CLIMATE INVESTMENT FUNDS

RENEWABLE ENERGY INTEGRATION PROGRAM INVESTMENT PLAN FOR UKRAINE

OCTOBER 2023

Contents

Acronyms and Abbreviations

ASM	Ancillary Services Market
BESS:	Battery Energy Storage System
CDM:	Clean Development Mechanism
CERC:	Contingency Emergency Response Component
CIF:	Climate Investment Funds
CoM:	Cabinet of Ministers of Ukraine
CTF:	Clean Technology Fund
DFC	United States International Development Finance Corporation
EBRD:	European Bank for Reconstruction and Development
ENTSO-E	European Network of Transmission System Operators, or
EnCS:	Energy Community Secretariat
FCR:	Frequency Containment Reserve
FRR:	Frequency Restoration Reserve
FiT	Feed-in- Tariff
GDP:	Gross Domestic Product
GHG:	Greenhouse Gas
GoU:	Government of Ukraine
GW:	Gigawatts
HPP:	Hydropower plants
IBRD:	International Bank for Reconstruction and Development
IE:	Implementing Entity
IFC:	International Finance Corporation
IP:	Investment Plan
MOE:	Ministry of Energy
MDB:	Multilateral Development Bank
MoE:	Ministry of Energy
MoF:	Ministry of Finance
NDC:	Nationally Determined Contribution
NEURC	National Energy and Utilities Regulatory Commission
RE:	Renewable Energy
REI	Renewable Energy Integration
TA:	Technical Assistance
TPP:	Thermal Power Plants
UES:	United Energy System
UE:	Ukreenergo
UHE:	Ukrhydroenergo
UKSF:	Ukraine Energy Support Fund
UN:	United Nations
UNFCCC:	United Nations Framework Convention on Climate Change
USAID:	United States Agency for International Development
VRE:	Variable Renewable Energy
WB:	World Bank
WEM:	Wholesale Electricity Market
WBG:	World Bank Group

1. Proposal Summary

Introduction

Ukraine's Investment Plan (IP) for the Climate Investment Funds (CIF) Renewable Energy Integration (REI) Program was developed under the guidance of the Ministry of Energy (MoE) with support from the World Bank the European Bank for Reconstruction and Development, and the International Finance Corporation. The primary focus of this IP is to address the inherent inflexibility within Ukraine's power system, a challenge that has hindered both the integration of existing renewable energy generation and the expansion of renewable energy sources. The IP was developed to bolster the adaptability and resilience of Ukraine's energy infrastructure, enabling it to effectively incorporate renewable energy sources and increase their contribution to the national energy mix.

Objectives

The primary objective of Ukraine's Investment Plan (IP) is to enhance the flexibility of the nation's energy systems, making it possible to seamlessly integrate a larger volume of variable renewable energy (VRE) into the national grid. This strategic imperative hinges on the widespread deployment of energy storage solutions, with a particular focus on advanced battery storage technology. The attainment of this goal relies on substantial investments from both the public and private sectors, underscoring the importance of collaborative efforts in advancing Ukraine's energy infrastructure.

Ukraine's Investment Plan (IP) is designed to support the urgent battery storage needs through allocating $70 million in funding to bolster Ukrhydroenergo's (UHE) 197MW battery storage project. Originally, this project was financed through loans from the International Bank for Reconstruction and Development (IBRD) and the Clean Technology Fund (CTF). However, due to the ongoing Russia's Invasion of Ukraine, UHE had to reallocate a large portion of the IBRD loan toward the restoration of damaged hydroelectric power plant (HPP) facilities. As a result, the battery storage component of the project faced a funding gap. The infusion of CIF REI funds is intended to bridge this gap, enabling UHE to install the most urgently needed battery storage capacity by 2026. This action is crucial for addressing the critical power system flexibility issue.

While the UHE project will fulfill the urgent flexibility need, private capitals will be mobilized through other programs within CIF and other financing resources given Ukraine's pre-existing need to develop around 2 gigawatts (GW) of battery storage capacity by 2030. This capacity is essential for enhancing power system flexibility, allowing for the effective integration of variable renewable energy sources. According to estimations from the Ministry of Energy, Ukraine's decarbonization goals may require an even more substantial 38 GW of battery storage. This underscores the immense scale of investment and development required to establish a resilient and sustainable energy infrastructure in the country, particularly in the context of the ongoing war. Under the current war situation in Ukraine, in parallel with preparation of private sector projects, various challenges will be addressed. Those include the availability of war insurance, regulatory changes, and investors' confidence among others.

Battery storage offers a wide array of applications, each with the potential to generate revenue. These applications encompass variable renewable energy (VRE) balancing, arbitrage, peak shifting, and ancillary services. Additionally, battery storage plays a crucial role in rapidly restoring power, thereby enhancing the resilience of the energy grid.

Expected Outcomes

CIF-REI financing will address the most imminent grid constraint to facilitate integration of VRE through deployment of battery storage and will facilitate additional resources from the public and private

sectors to meet the ultimate flexibility needs. The expected outcomes of Ukraine's Investment Plan (IP) for the Climate Investment Funds (CIF) Renewable Energy Integration (REI) arising from construction of new battery storage capacities encompass a wide range of benefits, including:

1. **Increased Power System Flexibility**: Achieve greater flexibility in the power system, reflected in the availability of Frequency Containment Reserve (FCR) and automatic Frequency Restoration Reserve (a-FRR) capacities.
2. **Reduced Renewable Energy Curtailment:** Decreasing the amount of curtailed renewable energy, leading to more efficient utilization of renewable resources. According to the World Bank project, the battery storage project is expected to reduce the renewable energy curtailment by 12.70 GWh.
3. **Emission Reductions:** Realizing significant emission reductions, estimated at about 124,721 metric tons of CO2 equivalent annually.
4. **New Business Model Establishment:** Establishing and commercializing a new business model that renewable sustainable energy integration.
5. **Diversified Energy Mix:** Accelerating the transition to cleaner and more sustainable energy sources, diversifying the energy mix.
6. **Stable Energy System:** Ensuring the stable operation of the energy system, providing reliable electricity supply to Ukrainian customers.
7. **Improved Reliability of the UES:** Enhancing the reliability of Ukraine's United Energy System (UES) and expanding capabilities for working in ENTSO-E conditions.
8. **Support for Renewable Energy Connection:** Facilitating the connection of new capacities of renewable energy sources to the networks.

2. Country Context

Macroeconomic Environment

1. **Russia's invasion of Ukraine continues to impose a severe humanitarian and economic toll**. Between February 24, 2022, and April 9, 2023, 22,734 civilians were killed and injured.[1] Russia's invasion of Ukraine also triggered one of the largest human displacement crisis in the world where approximately 5.4 million people (or one-eighth of the population) were displaced within Ukraine, and over 8.1 million people fled to neighboring countries.[2] Of those that were internally displaced, 60 percent were women and nearly half of the internally displaced people (IDPs) between ages 18 and 64 reported no income.[3] Ukraine's Gross Domestic Product (GDP) declined by 29.1 percent in 2022, with economic activity impacted by the destruction of productive capacity, damage to arable land, and reduced labor

1 https://www.ohchr.org/en/news/2023/04/ukraine-civilian-casualty-update-10-april-2023
2 https://dtm.iom.int/reports/ukraine-internal-displacement-report-general-population-survey-round-12-16-23-january-2023
3 International Organization for Migration (IOM). 2022. Ukraine Internal Displacement Report, Round 8. August 23, 2022. Available at: https://dtm.iom.int/sites/g/files/tmzbdl1461/files/reports/IOM_Gen%20Pop%20Report_R8_ENG_updated%20logo%20%281%29.pdf. It should be noted that Ukraine has seen an increasing number of returnees (as defined by the IOM) in recent months along with a decline in internally displaced people.

supply.[4] Moreover, poverty[5] is estimated to have increased from 5.5 percent in 2021 to 24.1 percent in 2022, pushing an additional 7.1 million people into poverty and setting back 15 years of progress.[6] Regions with active hostilities and those most affected by Russia's invasion of Ukraine are expected to have experienced even higher poverty rates.[7]

2. **Rising fiscal expenditure for defense and social protection increased the deficit, but higher tax collection, assistance from international partners, domestic borrowing, and monetization of the residual needs, partially relieved the stress on public revenues**. Due to the high spending on wages, goods, and services to meet security needs, and on social benefits to provide relief, general government expenditure in 2022 stood at 66 percent of GDP—26 percentage points more than in 2021.[8] Fiscal financing needs in 2022 reached 33.2 percent of GDP and included both needs for the deficit and for the repayment of debt principal. Having lost access to commercial external financing, Ukraine relied on official bilateral and multilateral assistance which provided a total of 21.1 percent of GDP in financing while the rest has been met by financing from domestic banks and National Bank of Ukraine monetization. Growth is expected to pick up only gradually. Under baseline projections, GDP is expected to expand by 2 percent in 2023 and starting from late 2024, the economy is expected to recover. This recovery would be driven by public investment as reconstruction activity picks up.

3. **Before the targeted attacks started in October 2022, the energy facilities had maintained stable operations and even exported electricity to Europe.** Amidst the war, Ukraine started synchronized operation of its power system with the European network (European Network of Transmission System Operators, or ENTSO-E) on March 16, 2022, after disconnection from the Russian Integrated Power System and Unified Power System (IPS/UPS). Emergency synchronization was authorized by ENTSO-E upon the successful completion of isolated mode tests (required as part of the synchronization protocol). Synchronization of the Ukraine power system has been a strategic long-term goal that had been prepared thoroughly for many years since Ukraine's expression of interest in the implementation of synchronization with ENTSO-E back in 2006. Synchronization allowed Ukraine and Europe to stabilize the entire synchronized power grid and make electricity exchanges between the regions. Since then and until the recent targeted attacks in October and November in 2022, the transmission grid has maintained its stability despite local disturbances incidental to indiscriminate shelling.

4. **Ukraine's economy is energy-intensive but per capita emissions are at the global average.** Ukraine makes up 0.5 percent of global annual carbon emissions, (185 million tCO2), and accounts for 1.8 percent (29 billion tCO2) of cumulative CO2 emissions since the industrial revolution. Ukraine's per capita emissions are roughly equivalent to the global average at 4.5 metric tCO2, and lower than the 6.5 mtCO2 for the European Union and 12 mtCO2 for Russia. Despite nuclear power constituting 55

4 Still, the contraction was less than initially expected, on the back of the return of nearly 4 million refugees and the resurgence of agricultural exports.

