

Ukrainian energy sector evaluation and damage assessment - II

(as of September 24, 2022)

**Cooperation for Restoring the
Ukrainian Energy
Infrastructure project**

Task Force



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INTRODUCTION

The full-scale military aggression by the Russian Federation launched on February 24, 2022 has had a significant negative impact on the Ukrainian energy sector. Due to their economic, humanitarian and geopolitical importance, energy infrastructure facilities were among the primary targets for the Russian army. The first Ukrainian energy sector evaluation and damage assessment report was published on August 24, 2022, on the six-month anniversary of Russia's full-scale invasion (Task Force, 2022).¹ From August 25 to September 24, 2022, Ukraine's military forces liberated about 8,500 km² (388 settlements) in the Kharkiv region, while about 4% of the region remains occupied. However, the liberation of the Kharkiv region brought new challenges to the Ukrainian energy system as Russia resorted to new strikes on the critical energy infrastructure to leave Ukrainian citizens without electricity, heat and hot water during winter.

In particular, on September 11, 2022, the Russian Federation shelled and heavily damaged Kharkivska combined heat and power plant -5 (CHP-5), Zmiivska thermal power plant (TPP) and three high-voltage substations, which resulted in the power disconnection of more than a million consumers in Poltava, Dnipropetrovsk, Kharkiv, Sumy and Donetsk regions. On September 19, 2022, Russia shelled Pivdenoukrajinska nuclear power plant (NPP), the second largest Ukrainian nuclear plant. With the beginning of the heating season, the systematic strikes and destruction of the critical energy infrastructure will directly threaten Ukrainian citizens' lives and well-being during the heating season.

As of September 24, 2022, Russia occupied or damaged about 40% of the country's installed power capacity, thousands of km of electric, gas and heat networks, transformers, compressor stations and heating points. The oil refining industry was destroyed. Electricity and natural gas consumption decreased by 30-35% compared to 2021. The 2022-2023 heating season in affected regions is at high risk.

As of September 5, 2022, the estimated damages to the Ukrainian energy sector, including utilities and district heating sectors, were at least \$3.1 bln, while the recovery investment needs amounted to \$5.2 bln, and the total losses related to the loss of energy access and revenue of energy companies stood at \$13.9 bln (Kyiv School of Economics, 2022).²

The damage assessment report was developed by the Task Force comprised of representatives of Ukrainian authorities and the Energy Charter Secretariat, established under the project, "Cooperation for Restoring the Ukrainian Energy Infrastructure" and in cooperation with other Ukrainian and international organisations. The general objective of the project is to assist the Government of Ukraine in the cost-effective restoration of energy infrastructure, taking into account the clean energy transition while ensuring energy security. The project is funded by the European Commission and implemented by the Energy Charter Secretariat.

DISCLAIMER

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¹ Task Force, "Ukrainian energy sector evaluation and damage assessment – I (as of August 24, 2022)", 2022,

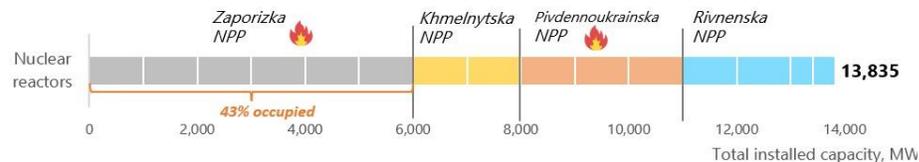
https://www.energycharter.org/fileadmin/DocumentsMedia/Occasional/20220829_UA_sectoral_evaluation_and_damage_assessment_final.pdf

² "Due to the last estimates, damage caused to Ukraine's infrastructure during the war is \$114.5 bln", Kyiv School of Economics, 2022, <https://kse.ua/about-the-school/news/due-to-the-last-estimates-damage-caused-to-ukraine-s-infrastructure-during-the-war-is-114-5-bln/>

POWER SECTOR

Nuclear energy

Nuclear energy provides a reliable base load and covers more than half of the electricity production in Ukraine (55.5% in 2021). There are four nuclear power plants (NPPs) in Ukraine with a total installed capacity of 13,835 megawatt (MW) (15 reactors in total, including 13 reactors with a capacity of 1,000 MW and two reactors with a capacity of 415 MW and 420 MW, respectively). Annex 1 shows the map of the Ukrainian power sector, while the figure below illustrates the nuclear power capacities under attack and/or occupation.



Source: Energy Charter Secretariat (ECS) based on publicly available data

Zaporizka NPP (ZNPP), the largest nuclear power plant in Europe and the fifth largest in the world (Power Technology, 2019)³, has been occupied by the Russian military forces since early March 2022. The installed power capacity of the plant is 6,000 MW, which is 43% of Ukraine's total nuclear power installed capacity. Before the Russian large-scale military invasion of Ukraine, the plant covered about 25% of electricity production in Ukraine. Since September 11, 2022, the operation at Zaporizka NPP has been completely suspended.

On September 1, 2022, the International Atomic Energy Agency (IAEA) delegation visited Zaporizka NPP. On September 15, 2022, the Board of Governors of IAEA, which consists of representatives of 35 United Nations (UN) member states, adopted a resolution demanding that Russia end its occupation of ZNPP.

On September 19, 2022, Russian forces shelled the Pivdennoukrainska NPP, the second largest NPP in Ukraine, located 130 km away from the front line. A Russian missile fell just 300 meters away from a nuclear reactor. The shock wave of the missile's strike damaged hydraulic units of the Oleksandrivka Hydro Power Plant, which is part of the NPP, the building of the NPP and broke more than 100 windows. To understand the magnitude of the strike, a shell crater made by the explosion of the missile had a 2-meter diameter and 4-meter depth. Fortunately, all three reactors were not damaged.

Pivdennoukrainska NPP after night shelling.



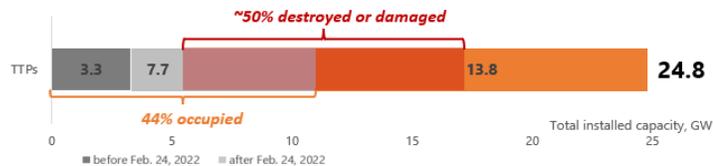
Source: Zelenskiy / Official

³ "Top ten nuclear power plants by capacity", Power Technology, 2019, <https://www.power-technology.com/analysis/feature-largest-nuclear-power-plants-world/>

Thermal energy

At the beginning of 2022, there were 12 thermal power plants (TPPs) in Ukraine with a total installed power capacity of 21.5 gigawatt (GW) (excluding the plants located in the territories temporarily occupied by Russia before February 24, 2022). Most TPPs are using coal as a primary fuel. In 2021, the TPPs' share in electricity production was 23.8%. Since 2014, two TPPs with an installed capacity of 3.3 GW have been located in the occupied Donbas region (see Annex 1 for more details).

After February 24, 2022, Russian military forces occupied three TPPs (Zaporizka TPP, Luhanska TPP, and Vuglehirska TPP) with a total installed capacity of 7.7 GW. As of today, 44% of Ukraine's total thermal power capacities are under occupation, and about 50% are either destroyed or damaged (see figure below).



Source: ECS based on publicly available data

The Russian military forces shelled Zmiivska TPP (2.4 GW) on September 11, 2022 and Slovianska TPP (0.8 GW) on September 17, 2022. The equipment of both TPPs was heavily damaged.

