Proceedings World Geothermal Congress 2015
Melbourne, Australia, 19-25 April 2015

Promoting Geothermal for Energy Security (A Case of Indonesia)

Siti Mariani, Arwin D.W. Sumari, Retno Gumilang Dewi

Indonesia Defense University, mariani.siti@den.go.id

Keywords: Load factor, Levelized cost of geothermal, Geothermal power plant, Structured tariff

ABSTRACT

This paper analyzes the necessity of a structured tariff calculation for geothermal electricity in Indonesia. Indonesia is blessed with abundant natural resources and choices of energy resources to generate electricity among other are coal, gas, biomass, hydro to geothermal, creating a fierce competition in electricity tariffs. While geothermal is inline with energy security principle and green growth initiative, it requires a huge capital funding. Geothermal electricity development consists of phases of project with each having its own financial characteristics. The Indonesian government has set a support in the form of ceiling price of geothermal electricity tariff by 11 U.S cents / kWh. However, the government did not set a levelized cost of geothermal, as an indication of lower limit capacity class, to which support is given. The government should establish a levelized cost of geothermal energy to reflect its financial capability in supporting geothermal development. Aside of that, the government is also need to establish a structured tariff calculation to reflect a fair and transparent business cooperation.

1. INTRODUCTION

Geothermal is a renewable resource that is impervious to the risks of climate change, clean, therefore should be endorsed by any government that is endowed with it. Countries in the world are embracing green growth, synchronizing development strategy with environmental sustainability, to synergize economic growth with environmental protection. Geothermal power plant project can be seen as such strategy.

Geothermal power plant project can also be seen as an attempt to enhance energy security. Diversifcation options is gauged by a "levelized cost of renewable energy", that the developer requires a guarantee of return. When diversification effort is limited by the capacity of government capital, a diversification program would be such like, i.e. :

1. 80% electrification ratio by 2014
2. To increase renewable energy mix
3. To cope with electricity crisis in area X

Whichever program is chosen, the government must ready to provide the necessary incentives. However, in the case of geothermal electricity project, the many phases of project, with each phases entitle specific financing characteristic, administrating incentive can be challenging.

2. ENERGY SECURITY

2.1 Energy Security of Countries

Energy security level is different for each country. The United States, which no longer have issues with domestic energy security, defines energy security as an independence of economic and political action in international affairs (American Security Project - ASP). ASP further highlights the relationship between utilization of energy and carbon emissions. Thus highlight that energy, climate change and security is a nexus that need to be solved simultaneously.

Indonesia, although endowed with abundant and diverse natural resources, still struggling with adequacy of supply infrastructures. Energy infrastructure spending is still very much less than energy subsidy spending. With the subsidy policy has becoming political issue. As outlined by Sumari (2013), energy is one of the Center of Gravity (COG) of a country and a state acquisition can be done at the level of leadership, which is reflected in the issuance of energy policies that are self-destruct. Therefore energy-related decision making mechanism becomes important.

The current Indonesian political reforms has brought the establishment of the National Energy Council that aside of drafting National Energy Policy, its task is to provide an unbiased energy information to leader, in this case the Ministry of Energy and Mineral Resource, and the President of the Republic of Indonesia. However, leader is still required to show wisdom in digesting energy information, and keeping public interests above all.

2.2 Indonesia's Energy Infrastructure and Security of Supply

How is Indonesia energy supply security, viewed from availability?. Availability implies stability, socioeconomic sustainability of short, medium and long term. Availability are related both in normal and in times of emergency.

In anticipation of an emergency situation, the availability is materialized with the release of emergency stocks, which are generally in the form of crude oil. For that, the amount of emergency oil stocks of a country can reflect its resilience in energy supply. However, coal stocks are also taken into account, given the coal can be easily converted to oil to gas, even used for military vehicles, as practiced by North Korea.

