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Striving for Access, Security, and Sustainability

Ukraine's Transition to a Modern and Decentralized Energy System

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Introduction

Since launching its full-scale invasion in February 2022, Russia has relentlessly attacked Ukraine's energy system, along with other infrastructure. In November 2024 alone, Russia fired **350 missiles and over 2,500 drones** at the Ukrainian power grid. As a result of these attacks, the total damage to the energy infrastructure—heating, power, and oil and gas—at the end of 2024 was estimated at **$20.5 billion**, while the cost to rebuild according to EU standards amounts to $67.8 billion. Combining the occupied, destroyed, and damaged power capacities, Ukraine has lost a total of approximately 27 gigawatts (GW) of its pre-war installed capacity of **56.1 GW**. Ukrainian citizens and businesses entered recent winters with less than half of their power generation available, forcing authorities to introduce restrictions on the supply of electricity. Emergency measures—such as repairing damaged generation capacity and deploying thousands of backup diesel generators—have provided stopgaps to the current dire situation.

Amid this crisis, energy decentralization as a strategy for survival has moved to the forefront of expert discussions. Small, distributed power units, ranging from 5 to 100 megawatts (MW) each, are regarded as the only way to prevent a nationwide blackout and ensure a stable electricity supply to people and businesses. In addition, these small units are not an easy target for Russian missiles. Importantly, decentralization also aligns with Ukraine's long-term commitment to a more sustainable and balanced energy mix. According to Ukrainian and international experts, rebuilding Ukraine's grid on the old, centralized model with outdated coal plants and dependence on imported fuel is not an option. Instead, Ukraine has a unique **opportunity** to build a modern energy system relying on a more balanced and efficient mix, strengthening its future energy security and economic resilience.

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The next two years are critical for Ukraine's energy security. As Russian attacks persist, Ukraine is racing to winterize its grid and add new generation capacity. At the same time, there is significant work ahead for the Ukrainian government—both at the national and subnational levels—in terms of regulations, reforms, and incentives to address Ukraine's energy challenges. The international donor community and foreign investors are watching developments in the country very closely, as they will be key players in achieving Ukraine's vision. For the United States, supporting Ukraine's energy modernization aligns with its strategic interests in the country and the broader region: It creates **markets** for U.S. firms, strengthens Ukraine's resiliency, and diminishes Russia's ability to cripple the Ukrainian economy.

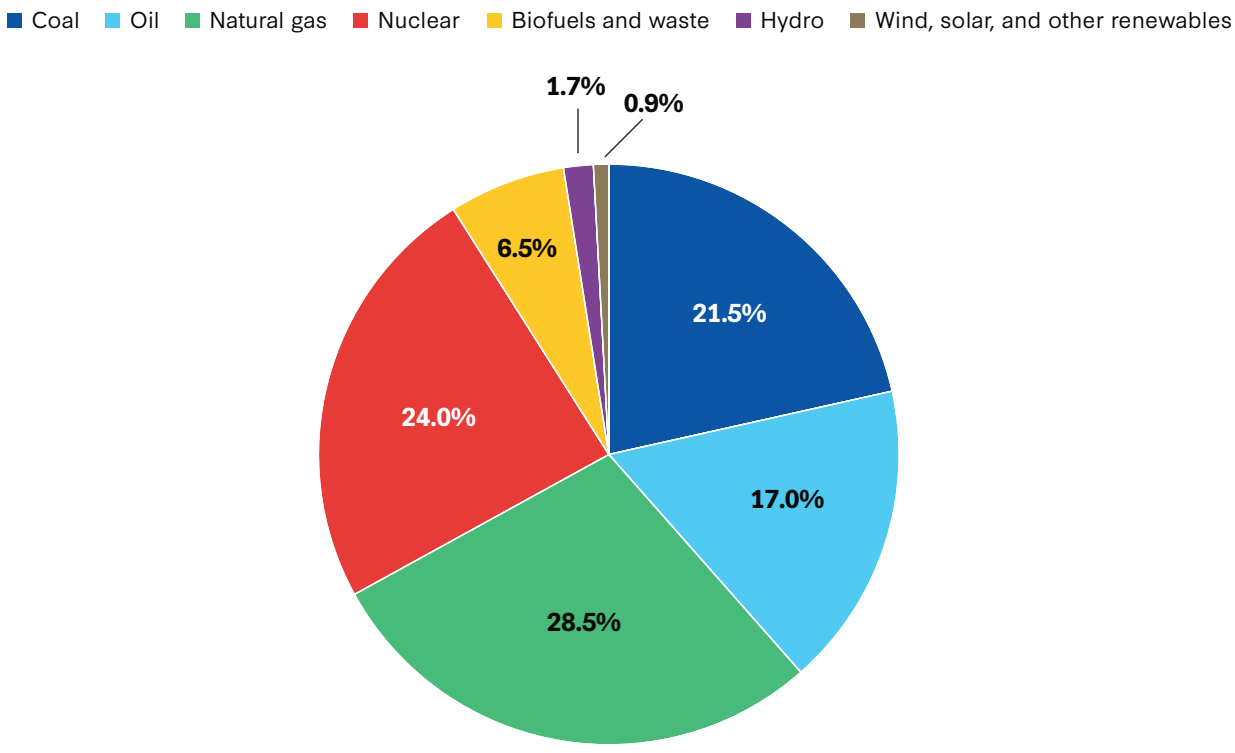
Building off **prior work** conducted by **CSIS**, this paper discusses how to rebuild Ukraine's energy system to ensure access, strengthen security, and promote sustainability. The paper provides a description of the country's future energy mix, the policy and regulatory reforms needed, and the role that international partners—including the United States—can play in its modernization.

