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# UKRAINE

## Energy Damage Assessment

EXECUTIVE SUMMARY

March 2023





**Completely destroyed 330kV 200M VA auto-transformer**

**Disclaimer:** The Ukraine Energy Damage Assessment Report was jointly prepared by the United Nations Development Programme (UNDP) and the World Bank with input from the Government of Ukraine. The report is based on data collected between 24 February and 31 December 2022, produced in a short timeframe to ensure the relevance of the damages. Given the ongoing nature of the war and the lack of access in territories temporarily not under government control, the data collection is primarily remote-based but validated through ground-based information. In-depth efforts have been made to check the accuracy of the information that was collected, analysed, and verified to the extent possible, including through site visits and satellite imagery. Given the constraints, the authors of the report cannot guarantee the absolute accuracy of the data included in this work. Boundaries, colours, denominations, and other information presented in this report do not imply any judgment on the part of the UNDP and World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.





**Completely destroyed combined heat and power plant**



**Damaged wind power plant**



**UNDP Ukraine and the World Bank, in cooperation with the Government of Ukraine, have carried out an Energy Infrastructure Damage Assessment for Ukraine.** This Energy Damages Assessment follows the Rapid Damages and Needs Assessment (RDNA) methodology that was globally established and recognized as Damage and Loss Assessment (DaLA) methodology jointly developed by the European Union, the World Bank Group, and the United Nations, which has been applied globally in post-disaster and conflict contexts to inform recovery and reconstruction planning. The report consolidates data from 24 February to 31 December 2022.

## Context

**Russia's invasion of Ukraine has resulted in civilian casualties, the displacement of millions of people, and widespread and significant destruction to homes, businesses, social institutions, and productive and economic activity.** Recorded civilian casualties amounted to 22,209 as of 20 March 2023, including 8,317 deaths and 13,892 injuries.<sup>1</sup> The invasion of Ukraine has also triggered the largest human displacement crisis in the world. Since the onset of the war, approximately 5.4 million people have been displaced within Ukraine and over 8.1 million have moved to neighbouring countries.<sup>2</sup> Ukraine's Gross Domestic Product (GDP) contracted by about 30 percent<sup>3</sup> in 2022, with economic activity scarred by the destruction of productive capacity, damage to arable land, and reduced labour supply. Poverty is estimated to have increased from 5.5 percent in 2021 to 25 percent<sup>4</sup> in 2022 and headline inflation hit 24.9 percent<sup>5</sup> in September 2022, with high food price inflation hurting the poor. The impact of the invasion will be felt for generations, with families displaced and separated, and deep disruptions to human development.

## Baseline

**Before the war Ukraine had a highly developed physical and social infrastructure. The energy sector played a key role in Ukraine's economic growth,** and supported the country's goal to modernize the economy. The energy supply sector represented 17 percent of GDP. One hundred percent of the population had access to electricity, and 94.9 percent had clean cooking fuel.<sup>6</sup> Central heating had high penetration (ca. 47 percent), particularly in the bigger cities. The gas distribution network covered 74 percent<sup>7</sup> of the population and 89 percent had clean water thanks to pumped water distribution systems.

## Description of damages

**Ongoing war and targeted attacks on energy infrastructure have caused extensive damage across the country.** Since 10 October 2022, Government of Ukraine estimates refer to more than 1,500 missiles and drones, as well as shelling and grenades, targeting the energy infrastructure of Ukraine, out of which more than 100 missiles are estimated to have hit large energy facilities. **In the electricity sector, the generating capacity has been reduced by 61 percent, due to damages from Russian Federation missiles or drone attacks.** In 2022, the available capacity<sup>8</sup> of Ukrainian power plants dropped from 36.0 GW to 13.9 GW.<sup>9</sup> About 10 GW of installed capacity remains in the territories under temporary military control of Russian forces and is not delivered to the grid, including a 6 GW Zaporizhzhia nuclear power plant.

