Electricity and gas supply in Ukraine: Winter 2025/26

Security of supply analysis following the November 2025 attacks

Robert Devon CARR, Frank MEISSNER & Vladyslav MIKHNYCH

26. November 2025 – V1.1

SPONSORED BY THE

Federal Ministry of Research, Technology and Space

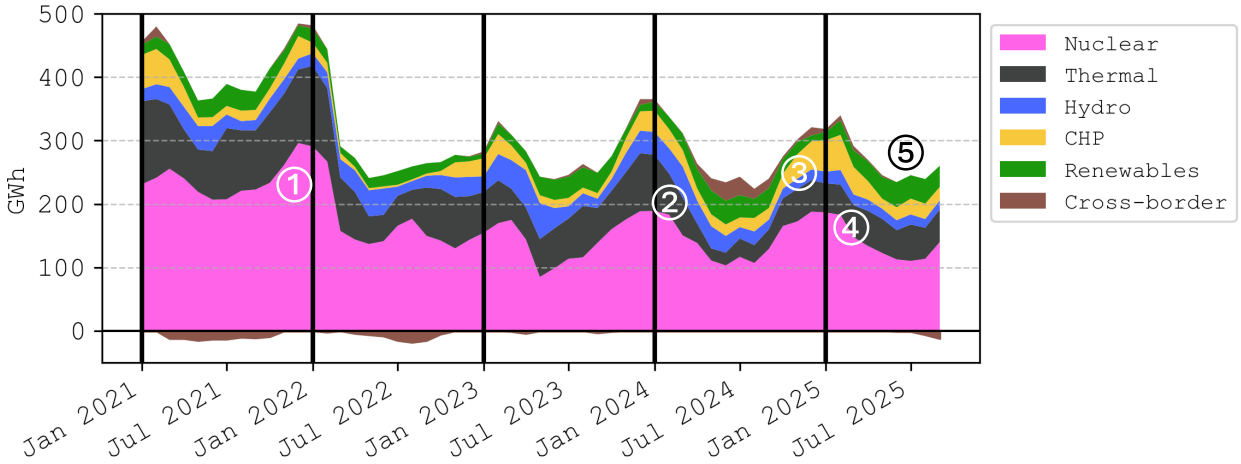
Scope and boundaries of our analysis

- Since late October, **Russia's intensified attacks on Ukraine's** energy system have caused the previously manageable winter electricity supply situation to deteriorate rapidly. A reassessment of the security of supply is needed.
- Our analysis rests on ever-shrinking and **uncertain data**:
  - Publication of official data is restricted, so we depend largely on long-term monitoring of Ukrainian news outlets and social-media sources.
  - The status of generators, the grid and transformers remains unclear; local outages may be worse than projected here if electricity cannot be transported within the country or from imports.
  - We are working to close these gaps, i.e by monitoring satellite data and collecting outage schedules.
- We provide an **overview of the power and gas infrastructure as of mid-November** and a forecast of gas storage levels through the heating season, based on domestic production and expected import increases after the late-October destruction. Unconfirmed reports of a near-full restoration of gas-production are not included.
- We present expected power outages, using capacity data from mid-November 2025, assuming no further attacks and no countermeasures.
- Finally, we show how the duration of scheduled outages for households increased after the attacks in November.

Electricity sector:
Review of the last 3 years of Russia’s war on the Ukrainian energy sector

Ukraine's electricity mix constantly adapts to Russian attacks

Average daily electricity supply in Ukraine by month (2021 – present)



Since the start of the Russian aggression, four major disruptions to the power supply in Ukraine have been identified:

① annexation of the **Zaporizhzhia NPP** in the winter of 2022 led to a loss of 6 GW of generation capacities,

② extensive destruction of **thermal capacities** in Spring 2024 resulted in significant generation losses,