Ukraine's Future Energy Mix: Outlook and Challenges

Ukraine inherited a Soviet energy model, characterized by a **centralized**, state-owned monopoly with huge generation facilities serving the entire country. Ukraine's power system was **dominated** by large nuclear, coal, and hydroelectric plants feeding a Soviet-era grid, run by state-owned companies (e.g., Energoatom for nuclear power and Ukrenergo for the grid) and a few private conglomerates, such as the Donbass Fuel-Energy Company (DTEK). Ukrenergo operates the national grid centrally, which was synchronized with the European Network of Transmission System Operators for Electricity (ENTSO-E) grid post-2022. Local generation was minimal, aside from some industrial cogeneration, and municipalities had little role in electricity beyond distribution utilities. As a result, fossil fuels and nuclear energy dominate the energy mix (see Figure 1).

The centralized nature of Ukraine's energy system has advantages such as economies of scale, better coordination, and reliance on proven technologies. However, it is vulnerable to large-scale disruptions, including grid failures or attacks, which can lead to widespread blackouts. The system also suffers from high transmission losses, as electricity must travel long distances from power plants to users. In addition, the system is inflexible and slow to adapt to changes in demand or new technologies. Building and maintaining them also requires significant investment and high capital costs.

Figure 1: Ukraine's Energy Supply, 2023



Source: "Ukraine: Energy Supply," International Energy Agency, https://www.iea.org/countries/ukraine/energy-mix.

While nuclear power currently provides approximately **50 percent** of electricity generation and remains a cornerstone of Ukraine's energy system, policymakers are increasingly emphasizing the need to diversify energy sources and decentralize power generation. The aim is to reduce dependence on a few large facilities, including high-risk nuclear sites, and shift toward a more distributed, resilient mix of **renewables**, storage, and flexible backup sources. Experts argue that the only way to modernize the system and ensure Ukraine's long-term survival is to build numerous local power facilities (ranging from 5 to 100 MW) instead of relying on a few large power plants. Post-invasion, there is an opportunity to allow more independent power producers and community-level generation. According to recent studies from the **Energy Community** and the **International Energy Agency**, the target energy mix for Ukraine includes adding gas and biomass units, batteries, wind, and solar photovoltaics (PV) over 10 years. If realized, this vision would significantly increase electricity capacity from varied sources by 2035, enhancing the system's efficiency and sustainability. A more diversified energy portfolio, including fossil fuels, renewables, and nuclear power, will be essential to building a more sustainable future for Ukraine.

Looking ahead, nevertheless, nuclear, large-scale hydroelectric, and gas-fired power will remain essential pillars of Ukraine's base load capacity. While small-scale, distributed generation is crucial for the system's resilience, it is equally important to recognize the role of centralized energy sources for Ukraine's energy security. Plans are underway to construct new reactors, including small modular

reactors (SMRs), to replace aging infrastructure and enhance resilience.[1] Additionally, natural gas-fired power plants provide flexibility to balance the grid, especially during peak demand periods. Biomass and gas-fired generation would be a good addition to renewables, helping to cover evening and wintertime peaks of consumption.

ENERGY REFORMS AND FINANCING

To support a more modern energy system, the Ukrainian government has enacted regulatory reforms, including tax and customs exemptions for importing energy equipment. In June 2024, Ukraine's cabinet of ministers approved a **National Energy and Climate Plan** (NECP) for 2025–2030, with investment needs estimated between $41.5 billion and $50 billion. The plan aims to reach 27 percent renewable energy in the final energy consumption by 2030, up from the current **10 percent**. The NECP includes adding approximately 10 GW of new renewable capacity and cutting greenhouse gas emissions by 65 percent below 1990 levels by 2030. Shortly after, the government of Ukraine **announced** a $20 billion plan to achieve these targets—aiming to increase the share of renewables in electricity generation from the current 10 percent to 27 percent by 2030—reflecting both wartime necessity and EU Green Deal alignment. Moreover, in August 2024 the cabinet of ministers approved a **Strategy for the Development of Distributed Generation** until 2035, aiming to enhance grid resilience through decentralized energy solutions.

In addition, to enable local authorities to contribute to the modernization of the energy system, in January 2025 the Ukrainian parliament adopted **Law No. 9381**, which simplifies regulatory procedures and stimulates investments to build a decentralized and sustainable energy sector. The law's provisions aim to (i) promote the development of a distributed energy system so that it is more resilient during wartime; (ii) simplify the connection of new power generation capacities, including renewable energy sources; and (iii) increase the transparency and predictability of energy projects. This law also aligns with the European Union's Ukraine Facility requirement that **20 percent of the funding** is directed to the recovery, reconstruction, and modernization of subnational needs.

