Conclusions and Recommendations

Renewable-Energy Generation

EUETh
EUROPE-UKRAINE
Energy Transition Hub

Roadmap for a climate-neutral, sustainable Ukrainian energy sector and its role in an integrated EU energy market

Roadmap for a climate-neutral, sustainable Ukrainian energy sector and its role in an integrated EU energy market

Citation

IKEM (2023): *Roadmap for a climate-neutral, sustainable Ukrainian energy sector and its role in an integrated EU energy market.* Conclusions and Recommendations, Renewable-Energy Generation.

Supported by

Breakthrough Energy

Authors

Dàmir Belltheus Avdic | IKEM
damir.belltheus-avdic@ikem.de

Josefine Lyda, LL.M. | IKEM
josefine.lyda@ikem.de

Ievgeniia Kopytsia, Ph. D.
Yaroslav Mudryi National Law University
ievgeniia.kopytsia@ikem.de

Jana Karras | IKEM
jana.karras@ikem.de

Dr. Hanno Butsch | BBH

Johannes Graetschel, LL.M.
IKEM
johannes.graetschel@ikem.de

Vera Grebe | BBH
vera.grebe@bbh-online.de

Valentyn Gvozdiy, Ph.D
GOLAW

Prof. Christian Held | BBH

Ivo Hlaváček | Horizon 2

Dr. Anna Lesinska-Adamson
BBH
anna.lesinska-adamson@bbh-online.de

Vivien Lorenz | BBH

Dr. Jana Maruschke | IKEM

Oleksandr Melnyk | GOLAW

Dennis Nill | IKEM
dennis.nill@ikem.de

Sergiy Oberkovych | GoLaw

Carina Rastan | IKEM

Dr. Simon Schäfer-Stradowsky
IKEM
simon.schaefer-stradowsky@ikem.de

Reviewers

Philipp Offenberg
Breakthrough Energy

Peter Sweatman
Climate Strategy & Partners

Graphic Designers

Julie Hertel | IKEM
julie.hertel@ikem.de

Odile Stabon | IKEM
odile.stabon@ikem.de

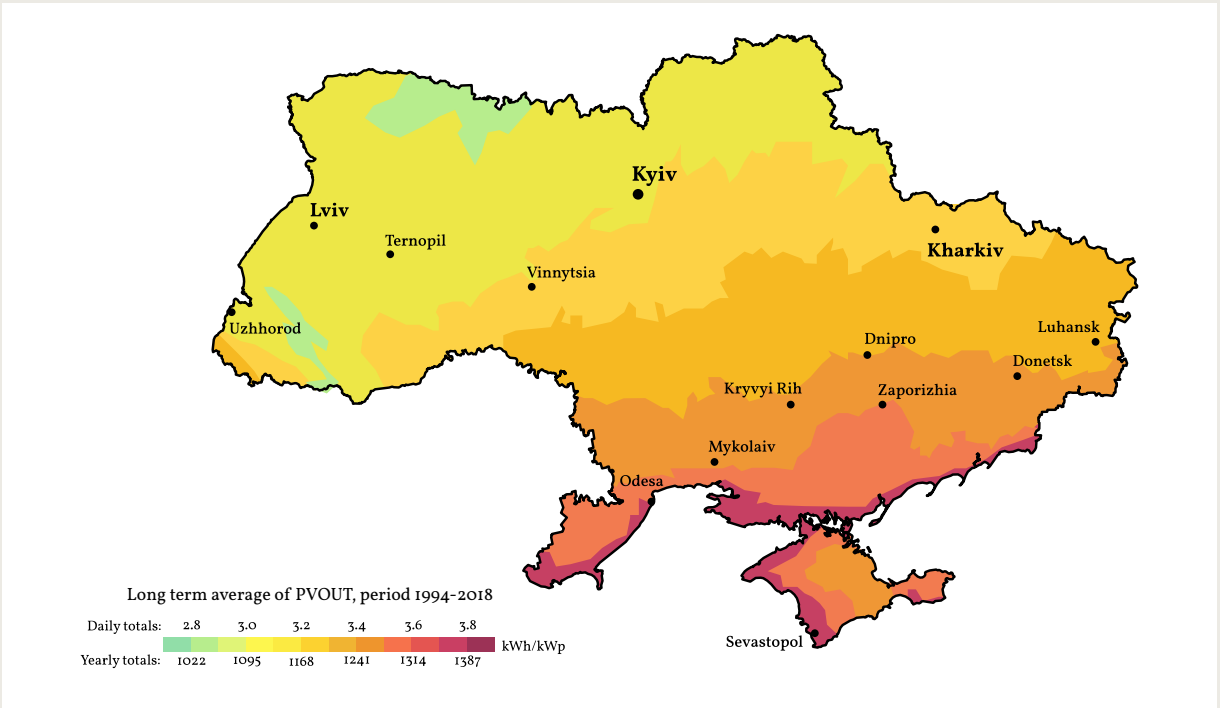
Renewable-Energy Generation

The production of renewable energy is the backbone of an energy transition. Clean forms of energy produce little to no net greenhouse-gas emissions in operation, but each have finite siting possibilities in terms of suitable rivers, resources and feedstock. Solar and wind are the lowest cost energy providers over their lives, but are intermittent and in the case of Ukraine will require balancing capacities (such as energy storage in the form of hydrogen – handled in the Energy Distribution and Storage section of this publication) and interconnections.

Pioneering countries such as Denmark and Spain have made the first steps towards the transformation this requires, and may provide inspiration on which path to take for other countries. Of course, the energy transition is incomplete, and there is no perfect model for Ukraine which will blaze its own trails based on its specific needs, resources, and particularities.

Solar power

At the beginning of 2022, Ukraine had total installed photovoltaic capacity of 7.6 GW, which equals 80% of the country's total renewable installed capacity; this excludes 0.4 GW located in the territories occupied by Russia before February 2022 and includes 45,000 prosumer installations with a total capacity of 1.2 GW. From a geographical perspective, Ukraine has substantial potential to produce solar electricity, with average annual amount of solar radiation ranging from 1070 kWh per square meter in the northern part of the country to 1400 kWh in the south. The overall potential of solar electricity production is estimated to be almost 83 GW with an annual potential of 100 TWh. The Energy Strategy of Ukraine until 2050 envisions an eventual increase in installed solar capacity to 17.5 GW.



