

Risks and Impacts from Attacks on Fossil Fuel Facilities in Ukraine

Environment and Conflict Alert Ukraine



PAX

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Cover photo: A gas station burns after Russian attacks in the city of Kharkiv, on March 30, 2022. Fadel Senna/ AFP

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Introduction

Throughout the history of modern warfare, the targeting of fuel infrastructure has been part of military operations, whether for strategic reasons or simply as revenge. Examples are numerous, from the Allied [Operation Tidal Wave](#) against Nazi Germany in 1943, to Saddam Hussein's Iraq's [scorched-earth tactics](#) to set fire to over 700 Kuwait oil wells in 1991, to the last decade's strikes by both the US-led Joint Coalition and Russia against oil fields and related [infrastructure](#) controlled by the Islamic State group in Syria.

Regardless of the military advantage, these operations often come with huge environmental and public health costs. The oil fires in Kuwait, for instance, [resulted](#) in a drop of over 10°C in the nearby region. While this was an extreme case, such attacks often have more localized impacts on human health and ecosystems, both immediate and long-term. These range from direct exposure to pollutants from the noxious fumes released to affected groundwater and soils, to accumulation of a range of toxic and hazardous substances found in oil products, including heavy metals. Timely identification and monitoring of these effects is therefore essential for the rapid assessment, clean-up, and remediation of affected areas, as well as providing insights as to the wider implications of warfare on the environment and livelihoods.

Since the start of the Russian invasion of Ukraine, the latter's energy and fuel infrastructure has been one of Russia's main targets. The use of fuel for airplanes, tanks, armored vehicles and trucks is essential for the Ukrainian armed forces, while power plants are key to keep a range of military and governmental facilities running. Often, the Russian strikes also targeted civilian fuel depots, as many smaller towns and cities have their own oil tanker farms for energy use for domestic, industrial and agricultural purposes. In turn, the Ukrainian army also took strategic military actions aimed at destroying fuel depots intended for the military needs of the invading army, targeting fuel depots located in the occupied¹ territories of Crimea and eastern Ukraine.

This Environment and Conflict Alert aims to analyze environmental and health risks stemming from those attacks against Ukraine's oil and gas infrastructure. Based on open-source information and satellite imagery analysis, the report takes stock of the damage inflicted upon the country's fuel infrastructure, with two specific case-studies examined in detail. It then provides an overview of the associated environment and health risks caused by air, soil and water pollution resulting from this damage. The report concludes with recommendations for further assessment and remediation work to be supported by the international community.

¹ Here and further in the text, "occupied" means the temporarily occupied territory according to the Law of Ukraine "On Ensuring the Rights and Freedoms of Citizens and the Legal Regime in the Temporarily Occupied Territory of Ukraine" – the law that determines the status of the territory of Ukraine temporarily occupied as a result of the armed aggression of the Russian Federation, establishes a special legal regime in this territory, determines the specifics of activity in the conditions of this regime, observance and protection of the rights of individuals and legal entities.

Oil and gas industry of Ukraine before February 24, 2022

Ukraine [possesses](#) substantial conventional and unconventional hydrocarbon reserves and has a century-long history of oil and gas production with [the following structure](#): natural gas 89 percent, oil 8 percent, and gas condensate 3 percent. Ukraine has been an important [transit country](#) for supplies of oil and natural gas from Russia to countries throughout Europe. Hydrocarbons resources are located in three Ukrainian regions, where 126 [deposits with industrial reserves](#) have been discovered:

- ◆ **the Dnipro-Donetsk basin in the east** (Chernihiv, Sumy, Poltava, Kharkiv and Dnipropetrovsk regions), which accounts for 80% of proven reserves and approximately 90% of gas production;
- ◆ **the Carpathian region in the west** (Ivano-Frankivsk, Lviv and Chernivtsi regions), which has 13% of proven reserves and 6% of production; and
- ◆ **the southern region** (Odesa region and the Autonomous Republic of Crimea), accounting for the remaining 6% of proven reserves. However, Ukraine lost a significant share of its offshore gas and oil deposits following Russia's occupation of Crimea in 2014.

Ukraine's oil refining industry is represented by six oil refineries and one gas and oil processing plant with a declared capacity of primary processing of over 50 mln tons of oil per year. Yet even before the Russian invasion, the [actual production capacity](#) was about 7.5 mln tons/year and was mainly based on the capacities of two plants: the giant Kremenchuk Oil Processing Plant in Poltava region (up to 7 mln tons/year) and the Shebelynka Gas and Oil Processing Plant in Kharkiv region (about 0.5 mln tons/year). The other refineries [have stood empty](#) for at least five years, due to their outdated technologies and poor management.

Before 2022, annual gas production in Ukraine was at the level of around 20 billion m³ per year, while gas consumption in the country was around 27-31 billion m³ per [year](#). Ukraine's [self-sufficiency](#) in gas is approximately 70%, with the remaining 30% being imported. Known Ukrainian gas reserves [amount](#) to 1.09 trillion m³ of natural gas, second only to Norway's known resources of 1.53 trillion m³, but these enormous reserves remain largely untapped.

The gas transportation system (GTS) of Ukraine is one of the largest gas transportation systems in the world, [consisting of](#) a uniquely dense network of multiple primary and secondary pipelines, coupled with major storage facilities. It performs two main functions: the supply of natural gas to domestic consumers, as well as the transit of natural gas through the territory of Ukraine to the countries of Western and Central Europe. The total length of main gas pipelines is 37,000 km, with another 4,000 km of oil pipelines. Ukraine [has](#) 13 underground gas storage facilities, which are the largest in Europe in terms of volume.