To develop the renewable power sector, Ukraine will require **$20 billion** in new investments by 2030. Approximately half of that capacity will replace generation destroyed by Russia's attacks, and the other half will support growth and energy diversification. Notably, these figures assume significant private sector participation. With domestic public finances strained by wartime budget deficits, Ukraine will have to rely on international financial institutions (IFIs) and private investors to supply most of the financing.

Some financing is underway even under wartime conditions (see Box 1). These cases illustrate how donor-backed risk mitigation tools and local financial institutions can jointly scale clean technologies. However, international partners expect Ukraine to implement clear reforms as conditions for renewed investment, such as removing local content requirements that often deter foreign companies from entering the market. Moreover, to attract sufficient financing, investors expect a stable regulatory framework, and unfortunately, Ukraine's energy policy remains unpredictable. In the **late 2010s**, a very generous feed-in tariff (FiT) spurred a renewables boom, only to be followed by retroactive FiT

1 Ukraine's Energoatom and Holtec International have signed a cooperation agreement to deploy SMR-160 reactors in Ukraine, aiming to strengthen the country's energy security.

cuts and unpaid debts to renewable producers in 2020–2021. This eroded investor confidence. An attempted transition to an auction-based incentive system was delayed for years. When pilot renewable auctions finally took place in late 2024 and 2025, they **failed** to attract interest. There were no bidders for solar or wind projects, and only one small hydro project secured a **contract**. The reasons are clear: policy instability, payment arrears, and flawed auction design. Investors have seen the "rules of the game" change repeatedly in Ukraine: FiT rates were cut by the parliament, contracts were not honored in full, and a **2020 mediation** memorandum of understanding with renewable associations was not fully implemented.

Box 1: Recent Financing Transactions for Energy Projects

- In early 2025, **OKKO Group** (a Ukrainian holding company that owns a large network of gas stations in Ukraine) secured €157 million ($176 million) in international finance through the European Union's Ukraine Investment Framework (UIF) to develop clean energy projects, demonstrating how blended finance mechanisms under the Ukraine Facility can unlock large-scale private sector involvement.[2]
- Similarly, the Ukrainian energy company KNESS **€9.6 million ($10.35 million)** from Oschadbank (also known as the State Savings Bank of Ukraine)—supported by a European Bank for Reconstruction and Development (EBRD) guarantee—to build large battery systems that help stabilize the electricity grid.
- Eco-Optima is constructing **the Sokal Wind Farm** in Lviv Oblast, with €40 million ($43.2 million) in financing from Oschadbank, including a €24.8 million ($28.3 million) green letter of credit facilitated by the EBRD.
- Additionally, Energy Trade Group (a Ukrainian private company comprising a conglomerate of businesses specializing in the trading of gas and electricity) is building **a 93 MW wind farm** in Kirovohrad Oblast, financed with **€26 million ($30.6 million)** from the large state bank Ukrgasbank, the EBRD, and the International Finance Corporation (IFC), utilizing financial instruments such as an EBRD credit risk guarantee.
- DTEK Renewables (a Ukrainian company managing the renewable energy assets of DTEK Group) received a **€67 million** ($76.5 million) loan from a consortium of Ukrainian banks—led by Oschadbank, together with PUMB (First Ukrainian International Bank, a leading bank in Ukraine owned by SCM Holdings) and Ukrgasbank (a leading Ukrainian state owned bank)—to construct five battery energy storage systems (BESS) across Ukraine by 2030. This is the largest domestic infrastructure loan for a BESS project in Ukraine. The project will deliver 180 MW of energy storage capacity in 2025, with a total 200 MW planned—enough to serve 600,000 households.

2 The European Union's Ukraine Investment Framework (UIF) is part of the $56 billion Ukraine Facility. The UIF is endowed with $10.5 billion in financial instruments, including $8.8 billion in loan guarantees and $1.7 billion in blended finance (grants and technical assistance). The objective is to mobilize approximately $45 billion in public and private investments for Ukraine's recovery, reconstruction, and modernization.

Table 1: How Auction Quotas Reflect Needed Generation Capacity vs. Transmission System Operator (TSO) Estimates

Technology	Current Capacity (GW)	Transmission System Operator (TSO) Target (GW)	To Be Built — Total (GW)	To Be Built — Renewable Auctions (GW)	To Be Built — Renewable Auctions (% of total)	Investments Required ($bn)
Solar	6.2	10	3.8	0.18	5%	2.1
Priority: New PV and wind power plants to replace destroyed thermal power plants						
Wind	0.6	5	4.4	1.31	30%	7.5
Priority: New PV and wind power plants to replace destroyed thermal power plants						
Biomass/ biogas	0	1.4	1.4	0.285	20%	1.5
Priority: Biomass and biogas power plants						
Battery Energy Storage System (BESS)	0	0.8	0.8	-	-	0.8
Priority: 2–4 hour BESS						
Hydro pumped storage	2	4	2	-	-	1.7
Priority: Construction/expansion of Kaniv and Dniester Hydro Pumped Storage Power Plants (HPSPPs)						
Flexible gas generation	0.2	4.4	4.2	-	-	4.7
Priority: New flexible gas-fired capacities						
Nuclear	7.8	10.2	2.4	-	-	20
Priority: Construction of two 1 GW nuclear power units and SMRs						

Note: Total quotas for renewable auctions that the government approved for the period of 2025–2029.

