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The World Bank

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Report No: PAD1366

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

PROJECT APPRAISAL DOCUMENT

ON

PROPOSED GRANTS FROM

THE GLOBAL ENVIRONMENT FACILITY'S SPECIAL CLIMATE CHANGE FUND

IN THE AMOUNT OF US$2.38 MILLION

TO

BELIZE

AND

IN THE AMOUNT OF US$5.62 MILLION

TO THE

BELIZE ELECTRICITY LIMITED

FOR AN

ENERGY RESILIENCE FOR CLIMATE ADAPTATION PROJECT

July 25, 2016

Energy and Extractives Global Practice
Latin America and the Caribbean

CURRENCY EQUIVALENTS

(Exchange Rate Effective as of July 4, 2016)

Currency Unit	=	Belizean Dollar (BZ$)
US$1.00	=	BZ$2.00
BZ$1.00	=	US$0.50

FISCAL YEAR

April 1 – March 31

ABBREVIATIONS AND ACRONYMS

AMI	Advanced Metering Infrastructure
BCRIP	Belize Climate Resilience Infrastructure Project
BEL	Belize Electricity Limited
BT	Belizean Team
CBB	Central Bank of Belize
CCI	Clinton Climate Initiative
CCRIF	Caribbean Catastrophic Risk Insurance Facility
CEO	Chief Executive Officer
CFE	*Comisión Federal de Electricidad* (the Power Utility in Mexico)
CQS	Selection based on Consultant's Qualifications
CPS	Country Partnership Strategy
DRM	Disaster Risk Management
ERCAP	Energy Resilience for Climate Adaptation Project
ESIA	Environmental and Social Impact Assessment
FM	Financial Management
FS	Feasibility Study
GDP	Gross Domestic Product
GEF	Global Environment Facility
GoB	Government of Belize
HV	High Voltage
IA	Internal Audit
IC	Selection of Individual Consultants
ICB	International Competitive Bidding
IFR	Interim Financial Report
IPP	Independent Power Producer
LCS	Least-Cost Selection
M&E	Monitoring and Evaluation
MFPSEPU	Ministry of Finance, Public Service, Energy and Public Utilities
MTR	Mid-Term Review
NCB	National Competitive Bidding
NCRIP	National Climate Resilience Investment Plan
NEMO	National Emergency Management Organization
NMS	National Meteorological Service
OLADE	Latin American Energy Organization

PDO	Project Development Objective
PMU	Project Management Unit
POM	Project Operational Manual
PRAM	Procurement Risk Assessment and Management
PSC	Project Steering Committee
PUC	Public Utilities Commission
QCBS	Quality and Cost Based Selection
SIB	Statistical Institute of Belize
SBD	Bank's Standard Bidding Documents
TTL	Task Team Leader
UNFCCC	United Nations Framework Convention for Climate Change
USE	Unserved Energy
VHF	Very-high Frequency

Regional Vice President:	Jorge Familiar
Country Director:	Sophie Sirtaine
Acting Senior Global Practice Director:	Anna Bjerde
Practice Manager:	Antonio Barbalho
Task Team Leader:	Migara Jayawardena

BELIZE

Energy Resilience for Climate Adaptation

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PAD DATA SHEET

Belize

Energy Resilience for Climate Adaptation (P149522)

PROJECT APPRAISAL DOCUMENT

LATIN AMERICA AND CARIBBEAN

Energy & Extractives Global Practice

Report No.: PAD1366

Basic Information			
Project ID P149522	EA Category B - Partial Assessment		Team Leader Migara Jayawardena
Lending Instrument Investment Project Financing	Fragile and/or Capacity Constraints [ ]		
	Financial Intermediaries [ ]		
	Series of Projects [ ]		
Project Implementation Start Date November 1, 2016	Project Implementation End Date July 31, 2020		
Expected Effectiveness Date November 1, 2016	Expected Closing Date July 31, 2020		
Joint IFC No			GEF Focal Area Climate change
Practice Manager	Acting Senior Global Practice Director	Country Director	Regional Vice President
Antonio Barbalho	Anna Bjerde	Sophie Sirtaine	Jorge Familiar

Borrower: Government of Belize			
Responsible Agency: Ministry of Finance, Public Service, Energy and Public Utilities			
Contact:	Peter Allen	Title:	Chief Executive Officer
Telephone No.:	501-822-2204	Email:	ceo@mps.gov.bz
Borrower: Belize Electricity Limited			
Contact:	Jeffrey Locke	Title:	Chief Executive Officer
Telephone No.:	501-227-0954	Email:	Jeffrey.locke@bel.com.bz

Project Financing Data(in US$, millions)					
[ ]	Loan	[ ]	IDA Grant	[ ]	Guarantee
[ ]	Credit	[X]	Grant	[ ]	Other

Total Project Cost:	11.975	Total Bank Financing:	0.00
Financing Gap:	0.00		

Financing Source	**Amount**
Borrower	3.975
Special Climate Change Fund (SCCF)	8.000
Total	11.975

Expected Disbursements (in US$, millions)

Fiscal Year	2017	2018	2019	2020	2021
Annual	0.82	1.90	3.14	1.94	0.20
Cumulative	0.82	2.72	5.86	7.80	8.00

Institutional Data

Practice Area (Lead)

Energy & Extractives

Contributing Practice Areas

Cross Cutting Areas

[x] Climate Change
[ ] Fragile, Conflict & Violence
[ ] Gender
[ ] Jobs
[ ] Public Private Partnership

Sectors / Climate Change

Sector (Maximum 5 and total % must equal 100)

Major Sector	Sector	%	Adaptation Co-benefits %	Mitigation Co-benefits %
Energy and mining	General energy sector	100	100	
Total		100		

☐ I certify that there is no Adaptation and Mitigation Climate Change Co-benefits information applicable to this project.

Themes		
Theme (Maximum 5 and total % must equal 100)		
Major theme	Theme	%
Environment and natural resources management	Climate change	100
Total		100

Proposed Project Development Objective(s)
The objective of the project is to demonstrate solutions that enhance the resilience of the energy system to adverse weather and climate change impacts.

Components	
Component Name	**Cost (US$, millions)**
1- Long-Term Planning and Capacity Building for Adaptation	2.359
2- Demonstration Measures to Enhance Resilience of Energy Sector	5.060
3- Project Implementation Support and Information Dissemination for Knowledge Sharing	0.421

Systematic Operations Risk- Rating Tool (SORT)	
Risk Category	**Rating**
1. Political and Governance	M
2. Macroeconomic	L
3. Sector Strategies and Policies	M
4. Technical Design of Project or Program	M
5. Institutional Capacity for Implementation and Sustainability	S
6. Fiduciary	M
7. Environment and Social	L
8. Stakeholders	M
OVERALL	**M**

Compliance	
Policy	
Does the project depart from the CAS in content or in other significant respects?	Yes [ ] No [x]

Does the project require any waivers of Bank policies?	Yes [ ] No [x]
Have these been approved by Bank management?	Yes [ ] No [ ]
Is approval for any policy waiver sought from the Board?	Yes [ ] No [x]
Does the project meet the Regional criteria for readiness for implementation?	Yes [x] No [ ]

Safeguard Policies Triggered by the Project	**Yes**	**No**
Environmental Assessment OP/BP 4.01	X	
Natural Habitats OP/BP 4.04	X	
Forests OP/BP 4.36		X
Pest Management OP 4.09	X	
Physical Cultural Resources OP/BP 4.11		X
Indigenous Peoples OP/BP 4.10		X
Involuntary Resettlement OP/BP 4.12		X
Safety of Dams OP/BP 4.37		X
Projects on International Waterways OP/BP 7.50		X
Projects in Disputed Areas OP/BP 7.60	X	

Team Composition

Bank Staff

Name	**Role**	**Title**	**Unit**
Migara Jayawardena	Team Leader (ADM Responsible)	Senior Energy Specialist	GEE04
Noureddine Berrah	Energy and Institutional Advisor	Energy Advisor Consultant	GEE04
Chrisantha Ratnayake	Power System Engineering	Power Engineer Consultant	GEE04
Robert Montgomery	Environmental Safeguards	Lead Environment Specialist	GEN04
Shaun Moss	Procurement	Lead Procurement Specialist	GGO04
Gabriela Grinsteins	Legal	Counsel	LEGLE
Yingwei Wu	Procurement	Senior Procurement Specialist	GGO04
Sonia Cristina Rodrigues Da Fonseca	Procurement	Senior Procurement Specialist	GGO04

David I	Financial Management	Senior Financial Management Specialist	GGO22
Noreen Beg	Environmental Safeguards	Senior Environmental Specialist	GEN04
Peter Lafere	Social Safeguards	Senior Social Development Specialist	GSU04
Kerry Natelege Crawford	Financial Management	Financial Management Specialist	GGO22
Tatiana Cristina O. de Abreu Souza	Finance Officer	Finance Officer	WFALN
Bernard Baratz	Environmental Safeguards	Environment Specialist Consultant	GEE04
Judith Lisansky	Social Safeguards	Development Specialist Consultant	GSU04
Maria Teresa Lasa Garcia	Energy	Energy Specialist Consultant	GEE04
Luisa F. Pacheco de Vincenzo	Program Assistant	Senior Program Assistant	GEE04
Elizabeth Sanchez	Program Assistant	Program Assistant	GEE04
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Leonardo Lemes	Caribbean Country Management Unit	Country Officer	LCC3C
Cecile Thioro Niang	Caribbean Country Management Unit	Program Leader	LCC3C
Jace Jeesun Han	Energy	Energy Specialist Consultant	GEE04
Borja Garcia Serna	Energy	Energy Specialist Consultant	GCCKN
Hua Du	Energy	Energy Specialist Consultant	GEE04

Locations

Country	First Administrative Division	Location	Planned	Actual	Comments
Belize					Activities cover entire country

I. STRATEGIC CONTEXT

A. Country Context

1. **Belize is an upper-middle-income country with a population of about 350,000 people, gross domestic product (GDP) of nearly US$4,850 per person, and a natural resource-based economy.** It is a Caribbean nation that is part of the Small-Island Developing States group located on the Central American mainland. Belize's GDP, estimated at US$1.7 billion for 2014 is generated primarily through agriculture/agro-industries, tourism, fisheries, logging, and some oil production. Over the past decade, the tourism sector has emerged as a major economic driver, and the first commercial oil discovery was made in 2005, sparking an additional export industry albeit at a modest scale. The private sector accounts for two-thirds of Belize's economic activity.

2. **The country's economic prospects are a concern because growth has fluctuated with a subdued trend more recently, placing the poor and the vulnerable at particular risk.** Economic growth in Belize has averaged a modest 2.65 percent from 2004 to 2014, which is unable to keep up with the increase in population creating stagnant economic conditions. Based on available data, which is for 2009, it is reported that somewhere from 40 percent[1] to 55 percent[2] of the population in Belize is poor or susceptible to falling into poverty.[3] Given the modest economic growth since then, these conditions are likely to persist today. Therefore, a sizable segment of the population will be challenged to overcome poverty in the present environment, and may even regress if the country were to face external shocks given Belize's relatively open and export dependent economy. The elimination of preferential trade quotas,[4] reduction in tourism revenues, and oil price shocks represent the types of risks that could impede growth and plunge more Belizeans deeper into poverty.

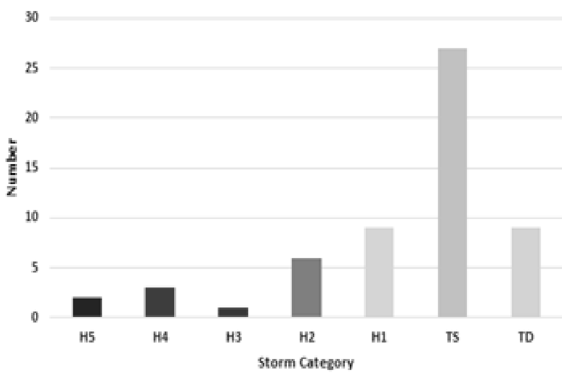
3. **These economic vulnerabilities are intensified due to Belize's exposure to risks posed by extreme weather from tropical storms and hurricanes.** Belize has a long history of experiencing hurricanes and tropical storms (see figure 1). They have severely affected Belize's economy and its citizen's well-being. In 1961, Hurricane Hattie, caused damages estimated at 600 percent of GDP and killed 400 people.[5] More recently, Hurricane Keith in 2000 caused damage exceeding 45 percent of GDP;[6] Hurricane Iris in 2001 submerged Belize City in storm surges that resulted in damages estimated at 25 percent of GDP;[7] Hurricane Dean in 2007 led to an estimated US$80–100 million in damages (6–8 percent of GDP)[8] and caused a near-countrywide power blackout; and Hurricane Richard in 2010 enveloped most of the country with heavy rainfall and flooding causing damages and losses estimated at about US$35 million (about 3 percent of GDP).[9] Tropical storms, which typically cause less disruptions, impact Belize with even greater frequency.

[1] Martin, Dougal. 2015. "Rekindling Economic Growth in Belize." Inter-American Development Bank.
[2] World Bank reports on Belize. 2011. "Country Partnership Strategy" and 2016. "Systematic Country Diagnostic"
[3] There is limited, up-to-date social and welfare data in Belize, with the last poverty assessment carried out in 2009.
[4] The elimination of the European Union sugar quotas for cane sugar and the removal of restrictions on comparative competitors (such as, corn syrup, beet based) are expected in 2017.
[5] EM-DAT, the International Disaster Database, accessed January 2013.
[6] World Bank. 2011. "Country Partnership Strategy for Belize."
[7] Ibid.
[8] PUC (Public Utilities Commission). 2007. "Preliminary Damage Assessment and Needs Analysis (DANA) Report"; Economic Commission for Latin America and Caribbean. 2007. "Macro Social-Economic Assessment of the Damage and Losses caused by Hurricane Dean."
[9] NEMO (National Emergency Management Organization). 2010. "Initial Damage Assessment (IDA) Report."

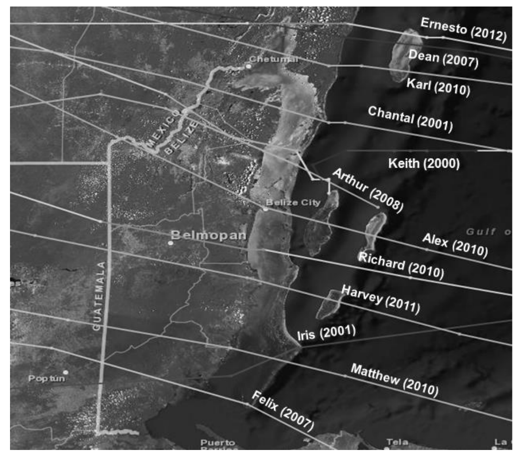
These extreme weather events cause casualties, damage property, and lead to disruptions in services. Their unpredictability poses a considerable development challenge, because it creates vulnerabilities for the economy, especially for the poor. The devastation from a hurricane can suddenly set back development gains and constrain growth, and recovery often takes time. Therefore, enhancing resilience to extreme weather is a development imperative.

Figure 1. History of Hurricanes and Tropical Storms making Landfall in Belize

Histogram of Hurricanes and Storms since year 1864



Trajectory of Hurricanes and Storms from year 2000 onwards



LEGEND: Saffir-Simpson Hurricane Wind Scale

	H5	H4	H3	H2	H1	TS/SS	TD/SD
Wind Speeds	>156 mph	131-155 mph	111-130 mph	96-110 mph	74-95 mph	39-73 mph	<39 mph

Source: based on data from the U.S. National Oceanic and Atmospheric Administration

Source: U.S. National Hurricane Center

4. **The extreme weather impacts in Belize are likely to be exacerbated because of climate change.** The United Nations[10] has identified Belize as being among the countries most vulnerable to the adverse impacts of climate change and a global index ranked 22 among 180 countries for climate risk[11]. This assessment for Belize is primarily because of: (a) its long, low-lying coastline; (b) its over 1,060 small islands; (c) its second-longest barrier reef in the world and 17,276 km^2 of forest cover supporting fragile ecosystems; and (d) it being prone to natural disasters, especially hurricanes.[12] The major risks posed by climate change are rising sea levels, increased intensity of tropical storms and hurricanes, greater flooding, extended droughts, rapid shoreline erosion, saltwater intrusion, and changes in temperature. Due to this exposure, Belize has been included as one of the top ten countries in the world that is at a high risk to combined impacts of multiple hazards (climate change induced heat, drought, and floods and disaster-induced poverty).[13] Estimates suggest that annual losses due to these impacts equate to about 7 percent of the country's GDP.[14] As such, climate change is sure to test the resilience of Belize in the future, placing considerable importance and urgency on developing ways to better adapt to these challenges.

[10] The United Nations Framework Convention for Climate Change (UNFCCC).
[11] Kreft, S. and Eckstein D. "Global Climate Risk Index 2014." Germanwatch
[12] United Nations Environmental Programme. 2011. "National Environmental Summary."
[13] Shepherd et al. 2013. "Geography of Poverty, Disasters and Climate." Overseas Development Institute.
[14] Harmerling, S. and Eckstein D. "Global Climate Risk Index 2013." Germanwatch.

5. **The infrastructure sector in Belize is highly exposed to extreme weather and climate risks.** When these risks are manifested, the resulting damages to infrastructure and disruptions to services can be significant. For example, the increase in global temperatures that is leading to rising sea levels poses particular risks in the low-lying, flood-prone coastal areas in Belize. When combined with either high winds or intense rainfall from storms and hurricanes, it will lead to increasing levels of inundation, especially along coastal areas, that can damage residential and commercial buildings, roads and related transport infrastructure, power generation facilities and transmission/distribution structures, and water supply equipment. These impacts can extend even beyond the coastal areas and affect the entire country, as was the case in 2008, when heavy rains led to massive flooding, resulting in the economy being crippled for weeks, with over a sixth of Belizean citizens being affected. Because infrastructure is interdependent in facilitating economic development, it is vital to have a comprehensive approach to addressing adaptive capacity so that future weather impacts, which are likely to be exacerbated by climate change, can be withstood with minimal disruptions to services.

6. **The Government of Belize (GoB) has progressively taken steps to enhance resilience and is seeking development partner assistance to improve and speed up implementation.** The Disaster Preparedness and Response Act (2003)[15] is the primary legislation governing disaster risk management (DRM) in Belize, which also led to the establishment of the National Emergency Management Organization (NEMO) as an institutional mechanism to coordinate responses during emergencies. In 2014, the GoB also adopted the National Climate Resilience Investment Plan (NCRIP) that takes a longer-term view to developing resilience and looks to mainstream climate adaptation investments in national planning. The Bank is already assisting the GoB implement parts of the NCRIP through the Belize Climate Resilience Infrastructure Project (BCRIP) [P127338] that primarily focuses on roads. While the NCRIP also covers energy and stresses the need to mainstream climate change risk considerations in utilities, it is less explicit about the precise engagements in the sector. Therefore, the GoB has requested assistance from the Bank to develop specific priority interventions that will enhance energy resilience so that the country can better adapt to existing and emerging impacts from climate change. The proposed Energy Resilience for Climate Adaptation Project (ERCAP) will complement the actions supported by the BCRIP [P127338] and reflects a comprehensive effort by the Bank to enhance infrastructure resilience in Belize.

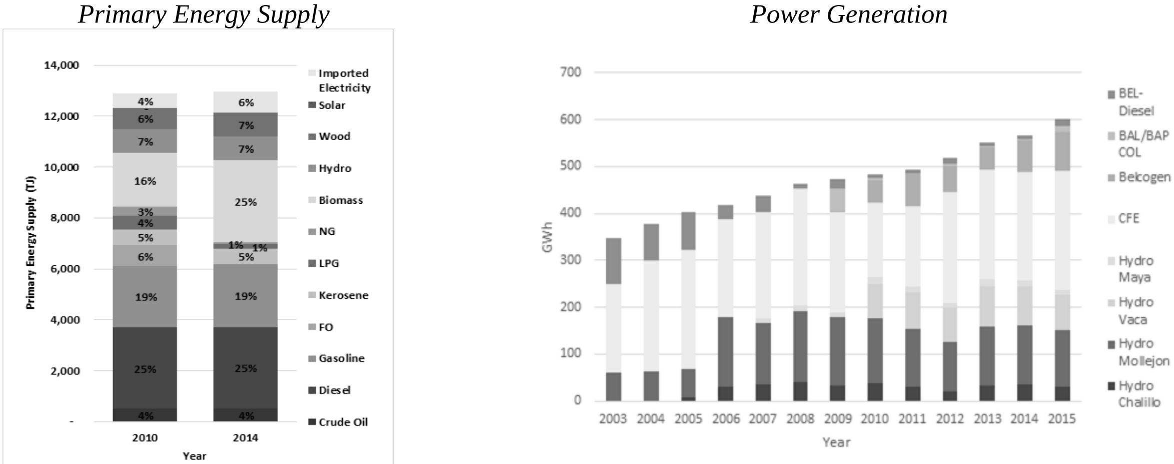
B. Sectoral and Institutional Context

7. **Primary energy demand in Belize has remained steady.** In 2014, the total energy demand in Belize was 11,014 TJ, which has remained steady from 2010 when it was 10,946 TJ.[16] The consumption is primarily from energy for transport, industrial use of liquid fuels and biomass, and power generation as well as the consumption of wood mostly for cooking. The primary energy supply is mostly through liquid fuels and electricity (see figure 2). Some significantly trending shifts from 2010 to 2014 include an over 50 percent increase in the use of biomass because of expanded power generation and nearly 50 percent increase in electricity imports.

[15] Initially issued in year 2000, revised in 2003.
[16] There is very limited data available in Belize, including in the energy sector. Energy balances are not tabulated yearly and the last two accounted years are 2010 and 2014. For 2014, primary energy consumption is an estimate.

Figure 2. Primary Energy and Power Supply in Belize

Primary Energy Supply *Power Generation*



Sources: National Energy Policy Framework 2011, Energy Report 2014, Government of Belize, and BEL.

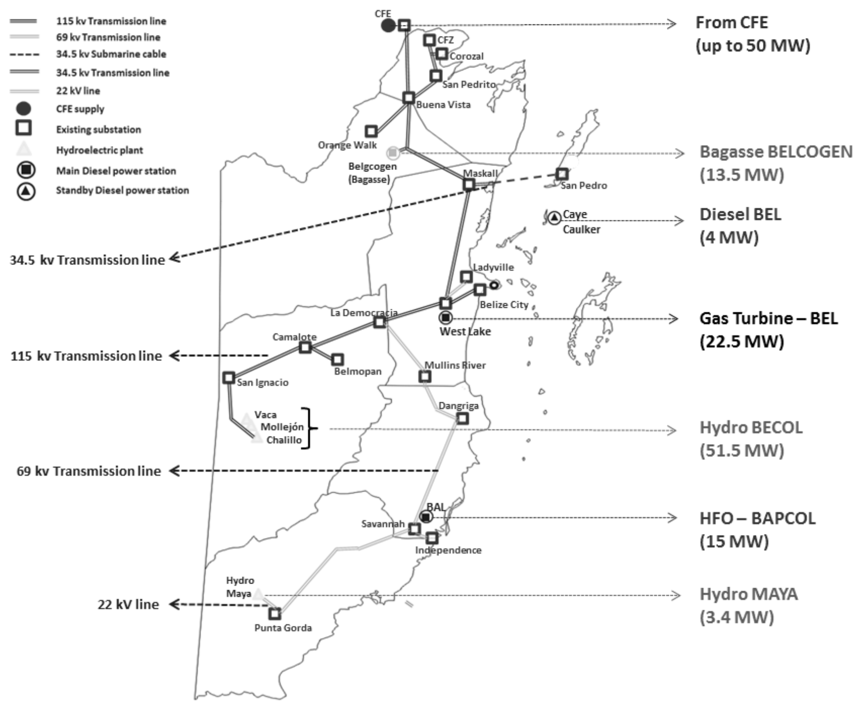
8. **Electricity demand is met mainly through hydropower generation and imports from Mexico**. The installed domestic power generation capacity in the country is 110 MW, with an additional 50 MW of non-firm capacity made available through an interconnection with Mexico.[17] Most of the domestic power generation facilities are privately owned independent power producers (IPPs), while the national power company owns several power plants that operate on diesel,[18] which are primarily used as backup due to their high operational costs. Peak demand is around 86 MW, with demand growing at approximately 5 percent per annum. A majority of the domestic generation is from hydropower[19] that is significantly supplemented by electricity imports from Mexico (see figure 2). However, because the availability of hydropower in recent years has been volatile due to significant variation in precipitation, some domestic generation has been supplanted through electricity produced from bagasse[20]. Such uncertainties are predicted to last and can be attributed to modulations by global climatic phenomena[21]—where the intensities as well as frequencies are likely to increase.[22]

9. **Electricity in Belize is transmitted through a single-circuit radial transmission network, which feeds various distribution systems.** It extends about 400 miles across the country at different voltage levels, ranging from 115 kV in most of the country to a 34.5 kV undersea link to the island of San Pedro (see figure 3). The transmission interconnection with Mexico is also a 115 kV line with a rated capacity of 65 MW. The distribution networks operate at 22 kV, 11 kV, and 6.6 kV in various towns throughout the country. They mostly operate without

[17] An agreement between BEL and the *Comisión Federal de Electricidad* (the power utility in Mexico, CFE) provides Belize up to 50 MW of capacity based on availability at spot market prices.
[18] A 21.5 MW gas turbine at Westlake, which operates on diesel, and 4.4 MW of standby generation capacity in Caye Caulker and San Pedro islands. BEL also has an arrangement with IPP Bapcol, which operates on heavy fuel oil to provide standby capacity for its power system.
[19] From IPPs: Hydro BECOL (51.5 MW installed capacity) and Hydro Maya (3.4 MW installed capacity)
[20] The PUC tendered for 75 MW of capacity from all energy sources, with 15 MW reserved exclusively for solar and wind power. Despite this effort, only a demonstration solar project has materialized to date.
[21] such as El Niño and La Niña and the Atlantic Multi-decadal Oscillation based on Acclimatize. 2016. "Building Climate Resilience in Belize's Energy Sector." Prepared for the Bank.
[22] EuropeAid. 2009. "Climate Change in Latin America."

stress, although some of the 22 kV lines feeding distant areas are excessively long and lead to voltage drops. However, many distribution networks are dependent on a single grid substation with a single transformer, thus limiting the alternate supply possibilities in the event of a major failure.

Figure 3. Diagram of the Generation and Transmission System in Belize (2016)



Source: BEL.

10. **A number of public and private stakeholders participate in Belize's energy sector.** The overall responsibility for the energy sector rests with the Directorate of Energy in the Ministry of Finance, Public Service, Energy and Public Utilities (MFPSEPU). Liquid fuels are supplied primarily through two private companies and they are regulated by different GoB agencies. Electricity services are provided by Belize Electricity Limited (BEL), the national power company. BEL owns and operates all transmission and distribution assets that make up the national grid, while it primarily purchases electricity from IPPs and the CFE with the exception of 26 MW of diesel-based capacity it owns and utilizes for backup purposes. BEL is regulated by the Public Utilities Commission (PUC).

11. **There are a number of risks posed by extreme weather that create vulnerabilities in the energy sector.** A high-level analysis[23] was carried out to map major climate-related risks that are likely to impact Belize and that will expose the vulnerabilities in the energy sector. A total of 23 risks were identified with 14 categorized as being 'very high' or 'high'.[24]

a) **Rise in sea levels** that results in storms surges and inundation makes energy infrastructure such as transmission lines, substations, fuel storage, and some generation vulnerable, particularly

[23] Acclimatize. 2016. "Building Climate Resilience in Belize's Energy Sector" prepared for the Bank, which utilized an energy adaptation toolkit developed by Bank's Energy Sector Management Assistance Program (ESMAP).
[24] The risk register ranks the 'likelihood of occurrence' (L) of a risk and the 'severity of consequence' (S) for each one. Risks of particular concern are the ones where the L and the S are both high.

those in coastal areas including various islands and Belize City. A Bank study[25] concluded that there could be more than a 40 percent increase in Belize's storm surge zone and that the related inundation risk could cover two-thirds of the country's wetlands.

b) **Increasing intensity of hurricanes and tropical storms** can significantly damage energy infrastructure throughout the country, because of a variety of resulting factors including high winds, storm surges, and inundation. This includes damages to infrastructure such as ports, storage depots, and roads that facilitate the supply of fuel; faults in transmission and distribution lines that disrupt electricity services due to fallen trees, damaged poles, and other operational challenges; and constrained access to critical energy facilities to carry out repairs and reconstruction. Climate models are predicting hurricanes and storms impacting the Caribbean region as becoming more intense in the future.

c) **Significant volatility in rainfall patterns** leads to unpredictability in the availability of hydropower, while periods of intense rainfall coupled with deforestation will result in increased sedimentation in reservoirs.

d) **Increase in temperature and severity of droughts** can lead to stresses on energy operations, gradual increases in demand, wild fires that damage energy infrastructure, and limited options that can be reliably cultivated for biomass/biofuels.

