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Sustainable Restoration of the Power and Heat Sectors in Ukraine: Implications for Energy Security and Resilience

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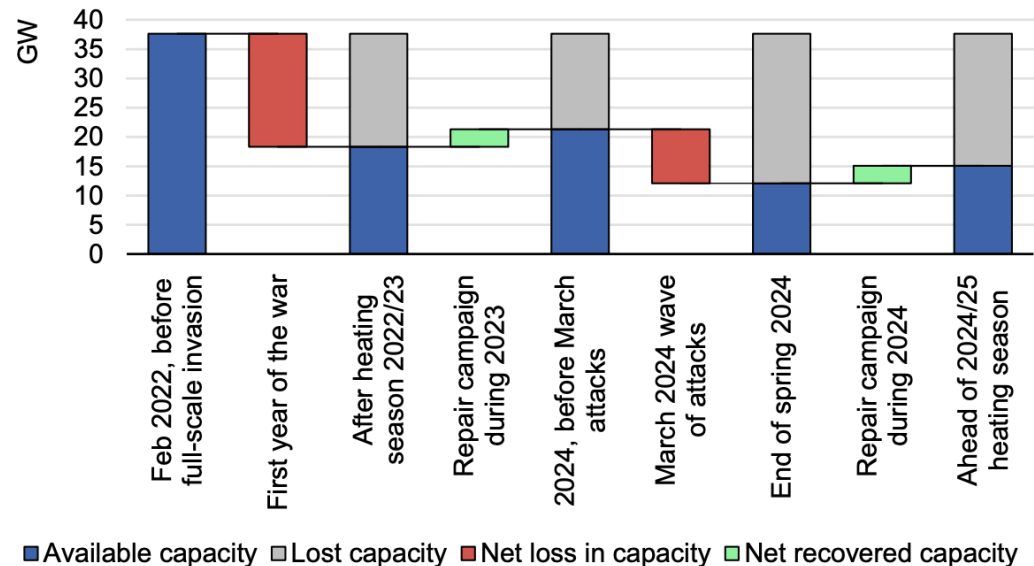
The IAM COMPACT project has received funding from the
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Motivation

- Nearly two-thirds of Ukraine's dispatchable power generation capacity has been occupied, damaged or destroyed by Russia since the invasion.
- Repeated Russian missile and kamikaze drone strikes have triggered widespread rolling blackouts, disrupting daily life for tens of millions and severely constraining access to electricity across Ukraine.
- Economic and energy resilience now depends on whether Ukraine can restore its electricity sector, the largest source of GHG emissions, into a more decentralised and sustainable system.
- Replacement of large fossil-fuel power plants with distributed energy resources will result in a more resilient and secure system but requires advanced modelling tools, integrated planning, and a cross-sectoral approach.
- The KSE modelling presents scenario-based insights both Ukrainian and EU's public authorities for planning sustainable restoration of the power sector after the end of the war and established strong peace.