Source: Yuri Kubrushko, Olga Gruzhinskaya, Georg Zachmann, *How to Attract Investors via Renewable Auctions in Ukraine Going Forward* (Green Deal Ukraine; Imepower: March 2025), https://greendealukraina.org/products/analytical-reports/now-to-attract-investors-via-renewable-auctions-in-ukraine-going-forward.

Ukraine needs to pursue a series of comprehensive market reforms and provide insurance mechanisms and guarantees that can reassure investors of the stability and predictability of the renewable energy sector. At the moment, Ukraine is overhauling its renewable energy auction program. In April 2025, the parliament introduced **Draft Law No. 13219**, proposing a shift from two-way contracts for difference (CfD) to one-way feed-in premiums (FiP), extended auction timelines, and more flexible participation rules. Concurrently, the **government** approved annual auction quotas for 2025-2029, starting with 330 MW in 2025—including 150 MW for wind—and scaling up to 400 MW by 2029. However, current auction quotas remain modest relative to national targets.

As illustrated in Figure 2, government-approved auction volumes for 2025–2029 will cover only a fraction of Ukraine's total renewable capacity needs by 2030: 5 percent for solar, 30 percent for wind, and 20 percent for biomass/biogas. This gap will require complementary mechanisms: direct private investments, donor-supported tenders, and long-term power purchase agreements (PPAs) with major producers. For instance, **Kazakhstan** has signed a 25-year PPA with TotalEnergies for the 1 GW Mirny wind project, which includes a 600 megawatt-hour (MWh) battery energy storage system and is expected to supply electricity to 1 million people. Similarly, **Uzbekistan** has entered into a 25-year PPA with Voltalia for the 526 MW Artemisya hybrid project, combining solar, wind, and battery storage to meet the electricity needs of approximately 2.5 million inhabitants. These models could offer valuable insights for Ukraine's renewable energy strategy.

Beyond cumbersome regulations, another challenging area affecting energy projects is currency stability and convertibility. Currently, Ukraine has currency **controls** due to martial law. Investors worry about being unable to repatriate profits in hard currency. Ukraine will need to gradually lift these controls and possibly hedge currency risk. The National Bank of Ukraine, with International Monetary Fund support, could set up a currency swap facility or guarantee that investors can convert a specific amount of hryvnia to dollars or euros at a predictable rate.

In parallel, Ukraine has introduced tax incentives to bolster renewable energy investments. As of July 27, 2024, the government enacted laws exempting certain energy-generating equipment from import duties and value-added tax (VAT), including PV panels, lithium-ion batteries, inverters, and specific components for wind turbines. However, complete wind turbine units remain subject to VAT and import duties, which may affect the competitiveness of wind energy projects. These **exemptions** are valid during the period of martial law but are set to expire on January 1, 2026.

A final challenge in rebuilding and maintaining the energy system is the availability of a skilled workforce. The war has displaced millions of Ukrainians, including engineers and electricians. For instance, a Ukrainian-American microgrid provider **noted** that many of the "best electricians left the front lines for safer places," leading to maintenance issues with backup generators in hospitals. Rebuilding the energy sector will **require** mobilizing and training a new generation of workers—from construction crews to power system operators. Ukraine's education and training institutions need to ramp up programs in renewable energy technology, engineering, and project management. Workforce readiness also means ensuring safety and security for personnel working in conflict zones—another reason why many projects focus on relatively safer western and central regions for now.

Despite these hurdles, workforce capacity is growing. Ukrainian companies and municipalities have gained experience operating microgrids and modular systems during the war, and many professionals are contributing their expertise remotely. With strategic support, Ukraine can cultivate the human capital needed to operate a modern **decentralized** grid.

THE ROLE OF SUBNATIONAL GOVERNMENTS

Historically, Ukrainian cities had little autonomy in energy matters: The system was top-down. But the war has thrust local governments, including city mayors, into a critical role in keeping the lights on and serving as frontline leaders during the energy crisis. Due to the war, they have had to improvise solutions to maintain heating and lighting for local businesses and residents. The wartime experience

has demonstrated the huge value of government decentralization, with empowered local authorities responding and targeting resources for communities in need. Mayors have spearheaded installing local generation and backup systems. Local governments are now drafting "resilience plans" that include building renewable energy at municipal facilities, procuring portable generators, and even exploring municipal utilities. The decentralization of political power in Ukraine in recent years has allowed local councils to enter partnerships and pilot projects.