12. **The power sector is particularly susceptible to extreme weather and therefore needs to strengthen its adaptive capacity.** Analysis of several past extreme weather events and their impact on the power sector illustrate these vulnerabilities (see Annex 5 for more details). The single-circuit radial transmission network is a reliability concern, because a fault or weather damage in one of its sections can compromise the integrity of the entire network. This was the case in 2007, during Hurricane Dean, when a fault in the CFE system in Mexico triggered a cascade of faults that led to a near-countrywide blackout in Belize. A similar incident occurred in 2010 during Hurricane Richard when a 'trip' in the transmission line was not contained locally leading to a sequence of faults along the East-West transmission line that also cascaded through the southern line. It cut off hydro BECOL from supplying key load centers, and affected over 18,000 customers (about 23 percent of BEL's customer base). Engineering inspections have also discovered several areas where transmission poles and associated structures are weakened because of decay and cracks in some wooden poles and corrosion in waterlogged and saline areas. BEL carries out an aggressive maintenance plan that has prevented a major collapse in the transmission infrastructure thus far. However, repeated storm impacts are progressively weakening some line sections that are more likely to experience a major 'downing' of poles, especially during hurricanes with high winds. In addition, most of the service disruptions during extreme weather events are caused by damages to the distribution systems. For example, 12 of the 13 faults recorded during Hurricane Dean and 15 of the 17 faults recorded during Hurricane Richard affected the distribution network, which, according to BEL, were primarily due to heavy rains, winds, and lightning as well as fallen trees/branches damaging the distribution infrastructure.

13. BEL and the Belizean authorities are experienced at dealing with extreme weather given the country's history. Nevertheless, following Hurricanes Dean and Richard, the recovery in the power sector extended to 4–6 days and 2–4 days, respectively, affecting over 10,000 BEL customers in each instance. While BEL presently has a Hurricane Preparedness Plan, it does not include well-developed protocols for quick and efficient recovery. BEL appears to have adequate

[25] Dasgupta, S. et al. 2009. "Sea-Level Rise and Storm Surges: a Comparative Analysis of Impacts." World Bank.

spare supplies to repair system damages, but its emergency response capabilities can be improved. This includes preventive measures such as better vegetation management, since fallen trees and branches are a significant reason for outages during storms. Planning and preparation are also challenged by the limited availability of data in Belize with regard to energy as well as localized impacts from a changing climate. Better weather information regarding precipitation, hydrology, flooding will improve ongoing sector operations and also help improve future decisions.

C. Higher Level Objectives to which the Project Contributes

14. **The ERCAP is fully consistent with the World Bank Group's Country Partnership Strategy (CPS) for Belize; is in line with the GoB's national development objectives; and supports the global Sustainable Development Goals (SDGs).** The CPS FY2012-FY2015 for Belize (Report#63504), discussed by Executive Directors on July 29, 2011, concentrates on a single area of support for inclusive and sustainable growth and enhanced climate resilience. It is designed to assist the GoB's efforts to adopt a sustainable natural-resource-based economic model while reducing vulnerabilities to the impacts of climate change and natural hazards. The CPS aims to help mainstream policies, strengthen institutional capacity, and support investments—all related to climate change and resilience.

15. The NCRIP, which the GoB prepared with the support of the Bank and other development partners, places particular prominence on "building climate resilience and improving DRM capacities across sectors."[26] The ongoing BCRIP [P127338] is an effort by the Bank to support the NCRIP, with a focus on the transport sector. The ERCAP is designed to address the energy sector aspects of the NCRIP and complement the efforts undertaken though the BCRIP [P127338].

16. The ERCAP is also in line with the broader national development goals that aim to promote economic growth and poverty alleviation, since the unpredictability of natural disasters and the damages and service disruptions pose a major development challenge in Belize. It can rapidly set-back development gains, constrain growth and plunge people into poverty. The interventions in ERCAP will help counter these impacts and contribute towards the Bank's twin goals—to alleviate extreme poverty and boost shared prosperity. The ERCAP is also consistent with the global SDGs, including those focused on 'Climate Action', 'Infrastructure' and 'Poverty'.

II. PROJECT DEVELOPMENT OBJECTIVES

A. PDO

17. The project development objective (PDO) is to demonstrate solutions that enhance the resilience of the energy system to adverse weather and climate change impacts. This will be collectively achieved by implementing a wide-ranging and complementary set of activities that include pilot initiatives, infrastructure hardening, and analytical and planning efforts. While most interventions will rely on proven technologies and established global experience, the project is demonstrative in nature due to its customized application to fit the specific conditions of Belize's power sector, learning aspects, and the effort to integrate localized impacts of climate change.

[26] Intended Nationally Determined Contribution submitted by the GoB to the UNFCCC on October 1, 2015.

Project Beneficiaries

18. The primary beneficiaries of the ERCAP are Belizean citizens, specifically residential and business energy consumers, who will have more reliable services, with fewer disruptions, especially during adverse weather. Given that energy is a key component of economic activity, the overall economic benefit from a more reliable power system can be significant and sizable (see Annex 5 for estimated economic impact due to electricity service disruptions during several extreme weather events). This reflects the interdependency amongst different sectors such as the need for electricity in order to facilitate emergency services including hospital operations and pumping water to relieve from flooding; as well as to maintain continuity in commercial and industrial operations. Therefore, implementing a wide-ranging set of solutions within a coordinated framework among multiple institutions, the ERCAP can have far reaching impacts on the well-being of Belizean citizens. Enhanced security of supply and greater reliability of electricity services will ultimately benefit all BEL consumers, which would total 274,000 people (78% of population) at present; although, the wider economic benefits will be reaped by anyone in Belize that rely on goods and services with electricity as an input. In addition, ERCAP's lessons can also have regional implications due to its potential replicability in other countries.

PDO Level Results Indicators

19. The following indicators are selected as proxy measures for evaluating the results of the project outcome and the achievements of the development objective (details included in Annex 1):

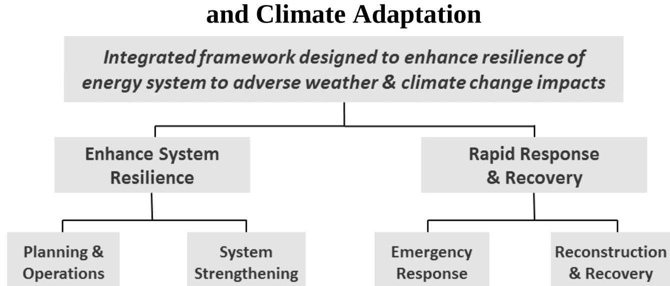
a) Methodologies and procedures to incorporate climate resilience in long-term planning of energy infrastructure and systems developed and adopted.
b) Enhanced security of electricity supply (due to reduced outages) despite weather events, for all electricity consumers, as a result of the greater availability of multiple generation sources (less supply disruptions) due to segmentation of entire transmission network (installation of protection to prevent cascading line faults).
c) Weak transmission sections in the system reinforced to be more resilient.

III. PROJECT DESCRIPTION

A. Project Components

20. Better adaptation to adverse weather that is likely to be exacerbated due to climate change impacts requires enhancing energy resilience through: (a) strengthening existing infrastructure (hardening) and operational capabilities in the sector to limit damages and minimize service disruptions; and (b) improving the capabilities to respond rapidly and recover efficiently from the residual damages that will occur. This integrated risk management framework could also include financial instruments/mechanisms for better allocation of risks and for compensation. This framework for resilience, as illustrated in figure 4, was applied to identify key risks and a set of priority investments and technical assistance activities that are included in the ERCAP. They form a wide-ranging and

Figure 4. Framework for Energy Resilience and Climate Adaptation



Source: Adapted from Ebinger and Vergara. 2011. "Climate Impacts on Energy Systems." World Bank.

complimentary set of solutions that will help immediately enhance and sustain the resilience of the energy sector over the long term. The ERCAP also provides a learning opportunity through piloting and demonstration that will better inform additional future actions for progressively and continuously enhancing the resilience of the energy system.

21. The ERCAP's primary focus will be on the power sector due to its risk exposure and significance, but will also cover the broader energy sector. It will be implemented by the MFPSEPU (including the National Meteorological Service, [NMS]) and BEL. The ERCAP includes three components with the following activities (implementing agencies noted in brackets):

22. **Component 1: Long-Term Planning and Capacity Building for Adaptation**

a) **Develop the capacity in Belize to carry out long-term energy and climate adaptation planning** to identify policies, investments, and capabilities that are necessary to achieve the GoB's objectives in addressing the vulnerabilities in the energy sector, including the introduction of climate change impacts. This will include addressing significant gaps in socioeconomic and energy data, systemic collection of localized climatic and weather information, developing a predictive model for the energy sector to test the impact of policies and investments, and strengthening capacity to periodically update and refine the model. It will have input from multiple stakeholders and citizens. (MFPSEPU)
b) **Enhance the collection of meteorological and hydrological data** through the installation of 23 meteorological and 6 hydro-meteorological monitoring stations, and the hydrological modeling of the Macal Catchment Area where the BECOL hydropower plants are located. The information collected will be made available to BEL in real time to improve its dispatch and operational capabilities, and serve as an input for integrating more reliable weather information and localized climatic impacts in long-term planning. (MFPSEPU/NMS)
c) **Design and implement an Emergency Response and Recovery Plan** for the power sector. This will include the assessment of BEL's current Hurricane Preparedness Plan, development of protocols and procedures for rapid response and efficient reconstruction from damages, and strengthening of the institutional capabilities for implementation. (BEL)

23. **Component 2: Demonstration Measures to Enhance Resilience of Energy Sector**

a) **Segment the transmission network** to isolate faults and limit the impact of system failures for minimizing cascading blackouts across the system. This will include upgrading of key substations with adequate protections that will help contain faults enabling all generation sources to be available for dispatch to parts of the system that are operational. (BEL)
b) **Strengthen transmission network structures** to withstand extreme weather events with minimal damages. This will include evaluating the suitability of different materials for identified terrain types; and demonstrating their application through the rehabilitation and replacement of transmission poles and associated infrastructure in line segments that are identified as being weakest. (BEL)
c) **Implement measures to enhance resilience of distribution substations** for maintaining system operations. This will include structural improvements to damaged control buildings at existing distribution substations, and the relocation and securing of battery banks within premises of substations that are susceptible to flooding. (BEL)

d) **Enhance the capabilities for better systems operation and management** to increase adaptive capacity. This will include the establishment of a backup load control and dispatch center that can substitute if BEL's main location in Belize City becomes inoperable; development of an outage management system; piloting Advanced Metering Infrastructure (AMI) that, among other things, enables enhanced awareness of customer outages; and access to real-time meteorological and hydrological information (via NMS/Component 1). These measures will enable improved system operations and response following storms. (BEL)

e) **Improve the communication network** for better command and control coordination during response and recovery operations. This will include the upgrade to a digital very-high frequency (VHF) system; purchase of mobile repeater stations; and the identification of dead spots that will be fortified through the installation of additional relays with the aim of providing full coverage to all transmission and distribution network locations. (BEL)

f) **Develop a strategy for better vegetation management practices** for reducing potential damages to the transmission and distribution infrastructure from fallen trees and broken branches, and improving access to sites during emergencies. This will include the incorporation of good vegetation management practices that are applied by other utilities, customized for application in BEL's operations under the conditions in Belize. (BEL)

24. **Component 3: Project Implementation Support and Information Dissemination for Knowledge Sharing**

a) **Disseminate information and engage citizenry on lessons learned and potential for replication** of approaches to resilience demonstrated through ERCAP, including carrying out national and regional citizen/stakeholder workshops. (MFPSEPU)

b) **Support incremental coordination and implementation activities**, including FM, procurement and safeguards support. (MFPSEPU/BEL)

25. ERCAP components and implementing agencies are further detailed in Annex 2; Annex 3; as well as section IV-A of the main section of the PAD.

Box 1. Financial Arrangements to Address Catastrophic Risks in Belize

The ERCAP primarily focuses on physical investments and technical assistance activities. It is complemented by additional financial arrangements made by the GoB and BEL to address the financial implications of catastrophic risks.

Caribbean Catastrophe Risk Insurance Facility - Private commercial insurance has become costly and unaffordable for many Caribbean countries, which have resorted to alternate means. One such endeavor is the Caribbean Catastrophe Risk Insurance Facility (CCRIF), which was established in 2007 with the assistance of the Bank, to pool resources to provide insurance that cover damages related to risks associated from tropical cyclones, earthquakes, and excess rainfall. The CCRIF has 17 member countries at present including Belize. The GoB currently subscribes to the tropical cyclone policy with coverage of US$16 million and earthquake policy with coverage of US$2.5 million. While the CCRIF insurance is not sector-specific, it could be channeled to support the energy sector, should the GoB decide to do so.

BEL Catastrophic Reserve Fund - Before 2002, the BEL obtained insurance coverage for its assets through private sources until the premiums in the Caribbean became cost-prohibitive. Since then, the GoB addresses the need for insuring assets through its utility regulator, the PUC, which mandates the BEL to maintain a reserve fund of US$5 million on its balance sheet. During a natural-disaster-led emergency, the BEL, in consultation with the PUC, may draw down on the reserve fund to cover costs toward response and recovery of the power system. Subsequently, the BEL may agree with the PUC to augment its future electricity tariffs to replenish the catastrophic reserve fund.

B. Project Financing

26. The ERCAP is to be funded through an US$8 million grant from the Global Environment Facility's (GEF) Special Climate Change Fund administered by the Bank. Each implementation agency will also contribute in cash and in-kind towards ERCAP. Further details are in Annex 2.

Project Cost and Financing

Table 1. Project Cost and Funding

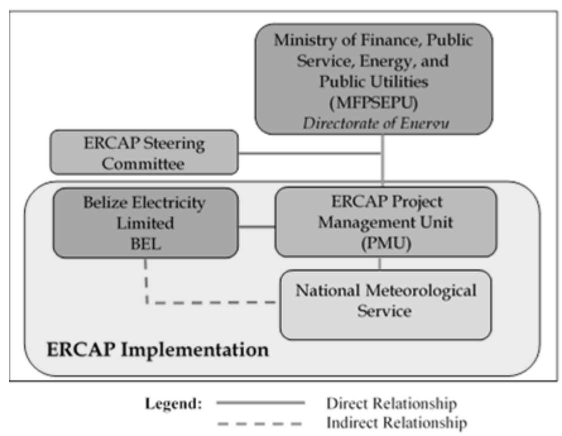
Project Components	Project Cost (000 US$)	GEF Funding (000 US$)	% GEF Funding
1. Long-Term Planning and Capacity Building for Adaptation	2,794	2,359	84
2. Demonstration Measures to Enhance Resilience of Energy Sector	8,435	5,060	60
3. Project Implementation Support and Information Dissemination for Knowledge Sharing	586	421	72
Contingencies	*160*	*160*	*100*
Total Costs	**11,975**	**8,000**	**67**

IV. IMPLEMENTATION

A. Institutional and Implementation Arrangements

27. The ERCAP is implemented by multiple agencies with a common thread of building resilience for climate adaptation in the energy sector. The multi-agency nature reflects the comparative advantage and responsibilities of each participating institution, which are needed to achieve the project objectives. Due diligence confirmed that each agency has sufficient capacity commensurate with project implementation requirements. (Figure 5 provides a graphical depiction and further details are in Annex 3).

Figure 5. Illustration of Project Implementing Structure



a) **MFPSEPU,** through its Directorate of Energy, oversees the energy sector. It will also be responsible for overall implementation of the ERCAP. MFPSEPU has established a PMU, which, with the assistance of a project manager, will help implement activities that are directly under the MFPSEPU as well as coordinate ERCAP activities with other implementing agencies. MFPSEPU will also establish a high-level, multi-stakeholder Project Steering Committee (PSC) at ERCAP's inception, which will help guide overall implementation.

b) **NMS** is a department within the Ministry of Works, Transport, and National Emergency Management, which is the GoB authority on weather and climate. The NMS will be a sub-implementing agency in the ERCAP responsible for hydrological and meteorological data collection. The fiduciary functions for the NMS will be carried out by the MFPSEPU.

c) **BEL**, as the national power company, will be responsible for implementing all activities directly related to the power system under the ERCAP. Within BEL, the ERCAP activities will be managed by the Directorate of Systems Planning and Engineering in coordination with other relevant departments. BEL will also participate in the long-term energy planning activity.

B. Results Monitoring and Evaluation

28. The ERCAP PMU will have overall responsibility for monitoring the project's results. Under Component 1, the PMU will coordinate with NMS to monitor the coordination of the various planning and data collection exercises, including the activities under the MFPSEPU. For activities associated with the power system and the utility under Components 1 and 2, BEL will report to the PMU on its implementation performance.

29. The ERCAP PMU will be required to monitor implementation progress and prepare monitoring and evaluation reports, which include: (a) semi-annual progress reports, based on framework in Annex 1; (b) quarterly interim financial reports (IFRs); and (c) annual independent financial audits of the project. In addition, a comprehensive evaluation of the project's results will be undertaken, including stakeholder and citizen consultation, during the midterm review.

C. Sustainability

30. The GoB has demonstrated a strong and consistent commitment to building infrastructure resilience as it is a development imperative for the country. This is reflected in the number of policy and institutional actions it has taken for disaster preparedness. The proposed project helps take it to the next level by helping develop the capacity in Belize to undertake long-term energy planning with consideration of climatic impacts; and assisting the GoB to take informed climate actions. Many of the activities to be implemented by BEL will improve its system operation even if the primary focus is on managing the risks posed by extreme weather. The demonstration solutions under ERCAP will provide a foundation for BEL to better adapt to evolving future needs.

V. KEY RISKS

A. Overall Risk Rating and Explanation of Key Risks

31. The overall risk rating for the proposed project is Moderate, as it is modest in scale and activities are relatively straightforward. Some key risks and mitigation measures are as follows:

32. **Multi-agency implementation.** Although the activities within the project are modest in scale and complexity, the ERCAP has multiple implementing agencies (that is, BEL, the MFPSEPU, and NMS as a sub-implementing agency) that pose a coordination risk. This is mitigated through the ERCAP PMU that will coordinate activities among the multiple agencies, and through the high level strategic guidance provided by the multi-stakeholder PSC.

33. **Limited institutional and technical capacity for strategic planning.** The ERCAP is supporting the urgent need to strengthen the capacity for climate adaptation and energy planning. A potential risk is that the transfer of knowledge and capacity built will be short-lived and the work will not continue beyond the ERCAP. This risk is mitigated by hiring two specialists, who will be initially funded and trained through ERCAP on energy planning taking into account climate impacts. They will be subsequently hired as staff of MFPSEPU, based on their performance.

VI. APPRAISAL SUMMARY

A. Economic Analysis

34. The ultimate economic benefit of the collective activities in ERCAP is to provide enhanced security to electricity consumers of reduced service disruptions due to risks posed by adverse

weather and climatic impacts. However, a traditional cost-benefit analysis is not an appropriate evaluation tool given the nature of the project. This is primarily because (a) the activities in the ERCAP are demonstrative and include pilots and small-scale investments; (b) while the general climatic trends are definitive, currently available information is not adequate to predict with precision the specific localized weather conditions; (c) given the various ways in which extreme weather can manifest (that is, some storms with high winds and others with greater precipitation/flooding), it is difficult to predict specific future impacts on the power system; and (d) the impact of climate change occurs over very long periods of time during which the project benefits may be realized. Component 1 aims to improve long-term energy planning introducing elements of climate change, which will result in improved reliability and optimized investments in the sector taking climate adaptation into consideration. With regard to activities in Component 2, several past extreme weather events were evaluated and its resulting disruption to electricity services were estimated in terms of lost economic value added (see Annex 5 for details). The overall economic impact on GDP due to unserved energy (USE) estimated between US$4 - US$5 million for each hurricane. It provides an indication of the scale at which there could be economic savings by protecting assets and limiting service disruptions due to extreme weather and climatic events. Such losses can set back development gains and efforts to alleviate poverty given the significant segment of Belizean population identified as poor or susceptible to falling into poverty.

B. Technical

35. The activities included in the project were selected for the ERCAP following a review of existing technical documentation and proposals, BEL's least-cost systems plan, discussions with senior GoB officials and management and staff at BEL, with reference to good industry practices. The planning exercise in Component 1 was developed in consultation with the Latin American Energy Organization (OLADE), which will provide the software and the planning model template. The weather monitor specifications are based on data requirement for BEL's systems operation and long-term planning requirements of MFPSEPU. The systems upgrades to BEL are based on a least cost systems planning study and engineer assessments. Upgrades to the transmission structures will be taken only after evaluating different materials for their suitability under different terrain types. The improvement to vegetation management practices and development of an Emergency Response and Recovery Plan will be undertaken with input from specialists on the subject before recommendations are adopted by BEL. The communication upgrade will be undertaken after carrying out a spectrum analysis to identify dead spots in the system. On the basis of this due diligence, all activities are designed in compliance with industry/best practice standards.

C. Financial Management

36. The project activities, for financial management (FM) purposes, will be implemented by two primary entities, the MFPSEPU and BEL (FM arrangements for sub-implementing entity, NMS will be handled by MFPSEPU). These entities will be responsible for the project fiduciary functions that cover their activities. A FM capacity assessment of the FM arrangements existing at the two entities was conducted by the Bank. The FM arrangements were deemed to be adequate and are acceptable according to the requirements of OP 10.00 - Investment Project Financing. The FM function will be intertwined with the existing structure used by each implementing entity; thus, the project's accounts will be maintained using the following accounting systems: (a) SmartStream (the GoB's accounting system) for MFPSEPU and NMS activities; and (b) Great Plains for BEL activities. Grant funds will be transferred to the two implementing entities as described in the funds

flow section of Annex 3. Annual external audits of the project's financial statements covering the periods ending March 31 are required to be submitted to the Bank within 6 months after each fiscal year end. Quarterly unaudited IFRs will be submitted within 45 days after each quarter end.

37. Although each implementing entity has good internal controls, they have limited or no recent experience with implementing Bank projects. Additionally, the project design is complex as implementation of activities is split among two separate entities (including a sub-implementing agency). The Bank will however ensure that the finance officers for the respective implementing entities maintain correct and appropriate records in line with good accounting practices and that relevant personnel from each implementing entity are duly trained in the Bank's operations and guidelines. The detailed FM arrangement is discussed in Annex 3.

D. Procurement

38. Procurement for the proposed RETF grant will be carried out in accordance with the WB "Guidelines: Procurement of Goods, Works, and Non-Consulting Services under IBRD Loans and IDA Credits & Grants, dated January 2011, Revised July 2014, and "Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits & Grants " dated January 2011 and Revised July 2014, and the provisions stipulated in the Grant Agreements. The various procurement actions under different expenditure categories are described in general in Annex 3. For each contract to be financed under the grant agreements, the various procurement or consultant selection methods, the estimated costs, prior/post review requirements, and timeframe have been agreed between the recipient and the Bank in the Procurement Plans (PPs), which will be updated annually or as required to reflect the actual implementation and institutional needs.

39. The procurement activities will be carried out by each implementing agency. Procurement Risk Assessment and Management of the capacity of each Implementing Agency was carried out over a series of missions from 2014-16 by the Bank in line with the Procurement Risk Assessment and Management System (PRAMs) Module, and the PRAM Questionnaire was completed by each implementing agency. The Procurement Assessment and Arrangements are detailed in Annex 3.

E. Social (including Safeguards and Stakeholder Consultations)

40. Overall, the project is expected to have positive social outcomes for the citizens of Belize since it improves the reliability of the energy system to adverse weather and climate change impacts. The direct beneficiaries are energy consumers, including business and households, which will experience more dependable energy services with fewer disruptions, especially during adverse weather conditions. Given that energy is a facilitator of economic activities, the entire economy will benefit from improved energy supplies and help mitigate some of the economically disruptive effects that result from catastrophic weather events.

41. Consultations on the overall project were held on June 2, 2015, with key citizen stakeholders including representatives from the private sector, government, non-governmental and regional organizations. Each project implementation agency presented the activities they plan to undertake through the ERCAP. Overall, the citizen engagement validated the project design acknowledging the benefits of addressing with urgency the impacts from climate change.

42. *OP 4.10-Indigenous Peoples*. Policy not triggered. A screening concluded that the project activities will not affect indigenous peoples, although overall they will likely benefit.

43. *OP 4.12-Involuntary Resettlement.* Safeguard not triggered. A screening determined that small works will not involve physical relocation of persons or land acquisition. Most works will be in uninhabited public lands except some weather monitors located voluntarily on private lands.

F. Environment (including Safeguards)

44. The ERCAP is classified as Category B since it is likely to have limited and reversible environmental impacts that can be readily mitigated. The environmental safeguards triggered are OP 4.01- Environmental Assessment; OP 4.04- Natural Habitats; and OP 4.09 – Pest Management.

45. Regarding Component 1 (installing 29 MET/HYDROMET monitors) and Component 2 (improving transmission and distribution infrastructure), potential adverse environmental impacts are minor because they are small works, and will be mitigated by the application of Environmental Codes of Practice (ECOP) developed for the ERCAP. The activity on improving BEL's vegetation management practices is confined to the study, and ERCAP does not support its implementation. However, OP 4.09 is triggered on a precautionary basis in case the study recommends a solution that utilizes herbicides; in which case the plan will be develop in compliance with Bank policy.

G. Other Safeguards Policies Triggered

46. **OP/BP 7.60 - Projects in Disputed Areas.** This policy is applicable to ERCAP because of the long-standing territorial dispute between Belize and Guatemala. The project will fund technical assistance and investment activities where most will focus on upgrading existing infrastructure in various areas of the country to be more resilient. Some locations may fall within the general area known to be in dispute. The ERCAP does not prejudice the position of either the Bank or the two countries involved. It is emphasized that by supporting the project, the Bank does not intend to make any judgment on the legal or other status of the territories concerned or to prejudice the final determination of the parties' claims. In line with OP/BP 7.60, the Bank has ensured compliance with the requirements of the policy. The Bank has determined that given that the project activities entail primarily pilots and small scale investments that upgrade existing energy infrastructure and technical assistance for long-term strategic planning, the Project is not harmful to the territorial interests of Guatemala in line with paragraph 3(b)(i) of the OP 7.60.

H. World Bank Grievance Redress

47. Communities and individuals who believe that they are adversely affected by a World Bank (WB) supported project may submit complaints to existing project-level grievance redress mechanisms or the WB's Grievance Redress Service (GRS). The GRS ensures that complaints received are promptly reviewed in order to address project-related concerns. Project affected communities and individuals may submit their complaint to the WB's independent Inspection Panel which determines whether harm occurred, or could occur, as a result of WB non-compliance with its policies and procedures. Complaints may be submitted at any time after concerns have been brought directly to the World Bank's attention, and Bank Management has been given an opportunity to respond. For information on how to submit complaints to the World Bank's corporate Grievance Redress Service (GRS), please visit http://www.worldbank.org/GRS. For information on how to submit complaints to the World Bank Inspection Panel, please visit www.inspectionpanel.org.

Annex 1: Results Framework and Monitoring

Belize: Energy Resilience for Climate Adaptation Project

Project Development Objective: The PDO is to demonstrate solutions that enhance the resilience of the energy system to adverse weather and climate change impacts.

PDO Level Results Indicators	Core	Unit of Measure	Baseline	Cumulative Target Values**				Frequency	Data Source/ Methodology	Responsible for Data Collection	Description (indicator definition, and so on)
				YR1	YR2	YR3	YR4				
Indicator One: Methodologies and procedures to incorporate climate resilience in long-term planning of energy infrastructure and systems developed and adopted	☐	Yes/No	No	No	No	No	Yes	Once, at conclusion of project when long-term energy plan is fully developed	Model developed, surveys carried out, trainings conducted, technical documentation	MFPSEPU	Measures whether the MFPSEPU has improved its institutional capacity to carry out long-term sector planning, including the ability to incorporate climate resilience considerations in its strategies
Indicator Two:	☐									BEL	Measures the successful implementation of protections at substations for segmenting key transmission sections linked to each generation node. This would result in: a) isolation of line faults without cascading through the system, b) all 7 generation sources able to dispatch to operational segments, c) up to full generation capacity is available for dispatch to operational segments and d) reduce service disruptions to all BEL residential customers, including e) female beneficiaries.
• Transmission network segmented and protected against cascading line faults		Partial/ Complete	Partial	Partial	Partial	Complete	Complete	Following segmentation	Specialist assessment		
• Generation sources available for dispatch despite line faults		Number	5	5	6	7	7	Yearly	Specialist assessment		
• Generation capacity available for dispatch despite line faults		MW	82.5	82.5	96	100	110	Yearly	Specialist assessment		
• Electricity consumers with enhanced security of electricity supply (reduced outages) despite weather events		Number[27]	-	-	-	274,000	274,000	Following segmentation	BEL and Census Data		
- Of which, those who are women		Number[28]	-	-	-	139,192	139,192	Following segmentation	BEL and Census Data		
Indicator Three: Weak transmission sections in the system reinforced to be more resilient	☐	Number of new poles installed	0	0	30–60	60–130	130–160	Yearly	Specialist assessment, technical reports	BEL	Measures how many new poles have successfully been installed in the weakest sections of the transmission line, resulting in increased resilience in the most vulnerable sections

[27] Based on total BEL residential customers (66,835 households in 2014) multiplied by the average number of people per household (4.1 based on 2010 census)
[28] Percentage of total population benefitting from project (274,000) multiplied by the proportion of female population (50.8 percent based on 2010 census)

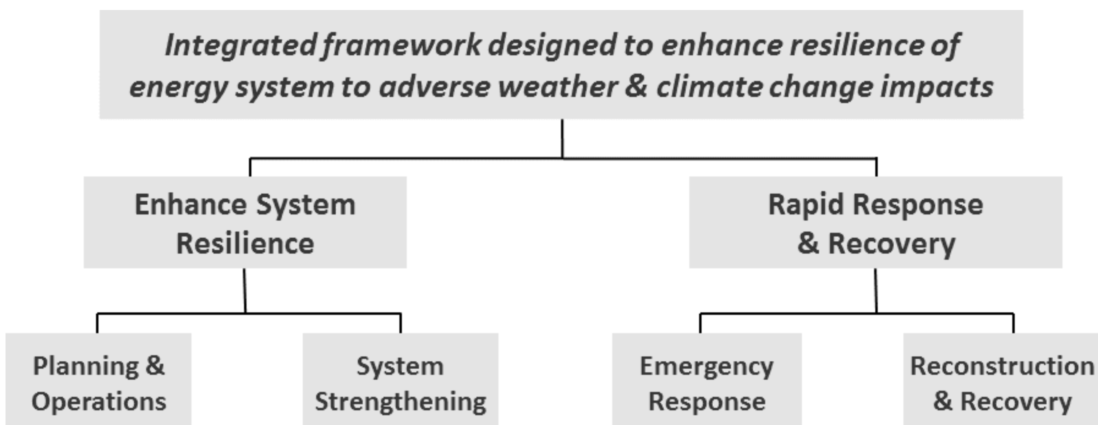
INTERMEDIATE RESULTS											
Intermediate Result (Component One)											
Intermediate Result Indicator One: Strengthened long-term planning capabilities for the energy sector	☐	Number of training sessions conducted	0	2	4	6	8	Yearly	Number of people trained, list of training sessions	MFPSEPU	Measures efforts to increase national capacity for sector long-term planning, including integration of climate impacts, through the training of key personnel.
Intermediate Result Indicator Two: Improved availability of weather and hydrological information	☐	Number of weather monitors installed	0	0	19	29	29	Yearly	Technical reports/visual observations	MFPSEPU/ NMS	Measures the increase in real-time availability of data for BEL for improved weather and hydrological forecasting and system operation.
Intermediate Results (Component Two)											
Intermediate Result Indicator Three: Appropriate technologies identified to be used for transmission line design for different terrain types	☐	Yes/No	No	No	Yes	Yes	Yes	Upon conclusion of options study comparing different technologies	Technical report	BEL	Measures if various technology material options have been evaluated to form a basis for informed decisions on an approach to strengthen the transmission line sections/network
Intermediate Result Indicator Four: Options for improving BEL's vegetation management practices identified.	☐	Yes/No	No	No	Yes	Yes	Yes	Upon completion of vegetation management study	Technical report	BEL	Measures if the study on vegetation management practices have been successfully carried out to provide BEL with options to consider for implementation.
Intermediate Result (Component Three)											
Intermediate Result Indicator Five: Regional stakeholder and citizen engagement conferences held to evaluate and disseminate lessons learned and results achieved in project for enhancing energy resilience	☐	Number of events	0	0	1	0	1	Mid-Term Review at end of year 2, & regional results sharing at end of project	Conference documentation	MFPSEPU	Indicates whether input from and useful lessons and conclusions from the project have been disseminated widely to Belizian as well as the regional stakeholders.

