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Institutionalizing Resiliency Programs for Geothermal Operations in Disaster-Prone Areas A Case Study of the Tiwi Geothermal Field

Edith Louise Batac, Jonathan Vizon, and Erwin Vargas

Philippine Geothermal Production Company, Inc. 14F 6750 Bldg. Ayala Ave. Makati City 1226 Philippines

ltbatac@pgpc.com.ph; JoVizon@pgpc.com.ph; ervs.vargas@pgpc.com.ph

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ABSTRACT

The Philippines was listed third in the 2016 World Risk Index of countries most vulnerable to disasters as the archipelago experiences many natural and human-induced calamities in the form of typhoons, volcanic eruptions, earthquakes, landslides, and armed conflict, affecting millions of people and resulting to significant costs to the economy. The Index also reports that impacts of disasters are exacerbated when critical infrastructures, such as energy (electricity, gas, and oil), are severely damaged as failure or degradation of such leads to disruption in supply or services which can have dramatic consequences on the nation's society.

Recognizing the country's high level of exposure to risks, the Philippine Department of Energy (DOE) issued in 2018 a policy mandating all participants in the energy sector (generation, transmission, and distribution) to submit a Resiliency Compliance Plan to mainstream disaster risk reduction by employing measures to ensure infrastructure, systems, and human resource disaster preparedness. Philippine Geothermal Production Company, Inc. (PGPC) actively supported this policy by participating in public consultations and being one of the first companies to comply with the said requirement given its program readiness in terms of strengthening existing infrastructure facilities, response and recovery, as wells as ensuring continuous operations of its steam field facilities. In fact, many of the programs required by the DOE under the Resiliency Compliance Plan have been in place and integrated in PGPC's policies, processes, and standards even before the issuance of the DOE regulation. These programs cover the steam field facilities and equally protect the host communities as well.

PGPC's Resiliency Compliance Plan was put to the test when the Tiwi Geothermal Facilities in the province of Albay was significantly impacted by floods and landslides as tropical depression Usman brought record rainfall in December 2018. Initial assessment shows that PGPC's programs under the Resiliency Compliance Plan generally mitigated the destructive impact of the disaster and enabled the immediate resumption of operations of unaffected facilities.

This paper provides a discussion of PGPC's Resiliency Compliance Plan, covering the process by which its components were consolidated by the respective subject matter experts and the consultation with the DOE. It also documents how the Plan was deployed during the onslaught of Usman and how it guided PGPC's response and recovery efforts through its dedicated Asset Emergency Management Team. Furthermore, this paper offers an assessment of what can be improved in PGPC's disaster preparedness and risk mitigation programs both in the operations level and in the host communities.

1. INTRODUCTION

1.1. Tiwi Geothermal Field

For 40 years now, the Tiwi Geothermal Field has operated safely and reliably to provide the island of Luzon with clean and renewable energy. Commercial operations in Tiwi began in 1979, ushering the birth of the Philippine geothermal energy industry and the first commercial geothermal project in Southeast Asia. With an installed capacity of 234 MW, Tiwi has generated a total of 54.4 TWh as of end 2018 (equivalent to 101 million barrels of oil equivalent). Tiwi is operated by Philippine Geothermal Production Company, Inc. (PGPC), a 100% Filipino corporation and a wholly-owned subsidiary of Allfirst Equity Holdings, Inc.

Tiwi Geothermal Field is located in the municipalities of Tiwi and Malinao, province of Albay. From Manila, Tiwi is accessible by one-hour commercial flight southeastward to Legaspi City and then a one-hour drive northeastward to Tiwi. The Field is within the geothermal reservation area established by Presidential Proclamation 739 and is bounded to the north/northeast by the Lagonoy Gulf and to the north/northwest by the Municipalities of Sangay and Buhi, Province of Camarines Sur. South of the project area is the Municipality of Malinao, Albay. Majority of the land within the contract area (73%) is devoted primarily to agriculture. Forestland comprises around 24% of the area, while other uses (built-up, commercial, industrial, tourism) accounts for 2% of the total area. The population of the host municipalities based on the latest national census is at 98,421. (Philippine Statistics Authority, 2015)

1.2. Disaster Risk and Vulnerability

The Philippines was listed third in the 2016 World Risk Index of countries most vulnerable to disasters as the archipelago experiences many natural and human-induced calamities in the form of typhoons, volcanic eruptions, earthquakes, landslides, and armed conflict, affecting millions of people and resulting to significant costs to the economy. The Index also reports that impacts of disasters are exacerbated when critical infrastructures, such as energy (electricity, gas, and oil), are severely damaged as failure or degradation of such leads to disruption in supply or services which can have dramatic consequences on the nation's society.

