

RESEARCH PAPER

Energy Sector Cooperation Opportunities between Ukraine and Germany



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Introduction

In this era of global interconnectivity and sustainable energy pursuits, collaboration between nations shapes the energy landscape. Ukraine and Germany stand out as potential partners, combining their strengths to advance greener and more secure energy solutions. Ukraine, rich in resources like coal, oil, gas, and renewables, can significantly contribute to Europe's energy sector. Meanwhile, Germany's leadership in renewable energy adoption and environmental policies makes it a valuable ally in the transition to sustainability.

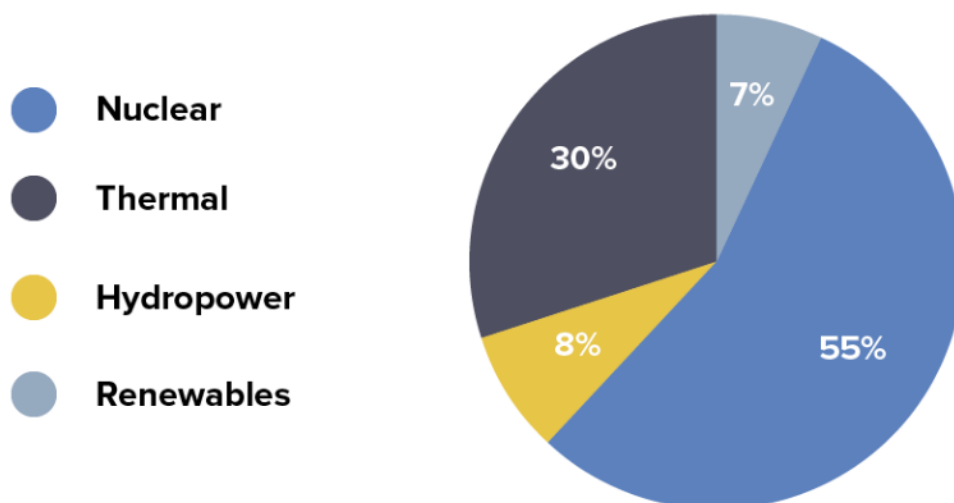
Despite geopolitical challenges, both countries share common interests in energy security, diversification, and decarbonization. Collaborating could lead to groundbreaking innovations, technology transfers, and knowledge sharing, benefiting not only their nations but the global community. **This article explores the potential of the energy sector cooperation between Ukraine and Germany, identifying mutual benefits.**

Through an in-depth analysis of the current energy landscape, regulations, and technology advancements, this article presents a **roadmap for a strategic and fruitful alliance**. Leveraging their expertise, resources, and experiences, Ukraine and Germany can strengthen regional energy security and promote a greener world. At the crossroads of the energy transition, fostering this partnership brings economic gains, technological advancements, and stronger diplomatic ties, reinforcing their commitment to combating climate change.

Overview of the Energy Sector in Ukraine

The electric power industry stands as a fundamental pillar of the Ukrainian economy, boasting a rich historical legacy as one of the country's oldest sectors. Electricity production relies on diverse sources, including coal, fuel oil, and natural gas, complemented by nuclear energy, hydropower, and renewable resources like solar, wind, biogas, biomass, and geothermal power.

Ukraine's Electricity Mix Before the War



Source: *Foreign Policy Research Institute*

The influence of Ukraine's USSR past continues to shape its energy landscape, primarily evident in the reliance on non-renewable sources like coal and gas for electricity generation. The lion's

share of electricity before Russian aggression was still produced at Thermal Power Plants (*hereinafter* TPPs) located in the Donetsk region (Vuhlehirsk, Starobeshevska, Myronivska, Kurakhivska, etc.), in the Dnipropetrovsk region (Prydniprovska, Kryvorizka), Kharkiv (Zmiivska), Kyiv (Trypilska), Ivano-Frankivsk (Burshtynska), Lviv (Dobrotvirska) regions, in Zaporizhzhia, Odesa, and others. TPPs are the main stations that provide electricity at half-peak and, together with Hydro Power Plants (*hereinafter* HPPs) and Pumped Storage Plants (*hereinafter* PSPs), during peak hours.¹

In recent years, nuclear power has taken a prominent position in the Ukrainian domestic electricity market. Despite the Chornobyl accident in the late twentieth century, Ukraine has witnessed rapid growth in nuclear power development. As of 2021, South Ukrainian, Rivne, Khmelnytskyi, and Zaporizhzhia NPPs collectively contributed to more than 55% of the country's electricity production.

Ukraine's energy sector has been influenced by global trends seeking to address climate threats and reduce reliance on non-renewable resources. As an independent state, Ukraine has actively embraced the principles of generating electricity through renewable sources, signaling its commitment to environmental sustainability.

Aligned with the course towards European integration, Ukraine has taken concrete steps to adopt the standards set by the Energy Community. By adhering to the Decision of the Council of Ministers, which implements Directive 2009/28/EC and amends Article 20 of the Treaty establishing the Energy Community, Ukraine has set a mandatory national target for renewable energy. By 2020, the aim was to achieve 11% of the country's total final energy consumption from renewable sources, providing a strong impetus for further advancements in the use of renewables. Unfortunately, it was not fully implemented, *i.e.*, at the end of 2023, it reached 10% of the total electricity generation.² Ukraine's ambitious plans entail increasing the share of energy derived from renewable sources to 25% by 2035, solidifying its commitment to a sustainable energy future.³

Considerable strides have been taken to modernize and expand hydropower in Ukraine. Before the war, the country boasted an impressive cascade of hydroelectric power plants along the Dnipro River, including Dnipro, Kremenchuk, Kyiv, Kaniv, Middle Dnipro, and Kakhovka stations. Additionally, HPPs located on the Dniester and in the Transcarpathian region (Tereble-Ritska HES). The Southern Buh cascade of hydroelectric power stations has also seen partial implementation.

Prior to the full-scale invasion, wind energy in Ukraine was harnessed by 34 wind farms, including those in the temporarily occupied territories of Ukraine in the Donetsk and Luhansk regions. Notably, major wind farms like Botievo, Prymorska, Myrnenska, Orlivska, Overianivska, and Novoazovska played a significant role. According to NPC Ukrenergo's report on generating capacities in 2020, wind electricity generation doubled from 3.5% in 2019 to 7.39% in 2020. This positive trend was projected to continue over the next three years (2021-2023).⁴

¹ *Istoriya enerhetyky*. [History of energy]. (2022). Ministry of Energy of Ukraine. Accessed May 8, 2024. <https://mev.gov.ua/storinka/istoriya-enerhetyky>.

² *Ukrayina protyahom dvokh rokiv vvela 660 MVt novykh potuzhnostey VDE*. [Ukraine introduced 660 MW of new RES capacity over two years]. (2024). ua-energy.org. Accessed May 8, 2024. <https://ua-energy.org/uk/posts/ukraina-protiahom-dvokh-rokiv-vvela-660-mvt-novykh-potuzhnostei-vde-minenerho>.

³ Bilyavs'kyy, M. (2020). Oriyentyry rozvytku al'ternatyvnoyi enerhetyky Ukrayiny do 2030r. [Guidelines for the development of alternative energy in Ukraine until 2030]. *web.archive.org*. Accessed May 8, 2024. <https://web.archive.org/web/20210123123722/https://razumkov.org.ua/statti/oriientyry-rozvytku-alternatyvnoi-energetyky-ukrainy-do-2030r>.

⁴ Kaydan, T. (2022). Vitrova enerhetyka v Ukrayini ta sviti. [Wind energy in Ukraine and worldwide]. *Hmarochos*. Accessed May 8, 2024. <https://hmarochos.kiev.ua/2022/01/18/vitrova-energetyka-v-ukrayini-ta-sviti/>.

As of the end of 2021, solar energy contributed to over 5% of Ukraine's total electricity production. The cumulative capacity of solar power plants reached 6320 MW (excluding those in the temporarily occupied territories).⁵

Ukraine's vast expanse of agricultural land presents abundant opportunities for biomethane production. Biomethane, an eco-friendly gas derived from the food industry and livestock waste, sewage sludge, and organic household waste, has great potential. Prior to the war, the country operated 77 biogas plants, producing up to 260 million cubic meters of fuel annually, with the potential to convert nearly 150 million cubic meters into biomethane.⁶ Plans were underway to launch the first two biomethane plants by the end of 2022, followed by five more in 2023. The Bioenergy Association of Ukraine estimates that by 2030, Ukraine could replace up to 10 billion cubic meters of imported natural gas per year and achieve energy independence in this aspect.

Renewable energy plays a pivotal role in various sectors, including power generation, heating/cooling systems, transportation, and off-grid power supply services in rural areas.

