia NPP, Zaporizhzhia and Vuhlehirsk TPPs, as well as about 1.2 GW of wind and solar power plants, certain generation capacities were preserved in the UES of Ukraine. These capacities provided the possibility of balancing the country's energy system with a significantly reduced electricity consumption due to military hostilities, the mass outflow of the population abroad, and the use of planned and emergency restrictions on the centralized supply of electricity to the country's consumers.

A massive missile attack on March 22, 2024, resulted in damage to the power units of several TPPs both on the Left Bank and on the Right Bank of Dnipro River. Dangerous consequences include the damage to the most powerful hydroelectric power plant in Ukraine - DniproHES in Zaporizhzhia - with following rupture of the only power supply line for the Zaporizhzhia NPP in Enerhodar, with a growing risk of a nuclear incident at the NPP.

This means that Russia activated the scenario of damaging key critical energy infrastructure to eliminate the residual surplus of power generation capacities in the UES of Ukraine and cause its collapse with subsequent fragmentation into «energy islands».

3.3.3. Measures to restore the technical resources of the UES.

A feature of the UES of Ukraine operation, in addition to the high personnel qualification level, was the presence in all generating and network companies of the country, except for wind and solar power plants, of their own operating and repair personnel, which provided comprehensive works for maintenance and repair of equipment. The staff had considerable practical experience in replacing elements and repairing faulty equipment, given its long term in operation. The maintenance and repair units were practically full-stuffed because at that time the personnel of energy companies were mobilized to the Armed Forces of Ukraine only voluntarily in limited numbers.

An important factor in the rapid restoration of electricity supply was the immediate engagement of private companies that carried out and/or took part in the construction, reconstruction (modernization) and service maintenance of the facilities of energy companies of Ukraine into repairs of damaged/destroyed facilities. They have not waited to sign the contracts for the necessary work.

The above proved to be one of the main preconditions for rapid electricity supply restoration and limiting disconnection periods through:

- transitions to backup/emergency power supply restoration schemes for consumers, in particular, on lines of lower voltage than expected when working in normal operating modes of the UES of Ukraine;
- performance of repair and adjustment works of damaged equipment;
- replacement of destroyed elements in electrical networks, in particular, transformers of relatively small power capacity.

A certain role in providing consumers with electricity played a massive purchase of autonomous electricity generators, primarily done by small and medium-sized businesses, and their delivery by foreign partners to meet the needs of critical infrastructure. However, autonomous generators do not have a backup power source, and in the event of their breakdown or the absence/impossibility of purchasing expensive liquid fuel, consumers equipped with them were left without electricity if it was impossible to obtain it from the UES of Ukraine.

The citizens of Ukraine also actively used electricity storage installations of different types. Their utilization helped to provide continuous electricity supply, but was dependent on periodic and regular recharging from the UES of Ukraine.

Considering the mentioned factors, the key role in preserving the integrity of the UES of Ukraine and minimizing restrictions in the electricity supply to consumers played the high professionalism of the staff and the effective organization of the operational and dispatching management systems of the UES of Ukraine.

At the same time, it was of great importance both to make optimal decisions to preserve the integrity of the energy system when managing the work of the UES of Ukraine, the risks of loss that arose because of emergencies, as well as effective operational planning of the energy system's operating modes. The latter ensured quick determination of the necessary supply restrictions to consumers and planning of their territorial distribution based on remaining power generation and transmission, measures to restore power supply, the priority of carrying out repair works, etc.

State authorities have not adopted additional decisions after the beginning of the Russian aggression against Ukraine to manage the electric power complex, given new threats to the energy security of the country in the context of targeted strikes on the facilities of the UES of Ukraine.

The electric power industry operated according to peacetime market rules, no changes were made to the regulatory framework to consider the peculiarities of its operation under martial law. No special measures were taken to physically protect critical elements of the UES of Ukraine - powerful power plants and key high-voltage substations, namely, by anti-missile defense/air defense systems, engineering protective fences and shelters for key elements of substations and distribution devices of power plants, in particular, transformers. The state authorities have not provided a centralized formation of emergency stocks and the creation of a centralized system for emergency recovery of UES of Ukraine, as well as backup power sources for objects of critical infrastructure.

The main attention in the period before the massive targeted strikes on the UES facilities of Ukraine, which began on October 10, 2022, was focused on the restoration of electricity supply to consumers in the war zone. The relevant experience and algorithms were developed during the previous 8 years of Russian aggression, starting from 2014, when the aggressor began to destroy energy facilities in Donetsk and Luhansk regions. In general, the UES of Ukraine was not specifically prepared for massive strikes on its infrastructure.

To sum up, quick restoration of electricity supply after disruptions, caused by Russian strikes against critical energy infrastructure, was possible due to:

- the professionalism of operational-dispatching, maintenance and repair personnel of energy companies, regardless of the form of ownership – state-owned Ukrenergo or private DTEK;
- the surplus capacity of transmission networks and generation;
- the certain stocks of equipment and spare parts, which were formed due to the preservation of dismantled or non-working equipment at different times;
- deployment of autonomous generators and electricity storage equipment, which to a certain extent provided an opportunity to compensate for the lack of electricity for individual consumers;
- aid from the EU in the form of natural gas supplies.

3.3.4. Aspects of damage to the gas transmission system and underground gas storage facilities

If the problems of providing Ukraine with electricity and heat during the heating season receive a lot of attention, then the problems of providing natural gas practically remain out of public attention. However, the consequences of the loss of the ability to obtain natural gas by power generation facilities can be much more severe than the loss of electricity supply.

A serious problem that may arise before Ukraine's provision of electricity is strikes on the gas transmission system (GTS) of Ukraine and surface elements of underground gas storage facilities (UGSF) (*see Annex 9. Map 3. Gas Transmission System of Ukraine*). This scenario is highly likely if the transmission of natural gas from Russia to the EU via Ukraine stops after December 31, 2024, the date of termination of the 5-year agreement between Gazprom and Naftogaz of Ukraine. **This may cause dysfunction of gas supply for the capacities of TPPs and municipal CHPs for the production of heat and electricity.** At the same time, the loss of heat supply from the CHP in the winter period will lead to mass attempts by consumers to use electric heating systems, which will cause the need for mass disconnections of consumers from the centralized electricity supply due to overload of networks and/or insufficient generation capacity and emergency import possibilities from the EU.

Restoring gas supply after strikes on gas compressor stations (GCS) and surface sections of the linear part of main gas pipelines appears to be a much more difficult task than restoring centralized electricity supply. In the event of the destruction of the GCS and surface structures of the UGSF, their restoration is possible only through new construction.

Given the reality of the threat of strikes on the gas infrastructure, it is necessary, first of all, to maximally strengthen the capabilities for anti-aircraft and engineering

protection of key facilities of the GTS and UGSF. Along with this, it is necessary to ensure a significant increase in the capabilities for emergency repairs of the linear part of main gas pipelines. But even with the adoption of such measures, the risk of losing the possibility of gas supplies for Ukrainian consumers will remain very high.

The continuation of gas transit from Russia to the EU does not guarantee a significant reduction in the risk of strikes on Ukraine's GTS. In practice, Russia has minimized the use of Ukraine's GTS for gas exports to the EU since 2022. Only one cross-border gas entry-exit point on the north-eastern border in Sudzha and one line of the route Urengoy – Pomary – Uzhhorod are used.

The geographical location of the infrastructure of the gas sector of Ukraine should be taken into account. The extraction zone of almost 90% of natural gas is concentrated in two regions of the Left Bank (Poltava and Kharkiv) near the border with Russia and the front line, and underground gas storages are located on the Right Bank, in the western part (Ivano-Frankivsk and Lviv regions) near the border with the EU.

During the offensive of Russian troops in the Kharkiv region in 2022, the gas production zone was under threat of seizure. The mining and gas transport infrastructure in the Kharkiv region was damaged. Three compressor stations on main gas pipelines were damaged or destroyed, 23 gas distribution stations (GDS) and 27 km of pipelines were damaged. Of the damaged ones, one GCS and 4 GDS were repaired.

Despite the risks for gas production in eastern Ukraine and a slight reduction in gas production in 2022, it was possible to increase it somewhat in 2023. 18.7 billion cubic meters of annual production fully covers the needs of Ukraine, and for the first time, the country passed the winter season without importing gas from Europe. Moreover, Ukrainian UGSFs helped European companies in gas storage. Last winter season, foreign companies stored 2.5 billion cubic meters of gas in Ukrainian gas storage facilities, in 2024 Naftogaz predicts the storage volume to 4 billion cubic meters. The season of 2020-2021 was a record when almost 10 billion cubic meters of gas of European companies were stored in UGSFs of Ukraine.

