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# Geothermal Regulatory Framework within the Proposed National Energy Authority in Papua New Guinea

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## ABSTRACT

Papua New Guinea sets to build geothermal investment in the coming years attributed to the passing of National Energy Policy 2017 to 2027. The National Energy Policy with the main theme "harnessing for life" forms the engine room to aggressively motivate internal domestic utilization simply to meet increasing energy demand in the light of very low electricity accessibility and coverage and the increased economic developments in PNG. The overarching policy constitutes the subsequent national policies and strategies for the energy sector that are aligned to the PNG Development Strategy 2010-2030 and the PNG Vision 2050. Geothermal resource is one the key renewable energy resources outlined in the National Energy Policy broadening the energy mix in Papua New Guinea. Although not yet commercially exploited, geothermal resources are abundant and hence more geothermal exploration studies are required to pursue geothermal system and find the feasible geothermal reservoir whereby the policy is optimistically accomplishing its legal and regulatory efforts to push the geothermal exploration and development. One of the key integral parts to realize geothermal opportunities is the establishment of National Energy Authority. The proposed National Energy Authority solves the specific geothermal regulatory barriers by streamlining the permitting requirements, uniting the relevant government bodies to explore, stimulate and develop geothermal resources, de-risking and managing financial worries and bringing and geothermal investments under PNG context.

## 1. INTRODUCTION

Papua New Guinea (PNG) is located in the Pacific Region, surrounded by Australia, Indonesia and Federates State of Micronesia. PNG shares a land border with Indonesia. PNG is located on the Pacific Ring of Fire and is a host to several volcanoes from the southeast to the northwest of the country with several known geothermal areas. Geothermal utilization is insignificant in PNG but is becoming a new player in the field of energy for the near future. Studies have demonstrated that potential geothermal capacity in PNG is 5,000 to 6,000 megawatts (MW). PNG's PNGNEP2017-2027 (PNGNEP) has been approved recently to pave the way forward for improvement of the energy sector to fulfil the PNG National Vision 2050 (NV2050). The policy, legalities and regulation of geothermal energy need to be strengthened to achieve its aspiration to accelerate geothermal exploration and development. PNG has not been able to progress into geothermal exploration and drilling for commercialization of geothermal development. PNG has not been able to progress into geothermal exploration/drilling and to commercialize geothermal development apart from the existing Lihir Geothermal Power Plant. The Lihir Geothermal Power Plant (Figure 1) is a first geothermal power plant in PNG which is an ancillary component to the Lihir Gold Mine to support power generation for mining development. There are obstacles that block the enactment of the geothermal policy from government endorsement. PNG resource ownership, legal implications and the electricity market remain to challenges to potential geothermal development.

The geothermal energy potential to produce electricity and to stimulate economic opportunities from its direct utilization has been recognized by the government of PNG, to support national development plans and the NV2050. There is reported interest from several geothermal companies to carry out geothermal utilization. The absence of geothermal regulation and policy prevents further geothermal exploration and surface drilling in PNG. Rabaul Karkar and Talasea geothermal sites are the main places of interest for geothermal companies (Figure 1).

However, the proposed geothermal regulatory framework is plagued by bureaucratic delays and legal implications which has led to the ineffective effort to legalize the geothermal energy in PNG. Issues surrounding of the proposed geothermal regulatory framework are:

- The Geothermal Resource Policy (GRP) that was fully developed by Mark Chris in 2013 and Marlene Oliver under the PNG-New Zealand Bilateral Technical Assistance through New Zealand Ministry of Foreign Affairs and Trade (Chris, 2014) did not eventuate. The process was not approved by Papua New Guinea's Chief Legal Advisor via Office of Solicitor General before the document was forwarded to the National Executive Council (NEC) for its deliberation. The policy document has not been approved hence no further progress has been formally ratified.
- The geothermal regulatory framework from the rejected GRP has not been defined under the current existing policy, legal and regulation mechanism. The adoption of the PNGNEP provides a complete energy policy and regulation and an amendment to the rejected GRP.
- A geothermal resource potential classification system in PNG is not systematically defined in the GRP. Although developing a classification system specifically for PNG would require a significant amount of data evaluation, a brief geothermal resource classification is required in the regulatory framework. This classification needs to be mapped and identified alongside volcanic landforms, geothermal manifestations, geothermal environmental hazards, protected areas listing and social and cultural connections. This is an important component of the geothermal regulatory framework in the PNGNEP.

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The procedures stated above are existing weaknesses which are classified as first wave barriers to geothermal energy development. Once the first wave barriers are addressed, second wave barriers, namely high market risk investment, lack of geothermal data availability and lack of political support from responsible government institutions are subsequently addressed. These second wave barriers have been identified as part of the geothermal strategies in the PNGNEP. In summary, there is a need for appraisal and reinforcement of geothermal legal, policy and regulation framework to eventuate, effective geothermal strategies from the PNGNEP.

The GRP has not been approved and it is still pending the legal clarification and the approval from the NEC. It is also part of the project's aim to evaluate and investigate the causes for the lack of approval of the GRP that could have paved the way for geothermal investment in PNG. Since the GRP was fully developed under PNG mining legislation, the geothermal policy, legislation and regulation will be changed into energy paradigm due to the approved PNGNEP.

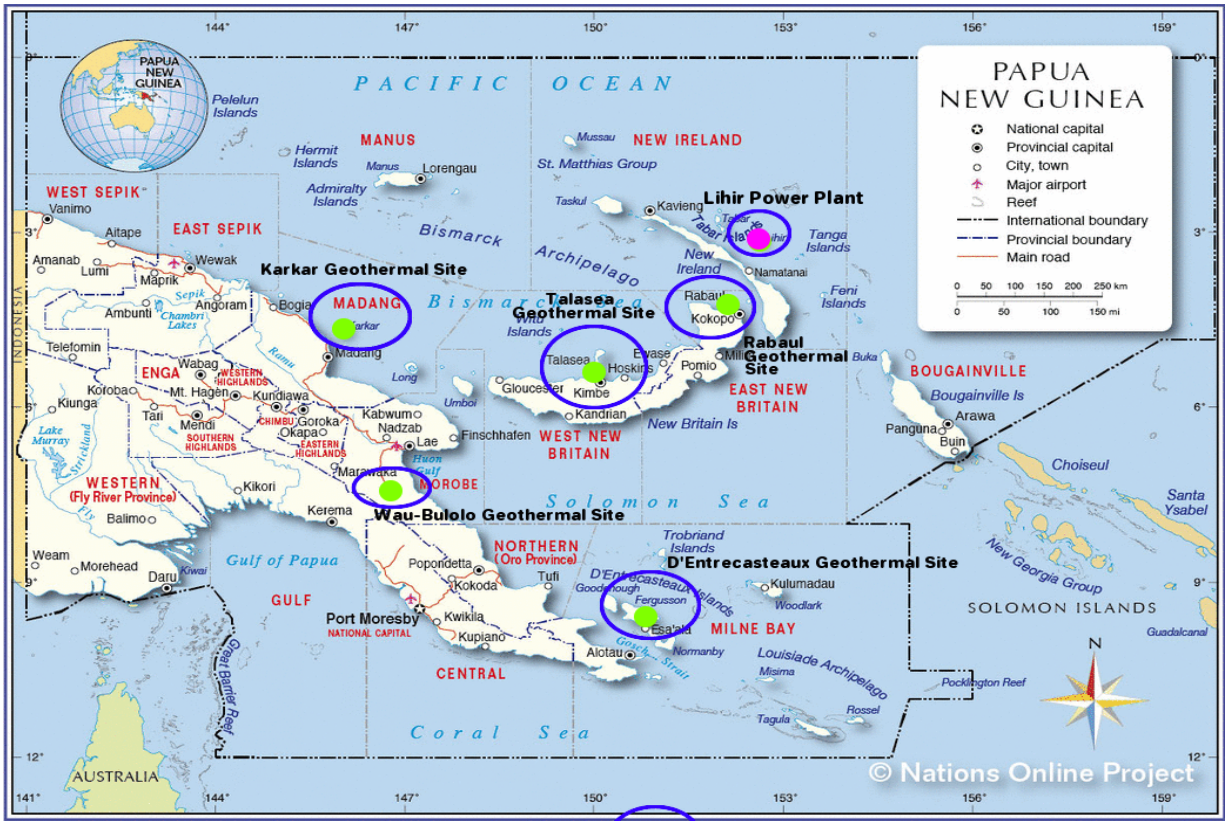


**Figure 1: Location of latest studies of possible geothermal sites in Papua New Guinea. The green dots indicate areas of potential field development for geothermal production while the pink dot indicate existing geothermal power production (Lihir).**

### 1.1 History of Geothermal Policies, Plans and Legislations

The concept of development of geothermal plans, policies and legislations began in the 1970s when Japan and USA deliberated the proposal to utilize volcanic energy from Rabaul site (Furumoto, 1974). There was not a GRP, legislation or plan developed until the significant emergence of Lihir Geothermal Field. This triggered the interest for more preliminary documentation of volcanology and geothermal resources, specifically the geothermal manifestations throughout PNG.

Lahan (2016) summarized the history of geothermal studies in PNG and that the geothermal policy began dating back to 1988 when the Stefansson reviewed all data held by then Geological Survey PNG (GSPNG). Stefansson provided three recommendations; the national exploration program, geothermal unit within the GSPNG and the training of geothermal scientists (Lahan, 2016). The recommendations were not implemented until 2008 when Lihir Geothermal Power Plant became operational. This initiated the significance of geothermal energy as alternative power generation from 2009 onwards.

Several attempts to formulate a geothermal policy and later the PNGNEP blocked geothermal investments from happening in 2008 when a small group of geothermal scientists collaborated with PNG geologists to framework the initial concept plan. The MRA team led by Nathan Mosusu explored the geothermal policy and legislation via preliminary geological survey in 2008. Prior to 2008, it was in 2005 when the National Member of Parliament for Rabaul Electorate, Hon. Dr. Allan Marat submitted an initial submission for geothermal power development for Rabaul in parliament. It was fully endorsed and supported by Rabaul District Joint Planning and Budget Priorities Committee (JDPBPC).

Significantly, the emergence of Icelandic geothermal company visits to potential geothermal sites instigated interest from the provincial government to the national government. In June 2011, negotiations and consultations were in place to drill geothermal wells to provide steam for a geothermal power plant within the Rabaul Geothermal Field in ENB. This followed the meeting between eight clan representatives of Matupit, proposed developers – Reykjavik Geothermal (RG Pacific Ltd) from Iceland and the

provincial administration. It was noted that Rabaul Geothermal Field has the potential to produce 50 MW of electricity to households in the area targeting Matupit Island where active geothermal sources are located. RG Pacific Ltd saw the potential of a geothermal project on Matupit due to its closeness to Mt Tavurvur volcano thereby making the environment at Matupit conducive. The provincial government was also keen to piggyback on the project as it was a clear case of the public-private partnership concept. It was the RG Pacific Ltd consultant, who was the reservoir engineer, Grimur Bjornson who took the lead in talking with respective government representatives. The company indicated they would like to kick off the project in 2013 if the provincial government had the funds to support the project (Bjornson, 2013). In the same year, RG Pacific Ltd visited another geothermal site in Madang Province also within the Southern Bismarck Sea Volcanic group in reference to Loffler's 1977 published report. According to Grimur Bjornson of RG Pacific Ltd, Karkar site was another potential geothermal site where feasibility studies had been carried out. Karkar Caldera could be a sustainable power source that could be established via submarine interconnection to provide 100 MW for Madang Province.

Because no geothermal regulatory framework was in place to allow further exploration and development at those times, the process did not lose hope and continued to work closely with the government on geothermal energy utilization. Both local level and provincial level governments in 2013 continued to maintain focus regarding getting this geothermal energy power plant off the ground as a pilot project. Although there was no legal policy framework to regulate exploitation of geothermal power in the country, the ENB provincial authorities became strong advocates of geothermal energy and called out for full support from the national government.