Achieving a more decentralized and sustainable energy future will undoubtedly require the involvement of subnational governments: regions (*oblasts*), districts (*rayons*), and municipalities (*hromadas*). If the concept of energy cooperatives is fully legalized, it will empower villages or city districts to develop shared energy resources. Ukraine is looking to models from the European Union (like German energy cooperatives) for guidance. The U.S. experience with co-ops and municipal utilities could also be instructive, illustrating how local entities can run parts of the energy system effectively.

Mayors often serve as vital connectors between national initiatives and local demands. These governments can identify suitable land or rooftops for solar projects, streamline permitting processes, and cofinance initiatives through city budgets. For example, the city of Vinnytsia in central Ukraine has championed the integration of renewable energy into the city's district heating system and is actively advancing plans for a municipal waste-to-energy facility. Another example is Mykolaiv—a southern city near the front line—which installed **5.5 MW** of its own generation capacity (a mix of diesel gensets, solar PV, and battery storage) to power critical facilities like water pumping stations. The city's water utility now has solar panels to ensure potable water supply even if the main grid fails. Such projects illustrate how mayors are leveraging decentralized energy sources to provide essential services to their citizens.

However, most Ukrainian municipalities cannot fully fund large energy investments on their own and must attract **outside capital**. Communities are "open for business" and eager to pilot innovative energy solutions, with donor support. Demand is high at the local level for decentralized solutions—from villages to large cities, there is an appetite to generate their own power if financing can be found. Many Ukrainian cities have concrete clean energy projects with future revenue streams (e.g., selling power to the grid or cutting energy bills for city services) (see Box 2).

In this regard, mayors are also promoting transparency and good governance to bolster investor confidence and attract private finance. For example, the city of Mykolaiv, in partnership with the European Union's Anti-Corruption Initiative, launched a public website to **track** international aid funds and updated procurement regulations to root out corruption. By improving accountability, cities aim to be "investment-ready" for donor-funded projects and public-private partnerships. As Mayor Oleksandr Syenkevych puts it, "Mykolaiv is ready to be a reliable partner" for energy reconstruction programs. However, there is a need for a national platform to connect cities, investors, and banks—essentially a matchmaking mechanism so that willing cities and private financiers can find each other. This could be as simple as a central project listing database or a more sophisticated endeavor such as an investment facilitation office.

The strategic role of mayors goes beyond individual projects: They are important partners in managing and sustaining decentralized energy systems in the long term. A microgrid in a town will likely be operated by the local private utility or the municipality, so local capacity and ownership is critical. By

involving mayors in planning and financing discussions now, donors and investors ensure there will be buy-in in the future.

Box 2: Examples of Decentralized Energy Projects in Ukrainian Cities

Mykolaiv Solar Water Utilities Project: 5 MW solar PV and 1 MWh battery to power the city's Vodokanal (water pumping and treatment facilities). *Status*: **1 MW already installed with local funds**; in May 2025, the Nordic Environment Finance Corporation (NEFCO) approved a €7.2 million (**$7.8 million)** grant to scale up the project across multiple water infrastructure sites in Mykolaiv. *Value*: Ensures continuous access to potable water during blackouts by reducing reliance on grid electricity and diesel. The solar-battery combination strengthens climate and war-related resilience for essential services. Long-term cost savings are expected through lower electricity bills and reduced operational risks.

Vinnytsia Waste-to-Energy Plant: Proposed 10 MW facility aims to convert municipal solid waste into electricity and heat, generating an estimated 80 GWh annually. *Status*: A feasibility study has already been completed, and the city is currently seeking approximately $30 million in public-private partnership investment. *Value*: The project would significantly reduce reliance on landfills while delivering around-the-clock energy.

The Khmelnytskyi region currently hosts multiple operational solar farms, adding up to roughly to **14.9 MW** of capacity on city-owned land. *Value*: The region is clearly scaling both solar and storage capabilities, and co-locating batteries with PV installations is part of their strategic resilience approach.

Financing Options

Beyond regulatory reforms, the involvement of subnational governments, and investment in workforce capacity, Ukraine will require substantial financial resources to realize its energy vision. This financing gap could be narrowed through a combination of guarantees (such as price floors or insurance), development finance, and innovative partnerships with Western companies.

In this regard, Europe and the United States have been strong partners to Ukraine by providing financial and technical assistance for the restoration of its energy infrastructure from Russian attacks. **Europe** is further stepping up with the **Ukraine Facility**, a $56 billion program for 2024–2027 to support recovery. Crucially, at least **20 percent** of EU grant funding must go directly to subnational projects—rebuilding regional and local infrastructure, including energy systems. This reflects a recognition that empowering cities and communities is vital for effective reconstruction.

In addition, the World Bank Group and the EBRD are heavily involved in Ukraine's energy sector recovery. They are considering mechanisms like a "**Premium Support Fund**" to ensure renewable auction winners get paid, as well as the **Electricity Price Guaranteed Fund** (EPGF), which is currently under elaboration by the EBRD. The concept of the EPGF is essentially a donor-funded mechanism

to guarantee minimum revenue for the power plant. If market electricity prices fall below an agreed minimum (the auction strike price), the fund pays the difference to renewable producers, ensuring revenue stability. If prices are higher, producers keep the majority of the upside, while paying special premium or commission to the fund (i.e., no "reverse payments" back to the state, unlike the current CfD scheme). This EPGF would be initially capitalized by grants from the European Union, IFIs, and others. One entity, perhaps the EBRD, would manage it, providing transparent administration.

