WORKING PAPER SERIES NO. 111-2016, AMETIS INSTITUTE

GEOTHERMAL RESOURCE CLASSIFICATIONS: CAN WE TALK THE SAME LANGUAGE?

Yuafrinaldi[1], Teuku Furqan[1], Jonathan Kartadjoemena[1], Reybi Waren[1]

[1]Ametis Institute, Tetra Pak Building, Jakarta, Indonesia

yrinaldi@ametis-institute.com

Keywords: *geothermal, resource, classification, inconsistency, terminology, homogenize, synchronize*

ABSTRACT

Raise in public awareness and understanding of geothermal energy and its environmental benefits have led to increase in electricity generated from geothermal energy. Increase of demand for clean energy requires the homogenize classification of resource and reporting requirements before geothermal resources are developed. Apparently, there is no universally recognised geothermal resource classification, and thus several countries have attempted to publish their own geothermal code. As a result, the terminology and methodology used at the code are different from one to another.

Inconsistency of terminology and its language in classifying geothermal resources would cause "confusion" for stakeholders as well as low confidence and interest in the development of geothermal energy. For that reason, equivalency of the language is necessary to build common understanding of the maturation level of geothermal resources from different areas. This paper provides an overview of four different established classifications which are Australian Geothermal Energy Association and Australian Geothermal Energy Group (AGEG) (AGEA & AGEG -2010), Geothermal Energy Association (GEA-2010), United Nation Framework Classification (UNFC-2009) and Indonesian National Standard (SNI-1998). In addition, terminology equivalent mapping has also been performed by considering main activities, and reporting requirements in each phase of geothermal resource classifications. Synchronized resource classifications have been obtained by classifying geothermal resources into two main categories (Discovered and Undiscovered) where the four classifications have been considered. Hopefully this synchronized language will bridge diverse languages in geothermal resource classification that we use today in order to accelerate the geothermal resources moving forward.

1. INTRODUCTION

Public perceptions of geothermal energy have increased significantly over the past few decades. Rising public awareness and understanding of geothermal energy and its environmental benefits is the main factor to the growth in electricity generation from geothermal energy. According to Geothermal Energy Association (GEA, 2016), as of January 2016 the global market operating capacity of geothermal energy is at about 13.3 GW and spread across 24 countries. Moreover, about 12.5 GW of planned capacity will have developed throughout 82 countries. The increasing demand for clean energy requires the homogenise classification of resource and reporting requirements before geothermal resources are developed and utilized. Apparently, there is no universally recognised of geothermal resource classification, and thus several countries have attempted to publish their own geothermal code. As a result, the terminology and methodology that are being used at the code are different from one to another.

A geothermal reporting code is one of the success factors for accelerating the development of geothermal industry. A geothermal reporting code, common in minerals and petroleum reporting codes, covers the way geothermal exploration results, resource and reserve assessments are classified and publicly reported (Yolanda, 2013). The geothermal resource classifications should be uniquely designed to be accepted by all investors considering geothermal energy becomes a global concern. A good resource classification would give strong investor's confidence and interest in the development of geothermal energy. On the other hand, it would cause *"confusion"* for investors as well as low confidence and interest in the development of geothermal energy. Hence, rapid growth in electricity generation from geothermal energy could be interrupted.

This paper provides an overview of four (4) different established resource classifications which includes Australian Geothermal Energy Association and Australian Geothermal Energy Group (AGEG) (AGEA & AGEG-2010), Geothermal Energy Association (GEA-2010), United Nation Framework Classification (UNFC-2009) and Indonesian National Standard (SNI-1998). Furthermore, terminology equivalent mapping has also been performed by considering main activities, and reporting requirements in each phase of geothermal resource classifications. Petroleum resource classifications system has been considered as guideline for levelling geothermal resource classifications. The synchronized, it is expected to bridge the differences in languages current geothermal resource classifications and stimulate the geothermal resources moving forward.

2. FUNDAMENTAL OF DATA ANALYSIS IN GEOTHERMAL RESOURCE CLASSIFICATION

Geothermal resource classification is a tool that can be used to convert the collected data into useful information. The

information then to be used during the tendering Geothermal Working Areas (GWA), is chiefly affected by the reporting code. For this reason, geothermal reporting code is an important element for resources classifications, and development of geothermal industry.

