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Commentary

Can Ukraine go ''green'' on the post-war recovery path?

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Introduction

The war in Ukraine has put a major toll on the country's economy, displacing the population, damaging physical infrastructure, and pushing businesses to shut down.[1] According to the National Bank of Ukraine, the country's GDP could shrink by over 33% in 2022,[2] and the recovery path is uncertain, though most studies suggest that it would likely be slow and prolonged.[3]

Earlier research has shown that the war in Ukraine could be a driver for accelerating the energy transition in Europe, reducing reliance on imported fossil fuels.[4,5] While in the case of Ukraine, a recovery represents a major challenge, in this commentary we argue that the country should use this opportunity to rebuild the economy in a carbon-free and environmentally friendly way. To support this claim, we assess the trade-offs across alternative development pathways for Ukraine's energy sector using a state-of-the-art energy system model—TIMES-Ukraine (see supplemental information for additional details on the methodological framework). Exploring two illustrative recovery pathways, we show that the ambitious decarbonization efforts can be implemented without major additional expenses, as based on the model and assumptions used here, the transition would cost only 5.1% more than the conventional fossil fuel-based

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path, even without taking into account multiple co-benefits from such mitigation. Targeted policy efforts, including the development of affordable financing options and the implementation of more transparent and efficient energy pricing mechanisms, would need to be adopted to ensure the transition.

The war could substantially reshape Ukraine's energy sector

Our analysis starts from the development of the least-cost post-war reference scenario based on the assumptions of the future demographic and macroeconomic trends (supplemental information, section S.2.1). We assume that the gross domestic product (GDP) in Ukraine will fall by 33.4% in 2022,[2] with a gradual recovery in the coming years (Figure 1). To estimate changes in the sectoral composition of GDP in 2022, we rely on the "territorial withdrawal" approach, which takes into account the structure of the economy of regions and territories that are assumed to be under the control of the Ukrainian government. Our refined demographic forecast takes into account the projected movements of refugees.

Results suggest that the war could substantially reshape Ukraine's energy sector under the developed reference scenario assumptions. Major transformations would be observed not only during the next several years due to the sharp reduction in energy demand and direct infrastructural damage but even in the long run. By 2050, the aggregate energy demand under the post-war reference scenario (Figure 2B) is 41% lower when compared to the pre-war projections (Figure 2A), largely driven by an overall lower level of economic activity. When combined with the falling costs of renewable energy technologies and increasing electrification of the transportation sector, even without additional policy efforts, greenhouse gas (GHG) emissions decline by around 44% in 2050 (relative to the 2020 level) under post-war reference scenario (Figure 2B)—a striking difference compared to the 4% increase in emissions projected under the pre-war assumptions (Figure 2A).

Ukraine can afford to take the sustainability road

While the post-war reference scenario sees a substantial increase in the share of carbon-free energy sources, as the latter reaches around 50% in 2050 (Figure 2B), observed emission reductions are still not ambitious enough to be consistent with limiting global warming below 1.5°C. Our estimates suggest that to achieve such a climate goal, Ukraine would need to cut emissions by around 93% in 2050 relative to the 2020 level (Figure 3D), aiming to become carbon neutral by 2060 (supplemental information, section S.2.2).

Although such mitigation efforts might seem to be too ambitious, especially for a developing country recovering from a full-scale war, the overall cost of such policies is only marginally higher than the least-cost reference path. Supporting the energy system with a substantial share of fossil fuels is not cheap and requires not only additional investments to replace depreciated equipment (Figure 3A) but also substantial fuel expenditures.[6] In addition, a substantial portion of the energy infrastructure damaged during the war would need to be rebuilt, and the latter can be used as an additional incentive to redesign the energy system toward a higher share of renewables.

Results suggest that the aggregate cost of the post-war energy system functioning under the considered reference scenario stands at 51.7 billion EUR per year (average over 2020–2050) (Figure 3C). While a stringent mitigation pathway would require substantial additional investments during a post-2035 period (Figure 3B), observed increases in overall costs are relatively modest. Based on the model and assumptions used here, annual expenditures under the mitigation scenario are only 2.7 billion EUR or 5.1% higher compared to the reference pathway (Figure 3C). When put in the macro perspective, additional costs of the 1.5°C pathway represent 1.1% of GDP over the analyzed period. This estimate is consistent with total mitigation costs for 1.5°C and 2°C scenarios provided by Child and Breyer,[7] where authors report a range of around 0.3%–2.7% of global GDP across various assumptions over the 2010–2100 period.