Since 2002 Indonesia is included in the category of a net oil importer. As a net importer, the need to have an emergency stock of oil is increasingly relevant. How is Indonesia's energy supply security conditions, when viewed from the availability of emergency stocks of oil in particular? Following the IEA data in 2013 in units of days of net imports in Table 1, shows that Indonesia emergency stock is the lowest among countries.

Table 1. Oil Stock of Various Countries (*Source: IEA*)

Countries	*Public Stock (Government, SOE)*	*Industrial Stock (Private)*	*Total Stock*
U.S.A.	91	119	210
Japan	83	65	148
Australia	0	61	61
Indonesia	22	0	22
Thailand	50	0	50

If reliability of oil supply is measured by the amount of oil stock, reliability of electricity supply is seen on the duration (System Average Interruption Duration Index or SAIDI) and frequency (System Average Interruption Frequency Index or SAIFI) of power outages, as well as the length of consumers waiting list.

Data of state electricity company PT. PLN (Persero) Statistic 2012 on Table 2 shows that the duration and frequency of power outage are still dominating PLN systems. Therefore the electricity supply continues to experience pressure, and deficit.

Table 2. SAIDI and SAIFI, PT.PLN (Persero) System (*Source: Statistik PLN 2012*)

PLN Area	*SAIDI Hour/Customer*	*SAIFI Times/Customer*
Kalimantan Timur	14,29	13,85
Kalsel & Kalteng	9,02	6,10
Maluku & Maluku Utara	9,45	5,44
Sulut, Sulteng & Gorontalo	8,72	5,32
Papua	7,63	9,51
NTB	6,77	9,21
Sulsel, Sultra & Sulbar	5,69	6,91
Sumatera Utara	5,21	6,64
Bali	5,15	4,74
Kalimantan Barat	5,03	5,81
NTT	4,46	7,46
Lampung	4,31	3,03
Sumatera Barat	4,16	4,61
Riau	3,94	3,23
Sumsel, Jambi & Bengkulu	3,72	3,72
Aceh	3,46	4,17
Bangka Belitung	2,6	2,2

Furthermore, its anticipated that electricity consumption will keep growing in the coming years. According to PT. PLN (Persero) data, the electricity consumption in the first semester of 2013 in reached 90.48 TWh (tera watt hour), while in the first semester of 2012 reached 84.43 TWh. This indicates an increase of electricity consumption of 7.2 percent from 2012. Growth in industrial sector electricity consumption rose by 8.3 percent in the same period.

As the nature of developing economy, energy consumptions are expected to continue to rise, inline with urbanization, economic growth, and population growth. In 2025 the National Energy Council projected that Indonesia will become a developed countries, with a projected electricity consumption of 1,487 kWh per capita, triplet of current consumption of 591 kWh per capita.

These conditions are increasingly demanding the government actions in providing adequate electricity supply and infrastructure. On the supply side, these conditions require the reservation of fossil fuel and discovery of an alternative primary energy for the future, an alternative energy that is owned and sustainable, a new and renewable energy.

3. GEOTHERMAL FOR ENERGY SECURITY

3.1 Climate Change and Renewable Energy Vulnerability

In the forum of "Media Transatlantic Dialogue 2009" its noted that the U.S. government has prepared a report on the impact of climate change on national security and concluded that climate change and global warming is a "threat multiplier" of instability in some regions of the world. the report specifically underlines 4 risks of climate change:

1. Water Scarcity
2. Food Security
3. Health Risk of communicable disease
4. Shrinkage and submerged land, flooding.

The first risk of climate change, water scarcity is posing threat to hydro renewable energy resource choice, as it is directly exposed to the seasonal cycle. An example is the case of the power crisis in North Sumatra. The effects of climate change results in a longer dry season, which in turn reduced the flow of water to the hydroelectric power plant reservoir, and reduces operational power of the plant into half of its installed capacity.

The second risks of climate change, food security is posing threat to biomass renewable energy choice, as in fact it had to compete the land usage with food crops. And as with other energy sources, biomass is commodity, and have been widely exported with its price is following the Asian market.