Annex 2: Detailed Project Description

Belize: Energy Resilience for Climate Adaptation Project

1. The ERCAP is designed to demonstrate solutions that enhance resilience of the energy system to adverse weather and climate change impacts in Belize. It covers a comprehensive set of investments/activities for enhancing resiliency in the energy sector, particularly as it pertains to electricity supply. As figure 2.1 illustrates, enhancing energy resiliency for climate adaptation through an integrated risk management framework is primarily separated into (a) enhancing system resilience to maximize capacity to withstand adverse weather and climatic impacts, through a combination of better planning and improved systems operations and strengthening the system itself and (b) being better prepared for expeditiously responding when damages are sustained, and for efficiently and quickly recovering from the event. This can also include financial instruments/mechanisms that better allocate risks and provides compensation to cover potential damages.

Figure 2.1. Framework for Energy Resilience and Climate Adaptation



Source: Adapted from Ebinger and Vergara, "Climate Impacts on Energy Systems", The World Bank, 2011.

Project Components and Key Activities

2. The following section details the three components included in the ERCAP. The supported activities reflect the framework for energy resilience and climate adaptation, as shown in figure 2.1.

Component 1: Long-Term Planning and Capacity Building for Adaptation (US$2,794,000 [GEF US$2,359,000; GoB US$435,000 in-kind])

3. The long-term success of climate adaptation in Belize rests on well-informed, evidence-based planning that mainstreams measures that enhance energy resilience. As noted by Ebinger and Vergara (2011), "all evidence suggests that adaptation is not an optional add-on but an essential reckoning on par with other business risks."[29] To achieve this end, it will require strategic

[29] Ebinger, J. and W. Vergara. 2011. "Climate Impacts on Energy Systems." World Bank.

planning, data collection, as well as strengthening the adaptive capacity of the energy sector in Belize.

4. The following activities will be carried out under this component.

a) **Develop the capacity in Belize to carry out long-term energy and climate adaptation planning** (MFPSEPU)

b) **Enhance the collection of meteorological and hydrological data** (MFPSEPU/NMS)

c) **Design and implement an Emergency Response and Recovery Plan** (BEL)

5. **Long-term energy planning and capacity building for climate adaptation.** The primary objective of this activity is to develop adequate capabilities in MESTPU's demand analysis and long-term energy planning to increase the resiliency of the energy systems by testing policies and programs that will address some of the risks induced by climate change on existing and future infrastructure to manageable levels. It focuses on the systematic preparation of a long-term energy plan (2035), using a scenario approach to test policy considerations and introduce the integration of climatic impacts. It will be carried out by a Belizean team (BT) established by the MFPSEPU with the assistance and support of high-caliber international experts/trainers and 1–2 local consultants with recognized skills and/or potential for carrying out energy planning post training. The local consultants are expected to be recruited to reinforce the energy team in the MFPSEPU and sustain capacity within the ministry team to revise the long-term plan periodically.

6. The preparation of the long-term plan and the associated capacity building of the BT will require a number of interrelated steps. First, it will require the acquisition, development, and adaptation of an appropriate energy-planning model to meet Belize's needs. The MFPSEPU has indicated a preference for a framework model utilizing the *Simulación y Análisis de la Matriz Energética* developed by OLADE, which also meets the needs of an effort for standardization across the Caribbean Community countries. Collection of the detailed data on energy consumption, energy resources, and energy transformation and development of databases to meet *Simulación y Análisis de la Matriz Energética* requirements. Reliable detailed data are paramount for the use of framework models. Therefore, any identified vital data gaps will be filled by means of additional targeted data collection by the Statistical Institute of Belize using a standardized pre-tested survey instrument with a representative sample of energy end users including residential, commercial, industrial/agricultural, and transportation users. This will help incorporate important socioeconomic dimensions such as gender and vulnerable populations. The meteorological and hydrological data that are collected through the proposed project will also be incorporated into the energy planning framework model. Once the relevant data are gathered, the BT, initially with the assistance of international specialists, will develop multiple planning scenarios including ones that will demonstrate potential climatic risks. The aim is to establish adequate capacity within the BT to sustain the long-term planning function where climate impacts are also mainstreamed; and allow them to periodically update the plans with progressively reduced external assistance. To facilitate the sustained capacity to carry out further analyses, a handbook on long-term energy planning will be prepared as a reference as well as to guide the MFPSEPU's Department of Energy as its personnel evolve. The cost of the two specialists within the BT will be covered by the ERCAP for the first two years, after which the MFPSEPU has agreed to hire them on its budget, subject to

their performance. Additionally, further steps will be taken to help address the institutional issues to sustain the long-term planning function within the Directorate of Energy within the MFPSEPU.

7. **Meteorological and Hydrological Data Collection.** Improvements to the accurate and consistent collection of metrological and hydrological data will significantly improve the understanding of localized impacts of long-term climate and weather related impacts; and also provide better short-term forecasts that will improve dispatch of hydropower, help better prepare for extreme weather events, and optimize system operations. Therefore, the proposed project, through the MFPSEPU, will support the NMS to install 23 automatic weather stations in government properties across the country, which will extend and upgrade NMS' existing capacity to monitor and collect data. It will help progressively develop a substantial database of meteorological information that will be made publicly available and also serve as input to the long-term energy and climate adaptation planning activities that are also being supported under the proposed project. The proposed project, through MFPSEPU, will also support the NMS to install six hydro-meteorological automatic weather stations and six rainfall stations on public properties in the Macal Catchment Area close to the three cascading hydro power stations. It will provide hydrological and related data, which will be utilized to develop a comprehensive hydrological model; and also serve as input to the long-term energy and climate adaptation planning, given the risk posed by increasing fluctuations in rainfall that is exacerbated due to climate change. The NMS will also provide this information and forecasts in real time to BEL, to improve the power company's short-term forecasts and dispatch capabilities for more resilient operations.

8. **Emergency Response and Recovery Plan.** BEL presently has a Hurricane Preparedness Plan, but it does not include well-developed protocols for quick and efficient recovery. Therefore, restoration actions during emergency situations or following extreme weather conditions are carried out on an ad hoc basis, reducing the efficiency of the interventions and likely extending the recovery time. Therefore, the ERCAP will include assistance for BEL to secure advice to explore options and develop a storm emergency preparedness and recovery plan; and the necessary institutional procedures and protocols for its effective implementation. The consultant (s) that assist BEL should be a firm with comprehensive emergency response and recovery expertise, including experience carrying out damage assessments based on internationally recognized good practices adapted to the institutional structure of BEL and specific conditions of the power system in Belize. As a part of this activity, engagement of and visit to selected utilities will be included for the exchange of knowledge and experiences.

Component 2: Demonstration Measures to Enhance Resilience of Energy Sector (US$8,435,000 [GEF US$5,060,000; BEL US$3,375,000 in-cash])

9. This component includes a wide-ranging set of strategic demonstration activities and investments that are focused around power sector transmission and distribution systems and infrastructure.

10. The following activities will be included under this component.

a) **Segment the transmission network** (BEL)

b) **Strengthen transmission network structures** (BEL)

c) **Implement measures to enhance resilience of distribution substations** (BEL)

d) **Enhance the capabilities for better systems operation and management** (BEL)

e) **Improve the communication network** (BEL)

f) **Develop strategy for better vegetation management practices** (BEL)

11. The Belize power transmission and distribution systems and infrastructure are particularly vulnerable to adverse weather conditions intensified by recent climate changes. Each major hurricane as well as tropical storm that affected Belize left behind fallen power lines and damage to various equipment and installations that resulted in substantial financial losses for rehabilitating and recovering the systems, often exceeding US$4 million per event. In addition, the loss of power at such critical moments has adversely affected electricity consumers and even cost BEL with regard to lost revenue or the need to utilize more costly alternative sources to supply the grid. The overall impacts on the economy have been estimated to be even greater, dealing setbacks to economic development efforts. The proposed project aims to strengthen the transmission and distribution networks to better withstand impacts from adverse weather in the future and, in circumstances when damage to the system does occur, to expeditiously respond and efficiently recover operations. The goal is to minimize loss of services and financial losses as a result of the enhanced resilience in the power system.

12. **Segmentation of the transmission network.** BEL's transmission system consists of about 400 miles of lines at two voltage levels, 115 kV and 69 kV. The network was built commencing in 1994 with successive expansion over the years and presently includes 15 grid substations (including both generating stations and grid substations to connect with the distribution system). When the network was originally constructed, many substations were supplied from 'tee off' or spur lines, which does not allow for the protection of the transmission line to be 'segmented' between adjacent grid substations. A majority of the 'faults' or disturbances that cause service interruptions on a transmission line are caused during adverse weather conditions (lightning and heavy rain).[30] The impacts on service can be widespread in the absence of protection or segmentation. However, if protection devices are installed to segment the transmission network, then the section of the line between the nearest circuit breakers is automatically disconnected when a disturbance to the system occurs. The disconnection affects only the section of the line between the two points at which line circuit breakers have been installed. When a line is 'segmented' (that is, circuit breakers are installed between two line 'segments'), only the section containing the fault will be disconnected keeping the remainder of the line energized and avoiding a cascading impact by leaving the rest of the system operational. Furthermore, although BEL's transmission system is a single circuit network, it is supplied by multiple generation points, and the loss of any one 'segment' will still enable the network to be supplied from other available generation sources on

[30] Power line faults have many causes: lightening discharges, trees touching the line, two-phase short-circuiting, insulation failures, and so on, most of which occur during adverse weather conditions. These 'faults' can be transient or permanent. In the case of transient faults, disturbances are cleared naturally (for example, when the lightening surge decays or a branch touching the line burns out). In such cases the line will 'hold' when reenergized by switching 'on' the circuit breaker. In the case of permanent faults, disturbances are not cleared and the line will not 'hold' until the cause of the fault has been removed physically (for example, when a damaged insulator is replaced or a grounded conductor re-strung).

either side of the disturbance. Thus, 'segmentation' will reduce the extent and frequency of power outages caused by transmission line faults, whereby the resilience of the system is enhanced.

13. Given its experience with adverse weather, BEL has installed some protection to segment parts of its network. However, two substations, at Belcogen and Bapcol, remain without adequate protection to isolate faults, and this could have a significant impact should line damage occur in the area because of future extreme weather events. Therefore, the proposed project aims to increase the resiliency of BEL's transmission system through the installation of switchyards at Belcogen and Bapcol with line circuit breakers for the 'in' and 'out' of each transmission line section. At Belcogen, the line will be segmented into two sections: from CFE supply to Belcogen and from Belcogen to Maskall. At Bapcol, the line will be segmented into two sections: from Dangriga to Bapcol and from Bapcol to Savannah. The proposed arrangements at Belcogen in the north and Bapcol in the south will essentially complete the segmentation of BEL's existing transmission network until further expansion and system upgrades are considered. As a result, all generation sources could be available for dispatch to operational segments of the system even in the event of a transmission fault.

14. **Strengthening of transmission network structures.** Transmission network structures are usually built to more robust standards than distribution network structures in view of the higher load carried at higher voltage levels. Damage to transmission lines including 'downing' of the structures from storms or hurricanes needs to be avoided because it will lead to extended power supply outages affecting large numbers of consumers. BEL transmission line uses wooden pole structures, and certain sections of the line pass through waterlogged and saline areas where substantial corrosion of the anchors, guy wires, and attachments has occurred. Many sections of the line have also been affected by premature wood decay due to termite attacks and fungal growths. Some poles are observed to have developed longitudinal cracks ('checking'), which will reduce the pole strength and also make way for further decay by allowing fungal growth. Bush fires have also affected some of the poles.[31] Records of BEL's annual walk-by inspections and three-year detailed inspections (including climbing to the top of each pole) indicate that a substantial number of poles are severely affected and their strength is severely reduced due to the various causes mentioned above. In fact, in 2014, two angle structures had pole failures caused by corroded guy wires. This is a warning of dangers it is likely to face in the future in the absence of taking effective and timely preventive measures. It is highly possible that during a future hurricane, strong winds generated will bring down a number of already weakened poles causing catastrophic damage to large sections of the line. In the event of such a failure, the power system will be truncated leading to massive power shortages for extended periods. Such a situation should be avoided due to the drastic impact it will have on the country's economy. As time passes, the risk of catastrophic damage to the transmission system at these compromised pole locations increases unless preventive action is taken in advance.

15. To mitigate this high risk and increase the resiliency of the transmission system, the project complements BEL's efforts to plan ahead and implement appropriate measures in a timely manner. The project will support a study to hire a firm of qualified consultants to examine the damaged pole structures and recommend measures including alternative line supports and new design standards for each type of terrain encountered along the transmission line routes. A number of

[31] BEL has reported losses of five poles per year due to bush fires.

alternative poles (fiber glass, fiber reinforced polymer, pre-stressed concrete, and so on) as well as support designs will be reviewed and their suitability to the terrain and climate conditions will be assessed. Measures to rehabilitate/strengthen poles that can be salvaged will also be studied. On the basis of the recommendations from the study, BEL will upgrade the pole structures and apply practices to sections of the line that have been identified as being the weakest and are most compromised, rebuilding such sections along the existing line route, and rehabilitating the salvageable poles.

16. Through the proposed project activity, BEL intends to ensure that some of the weakest transmission lines are substantially strengthened and that the supports are capable of withstanding the design loads. This will also ensure that the substantial risk posed at present by an insecure transmission system is reduced to the extent feasible. The rehabilitated sections will thus be more secure in withstanding frequent tropical storms and major hurricanes, whereby, the overall transmission system will be strengthened. In addition, the performance of the various support types and designs used in the rehabilitation exercise will be evaluated over time for its demonstrative impacts. Based on these results, BEL will be able to standardize its construction practices for each of the different terrain types it encounters along its transmission line routes.

17. **Enhance resilience of distribution substations.** Grid substations that transform the voltage level between the transmission and distribution systems are a critical part of the power supply network. Previous storms and hurricanes have affected a number of grid substations causing extended outages and substantial damage to the assets. Their security is all the more important because most of the distribution centers are supplied by a single substation with one transformer, thus limiting alternate supply possibilities in the event of a major failure. Some substations are prone to flooding, which can make the equipment unusable even after the waters subside. To address these deficiencies and to strengthen the substations and the related equipment and facilities, the proposed project will fund the following activities:

a) Structural improvements to the control buildings: Many previous hurricanes have caused damage to the metal structural panels and rooftops of control buildings and these components are particularly vulnerable. Hence, they will be replaced or strengthened as necessary.

b) Relocation of the battery bank to a separate building: Some substation DC batteries are susceptible to flood waters, and securing the battery banks in a safer environment at a higher elevation is desirable. These changes will be made at locations prone to flooding.

18. **Secure and strengthen sustained operational capacity of load control and dispatch center.** The load control and dispatch center is critical to maintain reliable operations and helps facilitate the restoration of the system after a fault or major network failure. Hence, it is important to secure this unit and also provide a reliable backup in the event of an emergency when the main unit is out of commission. Currently, the load control center is situated at the first floor of BEL's headquarters building in Belize City. A backup center located at Belmopan is considered desirable in the event of any damage to the main control center during a major storm or hurricane. The backup center will enable restoration work to be coordinated without delay in the event that the one located in Belize City is inoperable. The backup center will also store all related data in a backup server so as not to lose important information. The project will therefore finance the installation of a backup center to be located at Belmopan. Several additional activities are also

included that will improve BEL's capabilities for better system control and management. They include (a) the implementation of an outage management system; (b) the piloting of an AMI program; and (c) access to real-time data from meteorological and hydrological data from the NMS (from Component 1 of ERCAP). These investments will enhance BEL's capacity to operate the system with greater adaptive capabilities and demonstrate measures that will improve its ability to monitor and restore the system following a major network disturbance.

19. **Improve communications network.** At present, BEL operates an analog VHF private network with multiple frequencies. The control center, transmission and distribution, and substations teams use this network primarily for switching operations and general team communications. The communication system is critical for emergency response and system restoration during emergencies. The current infrastructure does not provide adequate national coverage for efficient operations and, as a result, BEL teams have to also rely on cellular communications. This is an inadequate solution because the cellular network itself could be overburdened while telephones only allow for communication between two users rather than a group. Therefore, the existing communication system within BEL is neither safe nor efficient, particularly during emergency conditions. The proposed project will support BEL to undertake a complete redesign of its communication system and build a new digital VHF network that will provide national coverage to 100 percent of all transmission and distribution network locations. Additional relays will be added to enhance signal strength at select existing repeater stations to reduce dead spots and improve coverage. In addition, two truck-mounted repeater stations will be purchased because it is essential to have rapid deployment capabilities to any location to maintain national or regional communications in the event of a major failure following a hurricane or tropical storm. BEL will carry out a preliminary study of the existing coverage limitations by surveying the entire network with a spectrum analyzer. The results of this study will then be used to determine the repeater stations within the existing network that need to be improved.

20. **Implement better vegetation management.** In a tropical environment, aggressive vegetation growth is increasingly hindering the management and upkeep of structures which affect BEL's performance especially during storms by exposing lines to damage due to falling trees/branches and extended drought conditions by increasing the risk of fire damage. In addition, BEL had indicated that inadequate vegetation management can render emergency areas inaccessible during and after extreme weather events hindering their capacity for response and recovery. The proposed project will help BEL undertake a study to help identify and define good vegetation management practices that will be applicable in Belize, including new bio friendly techniques that also consider social, economic and environmental factors. The proposal is to develop a detailed Vegetation Management Plan that can be subsequently implemented and tested in practice by BEL.

Component 3: Project Implementation Support and Information Dissemination for Knowledge Sharing (US$586,000 [GEF US$421,000; GoB US$165,000 in-kind])

21. This component includes a knowledge sharing activity to maximize the impact of the lessons learned from the proposed project and to provide incremental support to the respective agencies for implementing the ERCAP.

22. The following activities are included under this component.

a) **Disseminate information and engage citizenry on lessons learned and potential for replication** (MFPSEPU in coordination with BEL and the NMS)

b) **Provide support for incremental project coordination and implementation activities** (MFPSEPU and BEL)

23. **Information dissemination and citizen engagement for knowledge sharing.** ERCAP will build upon the stakeholder consultation that was held during project preparation, and continue to engage citizens during its mid-term review; to share results and obtain feedback. ERCAP is expected to yield useful information and lessons learned from operationalizing an energy resilience program for climate adaptation and provide a foundation for building future programs to address this significant development challenge going forward. The experience will also be beneficial to regional and international stakeholders who are also grappling with challenges of energy resilience in the face of climate change. Therefore, at the conclusion of the ERCAP, MFPSEPU will coordinate and carry out a diagnostic workshop with regional and other international stakeholders to disseminate knowledge and lessons learned from the project.

24. **Incremental project implementation support.** The comprehensive nature of the ERCAP's climate resilience interventions requires two separate implementing entities (including a sub-implementing agency) in order to harness each institution's comparative advantage toward the project goals. Each implementing agency (including a sub-implementing agency) is making its own contribution in both cash and in-kind towards implementing ERCAP, including for implementation support. To cover additional incremental implementation support costs, GEF grant funds are allocated to complement the funds committed by the implementing agencies. These incremental costs will cover activities that include overall project coordination across the implementing agencies (including a sub-implementing agency) as well as support related to FM, procurement and safeguards.

25. The next figure 2.2 illustrates the various activities included in the ERCAP arranged under the framework for resilience illustrated in Figure 2.1.

FIGURE 2.2. Illustration of Resilience Framework and ERCAP Design

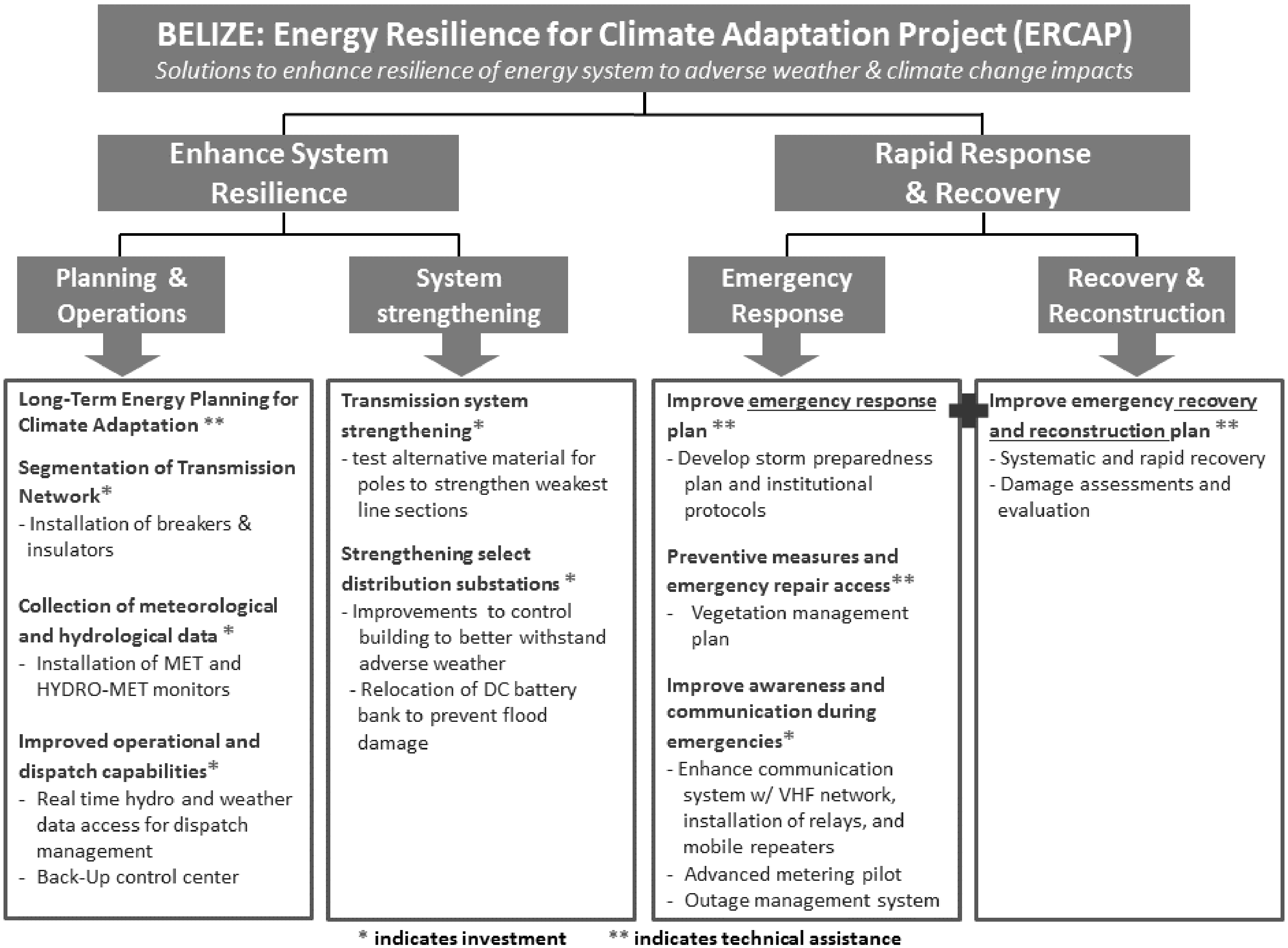


Table 2.1. Estimated Project Costs by Component and Funding Source

(Unit: US$, thousands)

Category by Component	GEF	BEL*	NMS**	MFPSEPU**	Total
COMPONENT 1: Long-Term Planning and Capacity Building for Adaptation					
Long-term Energy Planning for Climate Adaptation	657	-	-	425	1,082
Meteorological and Hydrological Data Collection	1,302	-	10	-	1,312
Emergency Response and Recovery Plan	400	-	-	-	400
Subtotal	***2,359***	***-***	***10***	***425***	***2,794***
COMPONENT 2: Demonstration Measures to Enhance Resilience of Energy Sector					
Segmentation of Transmission Network	1,889	1,355	-	-	3,244
Strengthening of Transmission Network Structures	2,471	250	-	-	2,721
Enhance Resilience of Distribution Substations	400	100	-	-	500
Secure and Strengthen Sustained Operational Capacity of Load Control and Dispatch Center	-	650	-	-	650
Improve Communications Network	-	920	-	-	920
Implement Better Vegetation Management	300	100	-	-	400
Subtotal	***5,060***	***3,375***	***-***	***-***	***8,435***
COMPONENT 3: Project Implementation Support and Information Dissemination for Knowledge Sharing					
Dissemination of Lessons Learned	100	-	-	5	105
Project Management					481
- MFPSEPU	246	-	-	160	
- BEL	75	-	-	-	
Subtotal	***421***	***-***	***-***	***165***	***586***
Contingencies					
MFPSEPU	***75***				***75***
BEL	***85***				***85***
Total	**8,000**	**3,375**	**10**	**590**	**11,975**

* in-cash ** in-kind

Annex 3: Implementation Arrangements

Belize: Energy Resilience for Climate Adaptation Project

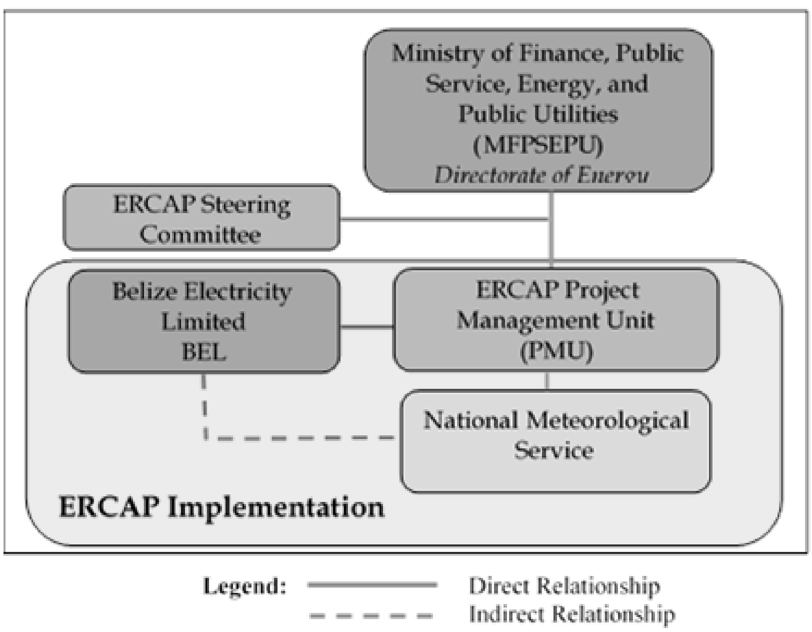
Project Institutional and Implementation Arrangements

1. The ERCAP is implemented by multiple agencies with a common thread of building resilience for climate adaptation in the energy sector in Belize. The multi-agency nature of the project reflects the comparative advantage and responsibilities of each institution participating in the ERCAP that is needed to achieve the project objectives. It also calls for clear delineation of the role of each agency and effective coordination among all of them for efficient implementation and successful achievement of the project goals.

Key Project Implementation Entities and Their Responsibilities in the ERCAP

2. The overall responsibility for the implementation and coordination of the project activities rests with the MFPSEPU. For the purposes of project implementation, the MFPSEPU, in addition to directly implementing some project activities, will rely on the following institutions: BEL and the NMS (as a sub-implementing agency). Figure 3.1 illustrates the organization structure for the ERCAP's implementation.

