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GEOTHERMAL RESOURCES AND RESERVES IN INDONESIA : A REVISION

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ABSTRACT

Indonesia is fortunate to have many high, medium and low enthalpy geothermal resources. From the early 1980s until the late 1990s the geothermal potential for power production was estimated at about 20,000 MWe. The most recent estimate exceeds 29,000 MWe derived from more than 250 sites of high to low enthalpy sources across Indonesia.

This resource estimate has been obtained by adding all of the estimated geothermal potential resources and reserves classified as "speculative, hypothetic, possible, probable, and proven" from all sites where such information is available. However, this approach to estimating the geothermal potential is flawed because it includes double counting of some reserve estimates as resource estimates, thus giving an inflated figure for the total national geothermal potential. This paper proposes to redefine and revise the geothermal resource estimate in Indonesia using a more realistic methodology.

INTRODUCTION

Much of the Indonesian Archipelago is situated on the boundary of the Australian-Indian and the Eurasian Tectonic Plates. Numerous active volcanoes are associated with this plate boundary, stretching from Sumatera to Java, Bali and Maluku up to Sangihe Island, resulting in many high enthalpy geothermal resources in these areas.

There are more than 177 volcanic centres in the Archipelago, of which about 88 bear evidence of fumarolic and solfataric activity (Radja,1990). Reconnaissance studies carried out since the mid-1960s have found in excess of 250 sites that identified as geothermal potential areas.

The first national geothermal energy potential estimate was reported to be about 16,000 MWe (Radja, 1990). This was later revised by Pertamina to be about 20,000 MWe (Fauzi et.al, 2000). A short time later, at the 2000 World Geothermal Congress, the Government of Indonesia released an estimate of the national geothermal energy potential to be approximately 27,000 MWe. The most recent estimate of geothermal potential is about 29,000 MWe (API NEWS, 2012).

This paper presents the results of a reassessment of the geothermal energy potential of Indonesia and proposes a new summation methodology.

DEFINITIONS

In general, “Geothermal Resources are defined as thermal energy beneath the earth at depths shallow enough to be tapped/extracted economically and legally by drilling at specific time. And, “Geothermal Reserves” are defined as that portion of the geothermal resource that is commercially extractable.

Geothermal resources: the estimates of geothermal potential determined on the basis of limited data and yet to be proven as potential reserves (SNI, 1998).

Geothermal resource is a term used to define a quantity of geothermal heat that is likely available if certain technologic and economic conditions are found in the future (specified) time (PERTAMINA, ?).

Speculative Resources: the estimate based on the presence of geothermal surface manifestations and other sign of heat flow. (Note: Speculation is about something that cannot be definitely proven. Theoretical)

Hypothetical Resources: Determined from regional geologic surveys and geochemistry of thermal features. Stored heat calculations and estimates are used for resource sizing. (Note: In science, a hypothetical conclusion is drawn before all the facts have been discovered and adopted for the time being as a guide to further investigation).

Geothermal Reserves: Total heat content stored in the subsurface that is economically recoverable and

estimated using the geosciences survey as a tool (SNI, 1998).

Geothermal reserves consist of identified economic resources that are recoverable at a cost that is competitive now with other commercially developed energy sources. Reserve estimates are calculated based on well data and or geoscientific data.

Possible Reserves: the geothermal energy potential in the subsurface is estimated by using integrated surface geoscientific survey data.

Probable Reserves: the geothermal energy potential in the subsurface is estimated by using integrated surface geoscientific survey data and the results of at least one discovery well.

Proven Reserves: : the geothermal energy potential in the subsurface is estimated by using integrated surface geoscientific survey works with reasonable certainty and include at least one discovery well and two delineation wells to obtain data on the subsurface parts of the system.

PAST AND PRESENT STATUS

The estimates of resource and reserve potential of geothermal energy in Indonesia has gone through three phases

In the First Phase, from the early 1980s until the late 1990s, estimates of resources and reserves were predominantly carried out by the Directorate of Geology & Mineral Resources and Pertamina.

The Second Phase, the estimates made by the Director General of Geology and Mineral Resources, and first released at the 2000 World Geothermal Congress.

The third Phase, the estimates of resources and reserves were carried out by Geological Agency of Indonesia, and published in API NEWS, 2012.

The most recent geothermal resource figures were obtained by adding all the numbers from all of the categories "speculative, hypothetic, possible, probable and proven" as shown in the published information (Table 1).

Table 1:Geothermal Resources and Reserves: 2008 Status

Location	Resources (MWe)		Reserves (MWe)			Installed (MWe)
	I	II	III	IV	V	
Sumatera	4973	2121	5845	15	380	122
Java	1960	1771	3265	885	1815	1135
Bali-N.Tenggara	410	359	973	-	15	-
Kalimantan	45	-	-	-	-	-
Sulawesi	875	32	959	150	78	80
Maluku	370	37	327	-	-	-
Papua	50	-	-	-	-	-
TOTAL	8683	4320	11369	1050	2288	
	13003		14707			1337
	27710					(2012)

Geological Agency (2008)
I = Speculative, II = Hypothetical, III = Possible, IV = Probable, V = Proven

REASSESSMENT OF THE RESOURCES AND RESERVES

Currently, the geothermal potential classification process includes estimating the geothermal potential of a prospect area in 1 of 5 categories defined above from a “Speculative Resource” (the least certain category of geothermal potential) to a “Proven Reserve” (the most reliable estimate of an area’s geothermal potential).

The preliminary "Speculative Resources" category of resources should cover the full potential of the area and form the base reference figure for the resource of the potential geothermal field. Eventually, further investigation of this resource may allow parts of the “Speculative Resource” to be upgraded to “Proven Reserve”. However, the total “resource capacity” does not increase in this upgrade (unless, of course, the estimated area of the geothermal field resource is increased).