According to the available information, the objects of GTS and UGSFs are periodically ordered by the Russian side for space photography from foreign commercial companies. In the course of the **Russian massive combined attack against the CEI facilities of Ukraine on March 22 and 29, 2024, the targets were not only the UGS facilities, but also the surface part of the Ukrtransgaz' UGSF in the Lviv region.**

3.3.5. Enemy's conclusions based on the results of the 2022-2023 winter campaign

Russia made conclusions regarding the limited – contrary to the expected – effect of strikes on the CEI of Ukraine with high-precision weapons, in particular:

- long breaks between missile strikes on the objects of the energy system of Ukraine made it possible to carry out repairs or replacement of equipment in a fairly short period of time;
- the effectiveness of strikes directly depends on their mass and combination;
- the growing density in 2022 – 2023 of Ukrainian air defense reduces the effectiveness of mass strikes; (in the spring of 2024, this principle works inversely)
- strikes on energy facilities deep in Ukraine do not affect directly the situation at the front.

The latter was important from the point of view of reorientation in the winter season of 2023-2024, to the destruction of key industrial facilities of Ukraine's defense industry and the intermediate storage bases of ammunition that came to Ukraine from foreign partners.

During the second year of aggression, the enemy reconsidered previous approaches, which was manifested in certain features of the use of naval forces, manned strike aircraft of the Russian Air Force, and unmanned aerial vehicles in relation to strikes on critical infrastructure. Among them:

- redistribution of tasks between missile strikes by the Air Force (air-based cruise missiles) and Navy (sea-based cruise missiles) and UAV strikes (Shahed-136 type attack drones) in favour of the latter, given the appearance of a larger number of them, more advanced (faster and more maneuverable, less visible, more interference-resistant) and cheap. Considering the fact that in world practice there has not yet been such a massive use of UAVs against CEI and the loss of manned aircrafts and forces of the Black Sea Fleet, this will continue to affect the redistribution of the tasks of hitting CEI objects with the help of strike drones;
- growing role of the short- and medium range ballistic missiles (Iskander-M) in solving the tasks of destroying critical infrastructure (powerful warhead - 10 times greater mass (~460 kg) compared to the warhead of the «Shahed» type UAV (~45 kg), short flight time – a few minutes, which gives little chance of interception) compared to air- and sea-based subsonic cruise missiles, which have a long flight time and are quite effectively hit by fighters or ground-based air defense equipment;
- the need for strike aviation to switch to hypersonic missiles, against which modern anti-aircraft defense has low interception efficiency, given that they are expensive;
- understanding that the use of high-precision missile weapons to solve the tasks of defeating CEI should be measured by a significant number (more than a hundred) of strike drones, cruise and ballistic missiles in each combined mass strike to achieve the desired effect in terms of defeating CEI objects. This is always a costly and difficult task. In addition, the production of missiles, unlike drones, is much slower and many times more expensive.

The striking of energy facilities in the Dnipro Industrial Zone (Dnipro, Pavlograd, Kryvyi Rih, Zaporizhzhia) in February and March 2024 is a reflection of the fact that CEI remains in the circle of priorities. The aim of these strikes was the destruction of generation and substations in order to de-energize the production capacities of important plants of the defense industry of Ukraine.

3.4. Recommendations related to protection of critical infrastructure (both what does and does not work in the current context)

In order to effectively organize the protection of critical infrastructure objects, in April 2023, the appropriate register was finally agreed upon and started functioning in Ukraine, as stipulated by the law «On Critical Infrastructure,» adopted by the parliament on November 18, 2021, shortly before the full-scale Russian invasion.

Comprehensive protection of critical infrastructure is carried out in the following main areas:

- air defense - covering key critical infrastructure facilities with anti-aircraft defense/ anti-missile defense, which would protect them from air strikes using UAVs, missiles and aerial bombs;

- engineering protection of elements of key objects of critical infrastructure;
- anti-sabotage protection – against the actions of enemy sabotage groups against key objects of critical infrastructure;
- cyber protection of relevant telecommunications networks that ensure the functioning of critical infrastructure.

The construction of a system of passive protection of CEI facilities includes the construction of physical protective barriers (U-shaped iron perimeter or perimeter of gabions with sand, soil, or stone filling around transformers - *see the photo below*) at energy facilities. The underground placement of certain CEI elements, which do not require ventilation, in the conditions of war seems unrealistic, although in some cases it may take place.

The use of electronic warfare is of great importance in the protection of energy facilities.

Of course, it is impossible to 100% guarantee protection against damage to critical infrastructure objects, and in this context, the speed of restoring their functionality after damage or solving the problem of restoring energy supply in another way (if technical capabilities are available) is of great importance.



Examples of engineering protection of the 1st (left) and 2nd (right) levels of CEI facilities.

The speed of energy supply systems restoration in the event of destruction/damage of their facilities will have a significant impact on the provision of energy resources. In this context, it is necessary to solve a number of problems, in particular:

- retention of qualified personnel in energy companies and companies that provide services for complex repairs of equipment, its adjustment, construction and installation works at energy facilities;
- development of distributed generation with guaranteed capacity, which can be generated by natural gas and biomass;
- maximum equipment of critical infrastructure objects with autonomous generators and energy storages, which minimizes the possibility of negative consequences at the level of individual communities in case of loss of centralized power supply.

Among the generating capacities of Ukraine, the following needed reliable protection, first of all:

- powerful thermal power plants - Prydniprovsk, Kryvorizka, Trypilska, Dobrotvirsk, Ladyzhynska, Burshtynska,
- powerful HPPs and PHES on Dnipro and Dniester rivers;
- transformer substations of the energy transmission system with a voltage of 220 kV and above.

Some of them have already suffered critical damage and as of April 1, 2024, it is not clear to what extent they can be restored.

Increased protection of the GTS, UGSFs and oil transportation system facilities is also necessary, considering the precedents of the attacks on March 22 and 29, 2024, when the surface structures of compressor stations of underground gas storage facilities in the west of Ukraine were hit.

Russia's attacks against Ukrainian fuel depots, oil refineries, electricity generation and transmission capacities, surface infrastructure of underground gas storages indicate that this year the aggressor will try to comprehensively destroy all energy systems of Ukraine. The goal is not only to bring the UES of Ukraine to collapse, but also to create longstanding deficits of electricity, heat and gas for the winter of 2025. Strikes on key substations of Ukrainian nuclear power plants also seem highly probable. Attacks on UGSF, which are used not only by Ukrainian, but also by European companies, indicate that Russia is challenging Europe. It is unlikely that the additional air defense equipment currently provided to the Armed Forces of Ukraine by Western countries will solve the problem of CEI protection. According to Ukrainian military experts, to protect sufficiently main zones with critical infrastructure, Ukraine needs 10-12 batteries (with 8 launchers each) of Patriot systems, which can hardly be provided by Western partners.

Likewise, measures to prepare for the period of peak electricity consumption undertaken by the Government of Ukraine (installation of distributed generation capacity up to 3 GW, increase in electricity imports from the EU countries, supply of equipment for rapid repair and restoration of damaged UES of Ukraine and generation facilities) may prove to be insufficient.

Given the above, Ukraine urgently needs more air defence systems, especially to protect the area from the **north-south line Rivnenska NPP – Khmelnytska NPP – South-Ukrainian NPP** to the west of Ukraine to the EU borders. The Ukrainian government is advocating strongly for its partners to send further air defence equipment. F-16 fighter jets as well as pilot training will be delivered in 2024. In addition, Germany and France co-lead the Capability Coalition on Integrated Air and Missile Defence, and Germany has launched the initiative for Immediate Action on Air Defence (IAAD) which urges Allies and partners to contribute to Ukrainian air defence in any way possible, as soon as possible. If air defence will not be increased, a large-scale humanitarian catastrophe is highly possible **not only in the winter period, but in the summer, if Russians will strike against critical water supply and distribution infrastructure (pump stations, reservoir dams, sewage and water treatment system etc.) of big cities (Chernihiv, Sumy, Kharkiv, Slovyansk-Kramatorsk-Druzhkivka-Kostyantynivka urban agglomeration, Poltava, Kremenchuk, Zaporizhzhzia, Dnipro, Pavlograd, Kryviy Rig, Kherson, Mykolaiv, Odesa and others).**

3.5. The role of international assistance (bilateral, multilateral) in building Ukrainian resilience including cyber defences, as well as in mitigating the attacks (kinetic, hybrid, cyber) on the critical energy infrastructure

3.5.1. The need for international assistance

As of September 2023, Russian troops have [fired](#) [26] more than [6,500 missiles and 3,500 drones](#) [27] over Ukraine. In addition to numerous damages to civil infrastructure, during October-December 2022, during a series of intensive strikes by missiles and drones, about 50% of Ukraine's CEI was destroyed.

