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...
in Ha’apai, limited communications caused significant delays in support. All on-island landline phones were out of service because the wires went down with the distribution lines. Cellphone towers and transmission equipment on radio towers (VHF) and their ancillary equipment were damaged, so cellular communication was almost completely cut off for a time, leaving only limited SMS (texting) capability and very limited external communications. It took days to assess the situation, and it was difficult to convey needs back to the head office on Tongatapu, Tonga’s main island. Tonga Power Ltd (TPL), the utility, has now purchased a satellite phone for Ha’apai.

After technical personnel and contractors from TPL arrived on the islands, providing shelter, food, water, and power for the responders proved a challenge. These resources had to be shipped in, which increased response times.

Because of these factors, recovery was slow. After nearly two weeks, TPL had restored power to no more than 100 residences. In October 2014, ten months after the disaster, 700 families—almost 50 percent of the population on the islands—were still living in tents.

New Zealand. On February 22, 2011, a devastating, shallow earthquake with a 6.3 magnitude struck Christchurch, New Zealand, a prosperous city of approximately 400,000 people, killing 181 and seriously injuring 161 (figure 1). More than 1,200 buildings in the central business district had to be demolished, and more than 300,000 buildings were damaged, contributing to an estimated $40 billion in damages.

The power distribution network faced severe damage from the earthquake. Four of the city’s 314 zone substations were rendered unserviceable owing to ground movement and falling rocks. Most of Christchurch’s 66 kV cables, 15 percent of its 11 kV cables, and 1 percent of its low voltage cables were damaged. About a hundred poles (a relatively small number) were displaced. As a result, approximately 80 percent of Christchurch’s network was without power after the earthquake; five days after the earthquake, more than 36,000 residents still lacked power.

What lessons were learned?

Lessons reflected differences in circumstances but also interesting similarities

Tonga. TPL managers interviewed in 2014 offered suggestions to improve the ability to restore power and make improvements.

Pre-disaster maintenance is critical. When Cyclone Ian hit Ha’apai, overhead lines were not in sufficiently good condition to withstand high winds (figure 2), and many poles and line conductors broke. The network would have been in a better condition after the storm if maintenance practices had followed TPL’s standards. For example, many wooden poles were severely rotten at their bases, and substandard poles had been used in some cases.
“Advance planning is needed to ensure that technical responders and their families are kept safe and supplied with water, food, shelter, and emotional support. Comprehensive support enables responders to work safely and turn in the best possible performance.”

Measures taken in advance of a disaster can lessen outage times. Such measures include: (i) placing distribution transformers well above sea level to avoid flooding, (ii) keeping a good stock of spare parts on each island, (iii) maintaining cyclone response kits (comprising vehicles, communications, and torches), (iv) compiling a restoration priority list so that the criticality of each section of the network is understood, and (v) isolating switchboards using residual current devices.

Ready access to equipment and external technical field staff is required after major disasters. After Cyclone Ian, transporting equipment and personnel (TPL staff and contractors) to the remote islands and providing for the needs of those personnel were major challenges. As noted, shelter, food, and water were shipped in with the responders. Per diems supported personnel working in harsh conditions, as well as their families. Emergency communications systems allowed the responders to communicate with their families. Straightforward and standardized designs sped recovery. At the time of the cyclone, TPL’s network equipment standards had recently been updated and were significantly different from the old equipment in Ha’apai. The new overhead line standard (aerial bundled conductor) was well documented, and personnel were trained in its application, enabling them to act quickly when equipment arrived on the remote islands. Based on this experience, standard designs are recommended, including simple resilience concepts (such as moving transformers above water surge levels) to enable fast restoration and improve power-supply resilience.

**New Zealand.** Several factors were critical in restoring power and making improvements in Christchurch after the earthquake.

As in Tonga, external support, including ample human resources, was critical in the aftermath of the Christchurch earthquake. Connetics, the network maintenance service provider, created an individual profile of every responder and his or her family and then ensured that each staff member’s family had shelter, water, food, and emotional support. These and other seemingly minor provisions such as laundry services were found to help responders to work long hours safely, knowing that they did not have to worry about their families. If necessary to prevent responders from becoming overtired and stressed, managers required them to take time off.

Information sharing with the public and institutions was critical. Despite severe damage to cellular networks, public communication about availability of the power network was highly successful in the aftermath of Christchurch’s earthquake. Simple, accurate network maps showing network status and recovery times were immediately available to the media from the utility’s geographical information system (GIS). From these single-city overviews, the public could determine areas of the network that were damaged and where they could find power. Additionally, in areas of particularly high damage, senior personnel organized street-corner meetings that were exceptionally well received. This rapid and transparent sharing of information is a prime example of quick action by power sector workers, action that enabled customers, in turn, to take appropriate action.

Good logistics and support from equipment suppliers were critical, highlighting the value of close relationships with key stakeholders. For example, when spare components ran out, equipment suppliers’ knowledge allowed factory stocks to be replenished within days. Similarly, good relationships with other distribution networks and their maintenance-service providers enabled hundreds of technical personnel to be assigned to Christchurch within 24 hours to assist with repairs. Good inter-institutional relationships enabled regulatory barriers to be quickly removed.

**Figure 2. Vulnerable power lines in Ha’apai, Tonga**

*Photo by Ray W. Brown.*
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No significant technological changes were made following the Christchurch earthquake because the utility already had high seismic standards. The wait for spare parts in Christchurch was shorter and less pressing than in Tonga owing to the proximity of international airports, but there was a greater need for efficient supplier logistics. Because field personnel in Christchurch had remote communication devices and GIS access, information could be shared quickly with the public and other organizations.

What is comparable in the two cases?

Several common success factors stand out

As noted, Ha’apai and Christchurch are very different places, and those differences are reflected in the response of the two locations to disaster. More surprising than the differences, however, are the common success factors that can be detected in the two cases.

The critical similarities in the lessons learned from the two disasters are as follows:

• The condition of the network before the event is crucial. Good maintenance reduces damage and hastens repair. In too many utilities, proper maintenance practices are compromised by poor management, inadequate budgets, and lack of skilled technicians.

• Advance planning is needed to ensure that technical responders and their families are kept safe and supplied with water, food, shelter, and emotional support. Comprehensive support enables responders to work safely and turn in the best possible performance.

• The presence of documented, up-to-date equipment standards and designs (drawings, guides, and manuals) accelerates recovery.

• Good relationships with other agencies and organizations (even competitors) allow regulatory barriers to be lifted and enable technical support and equipment to be sourced quickly.

• Open, fast, honest, and transparent communications among utilities, governments, supporting institutions, and the public enables all parties to respond quickly and appropriately, helping to mitigate negative consequences and support those in need.

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