**Ongoing war has destroyed almost the entire 750 kV high-voltage power grid used for power delivery from the Zaporizhzhia nuclear power plant in areas currently under the military control of the Russian Federation.** This creates significant problems for covering power consumption in the country and complicates the transmission of electricity from the western regions to the east. A total of 41 out of 94 crucial high-voltage transforming substations located in government-controlled territories have been damaged or destroyed by missiles or drones. More than half of these 41 substations have been hit more than once. The destruction of the high-voltage grid makes it impossible to fully cover needs.

<sup>1</sup> <https://www.ohchr.org/en/news/2023/03/ukraine-civilian-casualty-update-20-march-2023#:~:text=Related&text=From%2024%20February%202022%2C%20which,8%2C317%20killed%20and%2013%2C892%20injured>

<sup>2</sup> <https://www.unocha.org/ukraine>

<sup>3</sup> <https://www.worldbank.org/en/country/ukraine/overview#3>

<sup>4</sup> <https://thedocs.worldbank.org/en/doc/d5f32ef28464d01f195827b7e020a3e8-0500022021/related/mpo-ukr.pdf>

<sup>5</sup> <https://tradingeconomics.com/ukraine/inflation-cpi>

<sup>6</sup> Source: The World Health Organization (WHO) and the Global Health Observatory (2022)

<sup>7</sup> Source: State Statistics Service of Ukraine

<sup>8</sup> Generation capacity, available for usage within IES

<sup>9</sup> Source: Ukrenergo. Does not include RES and small regional CHP





**The gas sector infrastructure has also suffered significant damages.** The main gas pipelines with a total length of 27 km have been damaged or destroyed, of which 15 km have been restored, and about 20 km of branch gas pipelines have been damaged or destroyed (of which 17 km have been restored). Three compressor stations were damaged or destroyed (one of which was restored). Also, 175 gas distribution stations were disconnected (of which 92 gas distribution stations were restored). A total of 23 gas control stations were damaged and disconnected (of which 4 units were repaired).

**A large part of the district heating infrastructure in war-affected areas is damaged beyond recovery.** In addition, a large number of combined heat and power plants have been targeted, putting at risk district heating in the affected cities. The overall **value** of the damage (**\$1.2 billion**) is highly likely to be **underestimated**, considering lack of reliable information from areas, which are under the military control of the Russian Federation, where it is believed that district heating has been damaged or destroyed.

**As for the coal and mining sector, approximately a quarter of Ukrainian state-owned mines are located in territory currently under military control of the Russian Federation.** A significant problem is uncontrolled flooding of individual mines, which, according to the results of 2021, provided 3.2 percent of total production. The coal and mining sector damage was not quantified due to the lack of data. A summary of the damages to the key energy assets in physical terms is provided below.

## KEY ASSETS DAMAGED (PARTIAL OR TOTAL)

Type of energy assets	units	Baseline (before the war)	Currently working/ available	Damaged	Damages to the baseline, in %
Power generation plants, total	GW	36	14	22	61.4%
Thermal Power Plants and Combined Heat and Power Plants	GW	16	5	11	71.5%
High-voltage transforming substations	Stations*	94	53	41	43.6%
Heat-only boiler houses and central heating points	Units (houses and points)	24,548	23,968	580	2.4%
Gas distribution stations	Stations	1,389	1,366	23	1.7%

\* Only those located in government-controlled areas.

## Losses

**The damages to the energy infrastructure since October and the loss of access to the assets located on the in the territories under temporary control of Russian forces have led to over 12 million people suffering from energy supply disruptions.** Continuous and regular waves of attacks on energy infrastructure continue to cause destruction and have already left 12 million people across Ukraine with no or limited electricity, disrupting internet communications as well as water supplies and heating systems at a time when temperatures had fallen below zero in most parts of the country. The average Ukrainian household had to endure five cumulative weeks without electricity from 10 October 2022, to the end of December 2022, according to estimates based on Ukrenergo data. Resulting disruptions to gas and district heating networks and to electricity supply have also significantly affected the delivery of water in major cities,<sup>10</sup> as well as having a significant impact on the telecommunication and banking sector, e.g., processing of payments. The attacks also negatively affected the operational viability of the country and led to economic stagnation.

