Meeting the Challenges of Enhancing Power-Sector Resilience

EMERGING PRACTICES

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Asia-Pacific Energy Leaders’ Summit
Wellington, New Zealand
March 17, 2016
Key Questions

1. Why is this issue important? What are the **co-benefits** of investing in resilience?

2. Has the evolution in our thinking about resilience been matched by an **evolution** in technical, financing, institutional, and other arrangements?

3. What **new tools** are being applied to the resilience challenge?

4. What are the **implementation challenges**?

5. What is the **role of global financial institutions** in achieving resilience across the Asia Pacific region?
Context

- Reliability of power systems is weakened by increased weather-related outages and damages.

- Economic damages to the energy sector are high: $580 million of 2013 Yolanda in the Philippines; $280 million of 2011 floods in Thailand.

- Most utilities in developing countries treat natural disasters as an Act of God and rely on write-offs by donors or governments. Only 10% of them adopt appropriate disaster risk management approaches.

- Utilities in developing countries often struggle to keep up with existing standards, and lack the capacity to make decisions under such uncertainty as natural disasters; however, weak and ageing power systems are more vulnerable to natural disasters.
Context

**INCREASED FREQUENCY OF WEATHER-RELATED OUTAGES AND COSTS OF DAMAGES AND LOSSES (IN THE US, 2012)**

Sources: CEA estimates using data from Census Bureau, Department of Energy, Energy Information Administration; Sullivan et al. 2009
Context

**Short- and Long-term Resilience Concerns for Power Utilities to be Balanced**

**Long-term Climate Change Concerns:**
- Uncertainty with long-range predictions;
- Slow onset of climate change consequences;
- New energy infrastructure with life span of multiple decades should be climate resilient

**Short-term Concerns:**
- 10–15 year planning horizons;
- Pressing needs of providing reliable, sustainable energy services in real-time;
- Lack of capacity to cope with today’s extreme weather risks proactively
**Goal**

**TO BUILD A MORE RESILIENT POWER SECTOR IN DEVELOPING COUNTRIES THAT CAN BETTER MANAGE EXTREME WEATHER RISKS ACROSS THE ELECTRICITY VALUE CHAIN**

*Resilience* refers to “[t]he ability of a system and its component parts to *anticipate*, *absorb*, *accommodate*, or *recover* from the effects of a hazardous event in a timely and efficient manner, including through *preservation*, *restoration*, or *improvement* of its basic structures and functions.”

*Intergovernmental Panel on Climate Change 2012*
Enhancing Resilience: Emerging Practices

GLOBAL INDUSTRY SURVEY AND LITERATURE REVIEW

Extensive literature review, virtual survey, selected interviews, survey respondent interviews

196 organizations around the world contacted, 45 responded

- Australia or New Zealand: 20%
- East Asia: 12%
- Central Asia: 12%
- Pacific: 7%
- Western Europe: 5%
- Central or Southern Africa: 3%
- South Asia: 12%
- North America: 0%
- Latin America and Caribbean: 0%
- Middle East and North Africa: 0%
Integrated Disaster Risk Management Approach

**EMERGING PRACTICES**

1. Establish the Context
2. **Pillar 1 – Identify Risks**
3. **Analyze and Evaluate Risks**
4. **Identify Risk Treatment Options**
   - Pillar 2 – Risk Reduction
   - Pillar 3 – Preparedness
   - Pillar 4 – Financial Protection
   - Pillar 5 – Resilient Recovery
5. Treat Risks
Main Findings of Global Industry Survey

• **Awareness** of natural hazard exposure and risk management standards is **low** in developing countries.

• Disaster risk management **practices** in the power sector of developing countries are **weak**.

• The **failure to fund and conduct maintenance** often compromises the resilience capacity of the **infrastructure investments** made.

• Survey respondents recognize the **important role of educational approaches**—both public education and internal capacity building—**in reducing risk**.

• Power sector needs to assign a **higher priority to design of systems and processes** than design of equipment alone.