Quality of data will determine the project value. Development phase of any projects can be divided into value identification and value realization. Value identification has had a big influence on total value of the project. Assuming that good data quality, information and project definition at value identification, very-high success rate could be achieved if project execution is good or high success rate attained when project execution is poor. On the other hand, with poor data quality; moderate success rate is likely to be achieved even when project execution is good and especially low success rate if project execution is poor. In addition, with poor data quality; zero success rate is likely to be achieved if project execution performed badly during value realization. Therefore, data quality in identification of project opportunity shapes the level of project values.

3. REVIEW OF EXISTING GEOTHERMAL RESOURCE CLASSIFICATIONS

3.1 The Australian Geothermal Energy Association (AGEA) and the Australian Geothermal Energy Group (AGEG)

In 2008, the Australian Geothermal Reporting Code Committee (AGRCC) established "*Geothermal Lexicon for Resources and Reserves Definitions and Reporting"*. Two (2) years later, the committee revised the code with the goal of supplying a methodology for estimating, assessing, quantifying and reporting geothermal resources and reserves (Williams at al., 2010). Falcone at al., (2013) pointed out that the code has been designed based on the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code) together with its minimum and mandatory requirements for Public Reports. The code divided geothermal resources into inferred, indicated and measured. Whereas, geothermal reserves fallen into probable and proven reserve (AGRCC, 2010a). Resources and reserves classification and definitions are shown in Table 1.

As in Table 1, geothermal resources and reserves classifications are clearly established by AGRCC. The modifying factors, for instance energy recovery and conversions, economy, marketing, environmental, social, legal and regulatory factors, are the main components that distinguish between resource and reserve (AGRCC, 2010b).

3.2 The Geothermal Energy Association (GEA)

In 2010, the Geothermal Energy Association (GEA) published guidance that helping reporting and information organization of geothermal development in the USA which is called as *"New Geothermal Terms and Definitions"*. These guidelines based on classifying the resource type as well as identifying development criteria from each phases, and to be used when developers presenting information about geothermal resource development to GEA for public dissemination (Falcone et al., 2013). Phase of development, terms and definitions of geothermal resource classifications are shown in Table 2.

Table 2 demonstrates the terminology in classifying geothermal resources in the USA. The geothermal resources classifications are based mainly on development phase of project, where Phase I is Resource Procurement and Identification, Phase II equals Resource Exploration and Confirmation, Phase III is Permitting and Initial Development, and Phase IV equals Resource Production and Power Plant Construction (GEA, November 2010).

3.3 The United Nation Framework Classification (UNFC)

In 1992, The United Nation Framework Classification (UNFC) started development of resources and reserves classification system, and published *"Resources and reserves classification for solid fuels and mineral commodities in 1997."* In 2004, UNFC extended to cover oil, natural gas and uranium into classification system.

A decade later, the system was then mapped with Committee for Mineral Reserves International Reporting Standards (CRIRSCO Template) as well as Petroleum Resources Management System (PRMS) to ensure definition equivalence and uniformity. *"Resources and reserves classification for fossil energy and mineral comprising specifications for its application"* approved in late 2009 and released in 2010. The classification system used a numerical coding based on three (3) parameters, namely (E) Socio-economic viability, (F) Project feasibility, and (G) Geological knowledge (ECE, 2010). These parameters formed a three-dimensional (3D) system and each number (axis) represents its degree of favourability (Hot Dry Rocks, 2013). Explanations from each parameter and resources classification are shown in Table 3, and Table 4.

As in Table 4, the UNFC classifies quantities into three (3) categories, recovered and sold, recovered but not sold and will not be recovered. The term recovered amounts is being used when estimated qualities and values at the specific reference point. There is a potential implementation of geothermal resource classifications in the UNFC Framework (Segneri et al., 2013).