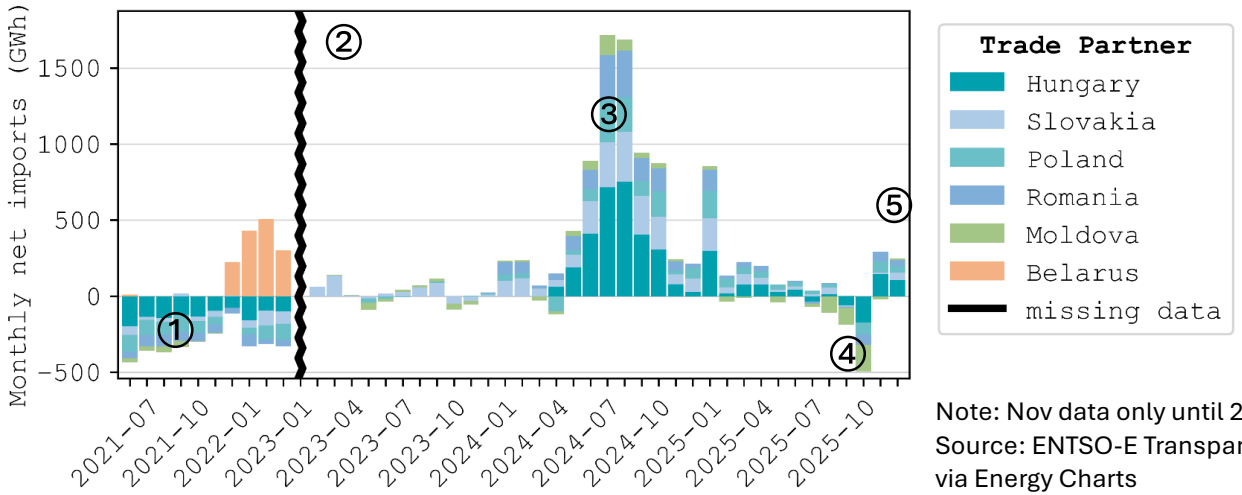
③ increase the **import limit for Ukraine** from 1700 to 2100 MW from 1st December 2024,

④ targeted attacks have continuously impaired **hydro capacities** - Ukraine's most flexible and fast-responding sources and

⑤ despite wartime damage and grid stress, **RES growth** remained resilient.

Ukraine turned back to a net importer in October following recent attacks

Ukraine Cross-Border electricity trade – monthly net imports (GWh)



Note: Nov data only until 20th
Source: ENTSO-E Transparency via Energy Charts

① **Prior to February 2022**, Ukraine was a net electricity exporter, integrated within the IPS/UPS system.

② **After full invasion**, synchronization with ENTSO-E early 2022 accompanied by a loss of imports from Belarus.

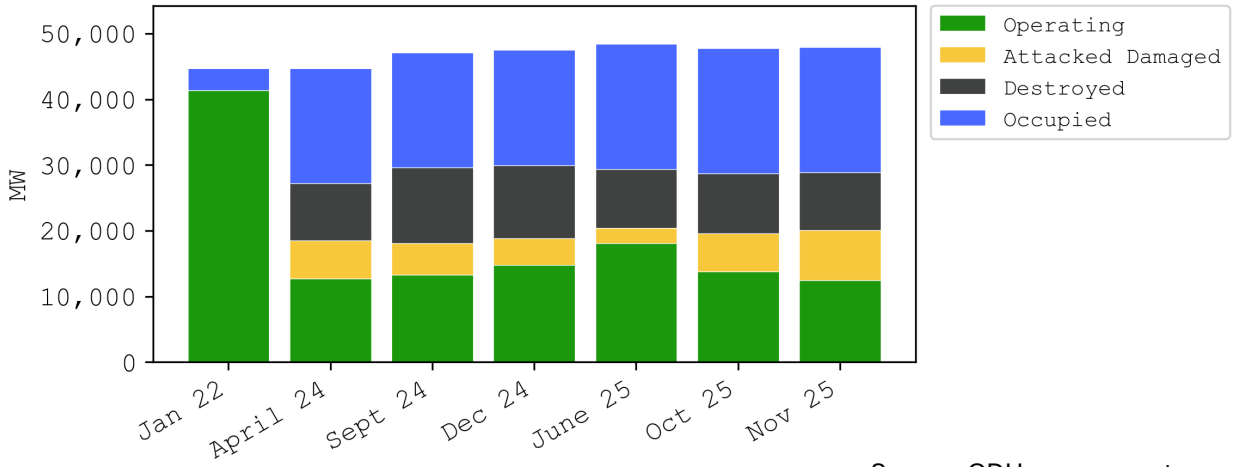
③ **Strong import surge** in mid-2024 (over 1.5 TWh/month) to cover domestic shortfalls after Russian attacks in spring 2024.

