CLIMATE CHANGE ASSESSMENT

I. BASIC PROJECT INFORMATION

Project Title:	Grid Reinforcement Project
Project Cost:	$127.8 million
Location:	Cambodia: Phnom Penh, Kampong Chhnang, Kampong Cham, Takeo Province
Sector:	Energy
Theme:	Electricity Transmission and Distribution
Brief Description:	The Grid Reinforcement Project (the project) will support the Electricité du Cambodge (EDC), the state-owned power utility, to improve transmission network capacity and stability. The project will (i) expand and reinforce the electricity transmission infrastructure by constructing 36.7 circuit-kilometers (cct-km) of 115 kilovolt (kV) and 13 cct-km of 230 kV transmission lines and ten substations in Phnom Penh, Kampong Chhnang, Kampong Cham, and Takeo provinces; and (ii) introduce as a pilot the first utility-scale battery energy storage system to understand the performance of the technology and assess different business models for (a) renewable capacity firming, (b) ancillary services, and (c) transmission congestions relief and investment deferral as a combined set of services. Cambodia is highly vulnerable to the effects of climate change, in particular from floods, heat/high temperatures, droughts, windstorms, and seawater intrusion. Infrastructure, agriculture, forestry, human health, and coastal zones are the most affected sectors. At the project level, the proposed sites of transmission towers and substations are at risk to impacts of extreme weather events or tropical cyclones, intense precipitation causing floods and prolonged high temperatures which may cause strong winds and intense frequency of lightings which may also cause damages to the transmission lines.

II. SUMMARY OF CLIMATE CHANGE FINANCE

Project Financing		Climate Finance	
Source	**Amount** ($ million)	**Adaptation** ($ million)	**Mitigation** ($ million)
Asian Development Bank Ordinary capital resources (concessional loan)	127.8	n/a[a]	6.04
Strategic Climate Fund (grant)	4.7		4.7
Clean Energy Fund (grant)	2.0		2.0
	134.5		12.74

[a] Identified and listed adaptation activities are already incorporated in EDC's standard designs for transmission lines and substations as normal good practice.
Source: Asian Development Bank.

III. SUMMARY OF CLIMATE RISK SCREENING AND ASSESSMENT

A. Sensitivity of Project Components to Climate or Weather Conditions and the Sea Level

1. Cambodia is highly vulnerable to the effects of climate change, in particular from floods, droughts, windstorms, and seawater intrusion. Agriculture, infrastructure, forestry, human health, and coastal zones are the most affected sectors.[1]

[1] Royal Government of Cambodia. 2015. Cambodia Cambodia's Intended Nationally Determined Contribution (INDC). https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Cambodia%20First/Cambodia%27s%20INDC%20to%20the%20UNFCCC.pdf

2. The high vulnerability score and low readiness score of Cambodia places it in the upper-left quadrant of the ND-GAIN Matrix. It has both a great need for investment and innovations to improve readiness and a great urgency for action. Cambodia is the 45th most vulnerable country and the 51st least ready.[2]

3. The project will (i) expand and reinforce the electricity transmission infrastructure by constructing 36.7 circuit-kilometers (cct-km) of 115 kV and 13 cct-km of 230 kV transmission lines and ten substations in Phnom Penh, Kampong Chhnang, Kampong Cham, and Takeo provinces; and (ii) introduce as a pilot the first utility-scale battery energy storage system. The infrastructure is sensitive to climate change.

IV. SUMMARY OF CLIMATE RISK SCREENING AND ASSESSMENT

A. Climate Risk Screening:

A literature review of climate impacts in Cambodia was used to assess the possible climate related issues. For the project specific location of the proposed infrastructure and ancillary facilities, a site-specific assessment was conducted using available open sourced software on climate related risk assessments (i.e., precipitation, flood). Available climate impact studies for Cambodia and online open sourced climate risk assessment tools (i.e., AWARE Report (generated by the Asian Development Bank) 2019, World Bank's Climate Change Knowledge Portal, and CAM Climate Risk and Vulnerability Assessment were used.[a]

1. **Temperature increase.**[b] Mean annual temperatures have increased by 0.8°C since 1960. The rate of temperature increase is most rapid in the dry seasons, increasing 0.2°C –0.23°C per decade and is slow in the wet seasons, increasing 0.13°C –0.16°C per decade. The frequency of 'hot' days per year has increased significantly (+46, with maximum increases noted in September-November), as has the frequency of 'hot' nights per year (+63, with maximum increases noted in December-February). The frequency of 'cold' days per year has decreased (-19, with maximum decreases noted in December-February). An array of climate change scenario models project that Cambodia can expect an increase in mean annual temperatures of 1.8°C by 2050 and by up to 4.3°C by the 2090's with respect of Representative Concentration Pathway 8.5 (footnote b). Climate change model projections also indicate substantial increases in the number of hot days (above 35°C) will increase by 49.2 days by 2050. Current projections suggest the frequency of days and nights that are considered 'cold' will become exceedingly rare.

