Disaster Management and Resilience in Electric Power systems: The Case of Chile

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ABSTRACT: Chile is one of the countries located at the Ring of Fire. This belt concentrates subduction zones such as between the Nazca and South America Tectonic Plate, which is the reason for the intense seismic and volcanic activity in Chile. The strongest earthquake in the last years (Mw 8.8), took place the 27th February 2010. The earthquake triggered a tsunami which devastated several coastal towns in south-central Chile. The official death toll was 521, while the number of missing was 56. The Government declared 6 regions as zone of Catastrophes: Valparaiso, Metropolitana, O'Higgins, Maule, BioBio, and Araucania. It is estimated that the earthquake generated a power outage that affected the 93% of the country; therefore, the electricity and communications were initially interrupted, but later mostly restored. However, it took some days in the case of some locations. Electricity infrastructure is key for the function of critical services (health, traffic control, water supply), which are necessary for undertaking the emergency response tasks after an earthquake and/or a tsunami. In normal times, the electricity infrastructure is necessary to sustain human and economic wellbeing since it supplies energy to industrial, commercial financial sectors, communication networks, and hence almost all activities in modern societies. There are four electricity supply systems in Chile: the Central Interconnected System, the Norte Grande Interconnected System, the Aysén and Magallanes. Nevertheless, the biggest system regarding installed capacity (75%) and population served (93%) is the Central Interconnected System, therefore the most important. In this project we want to support the implementation of community resilience due to power outages caused by earthquakes and tsunamis. To achieve this aim we plan to collect and analyze qualitative data to identify the needs of the affected population due to the power outage and its coping strategies.

Keywords: Resilience, earthquakes, tsunamis, electric power systems, power outages.

1. INTRODUCTION

Chile is a country located in South America and one of the countries located at the Ring of Fire. This belt includes subduction zones such as between the Nazca and South America Tectonic Plate, which is the reason for the intense seismic and volcanic activity in this country. At 03:34 on the 27th February 2010, an earthquake with magnitude 8.8 Mw struck the Chilean coast. The epicenter of the earthquake was located 325 Km southwest of Santiago (35 Km depth), and Concepcion, the second largest city in Chile, was most affected area (OCHA, 2010a). It is estimated that 1.5 million houses were damaged, several buildings in Santiago and Valparaiso collapsed (OCHA, 2010c). The Government declared 6 regions, as zone of catastrophes: Valparaiso, Metropolitana, O'Higgins, Maule, Bio-Bio and Araucania. The earthquake triggered a tsunami which devastated Juan Fernandez Island, and several coastal towns in south-central Chile were impacted by waves that advanced 3Km inland in certain areas (OCHA, 2010b). The official death toll was 521, while the number of missing was 56 (OCHA, 2010g).The location of this zone and the location of the country are depicted in Figure 1.

It is estimated that the earthquake generated a power outage that affected the 93% of the country; therefore, the electricity and communications were initially interrupted (OCHA, 2010a). Two days after the earthquake, in Valparaiso and Metropolitana, the electricity was established in 80%, but in Maule 18 communities continued without power supply at that time, and the same situation was reported in Bio-Bio. The Chilean government asked the international community for electricity generators as well as field hospitals equipped with surgery facilities, autonomous dialysis centre, satellite phones and related stations, salt water purification systems and field kitchens, among others (OCHA, 2010b). On the 3rd March 2010, Russia, Australia and Japan sent generators (OCHA, 2010c) but still access to food, drinking water and electricity remained among the priority needs, because shortfalls persisted in electricity supply (OCHA, 2010d). The 8th March 2010, the access to electricity and water was still a concern. Australia sent 50 generators and China sent 100 portable generators among other humanitarian aid (OCHA, 2010d). Eleven days after the earthquake was reported that more than 150 rural water supplies systems were damaged and others were not working due to the interruption and damage in the electricity network in coastal and rural areas, affecting 200, 000 people. However for the same time, the army reported that the electric supply was restored to 80% in the provinces of Conception, Bio-

Bio and Maule, but the coverage in the region of Araucania was still very poor (only 29% coverage) (OCHA, 2010e). The 10th March the World Health Organization supplied four generators to two hospitals in Chillan, and two others more in Talcahuano and Lebu (OCHA, 2010f).

Fig. 1: Zone of catastrophes in Chile after the earthquake on the 27 February 2010.

Electricity infrastructure is key for the function of critical services (health, traffic control, water supply), which are necessary for undertaking the emergency response tasks after an earthquake and/or a tsunami. In normal times, the electricity infrastructure is necessary to sustain human and economic wellbeing since it supplies energy to industrial, commercial financial sectors, communication networks, and hence almost all activities in modern societies. There are four electricity supply systems in Chile: the Central Interconnected System, the Norte Grande Interconnected System, the Aysén and Magallanes. Nevertheless, the biggest system regarding installed capacity (75%) and population served (93%) is the Central Interconnected System, therefore the most important.