④ **Following capacity repairs in 2024,** imports stabilised, declined and net exports restarted from mid-2025 onwards.

⑤ **Import dependency rises again in October 2025** following further attacks by Russia.

Successful repair campaign over the spring/summer month

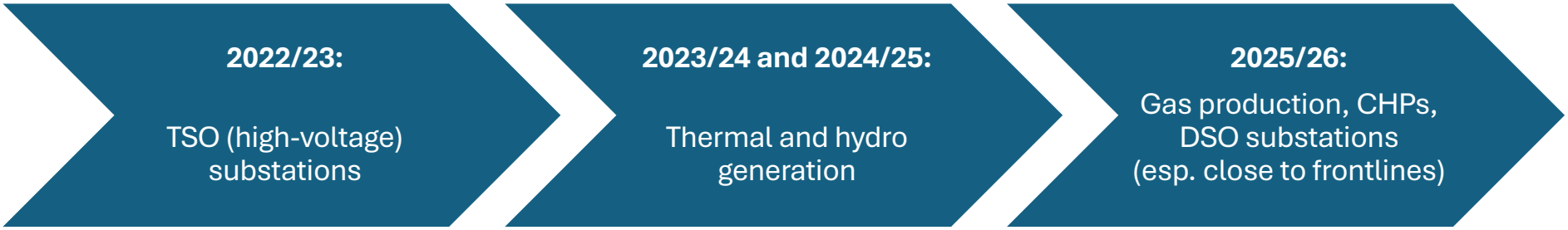
Installed capacity by operating status over time (excluding wind and PV capacities)



Source: GDU assessment

- Ukraine had **excess generation capacity before 2022**. This was particularly true for coal-fired power plants.
- Those were repeatedly subjected to **attacks by Russia, damaging the already old and inefficient infrastructure**.
- Destruction from **attacks in October 2025 has mainly affected CHPs, and infrastructure at DSO level**, such as transformers.
- Due to occupation and destruction, **renewable energy capacity fell from 9.6 GW (January 2022) to 7.4 GW in October 2025**.
- **November 2025 attacks** have hit coal-plants particularly hard, dropping available conventional capacity below 13 GW for the first time since April 2024.