This groundwork led to the following subsequent milestones:

a) June 2011 – Formulation of Geothermal Energy Act 2011 for enabling framework for exploration development of geothermal resources
b) March 2012 – Two National Government Officers sent to Iceland's United Nations University Geothermal Training Program for six-month training program;
c) June 2012 – The DPMGM, responsible for mineral policy supported by Mining Act 1992 formulated a draft GRP in-house as directed by the National Government.
d) November 2012 – ENB Provincial administrator (then) Akuila Tubal authorized Rabaul district administrator Wilson Matava to be the negotiating agent for the provincial government in matters relating to geothermal power development.
e) August 2013-June 2014 – 11 months staged consultative process of GRP (Chrisp, 2015)
    a. August 2013 – The DPMGM have since brought on a Consultant Mark Chrisp through the New Zealand's Ministry of Foreign Affairs and Trade/ New Zealand Aid Programme funding and will review and produce a draft by early next year 2014. The inter-agency consultation took place afterward.
    b. September 2013 – Study tour by three senior DMPGM to various New Zealand geothermal sites (WRC, Tui Pui, Ngati Tuwharetoa Settlement Trust, geothermal power stations in Taupo region, meeting with Contact Energy)
    c. October 2013 - The inter-agency consultation took place involving relevant stakeholders.
    d. February 2014 – Provincial consultations and visits (Madang and WNB Province and Lihir Geothermal Power Plant)
    e. May 2014 – Final consultation on formulation of GRP
    f. June 2014 – Completed and submitted to higher government authorities for approval
f) February 2014 – Provincial Governor of Oro Province, Hon. Gary Juffa argued in Parliament that geothermal energy is not mineral and claimed that it is just heat. He called on the Minister of Mining following the tabling of GRP to separate the department to deal with issues on environmentally friendly resources. He furthered claimed that geothermal energy should have its own legislation, which should come under its own department (National newspaper)
g) June 2014 - Public Enterprises and State Investment Minister Ben Micah visited New Zealand. He claimed that PNG did not have a clear policy for developing geothermal energy. He planned to table geothermal action plan in Cabinet on his New Zealand visit to enable the New Zealand government and companies to work with the Independent Public Business Corporation and PPL in the development of the energy sector. He also proposed a New Britain grid that would fully make use of the geothermal energy sources in New Britain and focus on providing electricity for the New Guinea Islands and to join into the Momase and Highlands Grid. He claimed that 5,000-6000 MW could be produced from geothermal energy alone (National newspaper, 2014)
h) May 2015 - The MRA (MRA), through its Geological Survey Division undertook surveys in several active geothermal sites, including WNB, Morobe (Wau/Bulolo) and MBP.
i) August 2015 - PNGNEP– a 2nd National Consultative workshop was conducted, and geothermal energy was considered in the national energy policy.
j) March 2016 - Government authorities in Talasea, WNB, claimed that they were still awaiting funds to complete the final stage of a feasibility study to develop a proposed geothermal power plant. The Pangalau Geothermal Field had been identified as a possible geothermal site. The provincial government put funds for two feasibility studies that have been concluded. It was claimed that after a third of the study was carried out to find the exact location of a reservoir and its capability, they would then work on the next step to progress this development. The local level government authority claimed that Pangalau villagers were using the hot spring to dry their copra, taking only a day to fill between 20 and 30 bags of first-grade hot-air dried copra. (National newspaper, 2016)

**1.2 Challenges and Issues – Geothermal Policies and Status**

PNG does not have a regulatory framework to cater for geothermal development. There are reported numbers of proposed exploration applications being made to carry out geothermal exploration in PNG areas. There are several applications pending the setup of a proposed regulatory framework. One case example is Kuth Energy PNG Ltd which has pursued geothermal exploration

at three geothermal potential sites which in 2008 were put on hold due to lack of a regulatory framework mechanism but still maintain their strategy to further explore the selected areas (Kuth Energy, 2012). Hence, a regulatory framework is required to motivate further geothermal research and exploration as PNG is potentially expected to benefit greatly from geothermal utilization and its possibilities to improve the living standards of people.

The GRP was administratively a segment of a mining policy which was developed in synergizing with the PNG Mining Act. This has now caused setbacks for the DPMGM. DMPGM has put considerable efforts to push for geothermal resource development. The environmental impact assessment and permitting process for geothermal activity in line with the ENV Act did not eventuate because of a no-show of legislation on geothermal energy. Such a method was also supposed to include preservation of natural geothermal features where PNG is host to high biodiversity values in known protected areas associated with the surface geothermal manifestations. Publication of protected areas needs to be known. The literature reviews explained above portray both strengths and weaknesses. These weaknesses refer to surface geothermal studies not completed, GRP not approved and no prescribed activity of geothermal in the regulation of environment impact. The strengths are that MRA has a good number of ongoing geothermal studies where information is available to support this project. Furthermore, geological baseline studies of geothermal resources in PNG from different sources are plentiful.

## 2. GEOTHERMAL SYSTEM AND GEOTHERMAL GEOLOGY

PNG geology is characterized by two major crustal tectonic plates, the Australian Plate and Pacific Plate which are attributable to its location along the Pacific Ring of Fire (Figure 2). The tectonic plates cause major fault events especially in the mainland PNG. PNG hosts a highly mobile zone of tectonic interaction between the continental crust on the south and oceanic crust to the north.

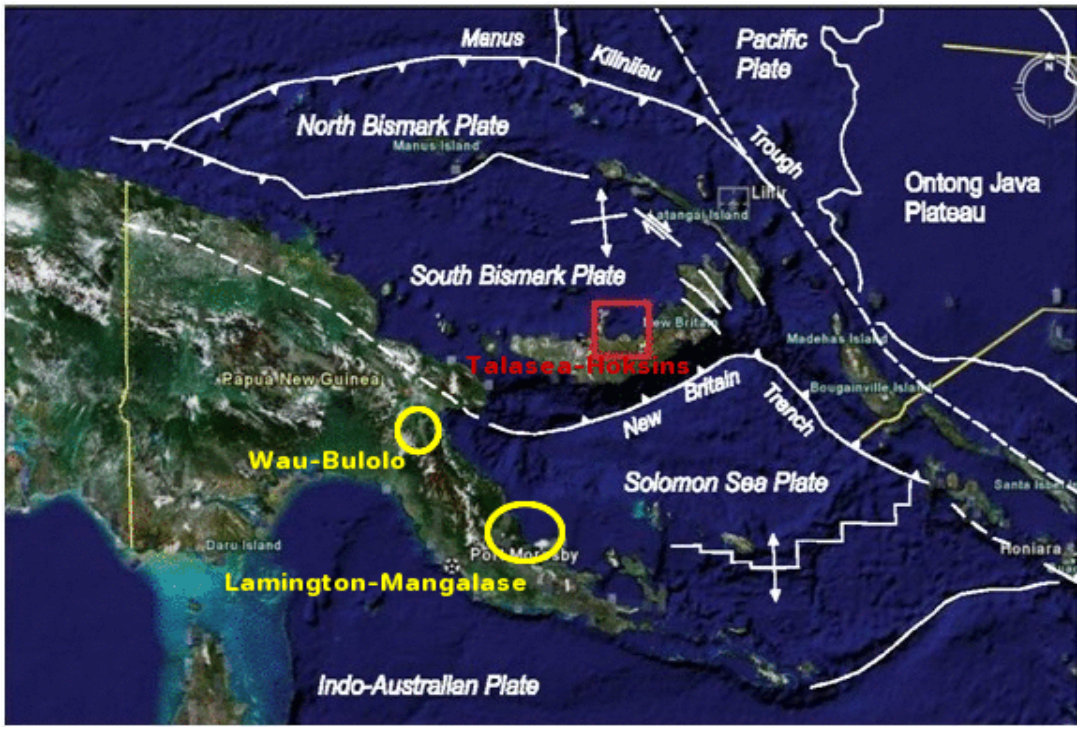


**Figure 2: Tectonic Plates in Papua New Guinea with major plates, Indo-Australian Plate and Pacific Plate (Source Adapted from Williamson and Hancock, 2005).**

The geological development of PNG forms young folded and faulted mountains, volcanic landforms, island arcs and other geomorphological processes. The mineral resources, geology and geophysics publication by Dow et.al (1972) further explains that besides the geological framework of PNG, its stratigraphy and structure, active volcanoes and earthquake activities are common features associated with the plate tectonics. Dow et al (1972) specifically describe the two main faults within the New Guinea Mobile Belt that are responsible for the displacement along the fault zone, which are Owen Stanley Fault and Markham-Ramu Fault Zone. These cover the investigated geothermal areas of Wau-Bulolo in Morobe Province (Figure 2) and the Lamington-Mangalase-Trafalgar in Oro Province (Figure 2). These account for geothermal systems and manifestations where occurrence of magma intrusion is established that could produce the convective circulation of groundwater (Utami, 2011). PNG has potential geothermal systems from the southeast to the northwest of the country. Figure 3 exemplifies the locations of possible geothermal thermal areas based on several publications especially the Mosusu (1997), Loffler (1972), Heming (1964) and Williamson and Hancock (2005).

In PNG, there are several active volcanoes as it is located along the Pacific Ring of Fire; a tectonic plate environment. The temperature classification of geothermal systems in PNG is similar to that in Indonesia and the Philippines which presumes volcanic systems and can be classified as a high temperature field. The general conceptual model of a high temperature field is shown in Figure 4. Utami (2011) describes the general model of a high temperature geothermal system in the Western Pacific consisting of Indonesia, Philippines and Papua New Guinea. Heat sources of a geothermal system are hot intrusions from the subsurface through shallow igneous intrusion heat sources and the upflow is characterized by fumarolic and steam-heated type

manifestations (Figure 4). The hot intrusions consisting of primary chloride type reservoir fluid are not fully reachable up to the surface as the outflow is concealed. This further causes the structure of outflow to spread parallel until the meteoric water causes the hot water to rise to the surface.

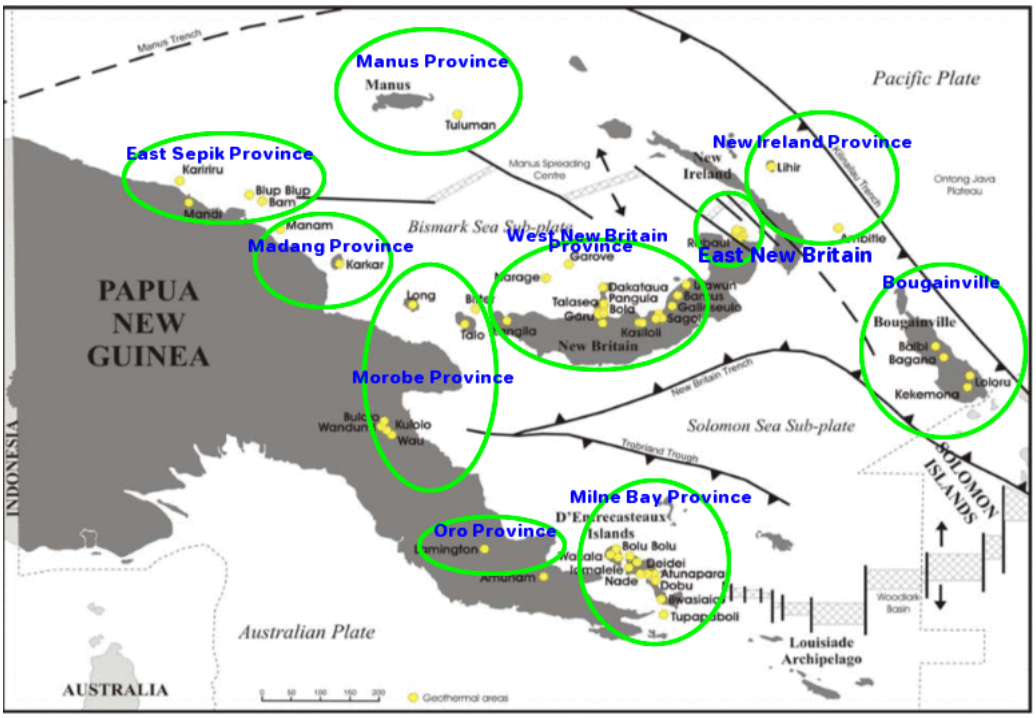


**Figure 3: Map of geothermal areas in Papua New Guinea. The yellow dots indicate the geothermal areas adapted from Mosusu (2008) and Heming (1969). The black lines indicate two types of plate and micro plate boundaries modified from Williamson and Hancock (2005). The green circles with blue names highlight the name of the administrative province in Papua New Guinea where geothermal areas are located. (adapted and modified from McCoy-West at, 2002).**

