Project Information Document (PID)

Appraisal Stage | Date Prepared/Updated: 23-Apr-2021 | Report No: PIDA31496

BASIC INFORMATION

A. Basic Project Data

Country	Project ID	Project Name	Parent Project ID (if any)
Ukraine	P176114	Improving Power System Resilience for European Power Grid Integration	
Region	**Estimated Appraisal Date**	**Estimated Board Date**	**Practice Area (Lead)**
EUROPE AND CENTRAL ASIA	15-Apr-2021	28-Jun-2021	Energy & Extractives
Financing Instrument	**Borrower(s)**	**Implementing Agency**	
Investment Project Financing	PJSC “Ukrhydroenergo"	PJSC “Ukrhydroenergo"	

Proposed Development Objective(s)

To enhance the flexibility of the Ukrainian power grid through storage investments and market expansion to support synchronization with the European electricity grid and decarbonization of power sector.

Components

Installation of Battery Energy Storage System (BESS) with solar Photovoltaic (PV) plants, establishment of an Energy Management System (EMS), and Supervision Consultancy
Technical Assistance for UHE

PROJECT FINANCING DATA (US$, Millions)

SUMMARY

Total Project Cost	250.00
Total Financing	250.00
of which IBRD/IDA	177.00
Financing Gap	0.00

DETAILS

World Bank Group Financing

International Bank for Reconstruction and Development (IBRD)	177.00

Non-World Bank Group Financing

Counterpart Funding	38.00
Borrower/Recipient	38.00
Trust Funds	35.00
Clean Technology Fund	35.00

Environmental and Social Risk Classification

Substantial

Decision

The review did authorize the team to appraise and negotiate

Other Decision (as needed)

The Project title is Improving Power System Resilience for European Power Grid Integration Project (Installation of Hybrid Systems for Electricity Production in Ukrhydroenergo)

B. Introduction and Context

Country Context

1. **Since 2014, Ukraine has undertaken wide-ranging institutional, political, economic, and social reforms aimed at increasing the role of market forces in the economy and to shift its economic orientation towards Europe.** Responding to the economic recession of 2014-2015, fiscal adjustments were made through: (i) energy tariff reforms aimed at closing the quasi-fiscal deficit; and (ii) a nominal freeze on wages, pensions, and social assistance despite high inflation. Consequently, the overall fiscal deficit was reduced from 10 percent of GDP in 2014 to 2.3 percent in 2016 [1]. From 2016 onwards, significant further reforms were implemented in the social sectors to promote fiscal sustainability. As a result, spending on social benefits declined from 16.3 percent of GDP in 2016 to 14.8 percent in 2019. Public and publicly guaranteed debt declined from 81 percent of GDP in 2016 to an estimated 51 percent in 2019. These reforms—difficult in the best of times—have been implemented against a backdrop of continued tensions and human, material and territorial losses on the Eastern border. Gradually, the economy has begun to grow again, following the deep contraction in 2014-15, and poverty and economic vulnerability have begun falling back towards pre-crisis levels. [2]

[1] Reform of energy pricing, primarily for natural gas, being the most important contributor to the reduction of public expenditures between 2014 and 2016.

[2] Tax revenues increased from 33 percent of GDP in 2016 to 34.4 percent in 2019. Fiscal deficit has been maintained at about 2 percent of GDP for the last three years.

2. Although the economic impact from the COVID-19 outbreak appears to be less severe than initially anticipated – GDP declined by 4.4 percent in 2020 (vs 6.5 percent decline in first half of 2020) – the pandemic has exacted a heavy toll in terms of health and mortality impacts; and undermined the government's commitment to undertake critical reforms. Ukraine's economic recovery in 2021 is expected to be moderate – annual gross domestic product (GDP) growth at just 3.8 percent – given high uncertainty associated with the rollout of the vaccine and the direction of economic policies to address bottlenecks to investment and safeguard macroeconomic sustainability. Strong economic recovery remains constrained by low levels of fixed investment, exacerbated by the COVID-19 crisis. Stronger growth in fixed investment depends on progress with reforms that address structural weaknesses in the financial sector, market distortions from the lack of an agricultural land market, an anticompetitive environment, large numbers of state-owned enterprises (SOEs), and macroeconomic vulnerabilities.

3. While poverty declined significantly in recent years, this trend is likely to be reversed as a result of the economic contraction resulting from the COVID-19 pandemic. The share of the population below the actual Subsistence Minimum (the national poverty line) amounted to 23.3 percent in 2019, down from 34.8 percent in the wake of the crisis in 2017, though it remains higher than in the pre-crisis period (8.4 percent in 2013). While unemployment increased markedly in 2020 due to the COVID-19 pandemic, household incomes remained stable on the back of rising real wages and pensions (data until Q3 of 2020). Overall, the poverty rate increased by 1.1 percentage points in the first three quarters of 2020. Poverty remains higher in rural areas (29.1 percent versus 20.6 percent in urban areas in 2019), where local communities face challenges such as poor living conditions, outdated infrastructure, and limited public services provision. The socioeconomic impact of the COVID-19 pandemic will also vary across the country and will require public health interventions and social assistance for vulnerable households. Decreasing poverty rates and promoting broad-based job creation remain significant development challenges that require Ukraine to capitalize on the drivers of growth through structural, policy, and investment reforms and the development of human capital.