In terms of future U.S. funding to support the energy sector, the Trump administration is in the process of evaluating its foreign assistance priorities and hence aid is currently on hold. This includes winding down the U.S. Agency for International Development's Energy Security Project and other technical assistance **programs** in Ukraine. While U.S. foreign aid retrenchment is part of a broader government efficiency agenda, the administration continues to emphasize "energy security" in geopolitical terms–chiefly, reducing dependence on hostile powers and promoting stable energy markets.

Supporting Ukraine's energy recovery not only undermines Russia's leverage but also opens avenues for U.S. investment in Ukraine's critical mineral resources, as evidenced by the recent **U.S.-Ukraine Mineral Resources Agreement**, signed in May 2025. This agreement provides the United States with preferential access to Ukraine's valuable natural resources, tying future aid to shared profits from its vast reserves of rare earth minerals, oil, gas, and other hydrocarbons. Such strategic economic partnerships reinforce U.S. interests in the region and contribute to global energy stability. In addition, developing Ukraine's mining resources will require complementary investments in transport infrastructure and energy.

In practice, this means U.S. support for Ukraine will favor facilitating private investment and trade (e.g., exporting U.S. liquefied natural gas technology and modular reactors) over direct aid. The U.S. Development Finance Corporation (DFC), which has a mandate to mobilize private capital in challenging environments, could become a key player in Ukraine in the near future. The DFC can provide political risk insurance, project financing, and loan guarantees to U.S. investors and Ukrainian ventures, effectively filling some of the void left by the U.S. Agency for International Development's closure.

Among a range of financial tools, the DFC has the ability to **provide** up to $1 billion in insurance and financing support per project. For instance, the DFC could back a political risk insurance facility specifically for Ukraine's energy sector–covering risks such as war damage, expropriation, or breach of contract. It can also deploy **equity stakes** in funds or projects, essentially giving a U.S. government seal of approval that can crowd in other investors. It can also guarantee loans made by banks to Ukrainian energy projects, lowering interest rates. One idea is setting up a "Ukraine Clean Energy Fund," where the DFC and European partners seed a fund that coinvests in dozens of decentralized energy projects alongside private investors. This diversifies risk and provides a one-stop vehicle for investors interested in rebuilding the energy sector under a facility with professional management.

In addition, joint U.S.-Ukrainian private sector initiatives can be part of the financing. An urban investment platform can be set up where U.S. and Ukrainian firms form consortia to bid on projects in municipal energy projects. The feasibility of joint investments is high in areas like wind, where Ukrainian developers have experience and U.S. firms have capital and technology. However, it is

contingent on risk mitigation: Without guarantees on political risk and a clear signal from the U.S. government (such as a **special envoy** or task force to promote U.S. investment), many U.S. private investors will remain hesitant.

Opportunities for U.S.-Ukraine Collaboration

As Ukraine rebuilds and transforms its energy system, it can incorporate lessons from the decentralized and flexible approach seen in the United States and the European Union. In the case of the United States, its energy system has evolved since the 1880s, resulting in a diverse and **decentralized** electricity model in many parts of the country. While the United States also has large power plants, it features robust independent power producers and distributed energy resources like rooftop solar, battery storage, and gas microturbines. Hundreds of microgrids—**over 700 as of 2024**—operate across the United States, especially for campuses, military bases, and critical facilities, providing resilience during outages.

Key elements of the U.S. model that could inform Ukraine's future energy system include:

- **The Role of Municipal Utilities and Co-ops:** In the United States, many towns and cities own their electric utilities or are served by rural electric cooperatives, which gives localities influence over generation choices. U.S. municipal utilities (like in Austin, Texas; Sacramento, California; and other cities) have successfully built solar farms, battery projects, and even owned shares in wind farms to serve their cities. Knowledge sharing or twinning programs could help Ukrainian mayors and utility managers adopt best practices in governance and energy planning.
- **Microgrid Technology:** U.S. companies are global leaders in microgrid controls, battery energy management, and gas engine generators. Collaboration could involve technology transfer—for example, U.S. firms supplying control systems that allow Ukrainian local grids to island, or disconnect, during an attack and then reconnect. The recent example of U.S.-Ukrainian firm New Use Energy **delivering** solar and battery units to Mykolaiv's trauma hospital is a case in point. Scaling this up, U.S. providers could partner with Ukrainian firms to deploy hundreds of such microgrids at clinics, water systems, and telecommunications towers across Ukraine. This would directly support the goal of a decentralized grid as called for by the **Group of Seven Clean Energy Partnership**.
- **Private Sector Culture:** U.S. energy projects typically rely on private capital with various risk mitigation instruments. Ukraine can emulate models like public-private partnerships for energy infrastructure. For example, a city could concession a solar plant project to a U.S. investor under a long-term agreement where the city agrees to purchase power (a municipal PPA). Such models are standard in the United States (e.g., cities buying solar power from private solar farms to meet renewable goals). To facilitate this in Ukraine, standardized contracts and credit enhancements will be needed (e.g., if a city's credit is weak, a donor agency could guarantee the payments).
- **Technology Transfer:** From smart grid equipment to small modular reactors (SMRs), U.S. companies have technology that Ukraine is interested in. Notably, Ukraine's NECP mentions **exploring** hydrogen, energy storage, and SMRs by 2030. U.S. firms like NuScale or Westinghouse (already working with Energoatom on nuclear fuel) could pilot SMR deployment in Ukraine's context, perhaps at a retired coal plant site. On a smaller scale, U.S. solar and battery