Figure 3.1. Illustration of Project Implementing Structure



3. **The MFPSEPU** has overall responsibility for project implementation. The MFPSEPU's roles will primarily include: (a) coordinating all project activities among the various implementation agencies as well as broader stakeholders and citizens; (b) implementing specific activities including the long-term energy planning for climate adaptation and information dissemination for knowledge sharing; (c) carrying out the fiduciary functions in support of the NMS for the activities related to meteorological and hydrological data collection; and (d) performing M&E functions for the overall project to assess progress and results. In particular, the

MFPSEPU will need to ensure that climate adaptation and energy resilience are reflected in other high-level government efforts such as the NCRIP and the protocol within the NEMO structure. Within the MFPSEPU, the ERCAP will be overseen by the Directorate of Energy. To successfully implement the project and coordinate activities, the following arrangements will be made:

a) **The PMU at the MFPSEPU.** The MFPSEPU has established and will maintain a PMU throughout the project. The PMU will be headed by a project manager who will report to the energy director at the MFPSEPU. The PMU will coordinate among ERCAP implementing agencies and other key stakeholders, take the lead carrying out activities designated for direct implementation by the MFPSEPU, coordinate with the NMS to procure and transact all activities related to the meteorological and hydrological data collection, ensure compliance with GoB and Bank safeguard requirements, and monitor and report on project progress. The PMU has prepared a Project Operational Manual (POM), which provides details regarding the roles and responsibilities of each project participating agency as well as the processes and procedures for implementing the ERCAP. The PMU will produce a semiannual Project Progress Report that may also include FM information, and submit it to the Bank for its review, no later than November 15 and May 15 of each year the project is under implementation.

b) **Project Steering Committee (PSC).** The MFPSEPU will establish a PSC at the inception of ERCAP to provide high-level strategic guidance during project implementation. The PSC will be chaired by the Chief Executive Officer (CEO) of the MFPSEPU and will include senior officials from the Ministry of Economic Development, Petroleum, Investment, Trade & Commerce; Ministry of Agriculture, Forestry, Fisheries, the Environment and Sustainable Development; Ministry of Works, Transport and National Emergency Management; BEL; and the NMS. The PSC will convene at least every six months to evaluate project progress, approve budgets, provide guidance on implementation and recommend necessary adjustments to be incorporated into the project in order to achieve its objective. The Terms of Reference (TOR) for the PSC is included in the POM.

c) **NMS.** The NMS is a sub-implementing agency in the ERCAP, as it is mandated with providing meteorological and climate-related information in Belize through systematic and accurate monitoring and data collection, reliable data analyses, and timely dissemination of information. The NMS, on the basis of an agreement reached with the MFPSEPU, will be responsible for implementing the activity on meteorological and hydrological data collection and will rely on the ERCAP PMU to support all procurement and FM aspects of the activity. The NMS will coordinate the activity with the ERCAP PMU, which will be responsible for ensuring that the collected meteorological and weather data will be incorporated into the long-term energy planning for climate adaptation activity that will be carried out by the MFPSEPU. Furthermore, the ERCAP PMU will coordinate to ensure that the meteorological and weather data collected by NMS will be available to BEL on a real-time basis so that it can be utilized to improve the management and performance of the power system.

d) **Grant funds transfer.** The grant funding for the MFPSEPU and NMS activities will be channeled following existing GoB procedures for transferring and utilizing grant funds. BEL will enter into separate grant agreements directly with the Bank to channel funds to implement the activities designated for each respective agency. More details regarding the grant funds transfer are provided in the FM section of this annex.

4. **BEL.** BEL is the national power company in Belize and is responsible for operating the country's transmission and distribution network in addition to the dispatch of generation from its own power plants as well as IPPs. As a central player in the energy sector, BEL is a significant implementing agency for the ERCAP, with the responsibility for implementing the majority of the grant-funded activities. BEL will be responsible for all activities related to enhancing the resilience of transmission and distribution systems, the operation of the power system, and the preparation of an Emergency Response and Recovery Plan for the power sector. In addition, BEL will coordinate with the NMS to access real-time data on meteorological and weather information that will be used to improve its planning and operations. BEL will also participate in the long-term energy planning for climate adaptation activity that will be led by the MFPSEPU and serve in the ERCAP's PSC. Within BEL, the ERCAP will be implemented under the Directorate of Systems Planning and Engineering, and it will be supported by the Departments of Energy and Material Supply; Transmission and Distribution, Safety, Health, and Environment; Information and Communication Systems and Customer Care; and Finance and Human Resource, as necessary for successfully implementing BEL's activities within the project. The implementation of ERCAP activities within BEL will be supported by a designated project manager, who will carry out day-to-day project activities, coordinate within BEL, and also liaise with the MFPSEPU for coordinating the ERCAP-related activities. The project manager will report to the senior manager for system planning and engineering. The BEL will produce a semiannual Project Progress Report that may also include FM information and submit it to the Bank, for its review, no later than August 15 and February 15 of each year the project is under implementation.

Financial Management, Disbursements, and Procurement

Financial Management

5. The overall FM risk of this project is assessed as Substantial. Although each implementing entity has a good internal control environment, they have limited or no recent experience with implementing Bank projects. Additionally, the project design is complex as implementation of activities is split between two separate entities (including an additional sub-implementing agency). The Bank will however ensure that the finance officers for the respective implementing entities maintain correct and appropriate records that are in line with good accounting practices and that relevant team members from each implementing entity are duly trained in the Bank's operations and guidelines.

6. The following FM arrangements relate to all implementing entities. Specific arrangements are placed under the entity itself.

a) **Financial reporting and monitoring.** For project management purposes, each implementing entity is required to prepare Unaudited Interim Financial Reports (IFRs) covering each quarter (April–June, July–September, October–December, and January–March) in line with the GoB's fiscal year ends. The IFRs are due within 45 days after each quarter end. Each implementing entity will prepare and submit withdrawal applications as necessary to document and withdraw funds. The format and the content of the IFRs have been shared with the PMU.

b) **External audit.** An external audit is required annually covering the period up to March 31 on the project's financial statements and will be due within 6 months after the fiscal year end. One consolidated audit on the entire project's activities across the two implementing entities (and an additional sub-implementing agency) will be performed by one audit firm that will be engaged by the MFPSEPU. Each implementing entity is responsible for preparing the necessary audit schedules and supporting documents, while the MFPSEPU will prepare the consolidated project financial statements.

c) **Supervision strategy.** The supervision strategy for this project is based on its FM risk rating, which will be evaluated on a regular basis by the FM specialist in line with the FM Sector Board's FM Manual and in consultation with the Task Team Leader for the ERCAP.

MFPSEPU

a) **Staffing.** There will be a financial officer or finance manager dedicated to the project who will receive support from the Accounting Department of the MFPSEPU. This department will be performing the accounting functions for the MFPSEPU and NMS activities. The unit has 4 staff members with an average of 4 years of experience in the unit and the requisite GoB qualifications for public sector workers. The Finance officer will report directly to the Project Manager of the ERCAP in the MFPSEPU and is responsible for recording and reporting of financial information relating to the project.

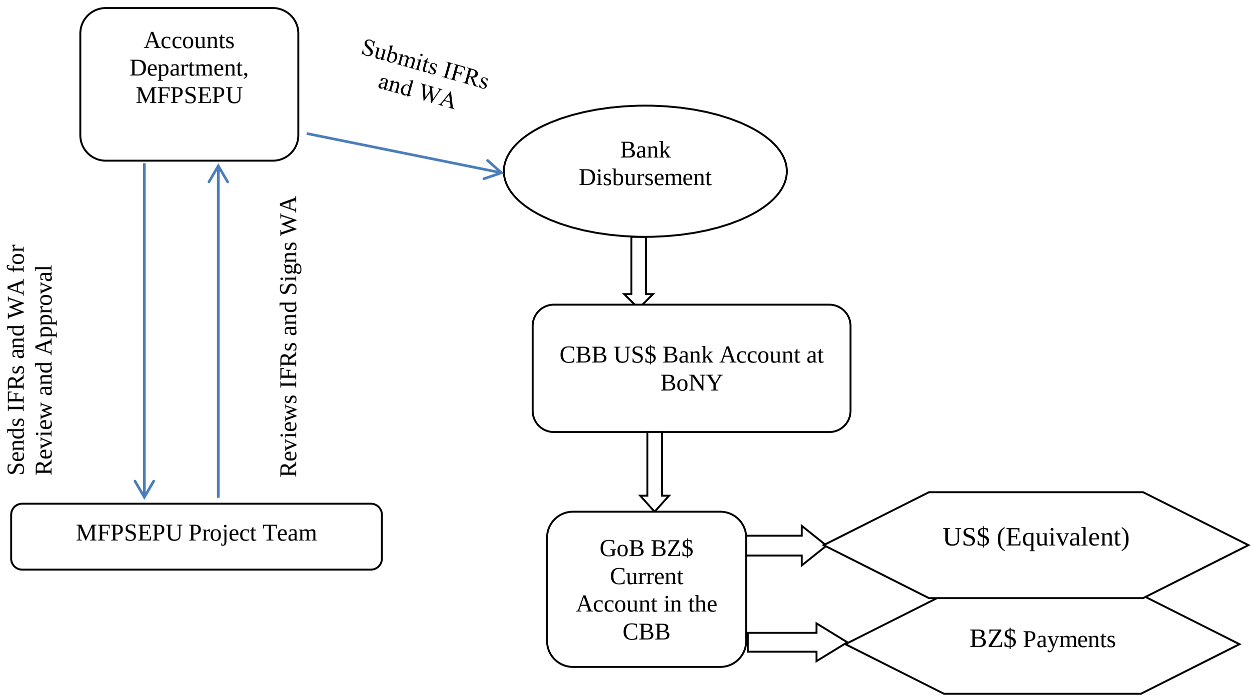
b) **Budgeting.** Consultations with the technical officers, the chief executive officer (CEO), the finance officer, and the task team in consultation with the ERCAP Project Steering Committee will develop a budget for the entire project implementation period based on the Procurement Plan (PP). This will be revised annually based on implementation progress and adjusted as necessary. Ad hoc revisions to the budget may also be performed. The annual estimated costs for this project will be included in the MFPSEPU's overall budgeted figure, which will be reflected in the GoB's annual budget under Capital 3. The project (all 3 grants) will be captured in the government's budget based on implementation plans for each fiscal year.

c) **Accounting and information systems.** Project accounts will be recorded using the cash basis of accounting, and daily operations will be guided by the existing GoB procedures covered by (i) Finance and Audit Act 2005; (ii) the Control of Public Expenditures; and (iii) Financial Orders 1965. A Project Management Manual should be prepared to reflect the FM procedures specific to the project as well as those required by the GoB. The GoB's Integrated Financial Management Information System, SmartStream version 7.0.03, will be used to record all financial transactions relating to the project. The accounting department at the MFPSEPU will work with the Central Information Technology Office to finalize the chart of accounts required to capture the transactions and report to the GoB and the Bank based on the Bank's requirements.

d) **Disbursements and funds flows.** Disbursement of project funds will be based on IFRs. Funds should only be used for implementation of the components as set out in the grant agreement and must comply with the disbursement categories. The funds will flow to the GoB's U.S. dollar pooled account at the Federal Reserve Bank of New York and then transferred to local currency GoB account at the Central Bank of Belize (CBB). All payments will be effected through SmartStream and will be made from the local currency account at the CBB. Payments to suppliers are normally done through wire transfers. The funds will flow as shown in the flowchart in figure 3.2.

e) **Internal audit.** There is currently no internal audit (IA) function within the MFPSEPU.

Figure 3.2. Funds Flow for the MFPSEPU



Note: WA = Withdrawal Applications; BoNY = Federal Reserve Bank of New York.

BEL

a) **Staffing.** The FM function for the activities being implemented by BEL will fall under the responsibility of the Finance and Human Resources Department of BEL as well as a finance officer of the projects unit. The Finance and Human Resources Department will mainly focus on recording the financial transactions, while other FM functions will be done by the project's finance officer who will be hired shortly. The finance officer will report directly to the project manager of the ERCAP and will be responsible for ensuring the accuracy of financial data and reporting of financial information relating to the project.

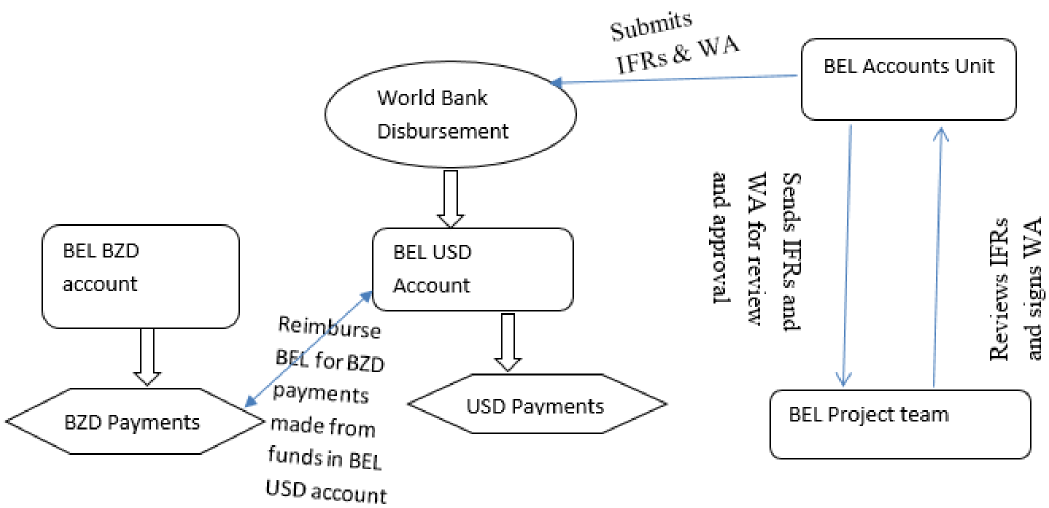
b) **Budgeting.** The grant activities will be reflected in the capital expenditure budget of BEL as a part of the major components of the business to which the activities relate (for example, transmission, substation, and so on). The budget is done for a five-year period. Annually, the budget will be developed by the project manager (for this grant it is the Manager of the Department of Systems Planning and Energies), in coordination with the managers of the respective departments. This is then reviewed by the senior management team, discussed with the CEO, and then finally submitted to the board of BEL for final approval. Annual detailed forecasts/budgets are uploaded into BEL's accounting system and revised quarterly. Additionally, a monthly variance analysis is conducted and material variances are explained to the CEO.

c) **Accounting and information systems.** The accounting function will be guided by the existing financial procedures of BEL, which uses the accrual basis of accounting. This is included in the operations manual of the grant to ensure that project funds and activities are correctly recorded, safeguarded, and reported to the Bank. The accounting system used by BEL is Great Plains and the grant expenditures will be captured in it. A General Computer Controls audit was completed in 2014 by an independent audit firm, Grant Thornton, and no major issues were noted.

d) **Disbursements and funds flows.** Disbursement of project funds will be based on IFRs. Funds should only be used for implementation of the components as set out in the loan agreement and must comply with the disbursement categories. A pooled U.S. dollar bank account at the Scotiabank (Belize) Ltd will be used as the designated account for the grant. The account has on average 15 – 20 transactions monthly and is mainly used for receipt of project funds. The balances will be tracked manually by use of a cash flow spreadsheet in the Finance Department. No separate local currency bank account will be opened. Instead, local currency payments will be made from a BEL Belizean dollar bank account on behalf of the grant and amounts subsequently reimbursed from the grant funds will be held in the U.S. dollar bank account. All payments have to be authorized by the project manager, and the project management team will receive a copy of the cash flow sheet monthly and then reconcile the cash balances. The funds will flow as shown in figure 3.3.

e) **Internal Audit.** The Internal Audit Unit at BEL consists of three persons and reports directly to the Audit and Risk Committee. The Internal Audit Plan is developed annually by the Internal Audit Unit and submitted for review and approval by the Audit and Risk Committee. The plan normally assesses processes or functions of BEL under which the grant activities will also fall. It has been agreed that grant transactions will always be included in the sample selection used during testing. At the end of each audit, an IA report is produced, which includes any internal control weaknesses identified, remedies recommended, and target dates for implementing recommendations. The IA report is submitted and discussed with the audit committee, which meets six times per year. The Audit and Risk Committee comprises six persons who are also members of the BEL Board. Once these reports become available, the Bank will review them to aid with its understanding of the internal control environment and areas of weaknesses.

Figure 3.3. Funds Flow for BEL



Note: WA = Withdrawal Applications

Disbursements

7. The disbursement of grant funds will be processed separately to each entity in accordance with normal Bank procedures, and as stipulated in the Grant Agreement and the Disbursement Letter. Funds will be disbursed in respect of eligible expenditures incurred or to be incurred under the Project consisting of goods, works, non-consulting services, and consultants services, training and operating costs. The primary disbursement method will be Advances, but Reimbursements and Direct Payments will also be available. The Minimum Value of Applications for Direct Payment and Reimbursement is US$ 250,000 equivalent, with the exception of the Retroactive Financing Application for withdrawal, which will have no Minimum Value. Retroactive financing will be allowed up to an aggregate amount not to exceed 20 percent of the grant amount to be made for payments made within one year prior to the Signing Date of the Grant Agreement for Eligible Expenditures.

8. The Advances will be made in US Dollars (USD) to GoB and BEL's pooled Designated Accounts opened at the Federal Reserve Bank in New York and at the ScotiaBank of Belize, respectively. Such Advances will be made in US Dollars (USD) based on periodic forecasts of project cash flow needs. The documentation of the uses of Advances and Reimbursement requests will be made through Unaudited Interim Financial Reports (IFRs) as per approved reports attached to the Disbursement Letters.

9. The Project disbursement deadline date (final date on which the Bank will accept applications for withdrawal from the Recipients or documentation on the use of grant proceeds already advanced by the Bank) will be four months after the Grant Closing Dates. This "Grace Period" is granted in order to permit the orderly Project completion and closure of the Grant

Accounts via the submission of applications and supporting documentation for expenditures incurred on or before the Closing Dates.

Procurement

Procurement Arrangements

10. Procurement for the proposed grant will be carried out in accordance with the WB "Guidelines: Procurement of Goods, Works, and Non-Consulting Services under IBRD Loans and IDA Credits & Grants, dated January 2011, Revised July 2014, and "Guidelines: Selection and Employment of Consultants under IBRD Loans and IDA Credits & Grants " dated January 2011 and Revised July 2014, and the provisions stipulated in the Grant Agreements.

11. **Procurement of small works**. Works procured under this project will include contracts for small works for: (a) the strengthening of transmission lines/poles; (b) the rehabilitation of two substations, including electrical installations; (c) improvement of control buildings; (d) installation of hydro-meteorological automatic weather monitors, rainfall monitors, and automatic weather monitors; and (e) the installation of 1 km of fiber optic cable. The above contracts will be procured as specified in the procurement plans.

12. **Procurement of goods and non-consulting services** will include all transmission line equipment and materials to be purchased following International Competitive Bidding (ICB) procedures. Goods contracts will be grouped, to the extent possible, into bidding packages of more than US$100,000 equivalent, using the Bank's Standard Bidding Documents (SBD). NCB and shopping for small value contracts shall be applied as agreed with the Bank. These will include hydro-meteorological automatic weather stations, rainfall stations and automatic weather stations, which will be grouped together and procured as a single ICB tender of three lots, using the Bank's SBD for the Procurement of Goods. Small-value goods contracts for the procurement of vehicles, computer equipment, lightning detection system and equipment and software for meteorological data integration will be procured by Shopping.

13. **Selection of consultants**. Selection of Consultants will be conducted in accordance with the Bank's *"Guidelines: Selection and Employment of Consultants under IBRD Loans & IDA Credits & Grants by World Bank Borrowers"* (January 2011, Revised July 2014). Consulting services would be required under this project for studies required for preparation of emergency response and recovery measures and procedures, evaluation of options for rehabilitation/strengthening of transmission lines including design and supervision, and the development of a vegetation management plan. Small-value contract with firm for development of a hydrological model for the Macal Catchment Area will be awarded using Quality and Cost-Based Selection, and contract for external financial audits will be awarded using the Selection based on Consultants' Qualifications selected method, in accordance with paragraph 3.6 of the Guidelines. Individual consultants would be selected following the procedures set forth in Section V of the Guidelines, whereas consulting firms would be selected following Quality and Cost Based Selection (QCBS), Least-Cost Selection (LCS), Selection Based on Consultant's Qualifications (CQS) etc. Short lists of consultants for services estimated to cost less than US$300,000 equivalent per contract may be composed entirely of national consultants in accordance with the provisions of paragraph 2.7 of the Consultant Guidelines.

14. For MFPSEPU the procurement requirements of the project are relatively modest, with goods, works and consulting services amounting to about $2.28 million in total being required for the implementation of the project. The majority of contracts for goods and civil works will be of low value and, therefore, will be procured by Shopping. The exception will be a single ICB tender, estimated to cost $556,000, for the procurement of hydro-meteorological automatic weather stations, rainfall stations and automatic weather stations, grouped together into three lots in one ICB. Small-value goods and non-consulting contracts for the procurement of vehicles, computer equipment, lightning detection system and equipment and software for meteorological data integration, and socio-economic and energy data collection and associated activities will be procured by Shopping. The consulting services requirements of the project will be met mainly by the selection of Individual Consultants (ICs), while small-value assignments, estimated to cost less than $300,000, for development of a hydrological model for the Macal Catchment Area will be awarded using QCBS, and the contract for external financial audits will be selected using CQS. Two small-value contracts, estimated to cost less than $200,000, Installation of hydro-meteorological automatic weather station, rainfall stations, and automatic weather stations and Installation of 1 km of fiber optic cable will be awarded by Shopping.

15. **Operating costs** mean the following costs incurred by the borrower, which are not subject to above procedures but to the borrower’s administrative procedures agreed by the Bank: (a) costs for utilities, maintenance, consumable office supplies, printing services, and communication services and (b) transportation costs and travel and per diem cost for project staff who will carry out supervisory activities under the Project.

Procurement Assessment

16. Procurement risk assessment and management (PRAM) of the capacity of the implementing agencies were carried out over a series of mission in September 2014, April 2015 and February, 2016, for the project by the Bank, in line with the PRAM System Module. The PRAM Questionnaire was completed by the MFPSEPU and BEL as the primary project implementing agencies responsible for the fiduciary aspects to implement procurement actions under ERCAP.

17. BEL is the sole distributor of electricity in Belize. It is a utility serving entity with about 85,000 consumers and has a network that essentially feeds the major towns in the country. It is regulated by the PUC and with majority shareholding by the government. The procurement practice followed by BEL has its origin from the practices in view of the small nature of its operations and the limited asset ownership. BEL is now using loans and grants from international financing institutes such as the Caribbean Development Bank, the European Union, and the Bank, and therefore has substantive experience of conducting procurement in accordance with the procurement policies of the international financial organizations.

18. The assessment further reviewed the MFPSEPU: the interaction of organizational structure for implementation of procurement under the project, and the procurement staff to be required by organizations in the procurement cycle and contract management. The overall project risk for procurement is rated as Moderate. This is based on the assessment of the capacity of implementation agencies, after considering the mitigation arrangement for procurement implementation under this project by the action plan.

19. Procurement under GEF funding to be conducted by the MFPSEPU and BEL shall be carried out as agreed in the Project Operations Manual, the Project Appraisal Document, and the Grant Agreements. For some of the items to be financed by BEL and procured as nonbank funding, the industry practice, which has served the company well over years, will be followed.

20. **An Action plan for strengthening the capacity to implement procurement actions** is agreed with the MFPSEPU as the overall coordinating entity for implementing the project and with the BEL, as the Project Management Units responsible for the fiduciary aspects :

a) An experienced national procurement consultant, with previous experience of World Bank procurement, will be selected to fill the Procurement Officer (PO) position in MFPSEPU PMU as an Individual Consultant under a contract whose duration will be approximately 18 months, given that the implementation of procurement will be front-loaded during the project implementation period. Once the contracts for goods, works and consulting services have been awarded, contract administration will be conducted by the Project Manager, who possesses substantive procurement experience under IFI guidelines

b) The procurement staff in the MFPSEPU and BEL shall attend procurement training in the Bank's regional fiduciary workshop.

c) The PP for the implementation of the project during the first 18 months has been agreed by project appraisal.

d) Tender/selection documents for the first year's procurement under ICB and Quality- and Cost-Based Selection in the PP should be prepared by the MFPSEPU and BEL and submitted to the Bank for review, by the time of effectiveness of the project (for readiness, not a condition for effectiveness).

21. **Procurement Plan.** The PPs for implementation of the proposed project for the first 18 months was agreed between the Bank and the project teams of the MFPSEPU and BEL in April, 2016. The full version of the PP is filed in the two IAs with major packages subject to international selection included in Table A below. The plan shall be made available at the website http://www.worldbank.org/procure within 30 days of the signature of the Grant Agreement. It will be updated annually and the updated PP shall be disclosed on this site after clearance by the Bank. The recommended thresholds for the use of the procurement methods specified in the Grant Agreement are identified in Table 3.1 as the basis for the agreed PP.

22. A general procurement notice has been prepared and submitted to the Bank. It was published in the United Nations Development Business online on May 4, 2016. For ICB goods and works contracts and large-value consultants contracts (more than US$200,000), a Specific Procurement Notice will be advertised in the United Nations Development Business online and in print.

23. **Frequency of procurement supervision.** Supervision of procurement will be carried out through prior review supplemented by supervision missions with post review at least once a year until such time as all contracts for goods, works and services have been awarded and their performance completed.

Table 3.1. Thresholds for Procurement Methods and for Prior Review

Thresholds for Procurement Methods

Expenditure Category	Contract Value (Threshold) US$ Thousands	Procurement Method
1. Works		
	>3,000	ICB
	<3,000	NCB
	<200	Shopping
2. Goods		
	>500	ICB
	<500	NCB
	<100	Shopping
3.Consulting Services		
3.1 Firms	>300	QCBS, QBS, FBS, LCS
	<300*	QCBS, QBS, FBS, LCS, CQS
	< 100	SSS
3.2 Individuals		Comparison of 3 CVs

Note: ICB = International Competitive Bidding; NCB = National Competitive Bidding; QCBS = Quality and Cost-Based Selection; QBS = Quality-Based Selection; FBS = Fixed Budget Selection; LCS = Least-Cost Selection; CQS = Selection Based on Consultants' Qualifications; SSS = Single-Source Selection

Table 3.2. Thresholds for Prior Review

Procurement Method	Contracts Subject to Prior Review
1. Works	
ICB	All
NCB	First contract
Shopping	None
Direct Contracting	All
2. Goods	
ICB	All
NCB	First
Shopping	None
Direct Contracting	All
3. Consulting Services	
QCBS, QBS, FBS, LCS > 300	All Contracts
QCBS, QBS, FBS, LCS < 300	First Contract
SSS	All
Individual Consultants	None

Note: Terms of Reference for all consulting services assignment, both with firms and with Individual Consultants, are cleared from the technical standpoint by the TTL. However, this does not constitute a procurement clearance and a "no-objection letter" is not issued by the Bank.