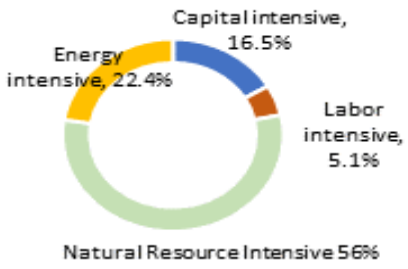
4. Despite notable progress in structural reforms undertaken in recent years, Ukraine's economic transformation to a full-fledged market economy still remains incomplete -- progress in increasing the role of market forces in key factor markets, such as energy and land markets has been particularly slow. Distorted price signals in energy sector provided short-term economic benefits to select industries, but this delayed much needed industrial restructuring. Over-reliance on commodity-based and energy intensive exports has delayed much needed industrial restructuring toward developing high valued-added export-oriented industries. In addition, distorted price signals in input markets have facilitated rent-seeking opportunities to special vested interest groups and to undermine the effectiveness of Ukraine's economic institutions.

5. Distortions in key factor markets can undermine a transition to post-COVID Green, Resilient and Inclusive Development trajectory by undermining incentives to accumulate capital, to attract foreign investment, and to reorient exports away from commodities.

6. Today Ukraine's export structure continues to have a high share of energy intensive exports (see Figure 1 below). Hence, energy sector reforms to create competitive and transparent energy markets are very important for achieving sustained growth. Financing and technical support from the World Bank, as envisioned by the FY17-21 Country Partnership Framework (CPF), in close coordination with the International Monetary Fund, the European Union (EU), the United States, and other bilateral partners, has been central to progressing key reforms in the energy sector. The unbundling of Naftogaz (the national oil and gas company) and liberalization of the gas and electricity markets went a long way towards

implementation of the EU Third Energy Package in Ukraine. In the power sector, generous Feed-in-Tariffs (FiTs) for renewables have resulted in 8 GW of privately-owned renewable energy assets being added to the generation mix. However, the rapid increase in renewables capacity has created financial and operational challenges for Ukrenergo (UE) - the Transmission System Operator (TSO), which has accumulated large debts (about $1.2 billion by end-2020). More details on the financial situation of the energy sector are provided below.

Figure 1. Ukraine's export structure



Sectoral and Institutional Context

7. Ukraine's economy is energy-intensive but per capita emissions are at the global average. Ukraine makes up 0.5% of global annual carbon emissions, (185 million tCO2), and accounted for 1.8% (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% 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 GDP is twice the world average at 0.25 toe/$1000 (2015 US$ PPP).

8. Traditionally, the energy mix in the power sector in Ukraine consisted of coal, nuclear, and hydropower, but a rapid increase in the share of renewable energy has taken place in recent years. Of the total installed power generation capacity[3], estimated at 54.3 GW, about half (27.9 GW) consists of thermal power plants (TPPs), with coal-fired power plants accounting for 90 percent of the TPPs. Nuclear power plants (NPPs) accounts for 26.7 percent (13.8 GW) of the installed capacity, while hydro power plants (HPPs), including pumped storage HPPs, represent 12 percent (6.3 GW) of the total installed capacity. Overall electricity production in 2019 was 154.0 TWh, out of which 150.2 TWh was consumed domestically while electricity exports and imports were 6.5 TWh and 2.7 TWh, respectively. Four nuclear

[3] Excluding generating facilities of the Crimean Electric Power System and the Uncontrolled Territory of the Donbas Electricity System.

power stations comprising of 15 reactors supply more than half of Ukraine's total electricity.[4] The remaining electricity comes from coal fired TPPs (30 percent), natural gas fired combined heat and power (CHP) plants (8 percent), and HPPs (7 percent).

9. The power system is inflexible, with fast growing RE 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. Both collectively account for less than 2% of generation. Hydropower (4.8 GW) and pumped storage hydropower (PSH, 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%). Even nuclear generators operate at 65% load, significantly below industry standards.

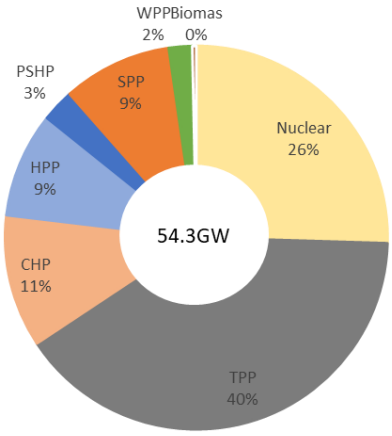
10. The recent rapid increase in renewable energy sources (RES) within the generation mix is driven by the Government's commitment to decarbonization and pollution reduction,[5] through incentivizing private sector investments. As shown in Figure 2, until 2018 RES accounted for a very small portion of 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[6], 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 has 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 PPAs), and part-loaded thermal power plants to provide the required reserves, which is leading to increased GHG emissions.