2. **Rainfall increase.** Mean rainfall trends in Cambodia are unclear, with some areas experiencing increases and others decreases, but these changes are not statistically significant. The National Committee for Disaster Management reported extreme weather conditions, 336 extreme rainfall events, caused 95 deaths across 22 provinces in 2019.[c] Climate model predictions agree that annual precipitation will increase in subproject locations, to a relatively low degree of uncertainty. Mean precipitation will rise by 98.8mm in 2050 (footnote b).

3. **Extreme Events.** There are two flood types in Cambodia: Mekong River flood and flash floods. The southwest monsoon begins in mid-May and lasts through October and contributes to three-quarters of the country's annual rainfall. Approximately 80% of the country's population lives along the Mekong River that is known for large river flow and discharge fluctuations.

   Over the past 50 years major riverine (13) and flash (3) flood incidents were recorded that resulted in significant flood events affected scores of people and communities and resulted in significant loss of life and economic loss.[d] In recent years, a succession of major flood events has continued to cause widespread impacts (footnote c). Mekong floods affect the provinces of Kandal, Kampong Cham, Kratie, Prey Veng, Stung Treng, Svay Rieng and Takeo. Flash floods in tributaries around the Tonle Sap Lake may affect Project provinces. All subproject regions are considered as being at 'high-risk' of future flood events.[e] However, localised flood data[f] suggested that rural subproject sites in Kampong Chhnang, Kampong Cham, and Takeo provinces were not historically impacted by flood events during the period researched.[g]

Climate Risk Classification: High

B. Climate Risk and Adaptation Assessment

Subproject	Potential Climate Risk	Risk Level	Possible Adaptation Measures

[2] ND Gain Index. Accessed on March 2020. Cambodia. Source: https://gain-new.crc.nd.edu/country/cambodia

Overall Transmission and substation infrastructure	Increase in intense precipitation events increase soil moisture levels that may cause deterioration of structural components of T&D systems	Medium	Transmission line and substation footings to be built above the highest recorded flood levels
	Stronger winds	High	High design standards for transmission towers incorporated Redundancy in control systems, multiple transmission routes, relocation specified
	Increase in storm intensity may cause damage to transmission infrastructure and increase probability of infrastructure failures	High	
	Increases in very hot days and heat waves will lead to increase in temperatures which may cause deterioration of	Medium	More effective cooling systems for substations and transformers Conductors to be designed to combat extended periods of drought that can cause dust to amass on conductors.
Underground cables	Increase in intense precipitation events are to cause flooding and may overload drainage systems	High	Increase drainage facilities in both number and size
	Changes in temperature that can damage lines	Medium	Design provisions and standards for underground cable engineering and design consider drought conditions / soil moisture reduction.
Towers	Increases in very hot days and heat waves may cause thermal expansion of joints and paved surfaces	Medium	Operational and maintenance standards take into consideration heavy precipitation, strong winds, and extreme prolonged temperature changes.
	Increase in intense precipitation events may lead to scouring of tower support structures	High	
	Increased storm intensities may Increase threat to stability of Towers		
	Increase in wind speeds may damage towers		
Transmission lines	Increases in very hot days and heat waves and decreased precipitation may lead to increased temperatures, humidity, and salinity leading to line losses	Medium	Design provisions for a maximum ambient air temperature of 40.5ºC as per EDC's specifications for transmission lines
	Droughts may cause dust damage to cables		Regular maintenance and monitoring programs of cables Ensure components are resilient to higher temperatures and humidity.
	Increases in temperature can reduce the current rating of transmission lines and increase their sag.		Design provisions to allow for maximum line sagging to maintain designated ground clearances
Battery energy storage system (BESS)	Increases in temperature increases the operational costs of BESS system as the HVAC inside the battery room has to maintain 23°C temp; else this leads to increased battery aging and loss of performance warranty	Medium	Design provisions for adjustment in sizing of HVAC due to the increase of temperature

C. Climate Risk Screening Tool and/or Procedure Used

A rapid climate risk assessment on the proposed sub-project outputs has been completed using available climate impact studies for Cambodia using the World Bank Climate Change Knowledge Portal and Think Hazard.

[a] ADB. 2019. *Climate Risk and Vulnerability Assessment.* Manila.
[b] World Bank's Climate Change Knowledge Portal.
[c] Open Development Cambodia (accessed on 25/02/20) https://opendevelopmentcambodia.net/tag/national-committee-for-disaster-management-ncdm/#!/story=post-132578
[d] EM-DAT | The international disasters database; https://www.emdat.be/emdat_db/
[e] GFDRR (2019) Available at: http://thinkhazard.org/en/report/806-cambodia-phnom-penh [accessed 19/02/19]
[f] http://surface-water-servir.adpc.net/ (funded by USAID, NASA and ADPC)
[g] ADB. 2020. *Climate Change Assessment Report.* Manila.