According to the [June 2023 UNDP report](#), [28] electricity generation capacity has decreased by about 50% from the level that existed until 2022. More than 67% of thermal generation capacities were lost, which significantly limited the possibilities of balancing the UES of Ukraine. As a result of the strikes on March 22-29, April 11 2024, the generation of thermal power plants and hydroelectric power stations was further reduced.

The destruction caused by Russian aggression required immediate action to restore the energy sector. Here, cooperation with partner countries is very important both for short-term goals and for strategic directions of energy sector development.

[Government Plan](#) [29] of preparation for the winter season 2023-2024, in addition to stockpiling of energy carriers and scheduled repairs of energy infrastructure facilities, also included:

- restoration of damaged objects, where possible and appropriate;
- construction of engineering protection around the most important energy facilities;
- creation of a distributed electricity generation network.

It is obvious that after the March and April 2024 strikes on generation facilities and the UES, the volume of work on the specified points has increased sharply and will require additional amounts of financing and the purchase of equipment to obtain when entering the winter season of 2024-2025 the necessary volume of heat generation and transformer generation capacities of the UES to pass seasonal consumption peaks.

The destruction of Ukrainian energy infrastructure also hurt the markets of neighbouring countries due to the cessation of exports from Ukraine, in particular on the energy industry of Moldova. This is due to geographical proximity and infrastructural connection. However, from March 16, 2022, thanks to the synchronization of the electricity transmission systems of Ukraine, Moldova and the EU, the two countries have the technical possibility to receive assistance from the EU electricity market. As a result, it significantly strengthened the energy sustainability of both countries.

3.5.2. Structure and role of international assistance

The energy sector has been identified as one of the five priorities for recovery in Ukraine. Its restoration requires significant resources. Their [possible sources](#) can be [30]:

Governmental assistance from different countries	Supplies of equipment and materials
The assistance of international institutions (WB, EBRD, EIB, IMF, etc.)	Mostly in the form of loans
EU assistance	Targeted financing, financial assistance, institutional reform
Private sources	Private funds, diaspora
Confiscated Russian assets	Russian state and private assets

In 2023-2024, urgent investments in the repair of destroyed energy infrastructure and other critical needs over the next decade are estimated as of the end of May 2024 at least at [\\$486 bln.](#)[31] Currently, there are several international initiatives to help Ukraine meet the urgent needs of recovery, reconstruction and strengthening of energy sustainability.

The Multi-Agency Donor Coordination Platform - «Financial Ramstein». On February 26, 2023, Ukraine, the EU, the G7 countries and international financial organizations established the Interagency Platform of Donors to coordinate existing and new mechanisms to support the budget of Ukraine, as well as to promote rapid recovery and reconstruction, including energy industry transparency, consistency and accountability in the provision of support must be ensured within the framework of the Platform's activities. An important priority of the Platform's work is the energy sector.

Ukraine Relief, Recovery, Reconstruction and Reform Trust Fund (URTF) [32] created in December 2022 has similar goals, which currently focus on critical sectors, particularly energy. Strategic management of URTF activities is provided by the Partnership Council, which is co-chaired by the World Bank and the Government of Ukraine. URTF members are partner countries, including Austria, Canada, Iceland, Japan, Latvia, Lithuania, the Netherlands, Norway, Sweden, and Switzerland.

The **EBRD** participates in meeting the urgent need to support the energy industry and energy infrastructure of Ukraine by providing \$1.5 bln annually, in particular through a revolving credit line with Naftogaz for the purchase of a sufficient amount of gas for the winter period.

Ukraine already has several ways to receive assistance from EU countries in ensuring the stability of the UES after March 16, 2022, when the emergency synchronization of the UES of Ukraine and Moldova with the energy system of continental Europe (ENTSO-E) took place. On March 29, 2023 [a new agreement](#) [33] on multilateral emergency assistance to Ukrenergo in the event of significant disruptions in electricity production/transmission in unforeseen situations, i.e., attacks on the

company's energy infrastructure, entered into force. Currently, the agreement has been approved by 15 transmission system operators (TSOs) of the ENTSO-E network, including all operators that have direct physical connections to the UES of Ukraine.

An important role in the organization of emergency assistance is played by **the Energy Community** and its Secretariat through several initiatives supporting Ukraine.

Ukraine Support Task Force (USTF) – The Energy Community Secretariat created the group immediately after the Russian full-scale invasion. The USTF supports Ukraine's energy sector by coordinating aid from European countries, companies/associations and delivering equipment, fuel and materials needed to rebuild war-damaged infrastructure. The USTF works closely with the European Commission's Emergency Response Coordination Center (ERCC) as part of the European Union Civil Protection Mechanism (UCPM). USTF forwards requests to ERCC, which, through the UCPM mechanism, arranges shipments from donor companies. Together with ERCC, the USTF monitors the process, assists and coordinates each shipment at each stage of the journey. On the Ukrainian side, the Ministry of Energy cooperates with the USTF.

Ukraine Energy Support Fund (UESF) was created to provide financial support for the restoration of Ukrainian energy infrastructure damaged by Russian attacks and to support the functioning of the energy sector. The UESF, managed by the Energy Community Secretariat, receives significant contributions from partner governments, international organizations and corporate donors. The fund attracted a total of more than 220 million euros. Donations have been specifically targeted to initiatives that prioritize grid restoration, sustainable and renewable energy solutions.

Ukraine Legal Support Platform (ULSP) [34] was created to provide **legal support** to energy enterprises and organizations of Ukraine to compensate for damages to the energy infrastructure of Ukraine caused by Russian attacks. The international legal community is encouraged to join the ULSP Platform for free legal support of Ukrainian state-owned energy companies. On this platform, law firms and qualified independent lawyers should join forces to redress the damage caused to Ukraine's critical energy infrastructure. The purpose of the platform is to create a database of qualified legal service providers ready to provide free legal assistance to Ukrainian companies in their attempts to recover damages from Russia for the destruction of energy infrastructure. ULSP cooperates with the largest state energy companies of Ukraine, which suffered significant losses: NPC Ukrenergo, SE NNEGC Energoatom, PJSC Ukrhydroenergo.

3.5.3. US assistance

Assistance is also provided within the framework of **bilateral relations with partner countries**. **US assistance** is critical to strengthening the resilience of Ukraine's critical energy infrastructure and comes through several projects and initiatives.

USAID Energy Security Project. [35] Within the scope of the project, the USA is making investments in the infrastructure of heat supply, for repairs, maintenance of heat lines, equipment supplies, strengthening the reliability of heating of buildings, hospitals, schools, and enterprises throughout Ukraine.

The USAID Cybersecurity for Critical Infrastructure in Ukraine Activity helps in identifying and studying threats and cyber defense of critical infrastructure. The project promotes [activity](#) [36] to the National Coordination Center for Cybersecurity.

Cooperation with the USA is carried out in ensuring the stability of the energy system of Ukraine, including critical energy infrastructure. On September 24, 2023, the United States and Ukraine adopted a [Memorandum of Understanding](#) [37] between Ukraine and the USA regarding Collaboration on Ukrainian Energy System Resilience. The document has a strategic nature, and states:

- the need to decentralize the energy supply system, which will strengthen the energy security of Ukraine and contribute to the transformation of the energy sector of Ukraine into a modern and diversified one;
- the need to support accelerated integration of Ukraine into the EU single energy market;
- a common desire to ensure the effectiveness of relevant reforms in the energy sector, in particular to promote transparency, accountability, anti-corruption measures and competitiveness.

It is important that the Parties specify in sufficient details the areas that will be developed to improve the sustainability of Ukraine's energy industry (*see Annex 6. The main spheres of US-UA energy cooperation within the framework of the Memorandum*). The direction of cyber security of CEI was separately noted, which emphasizes the importance of protection against cyberattacks of the aggressor and elimination of their consequences.

To review progress and resolve key issues to achieve the goal of the Memorandum, a Steering Committee consisting of state agencies of Ukraine (Ministry of Energy, National Commission for State Regulation of Energy and Public Utilities, Ministry of Infrastructure, State Inspection of Nuclear Regulation of Ukraine) and the United States (Department of Energy and USAID), is provided. The memorandum records the intention of the US government to assist in the total amount of \$522 million for the implementation of areas of energy cooperation.

Ukraine's cooperation with the United States following the principles of the Memorandum on ensuring the stability of the energy system opens up strategic opportunities for the protection, restoration, support and development of critical infrastructure on a modern basis. It is necessary to implement the monitoring of the deadlines agreed by the Parties for improving the corporate governance of state-owned enterprises - critical infrastructure operators of Ukraine following the principles of the OECD and EU legislation on transparency (REMIT).