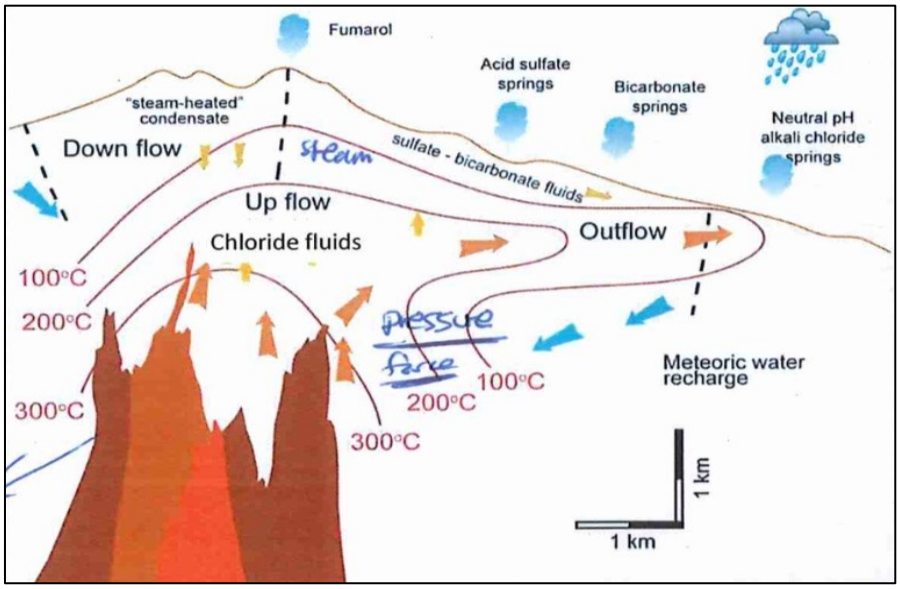


**Figure 4: A general conceptual model of a high temperature field showing steep terrain (adapted from Utami, 2011).**

High-temperature geothermal resources in PNG can be dry-steam, vapour dominated resources or hydrothermal, and liquid-dominated resources where further studies are required to ascertain the different models of a geothermal system. Although most geothermal systems in PNG are described as having vapor dominated resources, there are historical and current studies identifying geothermal spots along the Ramu/Markham Fault that are sedimentary geothermal systems. Mosusu (1997) reviewed the geothermal springs in Wau-Bulolo not related to volcanism and are characterized as alkaline manifestation. Figure 3 shows the location where Wau-Bulolo is located along the Ramu/Markham Fault line. Kumul and Lahan (2015) explain that PNG geothermal systems may be categorized into 2 types: volcanism and regional tectonics caused by deep magnetic activity. This constitutes the

geothermal systems in low-relief terrain. Furthermore, the PNG MRA via a Geological Survey derived from the Mosusu and Lahan studies propose the potential utilization of hard rock geothermal energy (PNG Geothermal Technical Working Group, 2016). Furthermore, Nautilus Minerals Niugini Limited (2008) documented the geothermal spot in the Bismarck Sea between the southern part of New Ireland Province and the northern part of ENB Province. The hydrothermal vent has been identified to be associated with active volcanoes which is characterized by the natural occurring plumes in the water column at depths of more than 1,000 metres (Nautilus Minerals Niugini Ltd, 2008). This is indicated from Hiriart (2010), the classification of other geothermal activity that is caused by the separation of the tectonic plates to allow the lava to discharge to the bottom of the oceans along ocean ridges.

### 2.1 GEOTHERMAL MANIFESTATIONS IN PNG

Given the literature on volcanology and morphology background in PNG, it is clearly documented that PNG has many associated geothermal manifestations. The geothermal manifestations in PNG include hot springs, hot lakes and pools, fumaroles and solfataras. This exhibits the potential location of potential geothermal systems associated discharge features on the surface. Geothermal manifestation has attracted both international and domestic tourists in PNG due to its beauty, uniqueness and heat. This is in reference to tourist hotspots where PNG has aggressively promoted the geo-tourism to boost the tourism revenue in PNG. The PNG Tourism Promotion Authority (PNG Travel, 2019) identifies three major tourism attractions that associate with geothermal manifestations, namely Mt. Tavurvur, Fergusson Island and Talasea. Figure 26 shows the three locations of three tourism attractions in PNG.

In addition, geothermal manifestations are associated with a significance of biological diversity values. It is clearly observed that geothermal manifestation harbours flora and fauna. Mutia (2011) explains that most geothermal resources are located within remote and protected areas. PNG is no exception where PNG government through the CEPA aims to cover as much as possible in line with PNG Sustainable Development Plan to protect the tourism, recreation and scenic areas. There are less than 15 protected areas closely associated with geothermal resources having the presence of geothermal manifestations. However, only 9 protected areas are classified as legal protected areas. (Figure 5). Pokili Wildlife Management Area (WMA) and Garu c (WMA) are two protected areas in WNB Province where the Talasea Geothermal site is located. The emergence of the PNG Protected Areas Policy 2020 provides more room to cater for the increased coverage of additional protected areas especially the hot springs, geysers and other associated geothermal manifestations.

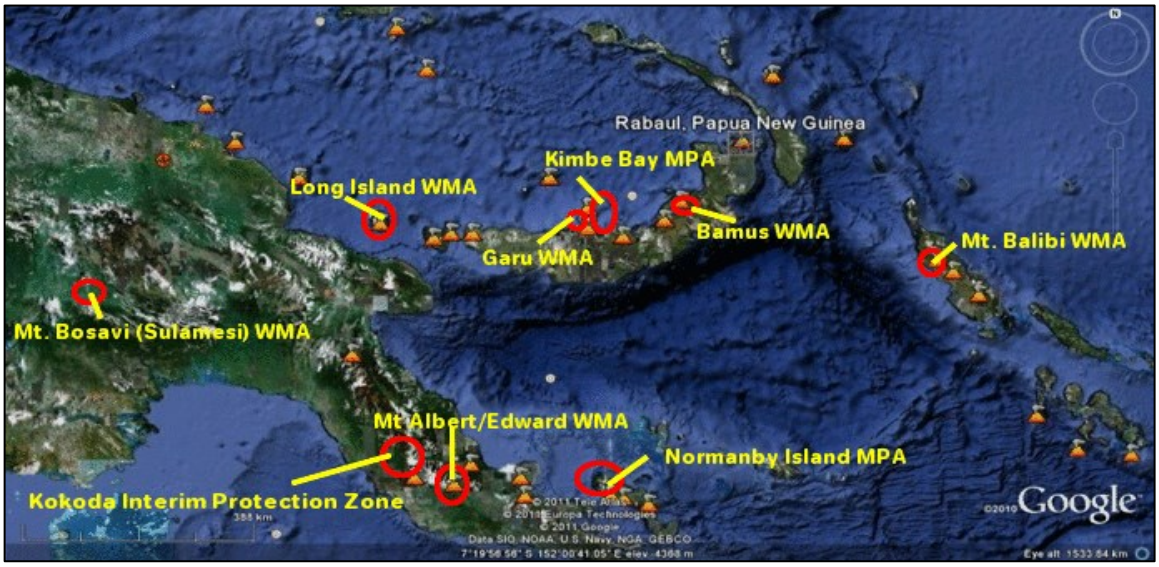


**Figure 5: Locations of identified protected areas in PNG associated with geothermal manifestations. WMA is indicated as WMA, and MPA stands for Marine Protected Area (adapted and modified from Bjornsson, 2011 and FAO, 2019).**

Generally, the geothermal manifestations in PNG comprises hot springs, hot lakes and pools, fumaroles and solfataras and other geothermal features that are spread across the country. These are the main potential geothermal systems that exhibit direct (concentrated) discharge features on the surfaces. There are reported features on hydrothermal and fluid-mineral interactions that are associated with geothermal systems in Wau/Bulolo areas (Koranga). The warm springs are located along the edge of the fault line system. Table 1 and Figure 6 highlight some of the recording of geothermal manifestations from the Volcanoalive (2019) associated with the types of volcanoes and the fault systems, and from Berhane and Mosusu (1997).

The geothermal manifestations are not fully mapped and documented throughout the identified sites to classify the thermal manifestations. Utami (2018) highlights the types of thermal manifestations namely diffused discharge, direct/concentrated discharge, intermittent discharge, catastrophic discharge and concealed discharge. The recordings of thermal manifestations from Figure 6 and Table 1 also relate to the volcanic landforms and fault structural regimes pertaining to the Highlands & Southern Fold Mountain, Bismarck Sea Volcanic arcs, Cape Vogel Basin and D'Entrecasteaux (Loffler, 1977). Therefore, the classification of surface discharge features is non-existent in PNG between the 1960s and 1990s. Until 1997, the initial geothermal reconnaissance was undertaken to document the key geothermal manifestations to constitute the geothermal investigation in PNG.

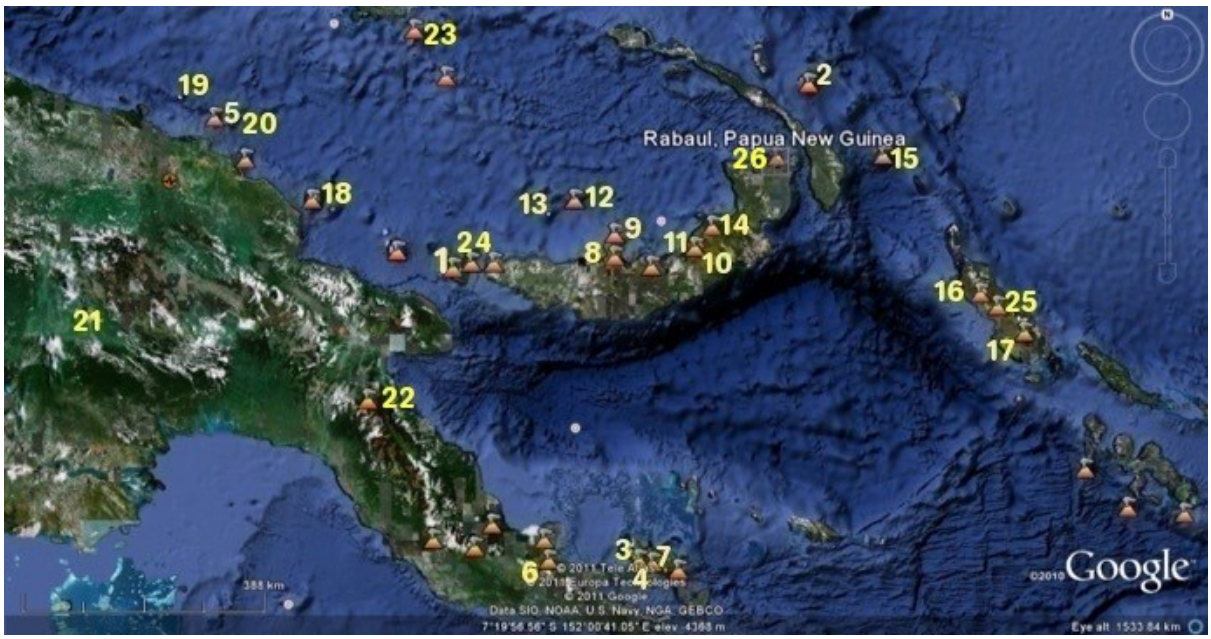


**Figure 6: Locations of direct discharge features and manifestations in PNG. The number highlights the names of the geothermal manifestations in the Table 6 below. The orange triangle indicates the types of volcanisms (adapted and modified from Bjornsson, 2011 and Volcanoalive, 2019).**

**Table 1: Main geothermal manifestations recorded from the Volcanoalive (2019) and from Berhane & Mosusu (1997).**

| | Name of Volcano | Province | Type | Summit Elevate. | Geothermal Features |
|---|---|---|---|---|---|
| 1 | Umboi | Morobe | Complex Volcano | 1584 m | Hot Springs, bubbling mud pools, solfataras |
| 2 | Lihir | New Ireland | Complex Volcano | 700 m | Hot Springs, mud pools, solfataras |
| 3 | Goodenough | MBP | Volcanic Field | 2566 m | Hot Springs |
| 4 | Dobu* | MBP | Strato Volcano | 300 m | Fumarolic Activity |
| 5 | Kairiru | East Sepik | Crater | 800 m | Hot Springs (Geothermal Activity) |
| 6 | Musa | Oro | Hydrothermal Field | 808 m | Hot springs |
| 7 | Oiau | MBP | Strato Volcano | 400 m | Fumarole activity |
| 8 | Garua* | WNB | Volcanic Field | 656 m | Hot springs, boiling pools, fumaroles, geysers |
| 9 | Dakataua | WNB | Caldera | 400 m | Solfataras, warm springs |
| 10 | Walo | WNB | Hydrothermal Field | 15 m | Solfataras and mud springs |
| 11 | Karai | WNB | Strato Volcano | 565 m | Hot springs |
| 12 | Narage | WNB | Strato Volcano | 307 m | Hot springs and geysers |
| 13 | Garove | WNB | Strato Volcano | 368 m | Solfataras field and thermal areas |
| 14 | Baimus* | ENB | Strato Volcano | 2248 m | Fumaroles |
| 15 | Ambitle | New Ireland | Strato Volcano | 450 m | Hot Springs, mud pools, fumaroles |
| 16 | Balbi* | Bougainville | Strato Volcano | 2715 m | Boiling mud, active fumaroles, solfataras |
| 17 | Loloru | Bougainville | Pyroclastic Shield | 1887 m | Thermal Activity |