Since the beginning of Russia's full-scale invasion on February 24, 2022, Ukraine's fuel infrastructure has been deliberately [destroyed](#) by Russian troops. Thus, the entire oil sector of Ukraine was forced to [stop refining operations](#) in June 2022. Approximately 15% of the country's

natural gas reserves are [under Russian occupation](#) as of May 2023, while the operation of more than 150 gas production facilities, primarily located in the Kharkiv region, was suspended due to hostilities.

Documenting military damage to Ukraine’s fuel infrastructure

PAX has been [monitoring](#) conflict-linked incidents in Ukraine since the full-scale Russian invasion on February 24, 2022. Data collection is based on credible media reports and social media channels such as Facebook, Twitter and Telegram. Incidents are verified where possible through satellite imagery, using public high- and medium-resolution satellite images from NASA and ESA, as well as commercial very-high resolution imagery provided by Planet and MAXAR. PAX’s database also includes information provided by [REACH](#) and the [Center for Environmental Initiatives EcoAction](#). Monitoring and verification of incidents is performed together with PAX’s partner, the [Centre for Information Resilience \(CIR\)](#), which conducts wide-scale [monitoring](#) in Ukraine.

Category area of incidents	Number of incidents	Subcategory affected facilities	Number of incidents
Fuel infrastructure (gas & oil)	66	1. Oil refinery	12
		2. Fuel depot	44
		3. Fuel stations	3
		4. Gas pipelines	5
		5. Gas and oil rigs	1
		6. Gas storage	1

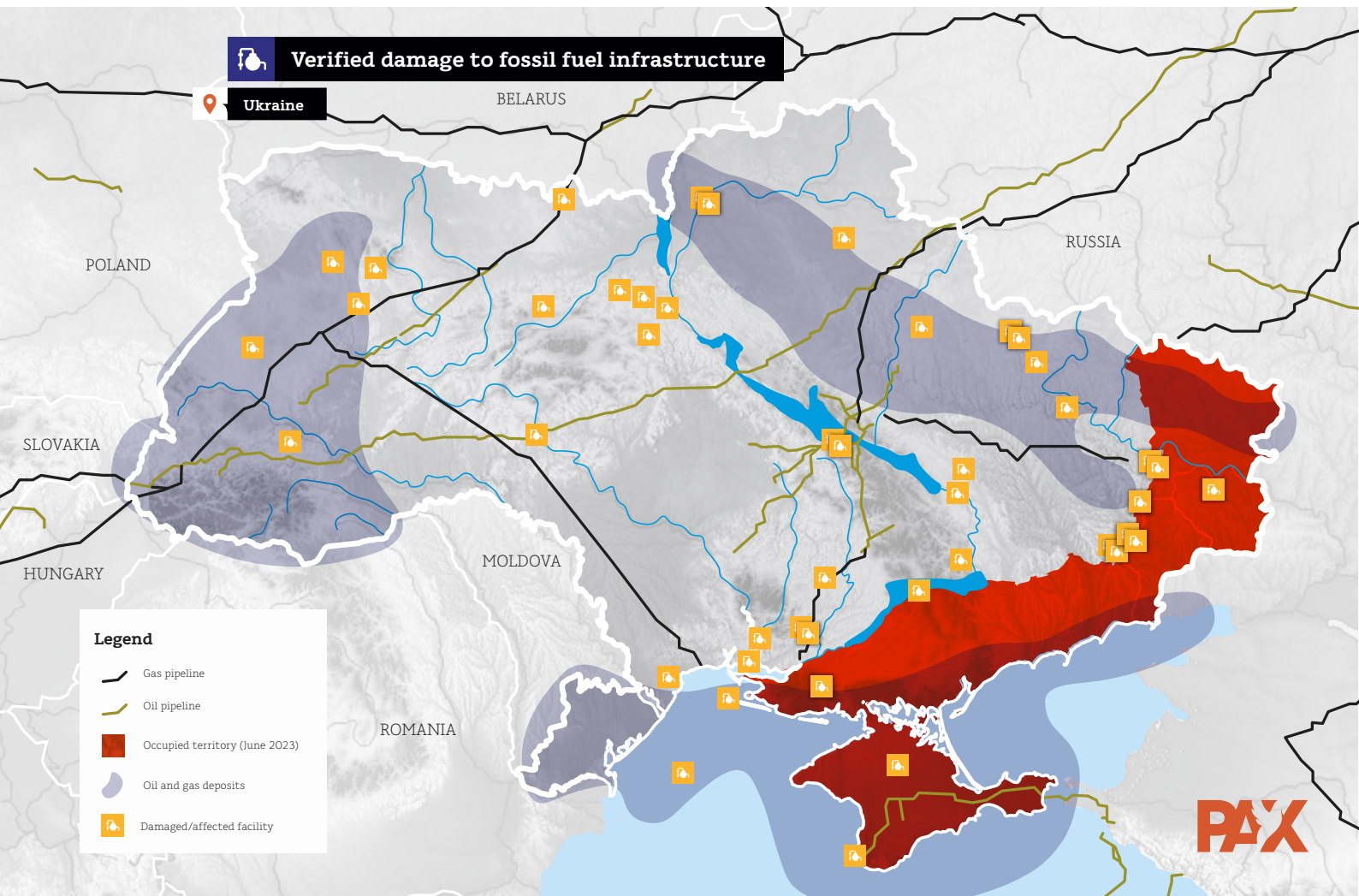
PAX’s database contains information on 277 incidents involving gas and oil facilities, 66 of which have been verified (last entry recorded in April 2023). The types of targets have been sorted into various sub-categories, ranging from large refineries in central Ukraine to offshore gas platforms in the Black Sea and small fuel depots scattered across the country. These reported incidents are likely not exhaustive.