Solar power potential in Ukraine
Source: Solargis, 'Photovoltaic Power Potential Ukraine'.

The Russian war of aggression has given solar energy an important role in terms of securing Ukraine's electricity supply. Solar electricity generation helps prevent power outages and protect critical infrastructures such as hospitals, improving resilience.

There are a number of solar panel manufacturers in Ukraine. In 2020 the product range covered everything from portable 10 W solar panels up to 390 W modules for solar power plants, as well as other materials, components, and equipment, like batteries, monocrystalline silicon ingots, silicon wafers, solar modules, and sapphire monocrystals. Some of the production is exported to other countries such as the United States, Japan, Germany or China.

Recommendations

During the immediate aftermath of the war, public authorities should set an example and increase renewable enhance generation by **supplying public buildings with solar panels** and stipulating that **reconstructed buildings should host solar panels.** Providing residents with small solar and storage systems to meet basic energy needs can also empower communities and **promote decentralized energy production.**

Moreover, it is advisable to **maintain the basic structure of the current market design** to continue promoting solar and residential solar plants. Simultaneously, **improving permitting procedures** and creating additional **regulatory incentives** will be essential to expediting solar project development. Early on, Ukraine should **explore innovative concepts** like floating solar on hydropower lakes and combining solar energy with agricultural land use, energy storage, or hydrogen generation. The development of a **handbook for greenfield solar projects** can serve as an additional resource for project developers, streamlining project implementation.

In parallel, Ukraine should conduct a comprehensive **assessment of financial and regulatory obstacles** hindering solar energy expansion. Subsequently, measures should be taken to address these challenges, ensuring a conducive environment for solar investments. Leveraging the existing solar industry is critical, and an assessment of local producers' needs can inform a **strategy to bolster local solar panel production**, fostering economic growth and energy self-sufficiency.

Eventually, Ukraine should build upon these foundations by **adapting regulations to facilitate the construction of medium and large-scale solar parks**, possibly in conjunction with other renewable energy generation sources. Additionally, regulatory and financial **support for local solar manufacturers**, in compliance with EU legislation, can bolster domestic production capabilities. Funding research to improve solar power technology can support the long-term advancement of Ukraine's solar industry. It is crucial also to develop a robust concept for an **optimal grid integration** of increased solar power capacity is crucial.