Tables 3.3. Procurement Plan for MFPSEPU

1. Consulting Services[32]

Number	Description	Basic Data			Start of Procurement	Estimated Date of Contract Award	Estimated Start of Exercise	Estimated Completion of Exercise
		Procurement Method	Estimated Amount in US$	Bank review				
MPSEPU CS-1	Procurement Officer	IC	24,000	Post	May 16, 2016	June 30, 2016	July 1, 2016	Jan. 15, 2017
MPSEPU CS-2	International specialist to assist in designing surveys, data collection and analysis.	IC	50,000	Post	May 16, 2016	July 31, 2016	August 1, 2016	Dec. 31, 2017
MPSEPU CS-3	International specialist to provide training on Long Term Energy Planning and lead the development of the long-term energy plan	IC	40,000	Post	Jan. 2, 2017	April 1, 2017	April 1, 2017	Sept. 30, 2018
MPSEPU CS-4	Energy Planner (national consultant) to provide technical support services to the Ministry of Energy, Science & Technology and Public Utilities in the elaboration of the long term energy plan.	IC	54,000	Post	May 16, 2016	June 30, 2016	July 1, 2016	July 1, 2018
MPSEPU CS-5	Research Assistant (national consultant) to provide research assistance to the MPSEPU in the elaboration of the long-term energy plan	IC	27,000	Post	May 16, 2016	July 1, 2016	July 1, 2016	June 30, 2018
MPSEPU CS-6	Project Manager	IC	60,000	Post	May 16, 2016	June 30, 2016	July 1, 2016	End of Project
MPSEPU CS-7	External Financial Audit (multi)	CQS	15,000	Post	Feb. 1, 2017	May 1, 2017	May 15, 2017	End of Project
MPSEPU CS-8	Development of a hydrological model for the Macal River basin	QCBS	275,000	Prior	Aug. 15, 2016	Jan.15, 2017	Jan. 16, 2017	Dec. 31, 2017
MPSEPU CS-9	Calibration of radar observations and training in radar image interpretation	IC	54,000	Post	Jun. 1, 2017	October 15, 2017	Oct 16, 2017	Jan. 30, 2018
MPSEPU CS-10	Consultant to provide training in the assessing the energy system vulnerabilities to climate change.	IC	25,000	Post	Jan 1, 2019	April 15, 2019	May 1, 2019	Jan 30, 2020
Subtotal – Consulting Services			**624,000**					

[32] For ICs, the TORs are subject to technical clearance by the TTL, noting that this is not a procurement prior review and the Bank will not issue a procurement no-objection letter

2. Goods

Number	Description	Basic Data					Start of Procurement	Estimated Date of Award	Arrival of Goods
		Package Number	Lot Number	Estimated Amount in US $	Procurement Method	Bank Review			
MPSEPU G-1	Computer, server, and software (license) for energy planning.	Pkg 1	Lot 1	31,000	Shopping	Post	May 16, 2016	Jul. 1, 2016	Aug. 1, 2016
MPSEPU G-2	Six-(6) Hydro-meteorological automatic weather stations, 6 Rainfall stations and twenty-three (23) automatic weather stations.	Pkg 2	Lots 1, 2 and 3	556,000	ICB	Prior	June 8, 2016	Nov. 16, 2016	Feb. 7, 2017
MPSEPU G-3	Two (2) off-road vehicles	Pkg 3	Lot 1	60,000	Shopping	Post	July 3, 2016	Sept 1, 2016	Aug 19, 2016
MPSEPU G-4	Lightning Detection System	Pkg 4	Lot 1	70,000	Shopping	Post	July 3, 2016	Oct. 15, 2016	Nov. 15, 2016
MPSEPU G-5	Equipment and software for meteorological data integration	Pkg 5	Lot 1	90,000	Shopping	Post	Jan 1, 2017	June 15, 2017	Sept. 1, 2017
MPSEPU G-6	Miscellaneous goods and incidentals for establishment of the National Energy Information System.	-	-	71,000	Shopping	Post	April 1, 2016	Ongoing	Ongoing
MPSEPU G-7	Miscellaneous goods for project management	-	-	41,000	Shopping	Post	April 1, 2016	Ongoing	Ongoing
MPSEPU G-8	Miscellaneous office supplies for data gathering by the SIB. **(Data gathering)**	-	-	2,000	Shopping	Post	N/A	Ongoing	Ongoing
MPSEPU G-9	License for climate change screening software			10,000	Shopping	Post	May 1, 2019	June 1, 2019	June 15, 2019
MPSEPU G-11	Training workshops on screening energy sector vulnerabilities to climate change and transportation.			15,000	Shopping	Post	May 15, 2019	June 15,2019	Dec. 2019
Subtotal - Goods				**946,000**					

3. Works

Number	Description	Basic Data			Start of Procurement	Estimated Date of Contract Award	Estimated Start Date	Estimate Completion Date
		Estimated Amount in US$	Procurement Method	Bank Review				
MPSEPU W-1	Installation of: a) hydro-meteorological automatic weather station, b) rainfall stations, and c) automatic weather stations.	181,000	Shopping	Post	Sept. 1, 2016	Feb. 20, 2017	March 1, 2017	June 30, 2017
MPSEPU W-2	Installation of 1 km of fiber optic cable	15,000	Shopping	Post	June 1, 2017	Sept. 1, 2017	Sept. 1, 2017	Oct. 30, 2017
Subtotal – Works		**196,000**						

4. Non-Consulting Services

Number	Description	Basic Data			Start of Procurement	Estimated Date of Contract Award	Estimated Start Date	Estimate Completion Date
		Estimated Amount in US$	Procurement Method	Bank Review				
MPSEPU NCS-1	**Printing** of questionnaires for data gathering under long term energy planning **(Data gathering)**	9,000	Shopping	Post	Sept. 1, 2016	Oct. 15, 2016	Oct. 16, 2016	June 30, 2017
MPSEPU NCS-3	**Data Collection** - inclusive of fees and social security contribution (estimated 6 Supervisors, 30 data collectors/surveyors/6 drivers) for total of three months NOTE: 6 districts in Belize **(Data gathering)**	99,000	Shopping	Post	July 1, 2016	Sept. 30, 2016	Oct. 1, 2016	Dec. 31, 2017
MPSEPU NCS-5	**Communication** for data collection, advertisements, etc. **(Data gathering)**	12,000	Shopping	Post	July 1, 2016	Sept. 30, 2016	Oct. 1, 2016	Dec. 31, 2017
Subtotal – Non-consulting services		**120,000**						

Tables 3.4. Procurement Plan for BEL

Civil Works	Contract Type	Description of Contract	Est. cost in US$	Procurement method	Bank Review	Start of Procurement	Start of Works	Expected Completion Date
BEL W-1	WORKs	Civil Works - Belcogen	300,000	NCB	Post	Jan-18	Mar-18	May-18
BEL W-2	WORKs	Civil Works - BAPCOL	320,000	NCB	Post	Aug-18	Nov-18	Feb-19
BEL W-3a	WORKs	Civil Works – Relocation of Battery Bank	150,000	NCB	Post	Mar-18	April-19	Dec-19
BEL W-3b	WORKs	Civil Works – Improve Control Buildings	250,000	NCB	Post	Nov.-18	July-19	Nov.-19
BEL W-4	WORKs	Line Construction for Belcogen Switching Station – 115kV	135,000	NCB	Post	Mar- 18	April-18	Sept-18
BEL W-5	WORKs	Electrical Installation – Belcogen SS	45,000	Shopping	Post	Feb-18	June-18	July-18
BEL W-6	WORKs	Line Construction for BAPCOL Switching Station – 69kV	50,000	Shopping	Post	May-19	June 19	Sept- 19
BEL W-7	WORKs	Electrical Installation – BAPCOL SS	45,000	Shopping	Post	Nov-18	Feb-19	May-19
BEL W-8	WORKs	Pilots for Strengthening of Transmission Lines	462,000	NCB	Prior	Aug-17	April-18	April-19
		Sub-Total	***1,757,000***					

Goods	Contract Type	Description of Contract	Est. cost in US$	Procurement method	Bank Review	Start of Procurement	Arrival of Goods	Last Date for Arrival
BEL G-1	Goods	Steel Materials – Belcogen SS	150,000	ICB	Prior	Sept-17	Jan-18	Mar-18
BEL G-2	Goods	Steel Materials – BAPCOL SS	240,000	ICB	Prior	Sept-18	Jan-19	April-19
BEL G-4	Goods	PS concrete poles, (Pilot Project)	118,000	ICB	Prior	Nov.-17	April-18	June-18

BEL G-5	Goods	FRP Fiberglass poles (Pilot Project)	174,000	ICB	Prior	Nov.-17	April-18	June-18
BEL G-6	Goods	Fiberglass poles (Pilot Project)	216,000	ICB	Prior	Nov.-17	April-18	June-18
BEL G-7	Goods	Metal Cribs / Stainless steel anchor bolts (Pilot Project)	529,000	ICB	Prior	Nov.-17	April-18	June-18
BEL G-8	Goods	Back Fill (Gravel) (Pilot Project)	21,600	Shopping	Post	Nov.-17	April-18	June-18
BEL G-10	Goods	Cross arms (two lots) (Pilot Project)	244,400	ICB	Prior	Nov.-17	April-18	June-18
BEL G-11	Goods	Insulator (Pilot Project)	162,000	ICB	Prior	Nov.-17	April-18	June-18
BEL G-12	Goods	Line hardware (Pilot Project)	81,000	Shopping (multi)	Post	Nov.-17	April-18	June-18
BEL G-13	Goods	Amphibious equipment (2 Units) (Pilot Project)	80,000	Shopping (multi)	Post	Nov.-17	April-18	June-18
BEL G-14	Goods	Substation Materials – Belcogen: Circuit breakers, protection relays, CTs, PTS+HV Switch	480,000	ICB	Prior	Sept-17	Dec-17	Mar-18
		Sub-Total	***2,496,000***					

Consulting Services	Contract Type	Description of Contract	Est. cost in US$	Procurement method	Bank Review	Start of Procurement	Start of Consultancy	Expected Completion Date
BEL C-1	Consultancy Services	Rehabilitation/strengthening of transmission lines including new designs	250,000	CQS	Prior	Oct-16	Mar-17	Sept-17
BEL C-2a	Consultancy Services	Preparation of emergency response measures and procedures	285,000	CQS	Post	Mar-17	Jan-18	July-18
BEL C2b	Consultancy Services	Review BEL's set up and existing procedures to scope the work	50,000	IC	Post	Aug-17	Oct-17	Dec-17
BEL C-3	Consultancy Services	Vegetation Study	300,000	QCBS	Prior	Oct -16	Mar-17	July-17
BEL C-4	Consultancy Services	Technical Assistance and Field Supervision BEL (Pilot Project)	133,000	CQS	Post	Jun -17	Feb-18	Dec-18
BEL C-5	Consultancy Services	Technical Assistance and Field Supervision BEL (Bapcol/Becogen)	124,000	CQS	Post	Jun -17	Feb-18	Dec-19
BEL C-6	Consultancy Services	Project Manager - BEL	75,000	IC	Post	Feb 16	July-16	Dec-19
		Sub-Total	***1,217,000***					

Environmental and Social (including Safeguards)

Environmental

24. The project is classified as Category B given that the project activities and works are likely to have limited and reversible environmental impacts that can be readily mitigated. The environmental safeguards triggered under the project are OP 4.01 - Environmental Assessment and OP 4.09 – Pest Management.

Civil Works: Meteorological Stations and Transmission and Distribution System Upgrades

25. Part of Project Component 1 includes installation of 23 meteorological and 6 hydrological-meteorological and rainfall monitoring stations. Installation of the meteorological monitoring stations primarily consists of equipment installation in an area of about 4 square feet with possible anchoring with guide wires. The rehabilitation works under Component 2 include the upgrade of existing substation buildings close to the Belcogen (biomass) and Bapcol (standby diesel) power plants and the upgrade of the existing transmission line connection from the Belcogen substation to the associated power plant. Other Component 2 works include the upgrade and replacement of damaged or weakened pole structures along the transmission lines. The works mentioned here are understood not to require the construction of new access roads and are not located in environmentally sensitive or protected areas.

26. Environmental Codes of Practice have been prepared, which will serve as Environmental Management Plans for the activities described earlier, and the borrower will be required to provide biannual progress reports on the environmental management of these works. OP 4.09 – Pest Management is triggered on a precautionary basis in case the study on ways to improve BEL's vegetation management practices recommends a solution that utilizes herbicides; in which case the plan will develop this option in compliance with Bank policy.

27. ***Responsibilities:*** The Directorate of Energy within the MFPSEPU will establish a PMU for implementing ERCAP. The NMS is a department within the Ministry of Works, Transport and National Emergency Management, that is the GoB authority on weather and climate and is responsible for the activity on hydrological and meteorological data collection including ECOP implementation. BEL, as the national power company, will be responsible for implementing all activities directly related to the ERCAP power system, including transmission and distribution activities and ECOP implementation. BEL is also responsible for the preparation of the Vegetation Management Plan (part of Component 2) to define good management practices for vegetation control along transmission and distribution lines. BEL has a Safety, Health, and Environment Unit staffed by an Environmental Management representative, who prepared the ECOPs under ERCAP. The activities under BEL are relatively routine and it has the capacity to implement the two ECOPs prepared for ERCAP.

Social

28. **Project stakeholder assessment**. Overall, the project is expected to have positive social outcomes related to improving the resilience of Belize's energy system to adverse weather and climate change impacts. The direct beneficiaries are energy consumers in Belize, including business and household consumers, who will have more reliable energy services, with fewer

disruptions, especially during adverse weather conditions that are expected to be exacerbated by climate change. Given that energy is a facilitator of economic activity, the entire economy will benefit from improved energy supplies, and the project will contribute to Belize's capacity to decrease and mitigate the economically disruptive effects of future catastrophic weather events such as hurricanes. This project will also benefit other sectors that rely on energy during adverse climatic occurrences, such as ensuring hospitals' ability to carry out emergency services and operations as well as store refrigerated vaccines, thus providing a greater degree of protection to Belizeans during times of extreme weather. Overall, by enhancing the energy resilience within a comprehensive framework for climate adaptation, the proposed project will contribute to sustainable economic growth and shared prosperity for the people of Belize.

29. **Consultations**. The Directorate of Energy held a national consultation regarding ERCAP on June 2, 2015[33], with key stakeholders including representatives from the private sector such as Belize Sugar Industries; government line ministries and departments such as the Departments of Environment, Forests, and Transport; nongovernmental organizations such as the Association of Protected Areas Management Organization; regional organizations such as the National Association of Village Councils; and the University of Belize. Overall, the consultations validated the project design and concluded that in light of climate change effects the project is viewed as positive for Belize. Another similar national stakeholder engagement will be carried out by the ERCAP PMU along with the other implementing agencies (including sub-implementing agency), during the mid-term review of the project.

Social Safeguards

30. *OP 4.10 - Indigenous Peoples.* This safeguard policy was not triggered. A screening was carried out that concluded that the project activities will not affect indigenous peoples, although overall they will likely benefit together with all Belizeans from improved national energy resilience.

31. *OP 4.12 - Involuntary Resettlement.* This safeguard was not triggered. A screening was carried out and concluded that the small works to be carried out under the project, such as installing meteorological and hydrological monitoring stations, testing new materials for the poles for transmission lines, and upgrading existing distribution substations, will not involve physical relocation of persons or land acquisition. Of the 29 very small hydro and/or meteorological monitors (7 existing ones will be upgraded and 22 are new ones), a total of 6 will be located in the Macal Catchment Area in either forest reserves or national parks. The remaining 23 weather stations will be located in selected sites throughout the country on either uninhabited public land or in the cases of private land only with the voluntary donation of the site (about 4 square feet) by the owner as documented by a Memorandum of Understanding with the NMS. Gaining a weather station is viewed positively in Belize, and in cases where an owner might not agree, another location will be selected. Small works to be carried out for improving transmission lines and transmission and distribution substations will occur on uninhabited land already in the right of way

[33] GoB. 2015. "National Consultation and Information Sharing Report, Energy Resilience for Climate Adaptation Project."

or existing easements of the implementing agency, BEL, or agencies where it has a 15-year commercial cooperative agreement (Belcogen and Bapcol).

Monitoring & Evaluation

32. The ERCAP PMU will have overall responsibility for monitoring the project's results. Under Component 1, the PMU will coordinate with the NMS to monitor the coordination of the various planning and data collection exercises, including the activities under the MPSEPU. For activities associated with the power system and the utility under Components 1 and 2, BEL will report to the PMU on its implementation performance.

33. The ERCAP PMU will be required to regularly monitor subprojects' implementation progress and prepare the project's M&E reports, which include (a) biannual progress reports, based on the framework detailed in Annex 1; (b) biannual IFRs; and (c) annual independent financial audits of the project. In addition, a comprehensive evaluation of the project's results will be undertaken during the midterm review.

Annex 4: Implementation Support Plan

Belize: Energy Resilience for Climate Adaptation Project

Strategy and Approach for Implementation Support

1. The strategy for implementation support has been developed based on the design of the project and its risk profile. It aims at providing sufficient technical support to the MFPSEPU, NMS (as sub-implementing agency), and the BEL, the three (sub) implementing agencies, ensuring fiduciary compliance with World Bank requirements, and adequately carrying out all risk mitigating measures identified in the Project Appraisal Document. Specifically, the strategy approach for implementation support includes the following:

a) Environmental safeguards: The World Bank team will supervise the implementation of the agreed Environmental Code of Practice (for BEL and NMS) and ensure compliance with World Bank safeguards policies.

b) Procurement: The World Bank team will provide sufficient support to the 2 implementing agencies to ensure timely review, evaluation and submission of key bid documents. Support will also include necessary training workshops provided to procurement officers designated by the 3 implementing agencies.

c) Financial Management: Supervision will review each implementing agency's financial management system, including but not limited to accounting, reporting and internal controls.

d) Institutional capacity: The Bank team will provide adequate support to enhance capacity of the Directorate of Energy within the MFPSEPU to transfer knowledge and carry out work with regards to climate adaptation and energy planning.

e) Governance: A project management unit has been established within the MFPSEPU to coordinate all project activities among the multiple agencies. It will also be guided at a strategic level by a multi-stakeholder Steering Committee.

Implementation Support Plan

2. To successfully implement the Energy Resilience for Climate Adaptation Project, the task team consists of specialists on long term energy planning, institutional development of utilities, transmission and distribution engineering as well as other relevant subject matters. Formal supervision and field visits will be carried out at least twice each year. Detailed inputs from the World Bank team are outlined below:

a) Environmental safeguards: An experienced environmental specialists on the task team will monitor and evaluate the implementation effectiveness of the agreed ECOPs. Formal supervision will be carried out bi-annually and continuous support is available as required by the clients.

b) Fiduciary requirements and inputs: Procurement and FM chapters for the Project Implementation Manual have been prepared to guide procurement and FM activities with full support of the task team. During project implementation, the procurement and FM specialists will conduct annual reviews, including reviewing of requisite reports as per the Grant Agreement, checking for compliance with agreed procurement and FM procedures, identifying potential capacity gaps, and evaluating adequacy of documentation and record keeping arrangements. Trainings will be provided to procurement officers designated by PMU within MFPSEPU, and BEL prior to the commencement of project implementation. Formal supervision will be carried out at least twice per year and continuous support will be made available by the procurement and FM specialists as needed by the clients.

c) Institutional capacity: The task team will ensure timely mobilization of two specialists who will be trained in the long term energy planning at the Energy Directorate in MFPSEPU, and availability of adequate resources to facilitate the training. The task team will also provide support to BEL in reviewing and reforming its response and recovery protocols, vegetation management approaches, and the analysis to identify transmission poles manufactured with different materials; and ensure they are in line with good industrial practices.

d) Governance: The task team will assess effectiveness of project steering committee, which is expected to guide the Energy Directorate at MFPSEPU, which is responsible for ensuring successful achievement of development objective of the project, by reviewing fulfillment of responsibility as required in their terms of reference. The task team will also evaluate effectiveness of project management unit, which is responsible for coordinating all project activities under the ERCAP, by reviewing overall project implementation progress and timely delivery of consolidated reports as required. Formal supervision will be carried out at least twice per year and continuous support will be available as required by the clients.

Table 4.1. Skills Mix and Resources Required

Skills Needed	Number of Staff Weeks (SWs)	Number of Trips
Task Team Leader	6 SWs annually	2 trips annually, field visits as required
Energy Planning/Institutional Specialist	4 SWs annually	2 trips annually
Environmental Specialist	2 SWs annually	2 trips annually
T&D Engineer	4 SWs annually	2 trips annually
Procurement Specialist	4 SWs annually	2 trips annually
FM Specialist	4 SWs annually	2 trips annually

Annex 5: Analysis of Extreme Weather on the Power Sector[34]

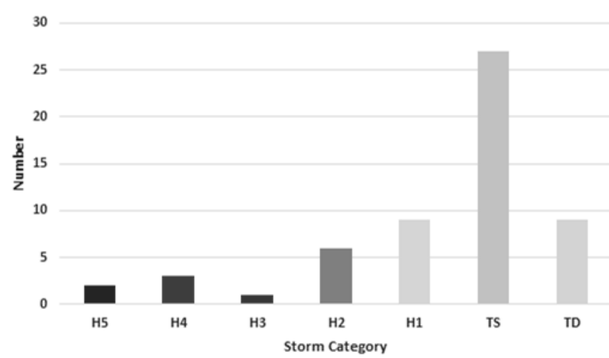
Belize: Energy Resilience for Climate Adaptation Project

1. This annex presents the results of an analysis evaluating two hurricanes and a tropical storm that made landfall in Belize and their resulting impact on the power system including damages and service disruptions, and estimates of the USE, the revenue lost by the power company, and the estimated economic impact; and identifies potential resilience measures that can be implemented to improve the adaptive capacity under similar circumstances in the future.

A. Vulnerabilities of the Power Sector to Extreme Weather

2. **Belize's power sector is already vulnerable to extreme weather events that are expected to be more intense and frequent due to climate change.** The transmission and distribution system already sustains considerable damage during hurricanes and tropical storms. Without further strengthening and implementation of response and recovery measures, the situation will worsen. Based on available data tracked since 1864, Belize experienced 21 hurricanes of which about a quarter were rated either category 4 or 5 with wind speeds in excess of 130 miles per hour, 27 tropical storms and 9 tropical depressions[35] (see Figure 5.1). Table 5.1 provides the main characteristics of the thirteen extreme weather events that affected Belize more recently since 2000. It does not include less severe storms and monsoon rains that occur yearly, which also affect the power system and progressively make it more vulnerable. A particular concern going forward is that future impacts could be much more frequent as the overall cyclone activity in the Caribbean and the wider North Atlantic Basin has shown a dramatic increase since 1995. While attribution of these weather patterns to climate change is still under debate, both frequency and duration of Atlantic hurricanes displayed statistically significant increasing trends and there has been a sustained increase in the proportion of category 4 and 5 hurricanes in the recent periods.[36]

Figure 5.1. Number of Hurricanes and Storms by Category (since 1864)



Source: Authors based on data from the National Oceanic and Atmospheric Administration, United States Department of Commerce

[34] Annex 5 includes excerpts from the pending publication, "The Call for Climate Adaptation in Belize: The Power System in the Eye of the Storm" by Migara Jayawardena, Borja Garcia Serna, and Jace Jeesun Han, 2016.
[35] National Oceanic and Atmospheric Administration, United States Department of Commerce
[36] Webster, Holland, Curry and Chang, 2005, "Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment"

Table 5.1. Summary Table of Hurricanes and Tropical Storms that Affected Belize (from 2000 to14)

No	Hurricane Name	Year	Maximum Wind Speed (mph)	Hurricane Category*	Districts along Storm Trajectory	Landfall	All Clear**
1	**Keith**	2000	138	H4	Belize, Orange Walk	9/30/00	10/04/00
2	**Iris**	2001	144	H4	Toledo	10/08/01	10/09/01
3	**Chantal**	2001	69	Tropical storm	San Pedro, Corozal	08/21/01	08/21/01
4	**Dean**	2007	190	H5	Corozal (near southern Mexico)	08/21/07	08/21/07
5	**Felix**	2007	23	Tropical depression	Toledo	09/04/07	09/04/07
6	**Arthur**	2008	46	Tropical storm	Belize, Orange Walk	05/31/08	06/02/08
7	**Alex**	2010	63	Tropical storm	Belize, Orange Walk	06/26/10	06/27/10
8	**Karl**	2010	63	Tropical storm	Corozal (near southern Mexico)	09/15/10	09/16/10
9	**Matthew**	2010	40	Tropical storm	Stan Creek, Toledo, Cayo	09/25/10	09/25/10
10	**Richard**	2010	98	H2	Belize, Cayo, Orange Walk	10/24/10	10/25/10
11	**Harvey**	2011	63	Tropical storm	Stan Creek, Cayo	08/20/10	08/20/10
12	**Ernesto**	2012	98	H2	Corozal (near southern Mexico)	08/07/12	08/08/12
13	**Barry**	2013	35	Tropical depression	Stan Creek, Toledo, Cayo	06/17/13	06/18/13

Source: National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Note: *Category: based on the Saffir-Simpson scale; **** All Clear:** NEMO declares the "All Clear" when the hurricane has passed and there is no substantial risk

3. **Evaluating past storm damage provides an indication of the vulnerabilities and impacts that may become even more severe in the future.** Based on data gathered and documented by BEL during two past hurricanes and a tropical storm, the remainder of section A attempts to identify the critical events that affected the power system, and evaluate the resulting impact on generation capacity and transmission and distribution failures that led to supply disruption (shortfall and duration) in electricity services. Estimating the economic costs resulting from the disruption in services and impact on end-users will provide a proxy for the development setbacks that arise from extreme weather events due to the vulnerabilities that exists in the power system in Belize.

Tropical Storm Alex

4. **Tropical Storm Alex struck Belize with heavy rainfall.** Alex made landfall in Belize City around 6:00 p.m. (2400 UT[37]) on June 26, 2010. The 'all clear' was declared by the GoB at 7:30 a.m. (1330 UT) on the following day indicating that the danger from the storm had passed. As with many storms that impact Belize, Alex took a northern turn as it moved west towards Mexico with wind gusts measuring 40-63 mph. Within Belize, it impacted the districts of Belize, Orange Walk, and Corozal.[38] Most of the country experienced heavy rains as a result of Alex. For example, near the Mountain Pine Ridge close to where most of the hydropower in the country is generated, 180 mm of rain was measured on the day Alex made landfall exceeding the average

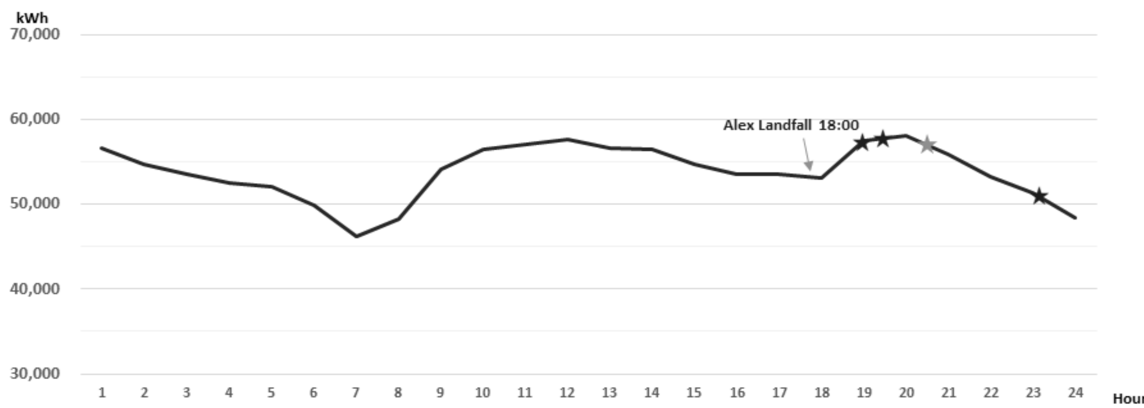
[37] UT = Universal Time.

[38] "Situation Report, Tropical Storm Alex Impacts Belize", the Caribbean Disaster Emergency Management Agency

rainfall for the entire month of June, which is 123 mm[39]. As a result, the Macal, Mopan, and Belize Rivers were flooded.[40]

5. **Alex's impact on the power system was not widespread, but electricity dispatch was reduced because of distribution system faults.** While the transmission system did not sustain significant damages due to Alex, the distribution system experienced four faults recorded by BEL's dispatch center. As seen in **Figure 5.2**, there was a steady increase in load toward the normal evening peak as Alex made landfall. However, the storm caused several distribution faults that led to outages cutting off nearly 3,000 customers, some as long as nine hours. As a result, the evening demand was lower by about 15 percent compared with the previous week. As illustrated in **Figure 5.3,** the first faults were reported in the island of San Pedro, followed by others in the districts of Belize and Orange Walk. Primary causes of the faults were tripped feeders and damaged distribution poles resulting in outages that ranged from two to nice hours.

Figure 5.2. Impact of Tropical Storm Alex on Hourly Dispatched Electricity Generation



Source: BEL

June 26 main events during Tropical Storm Alex

★ **San Pedro – Distribution line**
18:51 – Feeder 2 tripped affecting 1340 customers for 4-9 hours
19:14 -- Feeder 4 tripped affecting 328 customers for less than 5 hours

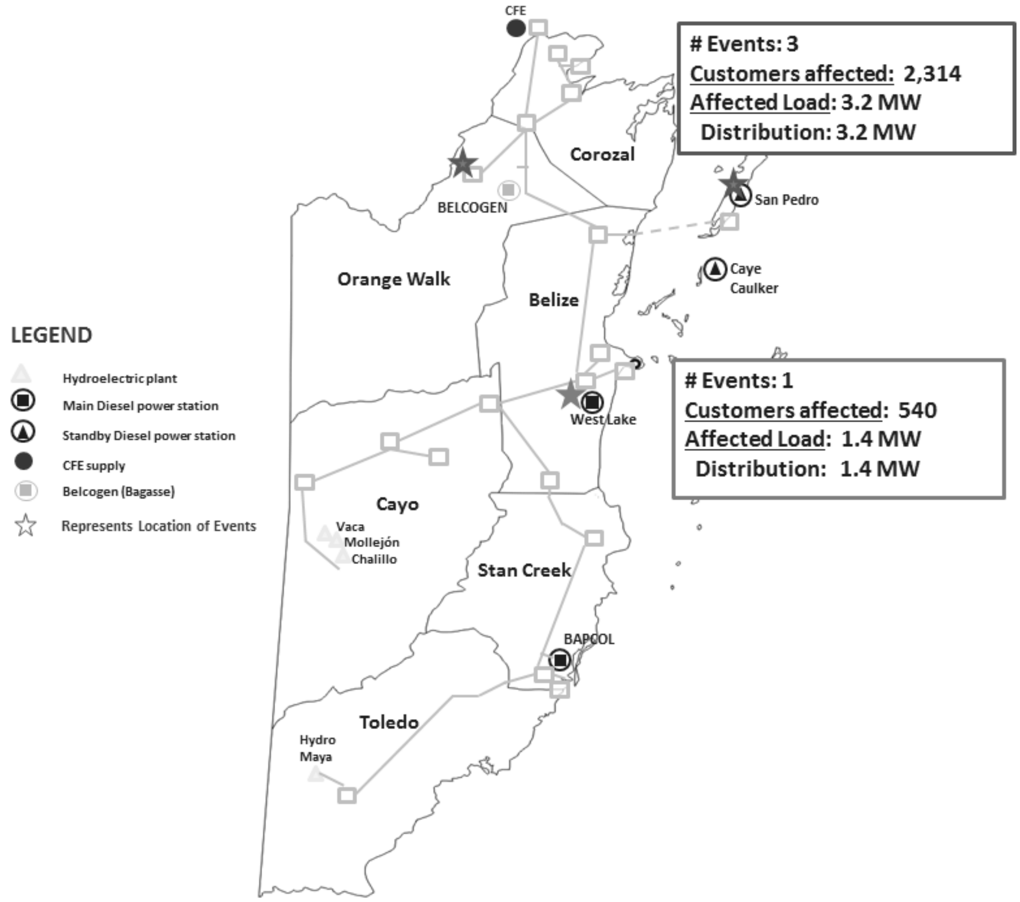
★ **Belize District – Distribution line**
20:28 – Feeder 1 tripped affecting 540 customers for less than 2 hours

★ **Orange Walk – Distribution line**
23:01 – Feeder 4 tripped affecting 646 customers for less than 9 hours

6. **Power outages during Tropical Storm Alex reduced weekly electricity consumption by nearly 10 percent, compared to a week earlier. Figure 5.4** shows about 10 percent decrease in total daily electricity generation on June 26 and 27 (the day of landfall and the following day) compared with the same days during the previous week (June 19 and 20). This decrease can be attributed to the reduction in load because of service interruptions as well as consumers curtailing activities (that is, closure of stores and firms) because of the storm. The suppressed demand lasted for about 22 hours.