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|---|---|---|---|---|---|
| 18 | Karkar | Madang | Strato Volcano | 1839 m | Fumarolic activity |
| 19 | Kadovar | East Sepik | Strato Volcano | 365 m | Fumarolic/Thermal Activity |
| 20 | Bam | East Sepik | Strato Volcano | 685 m | Hot Springs |
| 21 | Doma Peaks | Southern Highland | Strato Volcano | 3568 m | Geothermal Activity |
| 22 | Koranga | Morobe | Explosion Crater | 1200 m | Warm springs |
| 23 | Baluan | Manus | Strato Volcano | 245 m | Warm springs |
| 24 | Sakar | Morobe | Strato Volcano | 992 m | Hot springs, solfataras |
| 25 | Bagana | Bougainville | Lava Cone | 1750 m | Hot Springs, Solfataras |
| 26 | Rabaul | ENB | Caldera | 688 m | Fumarolic, Boiling mud |

## 3. NATIONAL DEVELOPMENT & SECTORAL PLANS & POLCIES ASSOCIATED WITH RENEWABLE ENERGY AND GEOTHERMAL ENERGY

### 3.1 National Vision 2050

In a country-wide plan, PNG has embraced the National Vision 2050 paving a long-term strategy that maps out the future direction for PNG. The vision of the long-term strategy is to become a smart, wise, fair and happy society by 2050 (PNG Treasury, 2010). The Vision 2050 is supported by seven pillars and these are:

- Human Capital Development, Gender, Youth and People Empowerment
- Wealth Creation
- Institutional Development and Service Delivery
- Security and International Relations
- Environmental Sustainability and Climate Change
- Spiritual, Cultural and Community Development,
- Strategic Planning, Integration and Control.

One of the seven pillars concerning renewable energy is Environmental Sustainability and Climate Change. This is the pillar that sets out the need for development of large renewable energy projects to promote sustainable development in all sectors and expects the provision of 100 per cent power generation from renewable energy sources by 2050. Hence, geothermal energy is covered in the context of renewable energy and this will enable the formulation of short-term and long-term development plans for increased utilization of renewable energy resources in line with Vision 2050 and the development of sustainable development policies to increase the electricity needs. According to the Treasury (2010), Vision 2050 also expects the establishment of a Sustainable Development Policy in all sectors, especially forestry, agriculture, mining, energy and oceans by 2015. This provides PNG with an opportunity to come up with the proposed regulatory framework to meet demands for geothermal exploration and utilization. The establishment of sustainable development policies, especially the provision of 100 per cent of power generation from renewable energy sources allows the possibility of future geothermal utilization in PNG in line with the Vision 2050. Such a policy drive will improve the wellbeing of the people and the economy of the country.

### 3.2 National Development Strategies 2010-2030

PNG Development Strategic Plan 2010-2030 is the home-grown document that provides development aspirations for the period of 20 years to achieve the NV2050. It is simply a development pathway to improve the living standards for the people of PNG by setting out the broad framework, targets and strategies to progress into the next 20 years leading up to 2050.

The energy development is one of the key development pathways in the 20-year plan which is aimed at two goals:

1. To ensure that all households have access to affordable energy
2. To provide sufficient power to be generated and distributed to meet future energy needs and demands.

It is also targeted that by 2030 over 70% of all households and businesses should have access to reliable, affordable and modern clean energy sources. Therefore, the 2010-2030 focuses on promotion of energy from hydro power and gas. The National Government aims to increase the power production from hydro power at 1,020 MW by 2030 followed by gas thermal at 390 MW. This is reflected in energy demand that projects to increase in preparation for future economic developments as outlined in the National Development Strategies 2010-2030.

In addition, the National Government also intend to make use of renewable energy as part of the environment sustainability and climate change in accordance with PNG Visions 2050. Although the National Government want to pursue renewable energy resources in partnership with private sector, it is acknowledged that there will be a huge amount of investment to establish the utilization of renewable energy resources in the likes of solar, biomass, geothermal and wind. As part of the projection by 2030, about 500 MW should be expanded from the use of renewable energy for electricity.

Specifically, geothermal is part of the renewable energy strategies. It is ideally fitted into the key economic corridor concept where the National Government identified the corridors of poverty where living standards and the basic services are very poor. It requires substantial investment of infrastructures in those economic corridors.

The key economic corridors that relate to potential geothermal infrastructures for power generation are:

1. Central Corridor (Central, Oro, MBP and Morobe)
2. Morobe – Madang Corridor
3. South Coast Corridor (ENB and WNB)
4. Momase Corridor (Madang, East Sepik and West Sepik)
5. Solomons Corridor (Autonomous Region of Bougainville)

### 3.3 MTDS III 2018-2022

The Medium-Term Development Strategy III is the third consecutive national development strategy for PNG, setting out the National Government's development priorities for 5 years between 2018 and 2022. Affordable and clean energy is the key areas to the sustainable development goals as part of the NV2050. It was integrated into MTDS from NV2050. According to the MTDS report, the performance of the previous development strategies shows that the target of household electrification rate in 2015 by 27% was not achieved. In reference to development strategies between 2010 and 2015, the National Government only achieved 21% in delivering electricity access to households.

MTDS acknowledges that energy is the backbone of the economic growth and development of the country. This is demonstration of the current National Government's collaboration and joint effort with private sectors to plan, improve and invest in energy sectors apart from agriculture and manufacturing sectors. In addition, the National Government has been working hard to achieve the target and produce results to commit the funds into quality infrastructure and utility. This is about the deteriorating conditions, in this case, the energy, on the context of creating an enabling environment for economic growth and the improvement of service delivery. The energy sector and other two sectors (ICT and Transport) are key areas that have the potential to address the deteriorating conditions in infrastructure and utility.

The National Government is committed to the infrastructure strategies of increasing electricity supply with extension of transmission power grid on to communities through National Electricity Supply Roll-out Plan. Compared to the previous MTDS, the National Government clearly states that more investment is needed in clean energy sources including hydro and geothermal to accelerate the energy expansion with moves to do away with dependence on diesel power generation.

### 3.4 PNG Economic Road Network Development & Maintenance Plan

The PNG Economic Road Network Development & Maintenance Plan is the national road development strategy that supports the National Development Strategy 2010-2030. This provides guidance for investments to economic corridors that is explained in Section 2.7.2. It is established key investments in a sustainable energy supply program that are feasible once the development of the new road is fully achieved.

This accelerates the demand for energy and the expansion of energy access to households. In addition, it enables the supply of reliable and renewable electricity supply with reduction of fuel imports. Such development of key economic corridors where presence of potential geothermal sites is located provides the opportunity to tap into geothermal heat not only for power generation but to construct power transmission along the roads.

### 3.5 PNG National Energy Policy 2017-2027 (PNGNEP)

The PNGNEP sets out the blueprint for energy expansion in PNG. The policy comprehensive and provides an overview, challenges and strategies for both fossil fuels and renewable energy. It addresses the development of electricity, institutional reform of the electricity, local participation in the energy sector, energy financing, trading, pricing and socio-economic issues, and the land, environment, health and safety. Specifically, fossil fuels entail expansion of upstream petroleum, midstream and down petroleum, mid and downstream natural gas and clean coal resources. It is also the centrepiece connecting PNG Visions 2050, National Development Strategies 2010-2030 and 5-years Medium Term Development Strategies and the corresponding policies in the likes of the National Electrification Rollout Plan, PPL Least Cost Development Plan and the PNG Economic Road Network Development & Maintenance Plan. Geothermal energy is heavily specified under the PNGNEP hence it should be become a catalyst for the management of the resources to be managed administratively under proposed National Energy Authority (NEA).

PNG is blessed with a range of resources and options for energy. It has petroleum, coal, hydropower, solar, and geothermal across the country. In addition to fossil fuels from petroleum, natural gas and coal, most of the renewable energy resources are not fully explored and exploited. The PNGNEP provides the right time solution to enable further exploration and exploitation especially when there is less than 50 percent electricity coverage to the increasing population and the increased economic development activities. PNG's population is growing at a fast rate where youth group dominates the population pyramid which is straining the government's effort to provide goods and services. Business houses are subject to frequent power blackouts and a lack of power accessibility and reliability remains a major factor to doing business in PNG.

The development of policy on energy now enables the plan for renewable energy resources to become a reality. With the support from the WB, the introduction of renewable energy policy and rural electrification policy enables the funding opportunities for utilization the renewable energy resources specifically the hydro and geothermal to take place. This is highlighted with the support geared towards the new Naoro Brown Hydro Power Plant Project and the massive improvement to the aged small-scaled hydro power stations (World Bank, 2019). The energy development stimulates the economic growth and geothermal resources is no

exception that can offer enormous potential to utilize energy not only for power generation but also for other economic uses including cocoa drying, mining operation, tourism and other direct uses.

### 3.6 National Electrification Roll Out Plan (NEROP)

This is an upcoming plan that will be completed in July 2019 supported by the WB under PNG Energy Sector Development Project. It focuses on expanding the distribution grid and establishing mini-grid systems for electricity access to households. It is vital plan other than the National Energy Plan and Policy that aims to strengthen the rural electrifications where most of the population lives in the rural areas. This will align with provincial and district development plans for electricity supply and distribution.

### 3.7 National Compatible Climate Change Management Policy 2014

The Climate Change Policy 2014 is an important policy that relates to the promotion of renewable energy. It is a compatible management approach with strategies that cross all sectors in response to impacts of climate change. The vision of the policy is to have a robust and sustainable economy for PNG through low a carbon pathway and green economic growth.

It is acknowledged that this policy is formulated to stage-manage the adaptation and mitigation frameworks. Amongst the issues and gaps that calls for a climate change policy, it is considered that there was no promotion of utilization of clean energy technologies considered for sustainable development. It is also related to greenhouse gas emissions (GHG) from economic sectors including the energy sector. The policy also recognizes CCDA as National Designated Authority in accordance with the Kyoto Protocol. This enables a pathway for PNG to tap into the Green Development Fund for energy technologies and development. The energy becomes key participation in the CCMP where DPE collaborates with CCDA in its efforts to reduce GHG related to the production and use of energy.

Energy-related strategies that promote low-carbon growth development are:

a) energy sources reduce climate change
b) support a transition to renewable energy
c) incentives for the small-scale use of renewable energy systems
d) local energy generation from renewable sources
e) design for alternative sources of energy.
f) energy generation
g) eliminate regulatory barriers to the use of renewable energy systems.

Investing in geothermal energy is significant for the renewable energy sector with a policy that recognizes to be transformed with hydro power. Simply, geothermal is one of the renewable energies that is also regarded as low carbon growth.

### 3.8 PPL's Least Cost Development Plan

Like the NEROP, the PPL Least Cost Development Plan is nearing completion. Developed by PPL.'s state owned power utility, it is going to be PNG's power sector report intended to guide the sector on collaboration with private energy investors on sector basis, generation opportunities from renewable energy sources, transmission network expansion and the improvement to the resource requirement in the existing infrastructures in PNG. This policy guidance is technically dominated by PPL with consultation with PNG's ICCC and the DPE. It basically guides PPL to follow its internal processes by planning,

Geothermal energy may not be an option for the business now as the focus is now on least cost generation options such as hydro and gas. It is acknowledged that geothermal resources are scattered around the country and not much development has taken place. Hence, it will be some years down the line unless PPL want to look at off- grid solutions in areas where geothermal resources are placed. Furthermore, coal and fossil fuels are not in the plan either. PNG CEPA is a party to the UN Conventions and Kyoto Protocol that advocates on climate change and its adoption and fostering of greener energy. PPL intends to make sure that it only delivers cheap, reliable, safe and clean energy to its current and future users in all sectors. Coal is not in the picture for the country.

### 3.9 PPL's Independent Power Producer and Major Infrastructure Policy

This is the policy relating to collaboration between PPL, a state-owned power electricity and private sectors explicitly independent power producers (IPP). The policy recognizes that IPPs are critical to the electrification program in PNG when PPL does not have funding to establish new power plants. There are no IPPs for geothermal energy to support PPL.'s Least Cost Development Plan. PPL strongly envisages for the power utilization from renewable energy sources. The policy clarifies the situations and way that private sector partners can participate in implementing PPL's least cost development plan and other strategic and economic enhancing opportunities in the power sector.