There are multiple co-benefits from going "green"

While the analysis presented so far largely focuses on the cost side of the mitigation efforts, the latter would bring multiple co-benefits for Ukraine beyond climate mitigation that could substantially reduce the overall costs of transition or even result in net economic gains.[8]

First, this would allow for the reduction of the country's dependence on imported fossil fuels and improve energy security. In 2019, Ukraine has imported over one-third of consumed natural gas, almost half of all coal, and over 87% of oil and petroleum products. A substantial share of these imports came directly or indirectly from Russia and Belarus. In the considered 1.5°C mitigation scenario, a share of imported fuels falls to 18% in 2035 and further to 3% in 2050—down from 42% in 2020. Reduced reliance on fossil fuels would also make Ukraine's economy more resilient to global energy price shocks.

Second, implementation of stringent mitigation policies would allow Ukraine to limit the adverse implications of the carbon border adjustment mechanism (CBAM) once introduced by key trading partners, such as the EU. Earlier studies suggest that Ukraine could be among the most-impacted countries following

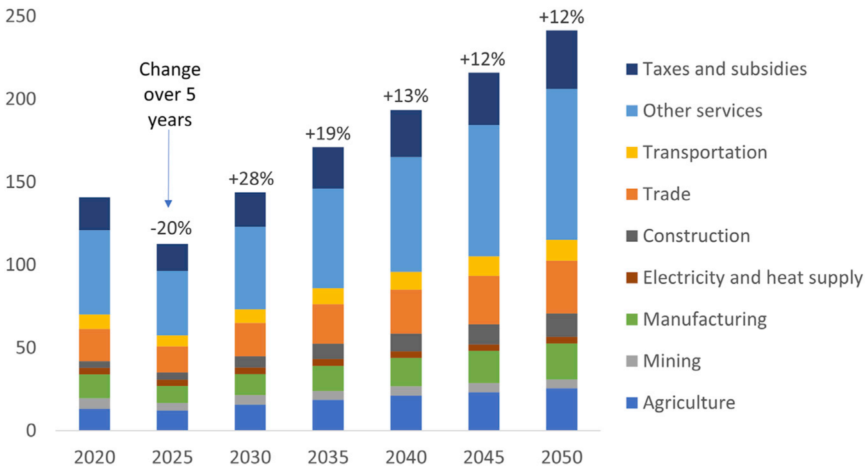

Figure 1. Ukraine's GDP forecast under post-war recovery pathway, billion EUR (constant 2020 prices)
Percentages reported at the top of the bars correspond to the cumulative changes in aggregate GDP over the 5-year period.

the EU's CBAM implementation.[9] Without ambitious mitigation measures, Ukraine would face a full scope of CBAM, while under the considered 1.5°C scenario, impacts would be substantially reduced if not fully eliminated.

Third, with substantially lower volumes of fossil fuel use, Ukraine's population would benefit from improved air quality and related reductions in mortality and morbidity. Results show that cumulative 2025–2050 emissions from coal-based power generation in the mitigation scenario fall by 69% (particular matter), 54% (NO_x), and 45% (SO_2) relative to the reference path. Literature suggests that the total economic cost attributed to air-pollution-related morbidities in Ukraine is in the range of 0.7%–1.3% of GDP or 1.1–2.1 billion USD per year.[10] Earlier studies suggest that both globally and in many developing countries, air quality co-benefits on morbidity and mortality could offset the costs of climate mitigation.[11] In the case of Ukraine, considering the rising role of biomass under the developed 1.5°C scenario, it is important to ensure that the newly constructed biomass-based generation plants are equipped with air pollution control technologies.

Finally, there is a wide range of other co-benefits that would accompany a low-carbon transition in Ukraine, including improved soil and water quality, increased biodiversity, as well as improved diet and physical activity.[8] While being more of a long-term nature, these are all important outcomes that would contribute to the improvements in the quality of life in Ukraine.

