Meeting the Challenges of Enhancing Power-Sector Resilience

EMERGING PRACTICES

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WORLD BANK GROUP Energy & Extractives

ESMAP Energy Sector Management Assistance Program

GFDRR Global Facility for Disaster Reduction and Recovery

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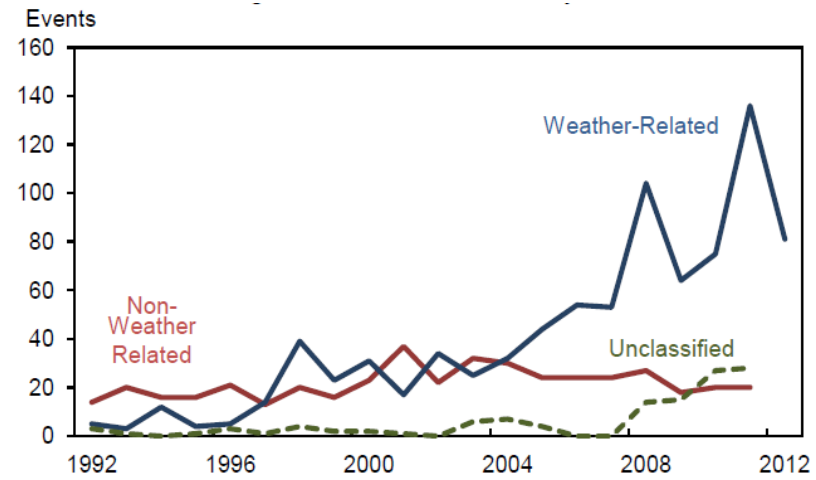
Context

- **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.



Source: Energy Information Administration

- 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

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

Main Findings of Global Industry Survey

- **Awareness** of natural hazard exposure and risk management standards **is low.**
- Disaster **risk management practices are weak**.
- **Weak organizational capacity** is the dominant constraint to risk management.
- **Failure to conduct maintenance** often compromises resilience of investments
- Needs to **prioritize design of systems and processes** rather than equipment alone.
- Relevant **datasets** are not linked and shared.

- Heavy reliance on **post-disaster financing** rather than pre-disaster mechanisms.
- Relationships with **insurance companies** are not very common.

- Recovery is more resilient when support is provided for **reconstruction planning**.

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

Integrated Disaster Risk Management Approach

Emerging Practices

Establish the Context

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Pillar 1 – Identify Risks

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Analyze and Evaluate Risks

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Identify Risk Treatment Options

Pillar 2 – Risk Reduction	Pillar 3 – Preparedness	Pillar 4 – Financial Protection	Pillar 5 – Resilient Recovery

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Treat Risks

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**

Orion risk acceptability matrix

Likelihood					
Frequent (happens often)	H	H	VH	E	E
Likely (happens sometimes)	M	H	VH	VH	E
Possible (happens rarely)	L	M	H	VH	VH
Unlikely (happens somewhere)	L	M	M	H	VH
Rare (hasn't happened yet)	L	L	L	M	VH
Consequence	Minor	Moderate	Serious	Major	Catastrophic

Example: Orion Networks Risk Management Prior to 2011 Earthquake

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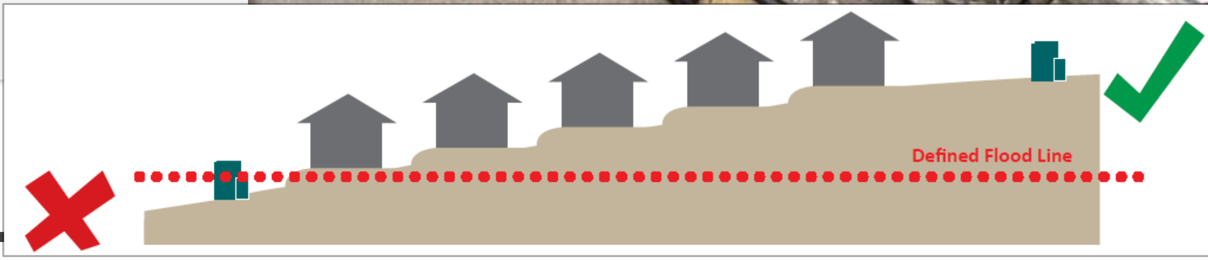
Pillar 2 – Risk Reduction