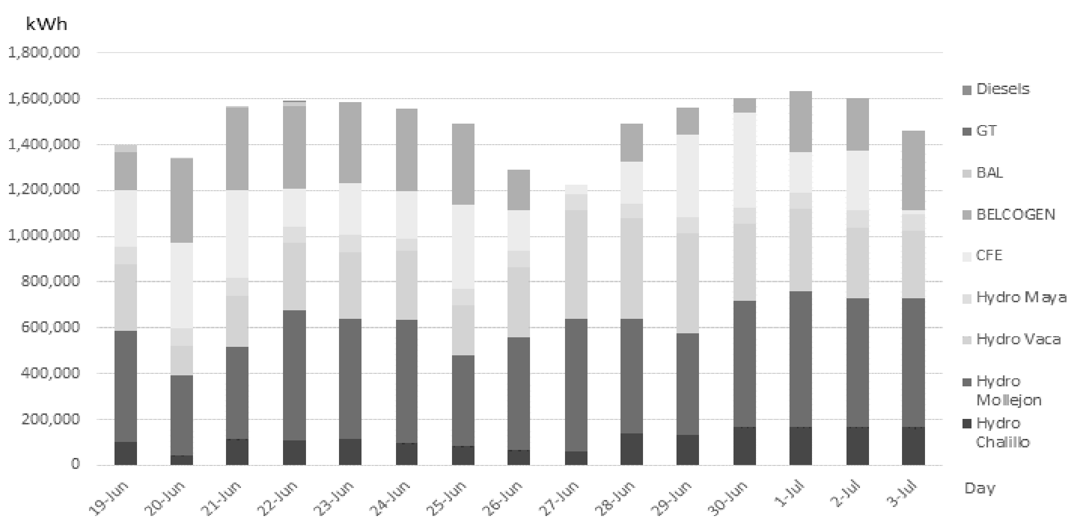
[39] "Tropical Storm Alex, the First Named Storm of the 2010 Atlantic Hurricane Season"
[40] Ibid.

Figure 5.3. Location and Impact of Tropical Storm Alex



Source: BEL

Figure 5.4. Daily Electricity Generation by Power Plant during Tropical Storm Alex

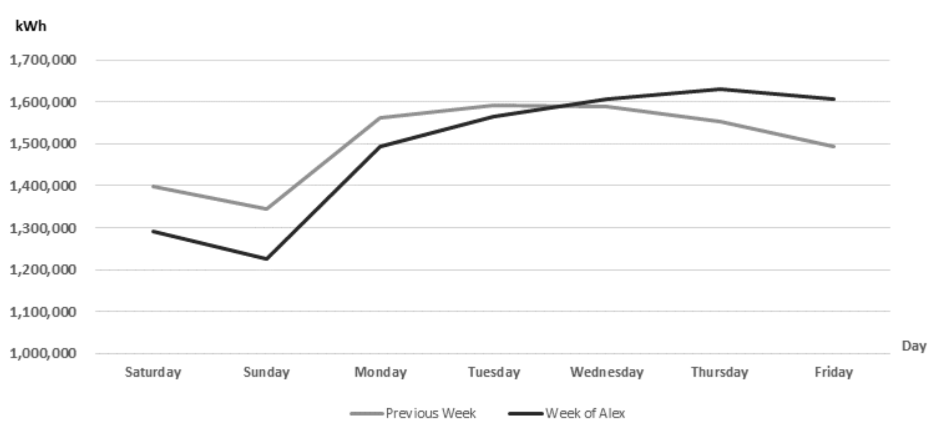


Source: BEL

7. **As demand recovered the day after Alex's landfall, BEL supplanted power generated from biomass and electricity imports due to increased availability of hydro because of the storm.** **Figure 5.4** shows that the daily generation by the major power plants of the system during the week before and after Alex's landfall. The storm related faults during the evening of June 26 resulted in a decrease in demand, which led BEL to reduce dispatch from the CFE and suspend dispatch from Belcogen although both generation sources remained operational: (a) Belcogen's generation fell from 355,404 kWh on June 25, the day before the landfall, to 179,714 kWh on June 26, the day of the landfall, and was reduced to zero on June 27, the day following landfall. Belcogen's generation levels remained noticeably reduced until June 30 before dispatch began to increase; and (b) CFE imports from Mexico fell from 366,680 kWh on June 25, the day before the landfall, to 175,410 kWh on June 26, the day of the landfall, then to 41,560 kWh on June 27, the day after the landfall. CFE imports peaked again when it reached 413,950 kWh on June 30. As the water levels topped off the reservoirs during Tropical Storm Alex, BEL continued to use more than 1,000,000 kWh of hydropower each day for at least an additional week because it would have been the least-cost option based on the merit order of dispatch.

8. **The estimated loss of revenue incurred by BEL amounted to over BZ$100,000 (US$ 50,000).** **Figure 5.5** shows the daily energy generation during the week of Alex's landfall and the preceding week. The USE because of Alex is estimated as the difference between the energy dispatched from June 26 to July 2, the week of Alex's landfall, and the energy dispatched during the previous week from June 19 to 25 that was unaffected by the storm. The USE during this period amounted to 115,913 kWh, resulting in an estimated BZ$51,813[41] (US$25,907[42]) of lost revenue for the utility, based on BEL's 2010 average sales price of BZ$0.45 per kWh[43] (US$0.22 per kWh).

Figure 5.5. Dispatch Comparison during Tropical Storm Alex and Business-As-Usual Scenario



Note:
Dark color Line: dispatch during the week when Tropical Storm Alex made landfall in Belize (June 26-July 2)
Light color Line: dispatch during the previous week that reflects business-as-usual in the absence of storm damage (June 19-25)

Source: BEL

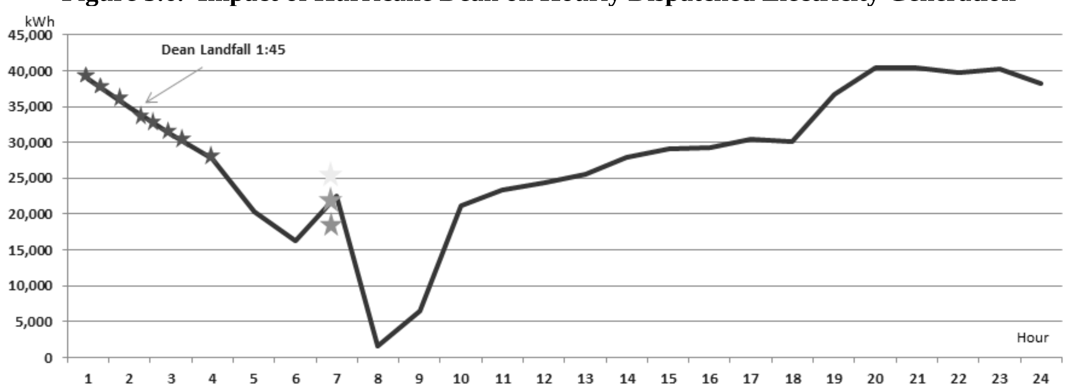
[41] BZ$ 0.447/kWh (average 2010 sales price/kWh rounded up to three decimals) * 115,913 kWh;.
[42] the exchange rate used in this paper for 2007 and 2010 is BZ$ 2 = US$ 1, based on the World Bank Development Indicators for official exchange rates.
[43] BZ$ 190,526,000 (BEL's 2010 annual revenue) / 426,233,000 kWh (BEL's 2010 total sales in kWh)

9. **The impact of the USE on GDP is estimated at about BZ$670,000 (US$335,000).** Belize's 2010 nominal GDP was BZ$2,794,226,900 (US$1,397,113,450)[44] and BEL's total net generation of electricity was 483,270,087 kWh indicating that the value added to GDP per kWh is BZ$5.78 (US$2.89)[45]. On this basis, the loss of GDP value-added to Belize because of unserved energy due to Alex is estimated at BZ$670,199 (US$335,100).[46]

Hurricane Dean

10. **Dean was a category 5 hurricane with high-speed winds but with minor rainfall.** Hurricane Dean landed along the Yucatan Peninsula near the town of Mahahual on Mexico's Caribbean Coast, about 50 miles northeast of Corozal Town in northern Belize on August 21, 2007 at 1:45 a.m. (0745 UT). The GoB declared 'all clear' at 1:00 p.m (1900 UT) on the same day. Dean was a fast-moving category 5 hurricane with maximum sustained winds of about 165 mph. Because of the rapid westward motion of Hurricane Dean, the accumulated rainfall over northern Belize was not as significant as forecasted.

Figure 5.6. Impact of Hurricane Dean on Hourly Dispatched Electricity Generation



Source: BEL

August 21 Main Events during Hurricane Dean

★ **San Pedro – Distribution line**

00:32 – Feeder 1 tripped affecting 870 customers for 23 hours
00:47 – Feeder 2, 3 and 4 tripped affecting 3,139 customers for 14 hours

★ **Corozal – Distribution line**

01:12 – Feeder 1 tripped affecting 3,277 customers for 4 - 6 days
01:57 – Feeder 2 tripped affecting 2,063 customers for 4 days
02:12 – Feeder 3, 4 and 5 tripped affecting 5,426 customers for 4 - 6 days

★ **Orange Walk – Distribution line**

02:36 – Feeder 1 tripped affecting 450 customers for 19 hours
02:50 – Feeder 4 tripped affecting 612 customers for 33 hours
03:35 – Feeder 2 and 3 tripped affecting 4,782 customers for 18 hours

★★★ **Cayo, Belize, Toledo and Stan Creek districts – Transmission line**

06:23 – System outage in various districts affecting 49,525 customers for 2 - 4 hours

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[44] World Bank Development Indicators, GDP (current US$)

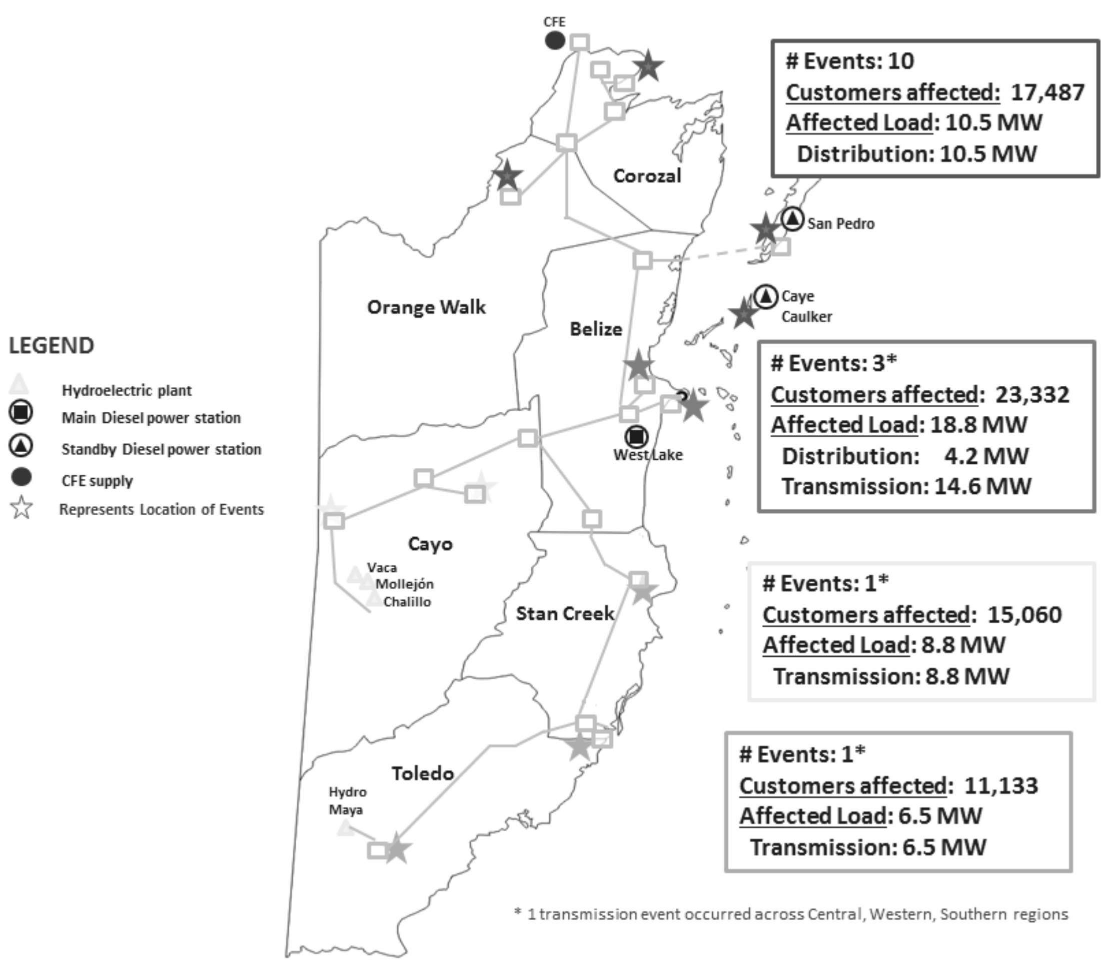
[45] US$ 1,397,113,450 (Belize's 2010 nominal GDP) / 483,270,087 kWh (BEL's 2010 total net electricity generation.

[46] US$2.89 per kWh (GDP value-added per kWh, rounded to two decimals) * 115,913 kWh

11. **Instantaneous and significant impacts brought the system to almost a total blackout.** Dean's impacts on the power sector have been reviewed and quantified based on BEL's internal reports, which record all the events affecting supply and dispatch of power during the operation of the system. **Figure 5.6** shows that the system began experiencing problem about two hours before Hurricane Dean's landfall as distribution lines failed to sustain the high-speed winds. In the first six hours of the manifestation of Dean (and about four hours after its landfall), the dispatched energy decreased by more than half (from about 41,717 kWh to about 16,224 kWh) mainly due to the failure of distribution lines. The system began to recover, but soon the failure of a transmission line brought the system to an almost total blackout.

12. **Most of the problems in the power system during Hurricane Dean were located in the northern region, in the vicinity of where it made landfall. Figure 5.7** shows that most of the documented events by BEL's dispatch center (10 out of 13) were located in the northern region of the country, where the highest winds were recorded and where the electricity system is more vulnerable to extreme weather conditions due to the lack of segmentation. The rest of events were located in the central (Belize and Ladyville systems), western (Belmopan and San Ignacio systems) and southern regions (Dangriga, Independence, and Punta Gorda systems).

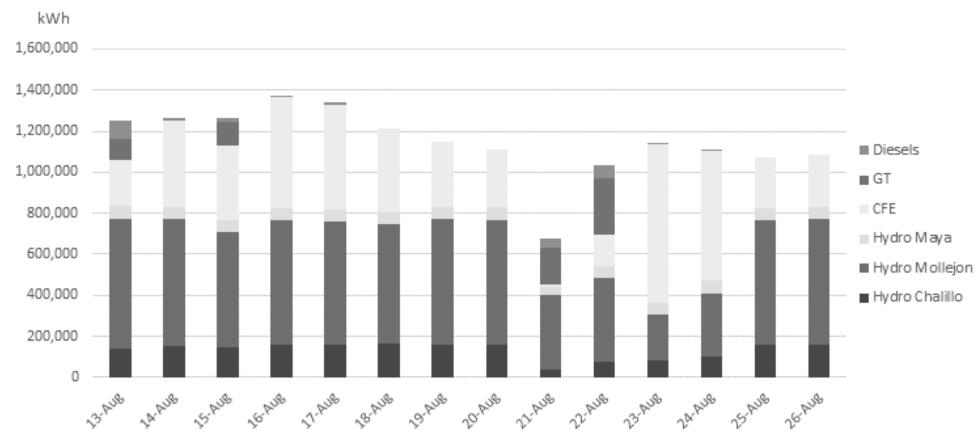
Figure 5.7. Location and Impact of Hurricane Dean



<u>Source</u>: BEL

13. **Hurricane Dean affected BEL's daily generation mix, significantly increasing the cost of supply. Figure 5.8** shows the daily generation by the major power plants of the system during the week before and the week after Hurricane Dean's landfall. The total generated electricity on Tuesday, August 21 (day of landfall) was about 54 percent of the previous and following Tuesdays' generation. The shortfall of generated electricity was mainly because of: (a) the interruption of imports from Mexico as Hurricane Dean caused a supply cut by 96 percent, compared to the previous week's supply. On August 22, imports resumed but at a lower level as they amounted to about 42 percent of the imports compared with August 15 and about 54 percent of the imports on the day before the landfall; and (b) the disruption of hydropower generation as the electricity generated by the Chalillo and Mollejon hydropower plants could not be dispatched due to transmission and distribution failures. On August 21, the generation from the Chalillo hydropower plant was reduced by 120,559 kWh (78 percent less than the previous week), and generation from Mollejon hydropower plant was reduced by 247,729 kWh (40 percent less than the previous week).

Figure 5.8. Daily Electricity Generation by Power Plant during Hurricane Dean



Source: BEL

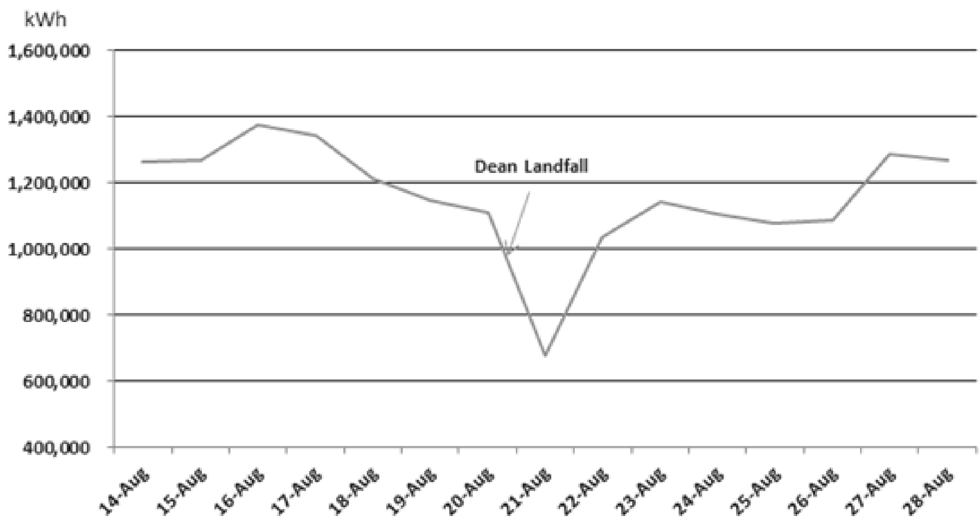
14. **BEL fell back on diesel-fired units to minimize the impact of the lost imports and hydropower generation.** To compensate for the loss of imports and reduction of hydropower generation on August 21 and 22, BEL operated its diesel fired gas turbine to generate 178,176 kWh and 272,384 kWh respectively and its diesel unit to generate 43,861 kWh and 63,518 kWh respectively. On August 23, imports increased to 775,610 kWh, a 42 percent increase from the previous week before returning to average levels, as hydropower generation was dispatched to levels preceding the landfall of Hurricane Dean.

15. **The disruption was sudden but the recovery was slow. Figure 5.9** presents the daily power generation showing the sudden disruption of the daily power supply caused by Hurricane Dean and the slow recovery as the system did not reach the daily dispatched electricity level until August 27, six days after the landfall of the hurricane. In the San Pedro area, BEL pointed out that it took them 24 hours to solve the problems with the feeders and four to six days to restore power supply in the severely affected Corozal area. However, restoration of supply was not fully achieved in the San Pedro area as the local news reported[47] that by August 24 there were still few

[47] Great Belize Television/Channel 5, "B.E.L. reports progress in restoring power", August 24, 2007.

customers on the north side of the island without electricity. The situation in the Corozal and Orange Walk districts imposed more drastic measures as the NEMO decided on August 21 to impose a nighttime curfew from 8:00 p.m. (August 21) until 6:00 a.m. (August 22). On August 22, the Corozal district was still on a blackout and power was restored to only 50 percent of customers in Corozal town by August 24. The north of Orange Walk district was also affected by failures of feeders and suffered blackouts. It took 33 hours to fully restore electricity supply. However, restoration of supply was not fully achieved in the San Pedro area as the local news reported[48] that by August 24 there were still few customers on the north side of the island without electricity. The situation in the Corozal and Orange Walk districts imposed more drastic measures as the NEMO decided on August 21 to impose a nighttime curfew from 8:00 p.m. (August 21) until 6:00 a.m. (August 22). On August 22, the Corozal district was still on a blackout and power was restored to only 50 percent of customers in Corozal town by August 24. The north of Orange Walk district was also affected by failures of feeders and suffered blackouts. It took 33 hours to fully restore electricity supply.

Figure 5.9. Daily Dispatched Electricity as Hurricane Dean made Landfall



Source: BEL

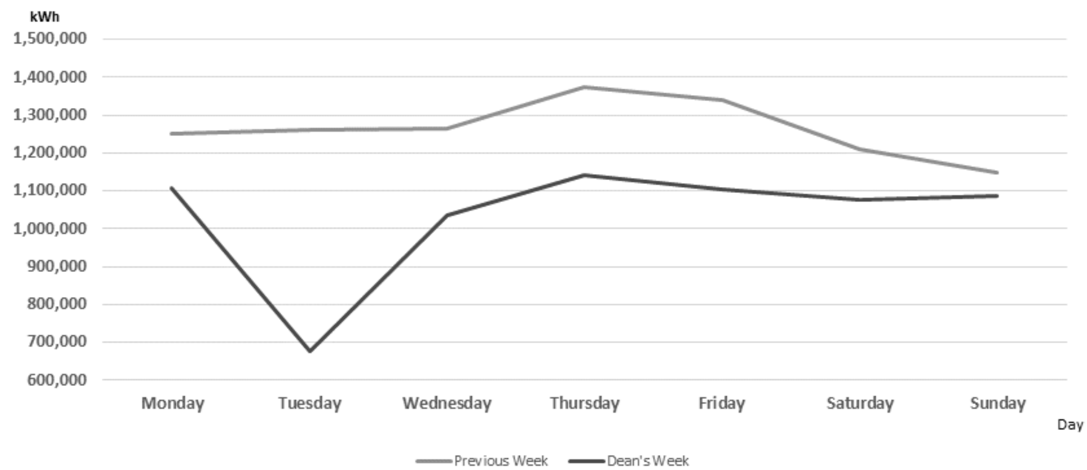
16. **Most of BEL's reported events were related to distribution system failures and led to significant amounts of USE.** Out of the reported 13 events, 12 were related to distribution system failures. The failures in the northern region (Corozal, Orange Walk and San Pedro systems) were the most acute, with 17,487 customers identified as being affected (24 percent of BEL's total customer base). The Corozal system was the most affected of the three regions with an estimated 7,634 customers losing power. It took four to six days to fully repair the northern system.

17. **Transmission failures were fewer and shorter but they affected higher numbers of customers.** At 6:23 a.m. on August 21, failures of the transmission lines in the western, central and southern systems affected all the feeders. The power outages lasted from two to four hours and affected 49,525 customers, about 68 percent of BEL's customer base.

[48] Great Belize Television/Channel 5, "B.E.L. reports progress in restoring power", August 24, 2007.

18. **The estimated loss of revenue incurred by BEL amounted to nearly BZ$700,000 (US$350,000).** The estimated USE because of Hurricane Dean can be estimated as the difference between the energy dispatched from August 13 to 19 (the week preceding Dean when there would have been a more normal consumption pattern) and the energy dispatched from August 20 to 26 when the hurricane was affecting Belize. **Figure 5.10** shows the energy dispatched during these two weeks. The estimated USE because of Hurricane Dean amounted to 1,624,100 kWh valued at BEL's 2007 average sale price of BZ$0.42 per kWh[49] (US$0.21 per kWh). BEL's loss of revenue is estimated at BZ$678,979[50] (US$339,490).

Figure 5.10. Dispatch Comparison during Hurricane Dean and Business-As-Usual Scenario



Note:
Dark Color Line: dispatch during the week when Hurricane Dean made landfall in Belize (August 20-26)
Light Color Line: dispatch during the previous week that reflects business-as-usual in the absence of storm damage (August 13-19)

Source: BEL

19. **An initial macro assessment of the damages because of Hurricane Dean indicated that the broader GDP losses resulting from USE were closer to BZ$10 million (US$5 million).** In 2007, Belize's nominal GDP amounted to BZ$2,581,085,100 (US$1,290,542,550)[51] and BEL's total net generation of electricity was 438,708,589 kWh, indicating that a kWh consumed generated added value BZ$5.88 (US$2.94)[52] to the GDP. On this basis, the lost value added to GDP during Hurricane Dean due to power outages is therefore estimated at BZ$9,555,182 (US$4,777,591).[53]

20. **Economic losses are well beyond the damages incurred by BEL and the power system.** The preliminary Damage Assessment and Needs Analysis report issued by PUC estimated the damages to BEL at BZ$1 million (US$0.5 million). They are in line with the damages reported in BEL's 2007 annual report. Additional detailed damage assessments were not carried out by BEL or the GoB thereafter. However, the Economic Commission for Latin America and the Caribbean's "Macro socio-economic assessment of the damage and losses caused by hurricane

[49] BZ$ 159,600,000 (BEL's 2007 annual revenue) / 381,759,000 kWh (BEL's 2007 total sales in kWh)
[50] BZ$0.418 per kWh (average 2007 sales price/kWh rounded up to three decimals) * 1,624,100 kWh
[51] World Bank Development Indicators, GDP (current US$)
[52] US$ 1,290,542,550 (Belize's 2007 nominal GDP) / 438,708,589 kWh (BEL's 2007 total net electricity generation)
[53] US$2.94/kWh (GDP value-added per kWh rounded to two decimals) *1,624,100 kWh

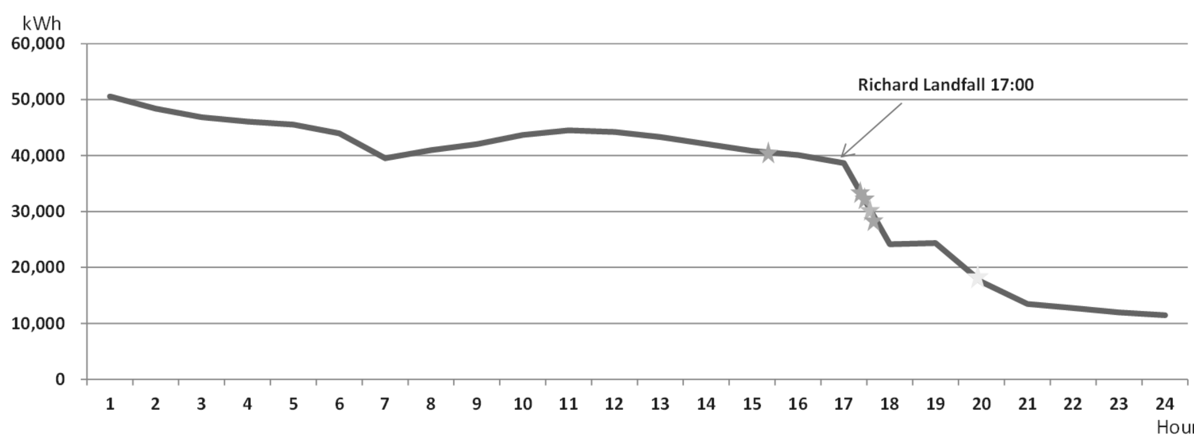
Dean," published December 17, 2007, estimated the total impact of the hurricane (damages and losses) to the economy at BZ $179 million (US$90 million), about 7 percent of GDP. Damages to assets and stocks represented 53 percent of the total while losses accounted for the remaining 47 percent.

Hurricane Richard

21. **Richard was a hurricane with strong winds and heavy rainfall.** Hurricane Richard made landfall on October 24, 2010, 20 miles south of Belize City, at approximately 5:00 p.m. (2300 UT) and followed a westerly track through Belize and Cayo districts before crossing to Guatemala. The 'all clear' was declared by the GoB at 6:30 a.m. (1230 UT) on the following day. Richard was a category 2 hurricane with sustained winds of 90 mph and recorded gusts of 115 mph. Much of the damage associated with Hurricane Richard was caused by the strong winds and heavy flooding that covered most of the country.

22. **Hurricane Richard brought the power system to a near blackout in about six hours. Figure 5.11** below shows that the system began experiencing problems about two hours before the landfall of Richard because of the problems on high voltage (HV) lines around the Ladyville area in Belize district. As soon as the hurricane landed, a chain of events drastically reduced the hourly generation from 40,095 kWh to about 13,494 kWh in just five hours. Most of the issues were related to system restoration outages and with problems in the distribution and transmission lines caused by fallen trees, poles knocked down and wires tangled as a consequence of high-speed winds.