Geographically, these 66 attacks on fuel facilities took place in 20 out of 24 regions of Ukraine. Most of the strikes took place in Luhansk region (10), followed by Donetsk (8) and Kyiv (7) regions. Cruise missiles were used against a range of targets in western and central Ukraine, while smaller fuel depots and gas facilities near or behind the frontlines in northern and eastern Ukraine were targeted by artillery and mortar strikes, as well as by other explosive weapons.

Early in the war, Russian strikes were concentrated against fuel depots at military airbases or near military locations. On February 26, the fuel depot at Vasylykiv air base in Kyiv region was hit, resulting in a massive fire with heavy smoke, leading to the evacuation of nearby neighborhoods to minimize health risks from smoke exposure. In March 2022, fuel tankers at at least four airports were targeted including March 10 strikes on an airport in the city of [Vinnysia](#) as well as military airfields in [Hostomel](#), [Lutsk](#) and [Ivano-Frankivsk](#). Another Russian cruise missile attack [struck fuel storage tankers](#) at two oil terminals, JSC “Eximnefteprodukt” Oil Terminal 1 and the “Odesanaftoprodukt” terminal, in Odesa city, resulting in heavy dark smoke plumes over the city.

The two largest refineries in Ukraine were attacked multiple times from March to October 2022, resulting in extensive damage. The Kremenchuk oil refinery was [severely damaged by missile strikes](#) and ceased operations in April 2022. Another damaged oil refinery is located in Lysychansk, Luhansk region, and was occupied by Russian forces in July 2022. The damage to these two sites is described in detail below, in the case study section.

Gas industry facilities were also targeted, with dozens of reported attacks on [gas distribution stations](#), as well as the [destruction of gas distribution pipelines](#) throughout 2022 and early 2023. In July 2022, Ukraine [targeted](#) the so-called “Boyko towers”, part of the “Chornomornaftogaz” company that was taken over by Russia in 2014, causing an oil spill into the Black Sea. Since these strikes, heavy (emergency) flaring is visible at the location on [satellite imagery](#), ongoing for nearly a year. Marine pollution was also documented from strikes against the Ukrainian cargo tanker ‘MILLENNIAL SPIRIT’, which was hit in February and [July](#) 2022, causing the leakage of 6,000 tons of diesel fuel into the Black Sea.



In 2023, Russia continued cruise and ballistic missile strikes on Ukrainian oil infrastructure. [On February 16, a massive missile attack was carried out](#) on the non-working Kremenchuk and Drohobycz oil refineries, as well as a strike at the “KNK” oil refinery in Kirovohrad region, where an estimated six fuel tanks were damaged. [On April 4, a strike occurred](#) on the large oil depot in Rovenky town in occupied Donbas, which used to store fuel for the Russian group of forces in the occupied region.

The most recent [oil incident](#) occurred in Sevastopol, Crimea on April 29. The Ukrainian army attacked a fuel storage base for warships of the Russian Black Sea Fleet. Satellite imagery confirmed that at least seven silos were severely damaged by the strike, with three more tanks showing light damage. According to open source information, 40,000 tons of fuel was lost. The strike caused a severe fire from burning fuel, but post-strike analysis did not show wider impacts on soil near the facility. The attacked site is an oil transshipment terminal with its services and specialized units. Fuel oil of various grades and crude oil are supplied by rail. Tanks with a total volume of **135,000 m³** are used to store petroleum products. Protective concrete embankment of the tank farm is designed to hold 50% of the volume of liquid in the tanks.

According to information on the official government website that tracks the environmental damage of the Russian invasion, called “[EcoZagroza](#)” of the Ministry of Environmental Protection and Nature Resources of Ukraine, the attacks on oil infrastructure caused over 144 tons of oil being burned, equal to nearly 500 tons of emissions of burning hydrocarbons. In addition, damage to oil facilities resulted in roughly 15,000 tons of oil leaked into the soil, and over 11,000 tons of oil spilled into surface waters. These numbers have not been independently verified. Additional information on damage from oil fires and the spillage of oil products into soil and water, calculated in monetary equivalent, can be also found on the website.