manufacturers can find a market as Ukraine rebuilds—this aligns with U.S. industrial policy to support domestic clean technology manufacturing. Facilitating export-import of this equipment, possibly via U.S. Export-Import (EXIM) Bank financing or the DFC, would accelerate Ukraine's energy transition.

- **Policy and Market Design Support:** U.S. **regulators** (such as the Federal Energy Regulatory Commission and state utility commissions) and grid operators (such as **PJM**—Pennsylvania-New Jersey-Maryland Interconnection, the largest grid operator in the United States—and the Electric Reliability Council of Texas, Inc [ERCOT]) have extensive experience integrating renewables and ensuring grid reliability. Ukrainian energy regulators and the Ministry of Energy can benefit from technical advisory exchanges. For example, learning how U.S. markets handle capacity payments, ancillary services, and demand response could help Ukraine update its electricity market to reward flexibility—a key for balancing renewables. Although Ukraine is already a member of the **Energy Community** (an organization bringing together the European Union and nine neighboring EU candidate or potential candidate countries to create an integrated regional energy market based on a legally binding framework) and synchronizes with ENTSO-E (the European grid), insights from the United States on how to develop a competitive market (and cautionary lessons from California's early blackouts or Texas's 2021 freeze) could also be valuable as Ukraine reimagines its energy sector.
- **Joint Ventures and Investment:** Perhaps the most impactful collaboration is through joint investment projects, with U.S. investors partnering on municipal energy projects. One example is Vinnytsia's solar farm proposal: The city has land available and demand for a 50 MW solar farm with battery storage to stabilize its grid. A U.S. investor could team up with a Ukrainian developer under the DFC's political risk insurance to build it, with power sold under Ukraine's upcoming auction or a contract with the city. Similarly, waste-to-energy plants in cities like Khmelnytskyi (which has a major nuclear plant and is **exploring** using nuclear heat for district heating) could use U.S. waste-to-energy tech. These projects could be structured as profit-sharing enterprises where both the U.S. and Ukrainian private sectors invest.

More importantly, U.S. stakeholders should approach Ukraine's energy modernization not from the traditional foreign aid lens, but as strategic commercial opportunities. For U.S. energy companies, this is a timely opportunity to enter a new and expanding market, build lasting partnerships, and support democratic allies through economic engagement. Partnering with Ukrainian municipalities offers a chance to deploy innovative technologies in real-world conditions, while contributing to the resilience and recovery of critical infrastructure.

Investing in Ukraine today lays the foundation for long-term business growth and aligns directly with U.S. interests in energy security and global competitiveness. This dual benefit—advancing national interests while opening new commercial avenues—should appeal to both Washington policymakers and the U.S. private sector.

Looking Ahead: Policy Recommendations

Ukraine's energy future hinges on providing a stable regulatory environment, resolving pending issues and off-taker agreements (i.e., arrangements between producers of renewable energy and

their buyers), empowering subnational governments and cities through direct funding and technical aid, and leveraging private sector joint ventures for technology transfer and investment. This final section provides specific policy recommendations to operationalize these solutions, ensuring that Ukraine's energy transformation moves from planning to implementation, even amid uncertainty. The following are key recommendations for U.S. government agencies, Ukrainian authorities, and international partners.

1. **Support Ukraine's Energy Market Reforms:** Ukraine needs to implement energy market reforms, and EU partners—together with the U.S. Department of Energy—can support this process by providing technical assistance, including the following actions:
    - Assist Ukraine's energy regulator, the National Energy and Utilities Regulatory Commission (NEURC), in developing reliable tariff **methodologies** that ensure cost-recovery for renewables and eliminate payment backlogs.
    - Encourage Ukraine to implement proportional curtailment compensation and priority dispatch for renewables to boost investor trust that their assets will not be arbitrarily shut off without compensation.
    - Assist in critical reforms under Chapter 15 (Energy) and Chapter 21 (Trans-European Networks) of the **EU Acquis** (the EU body of laws), including steps to liberalize energy markets, strengthen independent regulation, modernize and integrate energy networks with Europe, and accelerate the energy transition. Ukraine still needs to implement several energy reforms to align fully with EU standards, related to the following issues:
        - The electricity and gas markets remain only partially liberalized. Wartime interventions, price caps, and a remonopolization of the gas sector under martial law continue to distort competition and hinder a truly open market.
        - NEURC's autonomy remains limited. Although legal reforms have been enacted, the commission still operates under executive control, and with at least one plotted vacancy and a lack of transparent replacement procedures, it has yet to achieve the independent, EU-compliant regulatory structure required for Chapter 15 alignment.
        - In the renewables sector, Ukraine has introduced market-based support schemes (auctions and feed-in premiums), but these are not yet fully operational. Their proper implementation is crucial to attract investment and settle outstanding debts to renewable energy producers.
        - In parallel, Ukraine must modernize its electricity grid and expand cross-border interconnections, as wartime damage and inadequate network tariffs have impeded the investments needed for a reliable energy infrastructure.
        - Finally, building up strategic energy reserves remains a priority. While Ukraine adopted an oil stockpiling law in line with EU requirements, implementation is incomplete and minimum reserves are not yet maintained. Similarly, Ukraine must finalize its gas security of supply framework, including legal transposition, emergency planning, and strategic storage targets, to fully comply with EU rules.