Wind power

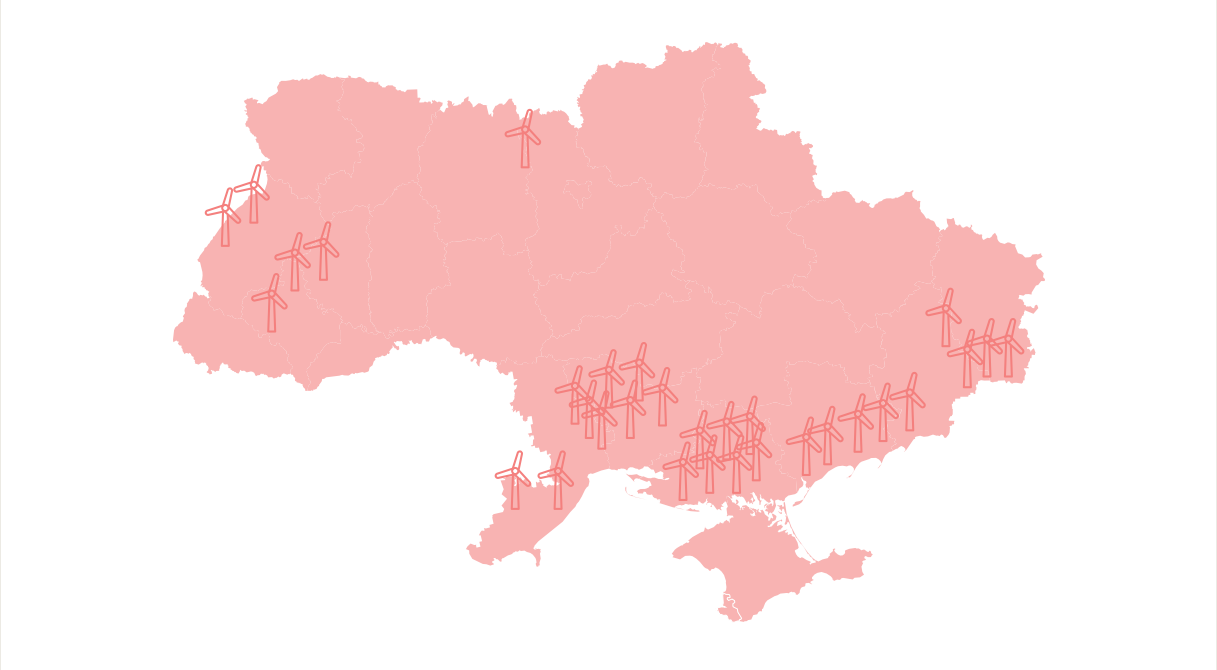
In 2021, wind power in Ukraine had a capacity of 358.8 MWp and produced 30.6% of total green electricity, making it the second biggest source of renewable energy after solar. Before the full-scale Russian invasion, the country counted 34 wind farms, mainly in the south and southeast, with around 85% situated on the Black and Azov Sea coasts. Ukraine's total installed capacity of wind power plants, mostly located in the Kherson and Zaporizhzhia regions, was 1.6 GW; this excludes the 0.2 GW located in territories already occupied by Russia at that time. Wind power produced 3,866 GWh of green electricity, which is enough to meet the annual electricity consumption of around 650,000 households with a monthly consumption of about 500 kWh.

Russia's attack has had a disastrous impact on Ukraine's wind energy sector, with most capacity being in occupied territories. The Ukrainian Wind Energy Association reports that 75% of the total installed wind capacity was offline and at least 10 wind turbines are damaged. The war also negatively affected the development and construction

of wind projects which would otherwise have added a capacity of around 300 MW.

According to a study by the Centre for European Policy Studies, Ukraine has overall capacity for as much as 320 GW of onshore wind energy. Steppe zones are best suited because of strong winds in both cold and warm seasons, and compensating local winds in-between. Furthermore, these areas in Ukraine already have good logistics infrastructure.

There are currently no offshore wind farms in Ukraine, but the country has great offshore wind power potential, thanks to the shallow waters of the Azov and Black Seas, the Dnipro cascade, the Dnister reservoir, and Sivash Bay, among others. According to the World Bank, Ukraine may have some 251 GW of potential capacity in offshore wind, of which 183 GW fixed and 68 GW floating. The Ukrainian Wind Energy Association envisions a significant boost in wind power capacity by 2030, including a contribution of 1 TWh in electricity production through offshore wind farms, which are meant to have an installed capacity of 300 MW in that year.