The commitment of the Ukrainian government, both organizationally and financially, has facilitated the comprehensive development of renewable energy. Notably, the introduction of the "green tariff" during 2016-2021 has spurred significant growth in the renewable energy sector, resulting in RES power plants contributing 8% of the total electricity generation in Ukraine by 2021.⁷

Russian War Influence on the Energy Sector in Ukraine

Until the beginning of 2022, Ukraine's Integrated Energy System (IPS) operated in tandem with the energy systems of neighboring non-EU countries such as Belarus, the Russian Federation, and Moldova. Ukraine's so-called Burshtyn Energy Island was linked to the integrated energy systems of Western, Central, and Eastern Europe, formerly known as UCTE (Union for the Coordination of Transmission of Electricity) from 2002 to 2022. This interconnectedness facilitated electricity exports in both eastern and western directions.

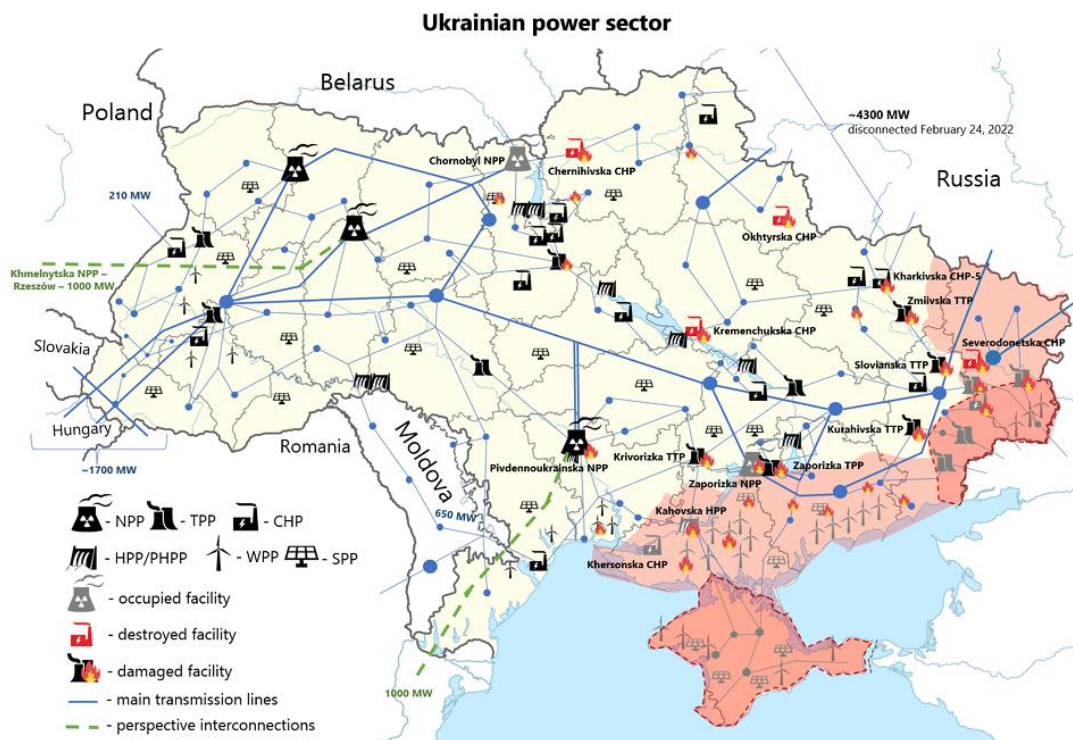
In a significant milestone, the Ukrainian power system has begun operating synchronously with the European continental network ENTSO-E since mid-March 2022, becoming an integral part of the European energy space.⁸ Subsequently, export-import operations between Ukraine and ENTSO-E commenced by the end of June 2022.

⁵ Haluz' sonyachnoyi enerhetyky v Ukrayini. [Solar energy industry in Ukraine]. (2022). LLC "Ukrainian Energy Exchange". Accessed May 8, 2024. <https://www.ueex.com.ua/presscenter/news/galuz-sonyachnoi-energetiki-v-ukraini/>.

⁶ Topalov, M. (2022). "Zelenyy" haz z vidkhodiv: koly biometan dopomozhe Ukrayini staty enerhonezalezhoynu. ["Green" gas from waste: when biomethane will help Ukraine become energy independent]. *Ekonomichna Pravda*. Accessed May 8, 2024. <https://www.epravda.com.ua/publications/2022/10/6/692287/>.

⁷ Omel'chenko, V. (2022). Sektor vidnovlyuvanoyi enerhetyky Ukrayiny do, pid chas ta pislya viyny. [Renewable energy sector of Ukraine before, during and after the war]. *razumkov.org.ua*. Accessed May 8, 2024. <https://razumkov.org.ua/statti/sektor-vidnovlyuvanoyi-energetyky-ukrayiny-do-pid-chas-ta-pislya-viyny>.

⁸ *Enerhetychnyy sektor Ukrayiny: torhivlya elektroenerhiyeyu*. [Energy sector of Ukraine: electricity trade]. (2023). DLF attorneys-at-law. Accessed May 8, 2024. <https://dlf.ua/ua/energetichnij-sektor-ukrayini-torgivlya-elektroenergiyeyu/>.



Source: *ECS based on Bintel and publicly available data*

Unfortunately, the outbreak of war had severe repercussions on Ukraine's energy sector. The full-scale Russian invasion on February 24, 2022, caused a devastating 35% plunge in electricity consumption.⁹ Russian forces captured critical energy facilities, including the Luhansk and Zaporizhzhia TPPs,¹⁰ and occupied the Zaporizhzhia NPP.¹¹ Air strikes further wreaked havoc, damaging TPPs in Ukraine, including the destruction of the Okhtyrka, Kremenchuk, Zmiivska, and Trypilska TPPs.¹²

⁹ *Vtrata polovyny eksportu, ruynuvannya promyslovykh hihantiv ta udar po derzhbyudzhetu. Ekonomika proyshla pershyi misyats' viyny. Shcho dali?* [Loss of half of exports, destruction of industrial giants and a blow to the state budget. The economy passed the first month of the war. What's next?]. (2022). Forbes.ua. Accessed May 8, 2024. <https://web.archive.org/web/20220429124914/https://forbes.ua/inside/vtrata-polovini-eksportu-ruynuvannya-promislovykh-gigantiv-ta-udar-po-derzhbyudzhetu-ekonomika-proyshla-pershiy-misyats-viyni-shcho-dali-golovne-zi-zvitu-tses-12042022-5408>.

¹⁰ *V Enerhodari ne pratsyuye Zaporiz'ka TES.* [The Zaporizhzhia TPP is not working in Enerгодар]. (2022). Hromadske Radio. Accessed May 8, 2024. <https://hromadske.radio/news/2022/05/05/v-enerhodari-ne-pratsiue-zaporiz-ka-tes-oskil-ky-zakinchylos-vuhillia>.

¹¹ Mazurenko, A. (2022). Okupanty stavlyat' pid zahrozu robotu ZAES. *Ukrayins'ka Pravda*. Accessed May 8, 2024. <https://web.archive.org/web/20220609055621/https://www.pravda.com.ua/news/2022/06/3/7350276/>;

¹² Kolomiyets', V. (2022). Viys'ka rf zнову vdaryly raketamy po Kremenchuts'kiy TETS — 180 tysyach lyudey mozhut' zalyshytysya vzymku bez tepla. [Russian troops hit the Kremenchug thermal power station with missiles again - 180,000 people may be left without heat in winter]. *Hromadske*. Accessed May 8, 2024. <https://web.archive.org/web/20220515203734/https://hromadske.ua/posts/vijska-rf-znovu-vdarili-raketami-po-kremenchuckij-tec-180-tisyach-lyudej-mozhut-zalishitysya-vzimku-bez-tepla>.

Rosiyany povnistyru znyshchyly Trypil's'ku TES — "Tsentrenerho". [The Russians completely destroyed the Trypil TPP - "Centrenerg".] (2024). *Ekonomichna Pravda*. Accessed May 8, 2024. <https://www.epravda.com.ua/news/2024/04/11/712285/>.



Trypilska TPP Source: [Priamyi](#)



Okhtyrka TPP Source: [Ukrinform](#)

The destruction of the Kakhovka hydroelectric station by the Russian forces was characterized by the President of the European Parliament, Roberta Metzola, as a heinous act that can be deemed a crime against humanity, affecting about 16,000 people and causing direct damages of about USD 2 billion.¹³ Many other HPPs were damaged and some stopped operations.¹⁴ The deliberate and systematic targeting of energy infrastructure by Russian troops resulted in about USD 12,5 billion in damages to the energy system,¹⁵ while during the full-scale war, DTEK energy workers "raised" the TPP 37 times from scratch after shellings.¹⁶



Kakhovka HPP Source: [Radio Svoboda](#)



Flooded Kherson Region Source: [Volodymyr](#)

¹³ *Prezydentka Yevroparlamentu nazvala pidryv Kakhovs'koyi HES zlochynom proty lyudyansti.* [The President of the European Parliament called the blowing up of the Kakhovskaya HPP a crime against humanity.]. (2023). *Ukrinform*. Accessed May 8, 2024. <https://www.ukrinform.ua/rubric-politics/3719026-prezidentka-evroparlamentu-nazvala-pidriv-kahovskoi-ges-zlocinom-proti-ludansti.html>.