Figure 5.11. Impact of Hurricane Richard on Hourly Dispatched Electricity Generation



Source: BEL

October 24 main events during Hurricane Richard

★ **Belize – Distribution line**
14:30 – System restoration, HV lines, affecting 623 customers for 3 days
16:47 – System restoration, HV lines, affecting 7,252 customers for 1-2 days
16:52 – System restoration, HV lines, affecting 5,003 customers for 2 days
17:03 – System restoration, HV lines, affecting 8,061 customers for one day
17:13 -- System restoration, HV lines, affecting 540 customers for 3 days

★ **Stan Creek – Distribution and transmission line**
16:56 – Issues with transmission line due to a fallen tree affecting 3,382 customers for 1 day in Independence system and 3 to 4 days in Dangriga and Mullins systems
19:41 – System restoration, HV lines, affecting 1,697 customers for 1-3 days in Dangriga area
20:55 – System restoration, HV lines, affecting 2,539 customers for 1 day

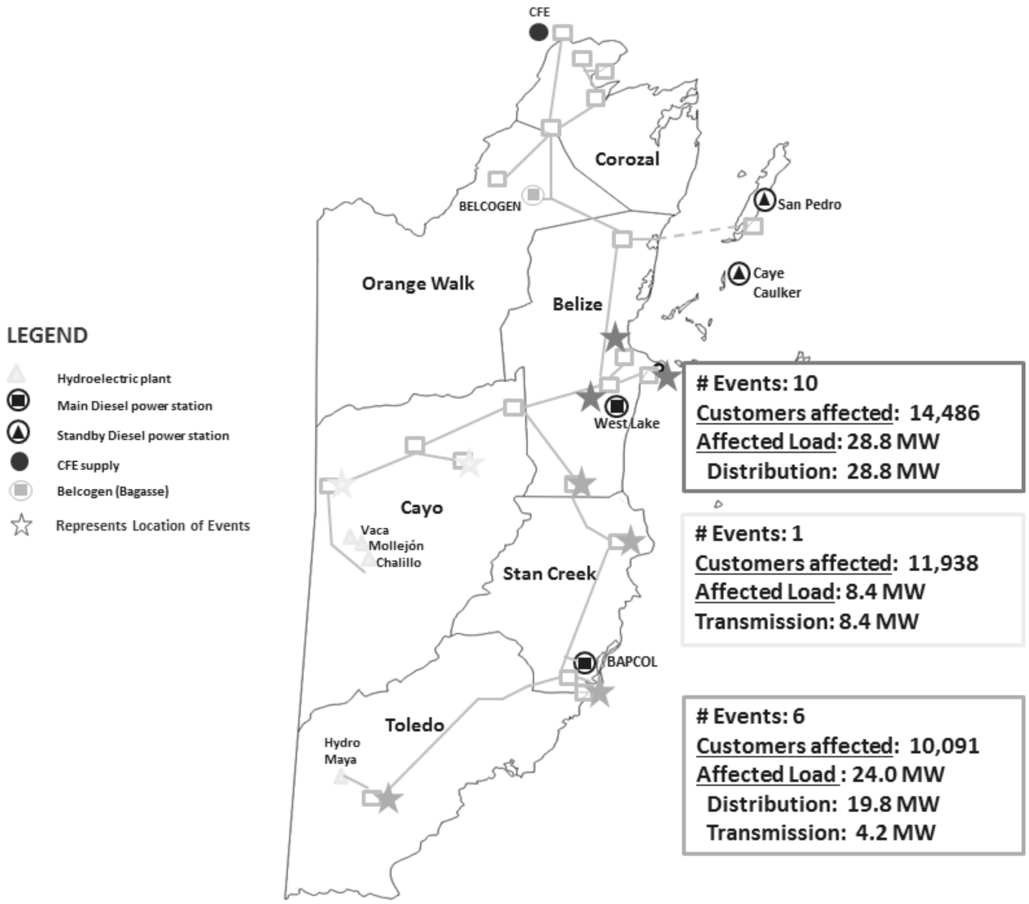
★ **Toledo – Transmission line**
16:56 – Issues with transmission line due to fallen tree affecting 3,492 customers in Punta Gorda for 1 day

★ **Cayo – Distribution and transmission line**
19:23 – Failures of distribution feeders affecting 6,726 customers during 1-2 days in Belmopan; Issues with a transmission line due to fall of poles and tangling of wires affecting 9,300 customers and during 1-2 days in San Ignacio area

23. **Richard affected mainly the central and western regions through Belize and Cayo districts towards Guatemala.** As shown in **Figure 5.12**, most of the documented events by BEL's dispatch center (11 of 17) were located in the central and western regions of the country. The westerly track of the hurricane caused major blackouts in the central regions (Belize, Ladyville and Mullins River systems) and the western regions (Belmopan and San Ignacio systems). The remaining six events were located in the southern region (Dangriga, Independence, and Punta Gorda systems).

24. **The damages in the power system persisted for several days following Richard's landfall.** Some of the documented events by BEL's dispatch center (9 of 17) occurred during the four days following Richard's landfall on October 24. On October 25, the southern regions (Independence, Dangriga and Punta Gorda systems) suffered complete blackouts because of failures of distribution lines. On October 27, the power in the central region (Ladyville and West Lake systems) was interrupted to repair a faulty HV line. Finally, on October 28, a large area in Belize suffered power outages because of a faulty insulator damaged by the hurricane.

Figure 5.12. Location and Impact of Hurricane Richard



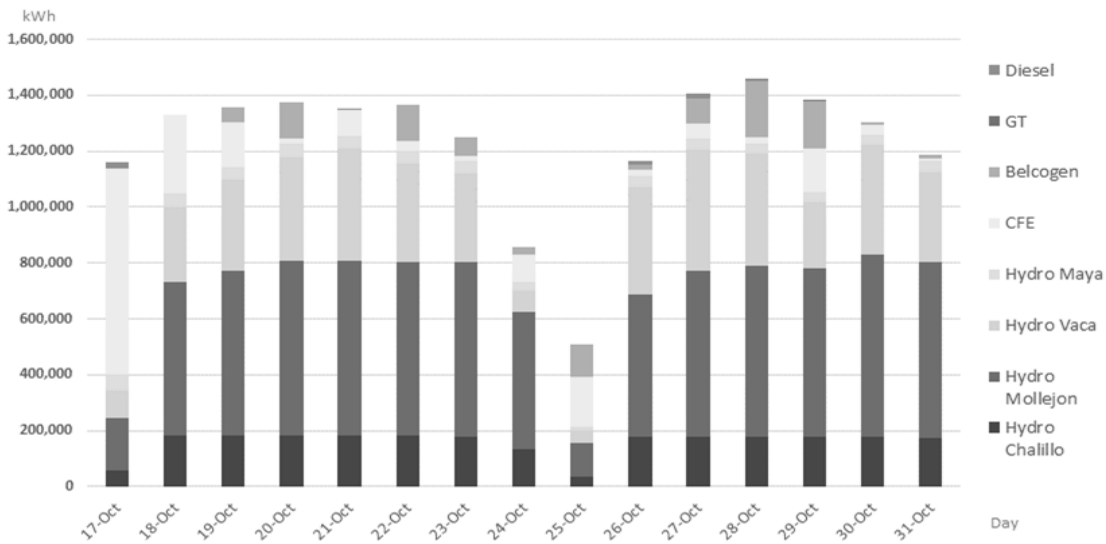
Source: BEL

25. **Hurricane Richard severely affected BEL's hydropower generation, interrupting the dispatch from all of the hydropower plants and impacting the daily generation mix. Figure 5.13** shows the daily generation by the major power plants of the system during the week before and the week after Richard's landfall. The total generated electricity on October 24 and 25 when Hurricane Richard made its impact in Belize was, respectively, 74 and 38 percent of the electricity generated during the previous week on October 17 and 18.

26. **The shortfall of generated electricity was mainly because of the system's inability to dispatch hydropower.** In comparison with the same day during the following week on October 31, the day when he hurricane made landfall on October 24, the electricity generated at Hydro Chalillo was 39,514 kWh less (23 percent less), at Hydro Mollejon was 136,325 kWh less (22 percent less), and at Hydro Vaca was 248,586 kWh less (76 percent less). The generation of all the hydropower plants were interrupted on October 24; Hydro Vaca was fully interrupted for 4 hours, Hydro Maya for 26 hours, Hydro Chalillo for 23 hours and Hydro Mollejon for 20 hours. The decrease in hydropower generation was even more severe on October 25; in comparison to the same day during the previous week on October 18, Hydro Chalillo's generation was reduced

by 149,282 kWh (81 percent), Hydro Mollejon's generation was reduced by 427,762 kWh (78 percent), and Hydro Vaca's generation was reduced by 222,734 kWh (83 percent).

Figure 5.13. Daily Electricity Generation by Power Plant during Hurricane Richard



Source: BEL

27. **BEL compensated the loss of hydropower generation by increasing imports from the CFE and generation from Belcogen and diesel engines.** To compensate for the loss of hydropower generation on October 24 and 25, BEL increased the imports from the CFE until October 25 before the hydropower generation was almost restored. On October 25, generation of Belcogen was increased to 114,371 kWh from 26,573 kWh of the previous day to minimize the impact of hydropower generation losses. On October 26, 27 and 28, BEL relied on diesel engines to meet local demand of electricity, generating as much as 19,191 kWh per day.

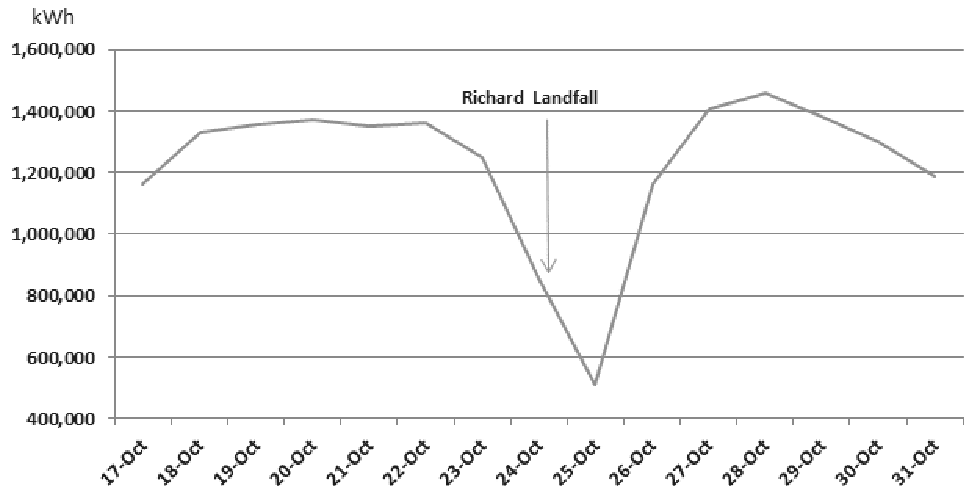
28. **Like Hurricane Dean, Hurricane Richards's disruption was sudden and the recovery slow. Figure 5.14** presents the daily power generation showing the sudden disruption of power supply caused by Richard and the slow recovery, as the system did not reach the normal daily generation of electricity until October 27.

29. From 6:00 p.m. on October 24 until the same time on the following day, the generated electricity was less than half of the observed levels the week before, causing drastic reduction of supply in central, western and southern regions. The central and western regions were badly affected and BEL pointed out that it took one to three days to restore generation and meet the demand. In the town of La Democracia in Belize District, there was also a blackout due to extensive damages on the western transmissions lines along the Western Highway up to the village of Blackman Eddy. Local media also reported that the local village of Lords Bank in the same district was without electricity for up to three days after the hurricane made landfall.[54] In the Southern region, many areas in the Stan Creek and Toledo districts were affected, but power was restored to most areas one day after landfall. Media reports indicated that there were some

[54] Channel 7 News, "Progress with Power Restoration", October 27, 2010

exceptions in the towns of Middlesex, St. Margaret's, Mullins River, Dangriga and Hummingbird Community– where restoration of service took longer.

Figure 5.14. Daily Dispatched Electricity as Hurricane Richard made Landfall



Source: BEL

30. **The distribution lines were the most affected by high-speed winds.** There were numerous transmission and distribution damages that extended across a large geographical area covering multiple districts reflecting the significant size of the hurricane. The distribution line failures affected 29,663 customers (about 39 percent of BEL's total customer base) while the transmission line failures impacted 13,726 customers (about 18 percent of BEL's total customer base). The main cause for the damages was the high-speed winds causing the collapse of poles (mainly distribution), tangling wires and knocking down trees and antennas on HV lines. The central region (Ladyville, West Lake, and the Belize City systems) was severely affected by Hurricane Richard affecting a total of 14,486 customers.

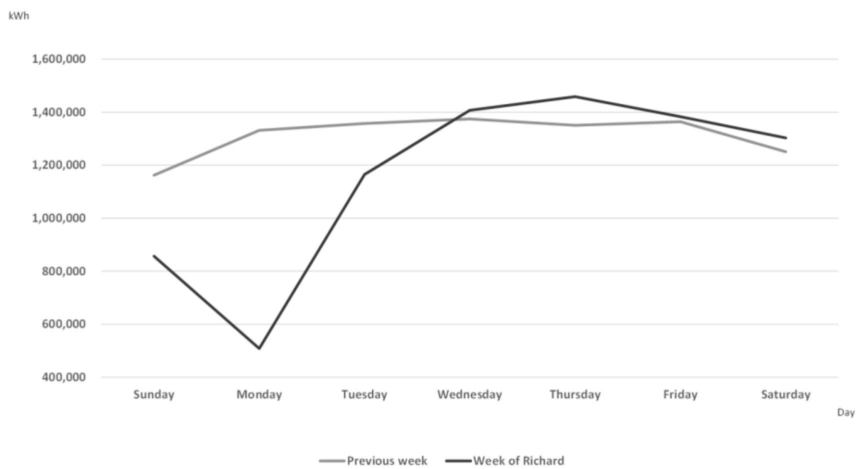
31. **Transmission failures were fewer but affected a large number of customers and led to a high load loss.** At 4:56 p.m. on October 24, there were failures in the western transmission line due to a fallen tree, which affected over 8,000 customers. At 7:23 p.m., the high speed winds knocked down poles and caused wires to tangle creating serious damages along the Western Highway from La Democracia to the village of Blackman Eddy badly affecting the western region leaving 11,938 customers in the San Ignacio and Belmopan load centers without power.

32. **The distribution line experienced failures in the southern and central region even after the hurricane left mainland Belize, affecting a significant number of customers.** On October 25, there were some residual impacts from the hurricane with distribution line failures affecting the southern region beginning after 5:30 p.m. In the Independence, Punta Gorda, and Dangriga systems, 9,088 customers (12 percent of BEL's total customer base) were affected. In the central region, distribution line failures that occurred from October 25 to 28 affected another 5,843 customers.

33. **The estimated loss of revenue incurred by BEL because of Hurricane Richard amounted to nearly BZ$500,000 (US$250,000). Figure 5.15** shows the daily energy generation

during the week of Richard's landfall and the preceding week. The USE due to Richard is estimated as the difference between the energy dispatched from October 24 to 30 during the week of the hurricane compared with the energy dispatched from October 17 to 23 when the system was unaffected by the hurricane. The USE amounted to 1,109,795 kWh resulting in an estimated BZ$496,078[55] (US$248,039) of lost revenue for BEL, based on the BEL's 2010 average sales price of BZ$ 0.45/kWh[56] (US$ 0.22/kWh).

Figure 5.15. Dispatch Comparison during Hurricane Richard and Business-As-Usual Scenario



Note:
Dark Color Line: dispatch during the week when Hurricane Richard made landfall in Belize (October 24-30)
Light Colr Line: dispatch during the previous week that reflects business-as-usual in the absence of storm damage (October 17-23)

Source: BEL

34. **The impact of the USE on GDP is estimated at about BZ$6.4 million (US$3.2 million).** Belize's 2010 nominal GDP was BZ$2,794,226,900 (US$1,397,113,450)[57] and BEL's total net generation of electricity was 483,270,087 kWh indicating that a kWh generated entails BZ$ 5.78 (US$ 2.89)[58] of added value to the economy. On this basis, the total amount of USE during Hurricane Richard was 1,109,795 kWh implying an estimated GDP loss of BZ$6,416,741 (US$3,208,371)[59].

35. **The total economic losses in Belize due to Hurricane Richard are well beyond the damages incurred by BEL and the power system.** In the Initial Damage Assessment Report (IDA) issued by the NEMO on October 27, 2010, BEL initially estimated its losses/recovery costs as being BZ$250,000 (US$125,000). The absence of electrical power also disrupted water systems in some rural communities because they did not have back up generation capabilities to sustain the operation of water pumps. The preliminary assessment estimated the total impact of the hurricane (direct losses + potential economic losses) on the economy at BZ$71 million (US$35 million), more than 10 times the above estimate, or about 3 percent of GDP.

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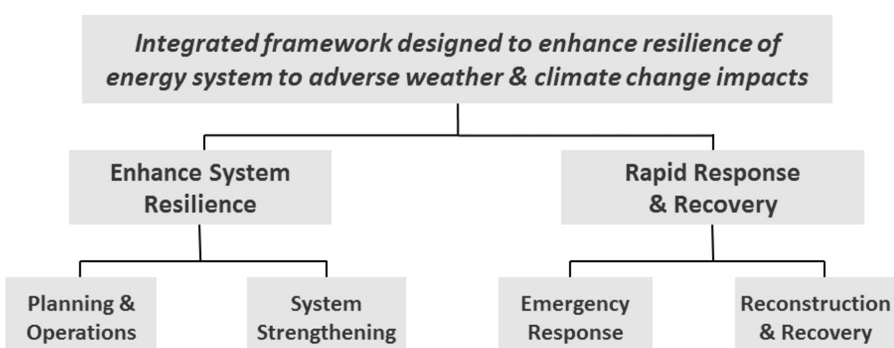
[55] BZ$0.447 per kWh (average 2010 sales price/kWh rounded up to three decimals) * 1,109,795 kWh
[56] BZ$ 190,526,000 (BEL's 2010 annual revenue) / 426,233,000 kWh (BEL's 2010 total sales in kWh)
[57] World Bank Development Indicators, GDP (current US$)
[58] US$ 1,397,113,450 (Belize's 2010 nominal GDP) / 483,270,087 kWh (BEL's 2010 total net electricity generation)
[59] US$2.89 per kWh (GDP value-added per kWh rounded up to two decimals) * 1,109,795 kWh

B. Building Resilience for Enhanced Climate Adaptation

36. **The GoB is taking action to enhance climate resilience in the country, including in the energy sector.** The previous analyses identified the vulnerabilities that extreme weather and climactic events pose for the power sector in Belize and attempted to quantify the resulting economic and financial impacts. The GoB recognizes that there are significant measures that can be taken to enhance its resilience to extreme weather events and better adapt to climactic impacts. Some of the steps the GoB has already taken in this regard include: (a) enactment of the Disaster Preparedness and Response Act (2003),[60] which is the primary legislation governing DRM in the country; (b) establishment of NEMO, with representation from the government cabinet, to ensure effecting coordination of the multiple agencies responsible for implementing the DRM legislation; and (c) adoption of the NCRIP (2014) that is designed to mainstream and ensure the consistency of climate adaptation investments with the national planning. The energy sector is represented in varying degrees in all these efforts, providing a legal, policy, and institutional framework for advancing measures for enhancing resilience.

37. **Enhancing resilience of the power system to adverse weather and climate change impacts will primarily focus on the following aspects: (a) strengthening the existing infrastructure and operational capabilities to minimize damages and disruptions, and (b) improving the domestic capacity to respond rapidly and recover efficiently from the residual damages that will still occur.** The power system in Belize can be physically strengthened ('hardened') and better strategically planned to improve its capacity to withstand the impacts of regular as well as extreme weather events. Such measures may not eliminate all future impacts on the power sector, but they can significantly reduce the likelihood and the negative impacts of such outcomes. Since some damages are inevitable irrespective of preventive actions, having in place an improved plan to quickly respond to emergencies and rapidly restore services will further minimize service disruptions and the overall impacts of storms on the power sector. Financial protections and institutional mechanisms can also be utilized towards enhance the resilience framework by shifting the risks from extreme weather to others who are better placed and capable of bearing them. A similar Integrated Risk Management Framework, as illustrated in **Figure 5.16,** is applied in designing the ERCAP supported by the Bank and GEF to assist Belize address some of its critical energy resilience and climate adaptation concerns.

Figure 5.16. Framework for Energy Resilience and Climate Adaptation



SOURCE: Authors, adapted from Ebinger and Vergara, "Climate Impacts on Energy Systems", The World Bank, 2011.

[60] Initially issued in year 2000, revised in 2003.

38. **Further evaluation of the impact of past tropical storms and hurricanes will help illustrate specific vulnerabilities of the power system, and measures that can be taken to enhance resilience to avoid similar damages and disruptions from occurring in the future.** Analyzing the sequence of events that led to some of the significant damages and service disruptions experienced during Tropical Storm Alex and Hurricanes Dean and Richard provides insights into some of the specific vulnerabilities in the power system. These *illustrations* focus on actual events that led to service disruptions and hypothetical events that have been avoided in the past but may materialize in the future. They also identify potential measures, which, if they had been in place at the time of the extreme weather event, would have either prevented or substantially reduced the damages or service interruptions. These illustrations helped identify and validate some of the priority activities that are included in the ERCAP with support from the Bank through funding from GEF.

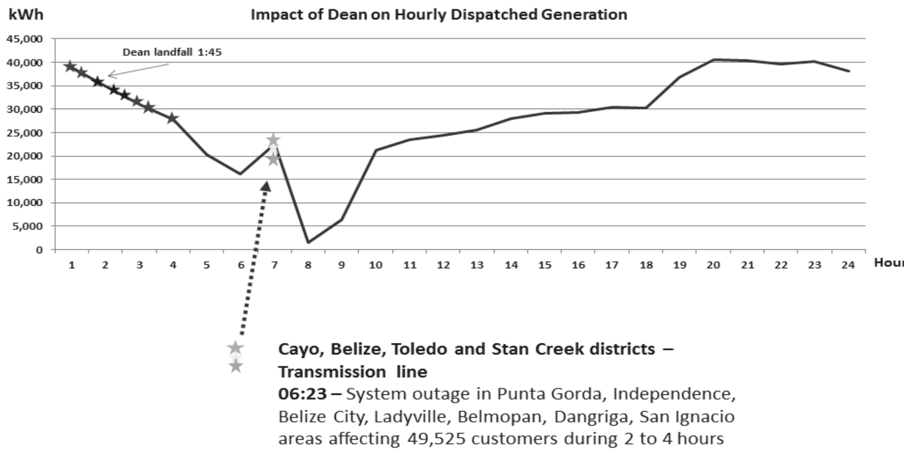
ILLUSTRATION 1: Segmentation of the Transmission Network

39. **BEL's transmission system lacks adequate segmentation, making it vulnerable to extreme weather.** When BEL's transmission network was originally constructed, many substations were supplied from 'tee off' or spur lines without segmentation between adjacent substations, which made the entire transmission line vulnerable in case of faults or disturbances.[61]

40. **Hurricane Dean, in 2007, illustrates the extent to which the transmission network is exposed in extreme weather because of inadequate segmentation of the system.** Revisiting the impact of Hurricane Dean on the hourly dispatched energy in Figure 5.17, the system steadily deteriorated initially because of the damage caused by high winds to the distribution system in northern Belize. However, as illustrated in the Figure 5.17, at 6:23 a.m., the transmission system began to experience cascading faults that affected the whole line and caused a near blackout of the entire power system in the country.

[61] Power line faults have many causes: lightening discharges, trees touching the line, two-phases short-circuiting, insulation failures, and so on, most of which occur during adverse weather conditions. These 'faults' can be transient or permanent. In the case of transient faults, disturbances are cleared naturally (for example, when the lightening surge decays or a branch touching the line burns out). In such cases the line will 'hold' when re-energized by switching 'on' the circuit breaker. In the case of permanent faults, disturbances are not cleared and the line will not 'hold' until the cause of the fault has been removed physically (for example, when a damaged insulator is replaced or a grounded conductor is re-strung).

Figure 5.17. Transmission Failure during Hurricane Dean and its Impact on Dispatch Energy



SOURCE: BEL

41. **During Hurricane Dean, a fault that occurred at a CFE transmission lines in Mexico led to a series of cascading 'trips' that left the entire transmission system on the Belize mainland inoperable.** Hurricane Dean, which brought winds in excess of 165 mph through northern Belize and the bordering region of Mexico, triggered a series of disruptions that began on the Mexican side but rapidly spread to render the Belize transmission system inoperable. The series of disruptions to the BEL transmission network, which is graphically illustrated with corresponding numerical references in **Figure 5.18**, are as follows:

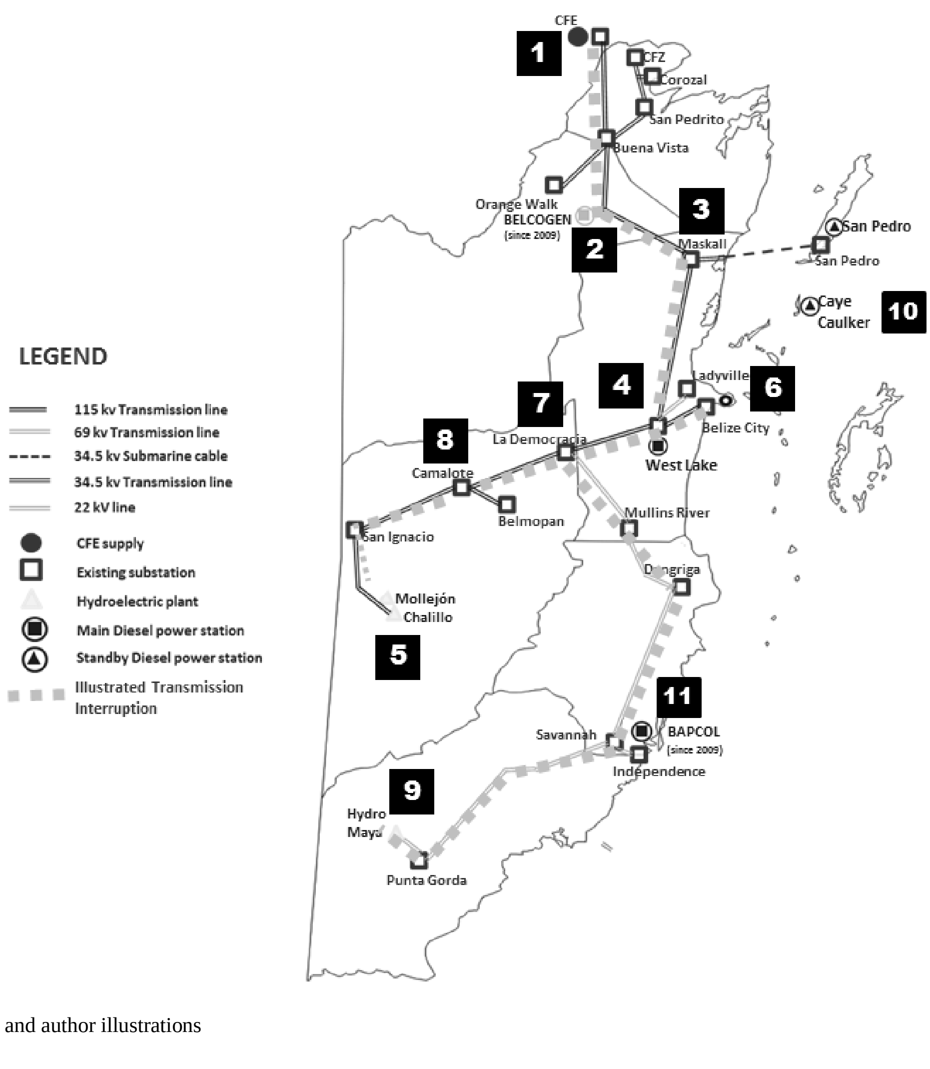
a) CFE transmission lines in Mexico near the border with Belize experienced a fault due to a fallen tree at 6:23 a.m. on August 21, interrupting power supply to BEL's system (Reference location 1 in Figure 5.18). This is the main substation that supplies up to 50 MW of power generation capacity from the CFE to BEL.
b) The fault at the CFE substation triggered a cascade that resulted in the northern part of the 150 kV transmission line in Belize, up to the Westlake substation, becoming inoperable (Reference distance from 1 to 4).
c) Due to the inoperable northern transmission line, electricity from the Westlake power plant (Reference location 4) also could not be evacuated to supply the northern part of Belize.
d) The "trip" in the northern transmission line then continued to cascade leading to the western transmission line from Westlake to beyond San Ignacio to become inoperable (Reference distance from 4 to 5).
e) As a result, Hydro BECOL (Reference location 5), which is the largest domestic power plant in Belize, could not evacuate the bulk of its power, and was reduced to supplying a limited local area. The transmission disruptions on the western line also cut off electricity supply to the capital Belmopan, amongst other significant cities in the west of the country.
f) The 'trip' in the western transmission line also extended east from the Westlake substation (Reference location 4) to Belize City (Reference location 6), cutting off electricity supply to the largest and most populated city in the country.
g) The cascading transmission 'trips' then affected the 69 kV southern transmission line from

La Democracia to Punta Gorda (Reference distance from 7 to 9) and the 22kV connection to the 7 MW the Hydro Maya power plant, cutting electricity service to the southern part of Belize.

h) As a result of this cascading disturbances, practically the entire transmission network in Belize was affected and the country experienced a near-blackout. Only the isolated small grid in Caye Caulker (Reference location 10) remained operational.