Meanwhile, Tiwi's provincial host Albay has been identified by the Philippine Department of Environment and Natural Resources and the Manila Observatory as one the provinces in the Philippines to be "very highly" vulnerable to climate and geological

disasters. Albay takes a major hit of about 20% of the typhoons that enter the Philippines yearly. (Salceda, 2012) Furthermore, the province is constantly under threat by the eruption of the Mayon Volcano, the perfect cone rising from the Albay Gulf and most frequently active volcano in the Philippines. These vulnerabilities exposes communities and industries in the province to hazards such as flooding, mudflow or *lahar*, landslides, earthquake, and storm surge.

2. DISASTER RISK REDUCTION AND RESILIENCY PROGRAM

2.1. Adoption of Resiliency Planning and Program in the Philippine Energy Industry

Recognizing the country's high level of exposure to risks, the Philippine Department of Energy (DOE) issued in 2018 a policy mandating all participants in the energy sector to submit a Resiliency Compliance Plan to mainstream disaster risk reduction by employing measures to ensure infrastructure, systems, and human resource disaster preparedness. This policy is underpinned by Republic Act 10121 or the Philippine Disaster Risk Reduction and Management Act of 2010, which provides for the institutionalization of programs, structures, and coordination mechanisms on disaster risk reduction from the national government level to the local government units.

Department Circular No. DC2018-01-0001 mandates all energy industry participants (generation, transmission, and distribution) to submit a three-year Resiliency Compliance Plan (RCP) that reflects the following principles:

a. Strengthen existing infrastructure facilities to withstand adverse conditions and disruptive events;
b. Incorporate mitigation improvements into reconstruction and rehabilitation of infrastructure damage in accordance to the Build Back Better principle;
c. Improve operational and maintenance standards and practices to ensure expeditious restoration of energy supply in the aftermath of disruptive events; and
d. Develop resiliency standards for future construction of energy facilities to ensure minimal damage and adoption of measures for timely recovery and restoration of facilities for the continued delivery of power supply.

The RCP should contain engineering and non-engineering measures to ensure preparedness during and in the aftermath of disruptive events. Energy industry participants should also include systems for strengthening infrastructure, stockpiling, and emergency response and recovery in their RCP. Compliance with the RCP is monitored by the Task Force on Securing Energy Facilities created by the DOE. Monitoring is conducted along with the quarterly field inspection by the concerned DOE division.

2.2. PGPC Resiliency Compliance Program

PGPC actively supported DOE's Resiliency Policy by participating in public consultations and being one of the first companies to comply with the said requirement given its program readiness in terms of strengthening existing infrastructure facilities, response and recovery, as wells as ensuring continuous operations of its steam field facilities. PGPC's resiliency programs cover the steam field facilities and equally protect the host communities. In fact, many of the programs required by the DOE under the RCP have been in place and integrated in PGPC's policies, processes, and standards even before the issuance of the DOE policy as the Tiwi Geothermal Field is located in the municipalities of Albay that are most susceptible to environmental hazards.

Following dissemination by the DOE of the draft policy in 2017, PGPC's subject matter experts reviewed relevant company policies, standards, and processes to assess compliance with the components of the RCP. The review concluded that PGPC's policies, standards, and processes are already aligned with the DOE requirement. Because of its completeness, PGPC RCP was vetted by the DOE Planning and Policy Bureau and was used as its model during the public consultations. Table 1 enumerates some of PGPC's existing policies, standards, and processes that meet the DOE resiliency policy requirements.