### 3.10 International Support for Electricity/Energy Development in PNG

<u>WB Power Section Support Program</u>

This program is termed as PNG Energy Sector Development Project approved from February 2013 to the end of July 2019. The project aims to strengthen the policy development and strategic framework for renewable energy and rural electrification and to enable attractive investment in new hydropower development to supply the Port Moresby electricity grid (the capacity city of Papua New Guinea is Port Moresby). The major component of the project is the Naoro Brown River Hydroelectric Project (80MW) which began its feasibility studies in 2017.

APEC 2018 Multi-Bilateral Electrification Support Program

This is termed as Papua New Guinea Electrification Partnership and is a major established commitment by combined Australia, New Zealand, Japan and United States in 2018 following the APEC Leaders meeting in Papua New Guinea. It is committed to provide US$1.3 billion support to expand the electricity coverage throughout Papua New Guinea. The PPL (monopolistic power utility) declared the initiative that funding from the PNG Electrification Partnership would assist the roll-out of electricity and thus, increase the number of connections with special focus on hydropower. The electrification partnership is expected to complement PPL Limited's Least Cost Development Plan on expansion of renewable energy projects.

## 4. ENERGY RESOURCES AND UTILISATION

PNG has a promising geothermal utilization with huge geothermal potential that could support the economy at 21.92 terawatt-hours (REEP, 2012). There are several sound developmental and strategic reasons for suggesting a geothermal energy approach (as part of a wider energy mix strategy in PNG). PNG is blessed with a range of resources and options for energy. It has petroleum, coal, hydropower, solar, and geothermal energy potential as the main options. Many rural areas have relied for decades on stand-alone diesel generators and more recently, solar energy. There are limited gridded electricity networks: 93% of the population are situated out of reach from the electricity networks (UNDP 2017). There is increasing pressure and encouragement for non-fossil fuel energy options from NGOs (Green Climate Fund, 2016). For PNG this already includes solar energy, wind energy, hydropower and geothermal energy. It is prudent to develop and expand a range of options for power to enhance energy security and economic development and mitigate further contributions to anthropogenic climate change. There is government and donor commitment to development and expansion of hydropower and solar power. Therefore, geothermal power generation has potential to fix into the mix of options for PNG as part of the national energy development program as per the PNG government commitments to extend power to a much wider percentage of the population, using renewable resources where possible.

### 4.1 Current Electricity Trends/Statistics

According to REEP (2012), the total installed electricity capacity in PNG was 582 MW in 2010. Hydropower accounted for about 40 per cent, diesel 37 per cent, natural gas 14 per cent. Only 9 per cent is accounted for by geothermal energy. As a result, about 90 per cent of the population has no access to electricity. Most of the electricity is available centrally in the capital city, Port Moresby and other urban areas. PNG has had capacity problems in providing power to urban developments and the major economic activities and numerous power interruptions have taken place. Electricity in PNG is often unreliable, and relatively expensive. This has led to difficulty in accessing proper power for most of the population and hence contributes to poverty in rural areas. Most of the populations still use petroleum products for the energy needs of their everyday lives. Such regular usage of petroleum products for energy leads to environmental problems.

### 4.2 History and Background of Energy Utilization for Electricity

Electricity in PNG has been transformed successively with constraints in providing power. PNG Power Limited (formerly PNG Electricity Commission) has been building, operating and maintaining all power activities from generation, transmission and distribution in PNG since the 1960s. According to PPL (2006), PNG Power Limited (PPL) is now managing 30 electricity operating systems throughout the country. Apart from 3 major hydropower plants, the rest are run by a diesel generation system. In fact, hydro is and continues to be the main source of generation which supplies electricity at 70% compared to the fuel burning power system/plant 14% (PPL, 2006). The Independent Power Producer (IPP) manages the total of 16% of electricity supply to PNG. Furthermore, PNG electricity is subject restricted to PPL's full control of the energy industry who has been licensed to produce, transmit and retail energy for all users including business and commercial industries.

Other power plants purposely built for running their own industrial operational activities are Lihir Geothermal Power Plant, Exxon Mobil Hides Gas Plant and NBPOL Methane plant.

#### 4.2.1 Hydro

Renewable energy developments began in the 1950s with high potential of energy sources but initially focused on natural river system utilization for power generation. Rouna Hydropower Project was the first major hydropower scheme of the renewable energy development in the 1960s when PNG gained independence in 1975. Rouna Hydroelectric Plant which started off at 6MW continues to provide electricity for Port Moresby and the Central Province. It is the cascade development involving Rouna 1, Rouna 2, Rouna 3 and Rouna 4 which produces 50MWs which is supplemented by another 60MW from the operation of the fuel burning power stations.

The second renewable energy development was proposed in the central mainland of Papua New Guinea in the 1970s which was to involve three stages of the project to harness the Ramu River in the Eastern Highlands (Furnstner, 1976). Ramu 1 power plant with Yonki Dam was completed and commissioned in 1976, which suppled power to Lae, Madang, and most of the Highlands provinces. The current capacity of the power under Ramu System is 87MW supplemented by an additional minor hydro-power plant in Panauda (12MW). Third hydro power development occurred in New Britain which is operated under the Gazelle System in Warongoi in ENB Province. The operation began in 1987 and continues to operate on 10 MW.

Trawen


**Figure 7: Map showing the power network and transmission system operated under monopolistic utility, PNG Power Limited in Papua New Guinea. (Red line indicates the transmission line and blue box indicates the power station/substations/generators) (Source: PPL, 2015).**

**Table 2: Existing Hydro power plants in Papua New Guinea (Source: ADB Power Sector Development Plan 2009).**

| Name of Hydro Power Plant | Year Operation Start | Capacity MW | Area Supplied |
|---|---|---|---|
| Rouna | 1960 | 50 MW | NCD Grid |
| Ramu | 1976 | 75 MW | Lae, Madang Provinces, Western Highlands, Eastern Highlands, Chimbu, Enga and Southern Highlands, Hela |
| Ok Menga | 1983 | 58 MW | Ok Tedi Mine and communities in North Fly District |
| Warongoi | 1987 | 10 MW | Gazelle Peninsula of ENB Province |
| Baiune | 1992 | 5.7 MW | PNG Forest Products and Wau/Bulolo Town in Morobe Provinces |
| Ru Creek | 1995 | 0.8 MW | Kimbe, WNB Province |
| Lake Hargy | 1997 | 1.5 MW | Bialla, WNB Province |
| Lihir | 1997 | 56 MW | Lihir Mine, New Ireland Province |

4.2.2 Fossil Fuels

Operation of a fuel burning power station is established and confined to two areas: 1) where power grid transmission from hydro power is not accessible and 2) where additional power capacity is required to meet the demand. There are about 21 fuel burning power stations, mostly with a capacity between 0.5 MW and 5MW. The largest power plant managed by PPL is Moitaka (31 MW), Lae (36 MW) and Kerevat (7.2 MW) followed by Wewak (6.9 MW).

Furthermore, under IPP investment, PNG Hydro Development Posco Daewoo Power has supplied 24MW internal combustion electric power to meet the power grid demand through a plant situated in Kanudi, Port Moresby. Upon serving a 15-year contract from 1999 to 2014, it accomplished to secure the basis for stable power production for an additional five years through successful rehabilitation, operation, maintenance and management (ROMM) by life extension and efficiency enhancement of the power plant. POSCO Daewoo also signed another power purchase agreement to establish and operate a 30MW internal combustion electric

power plant in Lae, the country's second largest city, which started commercial operation in June 2018, solidifying its position as a power producer in PNG.

4.2.3 Other Energy

Geothermal, biomass and natural gas are other energy sources in PNG that are emerging but are soon to be expanded gradually from the infant stages. Lihir Mine utilized the geothermal energy for power generation for its mining activities although it is a not PPL's managed asset. Lihir Geothermal Power Plant now operates 56MW. Similarly, at Hides Gas for the mining activity at Porgera Mine, the electricity supply is obtained from natural gas which is utilized for 62MW. Following the suit will be Port Moresby gas-fired power station is managed under independent power producer (IPP) arrangement. NiuPower is an independent power producer owned jointly by Kumul Petroleum and Oil Search for Port Moresby gas-fired power station. It aims to develop power generation facilities in PNG fuelled by PNG-produced natural gas. NiuPower is currently developing the Port Moresby Power Station as its foundation investment. The Port Moresby Power station is a nation-building infrastructure project. It will produce 58MW base load power to the Port Moresby power grid through a new 66kV power line and substation network being developed by PPL. The power station will commence commercial operations in March 2019.

Biomass is another renewable energy that will produce power and is now undergoing construction. Following the PNG Power Ltd's approval of power transmission in line with its Least Cost Development Plan, Markham Valley Power Project will produce power from biomass as a low carbon, renewable and sustainable energy initiative. Under IPP, PNG Biomass is a wholly owned Oil Search subsidiary that operates the Markham Valley Power Project. It will use wood chips from tree plantations, grown and sustainably harvested in Morobe, to provide low-cost, renewable and reliable biomass power.PNG Biomass will use wood chips harvested from sustainably-grown trees in surrounding plantations to fuel a biomass power plant to provide up to 30MW into the Lae and the Ramu grid, with generation due to commence in 2020.

Solar and wind resources are yet to be exploited despite potential to generate the renewable energy. It is included in the National Energy Policy 2017-2027 for its intention. In addition, solar farm is one of the PNG electrification programme under Australia-PNG Comprehensive Strategic and Economic Partnership (CSEP), valued up to AUD$250 million. It reiterates the scope of project pertaining to new solar power plant that will be first of its kind in PNG (Prime Minister of Australia, 2019).

4.2.4 Future Power Generation Project

It is desirable for the National Government to accelerate energy expansion programs for PNG. Currently, there is a $US1.7 billion multi-bilateral partnership deal which aims to electrify 70 per cent of PNG by 2030. This is the commitment that PNG Government wants to embark on in accordance with the NV2050, National Development Strategy 2010-2030 and the MTDS III 2018-2022 as explained in the Section 2.7 below. Simultaneously, PPL works to develop power from the renewable energy resources in PNG. As part of the commitment to the NV2050, PNG has produced the Least Cost Development Plan paving the way forward for energy expansion and the transmission and network programs. It comes at the right opportunity to capture the benefit from the K3 billion multi-country electricity initiative.

The development of the PNGNEP2017-2027 and the PPL.'s Least Development Plan drives not only hydro expansion opportunities but also petroleum and natural gas, geothermal, solar, biomass and other available energy resources. It is also in line with PNG's National Development Plan to critically address the power shortage considering increased economic opportunities. The future electricity project as documented from the PNGNEP2017-2027 and the PNG Power Section Plan in consultation with WB are:

a) Town Electrification Investment Programme (TEIP)
    a. 150km 66kV Kimbe-Bialla Transmission Line Interconnection – WNB Province
    b. Divune Hydropower Plant – Northern Province
        i. 3.0 MW Run-off- River scheme
        ii. 80km 33kV distribution line (60km to Popondetta town to 20km to Kokoda station)
    c. Ramazon Hydropower Plant – Autonomous Region of Bougainville
        i. 3.0 MW Run-off River Scheme
        ii. 40 km 33kV distribution line connection to Kokopau
    d. Rehabilitation of Warongoi Hydropower Plant
    e. Rehabilitation of Lake Hargy Power Plant
    f. Rehabilitation of Ru Creek Power Plant
b) Port Moresby Grid Reinforcement Project, Port Moresby, National Capital District
    a. Rehabilitation of Rouna 1 Hydropower Plant
    b. Rehabilitation of Sirinumu Toe-of-dam Hydropower Plant
    c. New Kilakila Substation and Transmission Line Project
c) Naoro Brown Hydropower Project – Central Province (80 MW Run-off-River Scheme)
d) Ramu Transmission System Reinforcement Project – Morobe Province
e) Ramu 1 Rehabilitation Project – Eastern Highlands Province
    a. Rehabilitation of Ramu 1 Power Station (increasing capacity from 45 MW to 60 MW
f) Ramu 2 Hydropower Project – Cascade hydro power plant of Ramu 1 – Eastern Highland Project
    a. 40 MW Run-of-River schemes
g) Renewable Energy Development Plan – Geothermal
h) Independent Power Producer initiatives
i) Power Infrastructure Plans (currently underway and proposals)
    a. IPP – Markham Valley biomass Project, Morobe Province
    b. IPP – PNG Forests Baime Hydro Power Project, Morobe Province

c. IPP – New Britain Palm Oil Ltd – Oil Palm Waste under Clean Development Mechanism – WNB Province, Oro Province and MBP
d. IPP – Port Moresby Gas-fired Power Station
e. Hydro potentials – 120 MW Mongi Hydro in Morobe Province, 40 MW Lake Hargy Hydro in WNB, 40 MW Gazelle Hydro, 2-5 MW mini hydro in provinces
f. Geothermal options in some parts of PNG (ENB Province, WNB Province, New Ireland Province, Bougainville, Oro, MBP).
g. Puarari Hydro Project – initial phase of 2,500 MW
h. Interconnection of Port Moresby and Ramu via 275 kV Transmission Line

## 5. GEOTHERMAL RESOURCES POLICY

The GRP is developed in response to the PNG Government's request to push the utilization of geothermal resources for electricity. The initial GRP was further expanded with the engagement of New Zealand Government-sponsored consultants. The policy was eventually completed in 2014 and became a final document prior to the National Execution Council for its consideration.