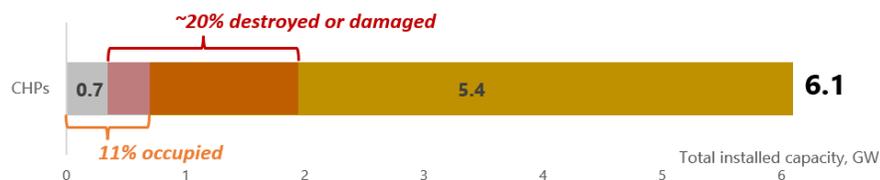
Slovianska TPP after Russian shelling



Source: [Bratchuk](#)

Combined heat and power

At the beginning of 2022, the total installed power capacity of combined heat and power plants (CHPs) was 6.1 GW (excluding the plants located in the territories temporarily occupied by Russia before February 24, 2022). Most CHPs are using natural gas as a primary fuel. In 2021 the share of CHPs and cogeneration units in electricity production was 5.5%.



Source: ECS based on publicly available data

As of today, around 11% of the installed capacity from CHPs is under occupation, while about 20% of installed capacities are either destroyed or damaged as a result of Russian attacks (see Annex 1 for more details). On September 11, 2022, Russian military forces shelled Kharkivska CHP-5. Given that the destroyed CHPs were the primary suppliers of thermal energy, the 2022/2023 heating season in many regions is at high risk.

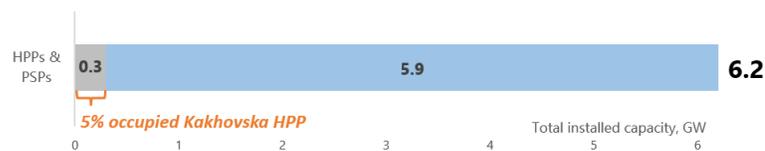
Kharkivska CHP -5 after missile attack



Source: [Znaj.ua](https://znaj.ua)

Large hydropower

At the beginning of 2022, there were ten large hydropower plants (HPPs) with a total installed power capacity of about 4.7 GW (101 units in total) and three pumped storage plants (PSPs) with an installed capacity of 1.5 GW (11 units ranging from 33 MW to 324 MW per unit) (see Annex 1 for more details). Hydropower plays a crucial role in the functioning of the Ukrainian power system, as HPPs and PSPs are the main providers of auxiliary services to meet the peak demand of the power system and balance intermittent Renewable Energy Source (RES) capacities. PSPs also contribute to flattening the night "gaps" of electricity consumption. In 2021, the share of HPPs and PSPs in electricity production was 5.8% and 0.8%, respectively.



Source: ECS based on publicly available data

Since the first day of the war, Kakhovska HPP (343.2 MW or about 5% of installed capacity) has been occupied and damaged by the Russian army. Public Joint Stock Company (PJSC) "Ukrhydroenergo", the main operator of HPPs and PSPs in Ukraine, has already filed a claim at the European Court of Human Rights regarding the damages caused to the Kakhovskaya HPP and the unfinished wind power plant (WPP) on Zmiiny Island. The total amount of the claim is above \$0.5 bln.

Renewable energy (excluding large HPP)

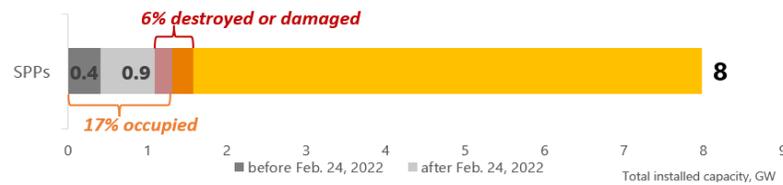
Ukraine has the highest technical RES potential among other countries in Southeast Europe - 874 GW⁴, including solar - 83 GW, onshore wind - 438 GW, and offshore wind - 250 GW (see Annex 2). Due to its high RES potential and efficient support mechanisms Ukraine's renewable energy sector has been developing rapidly, with the share of RES in electricity production increasing from 1.8% in 2018 to 8.2% in 2021. At the beginning of 2022, the total installed RES capacity (all grid-connected) reached 9.5 GW (excluding 0.6 GW of RES capacities located in the territories temporarily occupied by Russia before February 24, 2022). About \$12 bln was invested in the Ukrainian RES sector during 2009-2021.

Solar

The photovoltaic (PV) sector had the highest growth rate among other renewable energy sources in Ukraine during 2019-2021. At the beginning of 2022, the total installed PV capacity (excluding 0.4 GW

⁴ "Renewable energy sources of Ukraine", National Academy of Sciences of Ukraine, 2022, <https://www.ive.org.ua/wp-content/uploads/atlas.pdf>

located in the territories temporarily occupied by Russia before February 24, 2022) reached 7.6 GW or 80% of the total RES installed capacity in Ukraine (including 45,000 prosumer installations with a total capacity of 1.2 GW). In 2021, Ukraine was ranked 7th in Europe for the development of solar generation (IRENA, 2022).⁵



Source: ECS based on publicly available data

Currently, about 17% of Ukrainian PV capacities are under occupation. About 6% of the total installed solar capacity has been destroyed or damaged, including hundreds of prosumer installations. As a result of the de-occupation of the Kharkiv region in September, 2022, five solar power plants (SPPs) with a total installed capacity of 4.7 MW were reintegrated into the Ukrainian Power system.

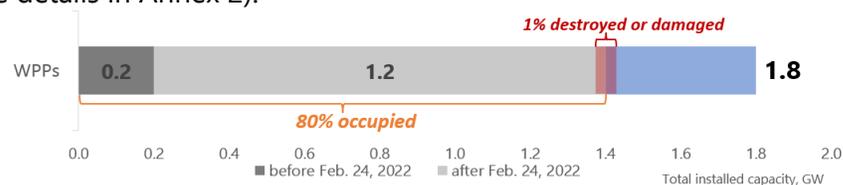
Destroyed prosumer solar PV installation



Source: Green power talk

Wind

At the beginning of 2022, Ukraine's total installed capacity of wind power plants (all onshore) was 1.6 GW (excluding 0.2 GW located in the territories temporarily occupied by Russia before February 24, 2022). Almost all wind power plants in Ukraine were built in the southern regions nearby the Azov and Black sea coasts (Kherson and Zaporizhzhia regions), where natural conditions for wind power plants are the most favorable (see more details in Annex 2).



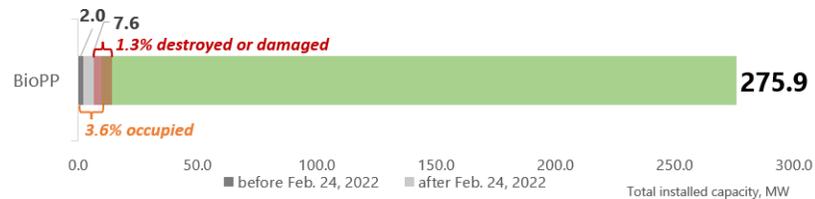
Source: ECS based on publicly available data

Currently, the south of Ukraine, where the highest wind potential is available, is occupied by the Russian Federation. Thus, approximately 80 % of wind generation capacities are located in the occupied territories. As of today, at least seven wind turbines are known to be damaged or destroyed as a result of the hostilities by the Russian army (about 1 % of the total installed wind capacity).