2.2.1 Strengthening Infrastructure and Geo-Hazard Mitigation

PGPC implements various projects to strengthen its facilities and address obsolescence of various components of its controls and surface facilities to maintain safe, efficient, and reliable operations. For several years now, the company has embarked on upgrading its steam and condensate lines, motor controls, valves, pumps, pressure control instruments, and other critical equipment.

Key to strengthening the Tiwi geothermal field's infrastructure is PGPC's Facilities Hazard Management Program, which the company has been implementing in the past 10 years. Geological hazards (geo-hazards) are common in geothermal energy facilities located in mountainous terrains. If not mitigated, geological hazards may adversely impact operations and result in injuries/fatalities through loss of containment, damage to electrical power transmission lines, access roads, spillways, and buildings. In response to these risks, PGPC's Facilities Hazard Management Program primarily focuses on geo-hazards mitigation.

The Facilities Hazards Management Program has four components: 1) geo-hazards mapping; 2) risk prioritization; 3) engineering controls; and 4) administrative controls. To identify risk areas, PGPC refers to geo-hazard maps produced in-house, by third-party consultants, and by the government, assessments from post-typhoon events, and incident reports. Prioritization for these risk areas depends on the evaluation in reference to the risk prioritization matrix, which ranks risks based on their likelihood and consequence. This is a collaborative process involving all work groups within PGPC, including Reservoir Management, Earth Science, Facilities Engineering, Health, Environment, & Safety, Operations & Maintenance, and service providers. Following this, appropriate engineering controls are implemented, such slope protection, retaining structures, rock fall protection, and rehabilitation of spillways. Administrative controls that are also incorporated in PGPC's RCP complement the engineering controls component of the Facilities Hazard Management Program. These include Asset Emergency Response Plans, Typhoon Preparedness Procedures covering sumps and spillway monitoring and shutdown scenarios, as well as Asset Emergency Management Team's annual Emergency Drills related to disruptive events.

Engineering controls under the geo-hazards mitigation project are supported by PGPC's community development programs focusing on reforestation in the host communities. PGPC works with the local government, National Power Corporation Watershed Management Department, the Department of Environment and Natural Resources, and various farmers associations in

implementing agroforestry projects, rehabilitation of coastal areas, and various tree-growing activities as part of its climate change adaptation and impact mitigation strategies.

Table 1. PGPC Policies, Standards, and Processes

Strengthening Infrastructure	Systems	Response and Recovery	Stockpiling
Facilities Hazard Management Program – Geo-hazards Mitigation Projects	Process Safety Management	Asset Emergency Response Plan (HES)	Procurement Process
Pipeline Rehabilitation Project	Risk Management	Emergency Response Procedure for Brine Spill Due to Sump Overflow (HES)	Warehouse, Inventory and Traffic Standard
Technology Upgrade Program (TUP)	Compliance Assurance	PGPC-Crisis Management Plan (HES)	Inventory Control - Cataloguing
TW Condensate Line Upgrade	Safe Work Management	Typhoon Preparedness plan (HES)	Inventory Control - ROP/ROQ
Typhoon Damage Rehabilitation	Motor Vehicle Safety	Mayon Eruption Contingency Plan	Inventory Control - Stock Reordering
	Emergency Management Process	PGPC-Business Continuity Plan (HES)	Fuel Stocking and Monitoring
	Incident Notification Procedure	Field Response Operations Guidelines (FROG)	Critical Spares Plan (O&M)
	Environmental Management System	Emergency Phone Tree (HES)	Procurement Process
	Security of Personnel and Asset	Contractor Emergency Response Procedure at the Worksite (HES)	Warehouse, Inventory and Traffic Standard
	Risk-based inspection program of pipelines	PGPC-Emergency Response Procedure (HES)	Inventory Control - Cataloguing
	Shutdown inspection of vessels	Medical Emergency Response Procedure (HES)	Inventory Control - ROP/ROQ
	Corporate Social Responsibility Plan and Employee Volunteerism Standard	Drilling Rig Emergency Response Plan (HES)	Inventory Control -Stock Reordering
		Community Relation Procedure (HES)	Fuel Stocking and Monitoring
		Public Relations Guide (HES)	Critical Spares Plan (O&M)
		Contingency plans for pressure vessel failures	