3.4 The Indonesian National Standard (SNI)

In 1998, Indonesia published Indonesian National Standard (SNI-13-5012) called as "*Classification of Geothermal Energy Potential in Indonesia"*. The standard is primarily based on solid fuels and mineral commodities published by UN ECE in 1996. In the following year, 1999, Indonesia released SNI-13-6171-1999 about "*Methodology for Estimating Geothermal Energy Potential"* and has been revised twice, which was in 2000 and 2004. The standard classifies geothermal resources into two (2) main classes, sumber daya (resources) and cadangan (reserves). The resources are then divided into spekulatif (speculative) and

hipotetis (hypothetic). Moreover, cadangan (reserves) are classified into terduga (contingent), mungkin (possible) and terbukti (proven) (BSN, 1998). Resources and reserves classification and definitions are shown in Table 5.

Table 5 shows Indonesian geothermal resources and reserves classifications. The five (5) common factors considered in pre-feasibility and/ feasibility study, includes technology and system, economic, legal, operational, and schedule, are indicated as important parameter to classify proven reserve.

4. GEOTHERMAL RESOURCE CLASSIFICATION IMPACTS ON GEOTHERMAL DEVELOPMENT AND INVESTMENT

Inconsistency of terminology and its language in classifying geothermal resources would cause "confusion" for stakeholders as well as low confidence and interest in the development of geothermal energy. Incomprehensive geothermal resource classification caused difficulty for Finance Institutions to give support on the development of geothermal industry if the probability of existence geothermal resources is still very low.

Geothermal resource estimation and classification have influenced on concession tender, Power Purchase Agreement (PPA), and capacity development for power plant. Thus, lack of bankable geothermal resource hinders the success of development geothermal energy. For that reason, equivalency of the language is necessary to build a common-understanding of the maturation level of geothermal resources classifications from different areas.

5. SYNCHRONIZED GEOTHERMAL RESOURCES TERMINOLOGY AND CLASSIFICATION

The diversity of viewpoints and definitions in four (4) geothermal resource classifications has been previously discussed; however, the terminology and its language used were neither inconsistent nor equally balanced. Many classifications considered geothermal similar with developing solid mineral (such as coal) and petroleum resources; however, we see that the classification of geothermal resources is more similar to petroleum than to mineral in term of resources exploration and confirmation method, and energy extraction. Therefore, we use the petroleum resource classification system as a guideline to level geothermal resource classifications through a detailed analysis of each activity and reporting requirements and thus, the classification system can be mapped and simplified. Table 6 shows equivalence mapping performed by considering main activities, and reporting requirements in each phase of geothermal resource classifications.

As in Table 6, the main activities and required parameters from four (4) established reporting codes are put in place together to identify similarity in activities and/ or confidence levels. Similar resource classifications are then grouped together in one (1) color.

For instance, inferred resource in AGEA, possible resource in GEA, exploration project in UNFC and the speculative, the hypothetic resources as well as the contingent reserve in SNI are classified into one group, called *Undiscovered Resource*. Undiscovered resource is applied when the total amounts of heat energy can be estimated to be retrievable from accumulations remain to be discovered since the resources are not yet drilled (Modified from CCOP, 1999). In this category, however, geological, geochemical and geophysical data are well-identified. Therefore, if an exploration well has not yet placed in a prospect resource, the term discovery should not be used because a probability of existence is still very low.

However, there must be at least one (1) full-size discovery or slim hole well drilled in a prospect resource, to move the resource status from undiscovered to discovered resources. Testing, sampling, or logging activities are performed when the exploration well is drilled. In this category, discovered resources are divided into *Potential resources* and *Reserves*. Moreover, reserves are classified for *Unproved* and *Proved reserves*.

A potential resource is delimited as discovered resources where the quantities of retrievable thermal energy can be estimated with a moderate / high confidence level due to explorations wells have been drilled (Modified from CCOP, 1999). At this stage, the resources are not expected to become economically viable. Inferred and measured resources in AGEA, possible resource in GEA, non-commercial projects and its additional in place in UNFC, and possible reserve in SNI are classified into *Potential Resources*. In general, resource classifications mentioned are equally balanced, furthermore, in SNI the possible reserve has undergone further requirement which is the pre-feasibility study. The pre-feasibility study is acting as an early stage of evaluation to determine economic viability even though quantities of thermal energy cannot be predicted with a high degree of assurance.