The purpose of the GRP (GRP) is to encourage, allow and facilitate the exploration, development, production, use and management of geothermal resources in Papua New Guinea. The policy has two purposes: 1) to legalize the regulatory framework for permitting any geothermal exploration and development, and 2) to guide applicants seeking geothermal tenements under the Mining Act 1992 and for any associated licenses under the ENV Act.

The policy document is therefore presented in two parts:

- Part One: Policy document on how geothermal resources are administratively managed under the MRA.
- Part Two: Policy handbook on how regulatory framework for geothermal energy is established and merging with existing permitting requirements from other institutions.

### 5.1 Part 1: Policy Document on Geothermal Resources and its Proposed Procedures

Part 1 of the policy relates to applications for exploration, development, production, use and management of geothermal resources in PNG. It describes the corresponding legislation and its existing regulations legalize the application mechanism for geothermal exploration and development. It specifically explains the current MRA licensing regime applied for key licenses such as an exploration license and special mining lease and how they should correspond to geothermal resources. It is documented that power production is incorporated as part of the application to be managed by MRA.

#### 5.1.1 Proposed Regulatory Framework

The framework is designed to make MRA the main administrator of geothermal exploration and development in PNG. This is considered based on mineral exploration and development where geothermal resource is defined as a mineral. According to the Mining Act 1992, minerals are defined as all valuable non-living substances excluding petroleum obtained or obtainable from land. This implies that any non-living substances that are obtained from the land are defined as mineral and hence the property of the State.

PNG MRA is the responsible body for the promotion of exploration, and geological studies and other earth sciences research, regulation and coordination of exploration and mining development and the regulation of exploration and mining in Papua New Guinea. Subsequently, MRA is mandated to promote, coordinate, regulate and administer geothermal exploration and development in PNG, consistent with the Mining Act 2000.

Therefore, the policy is used by the MRA and the CEPA as part of their assessment of geothermal tenement applications for exploration, development, produce use and management of geothermal resources.

#### 5.1.2 Mining Act

The Mining Act 1992 is the main mining legislation that governs mining in Papua New Guinea. It is the legislation that gives the power to State to own the minerals that are obtained.

It is therefore by legislative interpretation that geothermal resource falls under the precinct of the Mining Act 1992. Hence, the Act empowers the establishment of the MRA for administration and enforcement of the Mining Act and any other legislation relating to mining or to the management, exploitation or development of mineral resources in PNG.

#### 5.1.3 Mineral Resource Authority

Further to the Mining Act 1992, the MRA Act 2005 became effective to delegate its separate entity from department status to become sole management and regulation of mining activities in PNG.

Going back to the MRA Act 2005, the key function of the MRA are to:

a) advise the Minister on matters relating to mining and the management, exploitation and development of Papua New Guinea's mineral resources
b) promote the orderly exploitation for the development of the country's mineral resources
c) oversee the administration and enforcement of the Mining Act 1992 and any other legislation relating to mining or to the management, exploitation or development of Papua New Guinea's mineral resources
d) negotiate mining development contracts under the Mining Act 1992 as agent for the State

e) act as agent for the State, as required, in relation to any international agreement relating to mining or to the management, exploitation or development of Papua New Guinea's mineral resources
f) on behalf of the State, to administer and be responsible for the administration of any public investment program relating to miningconduct systematic geo-scientific investigations into the distribution and characteristics of Papua New Guinea's
g) mineral and geological resources, located on, within or beneath the country's land mass, soils, subsoil and the seabed
h) collect, analyze, store, archive, disseminate and publish (in appropriate maps and publications) on behalf of the state geo-scientific information about Papua New Guinea's mineral and geological resources.

It is further stipulated that geothermal resources are not petroleum or petroleum products under the Oil and Gas Act 1998.

5.1.4 MRA Licensing

The MRA licensing is existent and effective where regulation and licensing and allocation in relation to geothermal energy is synced and merged with additional requirement.

The regulations that directly legalize geothermal exploration and development are:

a) Mining Act 1992
b) Mining (Safety) Act 1977 and Regulations 1935
c) MRA Act – 2005
d) ENV Act 2000

Furthermore, conducting business in Papua New Guinea under Section 28 of the Investment Promotion Authority Act requires foreign business to apply and register.

Specifically, mining tenements are divided into six (6) licensing types:

a) Exploration License
b) Mining Lease
c) Special Mining Lease
d) Alluvial Mining lease
e) Lease for Mining Purpose
f) Mining Easement

The Exploration License, Mining Lease and Special Mining Lease are explained in Figure 34. The Exploration License is granted for no more than 2 years and it only allocates to no more than 750 sub-blocks (one sub-block is equivalent to 3.41 km2). It is an important pathway to obtaining a Special Mining Lease for large scale operations. This is where an Exploration License Holder must establish its participation in the Mining Development Contract with the state in accordance with the Mining Act 1992.

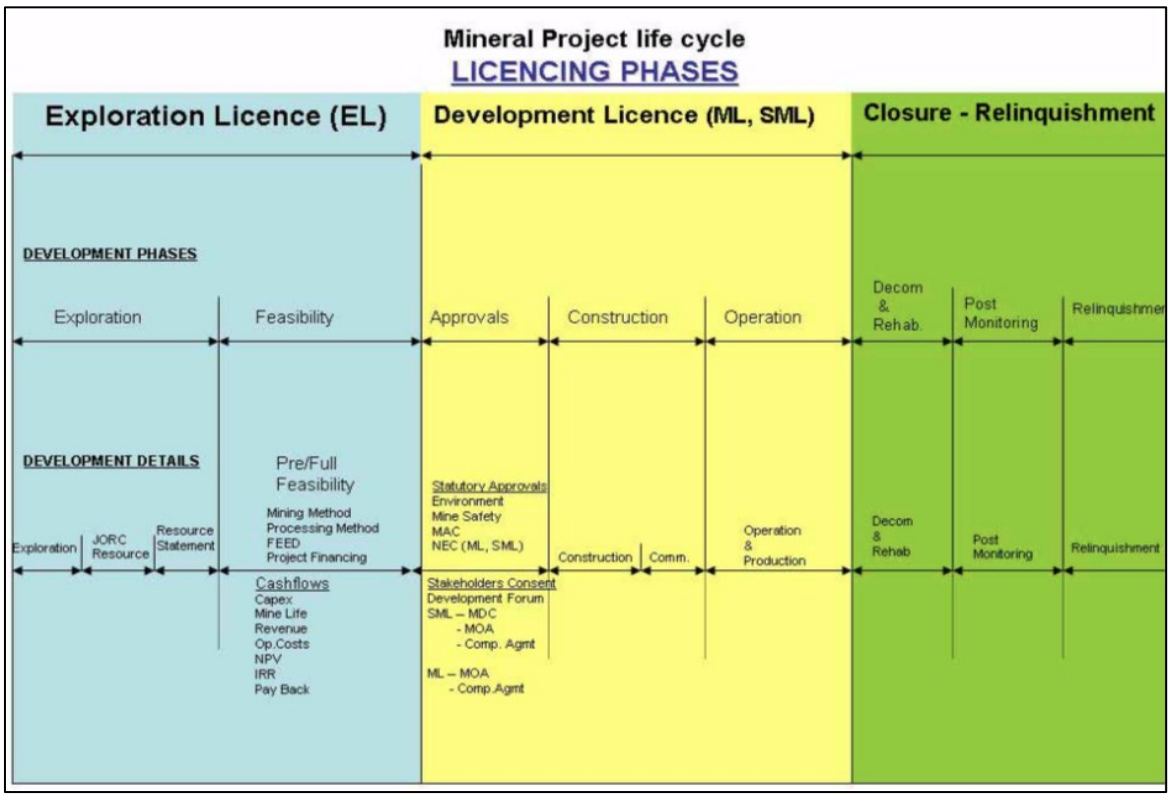


**Figure 8: The licensing phases and process for the mineral exploration and development under PNG MRA (adapted from MRA, 2019).**

5.1.5 Geothermal Licensing Regime

The geothermal regulatory framework introduces the MRA Licensing Regime for geothermal resource exploration and development as follows:

Geothermal Resource Tenements:

a) Geothermal Exploration License (GEL).
b) Geothermal Mining Lease (GML).
c) Lease for Geothermal Mining Purpose (LGMP).
d) Geothermal Mining Easement (GME).

There are four licensing phases that establish the systematic processes from exploration to decommission of a power plant and rehabilitation that relates to the geothermal resource tenements.

5.1.6 Exploration Phase

According to the policy document, this relates to identification and characterization of geothermal systems. A GEL is an appropriate application when the applicant intends to undertake exploration studies in the geothermal block.

The applicant pursuing the GEL is required to provide the following key information:

a) Identification of the geothermal system and documentation and mapping of the geothermal manifestations. It is stipulated that where there is no adequate information available to document the characteristics of the convective geothermal system, the Geothermal Management Area is to be given a standard geothermal system in question for the application
b) Description of proposed exploration program including well drilling
c) Description of impact and mitigation of proposed exploration program

5.1.7 Production Management Phase

The policy document defines the production management phase as production, use and management of geothermal resources. This is the phase where geothermal resources are utilized and is similarly classified under the Special Mining Lease under normal Mining Act. This specifies the large-scale mining operations when it is generally issued to the Exploration License, in this case, GEL.

Furthermore, production management phase is divided into two sub-phases:

a) Management of Geothermal Systems – this is a reservoir modelling plan where details are required to be provided to consider the capacity and sustainable yield of the system. It is also required to present the modelling on how it promotes the efficient management and use of the geothermal system in consideration of the needs of present and future generations
b) System Management Plan – this is a special mining lease application in the context of the Mining Act 1992. Under the Geothermal Regulatory Framework, the consent application is related to GML. It specifically permits production of 6,000 tonnes per day or more of geothermal water.
c) Conceptual Decommissioning Power Plant – this is a stage where decommissioning of a Geothermal Power Plant and Rehabilitation is proposed. This Plan is required to be submitted as part of the GML.

The applicant pursuing the GML is required to provide the following key information:

a) Submission of a Draft System Management Plan
b) Identification of a geothermal system and documentation and mapping of the geothermal manifestations. It is stipulated that where there is no adequate information available to document the characteristics of the convective geothermal system, the Geothermal Management Area is to be given standard geothermal system in question for the application
c) Description of the proposed use and development of the geothermal system including steam field layout showing location of wells, pipelines, production and discharge strategy (reinjection/injection of geothermal water) and operational flexibility and adaptive management (subsequent or cascade uses).
d) Extent of Reservoir Modelling and Subsidence Modelling
e) Environment Mitigation Plan
f) It is provided that an approved GML should be reflected from the approved System Management Plan. Technically, a peer review panel is conducted prior to the issuance of the GML. This is to ensure that a geothermal system is managed in accordance with the System Management Plan and in addition to further review in accordance with the international standards

5.1.8 Bond

The policy document states that the bond is considered as one of the conditions in the GML. The bond applies to consented activity involving well drilling and a development of geothermal extracting 1,000 tonnes per day or more of geothermal water.

5.1.9 Regulatory Implementation Procedures

a) Geothermal Resource Tenement and Exploration Rights – gives the power through the policy document that mineral rights and geothermal tenements and exploration rights are vested with the independent state of Papua New Guinea. This also effects Institutional Resource Sector Planning to produce, generate and supply electricity and heat
b) Application for geothermal resource tenement and its licensing regime – this explains the application process for the exploration and production of geothermal resource and the issuance of geothermal resource tenements.
c) Geothermal resource agreement – the policy document stipulates that the state is pursuing the agreement on benefit sharing arrangements between all relevant stakeholders.
d) Fiscal Regime – applicable to the Mining Fiscal section under the Mining Act, the document states that the geothermal resource is subject to determination on applicable rates.
e) Royalties – as it is also applied to other commercial mining development in PNG, the policy document stipulates that subject to fiscal regime, the royalties should be paid to the State from production of geothermal energy at the rate to be determined by the state. The policy document states that the rate of the royalty should be determined prior to any commencement of geothermal development.
f) State's Participation – the policy document provides that subject to the project economics, the State may consider participating in the following matters: state equity option, landowner equity, non-customary landowners and carbon credits.
g) Clean Development Mechanism – the state, through its nominee, PPL Limited or the Office of Climate Change and Development may apply for and develop geothermal resource projects in promoting sustainable socioeconomic development for PNG through the Clean Development Mechanism.
h) Geothermal Resource Database and Information Management – the policy document gives power to the MRA mandate to obtain and retain comprehensive information on geothermal resources in PNG provided by the holders of Geothermal Resource Tenements. The comprehensive information includes detailed logs of strata penetrated via bore well drilling, results of geochemical and geophysical analysis, and the geological interpretation of the records on boreholes drilled and the results of the geochemical and geophysical analyses, maps, profiles and diagram charts.
i) Dispute Resolution – the policy document outlines listings of concerned parties that deal with various disputes.