⁵ "Renewable Energy Statistics 2022", IRENA, 2022, <https://www.irena.org/publications/2022/Jul/Renewable-Energy-Statistics-2022>

Bioenergy

At the beginning of 2022, the total installed capacity of bioenergy power facilities was 273.9 MW (excluding the 2 MW biomass power plant located in the territories temporarily occupied by Russia before February 24, 2022). In 2021, the share of bioenergy in electricity production was 0.6%.

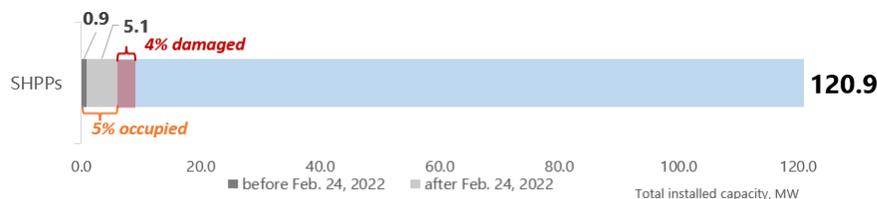


Source: ECS based on publicly available data

As of today, 9.6 MW (3.6%) of bioenergy facilities are under occupation. It is known that at least four plants were shelled and damaged.

Small hydro (<10MW)

At the beginning of 2022, there were 177 small hydropower plants (SHPPs) in Ukraine with an installed capacity of 120 MW (excluding one SHPP (0.9 MW) located in the territories temporarily occupied by Russia before February 24, 2022). In 2021, the share of SHPPs in electricity production was 0.1 %.



Source: ECS based on publicly available data

As of today, about 5% of the SHPP capacities are under occupation, and 4% are damaged. In September 2022, the Ukrainian army liberated Oskil'ska SHPP with an installed capacity of 4 MW located in the Kharkiv region. In March, Russian forces blew up the gates of the SHPP's dam, causing floods in nearby settlements.

Storage

In 2021, the first pilot energy storage facility with an installed capacity of 1 MW was built at the Zaporizka TPP, while approximately 212 MW of storage capacities were at different stages of development.

Nowadays, the only electricity storage facility in Ukraine is under occupation, and the implementation of all planned projects has been temporarily suspended.

Transmission system

The Ukrainian electricity transmission system includes 23,600 km of overhead lines and 141 substations with a voltage of 110–750 kV operated by the Ukrainian transmission system operator (TSO) National Energy Company (NEC) "Ukrenergo". On 16 March 2022, Ukrainian and Moldovan Power Grids successfully synchronised with the Continental European Grid (ENTSO-E) in response to Russia's invasion of Ukraine. On June 30, 2022, Ukraine started commercial electricity export to the EU countries (currently about 500 MW per hour). In the first two weeks of September 2022, Ukraine set a trade record, exporting \$131 million worth of electricity. The maximum available capacity of interconnectors with the ENTSO-E countries is ~2,300 MW per hour.

Nowadays, more than 30 overhead lines and more than ten substations with a voltage of 220–750 kV are damaged or disconnected due to continuous shelling and hostilities.

Transmission substation after a missile attack



Source: Vikna.tv

Distribution networks

The electricity distribution systems in Ukraine include more than 800 thousand km of overhead and cable lines with 0.4 — 150 kV voltage and about 200,000 6-150 kV transformer substations operated by 32 distribution system operators (DSOs).

As of today, more than 1,200 overhead lines (6-150 kV) and more than 8 thousand transformers (6-150 kV) are damaged or disconnected due to continuous shelling and hostilities.

Demand and supply

At the beginning of 2022, there were 17.7 mln electricity consumers in Ukraine, including 17.2 mln households and 0.5 mln commercial customers.

As a result of hostilities, electricity demand decreased by 30-35% compared to 2021. The consumption pattern also changed due to the shutdown of industrial enterprises and the massive displacement of consumers from Eastern to Western Ukraine. It is foreseen that the total electricity generation in 2022 will be 25% less than the “pre-war” forecast due to Russian military aggression. Since February 24, 2022, more than 7.5 mln consumers have been cut off from power supply. Currently, the electricity supply has already been restored to more than seven mln consumers. As of September 24, 2022, about 1299 settlements in Ukraine remained without electricity (completely or partially), covering about 738,000 consumers.

NATURAL GAS SECTOR

Natural gas production

Ukraine has the third-largest proven natural gas reserves in Europe (up to ~719 bcm) (EY, 2020).⁶ The largest reserves are located in the Poltava, Kharkiv, Lviv regions, and on the Black and Azov Seas shelf. In 2021, there were about 542 issued licenses and 25 large companies operating in the oil and gas exploration and production sector, including three state-owned and 22 companies with Ukrainian and foreign investments. Over the last 20 years, the volume of natural gas production in Ukraine was about 20 bcm/year (~ 55 mcm/day). Ukraine’s main gas production regions (excluding the temporarily occupied territories by Russia before February 24, 2022) are the Poltava and Kharkiv regions (~90% of total production).

⁶ “National report of Ukraine 2020”, EY Extractive Industries Transparency Initiative, 2020, https://www.geo.gov.ua/wp-content/uploads/presentations/en/UA_EITI_Report_2020_EN.pdf

After February 24, 2022, approximately 15% of the country's natural gas reserves are under Russian occupation. More than 150 gas production facilities, primarily located in the Kharkiv region, were suspended because of hostilities. Therefore, the average daily production decreased by almost 11% (~49 mcm/day). The information on damages to natural gas production facilities is restricted.

Underground gas storage

Ukrainian underground natural gas storages (UGS) are the largest in Europe and 3rd in the world after the US and Russia (Cornot-Gandolphe, 2018).⁷ There are 13 UGS facilities in Ukraine with a total working gas storage capacity of 31.95 bcm/y (including two UGS with a total capacity of 1.4 bcm/y located in regions temporarily occupied by Russia before February 24, 2022), with maximum gas injection and withdrawal capacities of above 250 and 260 mcm/day, respectively. Most UGS capacities are located in Western Ukraine (25.32 bcm/y or 79%) (see Annex 3 for more details).

After February 24, 2022, the operation of one UGS in the East (0.42 bcm/y) was suspended due to hostilities, and one UGS in the central part of Ukraine (capacity 0.31 bcm/y) was damaged. Thus, about 8% of UGS capacities remain unavailable, including 5.7% (1.82 bcm/y) in the temporarily occupied territories, and 2.3% are damaged. There is no information about damages and losses on UGS located in the temporarily occupied territories and areas close to active hostilities.

Currently, more than 13.2 bcm of natural gas has been pumped into Ukraine's UGS. And by October 1, 2022, 14.5-15 bcm of gas is planned to be accumulated.

Gas transmission system

The Ukrainian natural gas transmission system (GTS) is one of the most developed in Europe, with a total length of more than 38,000 km and interconnections with the following EU member states: Poland, Slovakia, Hungary and Romania. The total capacity of the GTS "entry" points is 281 bcm/year (770 mcm/day) and "exit" points – 146 bcm/year (400 mcm/day) (see Annex 4). 41.6 bcm of Russian natural gas transited via Ukraine GTS to Europe in 2021.