¹⁴ *"Ukrhydroenerho" vyvelo z ekspluatatsiyi 2 HES cherez znachni urazhennya 8 travnya.* ["Ukrhydroenergo" took 2 HPPs out of operation due to significant damage on May 8]. (2024). *Energy.org*. Accessed May 8, 2024. <https://ua-energy.org/uk/posts/ukrhydroenerho-vyvelo-z-ekspluatatsii-2-hes-cherez-znachni-urazhennia-8-travnya>.

¹⁵ *U Radi otsinyuyut' zbytky enerhetychnoyi infrastruktury vid atak u \$12,5 mlrd.* [The Council estimates damage to the energy infrastructure from the attacks at \$12.5 billion]. (2024). *Minprom*. Accessed May 8, 2024. <https://minprom.ua/news/311547.html>.

¹⁶ *Pid chas povnomasshtabnoyi viyny enerhetyky DTEK 37 raziv «pidymaly» TES z nulya pislya obstriliv.* [During the full-scale war, DTEK energy workers "raised" the TPP 37 times from scratch after shelling]. (2024). *Glavcom*. Accessed May 8, 2024. <https://glavcom.ua/economics/finances/pid-chas-povnomasshtabnoji-vijni-enerhetiki-dtek-37-raziv-pidijmali-tes-z-nulja-pislja-obstriliv-999910.html>.

From the onset of the conflict, Ukrainian energy facilities bore the brunt of attacks from the Russian military, and even the so-called green energy, which accounted for more than 13% of the production structure before the war, was not spared. According to Energy Minister Herman Halushchenko, approximately 75% of wind farms and 45-50% of solar plants had to be decommissioned by the end of October 2022. Consequently, the share of renewable energy sources (RES) in total electricity production dramatically declined from 13.4% to 5-6%.¹⁷ Compounding the issue, two-thirds of solar power plants were located in active conflict zones in the south, where damages to infrastructure were prevalent. Estimates suggest that over 30% of solar power plants in occupied territories, totaling approximately 1120-1500 MW of installed capacity, were adversely affected, while more than 25% of non-industrial (private) SPPs were destroyed.¹⁸ As a result, the share of renewable sources in the energy balance plummeted by more than half.

From October 11, 2022, until April 11, 2023, Ukraine temporarily halted electricity exports due to regular barrage shelling but later resumed exports to Poland and Moldova. Both Ukraine and the EU expressed their intention to expand export opportunities further.¹⁹

Prospects of the Energy Sector in Ukraine

The main task after Ukraine's victory will be the restoration and development of the domestic energy complex. Objective factors will support this process, including Ukraine's advantageous geographical position in the heart of Europe, boasting a well-developed system of land and water communications. Ukraine could become a transit country for energy resources from Azerbaijan, Kazakhstan, Turkmenistan, and Iraq to Central and Western Europe. Notably, the construction of gas pipelines from the Middle East through Turkey, the Black Sea, and Ukraine to Europe holds significant potential, with Turkey offering advantages as a transit country compared to the countries of the South Caucasus.

Ukraine possesses tremendous potential for the production of "green" electricity, with many solar and wind power plants already in operation. European organizations involved in planning Ukraine's energy system restoration after the war prioritize "green" and energy-efficient projects. Thus, when reconstructing destroyed power plants that previously relied on traditional sources like gas and coal, it makes sense to replace them with new energy facilities utilizing renewable sources or modern, energy-efficient technologies.

IRENA's pre-war estimates suggest that Ukraine could potentially install more than 320 GW of wind and 70 GW of solar energy. Additionally, the potential of wind and floating stations in the waters of Crimea, estimated by the World Bank to add more than 250 GW, further contributes to the vast potential of renewable energy in Ukraine. With this in mind, the potential total capacity of renewable

¹⁷ Topalov, M. (2023). Shcho zalyshylosya vid "zelenoyi" enerhetyky v Ukrayini. [What is left of "green" energy in Ukraine]. *Ekonomichna Pravda*. Accessed May 8, 2024. <https://www.epravda.com.ua/publications/2023/05/24/700431/>.

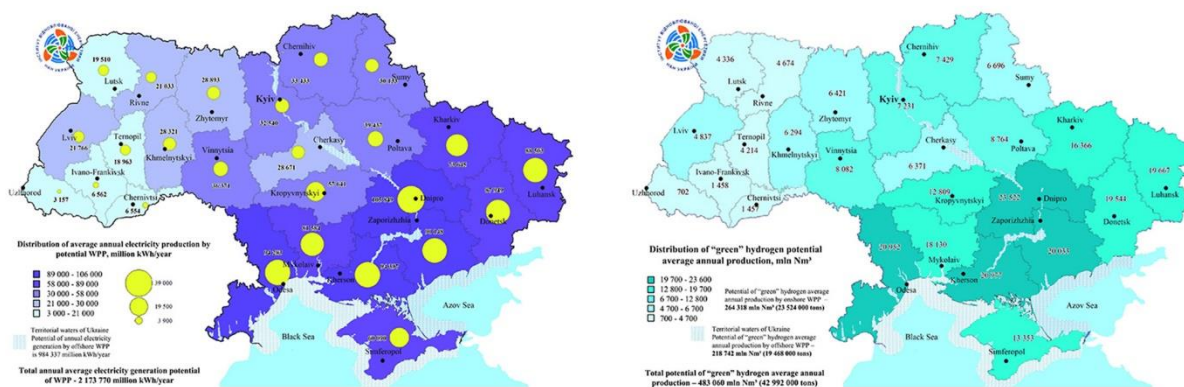
¹⁸ *Haluz' sonyachnoyi enerhetyky v Ukrayini*. [Solar energy industry in Ukraine]. (2022). LLC "Ukrainian Energy Exchange". Accessed May 8, 2024. <https://www.ueex.com.ua/presscenter/news/galuz-sonyachnoi-energetiki-v-ukraini/>.

¹⁹ *Enerhetychnyy sektor Ukrayiny: torhivlya elektroenerhiyeyu*. [Energy sector of Ukraine: electricity trade]. (2023). DLF attorneys-at-law. Accessed May 8, 2024. <https://dlf.ua/ua/energetichnij-sektor-ukrayini-torgivlya-elektroenergiyeyu/>.

sources in Ukraine in 10 years could exceed 415 GW and potentially more than 700 GW when considering the Crimean Waters project.²⁰

Ukraine possesses the economic and technical capability to localize the production of energy equipment, particularly in the realm of renewable energy and hydrogen production. The abundance of lithium reserves offers opportunities for developing capacities in energy storage systems.²¹ To achieve the goal of decentralizing the energy sector, Ukraine must embrace innovative and efficient technologies such as smart grids, microgrids, and vehicle-to-grid systems in the distribution sector. There is high hope for effective assistance from Ukraine’s friends and partners in the restoration of domestic electricity. Some plans for the reconstruction of the Ukrainian energy sector have already been declared at the international level.

Electricity Generation Potential «Green» Hydrogen Potential



Source: *International Journal of Hydrogen Energy*

During the Ukraine Recovery Conference in London, the G7+ Coordination Group, in collaboration with the Ukrainian government, made a steadfast commitment to establish a Clean Energy Partnership aimed at supporting Ukraine's sustainable recovery and reconstruction.²² The G7+ Group further pledged to assist Ukraine in building a modern, secure, decentralized, and environmentally friendly energy system aligned with the Net Zero goals and enhanced integration with Europe. Working together, the G7+ and Ukraine aim to develop and deepen this Clean Energy Partnership, with outlined objectives focusing on coordinating diplomatic efforts, fostering development and trade, and mobilizing investments to support Ukraine's Energy Strategy until 2050 and future National Energy and Climate Plan.²³

The envisioned Energy Strategy of Ukraine until 2050 encompasses the revival of the energy sector through state-of-the-art technologies, ensuring system stability, and reinforcing energy security not only for Ukraine but for the entire European continent. Within the framework of the Recovery Conference, a new economic model and Energy Strategy was presented, considering two scenarios that

²⁰ *Ibid.*

²¹ Denysyuk, M. (2023). Yakym bude enerhetychnyy sektor pislya viyny. [What will the energy sector be like after the war]. *Ekonomichna Pravda*. Accessed May 8, 2024. <https://www.epravda.com.ua/columns/2023/07/4/701854/>.

²² *Clean Energy Partnership: G7+ and Ukraine joint statement*. (2023). Gov.UK. Accessed May 8, 2024. <https://www.gov.uk/government/news/g7-and-government-of-ukraine-clean-energy-partnership>.