5 Measured as consumption below the global US$6.85 per person per day line in 2017 PPP.

6 Simulations by the World Bank that reflect the impacts of economic contraction, differentiated impacts on public and private sector income, and inflation impacts on poverty.

7 The United Nations Development Programme (UNDP) estimates the highest monetary poverty rates in Odeska, Luhanska, Khersonska, Kharkivska, and Rivnenska, which were among the poorest oblasts before Russia's invasion of Ukraine.

8 At the end of 2022 Ukraine's general government deficit (excluding grants) stood at 25 percent of GDP. Ukraine was able to collect 41 percent of GDP in revenues, 4.7 percentage points more than one year earlier. Underlying this was a strong collection of social security contribution and personal income tax, despite the increased eligibility for concessional tax regimes imposed immediately after Russia's invasion of Ukraine that temporarily reduced the tax base.

percent of electricity generation, the carbon intensity of Ukraine's economy is nearly three times that of the European Union. Ukraine's energy intensity per unit of GDP is twice the world average at 0.25 toe/US$1000 (2015 US$ PPP).

Power Sector Overview

5. **Ukraine's power sector has gone through several stages of reform starting with unbundling and partial privatizations in the 1990s.** Power generation, transmission, and Wholesale Electricity Market (WEM) operations are now conducted under separate entities, while the sector is regulated by the National Energy and Utilities Regulatory Commission (NEURC). Electricity distribution and retail were combined in several regional power companies (OblEnergos), most of these are now privatized and unbundled, albeit controlled by a handful of individuals. The State owns and manages all NPPs, which are operated by the state-owned entity, EnergoAtom. Similarly, all major HPPs belong to Private Joint Stock Company (PJSC), Ukrhydroenergo (UHE). The national transmission network is owned and operated by UE – the state-owned TSO. TPPs in Ukraine are grouped into five regional companies (Donbassenergo, Dniproenergo, Centrenergo, Zakhidenergo, Skhidenergo). Only Centrenergo is still under state ownership while a majority of the shares of the others are now owned by DTEK, a private sector company with interests in power generation, distribution, and coal mining. DTEK controls about 80 percent of the coal production in Ukraine.

6. **Generation**. Electricity production in the Integrated Power System of Ukraine in 2022 decreased 27.5 percent compared to the same period in 2021, to 113,678 GWh, with state-owned enterprises accounting for most of that production. NPPs reduced electricity generation by 28 percent compared to the same period last year, to 62,198 GWh. TPPs, CHP plants and cogeneration plants reduced their output by 34 percent to 30,210 GWh. HPPs and PSHPs increased production by 5.7 percent to 11,038 GWh, and the rest of the alternative sources produced 10,230 GWh. As illustrated in Figure 1a and 1b, the composition of electricity production in 2022 is as follows: Nuclear Power Plants (NPPs) contribute 54.7 percent, while Thermal Power Plants (TPPs), Combined Heat and Power (CHP) plants, and cogeneration plants contribute 26.6 percent. Hydroelectric Power Plants (HPPs) and Pumped Storage Hydroelectric Plants (PSHPs) account for 9.7 percent, and renewable energy sources, encompassing solar, wind, and bioenergy, contribute 8.4 percent to the overall electricity generation. The privately-owned DTEK Group, Ukraine's largest vertically integrated holding company, is responsible for producing 23 percent of the nation's electricity, primarily through coal and thermal units. Energoatom contributes to 55 percent of the electricity production, while Centrenergo accounts for 8 percent, Ukrhydroenergo for 7 percent, and the remaining share is produced by other units.

Figure 1a: Electricity Generation in 2021.[9]

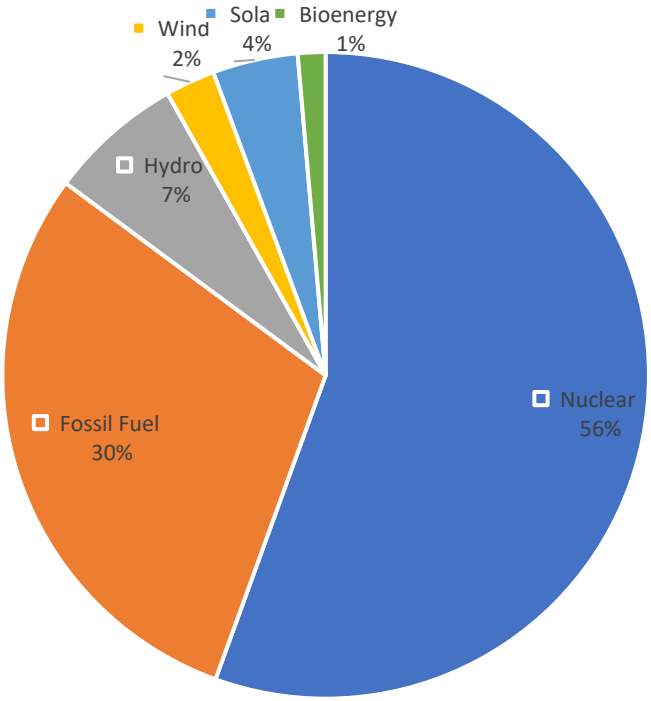
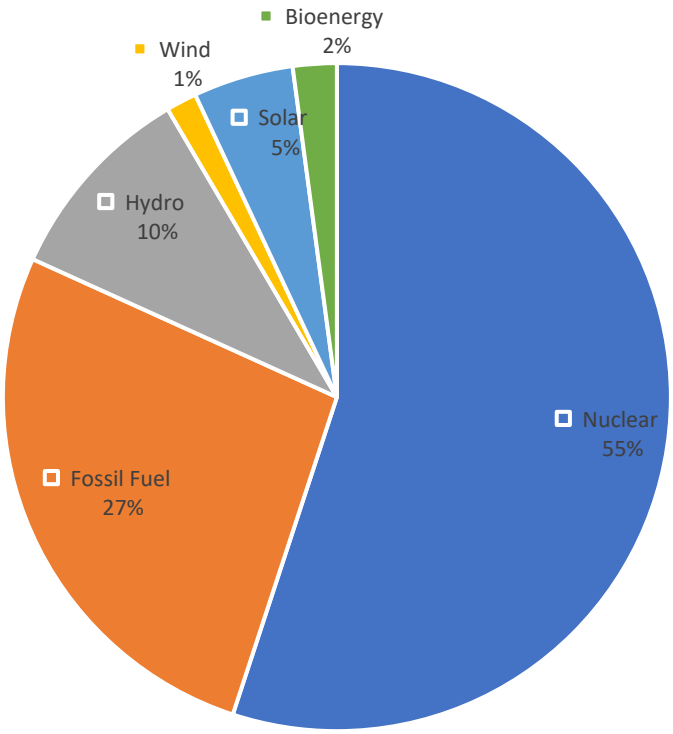


Figure 1b: Electricity Generation in 2022



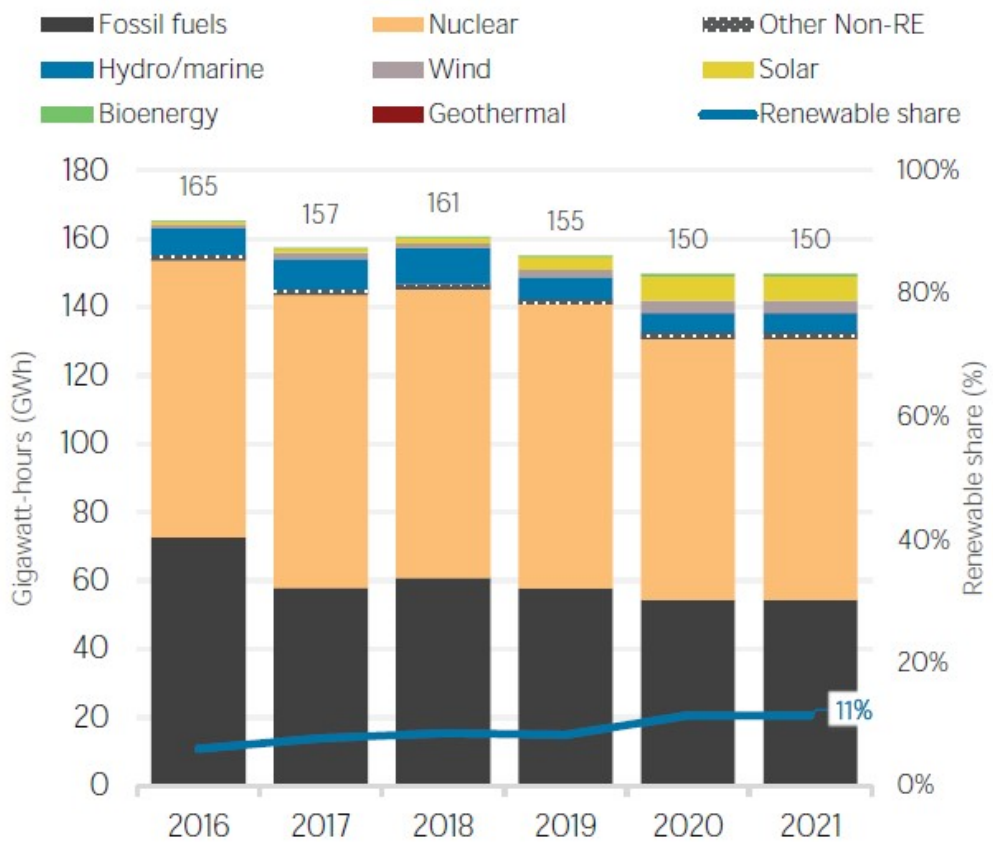
[9] Ukrenergo. Electricity balance for 2021-222.

7. **Transmission.** UE is responsible for operating Ukraine's integrated power system and transmitting electricity from generating plants towards distributors. UE currently has eight regional power systems covering Ukraine and manages more than 21,300 kilometres of trunk and cross-border high voltage transmission lines. Along with domestic operation, UE co-ordinates transmission system operation with neighbouring countries, and manages cross-border electricity flows with neighbouring states. UE is also responsible for the Ten-Year Transmission System Development Plan and a Generation Adequacy Report, that must be approved by NEURC. To meet requirements of the EU's Third Energy Package, in July 2019 UE was transformed from a state-owned unitary enterprise into a joint-stock company with 100 percent state ownership. Along with the electricity transmission and dispatching, its new roles include operating balancing and ancillary service markets, registering bilateral agreements, and serving as a settlements and commercial metering administrator. In 2022, UE obtained the observer membership with European Network of Transmission System Operators for Electricity (ENTSO-E) after Ukrainian power system's successful synchronization in March 2022.