• Preparedness focused on **resilience strategies** **not overly prescriptive solutions**, can provide better protection at lower cost against uncertain events.
Main Findings of Global Industry Survey

• Developing countries depend heavily on post-disaster financing, including donor assistance, while developed countries tend to rely on multiple layers of pre-disaster financing mechanisms.

• Recovery is more resilient when support is provided for reconstruction planning.

• Partner relationships dominate the level of interaction between service providers and regulators.

• Relationships with insurance companies are much less common among developing countries.

• While there is strong collaboration between members of the power sector, the relationship between datasets is not established or shared.

• Weak organizational capacity is the dominant constraint to risk management implementation among developing countries.

• There is a clear need among developing countries to build capacity in standard risk management practices.
Based on the results of the literature review and industry survey, along with a comparative analysis of their application in developed and developed countries, the study identified a set of emerging and potential practices.
Pillar 1 - Risk Identification

**Outcome:** By building capacity for risk assessment and analysis, risk identification improves our understanding of disaster risks.

Emerging Practices:
1. Hydro Generation Fuel-Risk Data Gathering
2. Probabilistic Modeling of Hazards and Risks
3. Medium-Range Weather Forecasting

Example: Orion Networks Risk Management Prior to 2011 Earthquake
Pillar 2 - Risk Reduction

**Outcome:** Greater disaster-risk consideration in policy, investment, asset design, and management and operating procedures avoids creating new risks and reduces risks in society.

Emerging Practices:

1. Real-Time Meteorological Services to Manage Renewable Energy Variability
2. Mandatory Information Transparency
3. Relocation of Assets above Flood Levels
4. Economic Valuation of Electricity Supply Reliability
5. Distribution Circuit Segregation
6. Micro-Grids
7. Local Backup Power Supplies
On January 10th 2014, the tropical cyclone Ian hit the Ha’apai Islands of Tonga with winds up to 287 km/h. 82% of buildings were destroyed and there was one fatality. The Ha’apai group was home to about 8,000 people, when the category-five cyclone hit, causing extreme damage to infrastructure.

About 95% of power lines were destroyed or severely damaged. The power station required major refurbishment. By January 23rd, Tonga Power Limited (TPL), the local power authority, had restored power to only about 100 residences.

When interviewing senior management at TPL, we asked what three main lessons had been learned from the disaster. One senior manager’s emphatic response was “Good Maintenance.”
Pillar 3 - Preparedness

Outcome: Developing an institution’s disaster-management and forecasting capacity can improve its ability to manage crises.

Emerging Practices:

1. Measuring Resilience
2. Review of Supporting Infrastructure
3. External Communications Approaches
4. Live GIS Systems
5. Demand Response
6. Unmanned Vehicles
7. Virtual Power Plants
8. Artificial Intelligence in Emergency Management Exercises

Example: Online Outage Map (source www.ComEd.com)
Pillar 3 - Preparedness

Measuring Resilience

Resilience Scorecards

Once organizational resilience is measured, it can be improved.

Other infrastructure sectors are a step ahead of the power sector in developing and adopting institutional resilience scorecards and strategies.

Example: Transport Agency
Pillar 4 – Financial Protection

**Outcome:** Financial protection strategies increase the resilience of governments, utilities, the private sector, and households.

Emerging Practices:
1. Weather Risk Hedging
2. Catastrophe Bonds
3. Contingent Event Reserve Funds
4. Contingent Credit Financing
5. Beneficiary Insurance Pools

Example:
High Electricity Cost Contingent Event Fund - Financial Protection Layering against High Energy Cost
Pillar 5 – Resilient Recovery

**Outcome:** Support for Reconstruction Planning Leads to Quicker, More Resilient Recovery.

Emerging Practices:

1. Mutual Aid Agreements
2. Mobile Telecommunications
3. Mobile Substations
4. Back-Up Control Centers

Example: 15/18 MVA, 110/33-22 kV Mobile Substation in Service (Transpower NZ Ltd)
# An Integrated Risk Management Strategy