Reserves are expected amounts of thermal energy that could be commercially recovered from known accumulations of a given date forward (Modified from CCOP, 1999). Reliable geologic and engineering data at estimation reserves have had much influence on uncertainty level; consequently, reserves are sub-divided into unproved and proved reserve. Unproved and proved reserves used similar geologic and/ or engineering data; however, the technical, economic, and regulatory or contractual uncertainties have a slight difference.

Probable reserve in AGEA, delineated resource in GEA, and potentially commercial projects in UNFC are classified as *Unproved Reserves*. This class is less certain to be recovered than *Proved Reserves*. And yet, possible reserve in SNI is excluded from this category because it still did not have sufficient information about reservoir characterization and suitability. The possible reserve has exploration well (wildcat) drilled, but no delineation wells have been drilled. It is believed that pre-feasibility study performed in this classification would not yield a positive output because of high technical (geologic) uncertainty. Therefore, the quantities of heat energy could not be projected with a high assurance level.

Proved reserve in AGEA, confirmed resource in GEA, the commercial project in UNFC, and proven reserve in SNI are classified as proved reserves. Having in mind, this category has equal activities and reporting requirements, where thermal energy can be predicted with a low level of uncertainty to be commercially recovered with reasonable confidence.

6. CONCLUSION

By considering main activities and reporting requirements in each phase of geothermal resource classifications, misnomer geothermal resource classifications have been mapped and identified. To help solve this issue, petroleum resource classification system is used as a guideline to synchronize unsuitable terminology in geothermal resources classification.

This study classifies geothermal resources into two main categories, undiscovered and discovered (potential resource, unproved and proved reserve). *Undiscovered* includes inferred resource in AGEA, possible resource in GEA, exploration project in UNFC and the speculative, the hypothetic resources as well as the contingent reserve in SNI. However *potential resources*, a part of discovered, are consist of inferred and measured resources in AGEA & AGEG, possible resource in GEA, non-commercial projects and it's additional in place in UNFC, and possible reserve in SNI. Probable reserve in AGEA, delineated resource in GEA, and potentially commercial projects in UNFC are classified as *unproved reserves*. And proved reserve in AGEA, confirmed resource in GEA, the commercial project in UNFC, and proven reserve in SNI are classified as *proved reserves*. The term reserve in the geothermal resource classification has no standard definition (misnomer) compared to petroleum resource classification system.

Hopefully, this synchronized language will bridge diverse languages in geothermal resource classification that we use today in order to accelerate the geothermal resources moving forward. In addition, the geothermal resource classification that has a lower confidence level should increase their minimum and mandatory requirements to give strong investor's confidence and interest in the development of geothermal energy.

ACKNOWLEDGEMENTS

The authors would like to thank Ametis Institute and staffs for their contribution in conducting the research and analysis, and helping to produce this paper.

REFERENCES

AGRCC. (2010a). *The Geothermal Reporting Code, Edition 2.* Adelaide: Australian Geothermal Reporting Code Committee.

AGRCC. (2010b). *Geothermal Lexicon for Resources and Reserves Definition and Reporting, Edition 2.* Adelaide: Australian Geothermal Reporting Code Committee.

BSN. (1998). *Klasifikasi Potensi Energi Panas Bumi di Indonesia.* Jakarta: Badan Standardisasi Nasional (BSN).

CCOP. (1999). *Petroleum Resource Classification System.* Bangkok - Thailand: Coordinating Committee for Coastal and Offshore Geoscience Programme in East and Southeast Asia.

ECE. (2010). *UN Framwork Classification for Fossil Energy and Mineral Reserves and Resources 2009.* New York and Geneva: Economic Commission for Europe - United Nations Publications .

Falcone, G., Gnoni, A., Harrison, B., & Alimonti, C. (2013). Classification and Reporting Requirements for Geothermal Resources. *European Geothermal Congress 2013, Pisa, Italy*.

GEA. (2016). *2016 Annual U.S & Global Geothermal Power Production Report.* Washinton D.C: Geothermal Energy Association.

GEA. (November 2010). *New Geothermal Terms and Definitions - A guide to Reporting Resource Development Progress and Results to the Geothermal Energy Association.* Washington D.C: Geothermal Energy Association.