<sup>10</sup> Power cuts have been one of the major reasons for at least 4.6 million Ukrainians being deprived of access to safe water.



## Preliminary quantification of damages

**Preliminary estimates based on information shared by the Government of Ukraine, energy companies and other sources indicate that damage to energy infrastructure is more than 5 times greater than at the beginning of June 2022.** Damage to power, gas, and heating infrastructure and coal mining is **above \$1 billion** versus the \$2 billion estimated to 1 June, 2022 (including estimated damage to some assets located in territories temporarily not under government control).<sup>11</sup> The largest share of damage is in the power sector (close to \$6.5 billion). Within the power sector, the largest contributor to damages is the generation sector (\$3.9 billion) followed by transmission (about \$1.9 billion). Damage to nuclear plants reached about \$770 million, mostly at Zaporizhzhia nuclear power plant.<sup>12</sup> Damages to the power distribution sector are estimated at about \$404 million (without including assets located in territories temporarily not under government control). The lack of data in this category has likely led to underestimation. The gas sector damage estimates are around \$1.2 billion (vs the \$500 million estimated by 1 June 2022), which comprises damage to gas distribution infrastructure as well as those reported by the Gas Transmission System Operator. Damage to the oil sector, including fuel depots and fuel stations are estimated at close to \$1.7 billion. Damages to the coal and mining sector are not included in these estimations as they have not yet been fully quantified, because many of the mines are in the territories under the military control of the Russian Federation or combat zones. Damage in the district heating sector was based on estimates and previous data provided by the government and compared with previous estimations in some cities. Further verification would be needed for greater precision.

## Needs

**Preparation for the 2023/24 winter season need to primarily focus on restoring access to electricity supply for millions of Ukrainians as well as to critical social infrastructure, including heating, potable water, wastewater treatment and communication. Immediate needs to cover this are around \$1 billion and it is critical to provide funding as soon as possible to technically prepare for the upcoming winter.**

Among the many needs, two areas are particularly important:

- (a) High voltage transmission equipment. Expedited procurement and installation of the high-voltage equipment required to fully restore the capacity of the transmission network. The equipment required includes the following: (i) ca. 60 autotransformers (750...110 kV ratings); (ii) ca. 340 current and voltage transformers and phase shifting and regulating transformers; (iii) auxiliary equipment for high voltage transformer substations.
- (b) Additional generation and heating capacity for the most vulnerable cities. Expedited design, procurement and installation of reserve/ additional capacity in the most vulnerable cities is critical to ensuring non-stop operation of district heating, water supply and sewage systems during blackouts or periods of deep power supply limitations, as well as to provide additional flexible capacity for the grid, thus increasing overall stability and resilience of the Integrated Energy System of Ukraine. Between 300 and 500 MW of installed capacity of gas turbines and/ or gas piston engines are crucial for the 2023-2024 winter season.

**In the medium-term, reducing gas consumption will be a primary lever to establish Ukraine's energy independence as a part of the country's post-war recovery.** To reach energy self-sufficiency, Ukraine needs to implement decisive simultaneous actions in three directions:

- The immediate recovery of damaged or destroyed gas extraction facilities to limit the reliance on gas imports in the short-term;
- The further promotion of energy efficiency, particularly, for combined heat and power generation and municipal energy systems;
- The further development of decentralized power generation based on renewable energy sources incl. biomass, biogas, and waste to energy.

## Next steps

The damage and loss numbers will continue to grow as the war continues. It is forecasted that the **Ukraine Energy Damage Assessment may be periodically updated.** In addition, the conclusions of the report will inform a forward looking analysis related to the energy sector, with the view of providing policy recommendations and a mid- to long-term green outlook.

<sup>11</sup> Assets located in territories temporarily not under government control are estimated to be partially damaged (50 percent). It is likely that some of the assets are completely destroyed while others are almost intact. There is limited ability to verify those damages at this point.

<sup>12</sup> Source: Energoatom's telegram channel. [https://t.me/energoatom\\_ua/10475](https://t.me/energoatom_ua/10475)







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