8. **Supply and Distribution**. Regional electrical supply and distribution companies (oblenergos) were established in the mid-1990s to supply and distribute electricity to consumers in Ukraine. Initially there were 27 oblenergos, and they were responsible for both supplying and distributing electricity at regulated tariffs only within the territory of their licensed activity. However, as tariffs were fixed for consumers, oblenergos began incurring losses, which were partially compensated through a system of subsidy certificates. To promote efficiency within the retail market, the privatisation of the oblenergos began in the late 1990s. At the moment, most of the oblenergos have already been privatised either fully or partially. In parallel, private suppliers began selling electricity to consumers at nonregulated tariffs. However, the privatized oblenergos and suppliers are still controlled by a handful of individuals. Consequently, in order to promote competition in the retail market, Ukraine aimed to unbundle the oblenergos by separating contestable activities (electricity supply) from activities with natural monopoly characteristics (electricity transmission and distribution) and creating electricity suppliers and DSOs through the electricity market reform. Due the ongoing conflict in Ukraine, some of the oblenergos returned to the public ownership to allow the State to directly control the distribution sector.

9. **Traditionally, Ukraine's power sector has relied on a mix of coal, nuclear, and hydropower sources, however, in recent years, there has been a rapid surge in the share of renewable energy (RE), as depicted in Figure 2a and 2b**. As of December 31, 2021, Ukraine's renewable energy sector had reached an installed capacity of about 16 GW, constituting a sizable portion of the country's total installed capacity, which was approximately 58 GW. Solar power has grown from 458 MW in 2016 to 6.2 GW in 2021, and wind has more than triple since 2016 (300 MW) to 1.6 GW in 2021. In 2021.The collective contribution of renewable energy sources (RES), including solar, wind, biomass, and biogas, as well as hydro, to Ukraine's electricity generation in 2021 amounted to 11%, equivalent to 17,136 GWh, a notable increase from the approximately 6% contribution observed in 2016.

Figure 2: Electricity Generation Trend



Source: IRENA 2023

10. **The functioning of the nascent Wholesale Electricity Market has been hampered by concentration of market power and an incomplete transition to market-based ratemaking**. On July 1, 2019, Ukraine transitioned out of the single-buyer wholesale electricity market model and launched the new WEM, in accordance with the 2017 Electricity Market Law. This made the power market in Ukraine compliant with the legal requirements under the EU's Third Energy Package. The WEM now competitively trades bulk electricity in integral market segments of the day-ahead market (DAM) and intraday market (IDM), which are supplemented by the bilateral contract market. This is further supported by the balancing market (BM) and the ancillary services market (ASM). The WEM started its operations in a phased manner to enable a smoother transition to the new structure by imposing various restrictions, including constrained bidding in the DAM and bidding caps in the BM and ASM. Additionally, two Public Service Obligation (PSO) mechanisms were introduced: (i) Household (HH) PSO to protect household consumers by keeping electricity tariffs below full cost recovery; and (ii) RES PSO to cover RES obligations under the FiT mechanism, since FiTs are significantly above WEM prices. Under the HH PSO, nuclear and hydro producers are obliged to sell the bulk of their production at low regulated rates to meet residential consumption needs. On the other hand, RES PSO is being funded through UE's transmission tariff. Since end-consumer tariffs – both for households and for industrials (that include TSO Tariff) are regulated by NEURC, there is a disconnect between the legislated HH and RES

PSO requirements, and the approved end-user tariffs, leaving a large and growing unfunded gap that is at the heart of the sector's financial stress.

11. **The systematic development of Ukraine's ASM is already underway in line with EU market practices**. Ukraine's ASM's first auction took place in Spring 2020. The market design is in line with other European Network of Transmission System Operator for Electricity (ENTSO-E) markets (see Box 1), including provision of several frequency control services. The ASM conducts short-term auctions for these services in several future timeframes, namely daily, weekly, monthly, and yearly. Frequency control reserve needs are bid, and capacity awarded is remunerated on an hourly basis. The accepted price from these auctions is included in dispatch tariff that is then covered by all users as part of TSO tariff. UE has evaluated each generating unit in the system from the perspective of providing ancillary services, and processed certifications for participating in the ASM. While as of 2021 the Ukrainian power system has thirteen certified units participating in the ASM, only five units have been certified for providing FCR as of February 2021, with a cumulative certified Frequency Containment Reserve (FCR) amount of 177 MW. Most of these units use coal (TPPs) and would need to transition towards greener options in the future. Work is ongoing on certifying more units for FCR, including nuclear plants, but now the FCR market is entirely subscribed by existing TPPs. While rules for improving ASM operations are progressing, it must be noted that fast response reserves (FCR and automatic Frequency Restoration Reserve (a-FRR)) continue to be provided as a default option through the Integrated Power System/Unified Power System (IPS/UPS) (and specifically by the Russian power system). In fact, Ukraine routinely fails to meet its FCR requirements and prevailing rules allow for instantaneous cross-border power exchanges and a-FRR provision to fill this gap without any significant financial consequence for the power system. This reliance in the IPS system has allowed the Government of Ukraine to keep very low pricing caps within ASM, which could not lead to sufficient participation of incumbents or new investments.

Box 1. Various Services in Ancillary Service Markets

A power system must possess a certain amount and type of reserves to manage instantaneous fluctuations to ensure balance between demand and supply. Under ENTSO-E rules, power system reserves are classified in the following three categories:

1. Frequency Containment Reserve - FCR – Active and spinning power (primary) reserves engage automatically (with special equipment) within 30 seconds to contain frequency after occurrence of an imbalance in the system.
2. Frequency Restoration Reserve - FRR (a-FRR and m-FRR) - (30 seconds -15 minutes) automatically (a-FRR) or manually (m-FRR) engaged spinning power (secondary) reserves to restore system frequency to the set point frequency value. For a synchronous area consisting of more than one load-frequency control area (LFC area), this includes restoring power balance to the scheduled value.
3. Replacement Reserve - RR - Active (standby, tertiary) power reserves available within 30 minutes to restore or support the required level of FRR preparing for possible additional system imbalances, including generation reserves.

12. **Russia's war on Ukraine has significantly deteriorated the electricity supply situation due the targeted damages on energy infrastructure, with consequent impact on human and social aspects of life, negatively affecting human and social development.** Based on the World Bank's Rapid Damages and Needs Assessment conducted as of February 24, 2023, the cumulative damage to power, gas, heating infrastructure, and coal mining has now exceeded US$10 billion. Among these

sectors, the power sector has borne the brunt of the damage, accounting for nearly US$6.5 billion in losses. Within the power sector, the generation segment has suffered the most substantial damage, totaling US$3.9 billion, followed closely by the transmission segment, which has incurred approximately US$1.9 billion in damages. It was estimated that US$0.9 billion in damages and losses were sustained at the Zaporizhzhia nuclear power plant, which is the largest nuclear power plant in Europe. Several combined heat and power (CHP) plants and thermal power plants (TPP) were also destroyed or damaged within the sector. Additionally, the estimated damage to the power distribution sector stands at about US$404 million, although it is important to note that this figure does not encompass assets located in territories temporarily not under government control. The gas sector damage estimates are around US$1.2 billion; this comprises damage to gas distribution infrastructure as well as damage reported by the gas transmission system operator (TSO). Damage to the oil sector, including oil refinery facilities, fuel depots and fuel stations, is estimated at close to US$1.7 billion.

13. **Amid the War, Ukraine power sector has made a strategic achievement: its power system synchronization with European Network of Transmission System Operators for Electricity (ENTSO-E).** Despite the invasion, on February 24, 2022, Ukrenergo, the national electricity transmission system operator, started an isolated operation test as planned disconnecting from the Russian power system and successfully completed the test on February 27, 2022. On March 16, 2022, Ukrainian and Moldovan power systems started emergency synchronous operations with ENTSO-E – the historical moment for Ukraine to achieve the long-awaited goal. Emergency synchronization with ENTSO-E helped Ukraine maintain a stable power grid and ensure electricity supply despite the war and subsequent disconnection of the largest nuclear power plant, Zaporizhzhia. Ukraine has also exported electricity to ENTSO-E countries, which generated additional revenues for the electricity sector and helped Europe diversify its energy supply sources. The electricity trade capacity between Ukraine and ENTSO-E was initially restricted by ENTSO-E due to grid stability issues, but with more technical measures implemented, the trade capacity increased to 1,200 MW as of June 21, 2023.

National and International Climate Change Strategies and Plans

14. **Ukraine's current Nationally Determined Contribution (NDC) mitigation target lacks ambition but has supported RE growth**. Ukraine's emissions have fallen by more than 60 percent since 1990 to 340 MtCO2-eq following a significant economic contraction with the dissolution of the USSR in 1991 and subsequent changes in economic structure. Under the Kyoto Protocol, Ukraine would keep its 2008–2012 emissions below 1990 levels, but this was achievable without specific measures. To promote RE capacity addition, legislation in September 2008 established a "green tariff" for renewable generation. Ukraine also imposed a carbon tax that applies to CO2 emissions from stationary sources (covering 71 percent of total emissions) in 2011, which has been raised over time, though it remains among the lowest in the world and is too small to have any effect. Ukraine's first NDC (2016) indicated that emissions would remain below the 525 MtCO2-eq, though this would allow substantial growth from the current level. International observers criticized this target as "critically insufficient" in relation to a "fair share" range for alignment with the Paris Agreement. The GoU in 2017 established the Energy Strategy of Ukraine to 2035 which sought to halve the energy intensity of GDP by 2030 and to increase RE to 25 percent of primary energy supply. However, coal and gas power largely maintain their share in the generation mix, with only a modest decline in emissions. The 2035 Energy Strategy was divided in three phases: 2017–20 (EU integration, coal restructuring, promoting RE expansion), 2021–25 (upgrading energy infrastructure and integration into the EU sphere), and 2026–35 (holistic reforms focused on promoting sustainable development). On December 2020 Ukraine announced its intention to update its Nationally Determined Contribution (NDC) target to between 58 to 64 percent reduction

below 1990 levels by 2030. This target, while a significant improvement from its previous target, still falls short of the ambition level needed to achieve a 1.5°C-compatible goal. The 2030 target will be achieved through aligning climate policy and legislation with the European Green Deal, particularly in the areas of renewables, hydrogen, and the transformation of the coal sector. The Government aims to phase out coal-fired power generation and increase the share of renewables in the energy mix.