Available installed capacity of dispatchable power generation in Ukraine



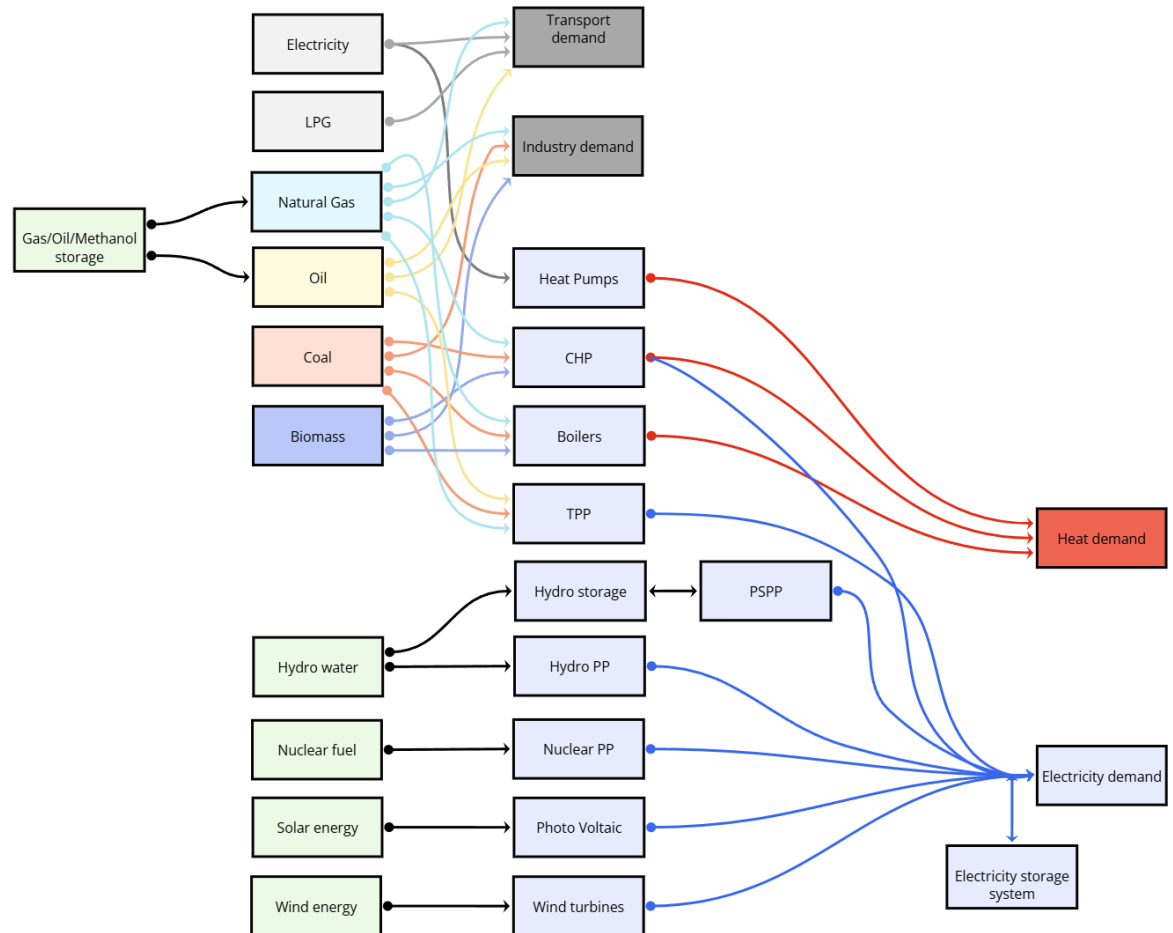
IEA. CC BY 4.0.

Source: IEA, 2024. *Empowering Ukraine Through a Decentralised Electricity System*, <https://iea.blob.core.windows.net/assets/1cb1324f-e145-41c3-b0c2-d78561b4f1fd/EmpoweringUkraineThroughaDecentralisedElectricitySystem.pdf>



Model Design

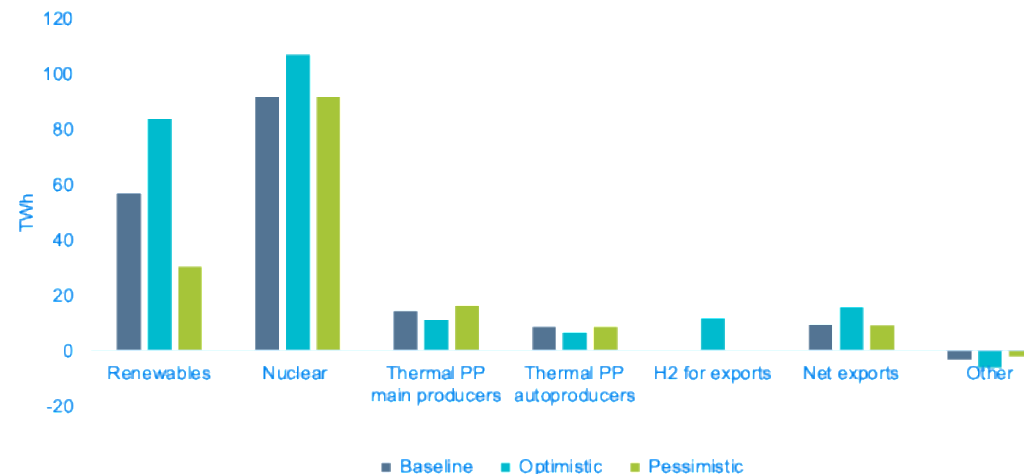
- KSE Institute employed [the EnergyPLAN](#) model, developed by the Sustainable Energy Planning Research group at Aalborg University and benefited from the assistance of its development from Aalborg University within the IAM COMPACT framework.
- The model enables the study of national energy systems' operation on an hourly basis, including electricity, heating, cooling, and transport.
- We developed three alternative scenarios based on a mixture of key drivers and enabling conditions, e.g. the end of Russian invasion, speed of the EU acquis implementation, implementation of the policy targets and measures, etc.
- The electricity generation is projected to increase to 161 TWh, 178 TWh and 225 TWh in pessimistic, baseline and optimistic scenarios respectively by 2035.