From May 2022, the volume of transit of Russian gas through Ukraine to EU consumers decreased by approximately 30% due to the interruption of gas transit through the "Sokhranivka" gas metering station (GMS) located on the territory temporarily occupied by Russia. As a result, in May-September 2022, the gas transit through Ukraine's territory decreased to 40-42 mcm/day or 37-38.5% of the capacity contracted by Gazprom (109 mcm/day). About 200 km of gas pipelines and equipment are known to be damaged due to Russian hostilities. Despite the damages, the Ukrainian TSO expressed its readiness to increase transit volumes to the EU via GMS "Sudzha" (capacity 77-244 mcm/day), while Gazprom reduced transit volumes.

Despite the suspension of natural gas transit via the Nord Stream 1 pipeline and increased demand on EU gas markets in August-September 2022, the Russian Federation did not increase the transit via Ukraine's GTS. On the contrary, Russia cut its natural gas production and increased flaring to keep EU market prices high.

Gas distribution networks

About 290,000 km of gas distribution networks are operated by 45 gas distribution system operators (DSOs) in Ukraine.

Since February 24, 2022, approximately 7,000 km of distribution networks in Eastern and Southern Ukraine have been destroyed or damaged (approximately 12% of the distribution networks in Eastern and Southern Ukraine). More than 5,000 gas distribution control units were either suspended or damaged.

⁷ Sylvie Cornot-Gandolphe, "Underground gas storage in the world - 2018 status", *Cedigaz Insight ed. 31*, November 2018, [https://cdn2.hubspot.net/hubfs/1982707/Overview%20of%20Underground%20gas%20storage%20in%20the%20world%202018%20\(1\).pdf](https://cdn2.hubspot.net/hubfs/1982707/Overview%20of%20Underground%20gas%20storage%20in%20the%20world%202018%20(1).pdf)

Demand and supply

At the beginning of 2022, there were 12.6 mln of natural gas consumers in Ukraine, including 12.5 mln households and 0.1 mln commercial customers.

As a result of the hostilities and damaged infrastructure, natural gas consumption decreased by more than 30% compared to daily consumption in 2021. As of September 24, 2022, about 597,000 households are left without the gas supply (5% of the total). Due to damages, natural gas consumers of the Donetsk region are almost entirely disconnected from the gas supply. DSOs regularly restore gas supplies where possible, but regular attacks by Russian troops lead to new damages and destructions.

OIL & PETROLEUM PRODUCTS

Oil production

Ukraine's oil reserves are estimated at approximately 85 mln tons (EY, 2020).⁸ More than 51% of the total reserves are concentrated in the North and Central regions, 36% in the Western and 13% in Southern Ukraine (Annex 5). Oil and gas condensate production in 2021 amounted to 2.4 mln tons (6.66 thousand tons/day). In 2021, 25 large companies were operating in the oil and condensate exploration and production sector, including two state-owned (that produced about 80% of total oil production) and more than 20 companies with Ukrainian and foreign investments (up to 20% of total oil production).

After February 24, 2022, almost 10% of the country's oil reserves are located in temporarily occupied territories. The volume of oil production in areas close to active hostilities and under the constant threat of occupation has decreased significantly. The information on damages to oil production facilities is restricted.

Oil transmission system

In 2021, the oil transmission system of Ukraine included 19 oil pipelines with a diameter of up to 1,220 mm, a total length of 3,506.6 km and 176 pumping stations. The total capacity of the tank park was 1,083 thousand cubic meters. The total capacity of the oil transmission system at the "entry" points was 114 mln tons/year at the "exit" points - 56.3 mln tons/year in 2021. The system transmitted oil from Ukrainian oil fields and seaports, i.e. imported by sea transport (including for the needs of the refinery of Belarus), as well as transited Russian oil through the "Druzhba" oil pipeline to Slovakia, the Czech Republic, and Hungary (Annex 6). In 2021, the Ukrainian oil transmission system transported 15.7 mln tons, including 12.7 mln tons of transit of Russia's oil and 3.0 mln tons to local refineries.

After February 24, 2022, a significant amount of principal and auxiliary equipment was damaged at three oil transmission facilities, including three cases of damage to cable communication systems. It is estimated that the volume of oil transit and transportation will be significantly reduced due to destroyed oil transmission facilities and Ukrainian refineries and the reduction/suspension of transit to Belarus in 2022.

Oil refinery and gas processing

In 2021, there were six refineries and one gas processing plant (GPP) in Ukraine, with a total designed oil processing capacity of over 50 mln tons/year.⁹ Still, the actual production capacity was about 7.5 mln tons/year and was mainly based on the capacities of two plants: Kremenchuk Refinery (up to 7 mln tons/year) and Shebelynka Gas Processing Plant (about 0.5 mln tons/year). The two plants covered about

⁸ "National report of Ukraine 2020", EY Extractive Industries Transparency Initiative, 2020, https://www.geo.gov.ua/wp-content/uploads/presentations/en/UA_EITI_Report_2020_EN.pdf

⁹ Note: Starting from 2014, only two out of six oil refinery and gas processing plants remained active in Ukraine, mainly due to changes in the structure of the owners as well as ageing refinery equipment.

25% of the needs of the Ukrainian demand for oil products, which was 12.35 mln tons in 2021 (Annex 6).

After February 24, 2022, the work of the Shebelynka GPP was suspended due to Russian hostilities and the plant was later damaged by a missile attack. In September 2022, the Russian military forces continued regular shelling of the Shebelynka GPP and its fuel reservoirs. Multiple missile attacks destroyed the Kremenchuk Refinery (in total, Russia shot 32 missiles at the Kremenchuk Refinery) and damaged the facilities of Odesa and Lysychansk Refineries (the latter is owned by the Rosneft - the second largest Russian state-controlled company after Gazprom).

As a result, the Ukrainian oil refinery industry has been destroyed, and the country is almost 100% dependent on imported petroleum products.

Oil products storage (oil depots)

Since oil product storage capacities were among the primary targets for Russian military forces, the information about the total number of oil depots and "pre-war" status is restricted.

Since February 24, 2022, more than 28 oil depots have been destroyed or significantly damaged in almost all regions of Ukraine. At the beginning of September, 2022, Russian forces shelled an oil depot in Kryvyi Rih, which caused severe fire destructions.

According to the Ministry of Environmental Protection and Natural Resources of Ukraine, the destruction of oil depots by the Russian military forces resulted in the additional emission of 499,000 tons of pollutants into the atmosphere. For comparison, the emissions of Ukraine's largest industrial polluter are estimated at 220,000 tons annually. The additional emissions pose substantial risks for neighbouring countries as, depending on the wind direction, dangerous pollutants from burnt oil products may move to the territories of other countries and fall there as acid rain. Since the beginning of Russia's invasion, the estimated volume of pollutants emissions has reached 46 mln tons. For comparison, this indicator was ten times lower in 2019 - about 2.4 mln tons, and in 2021 - 2.25 mln tons (Krechetova, 2022).¹⁰

Oil depot, Kryvyi Rih, Dnipropetrovsk region after a missile attack



Source: TOP ENERGY

Fuel stations

In 2021, there were more than 7,500 fuel stations in Ukraine, including petroleum, natural gas and electricity charging stations. The vast majority of stations belong to private companies.

It is impossible to accurately estimate the number of fuel stations damaged or destroyed due to occupation and ongoing hostilities.

