THE POWER SYSTEM
IN THE EYE OF THE STORM:
Energy Resilience and Climate Adaptation
in the Caribbean

Mark Lambrides
Senior Energy Specialist
mlambrides@worldbank.org

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What does climate resilience mean for the energy sector?

• **Climate resilience:** ability of the energy system to cope with or recover from a hazardous event, trend, shock or stress that is climate related; such as hurricanes, rising sea level, increasing temperature, flood and the like.
SUMMARY

• Mapped the impact of storms
• Evaluated the vulnerabilities of the power system
• Helped develop solutions for enhancing energy resilience
• Led to Energy Resilience for Climate Adaptation Project (ERCAP)

http://www.esmap.org/node/57353
HURRICANE DEAN
Hurricane Dean (2007)

- **Landfall**
  21st of August, 1:45 a.m.

- **All clear**
  21st of August, 1:00 p.m.

- **Wind speed**: at least 165 mph, CAT 4 at landfall

- **Districts affected by power failure**: Corozal, Belize and Orange Walk
Impact of Dean on Hourly Dispatched Generation

Main events

**San Pedro – Distribution line**
00:32 – Feeder 1 tripped affecting 870 customers for 23 hours
00:47 – Feeder 1 tripped affecting 3,139 customers for 14 hours

**Corozal – Distribution line**
01:12 – Feeder 2 tripped affecting up to 3,277 customers for 4 to 6 days
01:57 – Feeder 1 tripped affecting 2,063 customers for 4 days
02:12 – Feeders 3, 4 & 5 tripped affecting up to 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 – Feeders 2 & 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

Source: Belize Electricity Limited
Caused Near Black-Out of System

1) Fault in CFE substation in Mexico
2) Northern transmission lines fail
3) CFE Supply & West Lake PPs unable to fully dispatch
4) Hydro Becol PP dispatch reduced; Hydro Maya PP unable to dispatch
5) Only Caye Caulker isolated system remained fully operational

- Only 1612 kWh/3.5% of normal dispatch* in the grid;
- More than 64,000 customers (88%)** lost power completely

* Compared to the same hour in the previous week;
** Based on the 2014 customer base information
• 2007 nominal GDP in Belize: **US$ 1,290,542,550**
• BEL’s total net generation of electricity: **438,708,589 kWh**
• Total Estimated Loss of Revenue for BEL: **US$ 339,436**
• Estimated GDP value-added per kWh consumed: **US$ 2.94 per kWh**
• Estimated USE due to Hurricane Dean: **1,624,100 kWh**

• **Total estimated lost value (GDP + BEL) due to Hurricane Dean: US$ 511,7387**
  
  ($\approx$US$ 2.94/kWh \times 1,624,100 \text{ kWh} + 339,436$)
If today, segmentation at Belcogen SS would isolate T-Failure

- Most generators able to dispatch
- About 7,000 – 13,000 or 9% - 18% of customers effected (instead of 64,000 or 88%)
Vegetation management matters....

1) Tree fell on western transmission line between Democracia and Camalote

2) Failure of transmission lines in the West & South

3) Western lines recovered quickly; southern lines disabled for 21 hours

- 7,552 customers in the South lost electricity (9% of customer base)

Source: Belize Electricity Limited
OECS Power Systems are Vulnerable

- **BARBUDA**: Hurricane Irma (2017) destroyed the entire electrical grid and severely damaged the island’s generation assets. Estimate damage amounts to nearly $130 million.
- **DOMINICA**: Hurricane Maria (2017) damaged about 98% of the power transmission and distribution (T&D) network.
- **GRENADA**: Hurricane Ivan (2004) caused damages to 80% of electricity distribution system, left 75% resident w/o power, damages of $26m and losses of $8m.
- **ANTIGUA**: Hurricane Earl (2010) led to significant outages mostly due to fallen trees on power lines.
- **SAINT LUCIA**: TS (2013) produced excessive rain & flooding leading to T&D damages leaving 15% customers without power.
- **DOMINICA**: TS Erika (2015) led to wide power outages from heavy rainfall and strong winds; landslides damaged hydro plant; damages US$ 2m and losses of $0.3m.
In 2017, Irma caused damages estimated at 14% of Antigua and Barbuda’s GDP and Maria caused damages estimated at 226% of Dominica’s GDP.
Caribbean Energy Resilience Program Objective

**Objective:** Provide timely support to OECS utilities and policy-makers to accelerate efforts to build power networks which are resilient to extreme weather and climate-related risks as well as design rapid response and recovery mechanisms to tackle future extreme weather events.
Scale-up Integrated Framework Approach in the Caribbean

Integrated Framework to Enhance Resilience of Energy System to Adverse Weather & Climate Change Impacts

- Enhance System Resilience
  - Planning & Operations
  - System strengthening

- Rapid Response & Recovery
  - Emergency Response
  - Recovery & Reconstruction

OECS Work Program

On-Going Assessments - Conduct Energy System and Climate Risks Vulnerabilities Assessments for select Caribbean Islands

1. **Climate Risk Assessments** - Identify Vulnerable Energy Infrastructure and future key disaster-prone areas in each country that are likely to be impacted from extreme weather and climatic activity.

2. **Power System/Utility Assets Vulnerability Assessments** - Identify key risks associated with power generation, transmission and distribution systems

3. **Gap Analysis in Utility’s Prior and Post Disaster Preparedness** - Identify gaps in utilities existing disaster preparedness plan.

4. **Evaluate ways in which Climate Adaptation and Energy Resilience can be Mainstreamed in Long-term planning**

**Output:** Comprehensive and customized recommendations for enhancing energy resilience and climate adaptation leading to country-specific resilient infrastructure investments
Integrated Framework to Enhance Resilience of Energy System to Adverse Weather & Climate Change Impacts

Enhance System Resilience

Planning & Operations
- Long-Term Energy Planning for Climate Adaptation
- Segmentation of Transmission Network
  - Installation of breakers & insulators
- Collection of meteorological and hydrological data
  - Installation of MET and HYDRO-MET monitors
- Improved operational and dispatch capabilities
  - Real time hydro and weather data access for dispatch management
  - Back-Up control center

System strengthening
- Transmission and Distribution system strengthening
  - Underground lines and/or deploy resilient poles and wires
  - Redundancy of lines
  - Improve resiliency of substations
- Strengthen generation infrastructure
  - Elevate/protect/relocate generation assets from risks
  - Distribute and diversify generation resources (RE and batteries)

Emergency Response
- Improve emergency response plan
  - Preparedness plan and institutional protocols
  - Inventory of spare parts
  - Training of linemen
  - Regional response teams
  - Outage management system
- Preventive measures and emergency repair access
  - Vegetation management plan
- Improve awareness and communication during emergencies
  - Enhance communication system and establish resilient back up

Rapid Response & Recovery

Recovery & Reconstruction
- Recovery and Reconstruction Financing
  - Establish comprehensive insurance/guarantee to be deployed post disaster
  - WB tools: Guarantees, Lending, CAT DDO, ERL
- Improve emergency recovery and reconstruction plan
  - Damage assessments to guide investments in mitigation of future impacts