15. **A new EU-aligned net-zero emission policy and emissions trading scheme is expected.** Since 2014, the GoU has sought to progressively align with the European Union's climate objectives and is preparing to align with the European Green Deal, including through cooperation on efficiency improvement, renewables, and hydrogen. In December 2020, the Ukrainian President previewed that the forthcoming NDC revision would achieve a more substantial 58–64 percent reduction below the 1990 level by 2030, essentially holding emissions at their current level. But the EU plan is much more ambitious, seeking to achieve net-zero emissions of GHGs by 2050, and Ukraine has endorsed this as a "long-term goal" achievable by 2060. The EU plan calls for phasing out coal and decarbonizing gas, and although Ukraine has not committed to the same goal it plans to transition the coal sector and roll out a national emission trading scheme by 2025, with linking to the EU Emissions Trading System (ETS) by 2040.

16. **In March 2023, the Ukrainian Cabinet of Ministers approved the Energy Strategy of Ukraine until 2050.** This strategy significantly emphasizes the development of both nuclear and renewable power generation capacities. It also focuses on the modernization and automation of transmission and distribution systems. The goal is to achieve carbon neutrality in the energy sector by 2050, aligning with global efforts to combat climate change and promote sustainable energy practices. Despite the challenges posed by the conflict, Ukraine established an ambitious target to increase the share of renewable energy in its power generation to 50% by 2035. The remaining 50% of the power mix would be comprised of nuclear power, further bolstering the nation's energy security. As of the end of 2021, just before the onset of the conflict, Ukraine's power generation breakdown was as follows: nuclear power represented 55% (86 terawatt-hours), coal 24% (37 TWh), gas 6% (10 TWh), and renewables 15% (22 TWh), with 7% from wind and solar, 7% from hydro, and 1% from biomass.

17. **The National Renewable Energy Action Plan (NREAP) was adopted in 2014 in accordance with Ukraine's Energy Community commitments set forth ambitious objectives for the expansion of renewable energy capacity by 2020.**[10] These targets required significant investments and represented a substantial leap forward in Ukraine's renewable energy sector. Key aspects of the NREAP included:

    - **Wind Energy**: The plan aimed to increase wind energy capacity from 410 MW to 2,280 MW by 2020, signifying a fivefold expansion.
    - **Solar Energy**: Solar energy capacity was set to grow from 450 MW to 2,300 MW.
    - **Small Hydro**: NREAP aimed to augment small hydro capacity from 120 MW to 150 MW.
    - **Biomass Electricity:** A fortyfold increase in biomass electricity generation capacity was targeted, with the goal of increasing it from 24 MW to 950 MW.

    Ukraine's NREAP had an overarching goal of increasing the country's installed renewable energy capacity (excluding large hydro) by more than fivefold, from 1,024 MW to 5,700 MW. To attain these objectives, specific targets were established for renewable energy's contribution across various sectors, including heating and cooling, electricity generation, and transportation. These targets comprised:

[10] https://saee.gov.ua/documents/NpdVE_eng.pdf

- **Overall Share**: 11% share of energy generated from renewable sources in gross final energy consumption.
- **Heating and Cooling**: 12.4% of the demand for heating and cooling through the utilization of renewable energy sources.
- **Electricity**: 11% of the electricity demand would be met through electricity generated from renewable energy sources.
- **Transport:** 10% of the energy demand in the transportation sector is met with renewable energy sources.

Box 2: Incentives for RE Development in Ukraine

Development of Ukraine's renewable energy production has been supported by the following measures[11]:

1. Feed-in tariffs for electricity generated from RES;
2. Land tax reduction for renewable energy enterprises;
3. Number of tax exemptions:
    a. operating profits of the energy companies producing electricity from renewable sources; (II) biofuel producers' profits earned from biofuel sales;
    b. company profits earned from combined electricity and heat production;
    c. profits of producers of machines, equipment and devices for the manufacture and reconstruction of technical and transport means consuming biological fuel types;
    d. value-added tax exemption for the transactions related to importation to Ukraine's customs territory of equipment working on renewable energy sources.

3. Renewable Energy Integration Context

Renewable Energy Sector Growth

18. **Ukrainian power system is historically over-capacitated with fast growing Renewable Energy (RE) generation compounding the problem**. In 2021, emissions from the power sector were estimated at nearly 43 MtCO2-eq with overall electricity production in 2019 of 154.0 TWh. Ukraine's operating electricity generation capacity is 54.3 GW, with little growth in the past decade and a system peak less than half the installed base (23.5 GW). In 2010 there was twice as much coal power installed (27.3 GW) as nuclear, but coal retirements have reduced capacity to 21.8 GW. Solar power has grown from 458 MW in 2016 to 5.0 GW in 2020, and wind has tripled since 2016 (300 MW) to 1.1 GW in 2020. Collectively account for less than 2 percent of generation. Hydropower (4.8 GW) and pumped storage hydropower (PSHP, 1.5 GW) provide balancing and flexibility but are insufficient for the full system need, particularly during periods of water stress. Despite over-capacity, there are severe reserve constraints given that Ukraine's thermal generators tend to be old, with slow ramping rates and accelerated deterioration owing to frequent start-ups and shutdowns. Ukraine's thermal (mostly coal) generators operate at low-capacity factors (21 percent). Even nuclear generators operate at 65 percent load, significantly below industry standards.

[11] https://www.iea.org/policies/5673-national-renewable-energy-action-plan-nreap-through-2020

19. **The recent rapid increase in RE sources within the generation mix is driven by the Government's commitment to decarbonization**, through incentivizing private sector investments. Until 2018, RES accounted for a small portion of electricity generated. However, the generous FiTs for RES with no capacity caps have resulted in the rapid installation of over 8 GW of RES capacity at the end 2020, with the bulk of these additions occurring in 2019. According to the UE's Generation Adequacy Plan, an additional 2–3 GW would be secured through FiT-based power purchase agreements by the time FiT expires in 2029. Per these government projections, RES would account for 9 percent of the generated electricity in 2021 and 14 percent by 2029. Despite this rapid increase in capacity installed, the results in carbon emission reductions have not been as expected. Due to the lack of flexibility to balance this renewable energy generation, wind and solar generation is often curtailed (while compensated by the take or pay Power Purchase Agreements (PPAs)), and part-loaded thermal power plants to provide the required reserves, which is leading to increased GHG emissions.

20. **The rapid increase of RES capacity due to generous FiTs before the invasion has created financial and operational challenges for UE and for the power sector, including fast accumulation of arrears**. The FiT scheme, introduced in 2009 provided tariffs in the range of 12-15 EUR cents/kWh for utility-scale solar and 10 to 11.4 EUR cents/kWh for wind, much higher than the average tariffs awarded in other countries at that time. The FITs are regulated through a mandatory RES offtake by a Guaranteed Buyer (GB). This resulted in the introduction of the previously mentioned RES PSO scheme, that has led to financial deficits incurred by the GB due to insufficient politically motivated funding from the transmission tariff to cover the FiT prices. Under the additional new responsibilities assigned to UE in 2019, the TSO is obligated to compensate the deficits through the revenues from its transmission tariff, which must be approved by NEURC. In violation of the law of Ukraine, NEURC had not provided full tariff coverage to pay to renewables. This leads to a large and growing unfunded mandate of UE towards RES. As of July 25, 2023, the level of payments of the Guaranteed Buyer to renewable electricity producers under the FiT scheme for 20 days of July 2023 reached 43.3%. The average payment level for 2023 accounts for 52%. The average payment level for 2022 remains 52%. The debt of UE being the ultimate source of compensation under the Renewable Public Service Obligation to the GB increased to UAH 24.8 billion (+UAH 3.3 billion compared to this indicator provided as of 1 July 2023). The World Bank supported the UE and the Ministry of Energy (MoE) with preparation and implementation of the Financial Recovery Action Plan (FRAP).

21. **Battery storage has various applications and can earn revenues through services such as VRE balancing, arbitrage, peak shifting, and ancillary services**. Figure 2 lists potential services that battery storage can provide.

Figure 2: Battery Storage Applications

Application		Description	Duration
Energy Arbitrage		Purchasing low-cost off-peak energy and selling it during periods of high prices	Hours
Renewable (RES) Smoothing/Balancing		Smoothing variable RES outputs or provide firm capacity for RES plant	15 mins to 1 hour
Peak supply		Provide reliable capacity to meet peak system demand	4+ Hours
Ancillary Services	Frequency Containment Reserve (FCR)	Very fast response to unpredictable variations in demand and generation and to a contingency such as a generator trip.	Seconds
	Frequency Restoration Reserve (FRR)	Fast response to random, unpredictable variations in demand and generation.	15 mins to 1 hour
	Replacement Reserve (RR)	Units brought online to replace spinning units	Hours
	Ramping/Load Following	Follow longer term (hourly) changes in electricity demand.	30 mins to 1 hour
	Black-Start	Units brought online to start system after a system wide failure (blackout)	Hours
Transmission deferral		Reduce loading on T&D system during peak times	Hours

Box 3: Battery Storage Facility

UK Case Study – Glassenbury Battery Storage and Cleator Moor Battery Storage

The Glassenbury battery storage park, a 40MW storage project in Kent, and the 10 MW Cleator Moor Battery Storage Park in Cumbria were developed by Low Carbon Storage Investment Company in partnership with a subsidiary of the Rotterdam based energy and commodity trading organisation, the Vitol Group. The systems came on stream in January 2018 having been successfully awarded contracts in the National Grid's Enhanced Frequency Response (EFR) tender process and the Capacity Market Auction during 2016.

Cleator Moor Battery Storage Site

The latest sets of accounts for both companies that have been registered cover a nine-month period ending 30 September 2019. For Glassenbury, the accounts record a turnover for this nine-month period of GBP 3 088 205, a profit before tax of GBP 54 652 with a balance sheet showing tangible fixed assets of GBP 16 041 987. The equivalent figures for Cleator were turnover of GBP 668 793, loss before tax of GBP 30 439 and tangible fixed assets of GBP 4 429 341.