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2.2.2 Response and Recovery

The response and recovery component of the RCP is consistent with the administrative controls that complement the engineering controls employed by the Facilities Hazards Management Program. PGPC's Asset Emergency Response Team are trained to activate response and recovery plans for specific scenarios such as brine spill due to sump overflow, typhoon and volcanic eruption, drilling rig emergency, vessel failure and well blowout. The Asset Emergency Response Team is supported by PGPC's Crisis Management Team through the activation of the company's Crisis Management Plan at the level of the corporate headquarters. Headed by the company president, the Crisis Management Team ensures that the Asset Emergency Response Team receives the necessary support in a timely and efficient manner to carry out its response and recovery activities in times of emergency to secure personnel, host communities, facilities, and the environment.

PGPC also helps strengthen the emergency response capabilities of local communities by funding the training of members of the Tiwi Municipal Emergency Rescue Team (MERT) and Barangay Emergency Support Team (BEST) on community first aid, basic life support, water search, and rescue through the Climate Change Action Program. In partnership with the Philippine Red Cross, the Tiwi Municipal Disaster Risk Reduction Management Council, the Philippine National Police, and the Philippine Bureau of Fire Protection, PGPC supports the Tiwi MERT and BEST through learning and development activities as well as through donation of rescue equipment, and engages partners to plan for skills improvement of emergency support teams in eight barangays of Tiwi, seven of which are communities where geothermal facilities are actually installed. The Tiwi MERT and BEST are activated to support the PGPC Asset Emergency Response Team for emergency response and recovery as necessary.

Furthermore, PGPC's prioritization on resiliency is reflected in the systems, which the company has matured over the many years of its operating the Tiwi Geothermal Field. These systems pertain to risk management, compliance assurance, environmental management, routine inspections, safe work management, and even in its community development projects. Its procurement management system also takes into account the availability of critical spares in the event of emergency situations to ensure business continuity.

2.3. Effectiveness of Tiwi's Resiliency Program

Tropical Depression Usman hit the province of Albay on 28-29 December 2018, dumping record rainfall in two days (more than the normal December rainfall in the area), which resulted in landslides and flashfloods that affected the Tiwi Geothermal Field and its host communities. There was minimal to no damage observed in areas where geo-hazards were identified and mitigated by PGPC before the onslaught of the tropical depression. Geo-hazards mitigation projects such as rock catchers, steel barriers, redesigned spillways, and retaining walls provided effective mitigation to minimize and/or prevent the impact of heavy rains, flooding, and landslides on geothermal facilities. These engineering controls minimized the inflow of rock boulders, preventing the destructive impact of landslides on steam and brine lines, production and injection wells, and other surface facilities. Furthermore, the re-designed spillways and steel barriers installed effectively prevented major damage to piping and erosion of access roads.

PGPC conducts periodic evaluations of geo-hazards and has a prioritized annual program and budget to remediate them proactively. This project has been successful for many years, and examples of riprap, steel netting and other remediation measures can be seen throughout the field. Table 2 shows the effectiveness of the geo-hazards mitigation projects for typhoon events. The implemented geohazard projects provided effective mitigation either to minimize or prevent the impact of historical typhoons and heavy rains to the operating facilities.

Table 2. Geo-Hazards Mitigation Effectiveness on Typhoon Events

Geo-hazard Projects	Year Implemented	2013	2014		2015				2016				2017	2018	
		Yolanda	Glenda	Hagupit	Amang	Chedeng	Dodong	Egay	Carina	Karen	Lawin	Nina	Urduja	Ompong	Usman
		250 kph	185 kph	230 kph	80 kph	295 kph	150 kph	80 kph	45 kph	95 kph	315 kph	220 kph	65 kph	205 kph	55 kph
WS-10 Coconet Slope Protection	2017												●	●	●
WS-01 to WS-03 Slope Protection	2016									●	●	●	●	●	●
SS-03 Rock Catcher*	2016									●	●	●	●	●	●
WS-01 to WS-07 Rock Catcher*	2015						●	●	●	●	●	●	●	●	●
WS-01 to WS-07 Trash Barrier*	2013	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WS-01 to WS-07 Barrier Wall*	2011	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Matalibong Rip-Rapping	2011	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WS-08 Drainage	2011	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WS-08 Rip-Rapping	2011	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WS-07 Sump Rip-Rapping	2010	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WS-06 Spillway	2009	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WS-15 Slope Stabilization	2009	●	●	●	●	●	●	●	●	●	●	●	●	●	●
WS-13 Slope Stabilization	2008	●	●	●	●	●	●	●	●	●	●	●	●	●	●