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**



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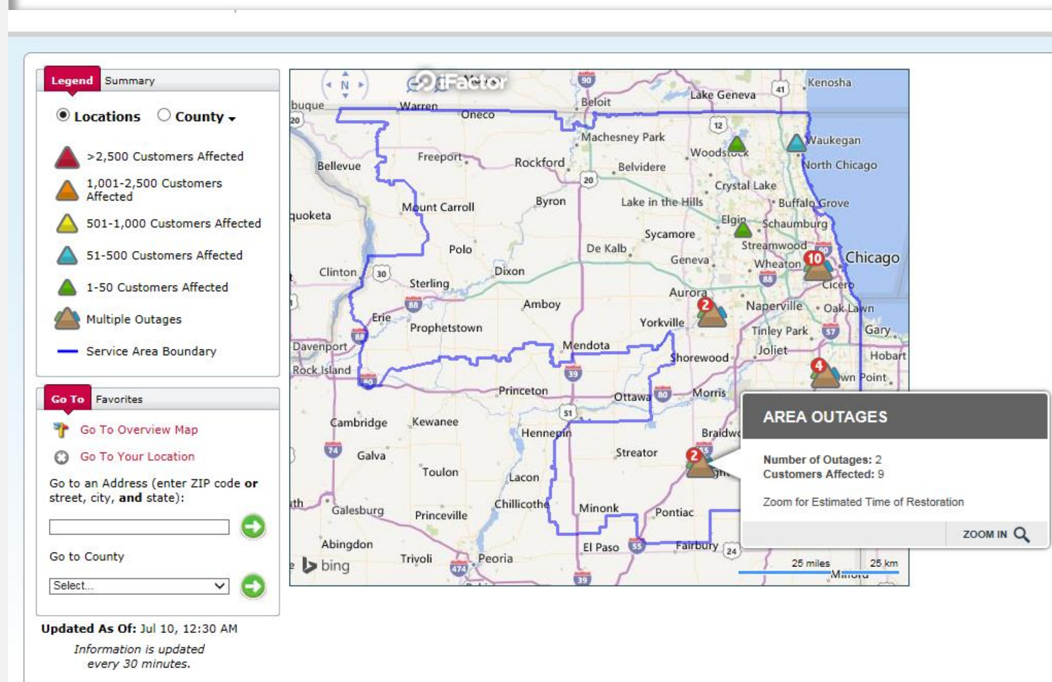
Pillar 3 – Preparedness

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)

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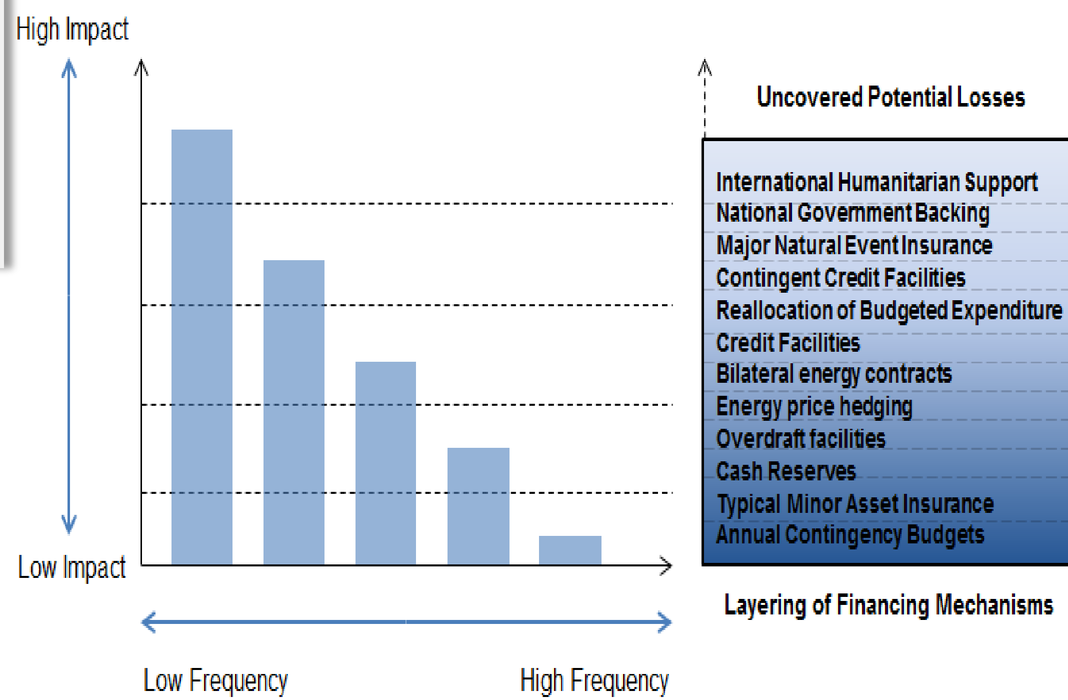
Pillar 4 - Financial Protection

Outcome: Financial Protection Strategies Increase the Resilience of Governments, Utilities, the Private Sector, and Households.