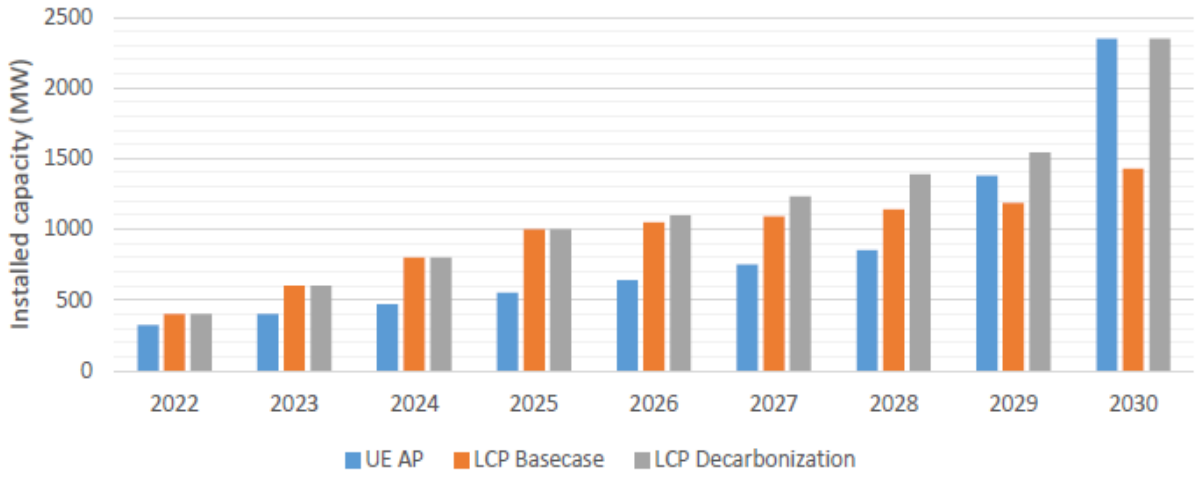
Gresham House Energy Storage Fund acquired Glassenbury Battery Storage and Cleator Battery Storage on 16 December 2019. At that date, the company described these two assets as contributing a quarter of the GB System Operator's EFR capacity.

22. **Grid-scale battery storage could play a key role in the development of Ukraine's ASM and BM, supporting the transition towards decarbonization.** Storage has been widely adopted in several countries over the last decade to provide a broad range of grid services. With rapid technological advances and improving battery products, applications of battery storage in the grid have been expanding. Thus, while PSHP still provides the bulk of the existing storage capacity for electric grids globally, battery storage has experienced rapid growth over the last decade, both in terms of installed capacity and the number of applications, especially as costs have continued to decline. Batteries are modular and allow for fast deployment. In addition, batteries can provide very fast response, enabling optimized frequency regulation, transmission and distribution investment deferral, and support for renewable energy integration by providing balancing services. This could be done through a standalone battery facility or through electric storage embedded in renewable energy facilities, that limit variability in plant outputs and allow the batteries to be used for other applications such as provision of ancillary services or participation in the BM.[12]

23. **Battery capacities starting at 400MW in 2023 and increasing to 2,000 MW in 2030 are identified as part of the least cost option for Ukrainian power system**. Both the Ukrenergo Adequacy Plan and the Least Cost Plan (LCP) show that batteries are already economically feasible and within the required range of lower cost infrastructure needed to provide several services. Figure 3 below shows a comparison of the battery capacity needs according to UE and the Bank's studies, under several scenarios. The battery storage capacity needed increases to 1,000 MW by 2025 and reaches 1,500-2,000 MW by 2030, driven by the need to provide fast response reserves traded in ASM and balancing services in BM for the growing VRE generation in the system. These studies confirmed that battery storage is the least cost option for the power system to provide reserves and manage variable renewable energy, compared with existing generation units and potential other new investments such as flexible gas-fired power plants. This phased and strategic expansion in battery storage capacity over the next decade assumes anticipated technological advances and conservative cost reductions. The LCP base case considers the target of 25 percent of renewable energy including hydroelectric generation by 2035, while the LCP decarbonization scenario aims to cut the CO2 emission by 80 percent by 2040 compared with 2022. While these studies were made before the war, USAID is currently conducting the power system adequacy analysis, which will inform the latest level of future battery capacity. It is expected that the new study will be in line with past studies.

Figure 3. Battery storage capacity needs towards 2030

[12] This is highly relevant for Ukraine where rapid deployment of renewables into the grid is causing grid stability issues and renewable curtailment, and even more, once coal-fired generation is retired, in-keeping with post-synchronization European Green Deal mandates.



Source: World Bank, Ukrenergo

24. **Amid Russia's war on Ukraine, the urgency for battery storage has even become more apparent, given the damages to flexibility facilities particularly Hydro Power Plants (HPPs)**. Hydropower plays a pivotal role in the operation of the Ukrainian power system, with HPPs and PSPs (Pumped Storage Hydropower Plants) serving as the primary sources of auxiliary services to meet peak power demand and balance intermittent RES capacities. PSPs also play a crucial role in bridging the nightly gaps in electricity consumption. According to UHE, all hydropower facilities have either suffered damage or been subjected to attacks, resulting in direct losses estimated at $464 million for HPPs and PSHPPs.[13] As of the end of April 2023, the available hydropower capacity had decreased to 4.7 GW, marking a significant 29.8 percent decrease from the 6.7 GW capacity recorded at the end of 2021. During the period from October 2022 to April 2023, most power plants sustained damage to their main or auxiliary equipment. Three hydroelectric power plants and one pumped storage plant were severely damaged by missile attacks, primarily targeting electrical equipment and machine rooms at HPPs. This resulted in a total of 2.1 GW of available HPP and PSHPP capacity being damaged, with 500 MW of damaged capacity subsequently restored.[14] As of July 29, 2023, the total requirement for fast-operating reserves stands at +829MW (upwards) / -379MW (downwards). Battery storage can fulfill this demand, providing essential support to stabilize the power system.

Institutional Framework and Capacity

25. **The key players in Ukraine's energy sector governance and regulatory framework are the Cabinet of Ministers of Ukraine, the Ministry of Energy, and the National Energy and Utilities Regulatory Commission**. The CoM is the highest executive body responsible for collective decision-making. MoE forms and implements state policy within the energy sector, and it reports to the CoM as well as to the Parliament (Verkhovna Rada) and the Presidential Administration. MoE is also responsible for developing the Energy Strategy of Ukraine until 2035, tracking and monitoring results while

[13]https://www.energycharter.org/fileadmin/DocumentsMedia/Occasional/2023_05_24_UA_sectoral_evaluation_and_damage_assessment_Version_X_final.pdf
[14] https://www.undp.org/ukraine/publications/towards-green-transition-energy-sector-ukraine

submitting annual progress reports. In addition, MoE measures economic incentives, monitors, and reports on energy demand and forecasts, and defines strategy and methodology for constructing facilities for energy generation. Accompanying CoM and MoE, is NEURC, which remains central to regulating the country's energy sector, particularly in setting tariff policies and in implementing relevant pricing formulation.

26. **Ukraine's public bodies are responsible for exercising ownership functions over SOEs**. Currently, there are over 3,200 SOEs in the country managed by more than 85 different state actors. Within the energy sector, MoE has been one of the main bodies responsible for the management and oversight of SOEs. Moreover, MoE has been responsible for approximately 130 companies, over which it can exercise the power to manage the corporate rights of the state. CoM has also been responsible for SOE governance in the sector. Currently, a transfer of responsibilities is underway. The Government of Ukraine issued instructions to prepare the Government's decision on transfer of UE from MoF to MoE. UHE was transferred from MoE to CoM.

Role of Private Sector, Innovation, and Leverage of Resources

27. **The significant amount of battery storage needs calls for a joint public and private approach to develop green battery storage in Ukraine, as an alternative to other flexibility sources**. Battery storage projects are well suited for private investments, given their modularity and relatively fast deployment, and can be installed as stand-alone projects or as a part of hybrid projects in combination with RE projects. Hybrid projects are seen as more competitive, and a recent Decree No. 3520 requires installation of battery storage in all new renewable energy projects. While Decree No. 35 is applicable only to new RE assets, Ukraine currently has 8 GW of renewable energy projects that could also provide added energy storage if proper incentives are put in place, which would help increase competition in the market. Over the medium term, there will be a need to retire the coal-fired plants under EU's Green Deal and the decarbonization agenda. Similarly, there will be a focus on the charging of the batteries that are newly installed to provide various services, with an emphasis on zero-carbon ("green") sources for charging. All these developments provide opportunities for the private sector, provided that the appropriate enabling environment is put in place to spur expanded participation of the private sector and competitive business models that align with the European best practices. An emerging global trend is to have multiple revenue streams contributing towards monetizing new investments in utility-scale batteries. Alongside technology improvements, the optimal deployment of storage technologies requires the institution of appropriate business models and an evolving enabling environment that allows for transparent and nondiscriminatory market rules and practices. New procurement approaches and business models are emerging globally. As Ukraine looks to integrating with Europe's energy markets, it is important to focus on instituting best practices for the synchronous operation with ENTSO-E.

28. **An inadequate regulatory framework and deficiencies in the legal system constrain the growth of investment in energy storage.** Attracting new players will require the availability of insurance mechanisms and concessional funding and other investment de-risking mechanisms put in place. Though elevated recently, price caps are still used in all segments of the market. As described in the section on renewable energy electricity generation sector, end-user tariff reform is critical. The Ukrainian government should define adequate incentives for private investments, including support to attraction of concessional and grant funding, and NEURC should amend the regulations governing the ancillary services market following a detailed analysis of reserve adequacy.

29. **Careful consideration of the potential long-term capacity contract must be made from the ASM market intervention perspective.** Currently the ASM conducts short-term auctions for various

ancillary services in several future timeframes including daily, monthly, and yearly. For new investors, longer contracts might be preferred even beyond one year and at least for the five-year period. In the meantime, such long-term fixed contracts could disrupt market activities within the ASM and thus should be carefully analyzed.

30. **The Ukrainian government has been making progress on regulatory reform.** In February 2022, just before the invasion, the legislature passed a law to incentivize investment in energy-storage systems. The Storage law (Law on Introduction of Changes to Certain Laws of Ukraine on Development of Energy Storage Systems (ESS) No. 5436-d) was adopted in February 2022, defining energy-storage system operator as any individual, firm, or legal entity that stores energy to sell it and/or renders ancillary services and/ or balancing services and introducing the concept of storage and establishing the possibility of revenue stocking. Storage would be key to reduce balancing costs and minimize curtailment. The law introduced the following key provisions:

    - The ESS operator is defined as any individual, including private entrepreneur, and legal entity which store energy to sell it, and/or render services ancillary services and/ or balancing services. If a person uses ESS for their own needs, it will not be considered as an operator. Similarly, only activity related to output of electricity to the grid (transmission, distribution, or consumer's one) will be considered energy storage.
    - Energy storage activities are subject to licensing by NEURC if they exceed certain thresholds envisaged by the respective conditions.
    - Transmission system operators and distribution system operators may not own and use ESS. However, the ESS Draft Law envisages certain exceptions similar to EU DIRECTIVE (EU) 2019/944.
    - ESS operators have rights and obligations similar to electricity producers and may participate in any electricity market.