Wind turbines and wind parks located in Ukraine in 2021
Source: Razumkov Centre, 'Сектор Відновлюваної Енергетики України До, Під Час Та Після Війни'.)

Recommendations

Ukraine can foster the development of onshore and offshore wind power through a series of strategic measures. An essential step in the early post-war period will be to conduct a **comprehensive assessment of onshore wind energy potential** across every oblast to pinpoint areas with optimal conditions for rapid onshore wind energy deployment, often referred to as "**go-to areas**." To further bolster onshore wind energy generation, Ukraine should also consider the development of instruments that **facilitate project development**. These may include the creation of a publicly accessible detailed wind atlas – a comprehensive handbook offering information on suitable areas, wind conditions, and power-generation potential.

Another critical factor will be the **simplification of permitting procedures and administrative workflows** to expedite project development and reduce project lead times, thus attracting more investments into the wind industry. Moreover, Ukraine can expedite wind energy growth by **initiating onshore wind projects on state-owned land**.

In parallel, it is essential to consider measures that **enhance local acceptance** of onshore wind projects. Drawing inspiration from successful practices in EU countries, Ukraine could explore the creation of schemes for **local buy-in**, such as energy cooperatives. Additionally, the implementation of local taxes or other **benefits for municipalities involved**, such as reduced energy costs, can help align community interests with the expansion of onshore wind power.

In the longer term, after the reconstruction phase, Ukraine should conduct a **strategic assessment** of the existing **know-how and infrastructure**, and the **needs of manufacturers** and other stakeholders. The country should also **facilitate joint ventures** with companies from EU countries, where appropriate. Moreover, it will be crucial to conduct a thorough assessment of the effects of increased renewable-energy generation on the **transmission system** at an early stage. This assessment should serve as a basis for creating a **national grid-development plan**, outlining the needs of the transmission system.

In parallel, it is imperative to establish clear and **effective guidelines for environmental-protection measures linked** to the installation of new wind turbines. Adhering to EU standards while maintaining speed in permitting procedures is crucial. Learning from successful models can provide valuable insights for the development and adoption of these guidelines.

Moreover, Ukraine should assess the supply chain for wind turbine production to find out which components can be produced within the country and which will have to be imported. Based on these findings, a comprehensive strategy should be formulated to establish a **Ukraine-based industry for renewable power plants and related services.** This strategic move can contribute to the growth of the local economy and the creation of a self-sufficient renewable energy sector.

Ukraine's existing expertise in maritime operations, particularly in offshore oil and gas, offers a strong foundation upon which Ukraine can **build an offshore wind industry**. Considering the unique challenges posed by the marine environment, environmental-protection measures must be robust. Exploring the possibility of implementing a **maritime planning procedure** specific to wind energy can help align environmental considerations with rapid project development.

In addition to domestic efforts, Ukraine should actively assess opportunities for offshore wind generation in **collaboration with neighboring EU countries** Romania and Bulgaria, as well as Turkey. Developing a long-term strategy for a meshed-grid approach for the Black Sea, mirroring successful concepts in the North and Baltic Seas, could enhance regional energy security and cooperation.

Lastly, Ukraine should explore the potential for **offshore hydrogen production**, taking inspiration from similar plans from EU countries. Engaging in cooperative ventures with these countries can facilitate knowledge exchange and joint projects, ultimately advancing Ukraine's offshore wind and renewable energy objectives.

Bioenergy

Energy carriers derived from biomass come in many forms. Practically any of the most common physical energy carriers today can be produced with biomass – this applies both to carbon-based fuels, such as biomethane, bioethanol, or biodiesel, and to carbon-free fuels such as biohydrogen or bio-ammonia. They are produced through a variety of processes which require different feedstocks, levels of energy input, equipment, and expertise.
As a country with one of the largest agricultural sectors in the world, Ukraine has no shortage of biomass. Biomass can be both combusted for heat production or turned into biogas – a mixture of methane and carbon dioxide – for electricity production or indirect heat production. In 2022, there were 73 biogas plants in Ukraine producing some 260 million cubic meters of biogas per year. The biomass currently used for heat production in Ukraine mainly comes from wood chips produced in lumber operations. Agricultural waste is not yet used on a large scale, despite great potential, especially from the country's abundant sunflower and wheat production.

In 2021, biomass accounted for 9% of Ukraine's total heat production (almost all of it in industrial processes), substituting imports of around 4 billion cubic meters of natural gas a year. Biogas is also used to produce electricity, with capacity in Ukraine increasing from less than 5 MW to 60 MW between 2017 and early 2020.