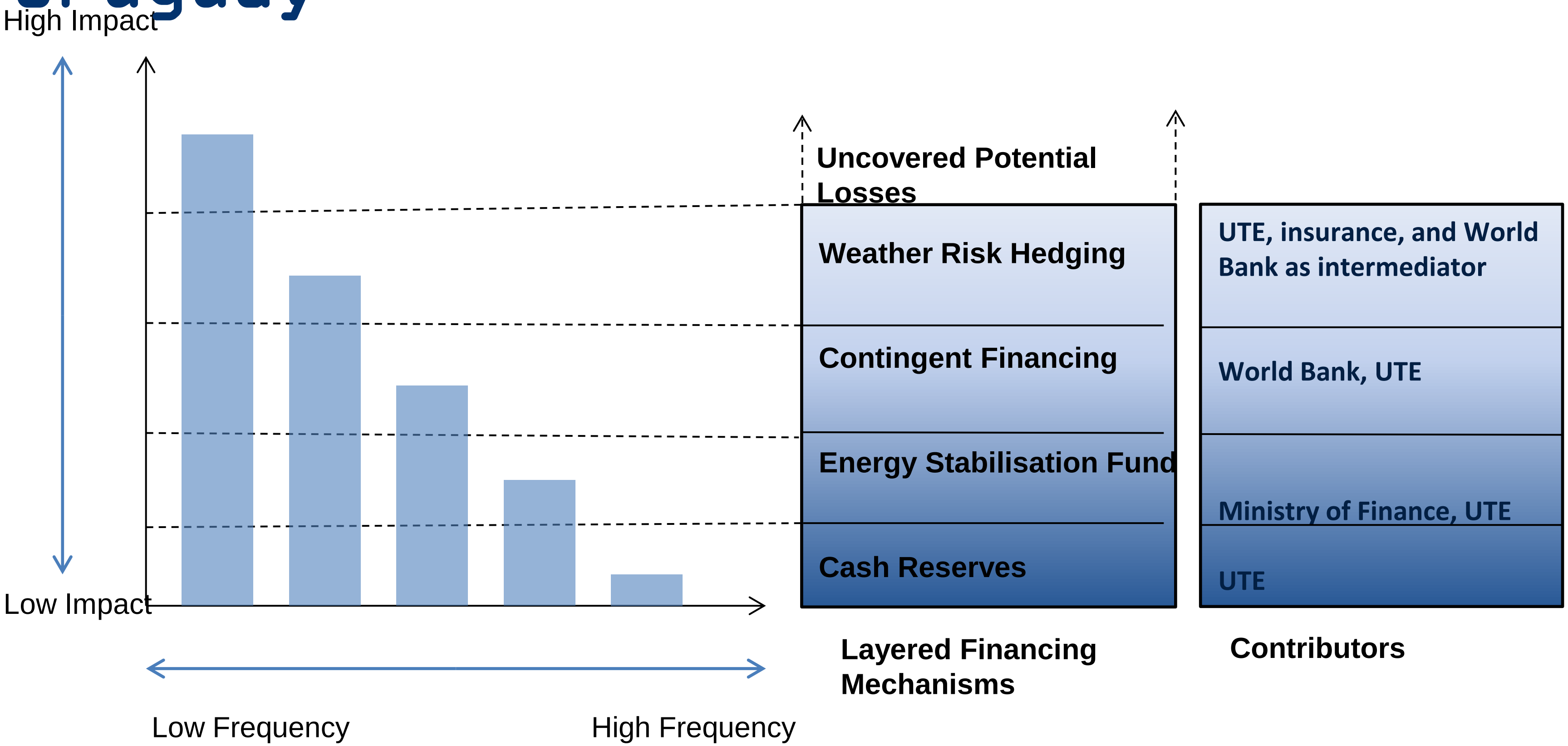
Emerging Practices:

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



Example: Layered Risk Financing Strategy For UTE, Utility in Uruguay



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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

RISK IDENTIFICATION	RISK REDUCTION	PREPAREDNESS
Hydro Generation Fuel Risk Data Gathering	Real Time Meteorological Services to Manage RE Variability	Measuring Resilience
Probabilistic Modelling of Hazards and Risks	Mandatory Information Transparency	Review of Supporting Infrastructure
Medium Range Weather Forecasting	Relocation of Assets above Flood Levels	External Communications Approaches
	Economic Valuation of Electricity Supply Reliability	Live GIS Systems
	Distribution Circuit Segregation	Demand Response
	Micro-grids	Unmanned Vehicles
	Local Back up Power Supplies	Virtual Power Plants
		Using Artificial Intelligence in Emergency Management Exercises

FINANCIAL PROTECTION	RESILIENT RECOVERY
Weather Risk Hedging	Mutual Aid Agreements
Catastrophe Bonds	National Inter-Organisation Communication
Contingent Event Reserve Funds	Mobile Telecommunications
Contingent Credit Financing	Mobile Substations
Insurance Pools	Back-Up Control Centres

Challenges to Implementa

- 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 **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.

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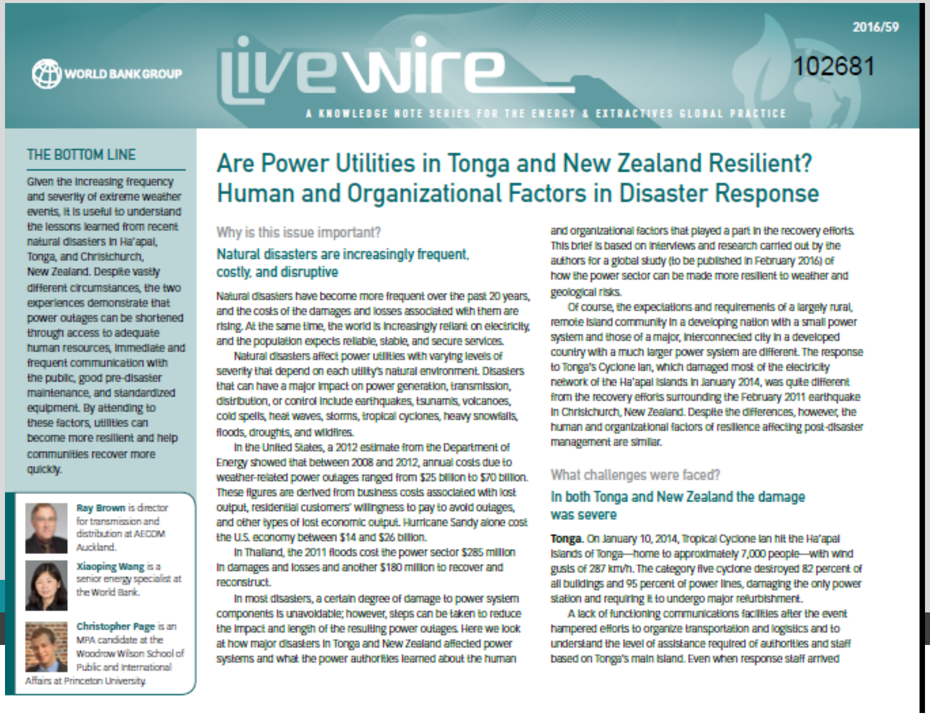
The Way Forward

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.



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THE BOTTOM LINE

Given the increasing frequency and severity of extreme weather events, it is useful to understand the lessons learned from recent natural disasters in Ha'apai, Tonga, and Christchurch, New Zealand. Despite vastly different circumstances, the two experiences demonstrate that power outages can be shortened through access to adequate human resources, immediate and frequent communication with the public, good pre-disaster maintenance, and standardized equipment. By attending to these factors, utilities can become more resilient and help communities recover more quickly.

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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

Natural disasters have become more frequent over the past 20 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, stable, and secure services.

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

In the United States, a 2012 estimate from the Department of Energy showed that between 2008 and 2012, annual costs due to weather-related power outages ranged from $25 billion to $70 billion. These figures are derived from business costs associated with lost output, residential customers' willingness to pay to avoid outages, and other types of lost economic output. Hurricane Sandy alone cost the U.S. economy between $14 and $26 billion.

