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Application of the United Nations Framework Classification for Resources (UNFC) to Geothermal Energy Reources; Experiences from Six Greenfield Projects in Flores Island, Indonesia

Suryantini[1,4], Graeme Beardsmore[5], Tony Widiatmoro[2], Dikdik Risdianto[3], Muhamad Firdaus Al Hakim[1], Angga Bakti Pratama[1], Juni Yesy Sianipar[1], Betseba Br Sibarani[1], Hendro Wibowo[4], Waldy Afuar[1], T. Welly Prabata[1], Reyno Rivelino[1], Rizki Trisna Hutami[1]

[1]Geothermal Master Program, ITB
[2]PT PLN Indonesia
[3]Pusat Sumber Daya Mineral Batubara dan Panas Bumi (PSDMBP)
[4]Geology Program, ITB
[5]School of Earth Sciences, The University of Melbourne, Australia

suryantini@gl.itb.ac.id

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ABSTRACT

In 2016, International Geothermal Association (IGA) Resource and Reserve Ad Hoc committee (R & R) released a new geothermal energy classification framework. This classification is adopted from UNFC-2009 (United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources) which is a globally recognized and accepted scheme applicable to a wide range of energy and earth resource types such as hydrocarbon and minerals. UNFC-2009 is a generic principle-based system in which quantities are classified by three fundamental criteria, which are combined in a three-dimensional system. Those criteria are (1) Geology knowledge, (2) Project fesibility and (3) Socio-economic viability, they are known as G, F and E criteria respectively. The classification was implemented in 2016, since then, various case studies have been carried out to test the maturity of the classification.

In 2018, IGA R & R requested Geothermal Community in Indonesia which is represented by ITB, Geological Agency and PLN to implement this classification to six (6) greenfield geothermal projects and two (2) brownfields geothermal project in Flores Island, Indonesia. This paper will describe the experience on using the classification to six greenfields geothermal project namely Atadei, Oka-Ile Ange, Lesugolo, Wae Sano, G. Sirung and Rana Masak. These areas are mentioned as greenfields projects because the geothermal energy resources, although it is indicated, not clearly defined. The geothermal systems occur in these areas but the resources are not known precisely. This is because the exploration program is still at the early stage. The most advanced exploration activities are mostly shallow gradient wells.

There are several problem encountered during classifying the project based on the three criteria mentioned above such as data mostly sparse and minimum but quite enough for geosciences data. However, data related to detail of projects are not available, as there are no owner with working license for the area of interest. Consequently, project definition cannot be confidently outlined, for example information about purpose of project, energy conversion process, actual plan, and project lifetime.

The objective of this paper is to share the experience of implementing UNFC classification to geothermal energy resources in order to optimize the classification and to solve similar problem for other areas.

1. INTRODUCTION

In 2016, International Geothermal Association (IGA) and UNECE (United Nations Economic Commission for Europe) have launched a guide book for the global classification of geothermal resource (UNECE and IGA, 2016). This guide book is entitled Specifications for the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) to Geothermal Energy Resources. The UNFC-2009 provides a universally recognized system for objective reporting of energy resources. Its adoption for Geothermal Energy Projects is expected to improve investor confidence. Since then, IGA keep promoting the application of this classification in various country, private sectors, government and many other stake holders including academia.

One of the program is by providing a short course during ITB Geothermal Workshop 2018 (IIGW 2018). It is intended in particular to introduce the guide book to Indonesia Geothermal Community such as Geological Agency, PLN, Private Sector and academia and requesting them to implement this classification to six (6) greenfield geothermal projects and two (2) brownfields geothermal project in Flores Island, Indonesia. This paper will describe the experience on using the classification to six greenfields geothermal project namely Atadei, Oka-Ile Ange, Lesugolo, Wae Sano, G. Sirung and Rana Masak (Nanlohy et al., 2003; Ditjen EBTKE and Badan geologi, 2017).