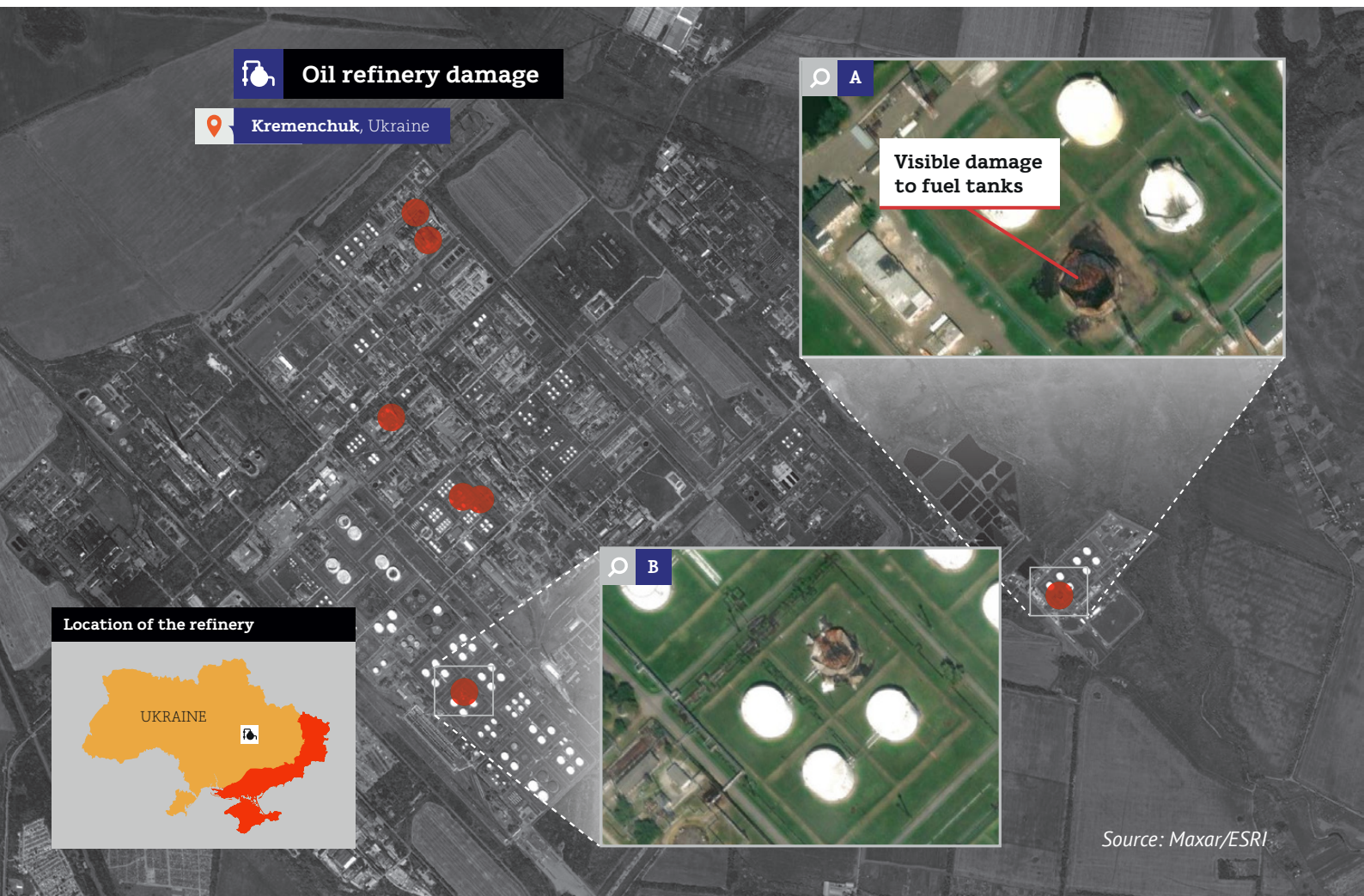
Case studies



Kremenchuk Oil Refinery

Prior to the war, the [Kremenchuk Oil Refinery](#) was the largest petroleum products enterprise in Ukraine, with an installed capacity of 18.6 million tons of crude oil. The enterprise covers an area of 1,500 hectares. The refinery was of significant importance for Ukraine as one of its sources for creating a strategic reserve of oil products, providing more than 30% of the entire Ukrainian market. Advantageously located in the country's central Poltava region, the oil refinery benefitted from a developed network of railway and road transport, allowing it to transfer its products both within Ukraine and abroad, through the seaports of Odesa, Mykolaiv, Kherson and Berdyansk.

In the course of the war, there have been recorded at least five attacks on the refinery. According to [the latest data](#), Russia has fired at least 32 missiles at the Kremenchuk refinery.



Timeline of Attacks on Kremenchuk Oil Refinery

- April 2, 2022** The head of the Poltava Regional Military Administration [reported](#) that Russian forces conducted massive shelling of the Kremenchuk Oil Refinery and the surrounding warehouses of fuel and lubricants. Several people were injured and received burns. Ukraine's State Emergency Service spent two days extinguishing the resulting fires. Other data sources showed the [aerial footage of the Russian strike](#) on the refinery. As a result of this attack, the infrastructure of the enterprise was severely damaged, leading to a halt in operations.
- April 24, 2022** Russia struck the Kremenchuk oil refinery with long-range missiles
- May 12, 2022** Four Russian missiles hit the Kremenchuk refinery
- June 18, 2022** Six Russian missiles hit the Kremenchuk refinery
- February 16, 2023** A massive missile attack was carried out across Ukraine, including the Kremenchuk oil refinery. The administrative building and 15 private houses were damaged during the bombing.

Despite the damage to the refinery, Russian forces have continued to bombard it. Over the following months, there were four more reported incidents of missile strikes launched, while another massive air strike occurred in 2023:

Lysychansk Oil Refinery

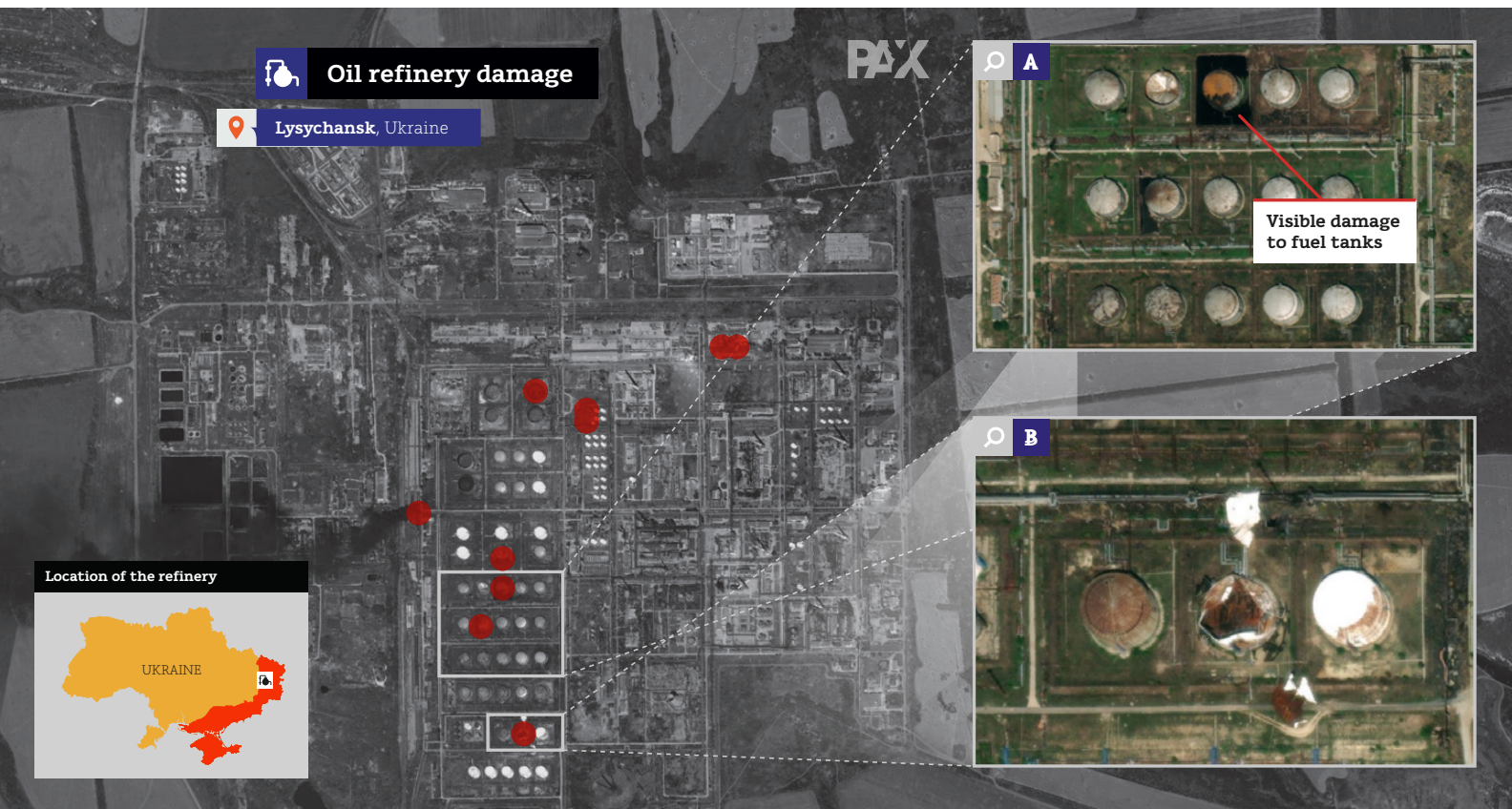


Lysychansk oil refinery (PJSC Linik) is located in the town of Verhnyokamyanka, Luhansk region, and has been [owned by the Russian state enterprise Rosneft](#) since 2013. Refining operations were [stopped in 2012](#), as the production was unprofitable, although some residual fuel was still present in tanks and pipelines. It is the second largest oil refinery in Ukraine, with a declared capacity of 16 million tons of oil refining per year and more than 800 hectares of territory. The capacity of its tank farm is about 14,000 cubic meters. The main products are solid, liquid, and gaseous fuels and similar products.

Since the start of the full-scale war in February 2022, Russia has bombarded the Lysychansk oil refinery, damaging its infrastructure. The plant was [captured by Russian forces](#) in July 2022. Satellite imagery analysis shows hundreds of impact craters from artillery or mortar rounds on the facility's grounds, with severe damage to various administrative buildings and technical facilities. At least nine fuel storage tanks were destroyed or severely damaged, causing massive fires and contributing to vast amounts of hydrocarbons burning up. In addition, there is also visible damage to pipelines throughout the facility, which caused oil spills on the sites of impact, potentially impacting groundwater reservoirs. The area around the facility is peppered with thousands of impact craters, as can be identified on publicly available satellite imagery.

Timeline of attacks on Lysychansk Oil Refinery

- **March 22, 2022** As a result of an **airstrike** on the Lysychansk Oil Refinery, a fire broke out.
- **April 16, 2022** The Lysychansk oil refinery was bombed, resulting in the fire spreading over 5,000 square meters, as **reported** by Serhii Haidai, the head of the Luhansk Military and Regional Administration. Haidai mentioned that this was not the first shelling of the refinery, as it had been systematically targeted by Russian forces before with the purpose to exhaust the local Ukrainian emergency services. While there was no more fuel at the plant, the remains of oil sludge were burning - a mixture of water, mechanical impurities, and chloride salts with oil or oil products, which settled in the tanks.
- **April 24, 2022** The Lysychansk oil refinery was **hit** for a third time.
- **May 8, 2022** Another **shelling** of the oil refinery, leading to the fire at the sulfur extraction plant and the substance mixing station. The area of the fire was reportedly 360 square meters, with a threat of explosion for a nearby group of fuel tanks.
- **May 26, 2022** The Lysychansk oil refinery was **damaged** again in a strike. **Black smoke** from the fire was seen from a bombed oil refinery the following day, May 27.
- **June 26, 2022** Another missile strike hit the refinery, causing a fire that took two days to be extinguished.
- **August 1, 2022** Satellite imagery from this day showed a large fire at the Lysychansk oil refinery in Luhansk region, although the facility was captured by Russian forces the previous month.