²³ *G7+ and Government of Ukraine Clean Energy Partnership for the Sustainable Recovery and Reconstruction of Ukraine's Energy System*. (2023). Federal Foreign Office. Accessed May 8, 2024. <https://www.auswaertiges-amt.de/en/newsroom/news/g7-ukraine-clean-energy-partnership/2604256>.

take into account various conditions of security and economic development: basic and intensive.²⁴ These scenarios are shaped by factors such as the conclusion of the war, recovery pace, projected GDP growth, market integration with the EU, and more. The pivotal goal of the strategy is to transform Ukraine into a European energy hub, thereby liberating the continent from its reliance on Russian fossil fuels by generating clean energy within Ukraine. Achieving climate neutrality in the energy sector by 2050 stands at the core of this strategy. Embracing "green" energy becomes key to ensuring energy security and fostering a robust Ukrainian economy. The country boasts the immense potential to increase wind generation to 140 GW, solar to 94 GW, nuclear to 30 GW, and further capacities for CHP, bioenergy, and hydrogeneration.

Beyond plans, concrete steps to support Ukraine in the energy sector are already being implemented. Notably, the Ministry of Energy of Ukraine and the Ministry of Foreign and Commonwealth Affairs of the United Kingdom signed a Memorandum on Energy Partnership between the two countries.²⁵ The European Bank for Reconstruction and Development (EBRD) is set to provide support worth EUR 600 million for Ukrainian energy this year. Several key memorandums were signed during the Ukraine Recovery Conference in London, encompassing areas of cooperation such as forming strategic natural gas reserves, investments in decarbonization and methane emission reduction, enhancing energy efficiency, and the restoration and modernization of hydroelectric power plants for improved reliability and efficiency. Furthermore, the United States announced an additional \$1.3 billion in assistance to Ukraine, including a significant portion to modernize and rebuild the nation's critical infrastructure. These efforts represent vital international support as Ukraine strives towards its sustainable energy goals and overall recovery.

Ukraine and the United States are preparing a joint program of cooperation on decarbonization and sustainability of the Ukrainian energy sector. Energy Agencies of Ukraine and the United States, together with the initiative Net Zero World, are preparing a program of cooperation for the development of the Ukrainian energy sector.²⁶

Ukraine's historical dependence on fossil fuel imports, with Russia being its primary supplier before the Great War, poses a considerable threat to the nation's national security and defense. In 2021 alone, Ukraine imported coal valued at \$2.5 billion, with the majority originating from Russia (62.1%) and Kazakhstan (10.2%). Additionally, over 50% of petroleum products, either directly or indirectly through Belarusian oil refineries, were sourced from Russia.²⁷ Addressing the influence of Russia in Ukraine's energy sector requires a robust response in the form of diversifying energy sources and supply

²⁴ Denysyuk, M. (2023). Yakym bude enerhetychnyy sektor pislya viyny. [What will the energy sector be like after the war]. *Ekonomichna Pravda*. Accessed May 8, 2024.

<https://www.epravda.com.ua/columns/2023/07/4/701854/>.

²⁵ *Ibid.*

²⁶ Mosorko, A. (2023). Ukrayina ta SSHA hotuyut' spil'nu prohramu spivpratsi z dekarbonizatsiyi ta stalosti ukrayins'koyi enerhetyky. [Ukraine and the USA are preparing a joint program of cooperation on decarbonization and sustainability of the Ukrainian energy industry]. *Mind.ua*. Accessed May 8, 2024.

<https://mind.ua/news/20255869-ukrayina-ta-ssha-gotyuyut-spilnu-programu-spivpraci-z-dekarbonizatsiyi-ta-stalosti-ukrayinskoyi-energetik>.

²⁷ Romanko, S. (2023). "Zelena" enerhetyka mozhe staty klyuchem do enerhetychnoyi bezpeky ta mitsnoyi ekonomiky Ukrayiny. ["Green" energy can become the key to energy security and a strong economy of Ukraine]. *Ekonomichna Pravda*. Accessed May 8, 2024.

<https://www.epravda.com.ua/columns/2023/06/20/701343/>.

routes. Key strategies to achieve this goal involve obtaining oil and gas from regions such as the Caspian Sea, Central Asia, and the Middle East.²⁸

Emphasising the importance of sustainable development, it is crucial for Ukraine to actively invest in clean energy infrastructure both presently and in the years to come. This approach not only contributes to environmental goals but also plays a significant role in creating high-quality employment opportunities for Ukrainian citizens. As Ukraine looks to its future, EU accession can offer the nation access to clean energy training through a comprehensive EU program specifically designed to foster such skills. Furthermore, Ukraine's recovery efforts have the potential to align with the European Green Deal, thereby fortifying the country's position in the global pursuit of sustainable development. A substantial source of funding for these endeavours can be derived from the EU's Next Generation Recovery Plan,²⁹ which involves €1.8 trillion in investments in conjunction with the seven-year EU budget.³⁰ Approximately one-third of this funding can be allocated to support Ukraine's path toward clean energy and overall recovery.³¹ By capitalising on these opportunities and pursuing sustainable energy development, Ukraine can bolster its energy security and contribute to a brighter, greener future for the nation and the European community as a whole.

Overview of the Energy Sector in Germany

The German energy sector, much like its Ukrainian counterpart, is currently undergoing active reforms in response to the challenging times and environmental changes. Notably, the Russian war against Ukraine posed a significant challenge in 2022. According to the analysis conducted by the renowned Fraunhofer Institute for Solar Energy Systems (ISE), Germany's energy sector in 2022 experienced extreme prices and a remarkable surge in renewable energy sources.³²

The share of renewables in net electricity generation, representing the electricity drawn from the grid, reached an unprecedented record of 49.6%. Among the renewable sources, wind farms led the way, followed by lignite, solar, hard coal, natural gas, biomass, nuclear, and hydro. However, progress towards the federal government's targets was not entirely on track, with only solar systems meeting their expansion goals by contributing 19% more to electricity generation. The surge in solar power was primarily attributed to the addition of new capacity and favourable weather conditions, making it the most substantial increase since 2013.

The growth in both onshore and offshore wind energy remained sluggish. By the end of November 2022, onshore wind capacity reached 58 GW, merely 2.1 GW higher than in 2021. Similarly, offshore wind capacity increased by a meager 0.3 GW, reaching 8.1 GW.

²⁸ Volovych, O. (2016). Balto-Chornomors'kyy Soyuz: perspektyvy realizatsiyi. [Baltic-Black Sea Union: prospects for implementation]. Borysfen.intel. Accessed May 8, 2024.

<https://web.archive.org/web/20191230175929/http://bintel.com.ua/uk/article/volodich-balto2/>.

²⁹ *Recovery plan for Europe*. (2022). European Commission. Accessed May 8, 2024.

https://commission.europa.eu/strategy-and-policy/recovery-plan-europe_en.

³⁰ Romanko, S. (2023). "Zelena" enerhetyka mozhe staty klyuchem do enerhetychnoyi bezpeky ta mitsnoyi ekonomiky Ukrainy. ["Green" energy can become the key to energy security and a strong economy of Ukraine]. *Ekonomichna Pravda*. Accessed May 8, 2024.

<https://www.epravda.com.ua/columns/2023/06/20/701343/>.

³¹ *A European Green Deal*. (2021). European Commission. Accessed May 8, 2024.

https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en.

³² *Net Electricity Generation in Germany in 2022: Significant Increase in Generation from Wind and PV*.

(2023). Fraunhofer.ise. Accessed July May 8, 2024. <https://www.ise.fraunhofer.de/en/press-media/press-releases/2023/net-electricity-generation-in-germany-in-2022-significant-increase-in-generation-from-wind-and-pv.html>.

Hydropower production experienced a notable decline, generating 16 TWh in 2022 compared to 19 TWh in the previous year, mainly due to a hot and dry summer. In contrast, biomass production stood at 42.2 TWh, slightly higher than the previous year, but the difference was negligible.

In total, renewable energy sources collectively produced approximately 244 TWh in 2022, representing a 7.4% increase compared to the previous year.

Germany's heavy reliance on fossil fuels remains a significant concern, with lignite being the primary domestic energy source apart from renewables. Unfortunately, in 2022, approximately 30% of the country's gross electricity generation still came from lignite and hard coal, two of the most polluting energy sources. This was further exacerbated by the fact that seven out of the ten most polluting coal-fired power plants in the EU were located in Germany in 2021.

Despite the government's prior commitment to end coal dependence by 2030, there was a setback in 2022 due to the global energy crisis, leading to a resurgence in fossil fuel usage.³³ This was also triggered by the shutdown of three nuclear power plants (Grohnde, Gundremmingen C, and Brokdorf), resulting in a 50% drop in nuclear energy production from 65 TWh to 33 TWh.