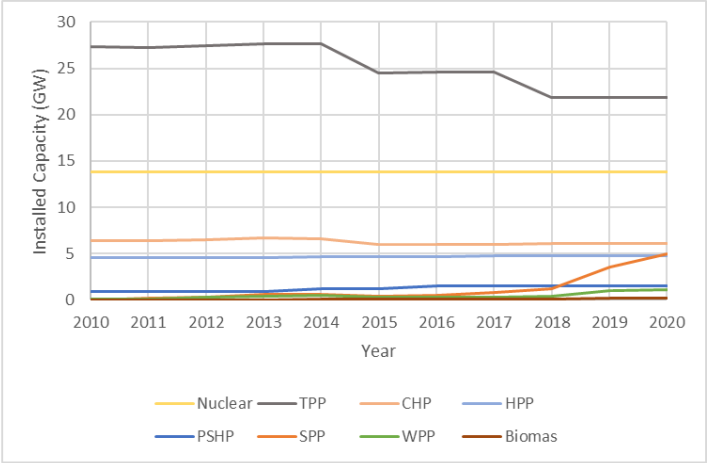
Figure 2. Installed capacity at the end of 2020 and its historical trend

[4] Development of several nuclear units was put on hold or stopped after the 1986 Chernobyl nuclear accident.

[5] In 2016, Ukraine had the highest mortality rates from air pollution per capita worldwide, according to the WHO data. Annually up to 66,000 people die because of air pollution in Ukraine. It is estimated that the health and mortality costs stemming from air pollution constitute a multi-billion-dollar burden for the national economy.

[6] Generation Adequacy Plan presents Ukrenergo's view on the long-term generation capacity need for the country. UE updates the Adequacy Plan regularly.





11. Ukraine's current NDC mitigation target lacks ambition but has supported RE growth. Ukraine's emissions have fallen by more than 60% 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% 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.

12. 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% 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 Ministry of Energy and Environmental Protection of Ukraine (MOEEP) has recently disclosed for public consultation the concept for "Green Energy Transition by 2050" that establishes a blueprint for full decarbonization of the energy sector by 2050. 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 ETS by 2040.

13. 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.

14. Functioning of the nascent WEM 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.[7] This is further supported by the balancing market (BM) and the ancillary services market (ASM). The World Bank has supported the transition process through the First Power Transmission Project (2007-2016) and the ongoing Second Power Transmission Project (PTP2). 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 a 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.

[7] DAM and IDM transactions account for up to 30 percent of the total power consumed[7], while the remaining is supplied through long-term bilateral contracts that lack the same level of transparency.

15. Ukraine's power sector continues to suffer from lack of transparent pricing mechanisms, and an environment where legislation rather than an independent regulation is used to set market rules. The large SOEs that supply 60 percent of electricity are not allowed to participate in the WEM and are obliged to provide power at low prices, that increases their financial stress, particularly as higher priced RES power puts a squeeze on their volumes. These practices could result in market distortions and price manipulations in the bulk power prices. In this context, the promotion of institutional reforms, transparency, and expanded competition in the power sector, which has a large footprint of SOEs, can help promote new investments and efficiency in this important area of the economy.

16. 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[8][9]. The ASM conducts short-term auctions for these services in several future timeframes. 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 UkrES currently 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 FCR amount of 177 MW.[10] All four of these units use coal (TPPs/CHPs), and must retire as the green agenda picks up strength. Work is ongoing on certifying more units for FCR, including nuclear plants, but at the moment the FCR market

Box 1. Various Services in Ancillary Service Markets

A power system must possess 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:

(a) 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.
(b) 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.
(c) 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.

[8] ENTSO-E represents 42 electricity transmission system operators from 35 countries across Europe. ENTSO-E was established and given legal mandates by the EU's Third Legislative Package for the Internal Energy Market in 2009, which aims at further liberalizing the gas and electricity markets in the EU.

[9] Such as Frequency Containment Reserve (FCR) (the fastest response), automatic Frequency Restoration Reserve (a-FRR), manual Frequency Restoration Reserve (m-FRR) and others

[10] (i) TPP Kurakhivska (±88MW); (ii) CHP5 Kharkivska (±27MW); (iii) TPP Zaporizka (±32MW); (iv) TPP Luhanksa (±20MW); and TPP Burshtinska (±10MW).

is entirely subscribed by existing TPPs. While rules for improving ASM operations are progressing, it must be noted that fast response reserves (FCR and a-FRR) continue to be provided as a default option through the 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 UkrES. 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.

17. The recent rapid increase of RES capacity due to generous FiTs has created financial and operational challenges for UE and for the power sector, including fast accumulation of arrears. The FiT scheme, introduced in 2009,[11] provided tariffs in the range of 15 to 20 US cents/kWh for utility-scale solar and 10 to 11.4 US cents/kWh for wind, much higher than the average recent tariffs awarded in other countries. The FITs are regulated through a mandatory RES offtake by a Guaranteed Buyer (GB).[12] 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 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. NEURC does not consider the RES PSO to be part of UE's mandate, and therefore, this PSO is not fully funded in the transmission tariff calculation. This leads to a large and growing unfunded mandate of UE towards RES and SOE power providers. As of December 2020, the accumulated arrears of UE to GB and SOE power suppliers exceeded UAH 34 billion ($1.2 billion). Per UE's estimate, nearly UAH 50 billion ($1.75 billion) will be necessary for RES purchases under FiT in 2021. This is expected to grow to about UAH 104 billion (US$ 3.6 billion) in 2029. The current financial stress at UE has made it difficult for the TSO to perform its core functions, including attracting investments in modern grid resilience capabilities, such as rapid response frequency regulation needed for timely UkrES grid synchronization with the EU, and integration of variable renewable energy (VRE) into the grid. The World Bank is supporting UE and the Ministry of Energy (MoE) with preparation and implementation of the Financial Recovery Action Plan (FRAP).