Biogas can be refined into biomethane, which is chemically almost identical to natural gas. In 2021, Ukraine consumed some 30 billion cubic meters of natural gas, of which one third was imported indirectly from Russia for billions of dollars a year – in other words, sustainable biomethane, which can replace natural gas in most applications, could contribute greatly to the country's energy security as well as its national accounts, economic activity and employment. Among the benefits of biomethane is the fact that a great deal of infrastructure already exists in Ukraine in the form of well-developed gas grids. According to the European Bank of Reconstruction and Development's (EBRD's) bioenergy program in Ukraine, with a high enough level of investment (some USD 2 billion), the country could realistically develop an annual production capacity of five to six billion cubic meters of biomethane.

Municipal district heating companies in Ukraine typically use gas-fired boilers or combined heat and power plants, consuming around 6 billion cubic meters per year. They are well-placed to use biogas instead. If 50% of the natural gas used by district heating companies (a realistic medium-term goal) could be substituted by biomass, Ukraine could reduce its consumption of natural gas by 3 billion cubic meters a year, or a third of its imports.

There are a number of issues standing in the way of an expansion in bioenergy production and deployment, however, including lack of connections from producers to district heating, low conversion efficiency (and therefore higher prices), lack of appropriate legislation or other state support such as certification programs and insufficient supplier guarantees. Moreover, natural gas is sold by the government to district heating companies at a steep discount, creating little incentive to invest in alternative sources (or increase efficiency).

Recommendations

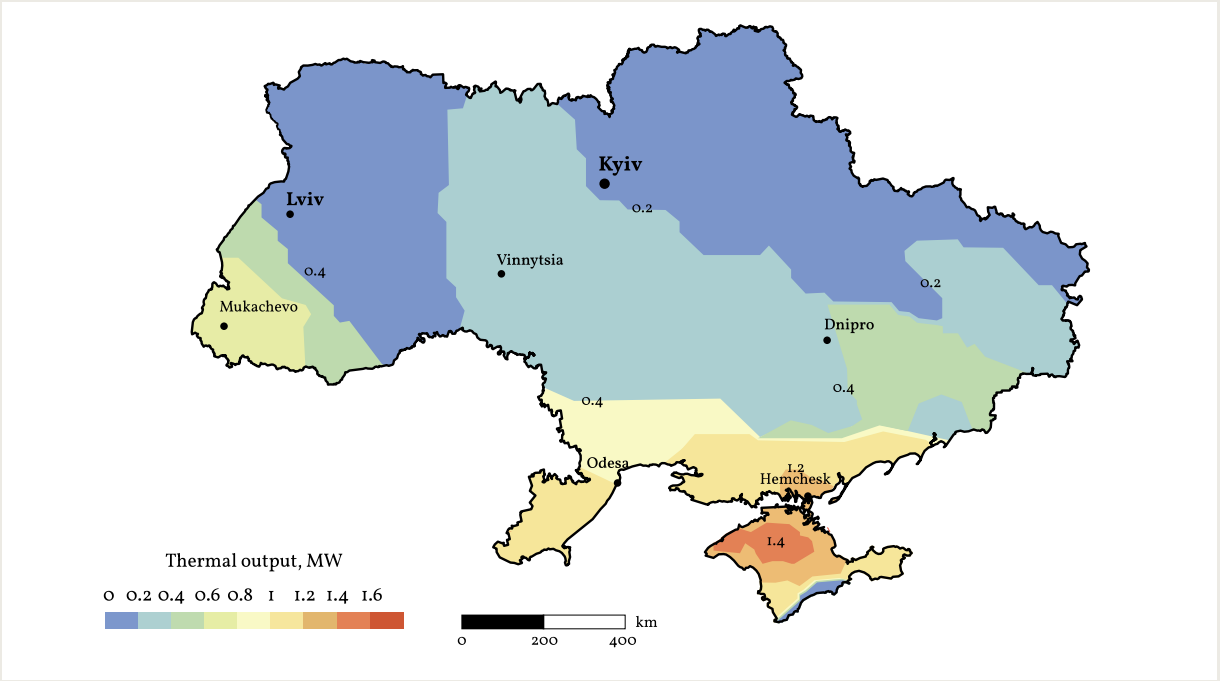
Once the war ends, Ukraine's priority should be to reintegrate the bioenergy production in previously occupied territories into its supply chains and distribution grids. The country should also start to lay the groundwork for a multifaceted expansion and deployment of bioenergy by assessing the overall biomass potential and infrastructure requirements for every region.