Russians employ a variety of strategies to damage UA energy infrastructure

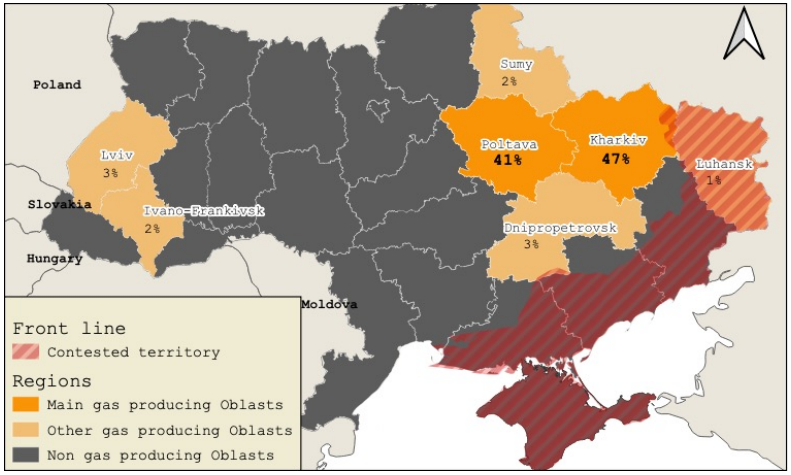


- During the first winter of the full-scale invasion, attacks focused mostly on the **high-voltage grid**, in particular high-voltage substations, in attempts to disrupt system operations.
- During the second and third winter, and especially since March 2024, Russia launched large-scale attacks on Ukraine's **thermal and hydroelectric power plants**. Electricity generation capacities take longer (and cost more) to restore than transmission, leading to extensive rolling blackouts after major attacks.
- In February 2025, and especially since October 2025, **gas production** was significantly affected by large-scale attacks, some sources imply losses of ~60% of production capacities.
- In the lead-up to the 2025/26 winter, we also observed an increase in attacks on **combined heat-and-power plants (CHPs)** and **medium/low-voltage substations** of the Distribution System Operators (DSOs), especially in areas close to the frontline.
- These strategies are **not mutually exclusive**, we still see continued attacks on high-voltage substations and power plants, but the shift in focus shows how the aggressor is adapting its strategy, requiring constant adaptation by Ukraine and its international allies to keep lights on and houses warm.

Gas sector:
Technical situation and winter 2025 – 2026 outlook

Overview of the gas sector in Ukraine

Regional shares of gas production (as of 2019)



Source: GDU based on Radio Free Europe

Key gas sector facts

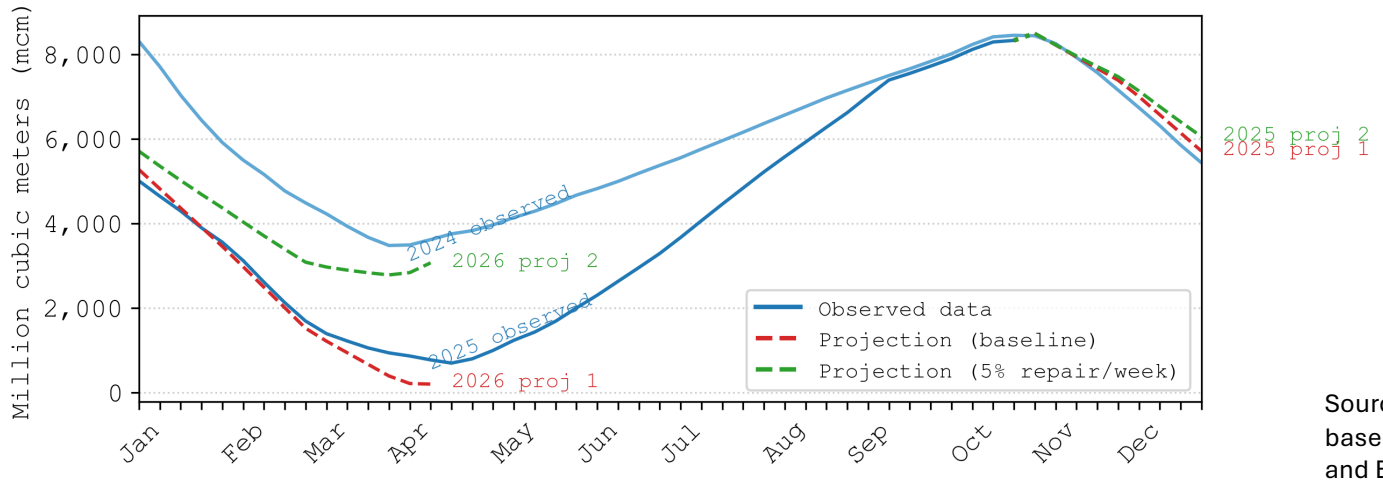
- Gas **consumption** declined from 80 million cubic metres per day (mcm/d) in 2021 to 55 mcm/d in 2023.
- During the winter, consumption is around 100 mcm/d, whereas in the summer it is only 23 mcm/d (2023).
- Over winter 2023, over 80% of gas was consumed by households, district heating, and CHPs.

- Gas **production** is concentrated in Eastern Ukraine.
- Total production was about 50 mcm/d in 2024, covering above 90% of consumption. Production reached 52mcm/d in July 2025.
- Russian attacks in October 2025 are said to have affect 60% of production capacities - this would imply a decline to 21 mcm/d.
- **Imports** must cover the difference. Available import capacities exceed 50 mcm/d.
- In July 2025 it was planned to import 26 mcm/d during the heating season 2025/26.
- An increase in winter imports of around 30% (+8 mcm/d) is planned from November onwards.
- **Storage** levels were at 8500 mcm in mid-October
- **Unconfirmed information from mid-November** indicates that 95% of production capacity is operational again (this is not reflected in our scenario).