Model Results

- Nuclear power plants remain the backbone of the electricity sector, accounting for approximately 58% and 61% of domestic demand in the baseline and optimistic scenarios, respectively.
- The share of renewable power in domestic electricity demand increases sharply in both baseline and optimistic scenarios to 37% and 45%, respectively, by 2035, from 13% in 2025. In the pessimistic scenario, it rises to just 24%, leaving Ukraine unable to meet its NECP target, even five years beyond the official deadline.
- The average annual capacity factor of FFPPs drops to 41% and 32% in the baseline and optimistic scenarios, respectively, compared to 84% in 2025.
- The planned 4.9 GW cross-border transmission capacity is sufficient for both imports and exports in the optimistic scenario, enabling a flexible response to peak load conditions. However, it must be extended to 5.8 GW and 3 GW in baseline and pessimistic scenarios from current 2.3 GW.

Domestic electricity demand and net exports by scenario in 2035



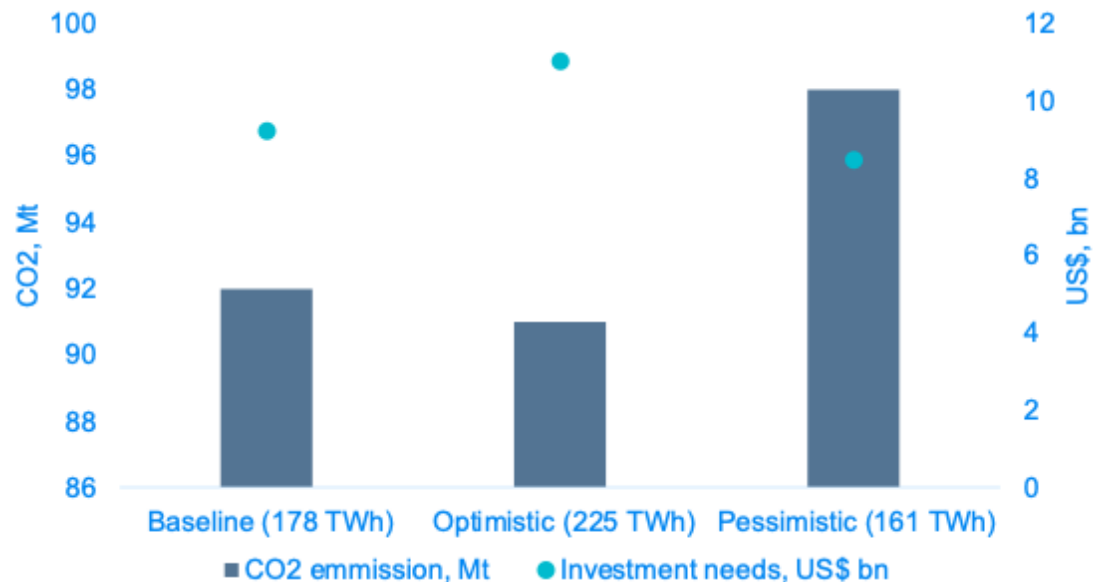
Source: KSE Institute



Model Design

- In the baseline case, emissions reach 92 million tonnes (Mt) per year, with yearly investment needs rising to US\$9 bn (in 2025 constant prices), as total electricity generation, increases to 178 TWh.
- In the optimistic scenario, annual CO₂ emissions reach 91 Mt, with investment needs rising to US\$11 bn, even as electricity generation, including net exports and production for hydrogen, expands to 225 TWh.
- By contrast, in the pessimistic scenario, emissions climbs to 98 Mt, while investment falls to US\$8 bn and total generation reaches just 161 TWh.

Total CO₂ emission and cumulative investments needs through 2035 by scenario



Source: KSE Institute



Policy implications

As Ukraine rebuilds its battered energy system and moves toward EU accession, reforms are urgently needed to unlock renewable energy sources, attract investment, and enhance grid resilience. Therefore, the government of Ukraine should:

- conduct a comprehensive assessment of system needs and dynamics, and translate high-level commitments into enforceable legal and regulatory measures as well as clearly define the power sector resilience and systematically integrate it into planning processes across all levels of government.
- create the playing-level field in the power sector by phasing out residential electricity price subsidies (estimated by the KSE Institute at €3.9 bn in 2024) and introduce time-varying, cost-reflective electricity tariffs, grid-friendly demand response mechanisms and targeted support for vulnerable customers. Otherwise, investment needs in the power sector, as projected at 4.3% of GDP in 2025 under the baseline scenario, will remain unmet.
- accelerate the rollout of smart meters and digital grid infrastructure to enable dynamic pricing and DER. Transmission capacity should be expanded beyond the currently planned 4.9 GW to ensure system flexibility and regional trade integration.
- design education campaigns on distributed energy, smart metering, and self-consumption for building trust and enabling informed participation in the energy transition.





Thank you!

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