Source: *Aenert*

Adding to the concerns, even though natural gas prices were high, 9.2% of the electricity supplied to the grid came from burning natural gas in 2022, with a 2.1% increase in electricity production from natural gas compared to the previous year.³⁴ Several factors contribute to the continued use of natural gas for power generation. One significant advantage is the flexibility of gas-fired power plants, as they can be quickly turned off and on, making them more suitable for meeting sudden spikes in electricity demand. Additionally, gas-fired power plants play a crucial role in pre-dispatching and balancing the electricity supply, which is sometimes necessary for ensuring a stable grid. Another important aspect is the economic benefit of gas-fired power plants, as they require fewer carbon allowances compared to coal-fired plants, making them a more viable option in terms of emissions

³³ *Germany: electricity mix 2022.* (2023). Statista. Accessed May 8, 2024. <https://www.statista.com/statistics/736640/energy-mix-germany/>.

³⁴ *Electricity Production.* (2023). Federal Statistical Office. Accessed May 8, 2024. https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Energy/Production/_node.html#265706.

regulations. Efforts to transition away from fossil fuels and boost renewable energy sources are still necessary to address the environmental impact and long-term sustainability of Germany's energy sector.

The vast majority of fossil fuels the country burns are imported, as is the uranium that powers the three remaining nuclear plants. Russia has long been the largest supplier of oil and gas. On the eve of the war in Ukraine, it supplied a third of Germany's oil, about half of its coal imports, and more than half of its gas.³⁵ A network of 317000 miles (511000 km) of pipelines crosses the country, delivering gas to homes, factories, and power plants.³⁶ Before the war, Germany imported about 1,8 billion euros (\$2 billion) of Russian gas, oil and coal every month.³⁷ Russia's attack on Ukraine in February 2022 led to serious changes in the energy markets and a collapse of natural gas imports from Russia.

After the outbreak of the war, Germany faced a significant 12% surge in energy costs.³⁸ However, the nation displayed remarkable agility in finding a viable alternative to its previous energy importer. In a swift move, in November 2022, Germany sealed a groundbreaking 15-year deal with Qatar, ensuring a supply of 2 million tons of liquefied gas.³⁹ To facilitate this new arrangement, the construction of specialized port terminals for gas shipment was promptly initiated. The urgency to secure new suppliers became even more apparent with the invasion of Ukraine by Russia.

Chancellor Scholz promptly announced the construction of two domestic import terminals to bolster energy resilience.⁴⁰ To streamline the permitting and construction process and bypass bureaucratic hurdles, the government introduced the LNG Fast Track Act. This act granted temporary waivers for certain procedural requirements, particularly in the realm of environmental impact assessments, under specific conditions. In addition to establishing one or more fixed land terminals, Germany also leased five floating storage and regasification units (FSRU) in the short term, two of which were scheduled for installation by winter 2022/23. In a strategic decision taken by July 2022, Wilhelmshaven, Brunsbüttel, Stade, and Lubmin were chosen as the locations for the seven terminals, out of which four are already operational. Meanwhile, a recent report by the German Institute for Economic Research (DIW) concluded that Germany does not need its own import terminals.⁴¹ The researchers warn that the projects “do not make sense due to long construction times and a sharp drop in demand for natural gas in the medium term.”

³⁵ *How heavily does Germany rely on Russian energy?* (2022). The Economist. Accessed May 8, 2024. <https://www.economist.com/the-economist-explains/2022/05/04/how-heavily-does-germany-rely-on-russian-energy>.

³⁶ Curry, A. (2022, May 6). How the Ukraine war is accelerating Germany's renewable energy transition. *Environment*. Accessed May 8, 2024. <https://www.nationalgeographic.com/environment/article/how-the-ukraine-war-is-accelerating-germanys-renewable-energy-transition>.

³⁷ *Can Germany cope without Russian gas?* (2022). The Economist. Accessed May 8, 2024. <https://www.economist.com/europe/can-germany-cope-without-russian-gas/21808482>.

³⁸ *War in Ukraine: Tracking the impacts on German energy and climate policy.* (2023). Clean Energy Wire. Accessed May 8, 2024. <https://www.cleanenergywire.org/news/ukraine-war-tracking-impacts-german-energy-and-climate-policy#:~:text=One%20year%20after%20the%20Russian,the%20start%20of%20the%20war>.

³⁹ *Germany agrees 15-year liquid gas supply deal with Qatar.* (2022). The Guardian. Accessed May 8, 2024. <https://www.theguardian.com/world/2022/nov/29/germany-agrees-15-year-liquid-gas-supply-deal-with-qatar>.

⁴⁰ *German government plans extensive LNG infrastructure build-up to ensure security of European supply.* (2023). Clean Energy Wire. Accessed May 8, 2024. <https://www.cleanenergywire.org/news/german-government-plans-extensive-lng-infrastructure-build-ensure-security-european-supply>.

⁴¹ *Energieversorgung in Deutschland auch ohne Erdgas aus Russland gesichert.* [Energy supply in Germany secured even without natural gas from Russia]. (2022). DIW Berlin. Accessed May 8, 2024. https://www.diw.de/de/diw_01.c.838843.de/publikationen/diw_aktuell/2022_0083/energieversorgung_in_deutschland_auch_ohne_erdgas_aus_russland_gesichert.html.

Part of the response to Russian aggression was saving electricity. Due to high electricity prices and high temperatures, the load on the power grid amounted to 484 TWh, which is approximately 20 TWh less than in 2021. At the beginning of 2022, electricity consumption was slightly higher than in 2021, but it fell in the following months and fell especially sharply from June. The biggest drop was recorded in October (-10,8%). In the first half of the year, consumption approached the level of 2020, and in the second half of the year, it was many times lower.⁴²

Decarbonisation Path of the Energy Sector in Germany

Germany, like other developed European states, faced the “energy trilemma.” It is a term that describes the ability of countries to supply energy in terms of finding the elusive balance between environmental sustainability, social impact and security. At the beginning of 2022, the European Union faced just a part of a trilemma, prioritising the first two criteria and neglecting the third. The EU's Green Deal aims to make Europe carbon-neutral by 2050 and cut emissions by at least 55% by 2030. The goal is to emit no more greenhouse gases than ecosystems are able to absorb naturally. The 2030 plan calls for reducing net greenhouse gas emissions by at least 55% compared to 1990 levels. The Green Deal gives priority to green technologies and careful treatment of nature.

Over the past year, Germany has been forced to limit its energy capacity in exchange for modernisation and an ecological transition to renewable energy. The rate of change in the sources of electricity production is slower than the rate of growth in the use of electricity in EU countries, particularly in connection with the popularisation of electric cars, so electricity is becoming a less accessible resource.⁴³

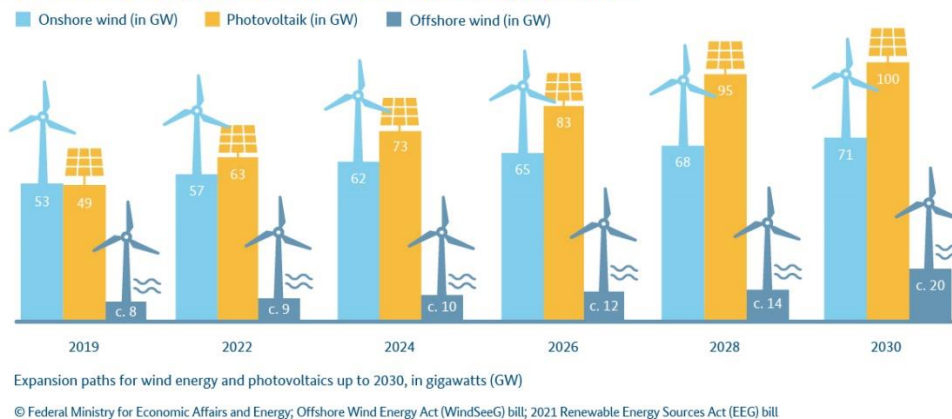
On July 13, 2021, the Federal Ministry of Energy (BMWi) announced that according to a new estimate of Germany's energy consumption in 2030, the country will need between 645 and 665 terawatt-hours of electricity.⁴⁴ Energy Minister Peter Altmaier (CDU) said that the calculations carried out by the consulting company Prognos on behalf of BMWi took into account the higher need for electricity for the production of heat both in industrial processes and in homes with the help of electric heat pumps; a larger fleet of electric cars; and greener hydrogen production using renewable electricity.

⁴² *The electricity market in 2022*. (2023). SMARD. Accessed May 8, 2024. <https://www.smard.de/page/en/topic-article/5892/209668>.

⁴³ Yakoviyk, I., & Tsvelikh, M. (2023). Energy Security of the European Union in the Context of Russian Aggression against Ukraine. *Problems of Legality*, (160), 170–191. <https://doi.org/10.21564/2414-990X.160.274518>.

⁴⁴ *German 2030 power use forecast up due to heat pumps, e-cars and hydrogen*. (2021). Clean Energy Wire. Accessed May 8, 2024. <https://www.cleanenergywire.org/news/german-2030-power-use-forecast-due-heat-pumps-e-cars-and-hydrogen>.

2021 Amendment of the Renewable Energy Sources Act: ambitious expansion of renewables up to 2030



Source: *Federal Ministry for Economic Affairs and Energy*

The Federal Government has faced a difficult situation as it needs to ensure a sufficient amount of electricity production through the use of limited renewable sources and taking into account climatic restrictions. Thus, it also has to meet the increased need for electricity domestically.