Where detailed geological, geochemical and geophysical surveys are conducted over the resource area then that part of the geothermal resource may be upgraded to the category of “Possible Reserve”. Further studies and surveys including at least one exploration well must be able to prove the existence of a high-temperature fluid that can be used for producing electric power - this will allow that part of the resource to be categorized as “Probable Reserves”. Again this does not make an addition to the “Possible Reserves” or the total “resource”. Additional produced exploration wells that can provide a three-dimensional model of the geothermal resource can result in the estimate being upgraded in the area of the drilling and model to “Proven Reserves”. Again, the estimate of the proven reserves

does not increase the estimate of the geothermal resource as a whole.

Thus, all activities (geo-scientific surveys and drilling) that follow an initial resource estimate of the geothermal potential are tools to prove, with increasing certainty, the existence of geothermal energy stored in the reservoir rocks in the form of high-temperature fluid. Once a geothermal resource is established, any further estimates (that upgrade part of the resource to a hypothetical resource or a possible/probable/proven reserve) should not be added to the total resource capacity.

The previous practice of "Summation" as depicted in Table 1 does not give a correct estimate as it leads to a greater estimate of the geothermal potential than is actually present. Based on this fact, the total summation methodology as a resource estimation tool needs to be improved.

PROPOSE TO BE REVISED

Initial estimation of the geothermal energy potential of an area is usually done through the study of literature and a brief visit to the area. This estimation is classified as a resource and placed into the speculative and/or hypothetic category. Further study using geoscientific surveys and exploration drilling can improve the level of confidence to the category of reserves that consists of possible, probable, and proven reserves.

The initial estimate that classifies the geothermal potential as a speculative resource, and the estimate using geoscientific surveys as a possible reserve, should be the main focus in terms of determining how large the geothermal energy resources are in a region. The initial estimate, and the geoscientific survey will substitute one to another.

The estimate of a "Possible Reserve", may be lower or higher than a Speculative Resources. If the estimate of "Possible Reserve" remains lower than the estimated "Speculative Resources", then the initial estimate remains a benchmark for the calculation of total Resources for the region. On the other hand, if the estimate obtained from the results of further investigation is higher, this figure becomes the new reference number for the "Speculative Resource" (Table 2).

It is proposed that the resource calculation of a geothermal field not be estimated by summing all the numbers from Speculative and Hypothetic Resources and from Possible, Probable, and Proven Reserves. Thus the estimate for the calculation of total resources of an area is that estimate recorded as the revised "Speculative Resource" (Table 2).

Using the methodology proposed in this paper, the geothermal resource potential of Indonesia is revised to be approximately 23,000 MWe, some 4,700 MWe less than the 2008 national estimate.

Tabel 2: Geothermal Resources and Reserves: Examples of Proposed Methodology using Selected Areas

Location	Resources (MWe)		Reserves (MWe)			Installed (MWe)
	I (A)	II (B)	III (C)	IV (D)	V(E)	
Sibayak	-	34	35	-	30	2
Sibayak	**35**	**34**	**35**	**-**	**30**	**2**
Dolok Marawa	100		40			
Dolok Marawa	**100**	**-**	**40**	**-**	**-**	**-**
Cubadak	73		100			
Cubadak	73/**100**		**100**			
Awibengkok	-	-	110	110	375	375
Awibengkok	-/**375**	**-**	**110**	**110**	**375**	**375**
Kamojang	-	-	-	300	260	140
Kamojang	-/**300**	**-**	**-**	**300**	**260**	**140**
TOTAL	-/**910**	-	-	-	-	-

Original data from Geological Agency (2008)
I = Speculative, II = Hypothetical, III = Possible, IV = Probable, V = Proven

NOTES:

1. Sibayak: if (C)>(B) or (C)>(A), then the number in (C) should be transferred to (A) or (B) and being as the reference that is used in summation as a resource in total.
2. Dolok Marawa: if (C)<(A), then the number in (A) as the reference without any changes used in summation as a resource in total.
3. Cubadak: if (C)>(A), then the number in (C) should be transferred to (A) to be used in summation as a resource in total.
4. Awibengkok (Salak): if (E)>(A), then the number in (E) should be transferred to (A) to be used in summation as a resource in total.
5. Kamojang: if (D)>(A), then the number of the potential in (D) should be transferred to (A) to be used in summation as a resource in total.
6. Thus the total resource being **910 MWe.**

Table 3: Revised Total Geothermal Resources and Reserves in Indonesia

Location	Resources (MWe)		Reserves (MWe)			Installed (MWe)
	I	II	III	IV	V	
Sumatera	11523	2117	5845	15	380	122
Java	7217	1771	3265	885	1815	1135
Bali-N.Tenggara	1315	359	723	-	45	-
Kalimantan	45	-	-	-	-	-
Sulawesi	1954	32	959	150	78	80
Maluku	864	37	327	-	-	-
Papua	50	-	-	-	-	-
TOTAL	22968	4316	11119	1050	2318	1337
	22968					(2012)

Resummation Speculative Resource Based on Geological Agency Data
I = Speculative, II = Hypothetical, III = Possible, IV = Probable, V = Proven

CONCLUSIONS

The previous estimate of the geothermal resources of Indonesia included double counting of some "Reserves" estimates as "Resources" estimates, thus giving an inflated figure of the total national geothermal resource potential.

Using the methodology proposed in this paper, where this double counting is removed, the geothermal resource potential of Indonesia is revised down to approximately 23,000 MWe. This is some 4,700 MWe or 20.6% less than the previous 2008 national geothermal resource estimate of 27,710 MWe.

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