It provides for the construction of modern highly maneuverable and more ecological generating capacities to increase the maneuverability of the energy system. Within the framework of the Memorandum with the USA, new gas generation is considered (to compensate for the destroyed units and increase the balancing capacity) on the sites of inactive CS (compressor stations) of the Ukrainian GTS.

3.5.4. Assistance in cyber protection

Russian cyber penetration into the energy infrastructure of Ukraine began on May 13, 2014 as a component of Russian hybrid aggression. At its peak, on December 23, 2015,

the cyber-attack caused large-scale failures in the management system of several regional energy distribution companies Prykarpattiaoblenergo, Chernivtsioblenergo, and Kyivoblenergo. As a result, 220,000 consumers (about 1% of the total number in Ukraine) were cut off. The outage lasted from 1 to 6 hours. About 30 substations were disabled because of the attack. The investigation into the cyber-attack was carried out with the assistance of a team of US experts, which included representatives of the Department of Energy, the Department of Homeland Security, the State Department and the FBI. On February 12, 2016, according to the results of the work of American experts in Ukraine, US Deputy Energy Minister Elizabeth Sherwood-Randall noted that Russia was behind the cyber-attack on the Ukrainian energy grid.

The GTS of Ukraine was subject to 3 powerful cyberattacks, which were unsuccessful. The targets of the attacks were the control center and technological communication system of the Ukrtransgaz – a gas transportation company.

On February 15-16, 2022, a few days before the start of a full-scale Russian invasion, Ukrainian state bodies and banks were subject to a massive cyber-attack. Cyber-attacks continue. Since the beginning of the full-scale invasion, the energy sector has come under increased scrutiny from cyber attackers. Cyber sabotage accompanies attacks on energy facilities with missiles and kamikaze drones.

The Russian concept of hybrid war involves the use of [all types of influence](#) [38] and [pressure](#) [39] on the country they attack. According to estimates, during the full-scale invasion, Ukraine repelled more than [10,000 cyber-attacks](#) [40] on various levels of state authorities, critical infrastructure and the private sector. Therefore, the issue of information and database protection has become particularly relevant.

3.5.5. Actions of Ukraine and partners on cyber protection

The danger of cyber-attacks and other cyber threats prompted the Ukrainian authorities to make serious decisions. The Cyber Security Strategy of Ukraine was approved by [Presidential Decree in 2021](#) [41], a corresponding Plan for its implementation has been developed. In April 2023, a [Resolution](#) [42] of the Cabinet of Ministers of Ukraine was adopted to implement the Cyber Security Strategy Implementation Plan, which defines the procedure for responding to cyber incidents and cyber-attacks, and enables:

- to detect quickly a cyber-threat and a cyber-attack;
- to inform about danger, prevent negative consequences or minimize them;
- to identify and fix vulnerabilities;
- to restore the functioning of elements of the cyber protection system.

On September 19, 2023, the Government of Ukraine approved [the National Plan](#) [43] for the Protection and Ensuring the Safety and Stability of Critical Infrastructure. Several specialized bodies/teams on cyber threats and cyber defense issues have been created.

Russian cyber-attacks on Ukraine's CEI increased the understanding of their threats to Western countries and the need for international cooperation in countermeasures. Employees of government organizations and private companies of partner countries take part in helping Ukraine with cyber protection. Thus, in June 2023, the British government's Ukrainian Cyber Programme received an increase in funding to 25

million pounds. Validity period – two years. The purpose of the program is to help Ukraine protecting its critical national infrastructure and vital government services online. The National Cyber Security Center of Great Britain (The National Cyber Security Center – NCSC) participates in ensuring the cyber security of Ukraine.

In addition to the NCSC, the US National Security Agency (NSA), the US Cybersecurity and Infrastructure Security Agency (CISA), the US Federal Bureau of Investigation (FBI), the National Cyber Security Center of New Zealand (NCSC-NZ), the Canadian Cyber Security Center participate in helping Ukraine with cyber security (as part of the Communications Security Committee - CSE) and the Australian Signals Authority (ASD). Foreign aid allowed Ukrainian specialists to significantly strengthen their work on cyber defense and countering Russian cyber-attacks on CEI.

3.6. Assessing the role of legal mechanisms to address Russia's violations of international law related to attacks on critical energy infrastructure

As evidenced by the results of a joint assessment of the UN Development Program and the World Bank from April 2023 [the damages](#) [44] caused to the energy, gas and heat infrastructure of Ukraine exceeded \$10 bln. In the year that has passed since April 2023, the amount has increased. These are only direct losses, indirect costs are difficult to calculate. The Ukrainian side insists on immediate compensation for CEI's losses through confiscation and sale of frozen Russian assets, but the process is delayed due to different approaches of Western countries and gaps in international legislation. As of March 2024, the International Criminal Court is only beginning to investigate the cases of Russian strikes on the CEI of Ukraine, the result of which was the appearance of [the first warrants](#) [45] for the arrest of responsible persons from the Russian military leadership.

3.6.1. Case of NJSC Naftogaz of Ukraine

Since the very beginning of Russia's unprovoked military aggression against Ukraine in 2014, the Case of NJSC Naftogaz of Ukraine' was the first successful case to apply legal mechanisms for the aggressor's damage to the CEI of Ukraine. Such damage refers to the expropriation of the assets of energy companies. The case of Naftogaz of Ukraine concerns losses and lost property of Naftogaz in occupied Crimea. The court decision was made in favour of Naftogaz - The Permanent Court of Arbitration in The Hague ordered Russia to pay \$5 billion in compensation for the losses caused by the seizure of the assets of Naftogaz Group companies in Crimea in 2014 - the aggressor voluntarily did not pay the funds, but the processing of available mechanisms for recovery of these funds in target jurisdictions where Russian assets are, is still ongoing. The arbitration proceedings initiated by the Naftogaz Group in October 2016 had been considered by the Arbitration Court for 7 years - until the decision was issued in April 2023. The period of preparation for the lawsuit by Naftogaz lasted two years - from 2014 to 2016. The arbitration decision is subject to enforcement following the United Nations Convention on the Recognition and Enforcement of Foreign Arbitral Awards (New York, 10 June 1958).

Due to the difficulty of reimbursing the awarded money and the reluctance of the Russian Federation to pay, the Covington International Law Firm on behalf of NJSC Naftogaz of Ukraine and five other subsidiaries of the Group has already filed a petition with the US District Court of Columbia to confirm the decision of The Hague Permanent Court of Arbitration, to whom Russia is obliged to pay \$5 billion (including

interest) in compensation. Naftogaz will be able to demand recovery of foreign assets belonging to the Russian Federation as a state, except for those protected by diplomatic or sovereign immunity, in particular, assets of the Russian Central Bank frozen in various countries.

3.6.2. Case of the NPC Ukrenergo

Adopting the case of Naftogaz regarding the filing of a lawsuit to the international arbitration court for Russia's expropriation of assets in Crimea, NPC Ukrenergo took as the basis of the lawsuit the same grounds as Naftogaz - violation of the Agreement [46] between the Cabinet of Ministers of Ukraine and the Government of the Russian Federation on the promotion and mutual protection of investments from 1998.

On August 27, 2019, Ukrenergo referred the dispute to an arbitration court (ad hoc) in accordance with the Arbitration Rules of the United Nations Commission on International Trade Law of December 15, 1976 (UNCITRAL). Claims for compensation for damages from the expropriation of Ukrenergo's investments in Crimea are part of the lawsuit along with compensation for the seizure by Russia during the occupation of Crimea of main networks and other facilities belonging to Ukrenergo. Considering the experience of the arbitration court's consideration of a similar Naftogaz case, the decision will probably not appear before 2025, and the next problematic issue will be compensation for the damage – make the aggressor pay.

3.6.3. Case of DTEK Group

DTEK Group is Ukraine's largest private owner of energy networks, electricity distribution systems, and heat generation. At the beginning of November 2023, the International Court of Arbitration in The Hague fully [satisfied](#) [47] the claim of the DTEK company against the Russian Federation as an aggressor country for seized assets in the illegally annexed Crimea. This is **the second** successful case to date of the writing of this research (April 2024), after the Naftogaz case. The arbitration awarded Russia to pay the Ukrainian private company damages in the amount of \$267 million, including interest and court costs as of the date of the decision. The trial of DTEK Krymenerho's lawsuit against Russia has been ongoing since 2017. Currently, DTEK Group, having suffered heavy losses from Russia's kinetic attacks on thermal and renewable energy plants after a full-scale invasion in 2022, is preparing to file a lawsuit in The Hague for wartime damages. During the kinetic attacks of late March and early April 2024, DTEK lost 80% of its generation capacity.