2. LITERATURE REVIEW

Natural phenomena such as earthquakes, tsunamis or extreme weather events like droughts can affect electric power systems in different forms. Likewise, these systems can be damaged due to non-intentional or intentional anthropogenic actions such as the terrorist attacks of the 11th of September 2001 in New York (Mendonça and Wallace, 2015). Electric power systems are critical infrastructures of modern societies, therefore is essential to boost their resilience to severe weather and other challenges (Panteli and Mancarella, 2015).

Extreme weather events such as hurricanes and storms are considered one of the main causes of wide-area electrical disturbance worldwide (Panteli and Mancarella, 2015). These events poses a serious challenges to the safety and wellbeing of communities (Ghanem et al., 2016).

The term resilience has been used in many disciplines, including psychology, natural and human ecology, engineering and geography; however, there is not an agreed upon definition of resilience. This concept is multifaceted and adaptable to several context and disciplines (Adger, 2000, Forino, 2014). Holling (1973) defined resilience as the time required for an ecosystem to return to equilibrium following a perturbation. Later, Timmerman (1981) elaborated on the concept, and defined it as the "capacity to adapt to absorb and recover from the occurrence of a hazardous event". Godschalk (2003) associates resilience with redundancy, efficiency, autonomy, and adaptability. Davoudi and Strange (2009) define resilience in terms of connectivity, fluidity, contingency, and multiplicity (Lu and Stead, 2013). Vale and Campanella (2005) consider resilience as the capacity of a zone to rebound from destruction, while UNISDR (2009) describes it as the ability of a system to recover in an efficient manner. Zhou et al.(2010) explained the concept as the capacity to face loss after a disaster and to recover from it (Forino, 2014). Pelling cited by Guo (2012) formulated the definition of resilience as "capacity to adjust to threats and mitigate or avoid harm". Aldrich (2012) defined resilience in the context of the community, as the capacity of the neighbourhoods to address crises through coordinated efforts and cooperative activities to achieve effective and efficient recovery. According to Alexander (2013) the term used in the context of disaster risk reduction means: "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions"(Alexander, 2013). Ifejika Speranza et al. (2014) cited the definition of resilience as "the capacity of individuals, communities or social-ecological systems (SES) to cope with disturbances, to self-organize, and to learn with the aim to improve essential structures and functioning".

The bioecological theory formulated by Bronfenbrenner (2004) considers that a lack of individual resilience can decrease resilience at other scales. Nevertheless according to Alexander (2013) it is not easy to extrapolate psychological resilience to other scales and especially to community resilience. In the framework of the Resilience Academy 2013-2014, one of the highlighted definitions of resilience was the power or ability to return to the original position, structure or function, after being disturbed, shocked or impacted by stress (UNU et al., 2013). Recovery in the resilience paradigm is easier when you have the capacity to anticipate and cope with stress (Aldrich, 2012). Resilience also considers the rate of recovery (Ifejika Speranza et al., 2014). According to Ganor & Ben-Lavy (2003) the basic ingredients of community resilience, termed as the "Six Cs" are: communication, cooperation, cohesion, coping, credibility and credo. According to Coaffee et al. (2009) resilience is part of urbanism and it is a goal for cities exposed to hazards (Guo, 2012). Social resilience is defined by Shaw et al., (2014) as the ability to avoid disaster, cope with change and recover from disaster.

In the context of power systems, resilience is defined as the ability of a power system to withstand the shock, recover from the disruptive event and apply adaptation measures for mitigating the impact of similar events in the future. Five elements are associated to the short. as well as the long term short-term resilience in power systems: robustness/resistance, resourcefulness, redundancy,response and recovery, and adaptability. Likewise, fourth phases are proposed in the resilience assessement framework of electric power systems: threat characterization, vulnerability assesment of the system's components, system's reactions, and system's restoration (Espinoza et al., 2016).

In February 2014 several storms affected UK, 80,000 homes were left without power for several days. The impacts of power outages on households, the description of the challenges faced and the strategies adopted by them were decribed by Ghanem et al. (2016). According to these authors the capacity of the households to respond to and recover from power outages, depends not only of the household itself, but also on other actors and the social resilience of the whole community. However, little is known about the capacity of the community to face daily life with power outages caused by earthquakes and tsunamis in Latin America.

3. EXPECTED RESULTS

In this project we want to develop a framework to support the implementation of community resilience due to power outages caused by earthquakes and tsunamis. We will gather information related to societal impact associated with past events, identify critical case studies, and determine societal impacts of severe power cuts. To achieve this aim we will collect and analyze qualitative data to identify the needs and coping strategies of an affected population during power outages. The aim is for citizens to have response strategies that are complemented by resilience measures prepared for (and by) the community.

4. ADDED VALUE FOR INTEGRATIVE RISK MANAGEMENT AND URBAN RESILIENCE

The results of this project will contribute to the reduction of the vulnerability and the implementation of priority for action 4 in the Sendai Framework for Disaster Risk Reduction 2015 – 2030: Enhancing disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction (UNSDR, 2015). The results of this project will allow to citizens and communities build resilience by how they prepare for, and respond to power outages due to earthquakes and tsunamis. This project will promote the preparedness among the community, and the cooperation with electricity companies by sharing accountability.

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