Sources: IEA, Expro, Reuters, EIA, Interfax, Bruegel

October destructions could be managed with increased imports

Storage levels by week: 2024 - 2025 actual & projected (2 scenarios)



Source: GDU assessment, based on Bruegel, and Bloomberg

- Assuming the reported 60% lower gas production to continue from November 2025 to March 2026, and the same level of consumption and imports as last year, **gas storage would be depleted by March 2026.**
- Significant **reverse flows (imports) from EU** are expected to cover demand in this case (baseline).
- An **additional restarting of production** gradually (repairing ~5% of the currently destroyed capacities per week) would result in a stock of 3,000 mcm by March 2026.

Electricity sector:
Winter 2025 – 2026 outlook

Methodology

- We analyse two scenarios:
  - In a **baseline scenario**, we assess the load shedding needed, given our assessment of the current state of the system.
  - In a **"heat shock" scenario**, we assume that further destructions of CHPs in autumn 2025 (of about 1 GW thermal) are compensated for by additional usage of electric heaters in homes.

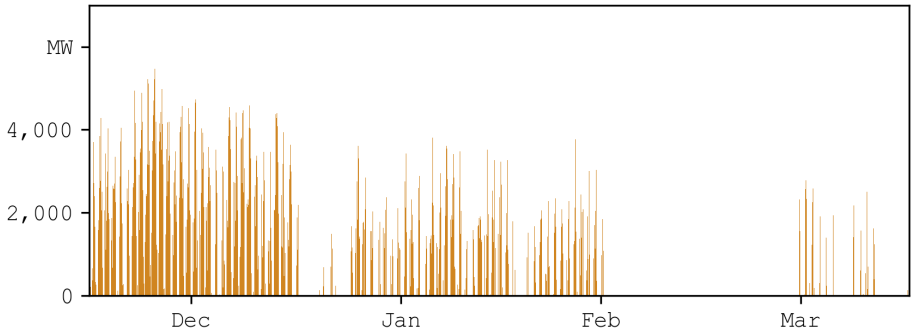
- This is based on an optimal hourly dispatch, taking into account:
  - fluctuating demand and generation from renewable capacities,
  - the technical parameters of thermal power plants,
  - maintenance schedule and the availability of nuclear power plants and
  - import capacities.

- We use a PyPSA-based (1) electricity system model, developed within the GDU project, to analyse the electricity sector. This model has already been used in previous analyses of necessary power outages.

(1) T. Brown, J. Hörsch, D. Schlachtberger, PyPSA: Python for Power System Analysis, 2018, Journal of Open Research Software, 6(1), arXiv:1707.09913, DOI:10.5334/jors.188

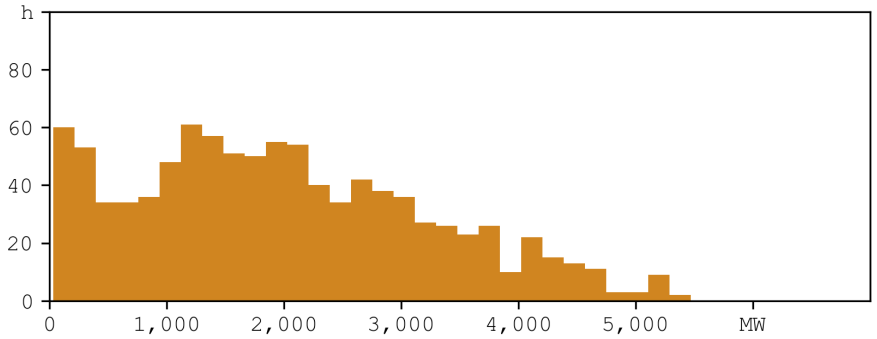
November outage analysis: **Baseline Scenario**