The incidents for the two refineries described above are a part of a series of attacks on Ukraine's oil and gas industry that were recorded in the PAX database. Explosions of tanks or pipelines always start a fire that is difficult to extinguish and, based on the available data, the elimination of a fire took two days on average. In a situation where there is no safe access to a fire site in an active war zone, the burning time of oil products or gas can last for multiple days, releasing substances hazardous to the environment and human health into the atmosphere, contributing to climate change through the release of greenhouse gasses during a fire, and destroying biodiversity at the location of the incident. Subsequent oil spills from leaking pipelines and storage tanks can go beyond the protected areas and seep into the soil, potentially affecting groundwater sources. Understanding these environmental risks and possible effects on public health can help to take preventive and mitigating measures on affected sites to minimize these negative impacts.

Brief Analysis of Strikes on Fuel Infrastructure

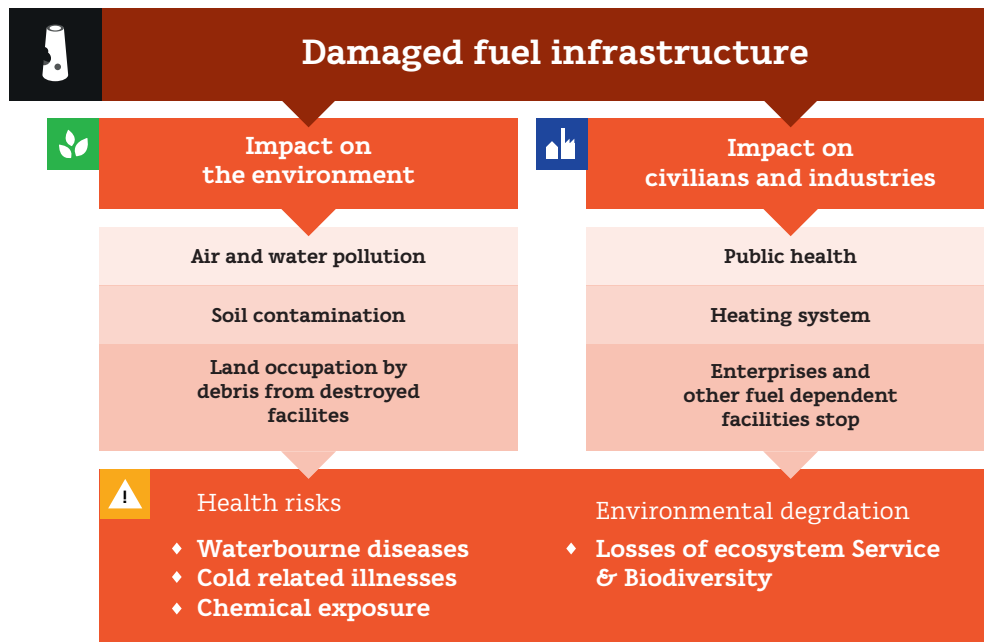
The following take-aways can be drawn from the analysis of documented attacks on Ukraine's fuel infrastructure:

- ◆ **Geography of attacks.** Oil and gas sites that have been damaged by military actions are located across the whole of Ukraine's territory, occurring in 20 of 24 regions as well as Crimea. The largest number of strikes were carried out in the areas of active hostilities in 2022-2023: primarily in Donetsk and Luhansk regions, although fuel facilities in Kyiv, Kharkiv and Mykolaiv regions also witnessed frequent attacks. Russian air strikes hit oil depots in the south and west of Ukraine, located in densely populated areas, including Lviv and Odesa.
- ◆ **Types of attacked fuel sites.** Out of 66 verified recorded incidents, 12 attacks targeted oil refineries and 44 more targeted fuel depots, meaning that oil facilities were the main targets of strikes.
- ◆ **Consequences of attacks.** As a result of Russian missile attacks, the main Ukrainian oil refinery in Kremenchuk was damaged and taken out of production, and oil refineries in both Odesa and Lysychansk were severely damaged. Ukraine's oil industry has thus been severely crippled, making the country almost 100% dependent on imported petroleum products. Moreover, for the period from February 24, 2022, to April 2023, about [30 oil depots](#) have been destroyed or significantly damaged in Ukraine.

Beyond the disruption of fuel supplies, economic losses and humanitarian effects, these attacks also pose a high risk of contamination of the environment and long-term impacts on public health of the communities in the vicinity of the targeted locations. Assessment of the amount of fuel burned also provides insights into the larger environmental footprint of the war and wider pollution risks associated with military activities in relation to the climate crisis. Environmental aspects of military damage to fuel sites and its possible consequences for human health are also considered in the relevant sections below.

Environmental and Public Health Risks

Missile strikes and shelling of gas and oil infrastructure have direct consequences in the form of the release of pollutants from oil products and the missiles themselves, from fires at oil depots and gas pipelines. Toxic substances could also enter into soil and water bodies in the affected area, impacting ecosystems, as well as forming debris containing hazardous substances from destroyed or damaged facilities. Interrelated patterns of environmental and public health risks associated with damage to fuel infrastructure is outlined in the graphic below.



Along with the direct impact on the environment, the targeting of fuel sites has significant cascading consequences that lead to the disruption of critical infrastructure, including limitations or a full stop of gas supply of industrial facilities and heating systems for households, which affect the health and well-being of civilians. As result of these strikes on energy infrastructure in the winter of 2022-2023, an estimated 244,000 users across Ukraine, including families, business enterprises and services such as schools or hospitals, had **no gas supplies** for days or even weeks, essential for heating premises and cooking. Thus, in addition to risks of the short- and long-term impacts associated with chemical releases of hazardous substances, damage to fuel infrastructure creates the conditions for a humanitarian crisis from a lack of access to energy supplies.