12 main tasks for the near future are established: make the electricity system more flexible, reduce carbon emissions reliably and shape structural change, integrate and flexibilise the European electricity markets further, assess the security of supply in a European context, and develop common instruments, strengthen incentives for the efficient use of electricity, improve competitive conditions for renewable electricity in the heating and transport sectors, provide incentives for modern power and heat systems, provide incentives so that biomass is increasingly used for transport and industry, expand the grid in a timely, needs-based and cost-efficient manner, continue to develop and coordinate measures and processes for system stabilisation, further develop regulations governing grid charges, roll out smart metering, build communication platforms, and guarantee system security.⁴⁵

On April 8, 2022, the Federal Government adopted a Targeted Package of Measures for Energy-Intensive Companies, known as the Energy-Intensive Industry Grant Scheme (EKDP).⁴⁶ It includes a program to reduce energy costs worth 5 billion euros for energy- and trade-intensive companies, as well as federal guarantees for credit programs and other guarantees without direct impact on the budget.

The developed National Hydrogen Strategy is of great interest. German experts also note: “Now we assume that we will produce 19 TWh of hydrogen in Germany in 2030 instead of 14, as indicated in the hydrogen strategy”.⁴⁷ In addition, in 2022, Germany announced the opening of two new funds that will allocate 550 million euros to support the creation of environmentally friendly hydrogen projects in developing countries. Both funds will be managed by the German development bank KfW, which has

⁴⁵ *Electricity 2030*. (2016). Foreign Ministry for Economic Affairs and Energy. Accessed May 8, 2024. https://www.bmwi.de/Redaktion/EN/Publikationen/discussion-paper-electricity-2030.pdf?__blob=publicationFile&v=1.

⁴⁶ *Press corner*. (2022). European Commission - European Commission. Accessed May 8, 2024. https://ec.europa.eu/commission/presscorner/detail/en/IP_22_4506.

⁴⁷ *German 2030 power use forecast up due to heat pumps, e-cars and hydrogen*. (2021). Clean Energy Wire. Accessed May 8, 2024. <https://www.cleanenergywire.org/news/german-2030-power-use-forecast-due-heat-pumps-e-cars-and-hydrogen>.

already launched a platform where companies can apply for support.⁴⁸ The increase in electricity consumption should be mitigated by increasing energy efficiency and reducing self-consumption by power plants.

Representatives of the renewable energy industry, as well as many researchers, have repeatedly pointed out that the demand for electricity will continue to grow – and therefore the capacity of renewable energy must be increased even faster to meet this demand. The estimate of Germany's electricity consumption until 2030 provides an important basis for the country's renewable energy expansion targets, which must be aligned with national climate targets.

Wind energy is expected to become the most important energy source in Germany by 2040. Onshore wind farms are expected to add 144,1 terawatt-hours to the country's power grid, while offshore wind farms will add another 122,7 terawatt-hours. The base wind power forecast predicts that more than 100 gigawatts of wind turbines will be installed by 2040.⁴⁹

According to the plan, the federal government should pay special attention to maintaining the competitiveness of the German economy. *“We want to promote future changes without structural breaks. It is about harnessing the power and creativity of the German market economy, as well as the forces of competition, to achieve existing national, European, and international climate protection goals.”* By 2050, the energy supply should be *“almost completely decarbonised,”* with renewables as the main source. *“In the long term, electricity production should be based almost entirely on renewable energy sources. [...] The share of wind and solar energy in the total production of electricity will increase significantly.”* If it is *“feasible and economically reasonable,”* renewable energy will be used directly in all sectors, and electricity from these sources will be used efficiently for heating, transport, and industry. There will be only limited use of biomass, mainly from waste. According to the plan, switching to a renewable energy source while ensuring the security of supply is *“technically feasible.”* During the transition, *“less carbon-intensive natural gas-fired power plants and existing state-of-the-art coal-fired power plants play an important role as intermediate technologies.”*

The gradual abandonment of the use of non-renewable sources for the production of electricity must be combined with social guarantees for people who work in extractive enterprises. Therefore, for example, it is planned to create a regional fund to finance projects aimed at the development of new enterprises in the regions of lignite mining.

State of the Partnership: Exchanging Strengths and Improving Weaknesses

The trends of comprehensive globalisation are vividly manifested in the energy sector. This includes both its ecological transformation and the rise of bilateral and multilateral international cooperation. Certain manifestations of countries' unique specialisations can be observed based on their resource capabilities and economic and social needs. This can be seen, for instance, in the actual and potential collaboration between Ukraine and Germany in the energy sphere. The aspects of such cooperation should be examined in several dimensions within the context of this study:

⁴⁸ *Deutschland beschleunigt den Klimaschutz durch weltweiten Aufbau grüner Wasserstoffwirtschaft.* [Germany is accelerating climate protection by developing a green hydrogen economy worldwide]. (2022). Bundesministerium Für Wirtschaftliche Zusammenarbeit Und Entwicklung. Accessed May 8, 2024. <https://www.bmz.de/de/aktuelles/aktuelle-meldungen/de-foerdert-weltweit-aufbau-gruener-wasserstoffwirtschaft-128378>.

⁴⁹ *Energy generation outlook in Germany 2040, by source.* (2023). Statista. Accessed May 8, 2024. <https://www.statista.com/statistics/1190099/germany-energy-production-outlook-by-source/>.

- Ukraine as an interesting and promising partner in the energy sector for the EU and Germany in particular (it is difficult to deny the demand-driven approach; since Ukraine is needed by Europe, it will approach Ukraine with greater interest as a prospective EU member). This was highlighted earlier, but the focus is specifically on relations with Germany.
- Benefits of energy cooperation: the positive experience and effective instruments in Germany's energy sector could be valuable for Ukraine.
- Existing forms of cooperation between Ukraine and Germany in the energy sector.
- What Ukraine can do to enhance cooperation today.

Ukraine is a promising potential partner for Germany in the energy sector due to the presence of various natural resources on its territory, the quantities of which are decreasing globally. These non-renewable resources include oil, natural gas, and coal. Due to various political and economic reasons, fortunately, they have not yet been fully exploited. A notable example is the potential for shale gas extraction. Ukraine boasts ample opportunities for intensive development of solar, wind, hydro, and bioenergy. For instance, agricultural residues from both plant and animal farming, of which there is an abundant supply, given the significant role of agriculture in the national economy, could serve as a potent source for biogas production.



Ukraine and Germany signed a statement on the expansion of energy partnership for the "green" recovery and reconstruction of the Ukrainian energy industry. *Source: [Ukrinform](#)*

Under conditions of effective management, Ukraine could ensure not only its own energy security but also that of its neighbors. It's worth mentioning the domestic nuclear energy sector (which certainly requires modernization but still holds substantial potential). Nuclear electricity can maintain an energy balance during challenging climate and crisis situations, particularly when there are difficulties in obtaining electricity from renewable sources.

Ukraine benefits significantly from its geographical location at the crossroads of key transportation routes. Ukraine possesses the potential to establish an efficient and effective logistic infrastructure for both domestic and international energy-related activities. This favourable geographic position gains additional significance within the context of strategies aiming to diversify energy sources and ensure energy security. This necessity was keenly felt by Germany after Russia started the full-scale invasion of Ukraine.

The Ukrainian energy sector presents itself as advantageous not only as a source of resources but also due to the presence of numerous technological startups in the energy field. These startups underscore the significant innovative potential and intellectual resources within the industry, which, given appropriate funding, can yield substantial dividends.

Furthermore, it is important to note that Ukraine's energy sector has gained substantial experience in "surviving" under extremely challenging conditions as a result of the Russian war. This experience could be valuable even to successful European energy players, considering that climate-related cataclysms are intensifying. Therefore, within the context of a partnership with Ukraine, Germany could gain access to diverse resources, cutting-edge technologies, and knowledge that would contribute to the balanced and sustainable development of the energy sector in both countries.

Partnership with the Federal Republic of Germany in the energy field offers numerous advantages to Ukraine. Germany's large consumer base and the robustness of its energy market provide ample space for effective planning and implementation of strategies related to domestic electricity supply.

Through collaboration with Germany, Ukraine gains substantial access to advanced innovative technologies in electricity production and consumption. The experience of German companies in renewable energy, energy efficiency, and smart technologies can make a significant contribution to the development of Ukraine's energy sector. This interaction can enhance innovation and dynamism within the domestic electricity industry.

Germany possesses substantial financial resources in its arsenal allocated as international development aid, and its businesses seek new external investment opportunities. This can contribute to the realization of ambitious projects aimed at improving energy efficiency, modernising infrastructure, and developing renewable energy sources in Ukraine. Thanks to strategies jointly developed within the framework of the energy partnership, Ukraine can counter its dependence on imports by increasing energy efficiency and expanding the use of renewable energy sources. Overall, a partnership with Germany in the energy sector can play a significant role in the development and modernisation of Ukraine's energy complex, fostering synergy between innovative approaches, investment opportunities, and expertise, thereby promoting a sustainable and stable energy future for both countries.