V. CLIMATE ADAPTATION PLANS WITHIN THE PROJECT

Identified and listed adaptation activities are already incorporated in EDC's standard designs for transmission lines and substations as normal good practice. They will also be reflected in the detailed engineering designs.

Adaptation Activity	Target Climate Risk	Estimated Adaptation Costs ($ million)	Adaptation Finance Justification
Overhead transmission line conductors designed to consider potential increases in line sag can cause flashover, due to increased temperatures. It is standard design practice to increase tension on the lines to reduce such risk[a]	Increasing temperatures, prolonged hot days/droughts events causing moisture movement, and higher risk of lightnings	No additional cost as adaptation activities are part of standard design practice already	The adoption of climate proofing measures against the projected impacts of climate change and variability are eligible climate adaptation measures that are already included in standard designs for transmission lines and substations by EDC.
It is standard design practice to add earth wires above live conductors and to substations, and fitting spark gaps and surge arresters to prevent lightning damages on line conductors; impact can produce ionized gases that can cause a short circuit fault as the electrical protection disconnects the affected circuit. Such flashover faults may increase in many regions owing to greater lightning frequency			
It is standard design practice that underground cables use suitable conduits to prevent damage due to drought conditions (i.e. moisture movement) resulting from more prolonged hot days.			
It is standard practice that conductor maintenance programs are maintained to prevent dust build during extended periods of heat and drought			
It is standard practice to prune and remove ROW trees to reduce damage of electric wires through tree damage	Increased wind strengths can cause mechanical damages causing power interruptions (e.g., flash over from flashovers caused by live cables galloping, tree over cables)		
It is standard practice that overhead towers are strengthened and aligned with national standards to prevent mechanical damage			
It is standard practice that transmission towers and substation structures are designed to withstand the highest projected wind loadings			
It is standard practice that tower inspection are conducted more frequently to maintain its integrity			
Transmission lines rerouted alongside roads or across open fields			
Access roads engineered to withstand localized flood events through elevating road levels	Impacts of intense precipitation, strong winds and tropical storms that		

Adaptation Activity	Target Climate Risk	Estimated Adaptation Costs ($ million)	Adaptation Finance Justification
above highest expected flood and inserting appropriate drainage to allow water to flow underneath.	bring strong winds and rains leading to flash floods and inundation may undermine the T&D infrastructure, ancillary facilities/substations, and equipment; increases in temperature may undermine facilities and equipment		
Battery energy storage system programmed to analyse and manage potential future solar radiation fluctuations and engineer the system to combat impacts of more extreme weather events such as increased precipitation and flooding.			
Use of Sf6 free high-voltage and medium-voltage switchgear and circuit breakers[b]	Climate extreme events causing increased humidity, corrosion can lead to Sf6 leakage		
VI. CLIMATE MITIGATION PLANS WITHIN THE PROJECT			
Mitigation Activity[c]	**Estimated GHG Emissions Reduction (tCO_2/year)**	**Estimated Mitigation Costs ($ million)**	**Mitigation Finance Justification**
Transmission losses reduced[d]	81,873[e]	6.04	Part which reduces losses is counted as climate financing.
Battery energy storage system (BESS) to facilitate integration of renewables in the grid[c]	2,265	6.7	100% of investment costs are counted as climate finance.
Total	**84,138**	**12.74**	

[a] As normal design practice, sag is designed to achieve specified ground clearances at designated maximum air temperatures. Inserting a higher temperature value in the formula will result in slightly higher tensions, which the towers will be designed for in any case.

[b] Switchgear and circuit breaker manufacturers have been researching alternatives to SF6 gas for many years, but this work has not resulted in a suitable substitute.

[c] The BESS is financed with grants from the Strategic Climate Fund and the Clean Energy Fund administered by the Asian Development Bank. Estimated mitigation costs are included but double counting should be avoided.

4. The construction of the four transmission lines and 10 substations under the project (output 1) will contribute to transmission loss reductions. The lifetime reduction in losses in the provinces included in the project, calculated as the difference in the loss percentage in the with- and without-project cases and multiplied by forecast supply in these provinces, is estimated at 3,529 gigawatt-hour (undiscounted) or an average annual reduction of 141 gigawatt-hours. Emission factor of 0.580kgCO2/kWh[3] has been applied to average annual reduction in losses to derive at the estimated greenhouse gas emission reductions per year.

5. The BESS uses mainly output from the solar photovoltaic power plant as energy throughout for charging and discharging. For the following services: i) solar power plant output smoothing, ii) primary frequency response, and iii) transmission upgrade deferral imported power from Vietnam and Thailand can mainly be reduced. The impact on emission reduction is likely to be very small. For its 0.5h curtailment reserve service, 10.7 megawatt-hours per day of stored solar power will reduce load shedding and thus displace non-renewable fuels that could otherwise be used to fill this gap. Emission factor of 0.580kgCO2/kWh has been applied.

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[3] Emission factor sourced from IFI Technical Working Group. 2019. The IFI Dataset of Default Grid Factors v2.0.