¹⁰ Diana Krechetova, "How did the destruction of oil depots and Russian missile attacks affect air pollution? The Ministry of Environment is in charge", Life Pravda, 2022, <https://life.pravda.com.ua/society/2022/09/13/250436/>

Destroyed fuel station, Chernihiv region



Source: *Suspilne.media*

COAL

Coal production

Ukraine is a coal-rich country with the largest coal reserves in Europe (TheGlobalEconomy.com, 2022).¹¹ According to various estimates, the total proved coal reserves are about 38 bln tons (including the coal reserves located in the territories temporarily occupied by Russia before February 24, 2022). About 92.4% of total coal reserves are located in the Donetsk hard coal basin (Donbas) (Annex 5). In 2021, Ukraine produced about 29 mln tons of hard coal. For comparison, the average coal production before Russia occupied Donbas’s territories in 2014 was 80 mln tons per year.

As of today, about 60% of the country’s coal deposits are temporarily occupied by Russia. By mid-September, Ukrainian companies had accumulated about 2.2 million tons of coal reserves in their warehouses. These are the largest reserves in recent years for this period. It is expected that up to 2.5 million tons will be accumulated before the heating season starts.

Coal mines

There were 151 coal mines in operation in 2013 (before Russia temporarily occupied the Donbas region in 2014) and only 47 coal mines in 2021 (before the full-scale invasion of the Russian Federation of Ukraine on February 24, 2022).

As of today, 95 mines are located in the Ukrainian territories temporarily occupied by Russia, including 28 privately owned and 67 state-owned mines. According to publicly available data, at least six coal mines are flooded, threatening an ecological disaster in the region.

URANIUM (mines and refinery)

There are three uranium mines and uranium refinery capacities in Ukraine located in Dnipropetrovsk and Kirovograd regions (Annex 5). In 2021, the domestic mining, processing of uranium ores and nuclear fuel production covered about 40% of the country’s needs. In 2021, Ukraine commissioned the centralised storage of used nuclear fuel in the exclusion zone of the Chornobyl NPP. The life cycle of the storage is at least 100 years.

¹¹ “Coal reserves Europe – Country rankings”, TheGlobalEconomy.com, 2022, https://www.theglobaleconomy.com/rankings/coal_reserves/Europe/

The exclusion zone of the Chernobyl NPP was under occupation from February 24, 2022, to March 31, 2022. As a result of the occupation, the Russian military forces looted and destroyed the newest Central Analytical Laboratory in Chernobyl, a unique complex with powerful analytical capabilities that could provide services related to radioactive waste management (from conditioning to disposal, as well as at the stage of research and development of technologies).

AMMONIA

Ukraine's ammonia pipeline is the fifth largest in the world. Ammonia is transferred from the Russian chemical enterprise in Tolyatti to the Odesa Port Plant in Yuzhny city. The length of the pipeline is 2,417 km, of which 1,021 km pass through the territory of Ukraine (Annex 4). The capacity of the ammonia pipeline is up to 2.5 mln tons per year.

Even if there is no supply of ammonia from the territory of Russia, the pipeline has the potential to be used to transport ammonia converted from "green" hydrogen.

On February 24, 2022, the first day of the Russian invasion of Ukraine, the transit of ammonia through the pipeline was stopped. On May 30, 2022, the Russian military forces damaged the ammonia pipeline branch in the Bakhmut district of the Donetsk region.

The UN calls for the restoration of the Tolyatti-Odesa ammonia pipeline. The President of Ukraine, Volodymyr Zelenskiy, said that Ukraine would agree to resume the supply of Russian ammonia through the pipeline through Ukraine only if Russia returned the Ukrainian prisoners of war.

LITHIUM

According to preliminary estimates, Ukraine's total lithium resource potential is relatively high (approximately 500,000 tons of lithium oxide) (Vasylenko & Uliana, 2022).¹² This ultra-light metal is a critical element for the future of the Ukrainian power system as it is widely used to make power batteries, including energy storage and electric vehicles. There are two explored deposits and two pre-explored areas of lithium ores in Ukraine.

As of today, at least two lithium deposits are located in the territories temporarily occupied by Russia in Zaporizhzhia and Donetsk regions (Annex 5).