Policy implications and potential challenges

The success of Ukraine's decarbonization efforts in recent years has been rather limited, while the energy and emission intensity of the country's economy remains one of the highest in the world.[12] To facilitate the low-emission development transition, several regulatory, market, and infrastructure-related measures have to be implemented.

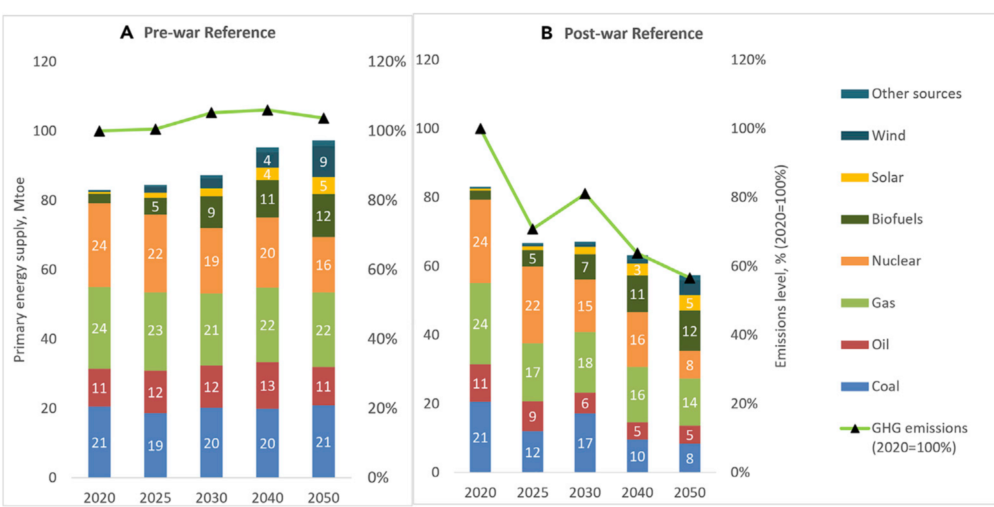

Figure 2. Energy supply mix and emissions in the least-cost reference scenarios
(A) reports the pre-war reference scenario, and (B) reports the post-war reference.
Stacked bars provide estimates of the primary energy supply. Green lines represent the level of GHG emissions measured relative to 2020 (2020 = 100%). Each year represents a 5-year average, e.g., 2030 corresponds to an average over the 2028–2032 period.