31. **By the end of 2022, the government had promulgated the implementing regulations for the new law.** Complementing this effort, a second law on e-vehicles and charging infrastructure has been developed to reduce reliance on fossil fuels. Despite the war, Ukraine continues to improve the regulatory environment for investment in energy storage. RES producers with awarded "green" tariff or auction price may own ESS which do not exceed installed capacity of their generation installations and their installation shall not be a ground for review of the "green" tariff or auction price. The compensation for curtailment of the RES producers with the ESS shall be reduced by value of electricity such RES producer has managed to fee to its ESS. A procedure is expected to be prepared to regulate this provision.

Box 5: Private sector players in Ukraine Battery Energy Storage

DTEK, a prominent investor in Ukraine's electricity sector including renewable energy development, achieved a significant milestone by successfully completing a 1 MW energy storage project in Energodar in early 2022. This achievement was made possible through collaboration with entities such as Honeywell and SunGrid, highlighting the private sector's dedication to advancing energy storage solutions and strengthening Ukraine's energy infrastructure. DTEK's Battery Energy Storage System (BESS) generates 1 MW of power with a capacity of 2.25 MWh. Following successful market participation tests, the battery has received certification to provide ancillary services, specifically frequency containment reserve (FCR). This certification underscores the BESS's ability to contribute to the stability and reliability of Ukraine's energy grid by providing essential services to maintain the grid's frequency within acceptable limits.

Several other private developers are also involved in energy storage projects at various stages, indicating a rising interest in this technology within the private sector.

32. **Large amounts of private capitals must be mobilized given Ukraine's pre-existing need to develop around 2 gigawatts (GW) of battery storage capacity by 2030.** This capacity is essential for enhancing power system flexibility, allowing for the effective integration of variable renewable energy sources. According to estimations from the Ministry of Energy, Ukraine's decarbonization goals may require an even more substantial 38 GW of battery storage. This underscores the immense scale of investment and development required to establish a resilient and sustainable energy infrastructure in the country, particularly in the context of the ongoing war.

Complementary Activities by Development Partners

33. World Bank

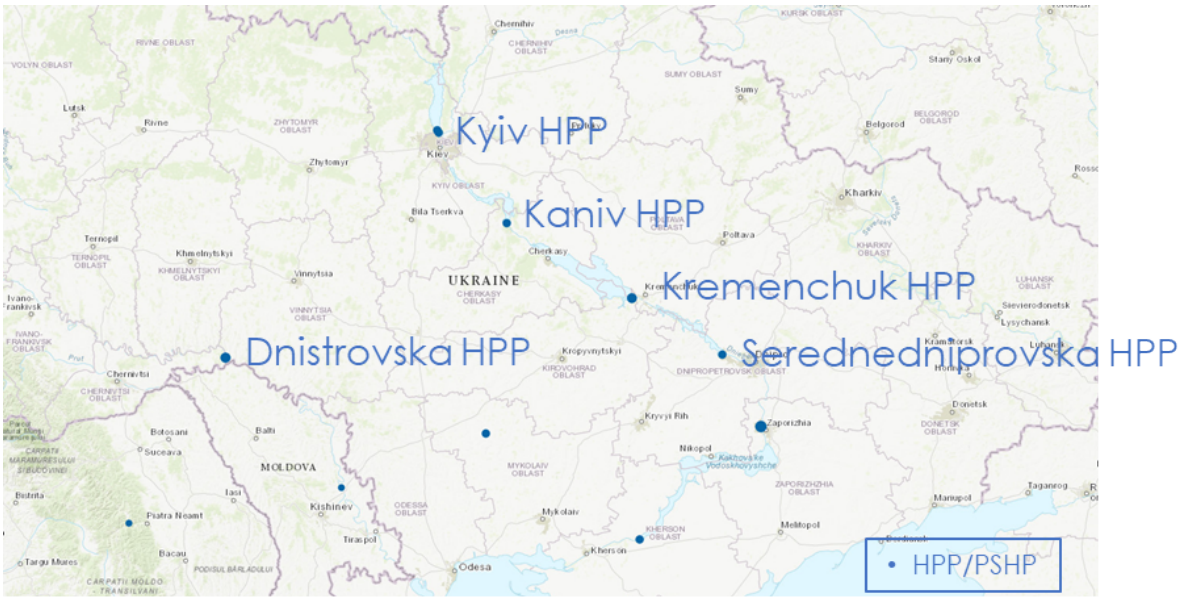
In 2021, WB agreed to finance 212MW of battery storage for Ukrhydroenergo for provision of frequency regulation services, with IBRD/CTF loans in the amount of US$250 million.

Project Name	Improving Power System Resilience for European Power Grid Integration (UHE Project)
Objective	To enhance flexibility in the Ukrainian power grid for EU synchronization and VRE integration.
Component	Component 1 (investment in BESS): Installation of 212MW of battery storage and 64MW of Solar PV at UHE's Hydro Power Plants Component 2 (technical assistance for UHE): Recycling/safety regulation as well as safeguards/gender support
Implementation Agency	PJSC Ukrhydroenergo
Closing date	Dec 31, 2026
Financing Arrangement	**Funding Sources** / **Funding Sum** / **% of Total** IBRD / USD 177M / 70.8 %

	Clean Technology Fund (CTF)	USD 35M	14.0 %
	PJSC “Ukrhydroenergo”	USD 38M	15.2 %
	TOTAL	USD 250M	100.0 %

The battery storage would be installed in five hydro power plants to be remunerated in the Ancillary and Balancing Service Markets.

Plants	BESS Installed Capacity	Solar PV Installed Capacity
Kyiv HPP	46 MW	10.6 MWp
Kaniv HPP	66 MW	13.5 MWp
Kremenchuk HPP	60 MW	6.5 MWp
Seredniodniprovska HPP	25 MW	5.3 MWp
Dniester HPP	15 MW	28.0 MWp



The WB Ukrhydroenergo (UHE) battery storage project could assume a pivotal role in demonstrating the technical and operational feasibility of large-scale battery storage while simultaneously establishing a track record for battery storage transactions within the Ancillary Services Market (ASM). This initiative can serve as a precursor for private sector investments, aiming to meet the substantial demand for battery storage capacity in Ukraine. Furthermore, the UHE project seeks to enhance the ASM and create an enabling environment for private sector involvement in battery storage.

34. International Finance Corporation (IFC)

The International Finance Corporation (IFC) actively collaborates with private sector entities interested in investing in energy storage and renewable energy integration. However, such collaborations are contingent upon the implementation of appropriate risk mitigation measures. A noteworthy example of this collaboration is the partnership between IFC and Scatec ASA of Norway, leading to the introduction

of "Release by Scatec". This innovative project introduces a containerized, modular, mobile, and redeployable solar PV plus battery storage solution. It offers flexible renewable power generation and battery storage capacity through standardized lease agreements. Importantly, this groundbreaking project was unveiled at the Ukraine Recovery Conference in London, with Minister Galushchenko in attendance. Currently, the project is in the active preparation phase, with financing anticipated to be secured within the next year.

35. European Bank for Reconstruction and Development (EBRD)

European Bank for Reconstruction and Development (EBRD) also has been actively collaborating with the TSO, Ukrhyhdroenergo, Energoatom and private sector investors in energy storage and renewable energy integration. EBRD has been progressing a potential 200MW battery storage project in Kyiv region and smaller scale capacities in other regions of Ukraine. Ukrenergo has already approved the grid connection to 200MW project.

36. Development Finance Corporation

EBRD is discussing potential mobilization of war insurance products provided by Development Finance Corporation (DFC).

4. Program Description

The objective of Ukraine's CIF-REI IP is to support the decarbonization of the economy by accelerating the country's clean energy transition. Specifically, the CIF-REI will reduce the most critical barrier hindering the integration of renewable energy generation into the Ukrainian power grid through enhancing the power system flexibility. CIF-REI concessional resources will catalyze MDB's financing, private investment and other co-financing in technologies/projects required to meet the country's NDC and decarbonization commitments.

Proposed Interventions

Financing to Ukrhydroenergo's (UHE) battery storage project (US$ 53 mln IBRD, US$ 70 mln CIF REI, US$ 35 mln CTF, and US$ 38 mln UHE)

CIF-REI funding supports Ukrhydroenergo's (UHE) battery storage project, which is aimed at installing 197 MW of battery storage within UHE's hydro power plants. This allocation of funds was requested by the Government of Ukraine, as detailed in the attached letters. The World Bank approved project is pivotal for providing essential frequency regulation and grid balancing services alongside existing hydro facilities. and new solar installations.

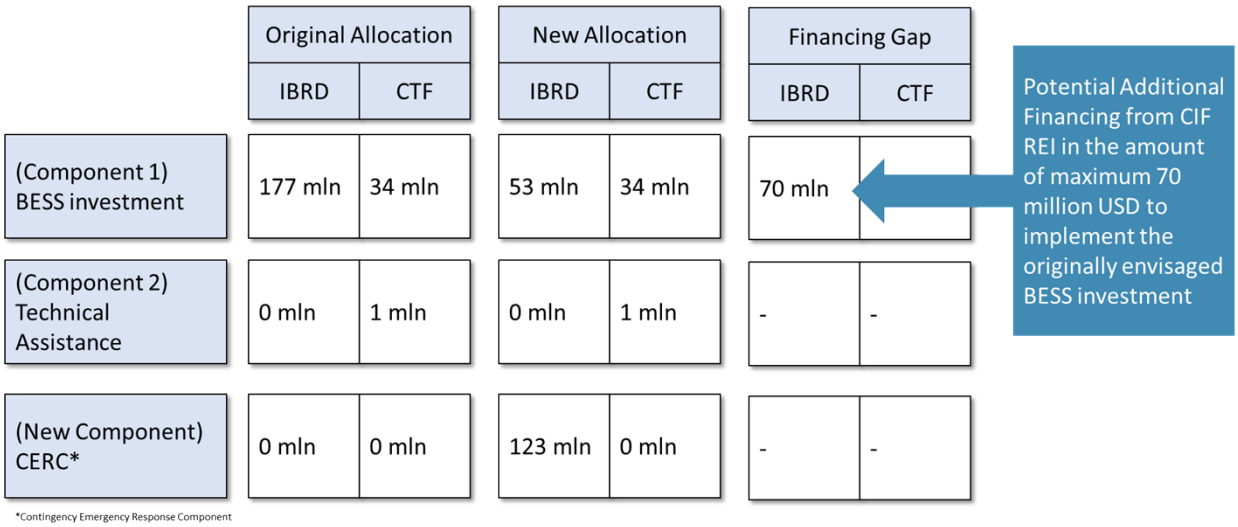
Specifically, the project will finance the installation of BESS, and an energy management system. The 197 MW of BESS will be deployed at selected hydro power plants, including Kyiv HPP/PSHP, Kaniv HPP, Kremenchuk HPP, and Seredniodniprovska HPP. These sites were chosen based on land availability and transmission capacities. The BESS units will provide ancillary services to the grid, notably Frequency Containment Reserve (FCR) and automatic Frequency Restoration Reserve (a-FRR). These BESS units will operate in coordination with the existing hydroelectric power plants through a newly installed Energy Management System (EMS), ensuring seamless provision of a wide range of grid services and optimizing charging/discharging operations.