While biomass and other energy resources is a commodity, geothermal is an insitu potential, therefore can not be exported. And with a discipline water catchment area environmental reservation, water scarcity threat of climate change should not directly affecting the continuity of geothermal hot steam.

3.2 Geothermal Electricity Potential

According to Sudarman (2012), of the 29,000 MW geothermal resource data recorded by the Energy and Mineral Resource, it is grouped into 3 temperature categories as in Table 3, with low temperature resource is not feasible to be developed into electricity;

Table 3. Categories of Indonesia Geothermal Resource Potential

Termperature	*Probable*	*Proven*
High (>220^{o}C)	15,000 MW	
Moderate (150-180^{o}C)	1,000 MW	1,000 MW
Low (<150 ^{o}C)	12,000 MW	

The magnitude of this potential can increase with more exploration activities. Meanwhile, the geothermal power plants in Indonesia can be classified into three categories:

1. Big Resource, High Demand = Java, Sumatra Island
2. Big Resource, Low Demand = Eastern Indonesia (e.g. Flores potential imply 150 MW but only 2.5 MW developed.
3. Small Resource (moderate temperature), High Demand = Sulawesi region (e.g. Sorowako potential, with temperature of 150-180 ^{o}C therefore only produce 20-40 MW therefore had to use the binary technology which is more expensive).

Small resource or moderate temperatures potential will imply a greater cost for the exploration and exploitation activity (e.g. going deeper wells).

3.3 Economic Viability

There are many options of primary energy for electricity generation in Indonesia. In considering the type of primary energy, PT. PLN (Persero) see load factors in the area. This is especially if the system is built is outside Wilayah Kerja Usaha (WKU) or areas of business, and the waiting list of customers in the area is low.

As we can see from Figure 1, load factor can significantly affect the competitiveness of geothermal power plant against i.e. gas combined cycle power plant, or biomass powerplant. Geothermal powerplant is more competitive than gas combined cycle power plant for a load factor of more than 70%, and coal beat the competition for load factor above 50%.

Can be understood then that most of the geothermal project enlisted by the government for 2012-2021 are located in Java island. The island endowed with high temperature resource implying large capacity (MW), and high consumer purchasing power, plus readily available electricity network infrastructure. However, as to be inline with green growth initiative, there are some projects that is in fact lower in load factor, but nevertheless developed.

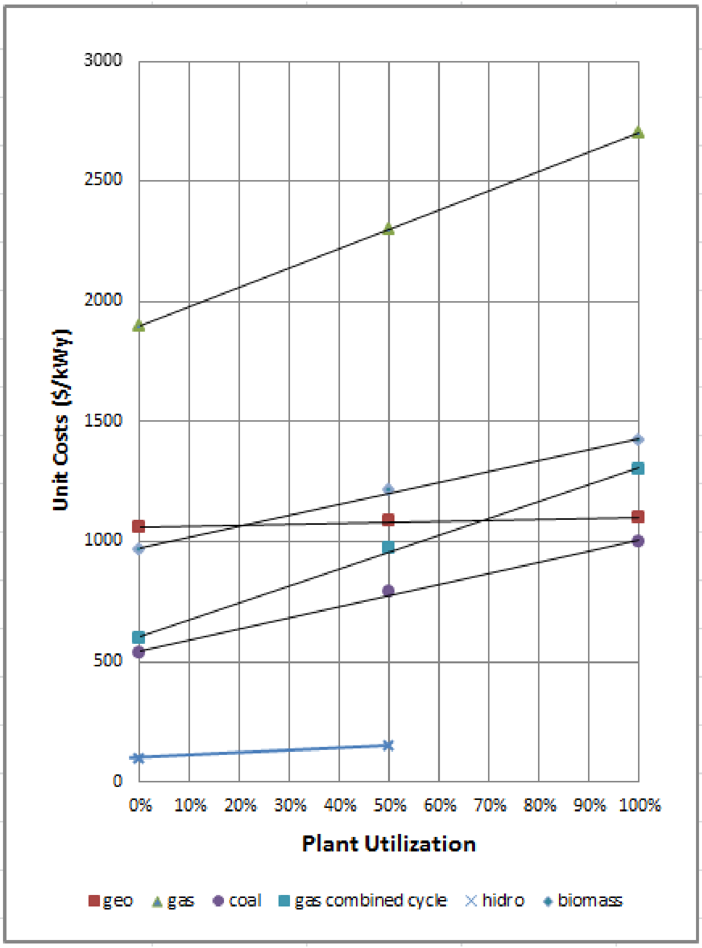

Figure 1. Load Factor vs Unit Cost (*Source: Ministry of Energy and Mineral Resource*)