Hot Dry Rocks. (2013). *Global Review of Geothermal Reporting Terminology.* Australia: Hot Dry Rocks Pty Ltd.

Segneri, B., Jenne, D., Young, K., Thorstensson, H., & Hass, E. (2013). Geothermal Codification Impacts on Geothermal Development and Investments. *The 38 Workshop on Geothermal Reservoir Eng. Stanford University.* California: U.S Department of Energy.

Williams, A., Lawless, J., Ward, M., Holgate, F., & Larking, A. (2010). A Code for Geothermal Resources and Reserves Reporting. *Proceedings World Geothermal Congress (WGC).* Bali: World Geothermal Congress (WGC).

Yolanda, L. (2013). *Code for Reporting Geothermal Resouces and Reserves*. Retrieved 8 10, 2016, from http://www.geothermal.statedevelopment.sa.gov.au/ageg/geothermal_reporting_code

Table 1: Resources and Reserves Classification and Definition Based on AGEA and AGEG (AGRCC, 2010)

Geothermal Resources			**Geothermal Reserves**	
Inferred	**Indicated**	**Measured**	**Probable**	**Proven**
The thermal energy has enough direct indicators of geothermal resource character or dimensions to provide a sound basis for assuming that a body of thermal energy exists, estimating temperature and having some indication of extent.	The thermal energy has more faithfully characterized volume of rock than the inferred geothermal resource, sufficient indicators to characterize temperature and chemistry, while few direct measures indicating extent.	The thermal energy within a drilled and tested volume of rock, which well deliverability has been demonstrated, with sufficient indicators to characterize temperature and chemistry and with sufficient direct measurements to confirm the continuity of the reservoir.	That part of an indicated geothermal resource for which commercial production for the assumed lifetime of the project can be forecast, or: that part of a measured geothermal resource which commercial production for the assumed lifetime of the project cannot be forecast with sufficient confidence to be considered a proven geothermal reserve.	Applies directly to production satisfying all Modifying Factors. Directly related to that part of a measured geothermal resource for which commercial production for the stated lifetime of the project can be forecast with a high degree of confidence.

Table 2: Phase of Development and Resource Terminology Based on GEA (GEA, 2010)

Phase I	**Phase II**	**Phase III**	**Phase IV**
Resource Procurement and Identification	Resource Exploration and Confirmation	Permitting and Initial Development	Resource Production and Power Plant Construction
Possible Resource Estimate	Possible Resource Estimate	Delineated Resource Estimate	Confirmed Resource Estimate
Possible Resource is geothermal project that known characteristics which lead the developer to conceive with appropriate confidence level, potential economic utilization could be achieved if further investigation carried on. **Installed Capacity:** A part of the possible resource that could be viable to develop and produce electricity economically under current economic and operational conditions.	Possible Resource is geothermal project that known characteristics which lead the developer to conceive with appropriate confidence level, potential economic utilization could be achieved if further investigation carried on. **Installed Capacity:** A part of the possible resource that could be feasible to develop and produce electricity economically under existing economic and operational conditions.	A Delineated Resource is a geothermal project that has undergone exploration testing and drilling to the extent needed to construct an accurate characterization of the geothermal reservoir as well as to give an accurate estimation of total recoverable energy. **Installed Capacity:** A part of delineated resource that could be executable to develop and produce electricity economically under current economic and operational conditions.	A Confirmed Resource is a geothermal project that has undergone extensive exploration testing and drilling so as to construct, with a high degree of confidence, an accurate characterization of the geothermal reservoir as well as to give an accurate estimation of total recoverable commercial energy. **Installed Capacity:** A part of confirmed resource that could be viable to develop and produce electricity economically under existing economic and operational conditions.

Table 3: Definitions of 3 Parameters in Resource Classification Based on UNFC (UNECE, 2009)

Parameters	Definition extraction
E1	Production and sales have been confirmed to be economically feasible
E2	Production and sales are expected to become economically viable in the near future
E3	Production and sales are not expected to become economically viable in the near future or the assessment is too early a stage to determine economic viability
F1	Feasibility of production for a defined development project has been confirmed
F2	Feasibility of production for a defined development project is subject to further evaluation.
F3	Feasibility of production for a defined development project cannot be evaluated due to limited technical data.
F4	No development project has been recognized.
G1	The quantity associated with the known deposit can be estimated with a high degree of confidence
G2	The quantity associated with the known deposit can be estimated with a moderate level of confidence.
G3	The quantity associated with the known deposit can be estimated with a low level of confidence.
G4	Quantity estimation associated with potential deposits that are primarily based on indirect evidence.

