economy runs through the logistics sector, and the journey has already begun.

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THE ROLE OF GREEN TECHNOLOGIES IN POST-WAR RECOVERY OF UKRAINE

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Ukraine is undertaking a reconstruction effort unprecedented in scale and complexity since the Second World War. With over US$55 billion in estimated environmental damage and nearly 70% of its pre-war power generation capacity destroyed or damaged by Russian attacks, the country faces a monumental task: to rebuild not as it was, but as it must become. Central to this vision is the integration of green technologies—renewable energy, sustainable construction, circular economy practices, and clean transportation—across every facet of recovery. This approach is driven by a convergence of necessity and opportunity: the imperative to build an energy

system resilient to military attack, the long-term economic logic of resource efficiency, and the political goal of accelerating integration into the European Union and its European Green Deal.

The Case for a Green Recovery: Security, Economy, and Sovereignty The rationale for a green recovery rests on more than environmental ideals. It is fundamentally about security, economic survival, and national sovereignty. Before the full-scale invasion, Ukraine's electricity system was built around large, centralized thermal and nuclear power plants interconnected by a vulnerable transmission grid. Russia's systematic campaign against these highly visible targets reduced the country's generation capacity to approximately one-third of its pre-war level by late 2024.

This destruction has exposed a fatal flaw in centralized energy systems: they present an adversary with high-value targets whose destruction causes cascading, nationwide blackouts. The alternative is a decentralized model based on thousands of smaller, geographically distributed renewable energy installations—solar panels on hospitals and schools, wind turbines across open plains, and biogas plants in communities. Such a system offers no single point of failure. Strikes can still cause local damage, but they cannot paralyze the entire country. This logic has driven an extraordinary acceleration in renewable deployment: Ukraine added an estimated 1.5 GW of new solar capacity in 2025 alone, a rate of installation that defied both the ongoing war and traditional expectations about energy transitions.

The economic case is equally compelling. Academic research published in Joule argues that renewables are the only energy source that simultaneously meets all four critical criteria for Ukraine's reconstruction: speed of deployment, resilience to attack, independence from imported fuel, and pollution reduction. Wind turbines can be built in approximately twelve months, compared to over seven years for a nuclear plant. Solar arrays can be installed in weeks. When the Ukrainian government speaks of becoming a "regional energy hub" through green investment, it is referring to a future in which the country supplies clean electricity to a European market seeking to decarbonize, generating export revenues and strengthening its geopolitical position.

Pillar 1: Rebuilding a Decentralized, Renewable Energy System Energy

reconstruction forms the core of Ukraine’s green recovery strategy, a transformation best understood through its concrete projects and ambitious targets.

Solar photovoltaic (PV) energy is the most visible and rapidly deployed technology. The International Energy Agency estimates that Ukraine must add approximately 4 GW of distributed solar PV per year until 2030—over 24 GW in total—to create a secure, decentralized power system. This is not a distant aspiration; it is a trajectory already underway. UNDP-led programs have installed more than 475 MW of new and backup renewable capacities, providing over 23 million Ukrainians with more reliable access to energy. A EUR 16.5 million initiative is equipping schools, hospitals, and kindergartens with solar panels, heat pumps, and battery storage, transforming these buildings into self-sufficient energy "prosumers" that can operate even when the main grid fails.

Wind energy offers the greatest scalability for utility-scale generation. Ukraine possesses a total geographical technical potential exceeding 187 GW of wind energy, among the highest in Europe. The national target calls for 6.2 GW of wind capacity by 2030, with integration into the European energy market. Seven large wind farms with a combined capacity of up to 4 GW are already under construction, including the expansion of the Tyligulska wind farm—now the country's largest. A €157 million financing package from the EBRD, IFC, and the Black Sea Bank is supporting private wind development, signaling growing investor confidence.

Bioenergy, biogas, and heat pumps round out the decentralized energy mix. In the Lviv region, an inter-municipal biogas production project demonstrates how communities can turn agricultural waste into local power. The most innovative demonstration project, however, sits in Trostyanets, a town just 35 kilometers from the Russian border that was devastated by occupation in 2022. There, a five-story apartment building at 53 Blahovishchenska Street became the first multi-apartment residential building in Ukraine to be heated entirely by heat pumps and geothermal energy, combined with a solar power plant. The €218,000 investment now provides residents with heating and hot water entirely independent of fossil gas—a model the city intends to replicate across Ukraine as part of its "Master Plan for Green Reconstruction".