However, geothermal surface facilities were heavily damaged in areas which were not previously identified to be landslide-prone and high risk based on available information and therefore no geo-hazards mitigation in place. One of the 19 well sites containing critical equipment (production wells, separators, and sumps) and some portions of the Tiwi cross-country pipelines were affected by landslides and flooding. Furthermore, the amount of rainfall dumped by Usman within two consecutive days was not expected. While PGPC has in place a Typhoon Preparedness Plan, the response procedures depended on the typhoon strength (signal) forecasted by the Philippine Atmospheric, Geophysical and. Astronomical Services Administration based on wind speed and not on the volume of rainfall.

Field inspection and geological hazards assessments were carried out by PGPC's Reservoir Management and Facilities Engineering Departments as part of the company's post-typhoon rehabilitation activities. Based on updated information about the field, engineering controls were designed and implemented as part of the Facilities Hazard Management program.

Figure 1. Retaining wall protected the pipeline from landslide in the Tiwi Matalibong area.

The Asset Emergency Response Team and the Operations Department activated PGPC's Typhoon Preparedness Plan to secure personnel and facilities and implement necessary preparations to bring operations back to normal following the passage of tropical depression Usman. Meanwhile, Tiwi MERT and BEST centered on rescue operations, and relief and recovery at the height of Usman flooding and landslides. These teams supported the host communities by establishing an operations center for ongoing retrieval and relief mobilization. Furthermore, through PGPC Asset Affairs and community development project partners such as the SM Foundation and the Philippine Red Cross, PGPC extended support to the families through continuing relief mobilization, provision of water supply, road clearing, and coordination with the Municipal Disaster Risk Reduction Management Council. PGPC had allocated funds from its Corporate Social Responsibility budget to purchase relief items for distribution to families in the evacuation centers. This relief assistance benefitted not only Tiwi but also families in adjacent municipalities affected by flooding and landslides, namely Malinao and Buhi.

3. CONCLUSION: INSTITUTIONALIZING RESILIENCY PLANNING

Mainstreaming resiliency in the company's policies, standards, and processes is central to institutionalizing resiliency programs of participants in the energy industry. PGPC's Resiliency Compliance Plan is aligned with the company's mission to ensure safe, efficient, and reliable operations of geothermal energy facilities, and is integrated in its operational and administrative policies, standards, and processes to identify and mitigate the risks inherent to the Tiwi Geothermal Field. This is made possible by the strong support of the PGPC management and the shared vision by the PGPC workforce to be the leading geothermal company recognized for its world-class operations. Following the aftermath of tropical depression Usman, PGPC was able to complete its rehabilitation activities and recover generation within a few weeks as systems are in place to readily execute the RCP.

PGPC's strategy to extend implementation of its RCP in the host communities has also helped the company to strengthen its geo-hazards mitigation and climate change adaptation projects. Community development projects that map out geological vulnerabilities in the host communities, restore forest and watershed areas, reinforce slopes in landslide-prone locations, and build capacities for emergency response and recovery helped strengthen Tiwi's capabilities to withstand disruptive events such as Usman, and demonstrated PGPC's commitment as a good neighbor to the communities where it operates. Coordination with the local and national government, partners in the not-for-profit sector, the academe, and residents is an important factor in mainstreaming the RCP as geothermal operations are heavily dependent on an enabling social environment and strong stakeholder support.

Finally, Government regulation requiring the formulation and implementation of appropriate mechanisms may also help the institutionalization of resiliency planning in the private sector. According to the Philippine Geothermal Energy Management Division, geothermal energy companies rank high among registered renewable energy developers in terms of compliance with the Department of Energy policy requiring submission of the RCP. The government can also help the private sector in resiliency planning by improving data collection, evaluation, and access to geological mapping on a wider scale as assessment by geothermal energy developers is limited within the contract areas due to right-of-way constraints.

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