2. **Expand Engagement in Municipal Energy Projects:** Given the importance of subnational governments in Ukraine's energy modernization, donors could engage more directly with city-level projects. For example, they could:

    - Encourage the EU Ukraine Facility and World Bank to allocate grants or subsidized-interest loans for municipal energy programs, through existing frameworks like the **Ukraine Municipal Infrastructure Program**.
    - Embed technical advisors, such as retired utility executives or engineers, with key cities to help mayors plan and execute energy projects.
    - Fund a Project Preparation Facility specifically for energy that helps Ukrainian communities conduct pre-feasibility studies, permitting, and tendering for clean energy projects—creating a pipeline of "bankable" projects ready for auction or direct investment.
    - Complete a small **auction** or reverse auction for municipal projects to build confidence for larger ones. For example, solicit bids for 100 MW of biomass and solar and battery storage projects across several city sites, with cofunding from an international donor. Ensure that the contracts are awarded quickly to start construction without major delays.

3. **Facilitate Partnerships with Businesses:** Business associations operating in Ukraine—such as the **American Chamber of Commerce Ukraine**, the **European Business Association**, and the **U.S.-Ukraine Business Council**—could act as conveners and facilitate alliances between U.S., European, and Ukrainian businesses and subnational governments. The activities they could pursue include:

    - Organizing trade missions and virtual pitch sessions where Ukrainian municipalities can present projects to U.S. and European companies and investors.
    - Launching a "U.S.-Ukraine Energy Partnership Exchange" by bringing Ukrainian mayors and energy officials to visit U.S. microgrid sites, while sending U.S. city energy managers to Ukraine, if security permits. These exchanges would build relationships that support technology transfer and twinning arrangements.

4. **Set Up an Electricity Price Guarantee Fund:** Work with allies to create an Electricity Minimum Price Guarantee Fund for Ukraine's renewable projects. Such a fund could address off-taker risk and unlock several billion dollars in private investment. The European Union or United States could contribute seed funding (e.g., via a DFC-administered fund) to help reach an initial $300 to $500 million target. Managed by a multilateral entity, this fund would guarantee a floor price for power from renewables, ensuring revenues.
5. **Expand U.S. Financing Options:** The United States should authorize and encourage institutions such as the DFC and the EXIM Bank to deploy their full suite of tools in Ukraine. Specifically, it should:

    - Expand DFC's insurance products covering energy projects. The DFC could also invest in **private equity funds** that cofinance dozens of renewable and battery installations.

- Include Ukrainian clean energy projects in the remit of the EXIM Bank for export credit support. For example, the EXIM Bank could finance U.S. equipment sales for a solar farm in Ukraine with sovereign or city guarantee.
- Extend the **U.S.-Ukraine Reconstruction Investment Fund** to cover energy infrastructure including grid upgrades, renewables, and storage, which involves minerals such as lithium, cobalt, copper, and rare earths used in batteries, turbines, and power networks. This would accelerate Ukraine's EU-compliant energy transition and support the resilience of U.S. critical raw materials supply chains.

6. **Address Workforce Gaps Through Training:** Workforce **development** should be built into every investment by promoting on-site training for Ukrainian technicians and prioritizing the use of local labor. Donors and investors could make skilled worker training a condition of funding—for example, pairing a solar plant project with the training of local electricians. Training not only helps ensure projects are properly staffed and run smoothly, but also strengthens Ukraine's pool of skilled workers. The United States could support this effort by helping expand Ukrainian vocational programs in fields like solar installation and electrical engineering, potentially through online courses offered by U.S. community colleges or companies.
7. **Set Up a Monitoring System:** Finally, donors and partners, in collaboration with Ukraine, could establish a strong monitoring system to track progress on reforms and the implementation of energy projects. This system would help identify setbacks early and enable timely adjustments. For instance, if a strategy is not working, such as auctions failing due to war-related risks, stakeholders should be ready to pivot, possibly by adopting negotiated PPAs or increasing donor guarantees.

Ukraine has a unique opportunity to transform its energy system into a decentralized, secure, and sustainable model. Such a transition would not only strengthen the resilience of its infrastructure against future Russian threats but also accelerate its integration into the Western energy market, advancing both Ukraine's energy independence and U.S. strategic and economic interests in the region. ■

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