Ukraine is gradually becoming a participant in the pan-European energy "revolution." Notably, the European Green Deal (EGD) initiated by the EU is one of the most ambitious climate and environmental protection programs. The plan envisions a climate-neutral continent by 2050, within which there will be a net-zero balance of greenhouse gas emissions and economic growth will be decoupled from the use of natural resources. As part of the EGD, the European Union adopted its Hydrogen Strategy in July 2020. According to this strategy, Ukraine was identified as a priority partner for hydrogen production and supply (exports) to Europe, particularly to Germany.

In August of the same year, a declaration was signed to initiate a joint energy partnership between Ukraine and Germany. One of its main provisions is precisely cooperation in the development, utilisation, and transportation of hydrogen.⁵⁰ The pre-war state of Ukraine's renewable energy sector allowed the country to have the second-largest potential for renewable energy sources in Europe. Ukraine also possesses capacities to transport hydrogen to Europe. Research has been conducted on the

⁵⁰ Petryshyn, N., & Melnychuk, K. (2021). *Vodneva Stratehiya YeS – Nova Real'nist' Dlya Ukrayiny*. [EU Hydrogen Strategy Is A New Reality For Ukraine]. *Kharkiv Polytechnic Institute*. Accessed May 8, 2024. <https://repository.kpi.kharkov.ua/server/api/core/bitstreams/d98bfc43-c874-48d4-8a61-07f5e53ceb92/content#page=41>.

potential use of Ukraine's gas transportation system to transport its own clean hydrogen to European countries, demonstrating the possibility of transmitting a gas mixture with a hydrogen content of up to 25%, which equates to 16 billion cubic meters currently or 10 billion cubic meters over the next four years.⁵¹ The signing of the agreement on a joint energy partnership between Ukraine and Germany envisioned the creation of a "green" fund amounting to €1 billion. This serves as an illustration that Germany views our country as a key partner in supplying "green" energy to the EU.⁵²

According to analysts' forecasts, the commencement of hydrogen transportation to Europe was planned to begin in 2024. A dedicated entity, the "Ukrainian Hydrogen Council," has developed a project for a national Hydrogen Strategy to facilitate the implementation of the planned initiatives within the partnership with Germany and Europe.⁵³ During an international roundtable organised by the Ukrainian Hydrogen Council in Hanover, an international memorandum of support for the "roadmap" and the development of hydrogen energy in Ukraine was concluded. This memorandum was signed with the main hydrogen energy agency of the European Commission, "Hydrogen Europe," as well as with the German and Latvian hydrogen associations.⁵⁴ By the decree of the Cabinet of Ministers of Ukraine dated December 9, 2022, No. 1134-p, Ukraine's Hydrogen Strategy for the period up to 2050 was approved.

The German-Ukrainian energy partnership serves as a platform supporting high-level intergovernmental dialogue on energy matters. It involves promoting political dialogue, facilitating the exchange of best practices, fostering unity between business and policy, and enhancing communication regarding energy transformation.⁵⁵ The dialogue between governments on energy policies should take place continuously within the established formats of energy partnership. The key directions of the German-Ukrainian energy partnership encompass improving energy efficiency, modernising the electricity sector, expanding the use of renewable energy sources, and reducing CO2 emissions. Future priorities might involve the transformation of coal regions, renewable energy integration, green hydrogen, and heating system transformation.

Key Directions for Collaboration within the German-Ukrainian Energy Partnership

These areas outline the possible key directions for collaboration within the German-Ukrainian energy partnership: Long-term energy planning and legal framework reform; Economic implications of renewable energy projects; Market mechanisms and legislative adaptation for renewable energy

⁵¹ *Voden' yak vykhid z ekonomichnoyi ta klimatichnoyi kryzy*. [Hydrogen as a way out of the economic and climate crisis]. (2020). *Ekonomichna Pravda*. Accessed May 8, 2024. <https://www.epravda.com.ua/projects/greendeal/2020/06/24/662145/>.

⁵² Petryshyn, N., & Melnychuk, K. (2021). *Vodneva Stratehiya YeS – Nova Real'nist' Dlya Ukrayiny*. [EU Hydrogen Strategy Is A New Reality For Ukraine]. *Kharkiv Polytechnic Institute*. Accessed May 8, 2024. <https://repository.kpi.kharkov.ua/server/api/core/bitstreams/d98bfc43-c874-48d4-8a61-07f5e53ceb92/content#page=41>.

⁵³ Repkin, O. (2021). *Proryv u vodnevyy ekonomitsi mozhlyvyy zavdyaky modernizatsiyi ukrayins'koyi HTS*. [A breakthrough in the hydrogen economy is possible thanks to the modernization of the Ukrainian HTS]. *Interfaax-Ukraine*. Accessed May 8, 2024. <https://ua.interfax.com.ua/news/greendeal/774011.html>.

⁵⁴ *Ukrayins'ka vodneva rada, Yevropeys'ka, Latviys'ka ta Nimets'ka vodnevi asotsiatsiyi uklaly Memorandum pro partnerstvo u vodnevyy enerhetytsi*. [The Ukrainian Hydrogen Council, the European, Latvian and German hydrogen associations signed a Memorandum on partnership in hydrogen energy]. (2019). Cabinet of Ministry of Ukraine. Accessed May 8, 2024. <https://www.kmu.gov.ua/news/ukrayinska-vodneva-rada-yevropejska-latvijska-ta-nimecka-vodnevi-asociaciyi-uklali-memorandum-pro-partnerstvo-u-vodnevij-energetici>.

⁵⁵ *The German-Ukrainian Energy Partnership*. (2023). [energypartnership-ukraine.org](https://www.energypartnership-ukraine.org). Accessed May 8, 2024. <https://www.energypartnership-ukraine.org/home/>.

sources, including wind energy, photovoltaics, biomass, and hydro energy; Integration of various renewable energy sources into the energy grid and sectoral linkage; Energy conservation through energy efficiency; Carbon emissions reduction; Digital technologies and modern energy system development; Hydrogen.⁵⁶

Through political support, it is anticipated that the German industry will undertake specific energy projects in Ukraine. Other important formats of energy partnership include workshops, partner meetings, and the publication of research and discussion materials.⁵⁷

The German-Ukrainian cooperation in the field of energy, according to the joint memoranda, should be based on the following principles: Exchange of information regarding the energy policies of governments and legislative planning for creating a sustainable energy system based on renewable energy sources and energy efficiency; Support for the development of renewable energy sources and their integration into the energy grid; Promotion of energy efficiency; Improvement of conditions for private investments in the sustainable energy sector; Knowledge exchange on energy technologies; Competency development, including measures to enhance public education and training activities; Ensuring effective protection of intellectual property rights related to activities associated with the implementation of this Joint Declaration of Intent, in accordance with the provisions of the World Trade Organization and national and international legislation.⁵⁸

The war Russia waged against Ukraine posed a serious challenge to the implementation of the declared and planned initiatives within the framework of the Ukrainian-German energy partnership. On the other hand, it also led to an even stronger desire from advanced nations around the world to support the progressive development of Ukraine's energy sector. Particularly, during the Ukraine Renewal Conference in London, members of the G7+ Coordination Group, in support of Ukraine's energy system, along with the Government of Ukraine, committed to developing a Clean Energy Partnership to facilitate sustainable recovery and reconstruction in Ukraine. The G7+ Group will collaborate with Ukraine over the coming months to develop and enhance the Clean Energy Partnership, with the following objectives: accelerate the adoption of relevant EU legislative frameworks, increase the efficiency of the energy market, and integrate with the EU market; boost the production and utilisation of low-carbon energy sources; implement principles of a just transition towards discontinuing the use of unabated coal by Ukraine in electricity generation, to expedite carbon neutrality and enhance the reliability and competitiveness of Ukraine's energy system; upgrade energy infrastructure to global best

⁵⁶ *Gemeinsame Absichtserklärung Zwischen Der Regierung Der Ukraine Und Der Regierung Der Bundesrepublik Deutschland Über Den Aufbau Einer Energiepartnerschaft Einleitung*. [Joint declaration of intent between the government of the Ukraine and the government of the Federal Republic of Germany on the establishment of an energy partnership]. (2020). Bmwk. d e. Accessed May 8, 2024. https://www.bmwk.de/Redaktion/DE/Downloads/G/gemeinsame-absichtserklaerung-zwischen-der-regierung-der-ukraine-und-der-regierung-der-bundesrepublik-deutschland-ueber-den-aufbau-einer-energiepartnerschaft.pdf?__blob=publicationFile&v=1.

⁵⁷ *German-Ukrainian Energy Partnership*. (2020). dena. Accessed May 8, 2024. <https://www.dena.de/en/our-place-in-the-energy-transition/international-energy-transition/bilateral-energy-cooperative-agreements/german-ukrainian-energy-partnership/>.