Pillar 2: Sustainable Urban Reconstruction and Green Building The reconstruction of Ukraine's damaged cities presents a once-in-a-generation opportunity to embed sustainability into the built environment from the outset. The scale is staggering: entire neighborhoods require rebuilding, and the decisions made now will lock in energy consumption patterns for decades.

The Science Neighborhood pilot project in Kharkiv, developed by the Norman Foster Foundation under the UN4UkrainianCities initiative, exemplifies this philosophy. The concept proposes a complete, livable district combining housing, research facilities, amenities, inclusive mobility, and generous green spaces—all designed around people rather than vehicles. The project deliberately rejects the car-centric, functionally segregated planning of the Soviet era in favor of a compact, walkable, mixed-use model that supports environmentally responsible lifestyles while positioning science and innovation as drivers of economic resilience.

At the municipal level, twelve Ukrainian cities—including Kyiv, Mykolaiv, and Vinnytsia—have joined the EU-funded SUN4Ukraine initiative, which guides them toward developing Climate Neutrality Plans and adopting climate neutrality targets by 2050. This program connects Ukrainian municipalities with the EU's 100 Climate Neutral and Smart Cities Mission, facilitating peer learning and technical expertise that will shape how reconstruction funds are spent.

Pilot projects across the country are testing innovative approaches. Sumy, Chernihiv, and Kharkiv regions are partnered with Germany's Fraunhofer Institute to advance urban mining—recovering and recycling construction materials from war-damaged buildings for use in new construction, simultaneously addressing debris management, material shortages, and carbon emissions. The FELICITY II program is assisting cities such as Kryvyi Rih and Mykolaiv with low-carbon infrastructure planning, connecting them with European expertise and international financial institutions.

UNEP has formalized cooperation agreements with Kharkiv, Mykolaiv, and Odesa to develop sustainable district energy systems. For Kharkiv, this means comprehensive feasibility studies demonstrating how fully decentralized and integrated

heating and electricity networks can provide sustainable alternatives to the centralized Soviet-era infrastructure that proved so catastrophically vulnerable.

Pillar 3: Environmental Remediation and Circular Economy The environmental toll of the war extends far beyond carbon emissions. Over 1.2 million hectares of protected areas—approximately 30% of Ukraine's Nature Reserve Fund—have been impacted. Soil contamination with heavy metals at levels five to ten times above safe thresholds, the loss of 70–80% of steppe ecosystems, a 25–40% decline in key bird species, and critical degradation of rivers including the Siverskyi Donets and Dniester all demand remediation on an industrial scale. Green technologies are central to this effort.

The FAO and WFP are leading a four-year initiative to map mine-contaminated farmland, assess soil health, and train Ukrainian experts in advanced analytical techniques for detecting pollutants, including heavy metals and radionuclides. The goal is to help farmers reclaim their land safely and restore food production. The UNDP Environmental Damage Assessment Project, funded by Sweden, is equipping Ukrainian inspectors with mobile laboratories, drones, and analytical reagents to document contamination and build the evidence base for future reparations claims.

Circular economy principles are being embedded in reconstruction planning. The urban mining initiative mentioned above recovers materials from debris. A project in Khmelnytskyi is developing a sustainable system for recycling light industry waste. Brovary is modernizing its wastewater treatment infrastructure through a twinning arrangement with German and Polish cities. These projects collectively establish the foundation for a reconstruction that minimizes waste, reduces reliance on virgin materials, and aligns with EU environmental standards.

Pillar 4: Green Agriculture and Food Systems Ukraine is one of the world's most vital agricultural regions, and the war has severely disrupted its farming sector. Green agricultural technologies are being deployed to restore productivity while building resilience against future shocks.

A major bilateral project with Japan, launched in 2025, focuses on technology transfer in the agricultural sector through modern biotechnology, modular production

systems for communities, and joint venture creation. The first high-tech greenhouse using Japanese agro-technologies has opened in Ukraine, employing film agriculture (Imec) that allows plants to grow on a thin hydrogel membrane, dramatically reducing water consumption while protecting crops from soil-borne diseases. These technologies are designed to enable resource-efficient, high-yield farming even in areas where soil contamination or water scarcity would make conventional agriculture impossible.

The FAO and European Union have provided over UAH 217.8 million in grant support to 378 agricultural producers, enabling investment in green technologies, critical machinery, and infrastructure. A partnership between Ukraine and Denmark focuses on sustainable land use, drawing on Danish experience to develop joint projects in bioeconomy, forest restoration, and emission reduction. Regenerative agriculture practices—reduced tillage, cover cropping, and diversified rotations—are being promoted to improve soil health, sequester carbon, and reduce dependence on chemical fertilizers.