Table 4: Resource Classifications and Numerical Coding Based on UNFC (UNECE, 2009)

Potential Deposit		**Known Deposit**			
Additional Quantities in Place	**Exploration Projects**	**Additional Quantities in Place**	**Non-Commercial Project**	**Potentially Commercial Project**	**Commercial Project**
E3, F4, G4	E3, F3, G4	E3, F4, (G1, G2, G3)	E3, F2, (G1, G2, G3)	E2, F2, (G1, G2, G3)	E1, F1, (G1, G2, G3)

Table 5: Resources and Reserves Classification, and Definition Based on SNI (BSN, 1998)

Geothermal Resources		**Geothermal Reserves**		
Speculative	**Hypothetic**	**Contingent**	**Possible**	**Proven**
Speculative resources are resources that estimate the thermal potential energy based on a literature review and preliminary investigation.	Hypothetical resources are resources that estimate the thermal potential energy based on the results of the preliminary investigation continued (3G).	Contingent reserves are reserves that estimate the thermal potential energy based on the results of a detailed investigation (3G).	Possible reserves are reserves that estimate the thermal potential energy based on the results of a detailed investigation and have been identified by exploration drill (wildcat) and the results of pre-feasibility study.	Proven reserves are reserves that estimate the thermal potential energy reserves based on the results of a detailed investigation, tested with exploratory wells, delineation and development as well as a feasibility study.