The project was approved by the Board of Executive Directors of the World Bank in 2021. Originally, the project planned to also finance 63.9 MW of PV plants at the four HPPs and additional BESS for e-mobility, as well as a PV plant at Dniester HPP, with US$177 million IBRD loan, US$34 million CTF Loan and US$ 38 million UHE's own funds. However, due to the ongoing Ukrainian crisis involving Russia's invasion, a portion of the IBRD loan initially designated for battery storage had to be redirected by UHE for emergency restoration purposes, to support the country's critical electricity supply.

In response to the substantial damage sustained by UHE's hydro power facilities during the conflict, a mutual agreement was reached between UHE and the World Bank. This agreement involved reallocating US$ 123.4 million from the IBRD loan through the Contingency Emergency Response Component (CERC) to expedite the emergency restoration of these facilities. UHE decided to drop the PV plants and the e-mobility BESS while keeping the ancillary services BESS due to the importance of the investment.

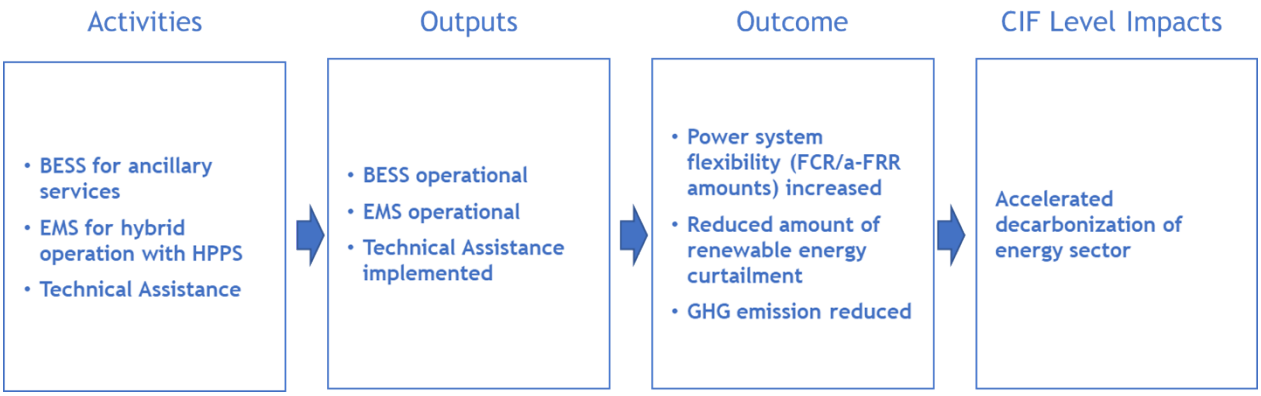
The construction of the planned battery project remains unfeasible unless additional financial support is extended to UHE, given the reallocation of funds to address the damage caused by the war. Therefore, the intervention through the CIF REI program is vital to fill the financing gap to install the critically important battery storage to enhance the flexibility of the country's power system.

Figure 3: An Illustration of the funding gap



The allocation of CIF REI funds in the amount of $70 million, to UHE's battery storage project in Ukraine is driven by several key considerations. Firstly, this initiative addresses Ukraine's urgent power system flexibility needs, vital for post-war reconstruction and decarbonization, by installing battery storage. Importantly, the project will operate within existing commercial markets, avoiding future market barriers like long-term capacity contracts. Given the war's challenges, attracting private investors for large-scale battery storage is difficult due to risks and investor confidence issues. Implementing a public sector approach is feasible and swift, as the project is well-prepared, with established legal frameworks, completed environmental and social assessments, implementation arrangements in place, and confirmed economic and technical feasibility. Furthermore, this public sector initiative not only serves immediate needs but also lays the foundation for significant future private investments, potentially reaching capacities of 2GW or more. UHE's technical capabilities and efficiency make it a reliable stakeholder in developing large-scale battery projects during the current war context.

Theory of Change



Expected Outcomes

The expected outcomes of Ukraine's Investment Plan (IP) for the Climate Investment Funds (CIF) Renewable Energy Integration (REI) Program are as follows:

1. **Increased Power System Flexibility**: Achieve greater flexibility in the power system, reflected in the availability of Frequency Containment Reserve (FCR) and automatic Frequency Restoration Reserve (a-FRR) capacities.
2. **Reduced Renewable Energy Curtailment:** Decreasing the amount of curtailed renewable energy, leading to more efficient utilization of renewable resources. According to the World Bank project, the battery storage project is expected to reduce the renewable energy curtailment by 12.70 GWh.
3. **Emission Reductions:** Realizing significant emission reductions, estimated at about 124,721 metric tons of CO2 equivalent annually.
4. **New Business Model Establishment:** Establishing and commercializing a new business model that renewable sustainable energy integration.
5. **Catalyzed Commercial Capital:** Attracting and leveraging commercial capital for energy infrastructure investments.
6. **Diversified Energy Mix:** Accelerating the transition to cleaner and more sustainable energy sources, diversifying the energy mix.
7. **Address Immediate Needs without Budget Impact:** Addressing critical energy infrastructure needs without straining the government budget.
8. **Private Investor Participation:** Attracting new private investors to participate in the energy sector, encouraging private-sector involvement in renewable energy projects.
9. **Stable Energy System:** Ensuring the stable operation of the energy system, providing reliable electricity supply to Ukrainian customers.
10. **Improved Reliability of the UES:** Enhancing the reliability of Ukraine's United Energy System (UES) and expanding capabilities for working in ENTSO-E conditions.
11. **Support for Renewable Energy Connection:** Facilitating the connection of new capacities of renewable energy sources to the networks.

Program criteria, priorities, and budget

The Project is based on the use of standard energy storage installations on each of the identified objects, taking into account the location and terrain;

1. New installations of energy storage systems will be dispatched jointly with HPP units to achieve maximum synergy in the provision of auxiliary frequency regulation services in the market, including frequency maintenance and restoration reserves;
2. The frequency maintenance reserve (FMR) will be able to be activated by a decentralized automated control system within seconds after an imbalance occurs in response to a measured frequency deviation to stabilize the frequency at 50 Hz;
3. Installation of ESS will significantly increase the response speed of power output in the UES of Ukraine after the dispatcher's command to turn on the hydro unit.

5. Financing Plan and Instruments

Requested Budget Envelope for Investments

This section presents the financing plan for the implementation of the activities proposed to be supported by Ukraine's CIF-REI Program, including costs and sources of funding. The requested envelope for Ukraine´s CIF-REI IP amounts to US$70 million. The IP proposes for CIF-REI resources to co-finance the UHE battery storage.

Table 1. Indicative financing plan for the CIF-REI Ukraine

	CIF-REI (through WB)	Leverage		
		IBRD	CTF	UHE
197MW Ancillary Services BESS	US$ 70 mln	US$ 53 mln	US$ 34 mln	US$ 38 mln

Costs and Sources of Funding

CIF-REI resources will be allocated through WB and channeled to UHE. The cost estimate was prepared based on recent global studies. Specifically, the unit cost of the proposed 2-hour duration Lithium-ion battery storage is estimated at US$ 659/kW, which is considered reasonable even taking into consideration the recent material cost increase, a figure considered reasonable, even when factoring in recent increases in material costs. The project has already secured financing from IBRD of US$ 177 million, CTF of US$ 34 million and UHE's own funds of US$ 38 million.

6. Additional Development Activities

Relevant parallel activities to the project include the following:

1. **Various IFIs are supporting the power sector through providing emergency equipment for sustainable electricity supply**. The Energy Community Secretariat (EnCS), an international organization that supports EU neighboring countries join an integrated pan-European energy market, has established the "Ukraine Energy Support Fund" (UESF) to arrange procurement and donation of emergency energy equipment and fuels. The United States Agency for International Development (USAID) is supporting the UESF acting as a procurement agency in verifying the list of urgent equipment and procuring the equipment. The UESF has received financial support from various countries including the US, Denmark, and Germany. EBRD, USAID and KfW are supporting UE on emergency equipment procurement. The World Bank is also implementing a project on emergency equipment supply with financial contribution through URTF.
2. **In the field of energy storage, the private sector initiated a pilot battery storage project before the war**. In 2021, DTEK, a major private operator, installed battery storage at the Zaporizhzhya Power Plant in the city of Energodar, with a capacity of 1 MW/2.25 MWh. The battery was aimed at storing and dispatching electricity to the grid, as well as maintaining the functioning of Ukraine's power system. With this pilot project, DTEK intended to establish a key role for energy storage systems use in various segments of the country's energy market and drive the decarbonization of Eastern Europe in support of the EU Green Deal. However, due to Russia' invasion, the battery facility is occupied by Russian military forces together with the power plant.
3. **Various opportunities on energy storage development have been explored**. IFC and EBRD have been actively exploring opportunities in investments in energy storage. IFC has collaborated with a private developer to introduce a containerized, modular, mobile, and re-deployable solar PV plus battery storage solution. It offers flexible renewable power generation and battery storage capacity through standardized lease agreements. EBRD has been progressing a potential 200MW battery storage project in Kyiv. Ukrenergo is reviewing the grid connection of the project.

7. Implementation Potential and Risk Assessment

The implementation of the proposed investment plan is confronted with potential risks, particularly considering the ongoing Russia war in Ukraine. These risks span a wide spectrum of concerns, including implementation, sector-specific, political, environmental, social, and contractual factors.

Table 2. Risk Analysis

Potential Risks	Mitigating Factors
Implementation risk: Delays in agreement and implementation across stakeholders.	Close coordination with MoF, MoE and key stakeholders.
Sector risk: Unprecedented challenges for the future of Ukraine's energy system development due to war and martial law imposed to protect population.	The MDB teams will monitor the evolution of the sector and the evolving priorities to adapt the scope and implementation arrangements as needed.