**5.2 Part 2: Policy Handbook on Geothermal Regulatory Framework**

Part 2 describes the Mining Act 1992 and MRA Act 2005 and the geothermal tenements and explains the regulatory framework involving associated legislations and their regulations that have influence on exploration and utilization of geothermal energy in PNG.

5.2.1 Associated Acts and its Regulations

The section outlines the legislation and policies concerning geothermal exploration and development in PNG. The relevant legislations governing the mining and use of geothermal energy are:

a) Constitution of Independent State of PNG
b) Mining Act 1992
c) ENV Act 2000
d) Land Act 1996
e) Mining Safety Act 1977
f) Electricity Supply Act 1970
g) MRA Act 2005

The policies that support and promote the realization and establishment of geothermal resource in PNG are:

a) Mineral Policy
b) National Goals and Directive Principles
c) Medium Term Development Plan 2011-2015
d) Development Strategic Plan 2010-2030
e) PNG Vision 2050

5.2.2 International Legal Framework

It is stated that the GRP is consistent with the United Nations framework convention on climate change and Kyoto protocol.

5.2.3 Institutional Governance

This section outlines the responsibility of the relevant institutions in the overall management of the policy. Each agency has specific planning, implementation and monitoring of the policy as follows:

a) DPMGM – PNG Department under the Ministry of Mining is responsible for policy formulation, planning and international coordination in mining matters. It is responsible for this GRP.
b) MRA – PNG Statutory Authority i.e. mining regulator operated under Mineral Resources Act 2005 and in pursuant to Mining Act 1992. It is the main regulator of geothermal exploration and development in PNG.
c) CEPA – PNG Department under the Ministry of Environment is responsible for regulation of environment impacts and environment permits in accordance with the ENV Act and in accordance with Environment Prescribed Activities Regulation.
d) CCDA – PNG State Authority under the Ministry of Environment that is responsible for coordination of geothermal resources under Clean Development Mechanism and carbon trade.

e) ICCC – PNG State Authority under the Ministry of Treasury and Finance is responsible for regulating prices, service standards and business/trade negotiations in disputes on access codes and access arrangements for generation, transmission and retailing of electricity.
f) PPL – PNG state-owned electricity utility is responsible for formulating the power plan from geothermal resources and for the supply of heat and electricity for domestic, commercial and industrial usage, consumption and development.
g) Water PNG – PNG state-owned water utility is responsible for supply of piped hot water extracted from the geothermal resource for domestic, commercial and industrial uses.
h) DPE – PNG Department under the Ministry of Petroleum and Energy is responsible for energy supply and security and energy policy and planning from geothermal resources for domestic, commercial and industrial needs.

## 6. THE SETTING & DEVELOPMENT OF PNG GEOTHERMAL ENERGY - POLICY & REGULATION: SITUATIONAL ANALYSIS

Lack of a policy framework continues to be a key barrier to geothermal development in Papua New Guinea since 2010. In a period of 10 years, several efforts were intended to review the draft Geothermal Policy for Papua New Guinea. Lack of regulatory framework still supresses the growth of geothermal development and until the government intervenes to realize the great potential in geothermal resources. PNG has a potential to harness more than 1,000 MW from geothermal energy due to the potential geothermal systems that are active. There are initial barriers identified as existing weaknesses in the draft GRP.

### 6.1 Volcanic and Geothermal System

PNG geothermal system is in steep terrain. Talasea Geothermal Field which is selected as one of the potential power productions under PNG PNGNEP2017-2027, is presumed to be a geothermal system in high-relief volcanic terrain is characterised by shallow igneous intrusion. Geothermal manifestations are even in most parts of PNG with similar geothermal system where vapour zones are common and the upflow is characterised by fumarolic and steam-heated type manifestations. In addition, primary chloride-type reservoir fluid may not reach the surface given that the long outflow structure compared to TVZ with small outflow structure which is easy to explore. The utilization of geothermal energy is non-existent in PNG except for Lihir Geothermal Power Plant in New Ireland Province. In this instance geothermal power production helps to boost the mine and processing production. Furthermore, geothermal utilisation at Lihir helps to combat CO2 emissions and thus contributes to the world´s effort in reducing the greenhouse effects caused by high consumption of fossil fuels. According to Lihir Gold Mine Ltd (2009), the utilization of the geothermal power plant has resulted in the reduction of 280,000 tonnes of greenhouse gas emissions per annum. Geothermal utilisation provides the impetus for a huge reduction in greenhouse gas emissions from major industries.

The demand for electricity in PNG has witnessed an upward trend since the 2011 due to accelerated economic growth but this is less than 2,000 MWh (ICCC, 2013). The major drivers of the demand are not only from economic activities in several zones, but also the national attention on a rural electrification programme to enable a move from 13% of the national populations access to electricity to targeting more than 50% in 2030. In addition, resource extraction and secondary industries have large electricity requirements to support the industrialization in PNG and many are not connected to power via PPL Limited's electricity grid system. PNG is yet operate on an interconnected national power grid. This is a critical challenge for the country as it aims to accommodate the electricity demand in energy intensive activities such as mining, infrastructure development, new LNG facilities, commercial and residential building construction and many other activities in the short to medium term. According to the PNGNEP2017-2027, it is projected that estimated demand will require more than 700 MW to accommodate electricity access for energy intensive activities in PNG. This is accommodate future commercial mining including Wafi-Golpu Mine Operation (200 MW), Freida River Mine Project (200 MW), Hidden Valley Mine Operation (20 MW), Ramu Nickel Mine Operation (85 MW), Yandara Gold Mine Project (135 MW) and several existing and upcoming major economic activities requiring power demand of more than 100 MW. It is for this reason that PNGNEP identifies four geothermal sites, as key generation projects under the PNGNEP to be initiated: TGF (>1000 MW), RGF (<500MW), LGPP (80MW) and DGF (<100 MW).

### 6.2 Barriers and Challenges in Planning Policy initiatives pertaining to Geothermal Energy

In comparison, the NV2050 asserts that by the year 2050, PNG will be 100% powered by renewable energy sources. However, the backdrop of the respective policies has not progressed thus far, and PNG is at the crossroads in its' urgency to promote indigenous resources such as geothermal sources to sustain not only the economic growth but also to stimulate the environmental, socially economic inclusiveness in the energy sector. The geothermal development process will require a lengthy progression to realise the full utilization of geothermal energy. There is no electricity industry policy put in place to promote the competition within the electricity industry in Papua New Guinea. Furthermore, Renewable Energy Policy and Rural Electrification in PNG which is being funded by the WB is progressing, which will complement the adoption of the PNGNEP2017-2027. The PNGNEP is possible to achieve without having renewable energy policy and or rural electrification established. The PNGNEP allows the competition of electricity industry participants however, the ICCC Act 2002 favours the regulation of state-owned monopolies such as PPL in managing 3 segments: generation, transmission and retailing of electricity.

The draft PNG Geothermal Energy Policy undertaken by the DPMGM with the support from the New Zealand Aid's Technical Assistance has not been successful. Certain issues have been raised in relation to bureaucratic and administrative implications in the policy formulation. The draft geothermal energy policy has provided an appropriate framework for the usage and regulation of geothermal resources however, complications have arisen in its' application to electricity generation from heat and steam. This is because the DPE strongly advocated the definition of the resources to fall, as under energy (heat) resource within its own jurisdiction. The policy aims to expedite the geothermal energy utilization by accommodating existing licensing regime in a similar manner under the Mining Act 1992 and MRA Regulation 2012 that deals with mineral exploration and the commercialisation of mining. Different countries have different policy and regulatory frameworks on the definition of geothermal energy resources. PNG is yet to fully define its meaning of the geothermal energy in its' legislation.

Moreover, the current backdrop of existing energy-related settings in PNG is from PPL Limited's Least Cost Development Plan. This Plan impedes the backdrop of the respective policies at the national level including the NV2050, PNGNEP2017-2027, upcoming Renewable Energy Policy, National Compatible Climate Change and Management Policy 2014. It logically omits other indigenous energy as fuel sources from participating in the power generation and other direct uses from this energy source. This means the electricity supply industry favours the hydro power and LNG gas to convert into electrical energy. Geothermal energy is not considered as a least cost energy resource, as PPL intends to concentrate on hydro power resources. This may complicate competition in the industry in the generation of electricity as well as in the commercial functions. Therefore, it remains a barrier to geothermal exploration and development, as this requires assurance and security from international funding donors and from potential geothermal investors to progress. Nevertheless, the national transmission infrastructure is not adequately put in place to accommodate the future system failures of electricity generation from geothermal plants. As alluded to earlier PNG is currently not operating on an interconnected national power grid. PNG operates on islanded electricity networks mostly around the populated areas and industrial sites.

### 6.3 Geothermal Risk Mitigations for PNG

The PNGNEP affirms the challenges of the exploration and utilization of the geothermal energy and develops the strategies to mitigate the geothermal risks. Out of 11 strategies identified, the most important mitigations to the main barriers for the geothermal development are:

1. The specific details of the Geothermal Energy Policy to be developed by NEA
2. The specific legislation to regulate Geothermal Resource to be developed by the NEA
3. The Geothermal Energy Policy shall streamline licensing and allocations of geothermal.
4. Undertake further geothermal resource assessments to determine additional economically viable geothermal resources
5. Increase Government allocation of funds for geothermal policy development and program

The other strategies provided for under PNGNEP are mitigation to the secondary barriers. Secondary barriers become feasible once the primary barriers as highlighted above are addressed. Fortunately, MRA has undertaken geothermal studies in four potential geothermal areas; Talasea, Fergusson Island, Karkar Island and Rabaul. Such exploration programs help to evaluate the quantities of the geothermal reservoir as well as developing the conceptual model of the geothermal system. Geothermal studies undertaken by MRA requires significant funding to develop the exploration drilling programs.

#### 6.3.1 Geothermal Energy Policy in correspondence to the National Energy Policy

The Geothermal Energy Policy to be developed by the NEA will address the national implications to progress the effective geothermal regulatory framework as well as bureaucratic bottlenecks. Significant milestones in GRP which was done with the support from the New Zealand Technical Assistance was technically not successful due to legal issues from the Office of State Solicitor and the NEC over the definition of geothermal resources. Political decisions also inhibited the progress under the MRA. The formation of Geothermal Working Group in PNG established in 2017 was way forward to establish coordination and collaboration between relevant government departments and other industry stakeholders associated with the geothermal business case. However, the slow bureaucratic process and the lack of inhouse technical capacities remain as impediments. For instance, PPL, DPE and MRA have been unable to reach consensus on the direction of the GRP to progress the advancement of geothermal energy.

#### 6.3.2 Geothermal Laws and Regulation and the Definition and Classification of the Geothermal Resources Energy.

As explained above, the definition of the geothermal resource needs to be simplified and reflected in the current backdrop in PNG. Currently the PNGNEP is endorsed at the ministerial level following a national-wide and inter-governmental consultation. This should culminate in the definition of the geothermal resource in the context of the PNGNEP and the pending Renewable Energy Policy. However, it will not eventuate on time until the NEA is formed, which is to be the responsibility body for dealing with energy resources, regulations and the rules related to energy in Papua New Guinea.