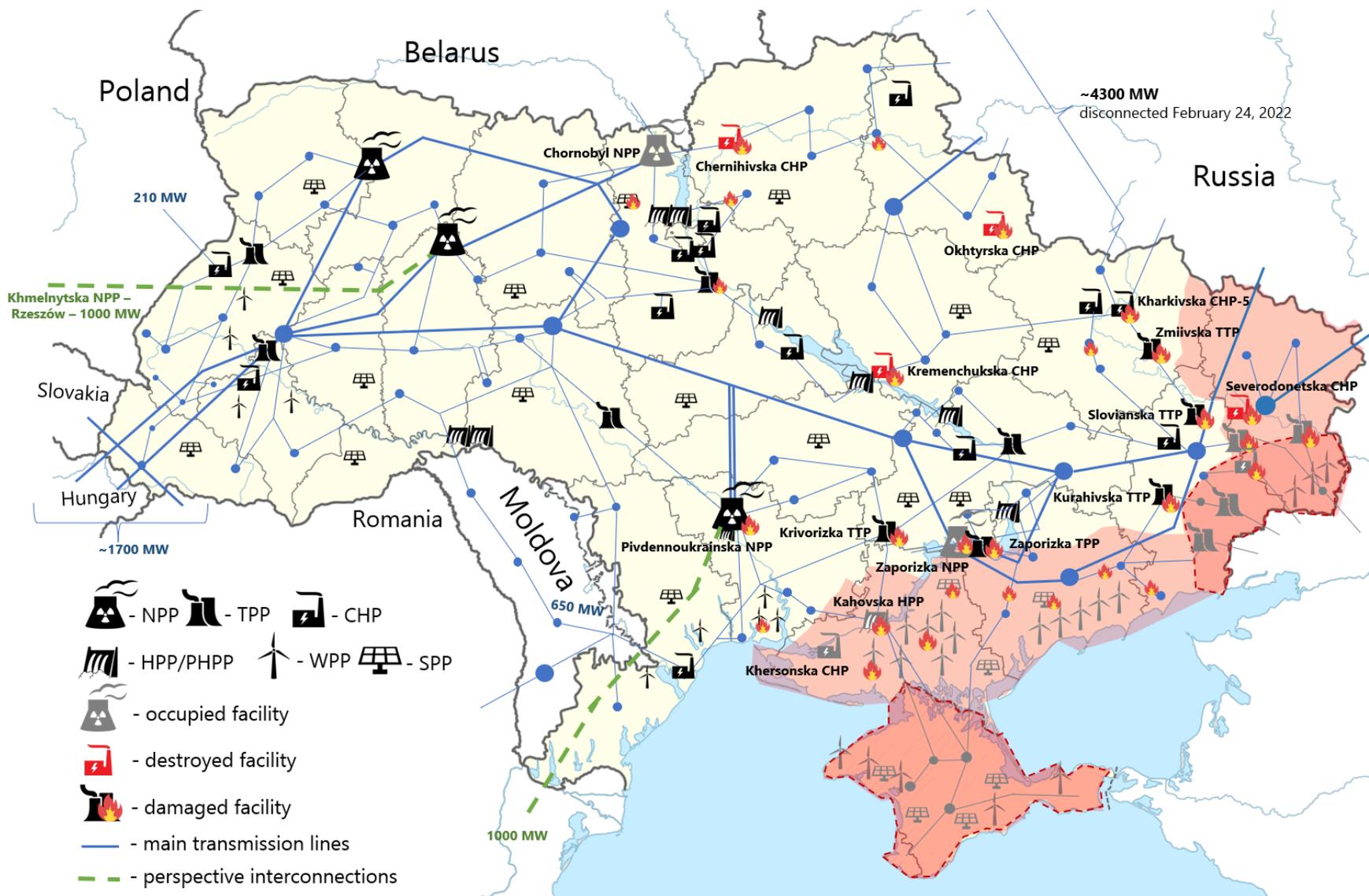
DISTRICT HEATING

Thermal energy is mainly produced by CHPs (described above) and heat-only boilers (HOBs) in Ukraine. In 2021, there were ~19,025 HOBs in Ukraine from which the thermal energy was transported by 1,9 mln km of pipelines and distributed through 5,523 central heating points. The energy balance in the district heating sector consists of gas and coal, which together make up 90%, and about 10% of bioenergy.

As of today, more than 300 HOBs, 200 km of pipelines and 100 central heating points have been destroyed or damaged. Since the local district heating infrastructure has been severely damaged due to Russian hostilities, there will be no heating season in some regions of Ukraine. For that reason, Ukraine is evacuating civilians from the Donetsk region. Ukraine will likely need to evacuate civilians from some parts of the Zaporizhzhia, Kherson and Kharkiv regions to avoid a humanitarian crisis in these territories during the coming winter.

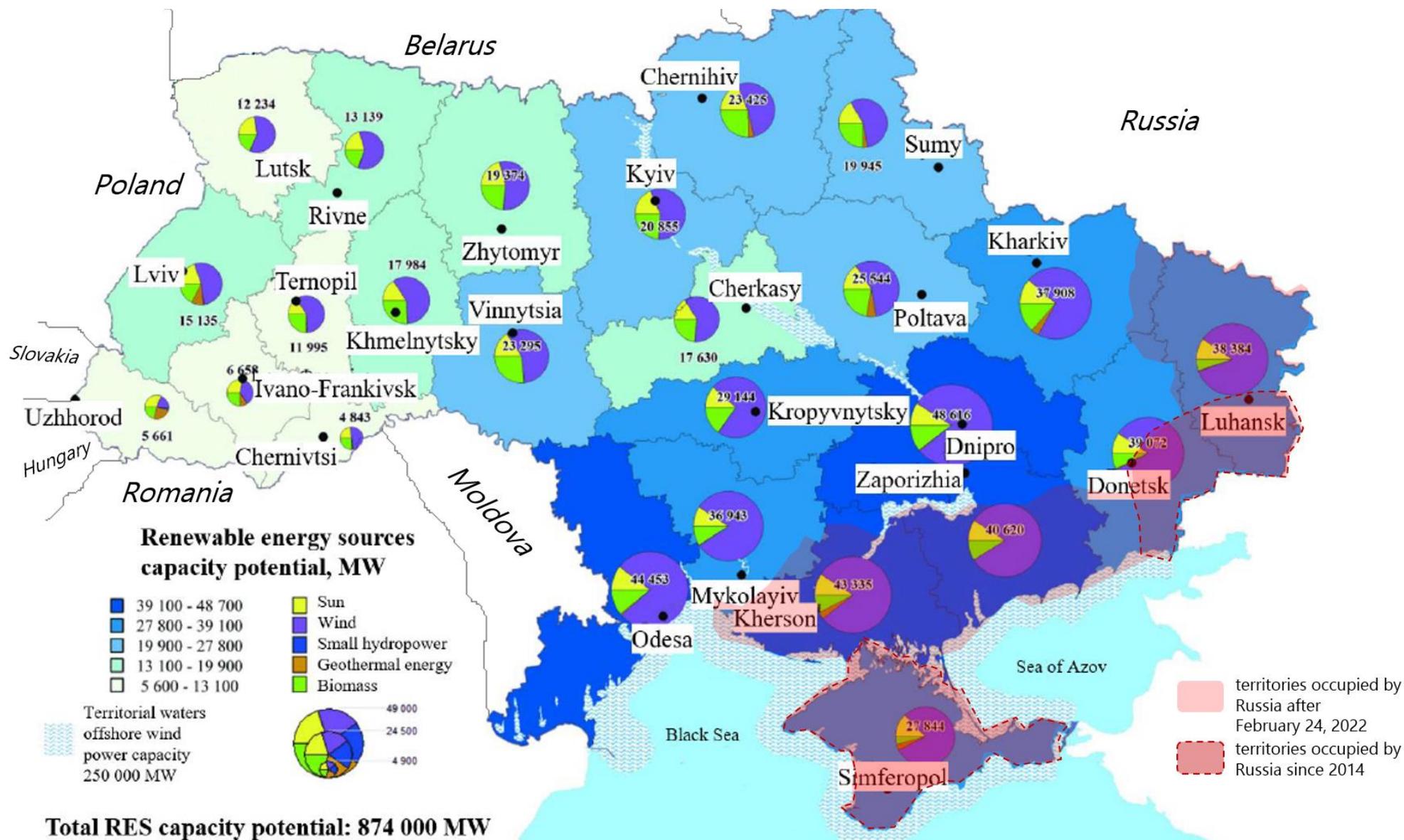
¹² Vasylenko, Svitlana & Uliana, Naumenko. (2022). PROSPECTS OF DEVELOPMENT OF LITHIUM RESOURCE BASE IN UKRAINE. InterConf. 10.51582/interconf.19-20.02.2022.072.