18. The COVID-19 crisis has further eroded the financial health of the sector. Power utilities and the TSO, already burdened by the issues mentioned above, are facing significant revenue shortfall due to retracted demand, exacerbated in some periods by reduced collections from residential and commercial users. This also limits available options for refinancing the debt of the utilities on favorable terms. Electricity consumption in UkrES decreased by 4.9 percent compared to the same period in 2019. As a result, several power sector companies face financial stress and are at risk of breaching debt service covenants (particularly those denominated in hard currency). On March 28, 2020, Ukraine's largest private power producer, DTEK, suspended interest payments on Eurobonds and bank loans, and requested creditors to restructure part of its debt, which resulted in a downgrade of the company's credit rating.

[11] The 2009 Renewable Energy Law enshrined the FiT based on the prevailing RE costs and practices. For solar generation, this has significantly changed in the last five years, rendering the FiT highly above the current RE prices.

[12] The Guaranteed Buyer was also created around the opening of the WEM and is tasked with fulfilling both HH and RES PSOs. Thus, the GB purchases electricity from the nuclear utility, Energoatom, and the hydropower utility, Ukrhydroenergo - both SOEs - at regulated tariffs and sells it to household customers at low tariffs. GB is also obliged to purchase electricity from RES producers under the FiT scheme and sell this in the WEM to recover prices that the market will bear.

19. As, against this backdrop, Ukraine is pursuing integration of its power system with the EU through Synchronization[13] with the ENTSO-E. Ukraine already has electricity interconnectors with EU countries, namely Poland, Slovakia, Hungary and Romania. However, only Burshtyn TPP, in the Ivano-Frankivsk region, is synchronized with the European grid and it is capable of exporting up to 650 MW of electricity to Europe from the so called "Burstyn (electric) island" which is disconnected from the rest of Ukraine power grid, while the rest of the Ukrainian power grid is synchronized with Russia, Belarus, Moldova and other CIS countries (the IPS/UPS system). This significantly limits Ukraine's electricity trade capacity with its western neighbors. In June 2017, Ukraine and Moldova signed an agreement with the ENTSO-E on conditions for future synchronization, including a catalogue of technological and regulatory measures. These measures include reinforcements of the transmission network, realization of frequency regulation reserves, establishment of a telecommunication network, and studies on future grid stability.[14] Once these are completed, UE would switch from the IPS/UPS system into isolated island mode operations in early 2022 followed by trial operation before the synchronization with ENTSO-E, planned by end 2023. When UkrES disconnects from IPS/UPS, the system must be prepared to demonstrate stable and resilient operations without the free cross-border frequency support from the IPS/UPS system.

20. Synchronization of the Ukrainian Electricity System (UkrES) with EU's power grid is an important strategic objective for the power sector and a key milestone on the journey to economic recovery and decarbonization as it is expected to lead to very significant benefits for the country. Timely synchronization in 2023 is deemed the most important transformational objective for the power sector by the Government. It is a key strategic plank for building power sector competitiveness and economic resilience that has become even more important for Ukraine in the wake of the global economic crisis resulting from the pandemic. Synchronization with the European power grid is an important commitment mechanism to get the price signals right and reduce the influence of vested interests. Moreover, synchronization implies adherence to the objectives of the European Green Deal that seeks to make Europe the first carbon-neutral continent through employment of new technologies and deep cuts in the use of coal in the energy and industrial sectors. ENTSO-E synchronization comes with very tangible benefits for Ukraine, including: (i) enhanced reliability and security of electricity supply through diversification of energy sources and access to the EU markets under a regional cooperation framework;[15] (ii) creation of competitive and transparent electricity markets aligned with EU market practices; and (iii) decarbonization and renewable energy integration through enhanced system flexibility. UE estimates that the monetizable economic benefits from ENTSO-E synchronization are more than US$1.2 billion annually, while the cost of synchronization is estimated at around $400 million.[16] According to the Bank estimate, ENTSO-E synchronization cuts GHG emission by 3 million tons per year.

21. 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 a number of

[13] In 2018, the Cabinet of Ministers of Ukraine approved an action plan for synchronizing the United Energy System of Ukraine with the ENTSO-E. On March 19, 2019, the European Commission adopted Annex 27 to the Ukraine-EU Association Agreement, allowing for synchronization of the energy markets.

[14] The World Bank and other development partners have supported the implementation of several of these measures, including telecommunication network upgrades and grid studies.

[15] This is expected to increase exports of Ukrainian electricity to European countries. According to Ukrenergo's expectations annual exports could range from 5 bln kWh to 18-20 bln kWh.