3.6.4. Case JSC Ukrhydroenergo

At the beginning of January 2024, JSC Ukrhydroenergo began preparing legal claims against the Russian Federation regarding compensation for damages from the destruction of the Kakhovska HPP on June 6, 2023. Ukrhydroenergo then [estimated](#) [48] the cost of rebuilding the Kakhovska HPP at \$1 billion. In June 2023, the Kyiv School of Economics [rated](#) [49] direct damage from the destruction of the Kakhovska HPP in the amount of \$2 billion.

In addition, at the beginning of September 2022, PJSC Ukrhydroenergo [submitted lawsuit](#) [50] to the European Court of Human Rights (ECHR) against the Russian Federation regarding compensation for damages caused as a result of Russia's unprovoked military aggression against Ukraine. The total amount of declared damages caused to the company's assets – the Kakhovska HPP and the unfinished

wind power plant on Zmiiny Island, at that time (before (!) the destruction of the Kakhovska HPP) reached almost UAH 17 billion (app. 425 million euros).

On March 22, 2024 the Russian army launched a missile attack on the Dnipro HPP (DniproHES), which resulted in damage to two stations that are part of its structure and the dam. The legal assessment of the damage is just beginning.

A high-level litigation and arbitration strategy is being developed to hold the Russian Federation accountable for targeted attacks on CEI and the company's assets. Two legal companies were involved in the preparation of legal claims, which were selected with the help of Pro Bono - the platform of the Energy Community Secretariat, which was created in July 2023 and should enable law firms and qualified independent lawyers to join efforts to redress damage to critical infrastructure in Ukraine. On August 23, 2023, the Energy Community Secretariat and Ukrhydroenergo signed a Memorandum of Understanding on the coordination of lawsuits against Russia for damage to the energy infrastructure. The Secretariat will provide Ukrhydroenergo with strategic and legal advice on receiving compensation for damages caused by Russia's military invasion. The company will also have access to the Legal Support Platform of the Secretariat of Ukraine, specially created for state energy companies.

3.6.5. Case of SE NNEGC Energoatom and legal mechanisms for the protection of nuclear power plants during an armed conflict

On March 4, 2022, Russian troops captured the city of Enerhodar and the Zaporizhzhia NPP located on the banks of the Kakhovsky Reservoir. A military contingent with weapons and equipment was stationed on the territory of the NPP. [Under international law](#), [51] given the serious risks inherent in nuclear power plants, parties must try to **avoid placing military targets, such as troops, weapons or military vehicles, on or near nuclear power plants** ([Article 56\(5\) API](#)) [52]. The Russian nuclear monopolist Rosatom de facto began to manage the ZNPP through two links - the subsidiary JSC Rosenergoatom and the specially formed JSC «Operating Organization of the Zaporizhzhia NPP». Therefore, there are all grounds for bringing Rosatom, which is an accomplice of the aggressor country in war crimes and [crimes against humanity](#) [53] for its actions at the ZNPP, both to sanction restrictions and to criminal liability.

Detailed provisions on ensuring the security of dangerous objects during hostilities are contained in the Protocol I Additional to the Geneva Conventions of 1977 (PA I), as well as in the Protocol II Additional to the Geneva Conventions of 1977 (PA II) and customary IHL. Nuclear power plants are civilian facilities, and as such are protected from direct attack and reprisals (Article 48 API [54]; Rule 7 CIHL [55]). In case of doubt as to whether a nuclear power plant is used to make an effective contribution to military operations, it should be considered civilian ([Article 52\(3\) API](#) [56]), even in the conflict areas ([Commentary of ICRC on API, 2034](#) [57]). Obligation of the parties to the armed conflict to constantly take care of the preservation of the civilian population, civilians and civilian objects during all military operations ([Article 57\(1\) API](#) [58]; [Rule 15 CI HL](#) [59]) is especially important when it comes to nuclear power plants. Given the risk of radiation release and subsequent severe consequences for the civilian population, the parties should exercise extreme caution during troop movements, maneuvers, and other military operations near such facilities.

3.6.6. Conclusions

The cases of Naftogaz and DTEK showed successful examples of publicly challenging the aggressor's actions. The thorough preparation of a lawsuit in cases of damage to CEI takes years, and the consideration of the case by arbitration is even longer - there are no quick solutions here. Even if the arbitration decision is in favour of the owner of the CEI, which was damaged or expropriated as a result of the aggressor's actions, there is a gap in international law in the mechanisms for the implementation of this decision and the collection of funds/expropriation of assets.

Legal compensation mechanisms for damage caused by an aggressor are always a long way to go, while restoring the energy system and CEI facilities, and overcoming the consequences of airstrikes on CEI, as in the case of the Kakhovska HPP, are emergency actions that require immediate investments and assistance from international partners and donors.

Due to Russia's non-recognition of the supremacy of international law and refusal to pay in cases lost in international courts, **the key problem of compensating damages caused to CEI facilities is the difficulty of reimbursing the awarded money.** Therefore, the effectiveness of the application of legal mechanisms for the damage caused to CEI will depend on the actions of the countries in whose jurisdictions the frozen Russian assets are located (in particular, the United States, Great Britain, Belgium, etc.), their ability to facilitate the process of execution of arbitration awards that are subject to enforcement in accordance with of the New York Convention of 1958. For example, a draft law has been submitted to the American Congress that expands the possibilities of confiscating Russian sovereign assets (in particular, the funds of the Central Bank) and their transfer to Ukraine, in particular, it gives the US president the right to confiscate frozen assets of the Russian Federation and transfer them to help our country - this draft law has not yet been adopted.

Therefore, closing the gaps in international law and developing legal compensation mechanisms at the expense of frozen Russian assets is a priority task. This can be used not only to compensate for damages caused as a result of kinetic attacks during hostilities on CEI facilities in Ukraine but also as a precedent in the future for EU countries to compensate for damages from hybrid impacts on CEI facilities in the Baltic Sea - Balticconnector and fiber-opticables, etc.

A DIFFERENT VIEW OF NATO'S AND EU'S CHALLENGES FROM THE UKRAINIAN POINT*

4.1. Challenges for NATO and the EU on the Eastern flank

Unlike Ukraine, where strategically important infrastructure companies are state-owned, which guarantees their full control by state operators during an emergency period, more than 80% of all critical infrastructure facilities in Europe are controlled and managed by private companies. As NATO Secretary General Jens Stoltenberg rightly noted, private companies such as Microsoft, Amazon, Starlink, and DTEK have become key players in Ukraine. They have responded to direct requests for help, put entire government departments in the cloud, and used satellite networks for secure communications, making it impossible to keep countries safe without the private sector. So you need to communicate more, plan and train together.

This requires constant cooperation between public authorities and the private sector, and the respective responsibilities between the public and the private sector must be clearly regulated and mutually agreed upon. At the Vilnius NATO summit, defense plans were agreed upon, containing requirements for force structure, and establishing the number and types of equipment and organization that NATO needs for all regions and domains. As the Chair of the NATO Military Committee, Admiral Rob Bauer noted: *"...Never before have NATO and national defense plans been so closely interlinked... we need a whole of society approach... In order to be fully effective also in the future, we need a warfighting transformation of NATO... For this too, public-private cooperation will be the key."*

Following the sabotage of the Nord Stream and Nord Stream 2 pipelines, the EU and NATO intensified their cooperation by launching the EU-NATO Task Force on the Resilience of Critical Infrastructure on 16 March 2023. Its [latest assessment report](#) [60] describes current security challenges, particularly under the energy section: *"Military activities depend to a significant degree on civilian energy networks and supplies, further underscoring the need to ensure security of critical energy infrastructure and supply chains. The sabotage of the Nord Stream pipelines illustrates the vulnerability of energy infrastructure. The risk of shortages as a result of Russia's war of aggression against Ukraine has also heightened popular awareness of the potential damage to everyday life. Energy infrastructure spans long distances (e.g. pipelines, electricity cables), making it difficult to constantly monitor or protect; a one-off attack can be enough to do major damage, as in the case of a hydroelectric dam, as shown by the recent attack in Ukraine"*.

In January 2023, the Critical Entities Resilience Directive entered into force in the EU. It should be transposed into the national legislation of member states by October 2024. It stipulates that member states must identify critical infrastructure objects, that is, create a basis for the future register within the EU by July 17, 2026. Such a long period of time will negatively affect the ability to quickly update existing defense plans and call into question Europe's ability to defend against a more serious attack than a hybrid one.