Following the endorsement of the PNGNEP in 2017 the NEA and the Energy Regulatory Commission (ENERCOM) and Community Service Obligation (CSO) Company will be restructured as proposed institutions to implement the Energy Policy. Accordingly, the NEA will be responsible for generation, importation, exportation, transmission, distribution, supply and use of electrical energy from both renewable resources and non-renewable resources. They will also undertake tasks including overseeing the implementation of the rural electrification program. This program will be financially supported by the US$1.3 billion-Papua New Guinea Electrification Partnership (APEC 2018 Multi-Bilateral Electrification Support Program). Simultaneously, GRP will be accommodated in the overarching PNGNEP by the strengthening of the regulatory framework and by incorporating into NEA and Geothermal Development Corporation (GEODEVCO). It is thus the intention of the PNGNEP to pursue the unbundling of PPL Limited whereby allowing for competition. This will result in the setting up of special state-owned energy resource company, Kumul Power Ltd and the subsidiary companies and specialized entities i.e. GEODEVCO to play specific roles in developing energy expansion in the country. In this context, this is following the current practice of the PNG Government in unbundling its other state-owned enterprises such as telecommunication to allow for competition. This will then become the jurisdiction of Ministry of Energy hence the geothermal resources become an energy resource. The establishment of the GEODEVCO in PNG will be the missing link to accelerate the development of geothermal resources in Papua New Guinea. This will then become a solution to secondary stage of barriers, as alluded to earlier, to developing steam fields and selling geothermal steam for electricity generation. Financing the geothermal risks associated with geothermal exploration and drilling will be efficiently managed by the proposed GEODEVCO. The formal collaboration between NEA and GEODEVCO necessitates the need for national resource data for geothermal and appraisal of geothermal energy potential in PNG.

PNG attempted to push a Geothermal Law Bill in 2011 to provide for a regulatory framework enabling the exploration and development of geothermal resources. The bill was not successful. Under the proposed bill, geothermal energy resource was

defined as “a source or accumulation of heat in a geological structure below the surface of the earth or the sea floor in the Offshore Area”. This classification defined the geothermal resource as heat energy in the form of heat or associated energy found in geothermal formations, but it did not include the water content in its definition nor the renewable energy embracing the geothermal processes including steam, hot water and hot brines. Nevertheless, the inclusion of offshore area in its definition under the bill was consistent with its geothermal resource in high-temperature system.

Nevertheless, the Geothermal Energy Act 2011 Bill needs to be revisited and strengthened to reflect the PNGNEP and the pending the Renewable Energy Policy.

### 6.3.4 Climate Change Mitigation Program

In PNG, Climate Change Development Authority (CCDA) recognizes the utilization of geothermal resource as a use of renewable energy (RE) mainly to reduce GHG emissions. Hence, CCDA as the National Designated Authority (NDA) for the various climate change-international funding facilities in PNG has been encouraging geothermal utilization. Through CCDA, Green Climate Funding (GCF) and Global Environment Facility (GEF) have provided funding support to several geothermal producing countries to accelerate geothermal exploration and drilling programmes. Importantly, financing geothermal exploration and development is very risky for PNG Government hence, participating and seeking support from international finance institutions under climate change-related programmes can be used as an avenue to address most of the geothermal barriers in PNG.

PNG stands to benefit from low emission programmes by promoting geothermal energy resources where PNG could access GCF resources for projects and programmes through existing international Accredited Entities (AEs) like UNDP, WB, ADB, IUCN or even through Direct Access. It is encouraged for proposals to be submitted despite the nonexistence of regulatory frameworks, particularly through utilising technology, toward achieving PNG National Visions (carbon neutral by 2050 as per PNG Vision 2015). CCDA is the sole National Designated Authority that can issue a "No objection" letter indicating that the any proposal in relation to geothermal energy project is in order, which then can be submitted to GCF Board. Therefore, based on this, it is highly recommended that proposals that come under legislations already in place have the upper hand in moving forward. This emphasises the endorsement of the PNGNEP which should be used as an occasion to establish the law as well as the NEA or PNG GEODEVCO. It is encouraged to pursue this proposal in relation to strengthening of legal and regulatory framework, additionally in line with the development of geothermal drilling that have been targeted with major input from the PNG MRA with preliminary geothermal studies. In addition, the only Geothermal Power Plant in PNG, Lihir is part of the Clean Development Mechanism which is a voluntary arrangement made by Lihir under the CDM. However, it is not regulated under CCDA which has not been kept in the loop with the arrangements.

### 6.3.5 Licensing and Allocation of Geothermal Projects

In PNG under the Mining Act 1992, an exploration licence is required from the MRA for any drilling program which geothermal may fall under. The environment permit is required under the ENV Act and is required for any drilling program with a depth of more than 2,500 metres. Neither geothermal projects nor any other activities concerning geothermal resource energy are defined in the ENV Act, for instance exploration to quantify geothermal resources or evaluation of the feasibility of large-scale geothermal production. The ICCC in PNG is responsible for electricity generation, transmission and distribution licences under the Electricity Industry Act. Under ICCC regulation, PPL Limited is the exclusive licence holder to supply electricity throughout the country in order to generate, transmit, distribute and sell electricity. The PPL exploits both hydro-energy resources for the operation of hydroelectric plant, and the operation of fuel burning power stations to supply electricity.

The PPL through ICCC regulation regulates the energy sector that issues approval for mix of energy into power production. It is also the same entity in PNG that establishes electricity tariffs and controls prices.

### 6.3.6 Regulation of Environmental Impacts

The EIA process is different in the two countries, where PNG does not have specific EIA legislation. Nevertheless, the environment regulatory framework in PNG is regulated under the ENV Act (Department of Environment and Conservation, 2000). It is this Act that provides the mechanisms for dealing with activities with potential for causing environmental harm. The ENV Act is PNG´s only legislation that provides the administrative mechanism for environmental impact assessment and evaluation of activities, regulating impacts on the environment through an environment approval and permitting system. However, neither geothermal projects nor any other activities concerning geothermal energy are defined in the Environment (Prescribed Activities) Regulation 2002 under the ENV Act for the purpose of undertaking exploration to quantify geothermal resources and to evaluate the feasibility of large-scale geothermal production. Environment (Prescribed Activities) Regulation 2002 is one of regulations under the ENV Act that categories the activity to be Level 1, Level 2 (Category A or Category B) or Level 3 activities.

Geothermal activity may be classified into Level 1, Level 2 or Level 3 activity. Generally, the environment regulatory framework determines criteria for geothermal project in the three-tier process that is potentially able to cause environment harm. Geothermal activities may fall into the following prescribed categories but their categorisation is not distinctively defined:

1. Level 2 Category A Activities
    - Sub-category 2.1 of Mineral Exploration – Any drilling program at a defined prospect where the aggregate depth of all holes is greater than 2,500 metres.
    - Sub-category 13.2 of Other Activities – Discharge of waste into water or onto land in such a way that it results in the waste entering water
2. Level 2 Category B Activities
    - Sub-category 12.6 of Infrastructure – Construction of electricity transmission lines or pipelines greater than 10 km in length
3. Level 3 Activities

- Sub-category 14 of General –Activities involving investment of a capital cost of more than K50 million, except where such investment is made in pursuing an activity otherwise dealt with in this Regulation in which case that category of activity will apply to the investment.
- Sub-category 14 of General – Activities that may result in a significant risk of serious or material environmental harm within WMAs, Conservation Areas, National Parks and Protected Areas or any area declared to be protected under the provisions of an International Treaty to which Papua New Guinea is a party and which has been ratified by the Parliament of the Independent State of Papua New Guinea.

The Level 3 category is where the full EIA process comes in. The consultation between the applicant (developer) and the CEPA including other relevant bodies is essential and should take place before an application is formally lodged. Permit applications from Level 3 activities for which an Approval in Principle has to be issued by the Minister are exempted from the notification and referral requirements under the permit assessment process (Department of Environment and Conservation, 2000). The Minister for Environment and Conservation is mainly responsible for the issuance of an Approval in Principle to a Level 3 geothermal activity before an Environment Permit can be obtained.

Technically, the ENV Act defines the water resources as all water in the country including river, reservoir, well, bore, surface and underground water and other waters including the seabed and subsoil underlying those waters. This specifies the significance of geothermal water associated with extraction activities including the diversion of groundwater. These are primary activities confined within the ENV Act in relation to geothermal resources. In addition, waste discharges are similar consented activity within the current environment legislation that relates not only to discharge of wastewater to water courses but also the discharge of separated geothermal water via reinjection wells and the geothermal water to the water sources.

The extraction and discharge rates are also regulated under the ENV Act and its regulation on waste discharge permit and water extraction permit. The permits provide the conditions for both extraction and discharge limit when undertaking consented activities.

### 6.3.7 Licensing and Allocation of Geothermal Projects

The PNGNEP affirms the challenges in timeframe of geothermal projects with relatively long lead time between 5-7 years from conception to production of electricity. It is similar to oil and gas exploration in the context of PNG resource extraction development. It is normally imposed that geothermal projects typically progress through stages of reconnaissance, surface exploration, feasibility study, exploratory drilling, appraisal drilling, production drilling, steam field development and power construction stages which normally involve high upfront investment costs. In contrast, schedules for most geothermal producing countries, for example New Zealand and Iceland, for the overall legal, regulatory and permitting timeframe is varied between 3-7 years as summarised below:

- ESIA and Permitting - 12 months
- Land acquisition - 6 months
- Well pad construction - 1-2 months
- Drilling items (wellheads, casing) - 6 -12 months
- Procurement - 8 months
- Drilling - 3 months
- Power Plants - 24 months

## 7. SUMMARY AND CONCLUSIONS

The success in the preparation and development of geothermal projects depends on the implementation of regulatory framework interconnecting the legal definition of geothermal resources, resource management and development of a coordinating body to implement regulatory framework. It also requires gathering of correct baseline data and background information to understand the geothermal system that will be crucial for the sustainable geothermal resource management.

The regulatory institutions play an important role in coordinating the preparation and development of geothermal projects and ensuring that legal requirements are satisfactorily met. The institutions in PNG must efficiently manage the geothermal resource management in the sustainable development since the geothermal features in PNG are viewed as insignificant despite the aggressive push for geothermal energy utilization as a renewable energy under national energy policy. Furthermore, PNG GRP does not consider the sustainable geothermal resource management in its fullest context. Preliminary classification of geothermal resources is needed to safeguard the significant geothermal features and to avoid issues surrounding volcanic hazards, mainly from volcanic eruptions that are ongoing in PNG. Although classification of geothermal system is inadequately undertaken throughout PNG, current geothermal studies undertaken by PNG MRA should be fully funded to produce the correct baseline data for geothermal systems and quantify the heat sources in geothermal reservoirs.

Whilst the MRA has an existing mineral regulatory regime concerning exploration and mining development, it may not be formally prepared to regulate geothermal energy resources especially when the PNGNEP is more advantageous to close the gap of mineral exploration and the extraction of geothermal steam for power production and other direct uses. This gives the appropriate entity responsible, the NEA, legitimacy for expanding and managing energy resources. This in turn, upturns the core responsibility above PPL. This is deemed appropriate, considering, PPL's Least Cost Development Plan is unfair and deprives the usage and opportunity for other indigenous energy resources such as geothermal resources.

Nevertheless, geothermal development is not ready to be implemented as there are outstanding policy and regulatory barriers to be removed. It is a general conclusion of this study that PNG can, and should, improve its legislation and regulatory framework to be better prepared to utilise the geothermal resources in the country in a sustainable manner. The utilisation of geothermal resources in

PNG has potential to increase the well-being of the people of PNG in the future but must be well prepared with effective cooperation from all stakeholders.

## 8. RECOMMENDATION

There are key recommendations from this situational analysis. Firstly, a road map for a Geothermal Regulatory Framework. The road map is needed to start exploring a geothermal system to identify potential geothermal sites. A clear policy is an essential part of the roadmap for the geothermal development and utilisation in PNG. Hence, the National Energy Authority (NEA) is the right pathway to enable the development of geothermal regulatory framework in the country.

Secondly the classification of geothermal activity into the Environment Act. It is necessary to incorporate geothermal activity into the existing legislation so as to allow geothermal exploration and development in line with relevant legislation. Although a geothermal resource is a renewable resource, it must undergo EIA as all development projects concerning exploration and utilisation must undergo EIA to ensure sustainable resource management.

A third recommendation is the development of Environment Policy specifically on geothermal resources. – This is the case in reference to the protection of the significant geothermal features in the country and the management of the geothermal resources for the extraction of the components of the geothermal energy mainly the geothermal steam and water, and the discharge of geothermal water into the environment.

Moreover, support should be sought from WB and specifically the New Zealand, United States of America, Japan, Indonesia and Philippines in the Asia-Pacific region. PNG needs financial support to push for geothermal exploration and development. Additional funding for a geothermal regulatory framework and for exploration and drilling programmes are needed.

High temperature geothermal system areas are valuable resource in their natural stage. Hence a final recommendation is that consideration must be given to the protection of important natural sites from development in PNG. Features like hot springs, volcanoes and geysers. Geo Tourism must be utilised as balance in the development of geothermal resources and be economically beneficial to the communities.

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