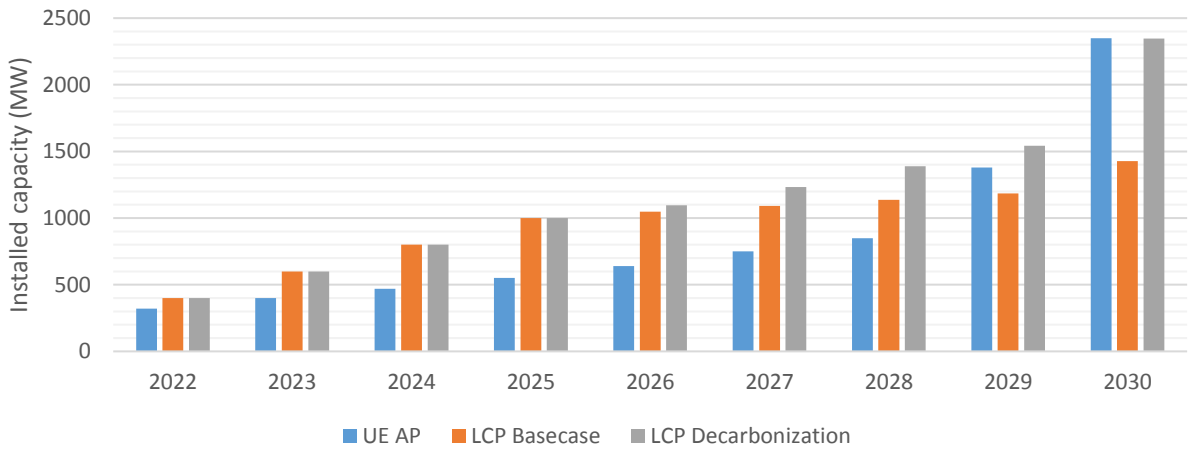
[16] Source: Ukrenergo 2017 presentation. UE estimates are not including the proposed Project investment cost.

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 (see Annex 4 for more information). Thus, while hydropower pumped storage 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.[17]

22. Battery capacities starting at 400MW in 2023 and increasing to 2,000MW 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. Starting with 400 MW in 2022, the needed battery storage capacity 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 WB 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 CO_2 emission by 80 percent by 2040 compared with 2022.

Figure 3. Battery storage capacity needs towards 2030

[17] 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.



23. Moreover, storage will play an important role to meet critical requirements for ENTSO-E synchronization in the short term. UE is planning to conduct islanding mode test starting in early 2022, where UKrES will be disconnected from IPS/UPS[18] and operated in isolated mode. During these isolated operation period, pre-defined generation unit and load will be disconnected, and behaviors of other generation units will be measured to assess those units indeed provided FCR and a-FRR as expected. It should be noted that an ongoing dynamic stability study conducted by ENTSO Consortium and expected to be completed in later 2021 could identify potential measures for the islanding test and for synchronization. After successful completion of the islanding test, UE will proceed to trial operations, where UkrES is synchronized with ENTSO-E and various power system regimes will be assessed. The trial operation could last from a few months to several years[19]. During these trial period for synchronization, UkrES must demonstrate the adequate response, and must maintain adequate and reliable levels of reserves.[20] This is challenging for Ukraine, given that: (i) UkrES is currently heavily dependent on the Russian power system for provision of FCR and other reserves; and (ii) The certified amount for FCR provision is merely 177 MW, as of today, and of that amount, only a small part is bid in the ASM. To complete the preparation stage for synchronization successfully, battery storage will play a critical role to provide FCR and a-FRR to stabilize the power system and avoid a potential black-outs and minimize disturbances in the synchronized area during the aforementioned test operation period. During trials, various unusual system conditions will be tested and assessed, and lack of reserves could lead increase significantly the risk of delays or trial suspension.

24. 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.

[18] During islanding operation, Burshtyn island power system will be disconnected from ENTSO-E and connected to UkrES.

[19] It took three years for Turkey to complete trial operation.

[20] In addition, an increase in the needs of fast aFRR is foreseen to minimize risks during this trial period, as has been the case in other countries.

Hybrid projects are seen as more competitive, and a recent Decree No. 35[21] 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.[22] Alongside technology improvements, the optimal deployment of storage technologies requires institution of appropriate business models and an evolving enabling environment that allows for transparent and non-discriminatory market rules and practices. New procurement approaches and business models are emerging globally.[23] 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.

25. Improvements in the governing ASM rules and in the current legal and regulatory environment are required to help attract larger private investments in battery storage for various services. The concept of storage does not exist in current regulation, and therefore storage systems are considered as generators by default, which implies certain disadvantages to compete in the market. Current legal and regulatory environment does not facilitate competitiveness of battery participation in the balancing and ancillary services markets. For example, unlike other generators, batteries need time to re-charge after being discharged.[24] In ASM, while certification for different services is provided at plant level, the legal requirements to monitor availability and delivery at plant level does not exist. Another gap is the flexibility currently available to substitute a-FRR in place of unmet FCR volume that will not be available once ENTSO-E rules apply, leading to the need to incentivize FCR over a-FRR in the market. Thus, key required changes include:

(a) Firstly, since battery storage has clear economic and environmental advantages to provide fast response reserves, an amendment to the Electricity Market Law (to make it inclusive of "storage") is needed to define the role of energy storage in the power system and to clarify the procedures for grid connection and rules of participation in different power markets. Additionally, changes allowing for revenue stacking (i.e. simultaneous participation of the same assets in several markets will allow for adding revenue streams, and thus, making

[21] On January 29, 2021, the National Security and Defense Council of Ukraine under Decree No 35 mandated all future utility-scale solar and wind power plants to implement at each such generation facility, energy storage systems.

[22] Longer duration battery storage is becoming cost competitive in a growing number of applications such as price arbitrage, load shifting, and peak power supply.