The concept of deterrence is based on the idea that, in the event of an invasion by Russian troops, the forces of the member states should hold out until the help of the allies, in particular the United States, is transferred. In the first days of the invasion of

Ukraine, Russian troops captured territories larger than some Baltic states. Preventing this means increasing the presence of permanently based troops along the Russian border, strengthening the integration of American and allied military plans, increasing military spending and more detailed requirements for allies, in particular, in terms of logistics and energy security.

The NATO 2022 Strategic Concept reinforces the Alliance's commitment to identifying and mitigating strategic vulnerabilities and dependencies, particularly in critical infrastructure and logistics chains. At the NATO Summit in Vilnius in 2023, Allies agreed to develop NATO's capacity to support national authorities in protecting the CEI.

As NATO depends on civilian energy networks, it is important to ensure the security of critical energy infrastructure and supply chains, and to develop innovative, sustainable, efficient and autonomous energy solutions for the military, such as decentralized grids with hybrid power generation. Well-secured fuel stocks and a multimodal distribution network can enhance resilience. In wartime, the infrastructure in the east will play a decisive role, so we are talking about the accelerated development of the fuel supply system on the eastern flank of the Alliance. The high fuel demand of combat forces can reduce their productivity, increase vulnerability, and may require the diversion of combat forces to protect supply lines.

As the Alliance changed its strategy from collective territorial defense to contingency operations outside NATO territory after the collapse of the Warsaw Pact and the USSR, modernization of the fuel infrastructure was halted. In the absence of unified guidelines approved by the North Atlantic Council, the new NATO members did not develop and adapt the existing infrastructure on their territory to the obligation of collective defense in the event of a war on NATO's eastern flank.

As the Alliance wound down in the 1990s, available fuel storage and logistical capabilities became limited. This is particularly evident in the Baltic and Black Sea regions, where oil refining, storage, transportation and distribution capacity may not be sufficient to support a surge in fuel demand during a prolonged period of hostilities. In a potential conflict scenario, this could be further influenced by Russia's hostile economic and military actions. In the countries of NATO's eastern flank, the existing army fuel storage and distribution facilities for jet fuel (F-34/F-35) and ship fuel (F-75/F-76) are insufficient to meet the needs of the contingents of the allied armed forces, which may be quickly transferred to the east. Civilian storage should cover possible shortages. However, this requires much deeper civil-military cooperation and integration, ensuring that civilian forces increase their readiness and are available at short notice in contingencies.

The EU Action Plan on military mobility 2.0 for the period 2022-2026, adopted in response to increased Russian aggression against Ukraine, highlighted the main limitations of logistics on NATO's eastern flank. It is obvious that there is a strong dependence on contractual civilian transportation, including commercial fuel delivery for the needs of the army. In particular, it is proposed to update the military requirements within the EU, with the aim of covering the infrastructure of the fuel supply chain when moving forces over a long distance. As the energy transition develops, there is an EU interest in making the armed forces less dependent on

fossil fuels. At the same time, there is a lack of awareness that a quick transition is impossible given the existing arsenal of military equipment that uses internal combustion engines running on hydrocarbon fuels.

In order for the combined forces of NATO to remain combat-ready and maneuverable for a long period of time, highly advanced logistics operations, primarily fuel, are needed. In the event of a potential kinetic attack in the Baltic or Black Sea regions, the Alliance will need to rapidly establish a sustained supply of fuel for its rapid response units, such as the NATO Very High Readiness Joint Task Force (VJTF) and the rest of the NATO Response Force (NRF). US Army Rapid Reaction Forces from the 82nd Airborne Division and allies on NATO's eastern flank would likely be alerted and move even ahead of the VJTF. These first combat units will significantly increase the demand for regional fuel supplies.

Illustrative example:

The fuel problems [encountered](#) [61] during NATO's Nordic Response 24 exercise as part of the wider Steadfast Defender 24 are illustrative, described in a story in the French publication *Le Monde*: «*On the first day of Nordic Response 24 ground operations, on Wednesday, March 6, French vehicles remained immobilized for ten hours due to lack of fuel, water and food. «Normally, the Norwegian army has to refuel us every three days at pre-determined logistics points. We have been waiting for them there since 11 in the morning, now it is 10 in the evening, and they are still not there,» Captain Vincent, responsible for the logistics of the 7th Bataillon of Alpine Hunters, pointed out that evening, shining a headlight on a dozen tracked snowmobiles scattered on the snow, **which became vulnerable to enemy detection and fire.** Finally, refuelling will be completed at 4 in the morning».*

In the conditions of real hostilities with Russian forces, this French unit, immobilized for 17 hours, moreover, without available anti-aircraft and electronic warfare equipment, would have already been detected by an Orlan-10 type reconnaissance drone and destroyed by a Lancet-3 type UAV swarm attack from a distance of 40-50 km.



Source: *Le Monde*

4.2. Weaknesses and vulnerabilities

When developing plans to expand the existing fuel infrastructure of NATO's eastern flank, existing shortcomings and vulnerabilities should be taken into account:

- NATO's existing fuel supply infrastructure in Western Europe was not expanded to the CEE to reliably supply Allied forces in the Baltic and Black Sea regions;
- civilian fuel infrastructure facilities are currently insufficiently prepared for crisis situations and martial law;
- civilian infrastructure — oil refineries, pipelines, storage facilities, fuel terminals — may not withstand the load from the simultaneous supply of allied forces, industry and the population under the circumstances of a prolonged conflict in Europe;
- refineries of Slovakia, Hungary and, to a lesser extent, the Czech Republic still rely on Russian oil, which is transported by the southern branch of the Druzhba oil pipeline, and received an exemption from the European Commission from the oil embargo introduced by the 6th EU sanctions package of May 30, 2022;

The main problem that needs to be solved urgently is the conflict of interests of the EU and NATO. The EU's policy of steadily reducing the use of fossil fuels (in this case: motor gasoline, diesel, jet and marine fuels) and e-mobility conflicts with the needs of the Alliance for the rapid expansion of fuel infrastructure, as combat equipment in wartime requires their increased use, which causes additional emissions of greenhouse gases and reduces the effectiveness of decarbonisation measures in Europe. **It is necessary to make an appropriate exception for military equipment and their fuel supply networks, guided by the principle of «Security first!».**

Another serious problem is the reluctance of the civil sector (operators of pipeline systems and fuel bases) to carry out capacity expansion projects in circumstances of uncertainty about its payback since the additional capacities required under the circumstances of hostilities will be redundant in peacetime and will require constant additional costs to keep them in a functional mode, which will make the operators' business unprofitable or even possess significant losses.

During the pre-crisis phase, the facilities of NATO's fuel and logistics infrastructure will be exposed not only to cyber-attacks but also attacked by enemy reconnaissance and sabotage groups. Both unpredictable and malicious actions are also possible - similar to the blockade of the Suez Canal in March 2021 due to the grounding of a container ship, a cyber-attack with subsequent dysfunction of the large-scale US East Coast Colonial Pipeline fuel supply system in May 2021, or attacks by illegal armed formations on commercial vessels, as is currently the case in the Strait of Bab al-Mandeb by the Yemeni Houthis. These cases demonstrate vulnerabilities that would threaten to have catastrophic consequences for NATO Allied Forces in wartime.

Refineries that produce NATO-standard types of fuel, as well as their delivery infrastructure, including key hubs of the Central European pipeline system and marine terminals, will be prime targets for combined missile-drone strikes. In order to avoid the fatal consequences of strikes, taking into account the Ukrainian experience, the concept of mobility should be applied, which involves storing operational reserves of fuel on wheels: in railway and automobile tanks, preventing the concentration of large volumes of it in one place.