⁵⁸ *Gemeinsame Absichtserklärung Zwischen Der Regierung Der Ukraine Und Der Regierung Der Bundesrepublik Deutschland Über Den Aufbau Einer Energiepartnerschaft Einleitung*. [Joint declaration of intent between the government of the Ukraine and the government of the Federal Republic of Germany on the establishment of an energy partnership]. (2020). Bmwk.de. Accessed May 8, 2024. https://www.bmwk.de/Redaktion/DE/Downloads/G/gemeinsame-absichtserklaerung-zwischen-der-regierung-der-ukraine-und-der-regierung-der-bundesrepublik-deutschland-ueber-den-aufbau-einer-energiepartnerschaft.pdf?__blob=publicationFile&v=1.

practices, enhancing resilience and efficiency; create a favourable environment for the adoption of innovative technological and financial solutions. The Group will focus on utilising existing donor instruments to provide coordinated support to a resilient, efficient, more decentralised, and smart energy system that will contribute to Ukraine's economic revitalisation and long-term growth.⁵⁹

Certainly, Russia's war against Ukraine has become a serious obstacle to the integration of Ukraine's energy system into the global energy sector of the EU and the establishment of close practical cooperation in the field of energy with Germany. Unfortunately, the G7 forecasts regarding the war end are discouraging.⁶⁰ Therefore, Ukraine must consider how to move forward in the unified European energy space despite the war. A unique example can be the practice of cooperation with Germany. And here, one should not only rely on the humanitarian and friendly efforts of German entrepreneurs and state structures in the field of energy. Business, despite its social responsibility at the crossroads of millennia, operates on market economy principles, including having economic and financial interests.



The G7 Summit in Hiroshima

Source: Volodymyr Zelenskyy

Relevant Steps for Strengthening Energy Cooperation between Germany and Ukraine

These are the practical steps currently relevant for strengthening energy cooperation between Germany and Ukraine. It is clear that the construction and reconstruction of energy-producing facilities that operate using renewable sources will be at the forefront. Some German companies have already launched projects to build wind power stations in Ukraine. Today as an example, one is planned in the Chernobyl zone.⁶¹ Enormous opportunities for the construction of a cascade of wind power stations exist in the Carpathian regions, where there are sparsely populated and underutilized territories with

⁵⁹ *G7+ and Government of Ukraine Clean Energy Partnership for the Sustainable Recovery and Reconstruction of Ukraine's Energy System.* (2023). Federal Foreign Office. Accessed May 8, 2024. <https://www.auswaertiges-amt.de/en/newsroom/news/g7-ukraine-clean-energy-partnership/2604256>.

⁶⁰ Marlow I., Nienaber M. (2023). US and G-7 Allies Now Expect War in Ukraine to Drag On for Years. *Bloomberg*. Accessed May 8, 2024. <https://www.bloomberg.com/news/articles/2023-09-19/us-allies-see-ukraine-war-grinding-on-need-for-long-term-plan#xj4y7vzkg>.

⁶¹ Zhylyns'ka S. (2023). Nimechchyna y Ukrayina planuyut' pobuduvaty vitrovu elektrostantsiyu v Chornobyli. [Germany and Ukraine plan to build a wind power plant in Chernobyl]. *The Village.com.ua*. Accessed May 8, 2024. <https://www.the-village.com.ua/village/city/city-news/343395-nimechchina-ta-ukrayina-planuyut-pobuduvati-vitrovu-elektrostantsiyu-u-chornobili>.

constant winds. The residents of local, territorial communities would support such projects because they bring new jobs that are currently lacking and provide certain revenues to the modest budgets of mountainous settlements. Is it profitable for a German investor? The honest answer is yes. Firstly, it is a long-term investment with guaranteed profitability. Secondly, for those who have been to Germany, it is apparent that Germany itself is already overcrowded with wind turbines. Simultaneously, the industry that produces them and the service that maintains them must continue to work. The business that manufactures wind turbines and the like requires movement in space and corresponding development; otherwise, it will fall into a state of stagnation. Ukraine offers significant prospects for it.

Certainly, the occupation of the sunny southern lands of Ukraine has reduced the opportunities for the development of solar energy. However, in the context of global warming, there are growing abilities for the construction of solar power plants in other regions of Ukraine. The same principles that apply to wind energy work here.

The German industry could produce the necessary equipment for Ukrainian small hydroelectric power plants. In our opinion, the war has taught many Ukrainians to have additional independent decentralised sources of electricity generation, and local communities have changed their attitude toward the construction of small hydropower plants on rivers (wherever possible).

Electricity generated from renewable sources also has its drawbacks. Regulating its production depending on the moment of need is challenging. Some experts point out that in Germany, there is a shortage of electricity during the day when life is bustling and an excess at night when everyone sleeps. In Ukraine, where the lion's share of electricity is produced by nuclear and thermal power plants, such utilisation can be easily balanced.

Due to the Russian blockade, Ukraine has faced the problem of grain export. Among the ways to address this issue is to shift from being a raw material supplier to processing grain and exporting grain products, as well as reviving animal husbandry. This would mean creating a new resource base for biogas production. Once again, there are significant opportunities for German businesses in this area with successful examples.⁶² Biogas, in general, is an environmentally friendly and cost-effective resource for obtaining thermal energy.

Germany has embarked on a path to replace thermal power plants with green energy. Of course, Ukraine cannot afford the same in the near future. Clearly, such a direction of energy eco-modernization will raise questions for the Germans about the use of thermal energy facilities and technologies, the fate of equipment manufacturers for thermal power plants, and so on. Ukraine is an excellent place to continue using and producing in this context. Domestic thermal power plants have long been in need of modernisation. A prominent example is the Burshtyn Thermal Power Plant, whose smokestack emissions can be seen for dozens of kilometers. Mutual benefit and interest are evident in this regard.

Germany's assistance in the reconstruction of the war-damaged energy infrastructure in Ukraine is also crucial.⁶³ On the one hand, this is support for Ukraine, and on the other, it means new orders for the German industry.

⁶² *MKHP: pryklad ukrayins'ko-nimets'koho eko-innovatsiyoho partnerstva*. [MHP: an example of Ukrainian-German eco-innovation partnership]. (2023). *Ekonomichna Pravda*. Accessed May 8, 2024. <https://www.epravda.com.ua/publications/2021/01/19/670097/>.

⁶³ *Vidnovlennya enerhetychnoyi infrastruktury: Nimechchyna peredala Ukrayini 334 tonny obladnannya*. [Restoration of energy infrastructure: Germany transferred 334 tons of equipment to Ukraine]. (2023). *Ukrinform.ua*. Accessed May 8, 2024. www.ukrinform.ua/rubric-uarazom/3668906-ukraina-otrimala-vid-nimeccini-334-tonni-obladnanna-dla-vidnovlenna-energeticnoi-infrastrukturi.html.

Conclusion

In the very end, what can be done today to specify mutually beneficial cooperation between Ukraine and Germany in the energy sector? German businesses can invest in the construction of energy facilities that operate on renewable sources: wind and solar power stations and small hydroelectric power plants. The potential of the German industry allows for the development of biogas production in Ukraine and the enhancement of its efficiency as a source of thermal energy. Germany's transition to green energy releases significant financial and technological resources from non-renewable energy sources, creating opportunities for their use in the modernization of Ukrainian thermal power plants. Ukraine continues to need the assistance of German companies supplying energy infrastructure objects. Cooperation in the energy sector yields mutual dividends: Ukraine gains modern energy sources, Germany promotes the development of its energy industry and energy companies, and German businesses have the opportunity for successful long-term investments.

What are the prerequisites for the integration of the Ukrainian energy sector into the European energy space and the implementation of advanced technologies, solutions, principles, etc., into domestic practices?

First and foremost, it is the victory in the war. Without victory, there will be no Ukraine and no Euro-oriented energy sector. Despite the war, Ukraine's Parliament and Government should establish a proper legal framework for effective energy cooperation with Germany and other supportive nations worldwide.

The restoration of the Ukrainian energy sector requires substantial capital investment. The Ukrainian political realm and leadership should not only rely on international financial aid but also create the necessary prerequisites and guarantees (legal, economic, organizational, and others) for external investors.

A significant obstacle to the partners' support for Ukraine's energy recovery and development could be the high level of corruption within the country. In order to dispel any doubts of Ukraine's friends and potential investors, strong and independent law enforcement and judicial systems should be established. A conscious civil society should play a key role in ensuring the irreversibility of Ukraine's reform process.

Lastly, there should be more educational resources on energy available to Ukrainian citizens so that they cannot be manipulated by politicians and foreign actors. We have examples in the past when large segments of society resisted different fracking projects. Developing proper societal awareness requires significant effort as well.

Ukraine holds numerous prospects and opportunities for energy cooperation with Germany, other European states, and the world at large. However, to enable them, a lot of homework has to be done.