[23] The Regelleistung platform in Germany, where 1.5GW of FCR are jointly procured on a technology-neutral basis by six participating countries (Germany, France, the Netherlands, Switzerland, Austria, and Belgium) is an example of current European trend for the provision of Frequency regulation services. Denmark, Poland and other European countries are expected to join the platform in coming years – indicating a widening acceptance of this approach and its governing rules.

[24] During the charging periods, batteries are not available. Therefore, there are some limitations in availability that need to be considered when defining performance requirements in the market.

investments in battery storage more attractive while reducing the cost of auxiliary services for the TSO. Linked to this, amendments are needed to the Grid Code to define connection and performance requirements, recognizing the specific technical features that battery storage can provide so that it can compete with flexible thermal power plants.

(b) Secondly, the current ASM short-term market could benefit from design improvements to become more attractive to new players. The trading of the different products in the ASM is restricted by price caps that are similar for all products. This does not appropriately incentivize the limited number of market participants to get certified for FCR or aFRR since the cost of providing these services is higher than others. Therefore, carefully planned modifications are needed in the current price caps to properly differentiate between ancillary service categories based on the cost of providing the service and the value of individual service categories to the grid.[25] New products, hourly blocks, and new contracting modalities are also being proposed as options to attract new participants. In order to define adequate incentives to guide private investments, the detailed reserves adequacy analysis must be completed. Once defined, the ASM rules will need to be amended to reflect the changes in the procurement processes and the regulatory changes to ensure that the market rules remain clear and consistent.

(c) Thirdly, the current methodology for measurement and monitoring of the provision of services needs to be modified. Monitoring at the busbar level does not give proper remuneration to the services and disincentivizes participation in the ASM. A more granular measurement would give providers proper remuneration for their services. Clear directives on this aspect will make it possible for providers and off-takers of these services to operate transparently and on a level playing field.

(d) Finally, it is apparent that an analysis of business models with private sector participation is necessary to scale-up battery storage beyond the UHE project. Ukraine's specific needs for ancillary services, proper risk allocation, and considerations linked to market creditworthiness of the off takers should be considered.

26. The proposed public approach is needed to meet the most urgent battery needs, while the Project demonstrational effect will increase the understanding of the technology, and create the enabling environment to facilitate private investments in battery storage to meet the much larger battery needs. The proposed public sector investment is needed to meet the urgent battery storage needs for synchronization. The very first large-scale battery storage investment will demonstrate technical and operational feasibility of a large battery storage and establish track-record of battery storage transactions in the ASM. Hence, it will pave the way for private investments to meet the large battery storage needs. In addition, the proposed Project will also support improve the ASM and create enabling environments for private sector battery storage. Through disbursement conditions, the Project will facilitate to develop legal, regulatory, and operational conditions for battery storage and improve the ASM. Finally, the Project

[25] This issue has been partially addressed in the recent approval by the Anti-Monopoly Committee of Ukraine of the proposal submitted by NEURC to increase price caps for FCR and a-FRR around 35 percent, while reducing the caps for other reserves, but further work is needed to differentiate between FCR and a-FRR and to evaluate if the current market levels provide enough incentive to attract new investments.

will support the introduction of energy storage as the enabler of e-mobility by providing UHE the experience and head-start in learning about and working with long-duration batteries that in the future could also have applications in load shifting and reduction of VRE curtailment. This component will be supported by appropriate technical assistance and capacity building, including collaboration with the World Bank's transport team on business models for e-Mobility.

C. Proposed Development Objective(s)

Development Objective(s) (From PAD)

The PDO is to enhance the flexibility of the Ukrainian power grid through storage investments and market expansion to support synchronization with the European electricity grid and decarbonization of power sector.

Key Results

27. PDO Level Result Indicators are as follows:

(a) Newly installed capacity of battery storage (MW)
(b) Available Frequency Containment Reserve (FCR) amount (MW)
(c) Reduced variable renewable energy curtailment (GWh)
(d) Number of privately owned units (power plants/storage units) certified for trading in Ancillary Services Market (number)
(e) Reduced GHG emissions (tCO2)

D. Project Description

28. Component 1: Installation of Battery Energy Storage System (BESS) with solar PV plants, establishment of an Energy Management System (EMS), and Supervision Consultancy (estimated cost: US$ 249 million, of which IBRD is US$ 177 million, CTF is US$34 million and UHE own fund is US$38 million).

29. ***Subcomponent 1.1: BESS with PV plants and EMS for provision of ancillary services:*** This subcomponent will support installation of BESS and solar PV plants, and an energy management system. In total, 197 MW of BESS will be installed at four hydro power plant sites (Kyiv, Kaniv, Kremenchuk, and Seredniodniprovska). Additionally, 35.9 MWp of solar PV plants will be installed. All facilities including connection power lines will be installed within the precincts of UHE's HPP territories. These sites are identified based on land availability and transmission capacities. The BESS will provide ancillary services to the grid, particularly FCR and a-FRR. Those BESSs will be under coordinated operation with HPPs and solar PVs through a newly installed EMS so that a wide range of grid services is provided seamlessly, and charging/discharging operation is optimized. The total size of the BESS is determined to meet the FCR requirement for ENTSO-E synchronization and then allocated to each site taking into consideration the connected HPP unit sizes as well as land availability. The proposed BESS will provide the necessary ancillary services to the grid, which will improve flexibility of UkrES. Therefore, the proposed investment will enable synchronization with the ENTSO-E, improve integration of VRE sources, and increase power system reliability through creating the most reliable source of system flexibility that is not contingent on the availability of resources (water, coal, gas) and the working status (in/out of operation) of the provider. PV plants will be used mainly to supply electricity to the battery storage facilities and also cater to auxiliary

consumption within the HPP facility. The PV plants will be developed and operated by UHE and not subject to the FiT scheme. To meet the timeline for synchronization, the subcomponent will be developed in a short period of time, starting procurement in late 2021 and reaching to contract signature in early 2022, expected to be commissioned by end of 2022.