Table 6: Geothermal Resource Classification Mapping

AGEA & AGEG - 2010 Classification	GEA - 2010 Classification	UNFC - 2009 Classification	SNI - 1998 Classification
Proved - Reserve	**Confirmed Resource**	**Commercial Projects**	**Proven - Reserve**
Investigations: * Literature study complete * 3G study (geological, geochemical, geophysical) * Indirect & direct measurements, rock & fluid assesments (reservoir temp, volume, and well deleverability) * Drill exploration and delineation wells (welltest) * **Modifying factors** (energy recovery & conventions, economic, marketing, environmental, social, legal, and regulatory) * Well deliverability has been demonstrated, and commercial production for assumed lifetime of project can be forecasted with a high level of assurance	**Geothermal phase developments:** * **Resources** (plant equipment/construction underway, production/injection drilling underway) * **Transmission** (interconnection agreement signed) * **External** (plant permits approved, PPA secured, EPC contract signed) * The parameters are identified with high degree of confidence **(Confirmed Installed Capacity)** A part of the confirmed resource that could be viable to develop and produce electricity economically under existing economic and operational conditions.	**Level of confidence:** * The extraction and sale of the project have been affirmed profitable * Feasibility of extraction by a defined project development and operation have been received the rite of confirmation * Quantities of known deposit can be predicted with a high degree of confidence	**Advanced Preliminary investigations:** * Literature study complete * Field investigation 3G (Geological, Geochemical, Geophysical) * Shallow temperature geothermal well drilled * Exploration well drilled (wildcat) * Drill delineation wells (welltest, laboratorium analysis, simulation) * **Feasibility study** (technical & system, economic, legal, operational, schedule & resource)
Probable - Reserve	**Delineated Resource**	**Potentially Commercial Projects**	**Possible - Reserve**
Investigations: * Literature study complete * 3G study (geological, geochemical, geophysical) * Indirect & direct measurements and rock & fluid assesments (reservoir temp, volume, and well deleverability) * Drill exploration and delineation wells (tested volume of rock and fluid) * Recoverable thermal energy can be predicted with high degree of certainty * **Modifying factors** (energy recovery&conventions, economic, marketing, environmental, social, legal, and regulatory) * Greater uncertainty than proven reserve (well deliverability or longevity of projects)	**Geothermal phase developments:** * **Resources** (at least 1 full size production /or injection well drilled and also operational, reservoir characterization and sustainability are completed and determined) * **Transmission** (transmission feasibility study complete, System Impact Study (SIS) or/ Interconnection Facility Study (IFS) are underway) * **External** (plant permit application complete, PPA/Finance secured) * Some parameters are identified with high level of confidence **(Delineated Installed Capacity)** A part of the delineated resource that could be executable to develop and produce electricity economically under current economic and operational conditions.	**Level of confidence:** * The extraction and sale is anticipated to become economically viable in predictable future * Feasibility of extraction by a defined project development and its operation is required further evaluation * Quantities of known deposit can be estimated with a high degree of assurance	**Advanced Preliminary investigations:** * Literature study complete * Field investigation 3G (Geological, Geochemical, Geophysical) * Shallow temperature geothermal well drilled * Drill exploration well (wildcat) * **Pre-feasibility study** (technical & system, economic, legal, operational, schedule & resource)
Measured - Resource	**Possible Resource**	**Non-Commercial Projects**	**Contingent - Reserve**
Investigations: * Literature study complete * 3G study (geological, geochemical, geophysical) * Indirect & direct measurements and rock & fluid assesments (reservoir temp, volume, and well deleverability estimated) * Drill exploration and delineation wells (tested volume of rock and fluid) * Recoverable thermal energy can be estimated with high degree of certainty	**Geothermal phase developments:** * **Resources** (1 full size discovery well or slim hole drilled) * **Transmission** (transmission feasibility study underway) * **External** (permit for production well or slim hole drilling applied or approved) * Several parameters are identified with appropriate level of confidence **(Possible Installed Capacity)** A part of the possible resource that could be feasible to develop and produce electricity economically under existing economic and operational conditions.	**Level of confidence:** * The extraction and sale are not anticipated to become economically viable in predictable future or early stage of evaluation to determine economic viability * Feasibility of extraction by a defined project development and its operation is required further evaluation * Quantities of known deposit can be figured with a moderate /high level of confidence	**Advanced Preliminary investigations:** * Literature study complete * Field investigation 3G details (Geological, Geochemical, Geophysical) * Drill shallow temperature geothermal well
Indicated - Resource		**Additional in Place**	**Hypothetical - Resource**
Preliminary Investigations: * Literature study complete * 3G study (geological, geochemical, geophysical) * Indirect measurements (complete) * Direct measurements and rock & fluid assesments * Drill exploration wells (welltest) * Drill delineation wells (widely spaced to confirm reservoir continuity and distribution)		**Level of confidence:** * The extraction and sale are not expected to become economically viable in predictable future or early stage of evaluation to determine economic viability * No project development and operation have been identified * Quantities of known deposit can be estimated with a moderate /high degree of assurance	**Preliminary investigations Continued:** * Literature study complete * Field investigation 3G (Geological, Geochemical, Geophysical)
Inferred - Resource	**Possible Resource**	**Exploration Projects**	**Speculative - Resource**
Preliminary Investigations: * Literature study * 3G study (geological, geochemical, geophysical) is assumed but not verified as to its extend /capacity * Indirect measurements (extrapolation of temp profile, rock properties and heat flow)	**Geothermal phase developments:** * **Resources** (literature survey completed, geologic mapping completed, geophysical and geochemical sample sites are recognised) * **Transmission** (internal transmission analysis completed) * **External** (land/lease acquired, permitting process for exploration drilling underway) * Several parameters are identified with appropriate level of confidence **(Possible Installed Capacity)** A part of the possible resource that could be viable to develop and produce electricity economically under current economic and operational conditions.	**Level of confidence:** * The extraction and sale are not expected to become economically viable in predictable future or early stage of evaluation to determine economic viability * Feasibility of extraction by a defined project development and operation cannot be assessed due to restricted-availability of technical data and information * Estimated quantities of potential deposit is mainly based on indirect evidence	**Preliminary Investigations /Reconnaissance:** * Literature study * Field survey (geological and geochemical)
		Additional in Place	
		Level of confidence: * The extraction and sale are not anticipated to become profitable in predictable future or early stage of assessment to determine economic viability * No project development and operation have been identified * Estimated quantities potential deposit based on indirect envidence