4. GOVERNMENT SUPPORT FOR GEOTHERMAL DEVELOPMENT

4.1 Government Regulation on Ceiling Price

Indonesian government awareness of the importance of the geothermal power plants project as energy security policy as well as environmental policy, has been shown by Presidential Regulation No. 4 Year 2010, which set a target for the development of geothermal power plants.

Furthermore, a ceiling price is settled with the issuant of Ministerial Regulation No. 22 Year 2012 which requires that state electricity company PT. PLN (Persero) to purchase electricity from geothermal resource. The ceiling price commitment can also be seen as a government's commitment to reduce emissions. Price cap or an upper threshold reflects a government budget capacity to support the development of geothermal energy.

1. Ministerial Regulation No. 22 Year 2012 on ceiling price include:
2. Sumatera island: 10 US c$ /kWh (high voltage) and 11,5 US c$ /kWh (medium voltage);
3. Jawa, Madura, Bali islands: 11 US c$ /kWh (high voltage) and 12,5 US c$ /kWh (medium voltage).

However, the government has not yet setting a levelized cost of geothermal, as a reference of capacity limitation. A levelized cost of geothermal will indicate the class of geothermal capacity to be covered with government support. How far the government shall endorse a small capacity plant size in a low load factor area?.

4.2 Levelized cost of Geothermal; World Reference

Tariff incentive systems are generally implemented by requiring that business entity has never received an incentive of any kind before, thus ensuring that the investor does not receive excessive compensation.

In estimating the total incentive budget need to be prepared by the government, we needs to have an overview of the levelized cost. On average levelized cost for geothermal projects range from 6-8 U.S. $c/kWh. Table 4 is a reference of levelized cost from various sources.

4.3 Levelized Cost of Paul Ngugi and of Sudarman

Paul Ngugi (2012) calculates the levelized cost of geothermal taking the cost of geothermal projects in Kenya, as Figure 2. Paul Ngugi took the assumption of non-commercial funding, with interest rate as low as 1%, lengthy debt term (25 years), and that the developer is owning the drilling rig.

Table 4. Reference of Geothermal Levelized Cost

Source	*Levelized Cost (c$/kWh)*
UN World Energy Assessment Report	2 – 10
Wikipedia	5 – 13
Center for Climate and Energy Solutions (C2ES)	6 – 9
International Renewable Energy Agency (IRENA)	5 – 9 Varied by geography
Lazard	8,9 – 14 (@30 MW) Varied by geography
California Energy Commission (CEC) 2007	8,8 – 9,2 (@50 MW)

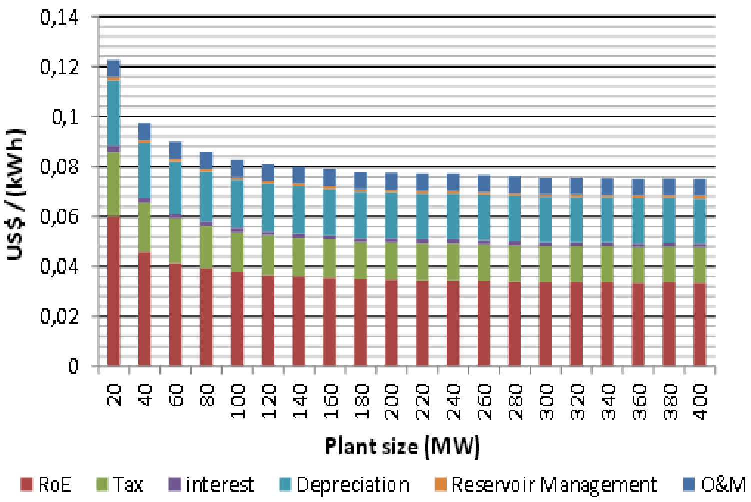

Figure 2. Levelized Cost of Geothermal by Paul Ngugi (*Source:Ngugi 2012*)