30. ***Subcomponent 1.2: E-mobility BESS:*** This subcomponent will support installation of 15 MW of long-duration BESS suitable for EV charging at Dniester HPP. The system will be used for charging of electric public transport vehicles (buses or trams) for the local community. This sub-component is an important tool for testing and progressing e-Mobility options for public transport in Ukraine. It will help prepare UHE and Ukraine's power grid for the upcoming convergence of power and transport sectors through increased use of electric vehicles. This sub-component will increase the knowledge and experience of UHE in long-duration batteries that shall have longer than 4-hour charge-discharge cycle, which can be also used for energy balancing and arbitrage. The proposed investment will be supplemented by the ongoing complementary work implemented by the Bank transport team to facilitate wider penetration of e-mobility in the country. Throughout operation of the proposed battery storage, UHE will progress charging rates and practices towards the commercial range, once sufficient experience has been built.

31. ***Subcomponent 1.3: PV Plant for E-mobility:*** This subcomponent will support installation of 28 MWp PV plant at Dniester HPP. PV plant will be used mainly to supply electricity to the battery storage facility and also cater to auxiliary consumption within the HPP facility. The PV plant will be developed and operated by UHE and not subject to the FiT scheme.

32. ***Subcomponent 1.4: Supervision Consultancy:*** This subcomponent will support project supervision, management, coordination, and knowledge sharing activities that will build UHE's capacity and experience in advanced energy management, through hiring a reputable international consultant as an Owner's Engineer. As UHE has no prior experience with BESS, the support will be critical as the technology is new to UHE and evolving quickly.

33. **Component 2: Technical Assistance for UHE (estimated cost: US$ 1.0 million, to be funded by CTF grant).** This Component will provide technical assistance to UHE on the following aspects: (i) Development of battery storage decommissioning/recycling procedures for UHE; (ii) Gender assessment of HR policies and practices at UHE, aimed at providing baseline understanding of factors influencing gender diversity and inclusion at UHE, and proposing specific recommendations for the company; (iii) Supervision, monitoring and implementation of the Environmental and Social (ES) Management tasks, including establishing and maintaining a Grievance Redress Mechanism (GRM); and (iv) capacity building for UHE such as training workshops and study trips to learn O&M best practices, safety measures, battery recycling, and other key technical areas.

34. **Disbursement Conditions**: **(DCs)**: The Project is designed to use Investment Project Financing (IPF) structure. In addition, some disbursement conditions would be included in the legal agreement with the Borrower (UHE). The disbursement conditions will require the completion of some regulatory milestones as shown in the Table 1 below. Some disbursement categories will be linked to the disbursement conditions. Once each disbursement condition is achieved, the Bank will authorize the disbursement associated to the disbursement category. Several regulatory milestones have been discussed with the relevant counterparts, including MoF, MoE, and the regulator (NEURC). The regulatory milestones associated to the disbursement conditions will enable access of storage to the grid, its participation in the ASM and improvements in the ASM rules to promote new private investments. Completion of the studies

linked to the definition of reserve adequacy using the European methodology could also be considered in order to inform market incentives.

35. These disbursement conditions are considered necessary to achieve the development objective of the proposed project. On one side, the legal and regulatory changes, once adopted, will enable the participation of the UHE project in the ancillary service market in a level playfield with other flexibility options. On the other side, the reforms will also enable private investments on storage by eliminating regulatory barriers and providing the key inputs to define future needs for flexibility and incentives for the markets to provide the required price-signals. The relevance of each of the disbursement conditions is summarized below:

A. **The inclusion in the Electricity law which enables to install and operate energy storage systems**. Currently energy storage is not defined in the law, which leads to uncertainty in treatment of such facility and its services in the legal framework. The uncertainty in the legal framework hinders private investments in battery storage.

B. **"Market Rule" published in MoE after consultations**. At the moment, a stand-alone storage facility is not contemplated in the regal and regulatory framework, and therefore, it could not be pre-qualified to participate in the ancillary service market. Adding pre-qualification criteria for participation of storage systems in ASM and allowing revenue stacking (i.e. simultaneous participation of the same asset in several segments of the ASM), which is critical for private battery storage.

C. **Draft "Grid code" published in MoE after consultations**: It is critical that unique technical characteristics of battery storage are recognized, and some exemptions shall be applied to battery storage for technical requirements that do not fit to the technology. It is also important to clearly define procedure for battery storage to connection to grid at transmission and distribution level and adapting performance requirements to accommodate batteries.