2. UNFC 2009 SYSTEM AND CODE (CRITERIA, CATEGORY – SUB CATEGORY, AND CLASS)

UNFCE 2009 is a generic, principles-based classification system which is initially applied for solid minerals and fossil energy. The detail about the classification is available online and can be downloaded from UNECE website (UNECE, 2013). Since 2014, geothermal energy sector through IGA has tried to adopt this classification for reporting the energy project, because until this time no single global classification is available.

The classification is based on three (3) criteria those are Geological Knowledge, Project Feasibility and Socio Economic Viability. Those three criteria is refered as 'G axis', 'F axis', and 'E axis' respectively. The 'G axis' indicate the level of confidence in the estimate of potentially recoverable quantities, the 'F axis' designates the maturity of studies and commitments necessary to implement project, and the 'E axis' designates the degree of favorability of social and economic conditions for establishing commercial viability of project. Combinations of these criteria create a three-dimensional system. It can be visualized in three dimensions, as shown in Figure 1. In this figure, combinations of these criteria create a three-dimensional system. Categories (e.g. E1, E2, E3) and, in some cases, sub-categories (e.g. E1.1) are defined for each of the three criteria as set out and defined in an annexes that give detail information about the definition of Categories and supporting explanation about each level of Categories. Meanwhile A Class is uniquely defined by selecting from each of the three criteria a particular combination of a category or a sub-category (or groups of categories/sub-categories). It can be concluded from Figure 1, that the smaller the code (e.g. Class 111), the more confidence in the estimate of potentially recoverable quantities, the more feasible and viable the project. On the contrary, the bigger the code (e.g. Class 444) the less confidence of geological knowledge and the resources, and the less feasible and viable the project.

For geothermal purpose, similar guidance has been established and published as "Specifications for the application of the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) to Geothermal Energy Resources" (UNECE and IGA, 2016) . UNECE (2017) also provide some examples on the application of UNFC 2009 to Geothermal Energy Resource in order to give better understanding for the users. The document is entitled "Application of the United Nations Framework Classification for Resources (UNFC) to Geothermal Energy Resources, Selected case studies" (UNECE, 2017).