Political Risk: The war poses a huge risk on the country's political and governance landscape.	The MDB teams will monitor closely geopolitical events to take actions to ensure implementation progress despite the war.
Environmental and social risks: The installation of equipment involves some environmental and social risks.	ESF and performance standards for each MDB will apply
Contract Risk: Adverse changes in the wholesale market could undermine the financial sustainability of the BESS operation.	Technical assistance and DPOs by IBRD will support reforms that promote energy storage financial sustainability.

8. Monitoring and Evaluation Framework

The projects will be monitored and evaluated in accordance with the procedures specified by each Multilateral Development Bank (MDB) as outlined in the respective project's legal agreements. Coordination of reporting from each MDB to the CTF will be conducted as per the directives provided by the CTF's REI guidelines.

Annex 1: Government's Request Letters

МІНІСТЕРСТВО ЕНЕРГЕТИКИ УКРАЇНИ

вул. Хрещатик, 30, м. Київ, 01601,
Тел.: 00(38)044-531-36-93, ф.: 531-36-92
E-mail: kanc@mev.gov.ua
сайт: https://www.mev.gov.ua

MINISTRY OF ENERGY OF UKRAINE

30 Khreshchatyk Str., Kyiv, 01601,
Phone: 00(38)044-531-36-93, fax: 531-36-92
E-mail: kanc@mev.gov.ua
Web: https://www.mev.gov.ua

Kyiv, Ukraine

Dear Ms. Bredenkamp,

Let me thank you and the joint team of the World Bank, European Bank for Reconstruction and Development, and International Finance Corporation for the committed and fruitful work during the recent scoping mission on preparation of the Investment Plan for Ukraine under the Climate Investment Funds Renewable Energy Integration Program.

As stated in the aide memoire of the scoping mission, that you kindly shared with us by letter Reg.No. 2023/08/15-02 dated August 15, 2023, several alternatives are considered, including support for Ukrhydroenergo battery storage project, modular mobile solar PV plus battery storage solution, and small/medium size private energy storage systems. All of the discussed projects could contribute to increasing flexibility of Ukraine's power system and promote further variable renewable energy integration.

However, given the different levels of preparedness of the discussed projects as well as approximate estimation of implementation period, the Ministry of Energy of Ukraine considers support for Ukrhydroenergo battery storage project. As this projects was approved in 2021 and already partially implemented, it is notably advanced compared to other alternatives, and thus it can deliver faster results in case of its implementation.

According to the provided timeline, draft Investment Plan should be prepared by August 27, within a very limited amount of time, and then finalized by September 18. In this regard, I kindly ask the World Bank together with European Bank for Reconstruction and Development, and International Finance Corporation to proceed with the selection of the project in the nearest possible time.

I am very much looking forward to your final decision and further implementation of the Investment Plan for selected project.

Availing myself of this opportunity, I would like to renew the assurances of my highest consideration.

Yours faithfully,

Herman HALUSHCHENKO

Minister

Ms. Caryn BREDENKAMP
Acting Regional Country Director
Eastern Europe
Europe and Central Asia

World Bank Group

UB
Міністерство енергетики України
№26/1.1-3.2-17541 від 30.08.2023
КЕП: Галущенко Г. В. 30.08.2023 13:03
3ED5083160DBC59B040000007CDD0600BFB5FF00
Сертифікат дійсний з 01.05.2023 17:01 до 01.05.2025 17:01

THE MINISTRY OF ECONOMY OF UKRAINE

M. Hrushevsky St. 12/2, Kyiv 01008, Ukraine

Tel. +38 044 200-47-53,

Fax +38 044 253-63-71

E-mail: meconomy@me.gov.ua

http://www.me.gov.ua

To: HE Dr. Arup BANERJI

The World Bank Regional Country Director for Eastern Europe

Kyiv

Excellency,

We would like to express our deep esteem and sincerely thank you and the World Bank for the initiatives in support of the energy sector of Ukraine in this difficult time of military aggression by the russian federation.

Recently, your team, together with those of the European Bank for Reconstruction and Development and the International Finance Corporation, have made significant efforts to successfully conduct the Joint Mission on Preparation of an Investment Plan for the Renewable Energy Integration Program for Ukraine (hereinafter - the Program) within the Climate Investment Fund (hereinafter – the CIF).

The main goal of the Program, as was discussed during the Joint Mission, is to increase the flexibility of energy systems in order to ensure a seamless integration

of variable renewables. One of the priority areas of funding under the Program is the implementation of energy storage systems (batteries).

Despite the full-scale military aggression by the russian federation and a difficult economic situation, we remain very ambitious regarding the implementation of structural reforms in various sectors, especially in energy.

Currently, the Government of Ukraine is on the stage of development and coordination with our European partners of the Country Restoration, Reconstruction and Modernization Plan within the Ukraine Facility program of the European Union where one of the key parts is devoted to the energy sector. In addition, the Ministry of Economy of Ukraine is coordinating the activities on the National Energy and Climate Plan that is being developed in compliance with methodological and structural approaches of the Energy Community.

It is important for us that the partnership with international financial institutions would become a part of a comprehensive plan for the post-war reconstruction of Ukraine and lays the foundation for implementation of a climate-neutral energy system based on renewables and low-carbon fuels, as well as energy efficiency.

Funding by the CIF under the Program is fully in line with both the spirit and ideas of renewable energy development and clean energy transition.

During the second Joint Mission, which took place on September 11-15, 2023, involving, in particular, representatives of the Ministry of Finance, the Ministry of Energy, and the Ministry of Economy, we discussed a number of possible directions for funding by the CIF under the Program including both public and private projects.

The Ministry of Energy of Ukraine, as an executive body making and implementing the public policy in the fuel and energy complex, expressed support for a joint with the World Bank and the Clean Technology Fund project “Ukraine – Improving Power System Resilience for European Power Grid Integration (Installation of Hybrid Systems for Electricity Production in Ukrhydroenergo)” (hereinafter referred to as the Project) in our letter dated August 30, 2023.

According to the information provided by the representatives of PJSC “Ukrhydroenergo”, funding by the CIF under the Program totaling at $70 million would allow PJSC “Ukrhydroenergo” to implement the Project, provide the energy

system of Ukraine with additional balancing capacity and improve reliability and resilience of its generating facilities.

In view of the discussions under the framework of the Joint Mission and the opinions of the Ministry of Energy and PJSC “Ukrhydroenergo”, the Ministry of Economy expresses its support for the Project and is hopeful that you make a decision on its funding at the soonest.

We avail ourselves of this opportunity to assure you and the World Bank of our highest consideration.

Yuliia SVYRYDENKO

First Deputy Prime Minister of Ukraine – Minister of Economy of Ukraine

МІНІСТЕРСТВО ЕКОНОМІКИ УКРАЇНИ
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http://www.me.gov.ua
Код ЄДРПОУ 37508596

MINISTRY OF ECONOMY OF UKRAINE
M. Hrushevskoho str., 12/2, Kyiv, 01008
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E-mail: meconomy@me.gov.ua
http://www.me.gov.ua

На № _____ від_____

Ваше Високоповажносте пане Банерджі!

Дозвольте висловити Світовому банку і Вам свою глибоку повагу та щиро подякувати за ініціативи щодо підтримки енергетичного сектора України у ці складні часи військової агресії російської федерації.

Останнім часом Ваша команда разом з командами Європейського банку реконструкції та розвитку та Міжнародної фінансової корпорації доклали суттєвих зусиль задля успішного проведення Спільної місії з процесу підготовки Інвестиційного плану для Програми Інтеграції відновлюваної енергетики для України (далі – Програма) в межах Кліматичного інвестиційного фонду (далі – CIF).

Головною ціллю Програми, як було обговорено під час Спільної місії, є підвищення гнучкості енергетичних систем з метою забезпечення безперешкодної інтеграції джерел відновлюваної енергетики, що мають мінливий режим функціонування. Одним з найбільш пріоритетних напрямів фінансування за Програмою є впровадження систем зберігання енергії (батарей-накопичувачів).

Попри повномасштабну військову агресію рф і складну економічну ситуацію, ми зберігаємо надзвичайно високу амбітність щодо впровадження структурних реформ в різних секторах, особливо в енергетиці.

Й.В. пану Арупу БАНЕРДЖІ
Регіональному директору Світового банку
у справах країн Східної Європи регіон
Європи та Центральної Азії
м. Київ

Наразі Уряд України перебуває на етапі розробки та узгодження з європейськими партнерами Плану відновлення, реконструкції та модернізації країни у межах програми Європейського Союзу Ukraine Facility, одна з ключових частин якого присвячена енергетиці. Також, Міністерство економіки України координує роботу з розробки Національного плану з енергетики та клімату, який розробляється згідно з методологічними та структурними підходами Енергетичного співтовариства.

Для нас важливо, щоб партнерство з міжнародними фінансовими інституціями стало частиною комплексного плану післявоєнного відновлення України та заклало основу для побудови кліматично нейтральної енергетичної системи на базі відновлюваних та низьковуглецевих видів палива, а також енергоефективності.

Фінансування CIF в рамках Програми повністю відповідає духу та ідеям розвитку відновлюваної енергетики та чистого енергетичного переходу.

Під час другої Спільної місії, яка відбулась 11-15 вересня 2023 року за участі, зокрема, представників Мінфіну, Міненерго та Мінекономіки було обговорено низку можливих напрямів спрямування фінансування CIF в рамках Програми серед яких наявні як державні, так і приватні проєкти.

Міністерство енергетики України, як орган виконавчої влади, що формує та реалізує державну політику в паливно-енергетичному комплексі, у своєму листі від 30.08.2023 висловило підтримку спільного зі Світовим банком та Фондом чистих технологій проєкту «Україна – Підвищення стійкості енергосистеми для європейської інтеграції енергомережі (Встановлення гібридних систем з виробництва електроенергії в ПрАТ «Укргідроенерго»)» (далі – Проєкт).

З інформацією, наданою представниками ПрАТ «Укргідроенерго», отримання фінансування CIF в рамках Програми загальним обсягом 70 млн дол. США дозволить ПрАТ «Укргідроенерго» реалізувати Проєкт та забезпечити енергосистему України додатковими балансуючими потужностями, підвищити надійність та стійкість власних енергогенеруючих об'єктів.

З урахуванням обговорень, які відбулись в рамках Спільної місії, позицій Міненерго та ПрАТ «Укргідроенерго», Мінекономіки також інформує про підтримку Проєкту та висловлює сподівання на найскоріше прийняття рішення щодо його фінансування.

Користуючись нагодою, поновлюємо Вам та Світовому банку запевнення у своїй найвищій повазі.

Юлія СВИРИДЕНКО

Перший віце-прем'єр-міністр
України – Міністр економіки України