D. **Study on resource adequacy completed and validated by UE and published in UE website**: The study will identify future resource needs to meet demands analyzing various options including new generation plants, energy storage, and demand response. This is a critical condition as the study will particularly identify future ancillary services market size and battery storage needs, which will mitigate some of market risks for private investors in entering the market.

E. **Methodology for monitoring ancillary services adopted**: According to the current market rule, FCR is evaluated at unit level, whereas other ancillary services are monitored at plant level. The difference in evaluation levels for different services introduces a challenge as multiple units in a plant may be providing multiple services simultaneously. A more granular measurement would give providers proper remuneration for their services. Clear directives on this aspect will make it possible for providers and off-takers of these services to operate transparently and on a level playing field.

Table 1. Categories of Disbursement and Disbursement Conditions

Disbursement Categories	Linkage to Disbursement Conditions	Disbursement Conditions

Category of Disbursement 1: Works and services under Subcomponent 1.1	No Disbursement conditions	N/A
Category of Disbursement 2: Works and services under Subcomponent 1.2	DC1	• Submission to Parliament of the draft amendment of the Electricity law which enables to install and operate energy storage systems. • Draft "Market Rule" published in MoE website after consultations. • Draft "Grid code" published in MoE website[26] after consultations.
Category of disbursement 2: Works and services under Subcomponent 1.3.	DC2	• Study on resource adequacy completed and validated by UE and published in UE website. • Methodology for monitoring ancillary services adopted.

42. Project Financing. The proposed Project's Component 1 will be funded by (i) an IBRD loan, (ii) Clean Technology Fund (CTF); and (iii) UHE's own funding. Additionally, CTF Grant will fund Component 2, technical assistance for UHE. A summary of project cost estimates is provided in Table 2. Please note that the Table does not include the Bank executed trust fund (BETF) TA, which is expected to be in the $1-2 million range.

Table 2. Summary of Preliminary Project Costs (US$ million)

Project		**Estimated Cost**	**Financing**			
			World Bank	**CTF Loan**	**CTF Grant**	**UHE**
Component 1: Installation of BESS and Solar PV plants, Establishment of EMS, and Supervision Consultancy	Subcomponent 1.1: BESS with PV plants and EMS for provision of ancillary services	210.0	150.6	28.3	0.0	31.0
	Subcomponent 1.2: E-mobility BESS	11.0	7.0	2.0	0.0	2.0
	Subcomponent 1.3: PV plant for E-mobility BESS	23.0	16.0	3.0	0.0	4.0
	Subcomponent 1.4: Supervision Consultancy	5.0	3.4	0.7	0.0	0.9
Component 2: Technical assistance for UHE		1.0	0.0	0.0	1.0	0.0
Total		**250**	**177**	**34**	**1**	**38**

[26] Any other dissemination way could be considered.

Legal Operational Policies

	Triggered?
Projects on International Waterways OP 7.50	No
Projects in Disputed Areas OP 7.60	No

Summary of Assessment of Environmental and Social Risks and Impacts

The Project will install battery storages and PV generators arrays within current footprint of the UHE facilities (hydro-power plants). The project environmental and social risks are both rated as 'Moderate'.
Although the implementing entity has some experience with working with IFI supported projects, they have no or limited capacity in applying the Environmental and Social Standards. As this is one of the first projects in the energy sector prepared under the Bank's new Environmental and Social Framework (ESF), the Borrower's capacity to deliver an ESF based project is limited; therefore, capacity building training for the client including engaged agencies and contractors will be conducted by the Bank's Environment and Social team during project preparation and implementation.

E. Implementation

Institutional and Implementation Arrangements

43. The Project is structured as an Investment Project Financing (IPF) with disbursement conditions. A loan agreement between UHE and the Bank will be signed for the IBRD portion of the loan. A separate legal agreement will be signed for the CTF loan (and up to USD 1 million grant to be used for Component 2 (TBC)). Disbursement Conditions will be included in the Loan Agreement with the Borrower and the Disbursement and Financial Information Letter. All the relevant stakeholders involved in the regulatory milestones linked to the disbursement conditions should participate in project negotiations.

44. The Project will be implemented by Ukrhydroenergo. UHE has experience in working with the World Bank and other IFIs, such as EBRD, including on the World Bank's Hydro Power Rehabilitation Project (2005-2016). It has a qualified project manager, procurement specialist, financial manager, environmental and social specialists, project accountants and an OHS specialist. A dedicated Project Management Unit (PMU) will be created with UHE Staff and external consultants to execute the tasks under the proposed Project. UHE will also implement Component 2 with funding support of CTF grant.

45. Project Operational Manual (POM). To ensure a smooth implementation process, UHE will prepare and adopt a POM. The completion and adoption of the POM will be a condition of effectiveness for the Project. The POM will describe detailed arrangements and procedures for: (a) institutional coordination and day-today execution of the Project; (b) project budgeting, disbursement, and financial management (FM); (c) procurement; (d) monitoring and evaluation (M&E), reporting, and communication; and (e) any other administrative, financial, technical, and organizational arrangements and procedures that will be relevant for project implementation.

46. **The Bank is proposing to define several regulatory milestones as disbursement conditions**. Once each of the milestones is achieved, the project can authorize disbursements against the associated category of disbursement.

47. Responsibility of Disbursement conditions lies with MoE, which can be bound by a collaboration agreement between MoF and MoE to ensure implementation of the measures.

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