Based on this assessment, Ukraine should develop and implement a **medium to long-term strategy to expand the production and use of bioenergy**. This strategy should include measures increasing production of all energy carriers based on biomass for domestic use as well as export, and creating the **regulatory and physical infrastructure** needed to deploy more bioenergy across all sectors.

Many farming and forestry enterprises in Ukraine may lack the scale necessary to profitably market heat and/or electricity produced through biomass. Ukraine could **incentivize smaller operations** by providing financial support schemes and information for navigating the relevant regulatory, economic, and technical environments, for instance by **dedicated government agencies** or private development companies.

Geothermal energy

Geothermal energy is generally sustainable and renewable, with some manageable environmental concerns. Ukraine has substantial untapped potential in this field, with the Institute of Renewable Energy of the National Academy of Sciences of Ukraine calculating the total geothermal potential for the whole country to be some 10.81 GW, or 80.5 TWh per year – substantial opportunities can be found especially in the regions Crimea and Kherson in the south, Chernihiv in the north, Zakarpattia and Lviv in the west, and Poltava and Kharkiv in the center-east. In theory, 80 TWh of geothermal energy could replace almost 9 billion cubic meters of gas, or about the equivalent of Ukraine's current indirect gas imports from Russia.



Distribution of expected thermal output across Ukraine
Source: Shogenov, 'Geothermal Prospects in Ukraine'.

Very little of this potential is currently harnessed in Ukraine (or elsewhere), due to high upfront-investment costs, environmental issues, and the need for advanced technological knowhow. The Ukrainian government should support an expansion of geothermal energy by facilitating investment and distribution through instruments such as loan guarantees, incentives attracting investment and the accompanying expertise from allied countries, and openness to new, non-centralized and bottom-up methods and ideas.

Initially, geothermal energy can be used for direct heating of buildings and low-intensity industrial heat applications in places where it is easiest to harness. Eventually, once large-scale investments are safe and realistic, deeper wells may be used for higher-intensity industrial processes or the pro-

duction of electricity or other green energy carriers such as hydrogen or ammonia. Particularly in the east of the country, geothermal energy may eventually help fire the industry which is currently powered by coal. Such large-scale projects could initially be pioneered by a few international consortia of large companies.

Recommendations

The Ukrainian government should establish an **overarching strategy for the expansion of geothermal energy which takes into account the relative maturity level of the available technology.** Initially, geothermal energy can be used for **direct heating** of buildings and **low-intensity industrial-heat applications** in places where it is easiest to harness. Eventually, once large-scale investments are safe and realistic, deeper wells may be used for **higher-intensity industrial processes** or the production of **electricity or other green-energy carriers** such as hydrogen or ammonia. Particularly in the east of the country, geothermal energy may partly **fire the industry** which is currently powered by coal.

Hydroelectric energy

Ukraine has a total installed hydro capacity of some 6,306 MW (this takes into account the unit added to the Dnister pumped-storage plant in 2021 and the destruction of the Kakhovka Dam in 2023). The World Bank is financing a project to expand this capacity by another 215 MW or so. Since 1985, the proportion of electricity produced with hydropower plants in Ukraine has fluctuated between 3 and 10%. More than half of the installed hydropower base is over 50 years old and requires renovation and rehabilitation. In theory, the country's total hydropower capacity could be expanded by more than 4 GW and there are in fact a number of projects in the planning or feasibility study phases, such as a plan to expand the capacity of the Dnister hydropower complex by almost 1 GW, for instance.

Hydropower plants play a major part in keeping power supply stably matched to demand with frequency-response ancillary services. Hydropower is reliable, dispatchable and produces no emissions during generation. At the same time, dams are not always as green as they may seem – hydropower can lead to serious environmental degradation and biotope disruption. As far back as 2010, a study estimated that 472 million people downstream from large dams suffer from regular flooding, reduced food security and/or issues with their livelihood.

Recommendations

After the end of hostilities, Ukraine's primary focus should be to thoroughly evaluate, stabilize, and, whenever feasible, undertake **renovation or reconstruction efforts** for its existing hydroelectric plants. The government should also explore potentials for symbiosis with other modes of renewable power generation, e.g., floating solar or the integration of hydrogen generation. To ensure any new hydro projects' compliance with EU regulations, careful **environmental impact assessments** considering the effects of dams on ecosystems and livelihoods should begin in the immediate afterwar period. These assessments should inform a comprehensive **cost-benefit analysis** for these projects. Overall, Ukraine's priority for additional renewable energy should be on more sustainable sources such as solar, wind, and biomass, with hydropower plants considered only on a smaller scale.