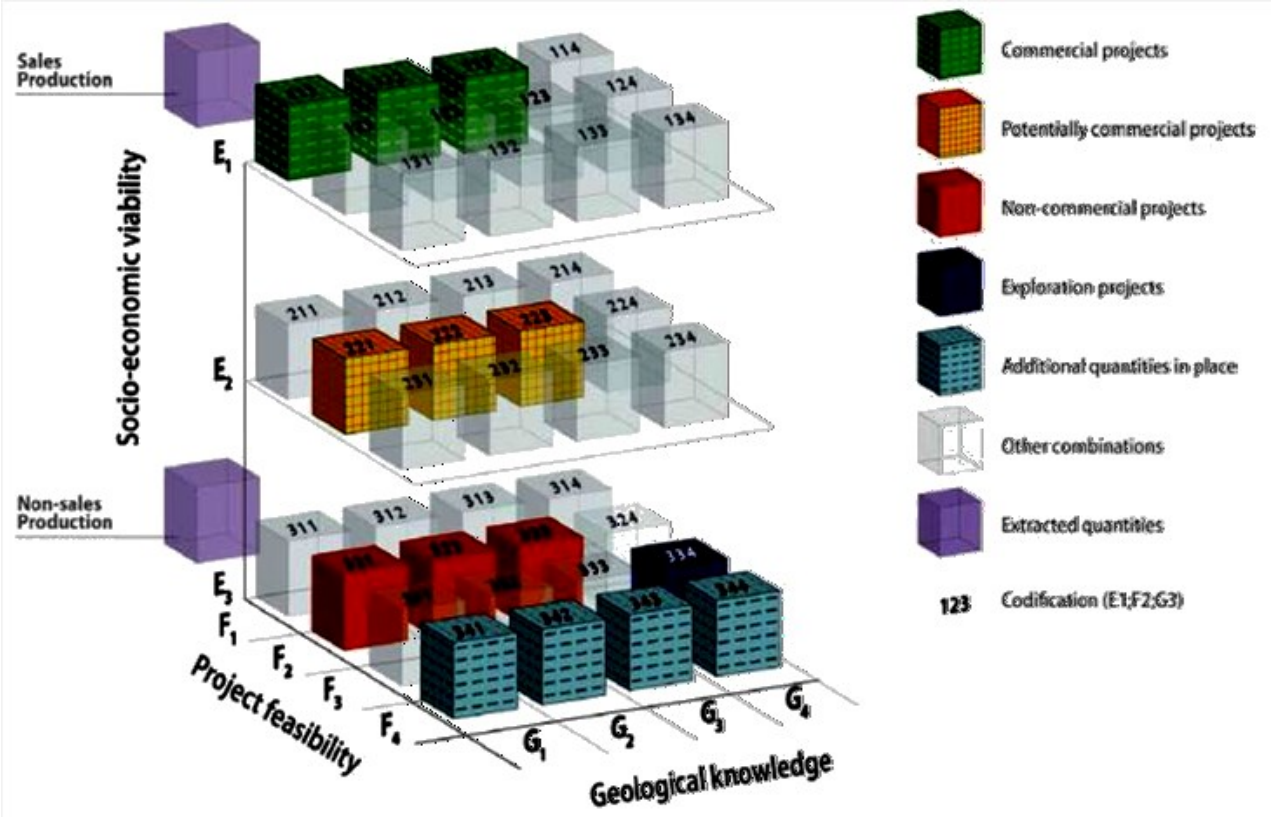

Figure 1:UNFC-2009 Categories and Examples of Classes

3. CASE STUDIES FOR SIX GREEN FIELD GEOTHERMAL PROSPECTS

The prospects areas those are Wae Sano, Rana Masak, Lesugolo, Oka Ile Ange, and Atadei which are in Flores Island and G. Sirung in Pantar Island are shown in Figure 2. All prospects are projected to produce electricity for Flores Island, except for Gunung Sirung that is to generate electricity for Pantar Island. Both project are to be developed for 2x10 MWe. The electricity is planned to be sold to PT PLN, a State Owned Enterprise (SOE), which is then distribute to end user such as households, local industries or public facilities. Project lifetime must meet 30 years of power production. Wae Sano is owned by PT SMI a State-Owned Enterprise engaged in infrastructure project financing with its total capital shares owned by the Republic of Indonesia through the Ministry of Finance. Atadei is owned by PT PLN while other prospects are open area.

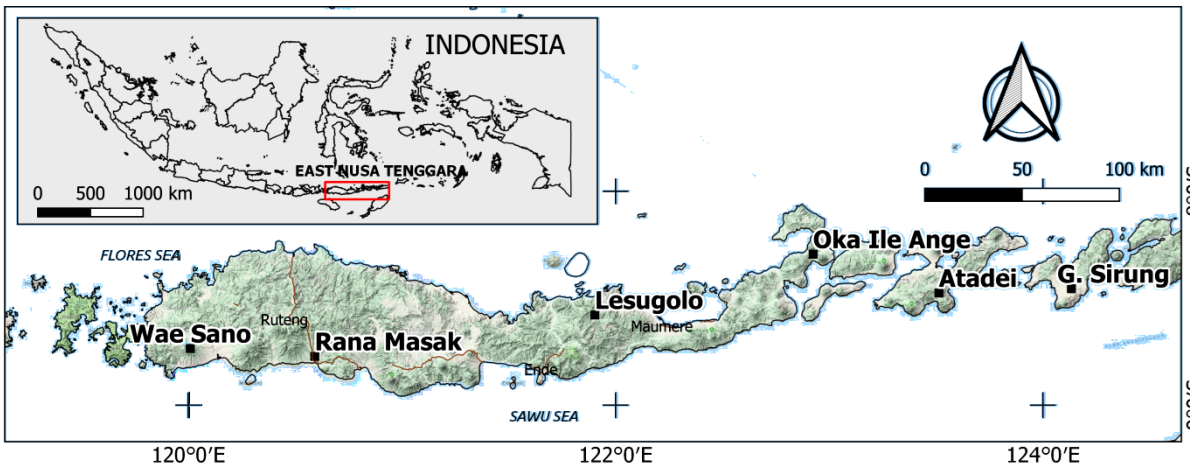

Figure 2: Location of Geothermal Prospects Areas discussed in this paper (the base map is Google map terrain)