Meanwhile in Indonesia, Sudarman (2008) extrapolate 16 bid datas and generate levelized cost as Figure 3. Sudarman took the assumption of commercial financing with interest rate rate of 9%, shorter debt term of 10 years, and that the developer rent the drilling rig.

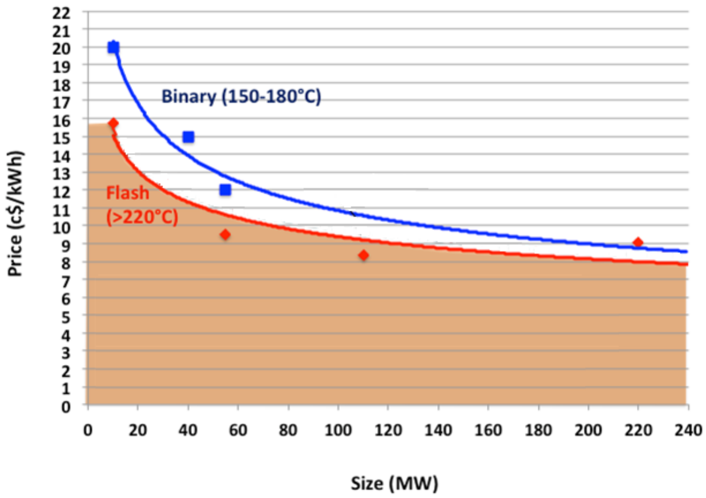

Figure 3. Levelized Cost of Geothermal by Sudarman (*Source:Sudarman 2012*)

Below is the detail comparison of parameters between the two studies of Paul Ngugi and of Sudarman:

Table 5. Comparison of Parameters

Parameter Pengembangan	Ngugi	Sudarman
POWER PLANT		
Plant Size (MWe)	2 x 50	2 x 55
Projected well output (MWe)	5	10
Drilling Sucecss Rate :		
Exploration wells	50 %	50 %
Appraisal wells	75 %	75 %
Production wells	90 %	80 %
Re-injection wells		
Ratio to production wells	1/5	1/3
Unsuccessful wells used for reinjection	30 %	30 %
Ratio of wellhead main plant	0 %	0 %
GENERATION PARAMETERS		
Excess steam at startup	10 %	10 %
Steam decline rate	3 %	3 %
Plant capacity factor	90 %	90 %
Economic life (year)	25	30
Service life (year)	25	30
Operational hours per day	24	24
Operational days per year	365	365
Parasitic Load (listrik untuk instalasi sendiri)	3 %	5 %
EQUITY RATE OF RETURN		
Expected rate of return on equity	15 %	16 %
DEBT		
Interest	1,00 %	8,5 - 10 %
Grace period	7	7
Term	25	10 - 15
Arrangement fee	0,5 %	0,5 %
Commitment fee	0,5 %	0,5 %
Pay-back period	17	5 - 8
Debt ratio/equity	70 %	70 %
TAX		
Corporate tax rate	30 %	25 %
INFLATION AND EXCHANGE RATE		
SALES		
UNIT PRICE	0,1075	0,094
O&M COST	0,007	0,016
PLANT SIZE	2 x 50	2 x 55 net
Ratio of production/injection wells	1/5	1/3
% steam wells used for reinjection	30 %	30 %
Estimated well output (MWe)	5	10
Drilling cost (US$)	3.500.000	6.000.000
Drill pad cost	10.000.000 (Kshs)	2.000.000 (US$)
Exchange rate	85 (Kshs/US$)	10.000 (Rp/US$)
PIPELINE COST (US$/MW)	400.000	400.000
PLANT COST (US$/MW)	1.500.000	1.500.000
Well testing cost to drilling cost	30 %	15 %

4.4 The Importance of Financial Support

If we look at the Table 5, Ngugi take assumption of concession loan with discount rate of 1%, while Sudarman take International Money market with discount rate of 9%. This is a huge different. In the case of Sudarman, even exploration funding is not funded by special fund from government, nor concession loan, but by international money markets.