Load shedding trajectory



Source: GDU assessment based on PyPSA modelling outputs

Load shedding histogram



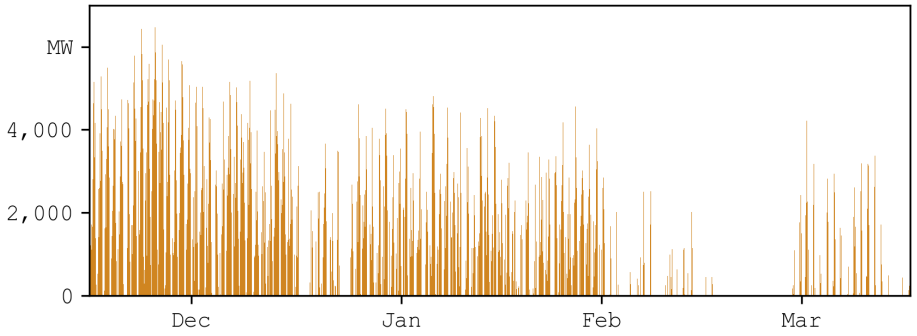
Source: GDU assessment based on PyPSA modelling outputs

- In the baseline scenario, we assume:
  - Our assessment of operating generation capacities is correct and remains unchanged till April 2026
  - Net electricity demand of 32TWh from December 2025 to March 2026.
  - Import capacities are increased from 2100 MW to 2300 MW in December 2025.

- Load shedding is required in 35% of hours and sums up to about 2 TWh.
- The maximum load shedding is about 5.5 GW, representing approx. 34% of the peak load.
- **Compared to our October outage analysis based on operating capacities as of October 24th, load shedding has increased sixfold.**

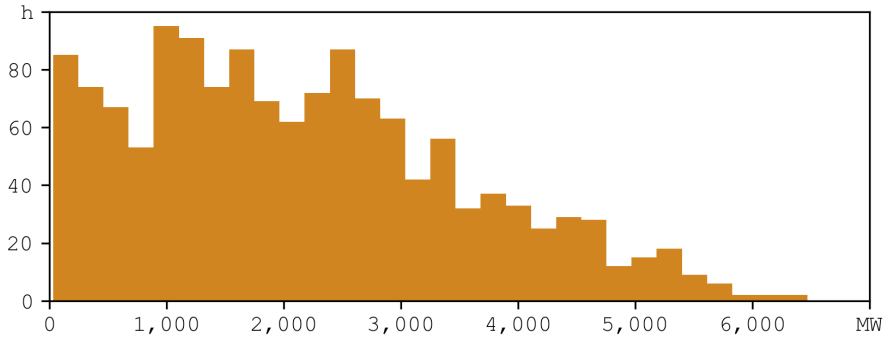
November outage analysis: **Heat Shock Scenario**

Load shedding trajectory



Source: GDU assessment based on PyPSA modelling outputs

Load shedding histogram



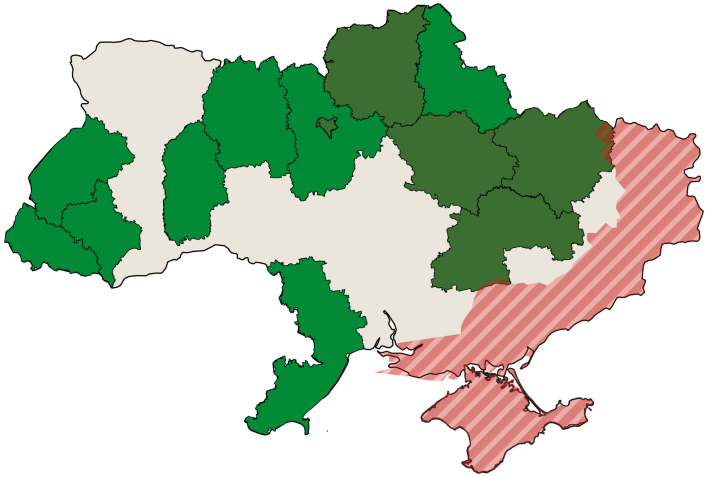
Source: GDU assessment based on PyPSA modelling outputs

- In the heat shock scenario, we assume:
  - Same assumptions as the baseline scenario, but
  - Electric heating increases electricity demand by 2 TWh: we assume households substitute district heat with electrical space-heaters in morning and evening hours of working days and from morning to evening on weekends.
  - The required electricity for additional electric heat (GW per hour) is temperature-adjusted based on climate year 2019.