**Taking into account Emerging Practices Incrementally**

<table>
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<tr>
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<th>RISK REDUCTION</th>
<th>PREPAREDNESS</th>
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**FINANCIAL PROTECTION**

- Weather Risk Hedging
- Catastrophe Bonds
- Contingent Event Reserve Funds
- Contingent Credit Financing
- Insurance Pools

**RESILIENT RECOVERY**

- Mutual Aid Agreements
- National Inter-Organisation Communication
- Mobile Telecommunications
- Mobile Substations
- Back-Up Control Centres
Challenges to Implementation

• Need to raise awareness of power-sector organizations on integrated risk-management practices.
• Need to broaden resilience responses from a primarily technical engineering focus to those encompassing an organizational and financial focus.
  ✓ Equipment design is not enough to prevent supply disruption.
  ✓ Good organizational resilience—including effective leadership and inspiration—provide the best support framework for recovery and rebuilding.
• Need to coordinate disaster risk management plan for the power sector with a \textit{nationwide plan since natural disasters impact other critical infrastructure.}
• Need to strengthen the implementation capacity of utilities, policy makers, regulators, and private sector to take adaptive, resilience-enhancing actions.
The World Bank Group comprises 5 institutions managed by 188 member countries.

Together, IBRD and IDA make up the World Bank.
Role of the World Bank Group and other International Development Institutions

The World Bank Group (WBG) provides:

- Package of Solutions, including
  - Technical Assistance
  - Capacity Building
  - Financing
  - Innovative Financial Products

- A Bridge between Public and Private Sectors
  - e.g., Intermediary between Clients and Insurance Companies

- Cross-Sector Teams
  - e.g., DRM, Treasury, Energy, etc.
The Example of Belize

BELIZE IS HIGHLY VULNERABLE TO STORMS AND HURRICANES

Source: National Oceanic & Atmospheric Administration
BELIZE: Energy Resilience for Climate Adaptation Project (ERCAP)
enhance resilience of energy system to adverse weather & climate change impacts

**Enhance System Resilience**
- **Planning & Operations**
  - Long-Term Energy Planning**
    - At national level integrating climate adaptation
  - System Segmentation + Protections*
    - Installation of breakers
    - Installation of insulators
  - Diversification of Power Generation Mix*
    - Expansion of biomass to offset hydro volatility (pilot)
  - Improve Load Dispatch through better Meteorological Data Collection*
    - Installation of additional real-time weather stations
    - VHF link BEL to Hydromet

- **System Strengthening**
  - Transmission & Distribution System Strengthening*
    - **Transmission**
      - Pilot alternative poles
      - Change/install repeaters
    - **Distribution**
      - Replace deficient poles
      - Additional lightning arrestors
      - Stub suspect poles
  - Strengthening Selected Substations*
    - Improvements to control building to better withstand adverse weather
    - Relocation of DC battery bank

**Rapid Response & Recovery**
- **Emergency Response**
  - Improve Emergency Response Plan**
    - Develop storm preparedness plan
  - Enhance Rapid Repair Capability*
    - Mobile control unit
  - Improved Access to repair Energy Infrastructure**
    - Vegetation management plan for areas surrounding infrastructure
  - Emergency Communication*
    - Enhance VHF network
    - Mobile repeaters
    - Increase number of relays

- **Damage Recovery**
  - Improve Emergency Recovery Plan**
    - Develop a recovery plan
    - Identify Rapid-response capabilities
  - Quicker Recovery of Power Sector Infrastructure*
    - Spares for rapid recovery of power system
    - Transformers
    - Breakers
    - Protection equipment

* indicates investment  ** indicates technical assistance
### WBG Disaster Risk Financing Instruments