Pillar 5: Policy, Legal Frameworks, and EU Integration Green reconstruction is being embedded in Ukraine's legal and institutional architecture, a process inseparable from the country's EU accession path. Official negotiations on EU membership opened in June 2024, and approximately one-quarter of the reform steps completed by Ukraine have directly contributed to alignment with EU law in areas including energy market transparency, industrial pollution control, and environmental assessments.

Landmark legislation includes the Law on the Principles of Green Recovery, which mandates that all public and private reconstruction projects comply with environmental criteria. The adoption of legislation aligning Ukraine's renewable energy policy with European Green Deal objectives has been recognized by the European Parliament as a significant step. Ukraine is also preparing for sovereign green financing, adopting European corporate reporting standards that will enable access to international green bond markets.

At the 2025 Ukraine Recovery Conference in Rome, the government presented the Green Platform—a digital catalogue of more than 60 green finance programs accessible to businesses, communities, and enterprises as a single entry point. The

conference resulted in agreements and pledges worth US$10 billion, with memoranda of understanding signed between UNEP and the key cities of Kharkiv, Mykolaiv, and Odesa for sustainable district energy development.

Pillar 6: International Partnership and Financing Mechanisms The scale of green reconstruction far exceeds Ukraine's domestic resources. A coordinated international response has mobilized billions in funding, structured through mechanisms designed to de-risk private investment and channel support efficiently.

The Green Energy Recovery Programme, funded by Japan, Denmark, Belgium, Sweden, and Norway alongside UNDP, has a total budget of approximately USD 245 million and has already procured and installed more than 450 MW of generating capacity in frontline regions. Korea's KOICA and UNDP launched a US$14 million four-year initiative targeting 100,000 direct beneficiaries across five war-affected oblasts, training 1,800 local specialists in decentralized energy system management. The Nordic countries, through Nefco, have mobilized over EUR 400 million for green recovery activities, funding projects from Lviv's wastewater treatment modernization to energy-efficient school buildings and solar installations.

The Ukraine Renewable Energy Risk Mitigation Mechanism (URMM), announced at URC 2025, represents perhaps the most significant structural innovation. Structured by the EBRD with €180 million from the EU and €12 million from the Netherlands, with additional support from Germany, Norway, Sweden, and Switzerland under consideration, the mechanism is designed to support 1 GW of new renewable capacity and potentially mobilize €1.5 billion in private investment by giving generators and investors greater confidence in future revenues.

Challenges and the Path Forward The green recovery faces formidable obstacles. The war continues, and Russia's targeting of energy infrastructure makes every investment a calculated risk. The total cost of reconstruction is estimated in the hundreds of billions, far exceeding currently committed funds. The speed required for emergency repairs often conflicts with the longer timelines needed for sustainable planning. Institutional capacity, weakened by years of conflict, must be rebuilt simultaneously with the physical infrastructure it is meant to oversee.

Yet the direction of travel is unmistakable. Ukraine's green recovery is being built not as a theoretical ideal but as a practical necessity—forged in the crucible of war, funded by an unprecedented coalition of international partners, and anchored in the legal and policy frameworks of European integration. The Trostyanets apartment building, heated by the earth beneath it rather than gas piped from Russia, is more than a construction project. It is a declaration that Ukraine's future will be built on different foundations than its past. As Deputy Minister Olha Yukhymchuk stated, decentralized generation based on renewable energy is "not only a demand of the times but also a guarantee of Ukraine's integration into the European energy market". The green recovery of Ukraine is, in the most profound sense, the recovery of its sovereignty.

ARTIFICIAL INTELLIGENCE FOR ENVIRONMENTAL MONITORING AND BIODIVERSITY CONSERVATION

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Biodiversity is declining at a pace unprecedented in human history. The statistics are stark: monitored vertebrate populations have declined by an average of 76% since 1970 (WWF, 2024), ecosystems are fragmenting, and species are disappearing before they can even be catalogued. Yet across the planet, a quiet revolution is underway—one in which artificial intelligence is being deployed not to optimize advertising or automate factories, but to listen to rainforests, identify whales from space, and predict where poachers will strike next.

This article examines how AI technologies—from deep learning models processing satellite imagery to edge devices listening for chainsaws in protected forests—are reshaping environmental monitoring and biodiversity conservation. It explores the major application domains, the technological breakthroughs enabling them, and the critical challenges that must be addressed if these tools are to deliver on their profound promise.

The Scale of the Challenge Traditional ecological monitoring relies on methods that have remained fundamentally unchanged for decades: scientists walking transects, setting camera traps, and manually reviewing thousands of hours