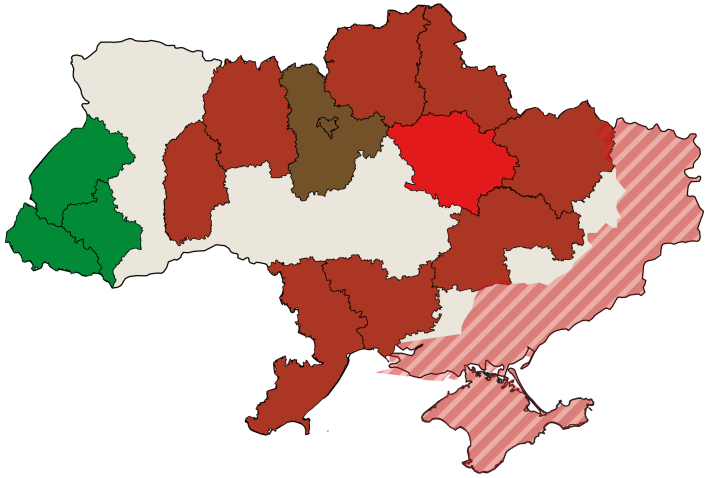
- Load shedding increases by 30% and sums up to 3 TWh.
- The maximum value is 6.5 GW (1 GW more than in baseline).
- Load shedding takes place in about 50% of the hours.
- Most load shedding occurs between 3 p.m. and 6 p.m.
- As unserved heating demand during load shedding hours will be compensated for later - additional electricity demand not modelled here might arise.

Scheduled power outages for household consumers by Oblast (ø hours per day)

27 October – 2 November



10 November – 16 November



Source: GDU assessment based various local DSO posts

- We compared scheduled power outages for household consumers in 14 Oblasts over two one-week periods: one before and one after the massive November attacks.
- The results revealed a significant increase in the average length of outages.

Contested territory

Daily hours with scheduled outages:

- 0 - 3
- 3 - 6
- 6 - 9
- 9 - 12
- Over 12

green deal UKRAINA

greendeal.ua@helmholtz-berlin.de

HZB Helmholtz Zentrum Berlin

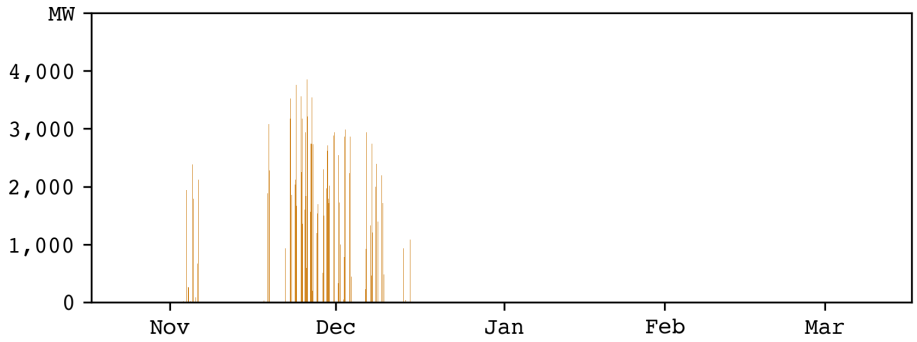
Forum Energii
Analizy i dialog

dixigroup

екодія
ecoaction.org.ua

For comparison: outage analysis based on state of the system in October

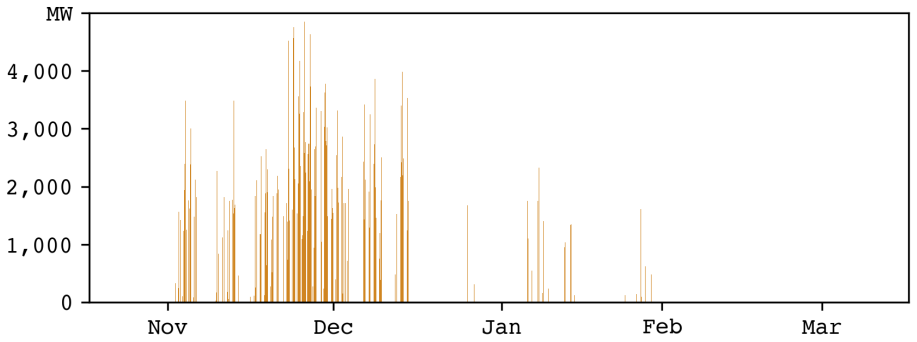
Baseline scenario



Source: GDU assessment based on PyPSA modelling outputs

- **Analysis based on information available as of October 24th and the destruction that had occurred up to that point. Modelled period is from November 2025 to March 2026.**
- Total net electricity demand is assumed to be 40 TWh from Nov-2025 to Mar-2026.
- Load shedding is required in 5% of hours and sums to 0.3 TWh.
- The maximum load shedding is about 4 GW, representing approx. 22% of the peak load.

Heat shock scenario

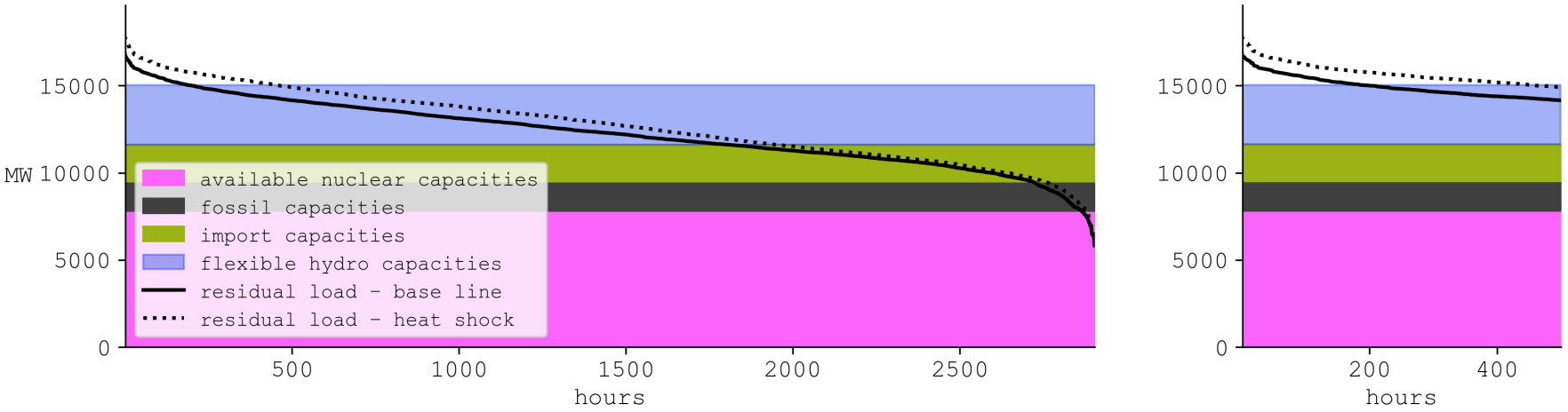


Source: GDU assessment based on PyPSA modelling outputs

- Assumption: a substitution of gas and district heating by electric heaters increase demand by 2 TWh mainly in the afternoon and evening hours.
- Under this assumption, load shedding takes place in 11% of the hours and sum up to 0.75 TWh.
- As unserved heating demand during load shedding hours will be compensated for later – additional electricity demand not modelled here might arise.

Scenario comparison

Load duration curve and available capacities for baseline and heat shock scenarios



Source: GDU assessment based on PyPSA modelling outputs

- The figures show that imports and flexible, albeit uncertain, actions such as hydro power plants and storage facilities must bridge the gap between thermal and fossil fuel capacities and residual load (demand minus wind and PV generation).
- As can be seen from the right section of the graph, demand will definitely not be met within about 400 hours in the case of the heat shock scenario.