Among all prospects, Atadei is the most explored area, where ATD-1 and ATD-2 thermal gradient wells were drilled until 250 m depth and two exploration wells (AT-1 and AT-2). AT-1 were drilled with total depth of 830.5 meter and sufficient data are available, whereas AT-2 data is unavailable. T-Logging measurement were done in AT-1 well until 450 m depth and indicates the highest temperature at that depth is 145ºC. After using the Horner-plot the actual temperature at 450 m could be around 180ºC. Surface manifestation in this prospect is sufficiently significant consist of steaming ground, weak fumaroles, hot springs and large rock alteration. Although drilling has been carried out in this prospect, it is not encounter the reservoir, therefore the geology knowledge to understand the geothermal quantities is still poor. Hence, the quantification is still at high uncertainties.

There are two shallow wells that were drilled to obtain thermal gradient of the area. Well WW-1 has total depth of 250.00 m and has thermal gradient of 15.20°C/100 m. Well WW-2 is similar to WW-1 that reach 250.00 m depth, however the thermal gradient is smaller than WW-1 that is 11.1°C/100 m. The area show impressive surface manifestation, consists of fumaroles, solfataras, hot and warm springs and also rock alteration. Limited exploration data such as geological mapping, geochemical survey and geophysical survey have been carried out in the areas. Limited Electromagnetic surveys (AMT, MT, and TDEM) have been carried out and suggest that the reservoir depth is about 1500m depth. The exploration result although various methods have been applied, suggests that the geological knowledge is still poor, the quantification contain high uncertainties.

Other prospects have not been drilled yet. The geothermometry applied in these prospects suggest that reservoir temperature might be <200°C. Limited exploration data such as geological mapping, geochemical survey and geophysical survey have been carried out in the areas. The results suggest that the geological knowledge is still poor, thus quantification of the resource contain high error with only one estimation. Usually the number is from Indonesian National Standard or SNI.

The legal, regulatory, market access, social, political, environmental issue for all projects are within acceptable commitment. For these issues, if problems occurred, it is expected to be resolved in the foreseeable future. However, the only concern is economic viability of extraction, where in exploration phase this issue cannot be determined due to insufficient data. With additional exploration data, this will improve the certainty of economic viability. It is still possible for Atadei and Wae Sano, because both are managed by SOE. Since it is on exploration stage, therefore the technology necessary to recover some or all of the quantities is not currently under research or development.

Based on the description above, all of six prospects are on category E3, F4, G4 (Table 1), which are the lowest rank of the classification. Atadei and Wae Sano might fall higher in the sub category level E3.2 and F3.2 where other prospects are within E3.3 and F3.3. The result is mostly driven by exploration data which is insufficient for further assessment.

4. LESSON LEARNED

Indonesia actually has its own classification of potential geothermal energy called the Indonesian National Standard or SNI. It has become the basis for calculating geothermal resources and reserves in Indonesia. However, this standard basically only calculates the energy potential in the reservoir and has not considered technological and economic factors and the development commitment of the concession owner.

For the case of Atadei and Wae Sano, if using SNI classification, the geothermal energy potential in these two prospects can already be considered in the class of possible reserves because there is already drilling. This class is actually high enough approaching proven reserve, possibly by adding 3 deep drilling to the top reservoir, it will move from possible to proven class, if drilling successfully proves the existence of a reservoir. But this is not the case if using the UNFC 2009 classification. Both of these prospects are on the lowest category. this is because the UNFC 2009 classification considers projects that are more ready to be executed. The data needed in this classification is more detailed and more extensive, not just geothermal geological data exploration and drilling data to calculate potential. For data on the E-axis and F-axis, most geothermal projects in Indonesia, especially for open areas and projects in the exploration phase, have not yet considered this. So in the case study of this paper, there are not enough data to carry out the study. However, based on the results of the study case in this paper, the categories on the E-axis and F-axis are closely related to the stages of exploration. So for prospects with green field exploration status, it is almost certain that the E-axis and F-axis will be in the lowest category.