4.3. Some recommendations

NATO, in tandem with the EU, should take measures to solve the problem of fuel supply to ensure stability, as well as the problem of protecting the CEI, by taking into account a number of positions in view of the experience of the war with Russia on the Ukrainian theatre of military operations:

1. The time frames for the analysis of critical energy infrastructure in the EU, with the creation of relevant registers at the national level, are calculated under peacetime conditions but the age of unconditional peace is over in Europe. It is necessary to speed up and carry out work on the categorization of the NATO member countries' CEI, with a special focus on the countries of the eastern flank, especially the Baltic countries.
2. The protection of gas and oil production areas in the North Sea is already necessary, the placement of sonars in pipeline corridors to monitor the surface and underwater situation, and patrolling of critical energy infrastructure facilities is a requirement of today, not tomorrow.
3. The planning work should determine the amount of additional investments required for alternative supply routes in the event of destruction or damage to existing critical infrastructure, the amount of fuel needed by NATO forces for forward stocks, the locations and methods of their storage in case of contingencies, what underground storage facilities can be used for protection against air strikes, etc.
4. An integrated Eastern European pipeline system should be established in the space between the Baltic and the Black Sea, as a key element that will provide the necessary fuel capacity for NATO forces on the eastern flank.
5. The EU should prioritize military access to fuel infrastructure during a crisis, as fuel outages can immobilize convoys of vehicles and create local transportation chaos.
6. Slovakia, Hungary, Bulgaria and the Czech Republic should switch their refineries to the processing of non-Russian oil to become completely independent of supplies from Russia.
7. Scenarios for countering and neutralizing a hybrid blockade of logistics by civilian actors, which can be organized by the enemy in the form of certain protests and blockades based on the example of the actions of Polish farmers and transporters on the Polish-Ukrainian border in 2023-2024, should be developed and modelled.
8. Strategic weaknesses in the Alliance's fuel supply should be identified and immediate actions taken to mitigate critical deficiencies. The EU-NATO Working Group on Resilience and Critical Infrastructure could be given a clear mandate from the NATO Washington Summit to develop measures to increase the resilience of fuel supply chains.
9. Europe has to create a reliable, sustainable and adaptive logistics system. A system of interoperable logistics hubs, particularly in potential theatres of war,

networked across Europe, will facilitate the development of flexible, scalable and resilient operational support systems to maintain planning superiority and provide improved operational flexibility and resilience. With this in mind, Europe has to develop and approve, with the identification of funding sources, an Energy Sustainability Plan, which will include measures to:

- 9.1. compile sectoral lists of critical infrastructure facilities, taking into account CEI facilities located on NATO's eastern flank;
 - 9.2. update the list of critical infrastructure objects that require priority anti-aircraft cover;
 - 9.3. introduce a system for monitoring and analysis of threats to the energy infrastructure and risks for the performance of vital functions and/or the provision of vital services;
 - 9.4. establish requirements for ensuring the safety and stability of CEI following the identified threats and taking them into account during the design of energy supply schemes;
 - 9.5. consider alternative (reserve) energy supply of critical infrastructure objects that ensure the performance of vital functions and/or the provision of vital services, primarily through the formation of decentralized energy systems based on small distribution systems, taking into account the best world experience;
10. A complex of intelligence and special measures should be implemented in order to determine an action plan for the destruction of the enemy's fuel infrastructure and logistics if it starts armed aggression in the South-Eastern Baltic operational area of NATO's Eastern Flank against the Baltic countries.
 11. Measures for joint training and strengthening the combat capability of mobile fire groups from the Armed Forces of Ukraine and NATO member countries should be executed, for the implementation of anti-aircraft cover, protection and defense of critical infrastructure facilities.
 12. Educational programs, advanced training courses in radio-electronic intelligence and radio-electronic warfare for servicemen of units involved in ensuring the protection and defense of critical infrastructure facilities should be carried out.
 13. NATO should work out together with the Ukrainian side the possibilities of using Ukraine's fuel infrastructure for its needs.

A brief history of the Russian hybrid tactics used in the energy sector against Ukraine

Gas sector.

On **September 3, 1993**, using gas blackmail, Russia [attempted](#) [62] to seize the entire composition of the Soviet fleet and infrastructure in the Black Sea.

On **April 15, 1994**, an [agreement](#) [63] was signed by which 80% of the former Soviet Black Sea Fleet was transferred to Russia, as well as the right of its stationing and long-term leasing of port and land infrastructure in Crimea was confirmed.

On **May 30, 1997**, the agreement on the stationing of the Black Sea Fleet until 2017 in exchange for repayment of so-called “gas debts”

Since 2002, after the arrival of Putin’s team at Gazprom, the practice of [intermediaries](#), [64] which were successively the companies Eural Trans Gas and RosUkrEnerg, became applicable. They are associated with the flourishing of corruption schemes and non-transparent conditions of import, export and re-export of gas. The financial resources generated by these companies were actively used to corrupt policymakers not only in Ukraine but also in the EU.

January 1-4, 2006, [the first «gas war»](#). [65] Ukraine managed to protect GTS and UGGSF from the control of the Russians, but the price of gas increased significantly, the position of RosUkrEnerg from the Swiss canton of Zug with an opaque structure of owners and distribution of profits strengthened, and the agreements reached allowed the continuation of [price blackmail](#) [66] in the following years. Ukraine lost access to Central Asian gas.

January 1-20, 2009. The second «gas war», which was prepared by the Russians much more carefully. A large-scale information campaign was carried out in the EU about the unreliability of the Ukrainian transit route and the «theft» of gas, physical blocking of gas supply at the border with an agreed schedule throughout the Russian GTS. The technical readiness of the Ukrainian GTS to work in the reverse mode probably saved the country from a massive failure of heat supply systems, especially in the east of Ukraine, a very possible scenario of a «cold war» and even a military invasion, which could be disguised as a «humanitarian mission.» The political conflict between the president and the prime minister of Ukraine became one of the key factors in the signing of extremely unfavourable [agreements](#) [67] on the supply and transit of Russian gas. Russia’s Gazprom managed to avoid multibillion-dollar lawsuits from European consumers and focus on further financial and economic pressure on Ukraine.

In April 2010 [«Kharkiv Agreements»](#) [68] became an example of huge political concessions on the part of Ukraine in exchange for a partial revision of the terms of the 2009 gas contract, fixed the continued presence of the Russian Black Sea Fleet in Crimea and expanded the possibilities for its use during the subsequent occupation of the peninsula.

2014-2015 The [«third gas war»](#) [69] became one of the elements of the Russian invasion in 2014, with the interruption of supplies to Ukraine and an attempt to apply the Moldovan scenario of gas supplies to the occupied territory of Donetsk and demand

payment to Naftogaz of Ukraine. Decisive actions of Ukraine to create alternative gas supply routes, rejection of political agreements and initiation of corporate court proceedings became effective methods of struggle against the Russian aggressor and saved significant financial resources for the domestic economy.

The rapid establishment of control over the Crimean oil and gas assets of the [Chornomornaftogaz](#) [70] company, both on the territory of the peninsula and on the sea deposits, was one of the components of the operation to occupy Crimea.

With their «gas blackmail», the Russians achieved one of their main goals in Europe - they convinced individual EU member states of the need to create transit-free routes for the supply of Russian gas through the Black and Baltic Seas.

Electric power industry

On the territory of Ukraine, 6 nuclear power plants, 18 large TPPs/CHPs, more than 20 TPPs, and in the 2010s also numerous industrial facilities of renewable energy (solar, wind, biomass) were built. The NPPs and part of the TPPs were kept in state ownership, and the privatized ones were mainly concentrated in the DTEK company, which did not want to share its market with Russian business. The DTEK Energy division was also involved in hard coal mining, which kept the Russians away from TPPs and mines. Since the beginning of the 1990s, Ukraine began cooperation with the American company [Westinghouse](#), [71] which made it possible to gradually replace Russian nuclear fuel. A powerful production base, in particular, JSC [Ukrainian Energy Machines](#) [72] (formerly «Turboatom») made it possible to provide repair and maintenance of most of the NPP equipment. Overall, this made it possible to avoid significant dependence on Russian energy resources and the threat of political influence on Ukraine's leadership through the electricity sector.

Nevertheless, Ukraine was in the so-called [IPS/UPS area](#), [73] which provided for Russian control over the frequency regulation of the energy system, as well as the absence of the possibility of exporting and importing electricity from the EU countries ([except a small Burshtyn Energy Island](#)) [74].

The occupation of a part of the Donetsk region by Russian troops in 2014-2015 was accompanied by the seizure of several TPPs (Zuyivska, Starobeshivska, Kurakhivska) and attempts to destroy those that remained in the territory controlled by Ukraine in the artillery range (Luhanska, Vuglegirska). In 2015-2016, there were several powerful cyber-attacks against the Ukrainian energy system.

Since 2017, [active work](#) [75] has been carried out to overcome the dependence on the Russian-controlled IPS/UPS, which greatly helped to obtain a positive decision to synchronize with ENTSO-E on March 16, 2022, in the midst of full-scale Russian aggression against Ukraine.

[In 2020-2021](#), [76] miscalculations in preparation for the heating season and the functioning of the electricity market led to a real threat of creating dependence on the import of Russian electricity and blocking synchronization.

A brief history of the Russian hybrid tactics used in the energy sector against Moldova

The de-facto Russian occupation of Transnistria deprived Moldova of access to the Cuciurgan power station as the largest producer of electricity. The country was forced to import both natural gas and electricity, which created ample opportunities for Russia to blackmail the state leadership through a unilateral change in prices and terms of supply of energy resources.

Gas sector.

On December 9, 1993, the Russian Gazprom, as part of a bilateral agreement, set one of the highest prices on natural gas for Moldova - [\\$80 per 1,000 m3](#), [77] the principle of prepayment, high fines and the obligation to cover the cost of gas consumed on the territory of Transnistria, which was already under actual Russian occupation.