<table>
<thead>
<tr>
<th>Insurance-linked Securities</th>
<th>World Bank Cat Bonds</th>
<th>World Bank direct insurance of Cat Bonds; e.g., CCRIF (earthquake &amp; tropical cyclone)</th>
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<tr>
<td>MultiCat Program</td>
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<td>Facilitate issuance of multi region, multi-peril cat bonds; e.g., Mexico (earthquake &amp; hurricane)</td>
</tr>
<tr>
<td>CAT/Weather Derivative</td>
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<td>Insures against weather + geological related losses, based on an index; e.g., Uruguay (drought &amp; high oil prices)</td>
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<th>Insurance Pools</th>
<th>CCRIF / Pacific</th>
<th>Regional facilities pooling risks to cover against natural disasters in different countries</th>
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<th>Contingent Loans</th>
<th>Investment DDO</th>
<th>Provides immediate liquidity following a predefined weather trend/event; e.g., Uruguay (investment loan/rainfall shortfall)</th>
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<td>Cat DDO</td>
<td>Provides immediate liquidity following a natural disaster; e.g. Philippines, Colombia, Costa Rica</td>
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Example: Layered Risk Financing Strategy For UTE, Utility in Uruguay

Low Impact | High Impact
---|---
Low Frequency | High Frequency

Layered Financing Mechanisms

Uncovered Potential Losses
- Weather Risk Hedging
- Contingent Financing
- Energy Stabilisation Fund
- Cash Reserves

Contributors
- UTE, insurance, and World Bank as intermediator
- World Bank, UTE
- Ministry of Finance, UTE
- UTE
**WBG Weather Derivative Example**

**Weather Derivative intermediated by the WBG (payout up to $450m)**

**Mechanism**

- **Strike**
  - **Strike < Rainfall index** → **No Payout**
  - **Strike > Rainfall index** → **Payout based on**

**Relations Among Counterparts**

- **Payout**
- **Premium upfront**
- **Allianz Risk Transfer**
- **Swiss Re**
The Way Forward

A menu of options are available for power utilities to consider emerging practices that will be of most value to their organizations’ particular situations.

By following standard risk-management procedures, combined with cost-benefit analysis, the value propositions for individual organizations become clear.

Power utilities need to develop an integrated, cost-effective disaster risk management strategy, taking into account emerging practices and their own situations and risk tolerance.
Are Power Utilities in Tonga and New Zealand Resilient? Human and Organizational Factors in Disaster Response

Why is this issue important?
Natural disasters are increasingly frequent, costly, and disruptive.

Vital and disaster-affected power systems have become more frequent, more severe, and costly over the past 30 years, and the costs of the damages and losses associated with them are rising. At the same time, the world is increasingly reliant on electricity and the population expects reliable and secure services.

Natural disasters affect power utilities with varying levels of severity that depend on each utility's natural environment. Disasters that have a severe impact on power generation, transmission, distribution, or control include earthquakes, tsunamis, hurricanes, wildfires, cold spells, heat waves, storms, tropical cyclones, heavy snowfalls, floods, droughts, and wildfires.

In the United States, a 2018 estimate from the Department of Energy showed that between 2008 and 2012, average costs due to weather-induced power outages ranged from $5 billion to $75 billion. These figures are derived from business costs associated with lost output, increased fuel costs, and other types of lost economic output. Hurricane Sandy alone cost the U.S. economy between $14 and $25 billion.

In Nepal, the 2011 floods cost the power sector $285 million in damages and lost revenue; while another $160 million is required to reconstruct and operate.

In most disasters, a complete diagnosis of damage to power systems components is challenging, however, efforts can be made to reduce the impact and length of the resulting power outages. For instance, in New Zealand, the government invested in a new power system and the power authorities learned about the human and organizational factors that played a role in the recovery efforts.

This report is based on interviews and research carried out by the authors for a technical study to be published in February 2019 on the power sector's resilience in Tonga and New Zealand.

ENHANCING POWER-SECTOR RESILIENCE: EMERGING PRACTICES TO MANAGE WEATHER AND GEOLOGICAL RISKS

EXECUTIVE SUMMARY