Ukrainian power sector



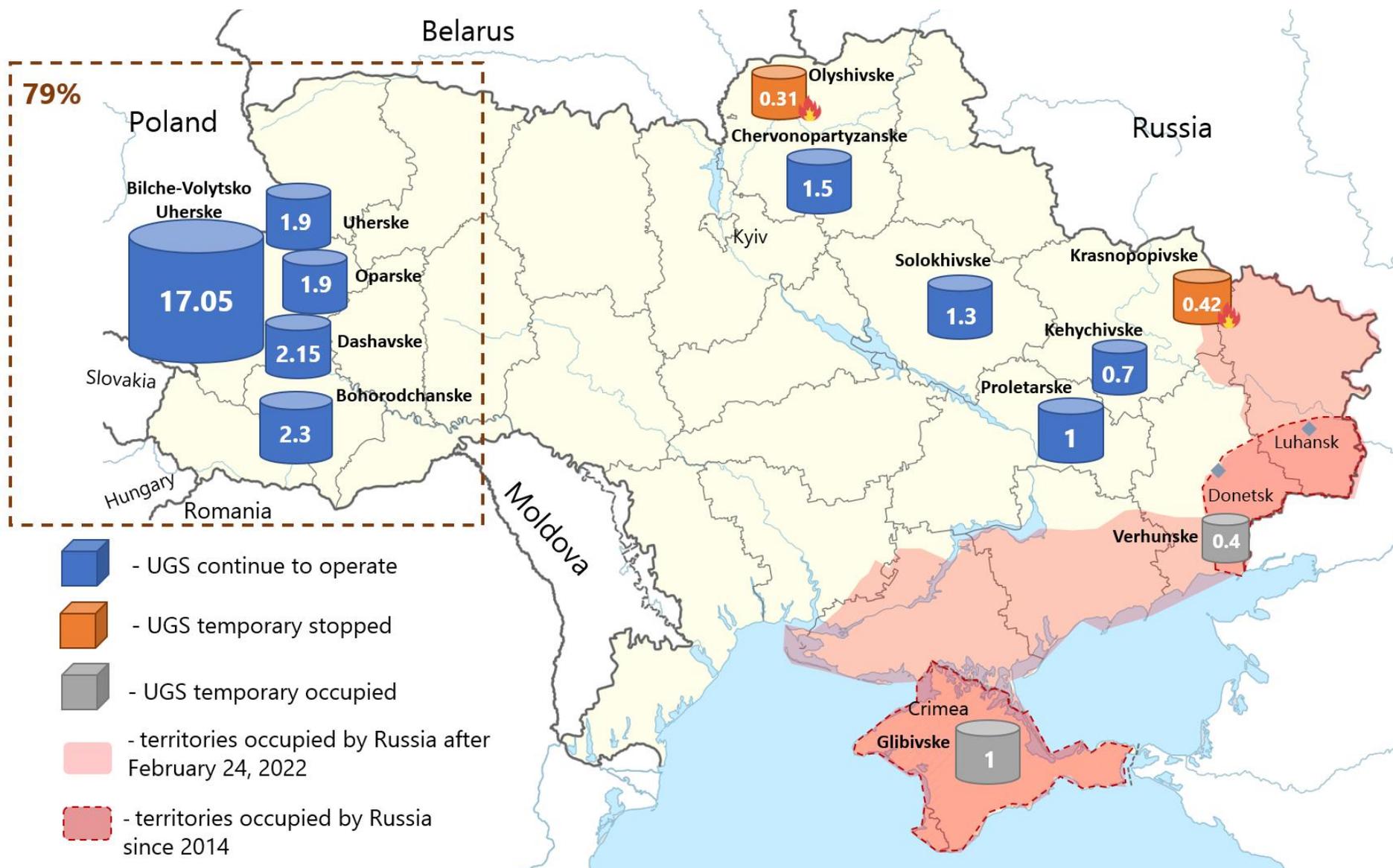
Source: ECS based on Bintel and publicly available data

Renewable energy sources capacity potential in Ukraine



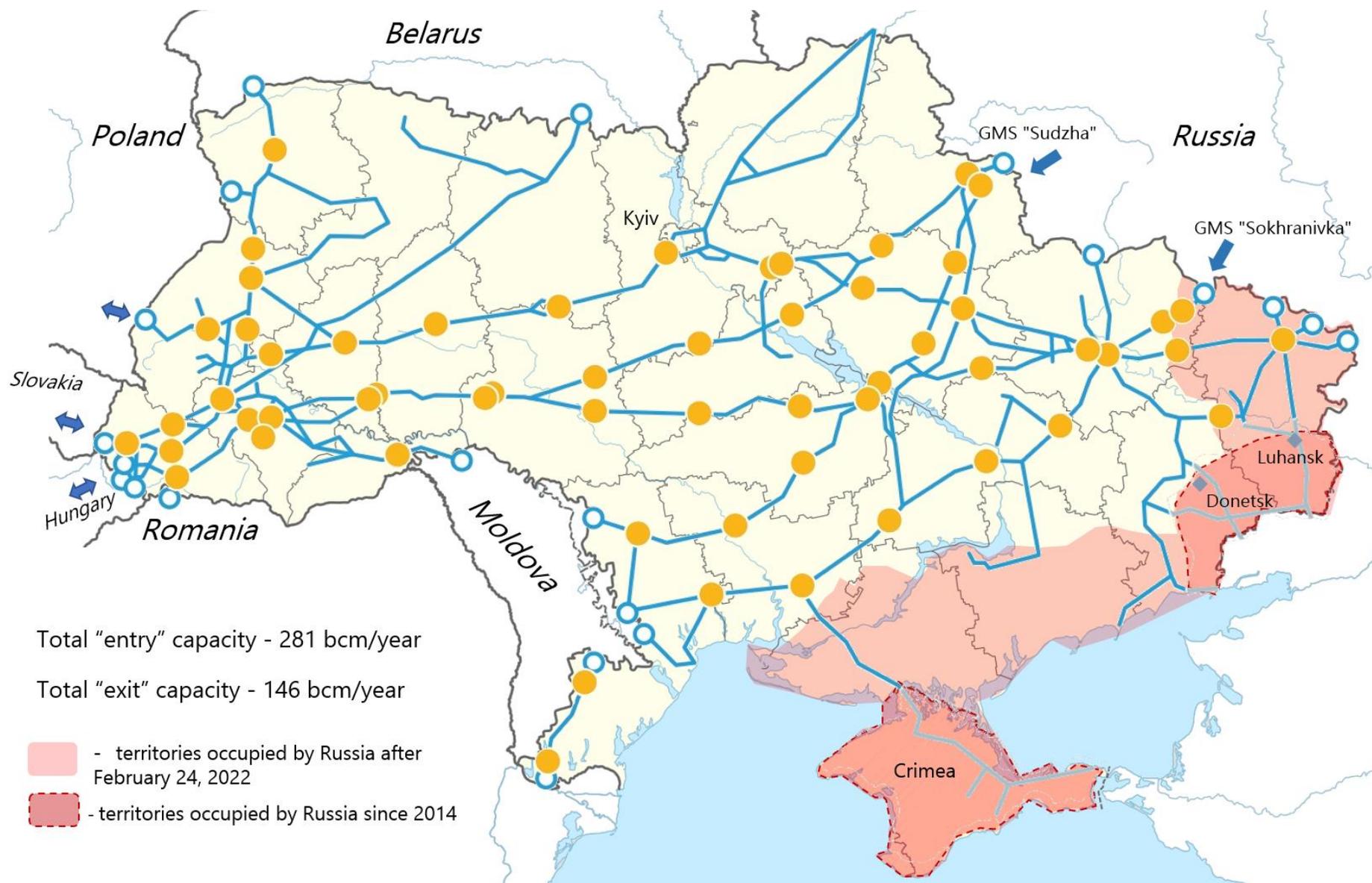
Source: ECS based on *Atlas of RES potential in Ukraine*, Renewable energy institute of Ukraine and publicly available data

Ukrainian underground gas storages (UGS)