Only recently that the government of Indonesia introduce exploration funding, but that is also of limited amount, compared to the vast potential of geothermal. The government need to priorities the support in the form of exploration funding, and mapping projects of "national interest", and let the electricity tariff be evaluated by a structured calculation.

5. IDENTIFIED HURDLES AND RECOMMENDATIONS

5.1 A Structured Tariff for Geothermal Electricity

Geothermal development consists of several phases with each phases has its own financing characteristics. For example, insurance companies will not be interested in providing capital resource in the identification and valuation stage, while private equity investors are a source of funding that is too expensive for the project development phase when it is available the data construction and term loans.

In determining the structure of the tariff calculation, the government can use a composite model of James B. Randle (2005), which presented the technical aspects of project development, construction and operations, to corporate finance input module that provides a target annual corporate financial data that comply with equity and debt. The Input-Output Financial Model with Input grouped into:

1. Construction & Capital Cost
2. Loan Schedule
3. Plant Operation
4. Corporate Financial Analysis
5. Financial Economic Performances

With the establishment of a structured tariff calculation, the government will not channel redundant or excessive support, and agreed tariff is a reflection of justice. A structured tariff calculation, may also forbid the collusion practice among the few players try to manipulating margin.

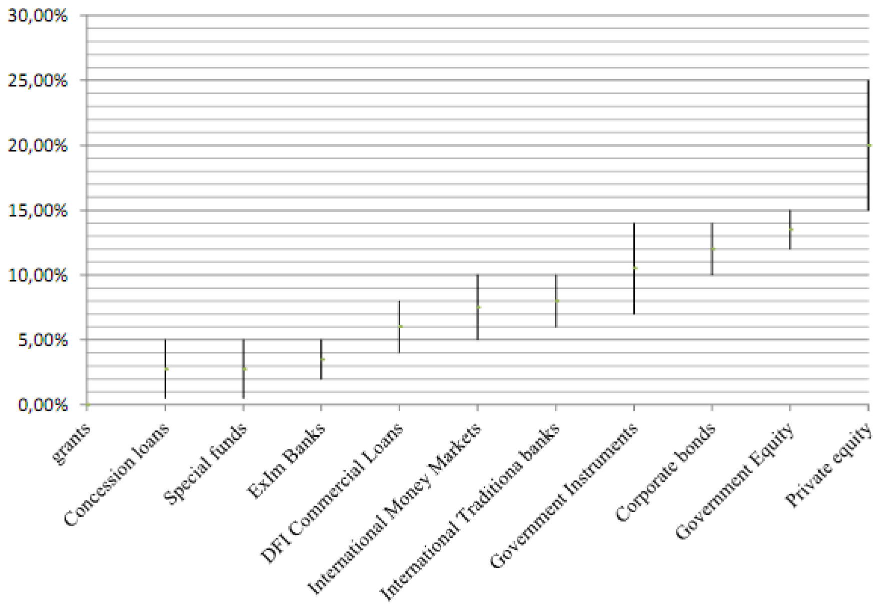

Figure 4. Indicated Capital Cost from various financing source (*Source: Ngugi 2012*)

Table 6. Phases of Geothermal Project (*Source:Islandbank*)

Start Up	Pre-Feasibility	Feasibility/ Resource Verification	Detailed Design & Construction	Start of Operation
Venture Capital	Development Equity	Drilling Equity	Project Equity	Tax Equity
- Developers - IPP - Venture Capitalist - Resource Speculators	- Private Equity - Public Markets - Financial Partners	- Private Equity - Strategic Partners	- Financial Players - Large IPP	

5.2 Policy Harmonizatiuon

As load factor will significantly determine geothermal electricity competitiveness, the government need to assure that geothermal is developed in area with a high demand of electricity. In other word government need to map load factors and or economic clusters, and harmonized it with geothermal potentials map, and electricity crisis.