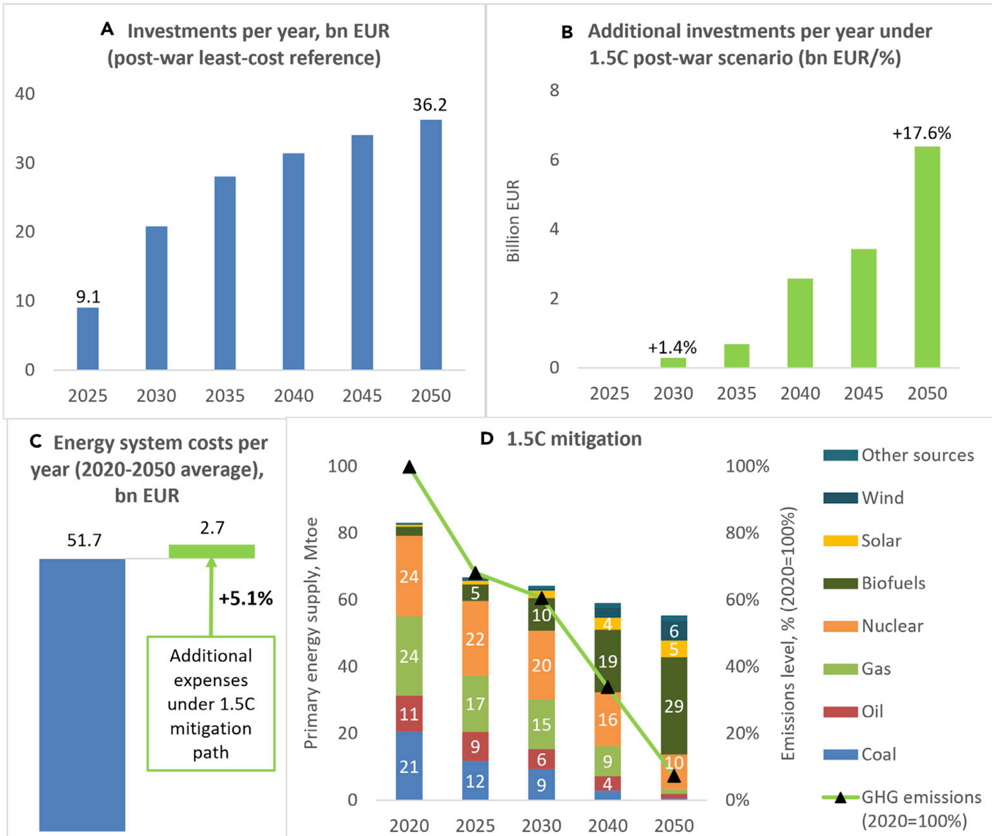

Figure 3. Key metrics of the post-war least-cost reference and 1.5°C mitigation pathway

Investments and energy system costs are reported in constant 2020 EUR and represent undiscounted estimates. Energy system costs cover all components, including fixed and variable costs. If a 5% discount rate is applied (default in the model), total system costs under the reference scenario equal 810.7 bn EUR over the 2020–2050 period. Under the 1.5°C mitigation pathway, total system costs increase by 26.3 bn EUR or 3.2% over the same period (under a 5% discount rate).

Poor access to affordable financing options has been a major constraint even before the war.[13] The situation becomes even more complicated with the recovery challenge. Targeted financial support of international financial organizations via programs aimed at increasing energy efficiency and expanding the share of renewable energy sources is of particular importance. A broad engagement of domestic banking institutions to facilitate corresponding initiatives would also be vital.

Measures toward more transparent and efficient energy pricing need to be implemented. These include a gradual increase in carbon prices (from the current level of 0.3 EUR/tCO_2) and/or introduction of the market-based mitigation mechanisms, such as an emission trading system. Elimination of cross-subsidization in the electricity sector and reduction of fossil-fuel subsidies to the coal mining industry should be also considered.[14]

Even moderately rising energy prices could have adverse distributional impacts.[15] Protecting the poorest households by designing targeted support measures should be a key feature of the low-emission development agenda.

While reducing a dependency on imported fossil fuels, stringent mitigation efforts could lead to the other form of import dependency—technological. When evaluating alternative energy supply options, it is important to consider whether the associated fuel and technological supply chains could be developed and scaled up domestically or whether they would be primarily of import origin. Creating and supporting supply chains with a high share of domestic inputs (equipment and parts, energy services, etc.) would be vital both from the economic, as well as energy security, points of view.

Addressing all the aforementioned policy challenges requires strategic planning. The Ukrainian government has been struggling to implement the latter even during less-demanding times.[16] While the recovery path provides a window of opportunity to rebuild the economy in a carbon-free and environmentally friendly way at a relatively low cost, the achievement of the corresponding goals should not be taken for granted. The benefits of such a transition are non-trivial, but so are the required policy efforts.

Finally, it should be noted that, while based on the plausible set of assumptions, an analysis presented here is primarily for illustrative purposes. Multiple uncertainties underly the future of the Ukrainian energy sector, including the cost of capital, global energy prices, costs, and availability of technologies, as well as economic growth rates, and the future structure of the economy. Assessing this wide range of uncertainties, while beyond the scope of this commentary, could provide important input to the future decision-making process.

Experimental procedures

A detailed discussion of experimental procedures is available in the supplemental information. All experimental data and replication instructions are available at the following link: https://github.com/mchepeli/UA-war-energy-recovery.

SUPPLEMENTAL INFORMATION

Supplemental information can be found online at https://doi.org/10.1016/j.joule.2023.02.007.

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AUTHOR CONTRIBUTIONS

Conceptualization, M.C.; methodology, O.D., R.P., and A.S.; software, O.D., R.P., and A.S.; formal analysis, O.D. and A.S.; investigation, O.D. and A.S.; writing – original draft, M.C.; writing – review & editing, M.C.; visualization, M.C. and A.S.; supervision, M.C. and O.D.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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