ERA OF INNOVATION: TOMORROW'S TECHNOLOGIES REBUILDING UKRAINE'S GRID

By Nancy Southern, Chair and CEO, ATCO Ltd. and Canadian Utilities Limited, Canada

In the early hours of February 24, 2022, a barrage of missile strikes illuminated the skies over Ukrainian cities, marking the onset of a full-scale Russian invasion. In the years since, the world has watched in awe as the people of Ukraine, despite being outmanned and outgunned, have mounted a Herculean resistance—grinding Russia's advance to a halt and gradually reclaiming lost territory. Despite all odds, the spirit of Ukraine remains steadfast, symbolizing a struggle for sovereignty and freedom that resonates far beyond their borders.

Beyond its unfathomable human toll, Russia's invasion has delivered persistent and systemic shocks to Ukraine's energy system. Unable to break the will of Ukraine and in flagrant disregard for international law, Putin has maliciously targeted hundreds of missiles, bombs, and drones at power plants, transmission lines, and substations. Rolling blackouts have become a recurring phenomenon and small diesel and gas-fired generators hum along sidewalks and street corners throughout the country.

Now, with another harsh winter looming and power shortages a certainty, questions have begun to arise on what the future of the country's electric grid should look like. Russia's invasion both disrupted Ukraine's climate commitments while simultaneously exposing the vulnerabilities of its heavily centralized nuclear and fossil fuel-dependent power sector. How are policymakers and grid planners to balance humanitarian pressures, political priorities, sustainability goals, energy security realities, and national security objectives?

It will undoubtedly prove to be a delicate balancing act.

In the near term, the country's principal focus must continue to be a decentralized approach to providing energy to communities. Ukraine's incumbent energy infrastructure, with its large power plants and extensive transmission network, has proven highly susceptible to repeated attack. By way of contrast, numerous modular gas turbines ranging from 5 to 50 MW can be readily dispersed throughout the country, connected with the country's robust underground natural gas infrastructure, and relocated with relative ease. Critically for Ukraine's industrial economy, these small-scale generators can also collectively achieve scale.

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Among the principal benefits of gas-fired generation is its reliability—a critical, though often underappreciated, attribute. With much of the country having already endured rolling blackouts, measures to improve reliability and resilience will be essential. For example, steps to "harden" the grid, such as burying or undergrounding critical electrical infrastructure, would provide some protection from future Russian aggression. Reinforced transmission corridors with neighboring countries would also provide some support; the synchronization of Ukraine's grid with the European Union has already demonstrated significant benefits, enabling both imports and exports and enhancing the overall stability of the system.

Each of these measures must be pursued with a firm eye on the cost to consumers. Ukraine is already bearing some of the costs for grid reconstruction, and safeguarding affordability is vital.

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Given the economic and humanitarian hardships created by the conflict, cost-effective energy solutions are essential for stimulating economic recovery and attracting the investment required to rebuild the country—particularly given Ukraine's heavy industrial base.

The urgent imperatives of decentralized and distributed systems, resilience and affordability need not necessarily conflict with Ukraine's pre-war decarbonization goals. Distributed wind and solar, renewable microgrids, virtual power plants and smart grid technologies are already being deployed across the country. However, in the months ahead, policymakers will need to balance pressing humanitarian and economic priorities with the inherent technological limitations of these technologies.

For example, the variability of wind and solar power—paired with their inability to provide consistent and reliable power—makes accelerated and widespread deployment particularly challenging for a nation that urgently requires considerable volumes of firm, dispatchable, and affordable power. Indeed, managing the widespread penetration of variable renewable energy while maintaining grid stability is proving to be an extraordinary technical challenge globally.

Other more novel solutions, including advanced battery storage, hydrogen and small modular reactors have potential—but they lack technological maturity. A besieged nation should not be treated as a proving ground for yet-to-be commercial technologies, however promising they may be.

Looking to the future, as Ukraine rises from the conflict, a revitalized electric grid will symbolize its strength, resilience, and unwavering commitment to a brighter, more prosperous future for all its citizens. It will empower communities, enhance living standards, and ensure lasting energy security. But above all else, it will serve as a beacon of hope, sovereignty, and freedom.

Glory to Ukraine!