With such mapping, the government can then classify which geothermal projects are categorized as national interest. A national interest status can be expected to avoid extra administration hassle related to regional autonomy, as well as promoting coordination among ministries.

And for smaller resource (moderate temperature) or small megawatt capacity, with low load factor, the government need to gauge budgetary capability, and even seek for carbon financing. i.e. geothermal project outside Java.

5.3 Partnership Platform

The Public-Private Partnership scheme in the development of electricity generation infrastructure only starts recently, with the first PPP scheme is coal power plant project in Batang Central Java, with the signing of PPA in 2011. In the future, there will be many more private sector involvement in the form of PPP scheme.

In the past, each geothermal electricity project is administered by a presidential decree. As lesson learned from the case of arbitration of Karaha Bodas Co LLC vs State Oil Company PT. Pertamina on project delays (of 1998 crisis), energy infrastructure projects should all shelter under the Public-Private-Partnership (PPP) corridor under the National Planning Board or Bappenas, so that every risks are addressed in the PPP.

However, the current regulation on PPP still needs a lot of improvement. To do so Indonesia can reflect to the Philippine case. Philipine have a comprehensive PPP legislation that mentions a variety of partnership contracts formats between government (public) and private, i.e. contract formats:

1. Build-operate-and-transfer (BOT),
2. Build-and-transfer,
3. Built-Own-Operate,
4. Build-lease-and-transfer,
5. Build-transfer-and-operate,
6. Contract-add-and-operate,
7. Develop-operate-and-transfer,
8. Rehabilitate-operate-and-transfer,
9. Rehabilitate-own-and-operate.

Furthermore, the PPP legislation also setting the Internal Rate of Return (IRR), direct government guarantee, and the priority of the winning bidder.

And for geothermal project, with the different project phases, there will be many financing scheme as the background. Therefore an identification of partnership platform is crucial to facilitate the determination of the cost structure, and form of sales agreement with PT. PLN (Persero) as the sole buyer of electricity, i.e;

1. Energy Conversion Agreement (ECA), or steam sales agreement, or
2. Purchase Power Agreement (PPA)

In case of concession right owned by PT. Pertamina, Public in term of PPP is PT. Pertamina. And in case of concession right owned by private even regional government, Public in term of PPP is PT. PLN (Persero).

In a geothermal project outside PT.Pertamina’s concession rights, and done by private companies, with a national interest status, the “Public” in the Public-Private-Partnership shall be represented by PT. PLN (Persero) as the sole buyer of electricity. In this case, local government should only be concern about royalty share from central government, and or transfer of concession right.

5.4 Government Role in Geothermal Exploration

Generally, in countries rich in geothermal energy resources, the exploration carried out by the government, up to a bankable state. This way will ease a Public-Private Partnership scheme. The indonesian government has committed to provide Fasilitas Dana Geothermal or exploration funding.

In June 2010, the National Planning Board has calculate financial need for upgrading greenfield to bankable brownfield, as below.

Table 7. Geothermal exploration cost (in thousand of rupiah) (*Source : Bappenas, 2010*)

Survei Geosain (3G)	Rp 9.200.000
Infrastruktur	Rp 32.200.000
Mobilisasi	Rp 13.800.000
Magneto Tulleric	Rp 700.000
Landaian Suhu	Rp 3.800.000
Pemboran 3 Sumur	Rp 165.600.000
Total per lokasi (WKP)	Rp 225.300.000

According to Bappenas, one WKP or one field will require 225 Billion Rupiah or US$ 24,49 Million to upgrade from greenfield to a bankable brownfield. Siding this data with the resource potential datas from Mr. Sudarman in Table 3, that is as much as 15,000 MW potential is high temperature resource that is economical to be developed as electricity. Assuming 1 WKP is 2x55 MW, then 15000 MW is equal to 136 WKP. Therefore the government will need to provide an FDG funding as much as 30 Trillion Rupiah. Furthermore, the government can support rig ownership by state company, as to push exploration cost further.