In Thailand, the 2011 floods cost the power sector $285 million in damages and losses and another $180 million to recover and reconstruct.

In most disasters, a certain degree of damage to power system components is unavoidable; however, steps can be taken to reduce the impact and length of the resulting power outages. Here we look at how major disasters in Tonga and New Zealand affected power systems and what the power authorities learned about the human and organizational factors that played a part in the recovery efforts. This brief is based on interviews and research carried out by the authors for a global study (to be published in February 2016) of how the power sector can be made more resilient to weather and geological risks.

Of course, the expectations and requirements of a largely rural, remote island community in a developing nation with a small power system and those of a major, interconnected city in a developed country with a much larger power system are different. The response to Tonga's Cyclone Ian, which damaged most of the electricity network of the Ha'apai Islands in January 2014, was quite different from the recovery efforts surrounding the February 2011 earthquake in Christchurch, New Zealand. Despite the differences, however, the human and organizational factors of resilience affecting post-disaster management are similar.

What challenges were faced?

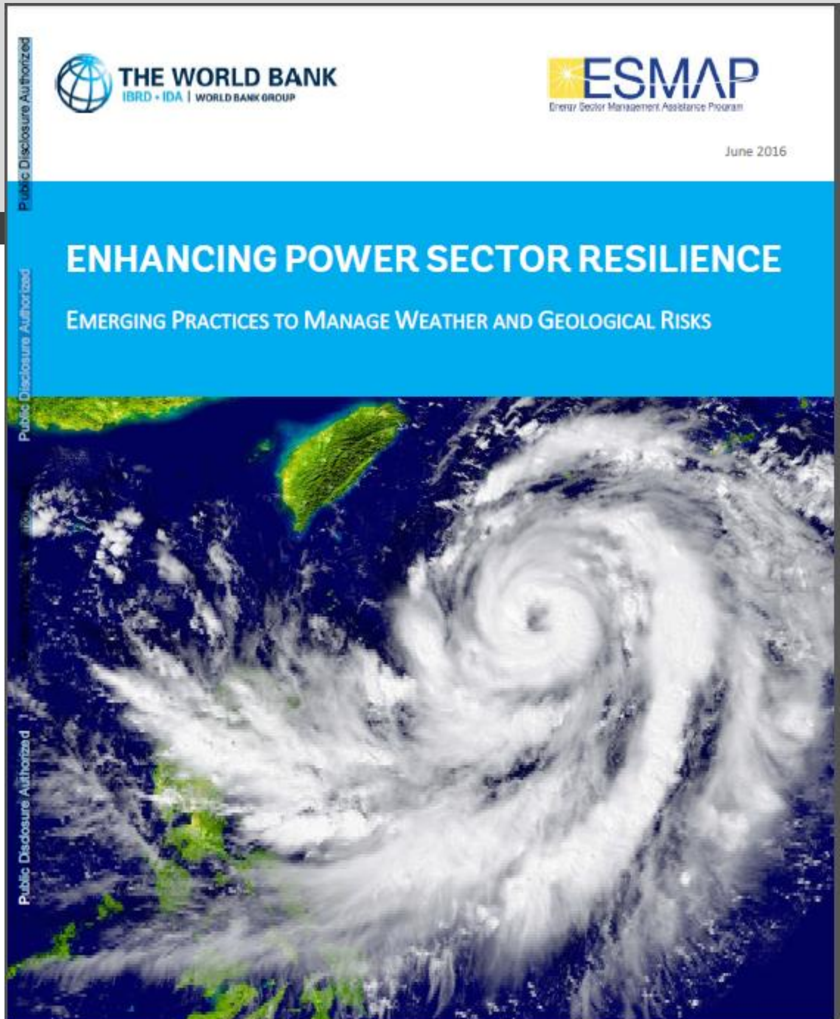
In both Tonga and New Zealand the damage was severe

Tonga. On January 10, 2014, Tropical Cyclone Ian hit the Ha'apai Islands of Tonga—home to approximately 7,000 people—with wind gusts of 287 km/h. The category five cyclone destroyed 82 percent of all buildings and 95 percent of power lines, damaging the only power station and requiring it to undergo major refurbishment.

A lack of functioning communications facilities after the event hampered efforts to organize transportation and logistics and to understand the level of assistance required of authorities and staff based on Tonga's main island. Even when response staff arrived

WB Publications:

http://hdl.handle.net/10986/23634
https://www.esmap.org/node/57858



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