On May 12, 1995, JSC Moldovagaz was forced to [approve the transfer of 50%](#) [78] of the gas pipelines passing through its territory (parts of the Ananyiv-Chernivtsi-Bogorodchany routes and the Trans-Balkan Gas Pipeline with three branches) to the joint venture Gazsnabtransit with a majority share of Gazprom at the expense of partial payment of debts, which arose mainly due to the terms of the above-mentioned agreement.

In 1998, Russia's Gazprom further expanded its influence on the Moldovan energy system, forcing Moldova to hand over gas distribution networks at the expense of paying off part of its «gas debts» to the newly created joint venture JSC «Moldovagaz». [79] With a majority in the board and supervisory board, Russia's Gazprom continued to actively accumulate debts of JSC Moldovagaz, while not ceasing to supply natural gas.

In 2006, [a new contract](#) [80] for the supply of natural gas was signed between Gazprom and JSC «Moldovagaz», which established the obligation to supply gas to the occupied part of Transnistria, regardless of the lack of payment for the consumed volumes, consideration of claims of any the parties transferred to the International Commercial Arbitration Court of Moscow and the proportional division of profits from gas transit between Moldova and the occupying authorities of Transnistria.

Electricity:

As a result of the actual Russian occupation of Transnistria in 1992, Moldova lost control over its largest power plant, the Cuciurgan TPP, with a capacity of 2.5 GW, which could use coal, fuel oil and natural gas as fuel. Having no alternatives, Moldova for a long time was forced to import about 70%-80% of its electricity from the Cuciurgan TPP. The contractual terms always remained opaque and could be used to corrupt Moldovan officials and keep Moldova under Russian control.

Cuciurgan power station was illegally privatized by the occupation authorities. The first owner of at least 49% of the shares could be the Hungarian company [EMFESZ Kft.](#) [81] created by [Dmytro Firtash in 2003](#). [82] It was in this company that in 2005, as reported, the Russian company [«Inter RAO UES»](#) [83] bought its share of shares to consolidate 100% control over the power plant. According to the publication «Dilova Stolytsya», the Belgian company Saint Guidon Invest N.V. owned a 49% stake as of March 2005, which sold it to Inter RAO UES.

Russia’s Gazprom supplied gas to Transnistria despite its unrecognized status and chronic non-payment of JSC Moldovagaz accounts. At the same time, Moldova was forced to buy electricity from Cuciurgan TPP at a rather high price, which led to the further accumulation of «gas debts» and ensured the financing of the occupation authorities in Transnistria until 2022.

Annex 3

The structure of the Air Forces Command of the Ukrainian Armed Forces

<p>Air Command «West» m/u A0780, Lviv</p>	<ul style="list-style-type: none"> • 114 Tactical Aviation Brigade (fighter) • 204 Tactical Aviation Brigade (fighter) • 11 Anti-aircraft Missile Regiment • 223 Anti-aircraft Missile Regiment • 540 Anti-aircraft Missile Regiment • 1 Radio Engineering Brigade
<p>Air Command «South» m/u A0800, Odesa</p>	<ul style="list-style-type: none"> • 160 Anti-aircraft Missile Brigade • 201 Anti-aircraft Missile Brigade • 208 Anti-aircraft Missile Brigade • 14 Radio Engineering Brigade
<p>Air Command “East” m/u A2533, Dnipro</p>	<ul style="list-style-type: none"> • 138 Anti-aircraft Missile Brigade • 301 Anti-aircraft Missile regiment • 302 Anti-aircraft Missile regiment • 164 Radio Engineering Brigade
<p>Air Command “Centre” m/u A0820, Vasylkiv, Kyiv region</p>	<ul style="list-style-type: none"> • 39 Tactical Aviation Brigade (fighter) • 40 Tactical Aviation Brigade (fighter) • 831 Tactical Aviation Brigade (fighter) • 96 Anti-aircraft Missile Brigade • 156 Anti-aircraft Missile Regiment • 138 Radio Engineering Brigade

Structure, armament, deployment of Air defense units [84] of the Ukrainian Armed Forces as of 2021.

Unit	Armament	Deployment
Tactical aviation brigades		
39 Tactical Aviation Brigade (m/u A2038)	Su-27	Ozerne, Zhytomyr region
40 Tactical Aviation Brigade (m/u A1789)	Mig-29	Vasylkiv, Kyiv region
114 Tactical Aviation Brigade (m/u A1349)	Mig-29	Ivano-Frankivsk
204 Tactical Aviation Brigade (m/u A0959)	Mig-29	Lutsk
831 Tactical Aviation Brigade (m/u A1356)	Su-27	Myrhorod, Poltava region
Anti-aircraft missile brigades and regiments		
11 Anti-aircraft Missile Regiment (m/u A3730)	9K37 Buk-M1	Shepetivka, Khmelnytskyi region
96 Anti-aircraft Missile Brigade (m/u A2860)	75R6 S-300PS	Danylivka, Kyiv region
138 Dnipro anti-aircraft Missile Brigade (m/u A4608)	75R6 S-300PS, 70R6 S-300PT	Dnipro
156 Anti-aircraft Missile Regiment (m/u A1402)	9K37 Buk-M1	Zolotonosha, Cherkasy region
160 Anti-aircraft Missile Brigade of Odesa (m/u A2800)	75R6 S-300PS	Radisne, Odesa region
201 Anti-aircraft Missile Brigade named after Hetman Pylyp Orlyk (m/u A2183)	75R6 S-300PS, S-300V1	Pervomaisk, Mykolaiv region
208 Anti-aircraft Missile Brigade (m/u A1836)	75R6 S-300PS, 70R6 S-300PT	Kherson
223 Anti-aircraft Missile Regiment named after the Ukrainian Sich Riflemen (m/u A2847)	9K37 Buk-M1	Stryi, Lviv region
301 Anti-aircraft Missile Regiment (m/u A0593)	75R6 S-300PS	Nikopol, Dnipropetrovsk region
302 Anti-aircraft Missile Kharkiv Regiment (m/u A1215)	70R6 S-300PT	Kharkiv

Unit	Armament	Deployment
540 Lviv anti-aircraft Missile Regiment named after Ivan Vyhovsky (m/u A4623)	75R6 S-300PS, 70R6 S-300PT	Kamianka-Buzka, Lviv region
Radio engineering brigades		
1 Galicia-Volyn Radio Engineering Brigade (m/u A4324)		Lypnyki, Lviv region
14 Radio Technical Slobid Brigade (m/u A1620)		Odesa
138 Radio Engineering Brigade (m/u A1880)		Vasylkiv, Kyiv region
164 Radio Engineering Brigade (m/u A1451)		Kharkiv

Annex 5

Air defense [85] of the Ground Forces of the Ukrainian Armed Forces

Air defense units of the Ground Forces are designed to: destroy the aerial enemy at all possible heights of his actions in any weather, both day and night, in conditions of active radio countermeasures; prevent the enemy from conducting aerial reconnaissance; fight against airborne troops and airborne troops on their flight routes and during landing; destroy fire support helicopters operating from ambushes; timely notify the troops about the actions of the air enemy; cover troop groups, control points, airfields, rear and other objects from enemy strikes from the air, as well as during regrouping (movements) of troops and their deployment.

As of 2021, each operational command of the Ground Forces has an anti-aircraft missile regiment (see the table below) in addition to the air defense units of [the Ground Forces](#) [86] under brigade command.

Joint Command South	38th Anti-aircraft Missile Regiment (m/u A3880)	Chornomorske, Odesa region
Joint Command West	39th Anti-aircraft Missile Regiment (m/u A2892)	Volodymyr, Volyn region
Joint Command East	1039th Anti-aircraft Missile Regiment (m/u A1964)	Gvardiyske, Dnipropetrovsk region
Joint Command North	1129th Anti-aircraft Missile Belotserkivsky Regiment (m/u A1232)	Bila Tserkva, Kyiv region

The main spheres of US-UA energy cooperation within the framework of the Memorandum.

	Directions of the energy sector	Areas of work
1	Critical energy infrastructure (electricity and thermal energy, gas)	Restoration of damaged infrastructure, including purchase and installation of main autotransformers.
2	Decentralization of the energy system and development of the network of small generation and heat energy in Ukraine	Implementation of gas generation facilities (including CCGT turbines manufactured in the USA) and generation from renewable and other energy sources
3	Integration of the energy infrastructure of Ukraine and the EU	Strengthening physical connection: – gas networks – electrical networks
4	Protection of critical energy infrastructure of Ukraine	Physical protection (anti-drone and anti-missile), physical security, cyber security, prevention of cascading failures in energy supply

Map 1. Oil Pipeline System of Ukraine



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