Environmental risks

Damage by conflict-related explosions of facilities at fuel infrastructure can create direct ✓ and indirect ⤿ impacts on the environment, as the following table explains.

Nr.	Type of incident	Environment's Component					
		Air	Water	Soil	Ground water	Climate	Eco system
1	Fires at oil and gas infrastructure	✓	⤿	⤿		⤿	✓
2	Leaks at oil infrastructure	✓	✓	✓	⤿		✓
3	Fires at gas wells within marine waters	✓	✓			✓	✓⤿
4	Debris of damaged facilities	⤿	⤿	✓⤿	⤿		⤿

The main risk to all the environmental components from attacks on the fuel infrastructure is created by **explosions** resulting in gas or **oil fires, oil leaks, and debris**. Oil and natural gas are flammable substances, and for this reason, the use of explosive weapons against such facilities causes massive fires that are difficult to extinguish and which contributes to air pollution and create additional human health risks. This particularly concerns wartime situations, characterized by risks of additional strikes, as well as fatigue and limited capacity among staff and equipment.

Oil fires. On the one hand, direct environmental pollution occurs from [the combustion of oil and oil products](#) by emissions of soot (mostly carbon) and gasses (mainly carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, volatile organic compounds [e.g., benzene], polycyclic aromatic hydrocarbons, hydrogen sulfide, and acidic gasses [e.g., sulfuric acid]). Nitrogen and sulfur compounds are associated with acid rain, which can lead to the acidification of soil that destroys vegetation and can cause severe short-term health effects.

On the other hand, fire extinguishers contain [fluorinated chemicals](#) such as PFOS (perfluorooctane sulfonate) and PFOA (perfluorooctanoic acid) that are classified as environmentally hazardous substances due to their toxicity, persistence, bioaccumulation in the food chain, and ability to travel long distances. Another indirect impact is the spread of hazardous substances well beyond places of incidents, which could contaminate groundwater sources throughout the soil and potentially penetrate into nearby rivers, lakes or other surface water resources that are used for drinking water resources or agricultural purposes.

Gas & oil fires. During natural gas and oil explosions and fires on pipelines or storages, air pollution by emissions of [greenhouse gasses](#) such as carbon dioxide (CO₂), methane (CH₄), and Nitrous oxide (N₂O) contributes to climate change. This also concerns the release of [methane](#), a very potent greenhouse gas which is able to trap a significant amount of heat and is responsible for roughly 30% of the rise in global temperatures since the industrial revolution.

Oil leaks. Damaged or destroyed oil storage facilities can leak into the surrounding environment with **toxic chemicals** like benzene, toluene, xylene, ethylbenzene, styrene, sulfur and nitrogen, as well as metals such as iron, nickel, copper, and vanadium. These chemicals do significant harm to ecosystems. **Oil leaks** may pose a significant hazard to land resources (fertile soil, wetlands), aquatic ecosystems (both marine and freshwater environments), vegetation and animals.

Soil largely accumulates pollutants due to its absorption abilities, **affecting** soil biocenosis, changing the chemical composition, structure and properties of soil, and reducing soil fertility and arable value. Highly oil-polluted soil has practically no biological processes, typically transforming into technogenic desert that is not suitable for agricultural and recreational uses.

Oil pollution can be especially problematic for local ecological receptors, as certain animals are very sensitive to exposure to petroleum compounds. The consequences of oil spills can be harmful to fish, birds and mammals through direct physical contact, toxic contamination, destruction of food sources and habitats, and reproductive problems.

Debris. There is also secondary pollution of water, soil and groundwater due to the seepage of contaminants like asbestos and heavy metals from the debris of damaged facilities, as well as the settling of particulate emissions from the air.

Ukraine Fuel Facility Hit by Russian Missiles, Lviv, Ukraine - 27 March 2022



The environmental impact of attacks against fuel infrastructure is thus multifold, ranging from air pollution to waterways and soil contamination, all of which poses risks (potentially with long-term impact) to nearby communities that rely on environmental resources. Explosions, fires and oil leaks also pose high risks to on-site staff being killed or wounded, and impact living organisms in the vicinity of the strike site, potentially resulting in the loss of their habitats. All these factors can cause the degradation of the local environment with subsequent losses of biodiversity and ecosystem services, particularly if limited remediation action is undertaken.

Firefighters are at work to put out a fire at an oil depot near Chuguiv, Kharkiv region, following Russian missiles strikes on April 22, 2022.



Health Hazards and Risks

The air, water and soil are the main pathways of the spread of hazardous substances from damaged oil sites that are harmful for human health and all organisms living in this environment. The routes of exposure include inhaling polluted air, eating food grown in contaminated soils and surface water, and drinking water from poisoned sources. This is described further in the table below, based on the toxic properties of the components released during oil and oil products fires.