Funding possibilities

Financing renewable-energy generation in Ukraine typically involves a mix of financial instruments to attract investors and secure the necessary capital. The choice of financial instruments depends on a range of factors, including project size, risk profile, market conditions, and the preferences of investors and lenders. The most promising instruments to foster the expansion of renewable-energy generation include:

- Government incentives, such as feed-in tariffs, tax credits, or grants, which reduce the overall project costs and encourage investment in renewable energy.
- Green bonds: debt securities earmarked specifically for environmentally friendly projects, which can attract environmentally conscious investors.
- Power-purchase agreements, which involve selling the electricity generated by renewable producers to buyers (often utilities or corporate entities) at a predetermined price over a fixed term. Such long-term contracts can provide a stable revenue stream, making projects more attractive to lenders and investors.
- International climate funds and multilateral development banks like the World Bank or the European Investment Bank often provide financing in emerging markets like Ukraine.
- Crowdfunding and community investment – especially interesting considering Ukraine's experiences with contributions from large numbers of individuals or communities so far – can help raise capital for local projects.

The choice of financial instruments should be carefully tailored to the specific needs and circumstances of each concrete project in Ukraine, as well as the regulatory and market conditions in the country.

Recommendations

Fostering renewable energy during the postwar reconstruction should be carefully reflected in a comprehensive and detailed regulatory framework. The adoption of the Green Transformation Law addressed a range of challenges which hinder the development and optimal operation of renewable energy in Ukraine. However, a significant amount of legislative work still needs to be completed. This should include at least:

1. conducting a **thorough analysis of secondary legislation to identify obstacles or bottlenecks** in the implementation of the Green Transformation Law (with special attention to tax regulation) to grant renewable-electricity producers the right to sell electricity;
2. speeding up the development of secondary legislation to:
   - implement a mechanism for **suspending and renewing contracts with the guaranteed buyer** and
   - develop standard additional agreements to the contract for the purchase and sale of electricity **at the feed-in tariff** and the contract on participation in the **balancing group of the guaranteed buyer**;
3. adopting secondary legislation to implement a **market-premium mechanism** and design a model contract for the provision of and payment for services under the market-premium mechanism;
4. approval by the Cabinet of Ministers of Ukraine of a **dedicated procedure** for issuing, circulating, and redeeming **guarantees of origin**;

5. granting authority to the National Energy and Utilities Regulatory Commission (NEURC) for **issuing guarantees of origin**;
6. creating a separate **register of guarantees of origin**, which should be integrated into the regional register of the Energy Community; and
7. Defining and adopting annual support quotas and auction schedules by the Cabinet of Ministers to ensure full operation of green auctions in Ukraine.

Ukraine should encourage private-sector investments in bioenergy by establishing a **clear and stable regulatory framework** that provides **long-term predictability** for investors. A major building block could be the reintroduction of a **feed-in tariff** both for electricity generation and gas production. Another effective incentive could be to continue to offer **loan guarantees**, such as those currently provided in Ukraine by the German state investment and development bank KfW.

.

In the near term, Ukraine must prioritize the rebuilding and reconstruction of destroyed energy infrastructure using the best available technologies that minimize greenhouse-gas emissions. The Ukrainian authorities should, wherever possible, also include **climate and sustainability considerations** in their privatization plans (the exact definitions depending on the given industry sectors). Special care should be given to **iron and steel production**, which are particularly important to Ukraine's economy but have high energy consumption.

Combined heat and power (CHP) plants should be explicitly included in medium and long-term strategies and considered in the relevant cost-benefit analyses as an efficient measure to balance the grid system or during capacity shortages. The government should see to it that **no lock-in effects** occur with CHP plants that initially operate with fossil energy carriers – CHP plants should be planned to eventually use **hydrogen or similar** energy carriers. Regulations should be implemented to support the use of sustainable bioenergy originating in residual materials and waste, improving economic circularity. Eventually, CHP plants can be retrofitted for use with more renewable-energy carriers.