Related to the classification of greenfield to brownfield, the government has yet to establish a coding system as to which extent, a completion of field testings can be categorized as brownfield or is ready to be commercially tendered.

5.4 Land Use & Water Catchment Area

While the previous hassle of land use permit in a protected forest area has seems to be overcomed by the correction of geothermal term as mineral rather than mining product, the land use requirement limit for geothermal field has yet to be addressed. Land requirement per gigawatts of geothermal power plant is still lower than that of fossil fuel power plants installation. According to the study of the National Renewable Energy Laboratory (NREL) USA and SMU Geothermal Laboratory, a geothermal field requires an average of 1 to 8 acres per megawatt installed. In Indonesia, Sudarman (2012) estimate a geothermal field requires a maximum of 0.5 acres per megawatt installed. This figure already includes an office complex and a short transmission maximum of 3 kilometers.

The central government need to set up the technical limit of such land requirement, as geothermal potential is usually sits on protected forest. Ministry of Environment may revoke the permit if it braced the maximum required area according to technical calculation by Ministry of Energy.

Aside of ensuring a discipline land use allocation within a protected forest, the government needs also to monitor water catchment area reservation. A discipline area reservation should be on every stakeholders interest. A lousy control on water catchment area can result in a poor quality of geothermal hot steam. The case is reflected in the Dieng geothermal site in Central Java. The water cathment area has been so abruptly converted, the geothermal hot steam output declined and its quality degraded to contain more salt thus require higher maintenance budget. Each geothermal developer needs to preserve its steam productivity, and work closely with relevant authorities such as forestry ministry and local authority, in maintaining the water cathment area.

ACKNOWLEDGEMENT

The authors wish to thank the principal subject, Mr. Sayogi Sudarman, Mr. Sigit for their extensive support. We express our sincere thanks also to Mr. Abadi Poernomo and Mr. Herman Darnel Ibrahim from Association of Geothermal Indonesia, and the Secretariat General of National Energy Council in facilitating the data collections among energy stakeholders.

REFERENCES

Penyampaian hasil perhitungan FDG untuk proyek pembangkit listrik panasbumi, atau biaya yang diperlukan untuk melakukan kegiatan eksplorasi untuk satu Wilayah Kerja Pertambangan (WKP), dari KESDM ke Bappenas, Juni 2010.

Statistik PLN 2012

Phillipine Republic Act No. 7718 on "An Act Authorizing the Financing, Construction, Operation and Maintenance of Infrastructure Projects by the Private Sector, and for Other Purposes”.

Sumari, Arwin D.W., “Ketahanan Energi Dalam Perspektif Sistem Pertahanan Negara”, Universitas Pertahanan Indonesia, 1 Juli 2013.

Ngugi, Paul K. “Financing the Kenya Geothermal Vision Short Course on Geothermal Development and Geothermal Wells”, United Nations University – Geothermal Training Programme, Elsavador, 11 Maret 2012.

Sudarman Sayogi. “Ekstrapolasi data-data tender panasbumi Indonesia untuk mengambil levelized cost panasbumi”. Presentasi dihadapan Dewan Energi Nasional, Juni 2012

Ngugi, Paul K. “What Does Geothermal Cost? –The Kenya Experience”, Short Course on Geothermal Development and Geothermal Wells. United Nations University – Geothermal Training Programme, Elsavador, 12 Maret 2012.

American Security Project, “Climate Change and Energy Security “http://americansecurityproject.org/issues/climate-energy-and-security/energy/energy-choices/energy-security/

Islandsbanki

James B Randle, “Financial Modelling of Geothermal Projects”, World Geothermal Congress, Antalya Turkey, April 2005.