Pathways of exposure	Routes of exposure	Health hazards and risks
Air	<p>Inhalation of chemicals and particles carried in smoke plumes near the source or beneath the plume is the primary route of exposure. Factors affecting human exposure and potential health hazards from burning oil:</p> <ul style="list-style-type: none"> ◆ Duration of the fires ◆ Weather conditions ◆ Proximity of population to the fires ◆ Concentrations of harmful pollutants in the breathing zone of adults and children ◆ Availability of enclosed shelter and personal protection such as face masks ◆ Health conditions of affected populations 	<p>Hazards</p> <ul style="list-style-type: none"> ◆ Sulfur dioxide (SO₂) and nitrogen dioxide (NO₂) are gasses that are reactive, toxic, and a strong irritant for people by forming acids. ◆ Carbon monoxide (CO) is a common by-product of incomplete combustion, with acute toxicity. ◆ Particulates are mostly elemental carbon (soot) and hydrocarbons. The lower the particulate's size, the longer it remains suspended in the air. ◆ Polycyclic aromatic hydrocarbons (PAHs) are characterized as carcinogens. ◆ Toxic metals: lead and mercury are harmful toxicants to human health. <p>Risks (by air)</p> <p>The main target system of gasses and smaller particles is respiratory – nose, sinuses, throat, lungs. Pre-existing breathing conditions, children and people with cardio-respiratory conditions are at higher risks.</p>
Soil and surface water	<p>Significant deposition of plume components in soil and open water.</p> <p>In aquatic environments the toxic metal mercury is converted to methylmercury, which bioaccumulates and biomagnifies in aquatic organisms.</p> <p>Fish and shellfish contaminated by mercury are a source of exposure to people who regularly eat these foods.</p>	<p>Risks (by soil and surface water)</p> <p>Low-level dermal and ingestion exposure to PAHs and toxic metals.</p> <p>Lead is harmful to the brain and nervous system of children. Chronic exposure can also increase the risk of cardiovascular and kidney disease in adults.</p> <p>Mercury: high levels of exposure to methylmercury damage the central nervous system and are also harmful to the developing fetus.</p>

The massive release of carbon-hydrates and burning gas can have serious acute and long-term health impacts on exposed people. The type of risks depends on both the pathway and the receptors, as well as the amount and type of substance people are exposed to, as fuel products contain a range of hazardous pollutants.

Oil-related substances such as benzene, toluene, ethylene and xylene (BTEX), which are short-chained aromatic compounds, have highly mobile and volatile properties, while long-term exposure to very persistent organic compounds of polycyclic aromatic hydrocarbons (PAHs) may lead to the variety of [health problems](#) - respiratory disorders, liver problems, kidney disorders, and cancer, depending on the duration and intensity of exposure. When released by fires, PAHs can be transported over a large area before being deposited in soil. Another aspect of oil incidents

involving fires is that **fluorinated firefighting foam** can cause water contamination by toxic chemicals associated with cancer, endocrine disruption, and harm to fetal development.

To summarize, civilians in the zone of influence of affected fuel sites face high risks of both acute injuries and long-term chronic diseases, while their health may also be affected by contaminated water and soil resources, especially if environmental monitoring and remediation efforts are not conducted.

Conclusion and Recommendations

Russia's full-scale invasion of Ukraine was accompanied by dozens of attacks on various types of fuel infrastructure facilities throughout the country. These strikes have hit oil depots, refineries, pipelines and gas drilling platforms, considerably impacting the local environment and posing additional public health risks, having both an intense short-term effect from the release of pollutants into the air during explosions as well as long-term health impacts on nearby communities from large-tonnage oil spills.

Beyond their effects on the environment and public health, Russia's targeting of Ukraine's oil and gas infrastructure has additional humanitarian and socioeconomic impacts. Ukraine now depends on fuel imports from partner countries, while the shortages of affordable energy supplies affect Ukraine's industrial sector and the livelihoods of Ukrainians, especially during the winter period when the need for heating and cooking are particularly acute.

As argued in this report, such conflict-related incidents require an immediate response and further action to clean up the contaminated areas. In this regard, the following measures to mitigate environmental harm and decrease human health risks in Ukraine are recommended, and where additional support to Ukraine from the international community is warranted in terms of providing capacity, equipment and training:

- ◆ **Improving emergency response:** to be prepared for immediate response to incidents that are specific to the oil and gas industry sites, including the elaboration and implementation of pollution incident response planning to deal with polluting foams safely, and to control firewater in order to avoid foam and firewater entering the environment;
- ◆ **Mapping of high risk sites:** A coordinated effort by the Ukrainian government with support of relevant EU and/or UN organizations to bring different datasets and expertise from governmental and civil society groups together. These can be used to create a list of priority contaminated sites after military incidents that will support improved planning, clean-up and remediation measures. Documentation of broader environmental impacts from oil and gas conflict-related damage can also be relevant for accountability mechanisms linked with environmental damage.
- ◆ **Assessment of contaminated sites:** The Ukrainian government, with support of international experts, should conduct pilot projects of environmental sampling at contaminated sites, when and where the security situation allows, and to assess the contaminated sites. Based on the assessment results, further development of a remediation plan of the affected area

and the facilitation of environmental recovery will be needed. Additional support to civil society groups, local communities and academic institutions to make use of citizen-science tools for sampling and monitoring should also be developed and implemented.

- ◆ **Exchange of experience:** Building on the previous coordination efforts, Ukraine and relevant international organizations, including environmental experts, should share successful cases of land remediation after incidents on oil sites in other armed conflicts. For example, a UNEP pilot project applied [biological remediation](#) to clean up the contaminated sites by oil spills in Iraq' the use of [Nature-based Solutions](#) (NbS) during restoration of the environment in affected areas could also be explored.

Fuel infrastructure is one of the main targets of Russian missile attacks at various areas of life support in Ukraine. Water infrastructure, the [energy sector](#), and the [agricultural industry](#) are being damaged, including where facilities with hazardous materials are located. The environmental safety of such industrial facilities depends on preventing accidents and ensuring their safe operation, something impossible during armed conflict. Environmental damage is thus inevitable in war and should be addressed. In this regard, Ukraine needs the support of the international community in order to assess and minimize both the local and transboundary consequences of the war's impact on the environment. Thus, a [10-step action plan to address conflict-related environmental issues in Ukraine](#) was developed by various Ukrainian and international non-governmental organizations that have experience in the field of environmental protection in armed conflicts.

Burning fuel depot at Sevastopol, April 2023. Source: Twitter