In this case study, Initial assessments are carried out by master students. The interesting thing here is that, even with the help of the 'Specification' book, it is still very difficult to make a comprehensive and concise report. This is because of lack of experience in describing each part requested in the specification, and in addition, due to lack of data that can be accessed by the student. In this case, the person needs to write a better and more appropriate specification report, especially for the audience report.

Table 1: A. Category in E-axis (UNECE and IGA, 2016)

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Sub Categories*	*Definition*	*Additional Renewable Energy Context*	*Additional Geothermal Energy Context*
E3	*Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability*	*On the basis of realistic assumptions of future market conditions, it is currently considered that there are not reasonable prospects for economic extraction and sale in the foreseeable future; or, economic viability of extraction cannot yet be determined due to insufficient information (e.g. during the assessment phase). Also included are quantities that are forecast to be converted, but which will not be available for sale.*	***E3.1***	*Quantities that are forecast to be extracted, but which will not be available for sale.*	---	For example, quantities produced and used internally (e.g. parasitic use, such as well pumping, power conversion loss, etc.)
			E3.2	*Economic viability of extraction cannot yet be determined due to insufficient information (e.g. during the exploration phase)*		For example, pre-successful well drilling exploration complete (if a drilled 'dry' or unsuccessful, but further drilling is planned, this sub-category is still appropriate). Or, Where there is an active effort to obtain approval, the outcome is unknown or unclarified.
			E3.3	*On the basis of realistic assumptions of future market conditions, it is currently considered that there are not reasonable prospects for economic extraction and sale in the foreseeable future.*		Uneconomic sites, for example sites far from transmission and/or demand Or Where there is an active effort to obtain approval, the likelihood of receiving approval is low.

Table 1: B. Category in F-axis (UNECE and IGA, 2016)

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Sub Categories*	*Definition*	*Additional Renewable Energy Context*	*Additional Geothermal Energy Context*
F4	*No development project or mining operation has been identified.*	*In situ (in-place) quantities that will not be produced by any current development project or mining operation.*	***F4.1***	*The technology necessary to recover some or all of the these quantities is currently under active development, following successful pilot studies on other deposits, but has yet to be demonstrated to be technically feasible for the style and nature of deposit in which that commodity or product type is located;*	*Category F4 can be used to classify the currently non-extractable quantities at the geographical location of the defined Project due to, for example, site/area constraints, technology limitations and/or other constraints*	---
			F4.2	*The technology necessary to recover some or all of the these quantities is currently being researched, but no successful pilot studies have yet been completed;*		---
			F4.3	*The technology necessary to recover some or all of these quantities is not currently under research or development.*		---

Table 1: C. Category in G-axis (UNECE and IGA, 2016)

Category	*Definition*	*Supporting Explanation (UNFC-2009, Part I, Annex I)*	*Sub Categories*	*Definition*	*Additional Renewable Energy Context*	*Additional Geothermal Energy Context*
G4	*Estimated quantities associated with a potential deposit, based primarily on indirect evidence.*	*Quantities that are estimated during the exploration phase are subject to a substantial range of uncertainty as well as a major risk that no development project or mining operation may subsequently be implemented to extract the estimated quantities. Where a single estimate is provided, it should be the expected outcome but, where possible, a full range of uncertainty in the size of the potential deposit should be documented (e.g. in the form of a probability distribution). In addition, it is recommended that the chance (probability) that the potential deposit will become a deposit of any commercial significance is also documented.*	*G4.1*	*High-confidence estimate (low estimate*	*Category G4 is equally applicable to renewable energy, for "Estimated quantities associated with a potential Renewable Energy Source, based primarily on indirect evidence" (e.g. mapping studies).*	For example, delineation by surface surveys; evidence, of rock-water interactions, spring analysis, temperature gradient, regional heat-flow maps, etc. For GSHP projects, G4 does not apply.
			G4.2	*Moderate-confidence estimate (best estimate) incremental to G4.1*		
			G4.3	*Low-confidence estimate (high estimate) incremental to G4.2)*		

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