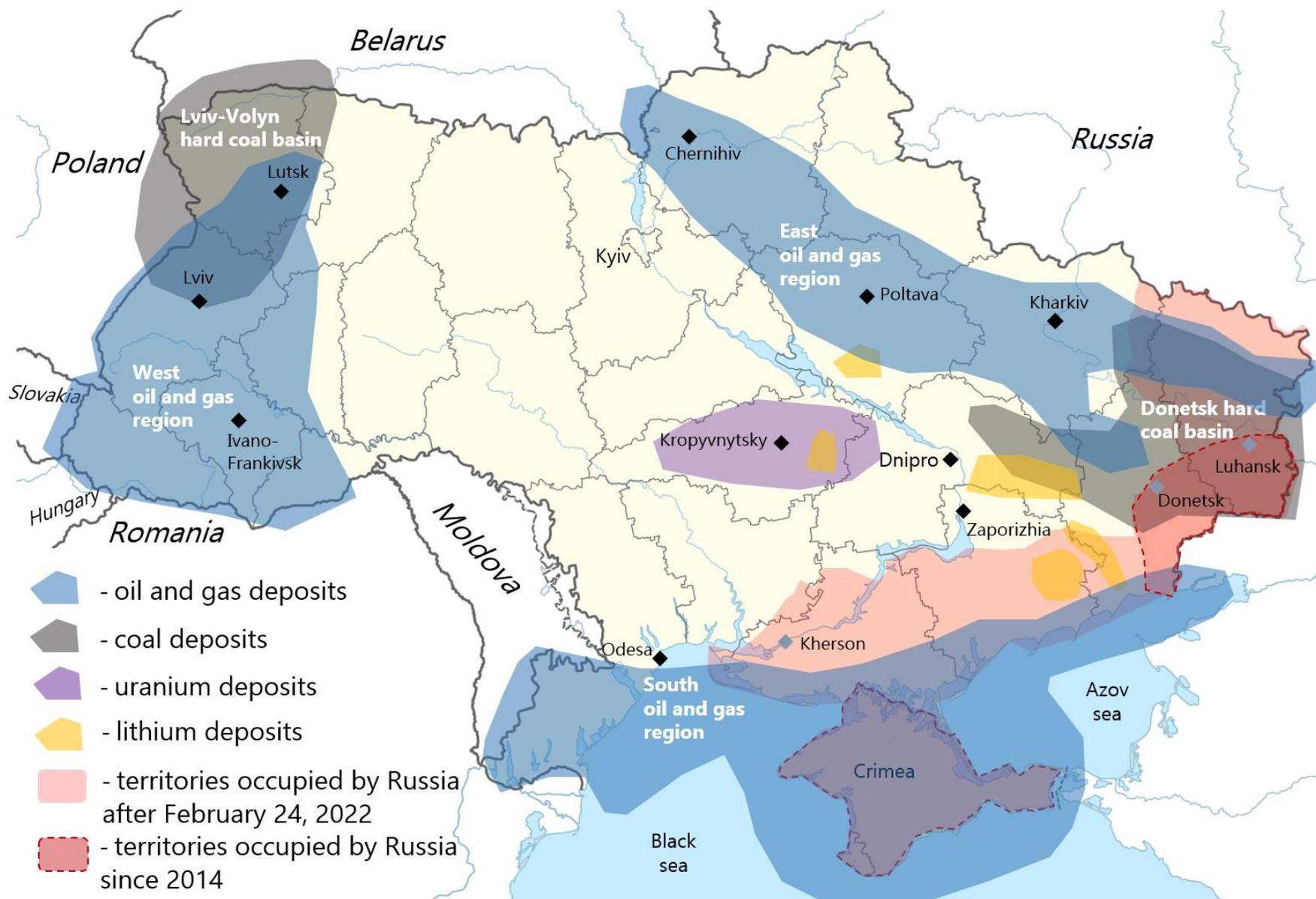
Source: ECS based on UA UGS operator and publicly available data

Ukrainian gas transmission system



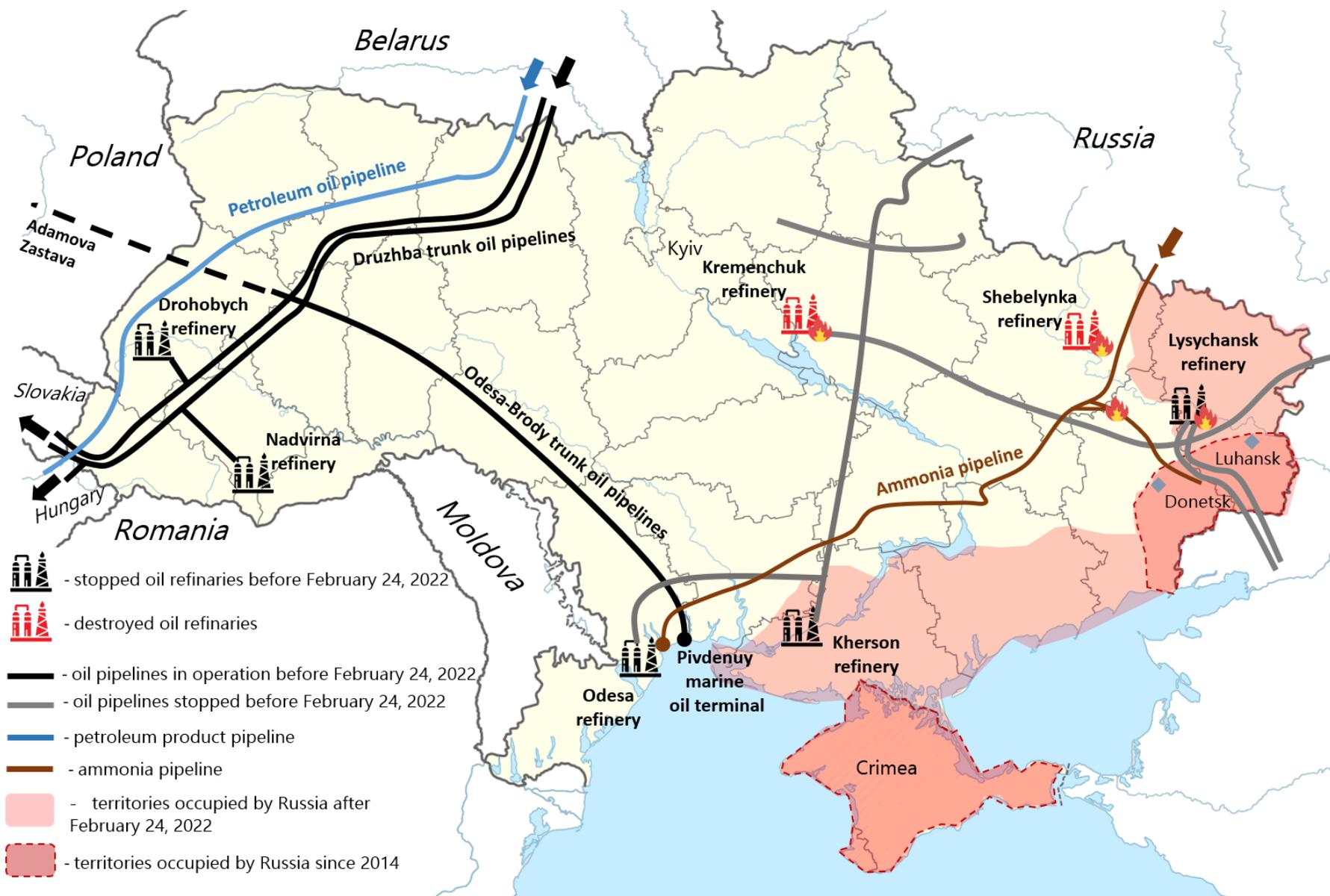
Source: ECS based on UA transmission system operator and publicly available data

Natural gas, coal, uranium and lithium deposits in Ukraine



Source: ECS based on *EITI report 2020, PROSPECTS OF DEVELOPMENT OF LITHIUM RESOURCE BASE IN UKRAINE* and publicly available data

Oil refineries, oil & petroleum transportation system and ammonia pipeline in Ukraine



Source: ECS based on Ukraine EITI report 2020 and publicly available data