42. These events resulted in the dispatch of only 3.5 percent of the electricity supplied on August 14, a week before the events. Consequently, more than 64,000 customers (about 88 percent of BEL's customer base) lost power, although none of the power plants sustained significant damage due to the hurricane.

Figure 5.18. Cascading Disruptions in the Transmission Network during Hurricane Dean



SOURCE: BEL and author illustrations

43. **Hurricane Dean's impact on the power system in Belize could have been significantly reduced if the transmission system was adequately segmented.** If the transmission network

had been segmented at key substations, then the damage at the CFE transmission lines (Reference location 1) would have been isolated to BEL's northern transmission line section. By enabling the system to decouple the transmission and isolate the section affected by the fault, the rest of the transmission network in Belize could have remained energized and most of the power system operational. The loss of significant supply from Mexico's CFE would have still posed a challenge, but given the multiple other generation sources in the BEL system, they could have been brought online to make up for the shortfall. For example, additional electricity could have been supplied from the 22.5 MW Westlake power plant, which is a gas turbine that operates on diesel. While operating the Westlake power plant would have been a costlier option than electricity purchased from the CFE at that time, it would have nevertheless been a useful temporary solution that could have avoided the major blackout that Belize faced during Hurricane Dean. Since Hurricane Dean, there is now a 13.5 MW Belcogen biomass co-generation power plant (Reference location 2) that is in operation, commissioned in 2009. If Belcogen had been in operation at the time of Hurricane Dean, it would have been another power generation node that would have been cut off from the system due to cascading faults as a result of the lack of segmentation; and would have had an even greater impact. Therefore, it can be concluded that had there been adequate segmentation of the system with circuit breakers at the time of Hurricane Dean, it could have prevented the cascade of 'trips' from spreading beyond the Maskall substation (Reference location 3), and avoided the near-system wide blackout of the system. Under such a scenario, only an estimated 13,000 or about 18 percent of BEL customers would have been affected by the transmission failure compared to the 64,000 that were actually affected.

44. **During Hurricane Richard, in 2010, Belize also faced an extended transmission failure due to a 'trip' that cascaded.** On October 24, at 7:23 p.m., several transmission poles fell tangling the wires on the 115 kV western transmission line (Reference distance from 7 to 8), between the substations at La Democracia and Camalote. Since the western transmission line was not segmented at the time, the fault cascaded and rendered the entire western transmission line inoperable for over 20 hours. As a result, the 51.5 MW Hydro BECOL was unable to dispatch, cutting off supply to San Ignacio and the capital, Belmopan. Over 18,000 customers (23 percent of BEL's total customer base) were affected. If the western transmission line was segmented with circuit breakers at the time, the fault could have been isolated between the substations at La Democracia and Camalote (Reference locations 7 and 8, respectively), fewer customers (between the two substations) would have been impacted and electricity supply from Hydro Becol to the key cities of Belmopan and San Ignacio would have continued.

45. **BEL is making efforts to segment its transmission lines throughout the system, which is being supported by the Bank and GEF.** Given its experience with adverse weather, BEL has installed some protections to segment parts of its transmission although some critical substations that are generation nodes remain unsegmented. Since these unsegmented sections makes the transmission system vulnerable during a future tropical storm or hurricane should a line damage occur in these areas, BEL, through the ERCAP, is expected to install switchyards at Belcogen (Reference location 2), and Bapcol[62] (Reference location 11), with line circuit breakers for

[62] The substation at Bapcol, located near Savannah and Independence, evacuates power from a 15MW high-speed fuel oil plant, which is presently kept on stand-by by the BEL as a back-up. The Bapcol power plant was not in

the ‘in’ and ‘out’ of each transmission line section. At Belcogen in the north, the line will be segmented to two sections: from CFE supply to Belcogen, and from Belcogen to Maskall. At Bapcol in the South the line will be segmented to two sections: from Dangriga to Bapcol and from Bapcol to Savannah. This would effectively complete the needed segmentation of BEL’s existing transmission network until further expansion and system upgrades are considered.

ILLUSTRATION 2: Strengthening of Transmission Network Structures

46. **BEL’s transmission line structures are deteriorating and can jeopardize the resilience of the overall power system.** It is important for the reliability and resilience of the power system to prevent or limit damages to the transmission lines, including from ‘downing’ of the structures during tropical storms and hurricanes, because they can lead to extended power supply outages affecting large numbers of consumers. Large power companies usually design and build their main transmission in-line with secure standards utilizing self-supporting lattice steel structures. This practice, however, can be too costly for a small utility such as BEL, which utilizes wooden pole structures for its transmission network, a substantially lower cost option.

47. **Specific portions of the transmission lines remain particularly vulnerable to increasing climatic events even if they were avoided until now.** Regular inspections carried out by BEL have revealed that certain portions of the transmission line are experiencing substantial corrosion of the anchors, guy wires and attachments. Many sections of the transmission line have also been affected by premature wood decay due to termite attack and fungal growths. Some transmission poles have also developed longitudinal cracks (‘checking’), which weaken them and make way for further decay by allowing fungal growth. Bush fires have also affected some of the poles[63]. Such signs are a warning of the increasingly greater possibility that strong winds generated from future tropical storms or hurricanes will cause a number of already weakened poles to collapse. This has been avoided to date due to BEL’s inspections, aggressive approach to maintenance, and through temporary limited fixes. However, the weakened state of the structures can lead to catastrophic damages to large sections of the transmission line, causing significant power shortages for extended periods.

48. A transmission section that was identified by BEL as being particularly vulnerable due to its weakened state is the line from Maskall to Westlake. It is responsible for transmitting significant amount of electricity from the CFE and other generators in Belize to multiple load centers in the country. Successive storms and hurricanes will continue to batter and further weaken the structures along this line making them progressively more vulnerable to a catastrophic collapse. While such a major event has been prevented to date, this illustration explores disruptions that can be caused due to the downing of some of the weakened poles. The hypothetical events are graphically illustrated with corresponding numerical references to **Figure 5.19**:

a) A collapse of transmission structures along the 115 kV transmission section between Maskall and Westlake substations (Reference distance from 1 to 2 in Figure 5.19) due to high winds during a future storm or hurricane would truncate the power system in Belize.

existence at the time of Hurricane Dean, as it was commissioned later in 2009. However, segmentation at Bapcol is important for system reliability in BEL’s current transmission network.

[63] BEL has reported losses of 5 poles per year due to bush fires

This section is particularly vulnerable as it passes through water logged and saline areas that have led to the corrosion of metal structures as well as wood decay and other factors that have weakened the infrastructure.

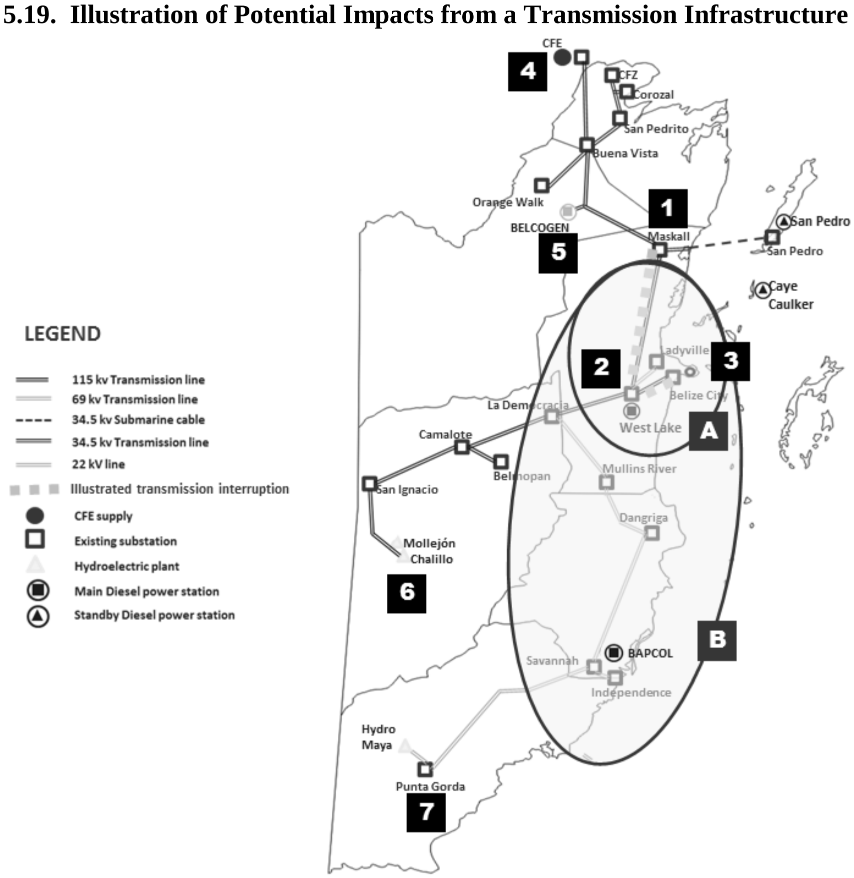
b) The result following such an occurrence would be the immediate cut off of power supply from the north and the loss of service to consumers along the inoperable transmission section. It would cut off electricity supply from the CFE (Reference location 4) and the Belcogen bagasse co-generation power plant (Reference location 5) to the load centers in central and southern Belize.

c) An estimated 24,500 customers (30 percent of the 2014 customer base) or more in the central area of Belize (Reference shaded area marked A) would experience extended loss of service as a result of the damage to the transmission line and its inability to evacuate power from the north.

d) If the transmission damage would impact the southern part of the country creating electricity shortages, an additional estimated 11,000 customers would experience supply shortages (Reference shaded area marked B).

e) Since the inability to evacuate electricity from the critical northern generation sources would leave Belize City, the country's largest load center, without supply, BEL would have to resort to operating the costlier, 22.5 MW diesel-fired gas turbine (Reference location 2). While this could reduce supply disruptions to Belize City, it would temporarily increase BEL's cost of supply.

Figure 5.19. Illustration of Potential Impacts from a Transmission Infrastructure Collapse



SOURCE: BEL and author illustrations

49. A transmission section that was identified by BEL as being particularly vulnerable due to its weakened state. There could be additional disruptions from a collapse of transmission infrastructure as a result of extreme weather compared with those indicated in the previous illustrative example. During inspections, weaknesses were also detected in the infrastructure that extends the transmission line from Westlake to Belize City. Damage to this section would lead to additional disruptions, which are also graphically illustrated with corresponding numerical references to **Figure 5.19**:

a) A collapse of transmission structures along the 115 kV transmission section between Westlake and Belize City (Reference distance from 2 to 3 in Figure 5.19) could occur because of weakened poles and infrastructure that would collapse from the impacts of a tropical storm or hurricane.
b) Coupled with the disruptions along the Maskall-Westlake transmission link (Reference distance from 1 to 2), the above event would leave Belize City (Reference location 3) without electricity, since electricity from the northern power stations (Reference locations 4 and 5) or the back-up facility at Westlake (Reference location 2) could no longer be evacuated to the Belize City distribution network. This would leave over 17,500 customers in Belize City without electricity (21 percent of BEL's 2014 customer base) until the lines can be restored.

50. **BEL is taking measures to 'harden' the transmission infrastructure to enhance resilience and ensure reliable operations, helping avoid catastrophic damage to the power system during future extreme weather events.** The immediate focus is on the transmission sections from Maskall to Westlake substations and Westlake to Belize City substations, which were identified as being in particularly poor condition and the most vulnerable. With Bank and GEF support through the ERCAP, BEL plans to evaluate alternative line supports and new design standards for each type of terrain encountered along the identified transmission line routes. This may include various types of pylons such as fiber-glass, fiber reinforced polymer, pre-stressed concrete, as well as alternate support designs; to determine their suitability to the specific terrain and climate conditions. The evaluation will also review measures to rehabilitate/strengthen poles that are salvageable. The rehabilitation and replacement of transmission infrastructure along the Maskall-Westlake line (Reference distance from 1 to 2 in Figure 5.19) will significantly enhance resilience and minimize potentially major supply disruptions. It will considerably reduce the risk of interruption of imports from Mexico (Reference location 4) as well as from the Belcogen biomass co-generation plant (Reference location 5) and enable uninterrupted supply to load centers in the central and southern areas of the country. If the upgrade also included the only transmission section linking Westlake to Belize City (Reference distance from 2 to 3 in Figure 5.19), it will prevent a potential blackout for over 17,500 customers based in the city[64]. The proposed evaluations and investments supported by the ERCAP will immediately enhance the resilience of the system by strengthening the transmission sections that are the most compromised. It will also help BEL in deciding to strengthen existing standards or introduce new standards that are better adapted to characteristics of specific terrains traversed by the transmission lines, and

[64] Resilience will also be strengthened due to the ongoing construction of a 'by-pass' transmission link from Ladyville that is a little farther north that will provide another supply feeder from Westlake to Belize City.

apply them in the upgrade and expansion of the remainder of its transmission system across the country.

51. **Segmenting the transmission network and hardening the infrastructure are complimentary and together provide greater resilience to the power system.** Illustrations 1 and 2 highlight how each set of measures would enhance the resilience of the power system individually. However, together, they would provide greater security. For example, the strengthening of the poles and associated equipment along the transmission section from Maskall to Westlake (Reference distance from 1 to 2 in Figure 5.19) would help prevent a catastrophic collapse in that area, and avoid severe impact on the system. However, segmentation of the transmission line at the Maskall (Reference location 1) and Westlake (Reference location 2) substations, limits the impact of the collapse to the Maskall-Westlake line segment. It prevents additional "trips" north of Maskall and west of Westlake, providing an additional layer of resilience for the overall power system.

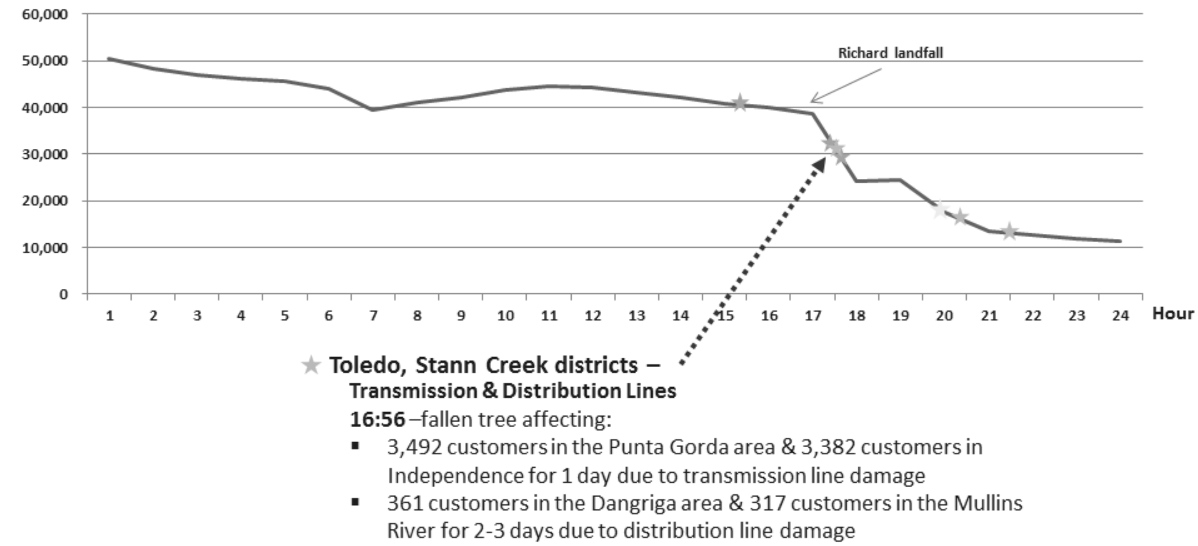
ILLUSTRATION 3: Improved Vegetation Management

52. **Good vegetation management practices are vital to maintain system resilience especially in tropical climates.** One of the highest recurrent maintenance costs in most utilities is vegetation management[65]. It can have even more significance in tropical climates where vegetation growth can be particularly aggressive. Excessive and unwanted vegetation can hinder management and upkeep of electrical infrastructure. It will affect BEL's system performance especially during storms as lines can be damaged due to falling trees/branches and during extended droughts when the risks of damaged structures from wildfires increase. BEL also indicated that inadequate vegetation management resulted in certain infrastructure being inaccessible during and after extreme weather events hindering their capacity for emergency response and recovery. BEL already has in place a vegetation management plan. It recognizes the need to further improve its practices given its importance to maintaining a resilient power sector operation.

53. **Hurricane Richard, in 2010, provides an illustration of the extent to which disruptions can extend because of a damage caused to the power lines from a fallen tree.** Figure 5.20 shows how, at 4:56 p.m. on October 24, a fallen tree on a transmission line caused a succession of events that led to a significant reduction in the dispatched electricity.

[65] Edison Electric Institute, 2014. "Before and After the Storm: A Compilation of Recent Studies, Programs, and Policies Related to Storm Hardening and Resiliency."

Figure 5.20. Transmission Disruption due to a Falling Tree on HV line during Hurricane Richard and Its Impact on Electricity Dispatch

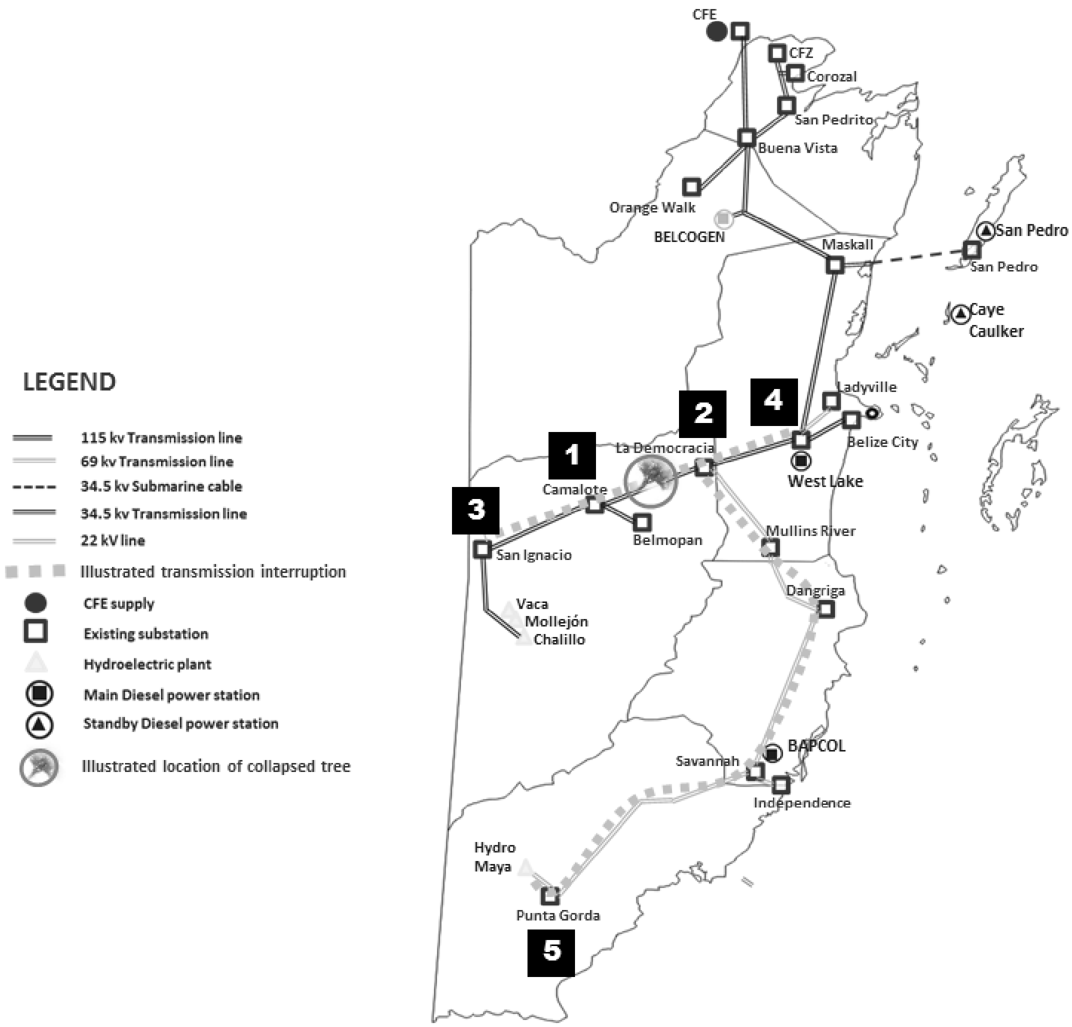


SOURCE: BEL

54. A further review of the events surrounding the disruptions from the falling tree is graphically illustrated with corresponding numerical references in **Figure 5.21**:

a) The impact of Hurricane Richard that swept across central Belize resulted in a tree collapsing on the transmission line between the Camalote and La Democracia substations (Reference distance from 1 to 2 in Figure 5.22).
b) This led to the failure of 115 kV line segment from Westlake to San Ignacio (Reference distance from 3 to 4).
c) It also caused the failure of the 69 kV southern distribution line from the La Democracia to the Punta Gorda substations (Reference distance from 2 to 5).
d) While the 115 kV western line was quickly restored, the 69 kV southern distribution line remained inoperable for an additional 21 hours before it was repaired. As a result, over 7,500 customers in the southern part of the country, about 10 percent of BEL's 2010 customer base, remained without electricity service until the damage was repaired.

Figure 5.21. Illustration of Transmission Disruption due to Collapsed Tree during Hurricane Richard



SOURCE: BEL and author illustration

55. **BEL plans to improve its vegetation management practices so it can proactively mitigate damages to its system and improve access during emergency response operations.** BEL would like to reduce the likelihood of events such as the one that occurred during Hurricane Richard. It is possible that with more effective vegetation management before Hurricane Richard, BEL could have prevented the tree falling and damaging its infrastructure avoiding the system outages that followed. It is even possible that better planned vegetation management would have increased accessibility for emergency vehicles and crews to locations with damaged infrastructure reducing the extensive time it took to energize the 69 kV southern distribution line. Therefore, through the ERCAP, BEL is expected to review its vegetation management practices to bring them in-line with best practice approaches necessary in a tropical climate. This might include various strategies to vegetation management based on emerging trends[66] such as identifying and targeting

[66] Ibid.

the removal of trees dangerous to the system in addition to routine trimming of branches and clearing ways; applying new bio-friendly techniques; and better coordinating with concerned local officials.

ILLUSTRATION 4: Distribution System Infrastructure Strengthening

56. **While transmission damage can lead to significant and extended outages, a large proportion of the storm damages occur in the distribution system.** As shown in the table in Table 5.2, there was widespread damage to the distribution system as a result of Hurricanes Dean and Richard, and Tropical Storm Alex. While Hurricane Dean triggered a CFE transmission fault in Mexico that cascaded through Belize's entire transmission system, most of distribution failures were concentrated along the path of the storm in northern and some part of central Belize. Hurricane Richard, on the other hand, was a storm that covered most parts of the country causing damages to a large number of distribution systems. In fact, 12 of the 13 faults recorded by BEL during Hurricane Dean affected the distribution network and 15 of the 17 faults recorded during Hurricane Richard also affected the distribution network. According to BEL, the damages were primarily due to heavy rains, winds and lightening as well as fallen trees/branches damaging the distribution infrastructure. As a result of the distribution failures during Hurricane Dean, over 21,000 BEL customers, nearly 30 percent of its customer base at the time in 2007, experienced service interruptions. During Hurricane Richard, the customers effected by the distribution failures totaled nearly 25,000, over 32 percent of BEL's customer base at the time in 2010. All four recorded faults during tropical storm Alex were distribution related, and impacted nearly 3,000 customers.

Table 5.2. Summary Table of Distribution Damage Sustained from Storms and Hurricanes

Geographical Region	North	Central	West	South	TOTAL
Tropical Storm Alex (2010)					
Faults on Distribution Line (#)	3	1	-	-	**4**
Customers Affected (#)	2,314	540	-	-	**2,854**
Affected Load (MW)	3.2	1.4	-	-	**4.6**
Hurricane Dean (2007)					
Faults on Distribution Line (#)	10	2	-	-	**12**
Customers Affected (#)	17,487	4,003	-	-	**21,490**
Affected Load (MW)	10.5	4.2	-	-	**14.7**
Hurricane Richard (2010)					
Faults on Distribution Line (#)	-	10	-	5	**15**
Customers Affected (#)	-	14,486	-	10,091	**24,577**
Affected Load (MW)	-	28.8	-	19.2	**48.0**

SOURCE: BEL

57. **Several factors contributed to the vulnerabilities of BEL's distribution system.** Given the recurrent nature and destructive power of tropical storms and hurricanes, it is difficult to fully avoid damages to the distribution system in Belize during such weather events. In fact, distribution infrastructure can sustain damages even during tropical monsoons that are commonplace in countries such as Belize. Nevertheless, it is essential for system reliability and resilience that BEL carry out regular maintenance where the infrastructure is routinely tested, followed by rapid replacement or rehabilitation of equipment and infrastructure when necessary. BEL is attempting to progressively address some weaknesses that have been identified in its distribution network including the following:

a) Routine inspections, strengthening and upgrading of distribution line poles, cross arms, and lines as well as conductivity improvement of ground wires.[67]
b) Improvement of the vegetation management practices to sustain the integrity of the distribution network.
c) Upkeep and maintenance of the grid substations since most of the distribution load centers are dependent on a single substation with a single transformer, thus limiting the alternate supply possibilities in the event of a major failure.
d) Reinforcement of the design and equipment of the substations prone to flooding, which can damage or even render equipment unusable even after the waters subside. Therefore, equipment such as battery banks can be relocated to safer locations that may include elevated platforms to reduce the likelihood of flood damage.
e) Strengthening of control buildings that have suffered damages to metal structural panels and rooftops, which make them particularly vulnerable to future storms unless they are strengthened or replaced.

58. The ERCAP will support investments in the relocation of battery banks in several locations and strengthening the control buildings as well as the upgrade in vegetation management practices. For various other distribution-system related upgrades, BEL is being supported by the Caribbean Development Bank. BEL funds its own routine inspections and maintenance.

59. While the above-mentioned 'hardening' measures will help upkeep the distribution system and reduce the scale and impact of likely damages during future weather events, it will be just as important for BEL to improve its preparedness to respond to some events and damages that are inevitable. Therefore, BEL will need to develop its response and recovery capabilities concurrently with its efforts to strengthen network infrastructure, to maximize the resilience of the power system. This is further elaborated in the next illustration.

ILLUSTRATION 5: Emergency Response and Recovery Planning

60. **Experience indicates that the efficiency and speed of response and recovery during extreme weather events can be improved to enhance resilience.** While many of the system 'hardening' measures identified previously will reinforce the power system to better withstand the impacts of extreme weather events, reviewing experiences has also illustrated the need for BEL to

[67] BEL has indicated that the fittings in many distribution poles are removed and stolen for its metal content, requiring regular monitoring and replacement.

develop its capacity to better respond to emergencies and quickly recover its full operational capability. For example, during Hurricane Dean in 2007, there were three events where the associated outages lasted between four and six days before service was fully restored. More than 10,000 customers or over 13 percent of BEL's customer base remained without service during this extended period. Similarly, there were outages that resulted from five events during Hurricane Richard in 2010 that required up to four days to restore full service to about 10,000 customers.

61. **BEL is seeking to improve its preparedness capabilities to better respond to emergencies including extreme weather events.** BEL has protocols in its Hurricane Preparedness Plan to respond to major weather events, but it can be improved to meet latest industry practice and further reduce the time it takes to reconstruct and recover. There are also indications that improvements can be made to its infrastructure, system operations, and technological capabilities that will complement and facilitate the implementation of a revamped Emergency Response and Recovery Plan. For example, BEL's current communication network is outdated and often have patchy coverage, forcing BEL emergency workers at times to rely on cellular phones for communications during storms and hurricanes. BEL also acknowledges that it is often unable to quickly identify the causes and locations of disruptions when line segments get truncated severing communication or would be constrained to maintain system reliability if the main load control and dispatch center based in Belize City were to become inoperable. Therefore, BEL is planning to undertake the following actions as a part of improving its emergency response and planning capabilities:

a) Preparation of a more effective **Emergency Response and Recovery Plan** by upgrading its existing Hurricane Preparedness Plan to include good practice recovery protocols. This will help to shift away from restoration actions taken on an *ad hoc* basis and increase the efficiency of the interventions and likely reducing the recovery time.

b) Redesign of its **communication system** and shift to a new digital VHF network that will provide national coverage to all of its transmission and distribution network locations. Additional relays are needed to enhance signals at some of the existing repeater stations to reduce dead spots and improve coverage; as well as purchase of several truck mounted repeater stations that can be rapidly deployed to areas where there is a major failure.

c) Strengthening the **load control and dispatch capabilities** particularly when faced with extreme weather disruptions. This will include the construction of a back-up control and dispatch center in Belmopan should the primary facility in Belize City become inoperable or disconnected from parts of the power system.

d) Coordination with the National Meteorological Service (NMS) to gain access to real-time **meteorological and hydrological data** through the installation of monitoring stations. The real time data will improve BEL's preparedness as well as response and recovery during extreme weather events.

e) Installation of **Advanced Metering Infrastructure (AMI),** which has multiple functions, can also remotely provide information when electricity service is either disrupted or restored at the household level.

f) Implementation of an **outage management system** that utilizes a combination of hardware and software that will identify, record and help BEL personnel better manage responses to faults and outages, including facilitating customer interface (including linkages to AMI). The data collected will also help evaluate the frequencies and durations of system outages.

62. The analysis in this annex helped identify and justify many of the activities that are included in ERCAP to help BEL enhance its operations. Targeted GEF grant funds are being provided to support the implementation of select activities.