Given its EU candidacy, Ukraine must join **the EU's emissions trading scheme (ETS)** or develop **its own carbon-pricing system**. Both options have economic implications that need careful evaluation. Joining the ETS is a shortcut to high standards but requires adjusting to demanding EU policies. Establishing a national scheme would offer more flexibility but less access to European markets. Strengthening the efficiency of the sector is vital for both options. Considering circumstances post-war, it may be prudent to introduce a **gradual and phased approach** to avoid overburdening the industrial sector.

Transition bonds can be used as a debt instrument for projects that enhance energy efficiency, reduce emissions, or support renewable-energy adoption in their operations. Leveraging **government grants and incentives** can help reduce the financial burden of deploying inventive new methods and technologies, as well as energy-transition initiatives.

A legal basis should be established for an **energy exchange**, giving energy-market participants access to transparent liquidity, standardized contracts, and centralized clearing, There should also be a legal framework that makes it easier for industrial enterprises to run **small-scale renewable-power plants** to meet their own demand. A circular-economy law should also be adopted to promote sustainable **resource management and supply chains**, not least when it comes to batteries. This would help promote **greater investment, transparency, and sustainability** in **critical industries**.

Hydrogen

Hydrogen and its derivatives will be essential in the future energy mix required to achieve a prosperous, technologically advanced future and energy independence for Ukraine. Europe's energy transition, for instance, foresees large-scale production and use of hydrogen – and given European climate goals, this may eventually largely have to be renewable or climate-neutral hydrogen, that is, hydrogen produced through electrolysis powered by renewable solar, wind or hydro energy. Pink (made through nuclear-powered electrolysis) and blue (made with fossil-powered electrolysis with carbon capture) hydrogen are, however, also admissible under EU rules, and likely to remain so indefinitely.

The production of hydrogen requires great amounts of energy. Ukraine has plenty of renewable-energy resources compared to its European peers. The country may also have spare nuclear-power capacity which can be used to keep electrolyzers running when general demand for electricity is low.

The choice of financial instruments for hydrogen projects depends on the specific technology, scale, and market conditions. The following instruments show promise in the financing of hydrogen projects in a Ukrainian context:

- governmental subsidies and incentives, e. g. grants or tax incentives to promote hydrogen projects, especially those focusing on green hydrogen production from renewable sources;
- public-private partnerships, which help mitigate risks and provide access to government resources;
- green bonds, which are especially favorable for investors looking to support sustainable-energy projects; and
- hydrogen-investment funds specifically focusing on hydrogen-related projects to provide financing and expertise in the hydrogen sector.

No large-scale hydrogen production projects will come on stream within the first few years after the war in Ukraine ends. However – as with the energy transition in general – it is important that no path dependencies be created during this time that might prevent the later deployment of innovative solutions and technologies. To give just an example from the steel industry, the lifetime of a blast furnace – that is, the period until its refractory lining needs to be completely renewed – is around 15-20 years. Other plant components can have even longer lifetimes.

Recommendations

It is important for Ukraine to design projects and establish partnerships between domestic hydrogen producers and buyers as well as between domestic hydrogen producers and international buyers – a global market for hydrogen does not yet exist, but is emerging. This applies to **political agreements as well as concrete partnerships** and projects at company level. Declarations of intent should gradually be backed up with concrete project approaches so as to **build a project pipeline** during the period right after the end of the war.

In addition, renewable-energy generation must be expanded, as this is the main bottleneck of hydrogen production. The first pilot projects involving the production and deployment of hydrogen should be carried out soon after the end of the war to build up expertise. Above all, Ukraine's long-standing expertise in European **gas transport should be harnessed** for possible export ambitions. It is crucial that the country be continuously guided by **European requirements**, ensuring that products are **qualified for export** to the EU. Specific measures for the near term include:

- adapting regulations and incentives to foster innovation and investments into **hydrogen infrastructure**;
- preparing **licensing authorities for new technologies, allowing them to implement appropriate processes and train employees in a timely manner;**
- connecting with European transmission-system operators and fostering knowledge transfer; and
- carrying out cost-benefit analyses and plans for **making gas infrastructure hydrogen ready**.

In the medium and longer term, the first **blast furnaces** should be converted to **direct reduction** with hydrogen, creating know-how that can be transferred to other plants. Partnerships between hydrogen producers and the steel industry should be intensified and binding contracts concluded.

In **road transport**, too, the use of hydrogen or its derivatives should be ramped up where there is no alternative. And the **ammonia industry** – for which hydrogen is a major feedstock – should be gradually decarbonized, making it ready for export to the rest of Europe.