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ECONOMIC ASPECTS OF GEOTHERMAL DEVELOPMENT IN INDONESIA

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ABSTRACT

In accordance with its policy of diversifying energy sources, the Government of Indonesia is very keen to develop the country's abundant geothermal energy resources. Two geothermal development systems have been established, these are PERTAMINA'S own operation, and Joint Operation Contract systems. This paper discuss the economic aspects of those development systems with steam pricing as a major issue. In price setting policy the factors to be considered are not just based on the financial and the microeconomic aspects, but also the macroeconomic point of view.

1. INTRODUCTION ,

Concurrent with the government energy diversification policy, the Indonesian Government has determined to develop geothermal energy resources for elecmc power generation to reduce dependence on oil for domestic energy consumption.

The state Oil and Gas Company, PERTAMINA is in possession of the expemse and technology required to develop geothermal energy resources.

Through Presidental decree No. 22 of 1981, the government has granted the authority to undertake exploration and exploitation of geothermal energy resources to PERTAMINA. PERTAMINA is obliged to sell the energy/electricity produced from geothermal energy sources to the State Elecmcity Public Corporation-PLU.

To carry out operations that cannot, or cannot yet, be executed by PERTAMINA, the Minister of Mines and Energy may appoint other parties as contractors by entering into cooperation with PERTAMINA in the form of a Joint Operation Contract (JOC).

So, based on the above regulation, there are two systems in geothermal development in Indonesia, these are PERTAMINA'S own operation, and contractors of JOC's operation. At present, PERTAMINA has explored more than 40 fields in Java, Sumatara, Bali and North Sulawesi, while JOC contractors, UNOCAL Geothermal Indonesia (UGI) and AMOSEAS, operate the G. Salak and Darajat fields respectively.

This paper will discuss economic aspect of those developments, with the example of the development of Jang and Salak.

2. FINANCIAL AND FISCAL ASPECT

In executing the authority to undertake exploitation of geothermal energy resources, the financial and fiscal term is regulated in a decree of President and Minister of Finance, the flow chart of which is shown in figures 1 and 2. The summary of financial terms for JOC are as follows:

1. Tax Rates	40 % income tax
	10 % dividends tax
	46 % Total tax on income

2. To be expensed:
Intangible well costs, operating expenses, administrative and general costs, geological and geophysical costs, taxes other than income tax and dividends tax.

3. To be capitalized and depreciated:
Tangible well costs. Construction and materials costs of surface facilities.

4. Depreciation of capitalized costs:

year 1:	1/8
year 2:	1/8
year 3:	3/8
year 4:	1/8
year 5:	1/8
year 6:	1/8

with year 1 being the year expenditure is incurred whether before or after production commences.

5. Loss carry forward:
Tax losses carried forward without limitation, and recovered in the succeeding year or years for losses incurred during first 5 years after commencement of production of initial unit; thereafter, 4 year loss carry forward limitation.

6. Investment Credit :
Investment credit is 20% of capitallized costs at 5% per year for 4 year beginning the year expenditure is incurred whether before or after production commences.

For PERTAMINA'S own operation the financial terms are slightly different than for JOC, that is there is no investment credit and the depreciation method is depreciation of surface well equipment is 7 years, while for sub surface well equipment (casing) is 20 years and for pipeline is 15 years.

Referring to the above regulation and flow chart of financial terms, the cash flow model is as follows:

* Taxable Income = Revenue - Operating Cost - Depreciation - Investment Allowance

* Tax = 46% x Taxable Income. when cumulative taxable income is greater than zero.

* Net Cash Flow = Revenue - Investment - Operating Cost - Tax

In developing a project, the dominant criterion from which the decision is taken is Rate of Return (ROR), derived from the above cash flow model, in which the steam price is one component.

There are two different price setting systems applied, these are for PERTAMINA'S own operation and for JOC operation.

For PERTAMINA operations. the formula is as follows:

$$P = 80\% \times ECF \times DF,$$

where,

P = Steam Price, Rupiah (Indonesia Currency) per Kwh,
ECF = Energy - Electricity Conversion factor, 0.28 liter per Kwh,
DF = Domestic fuel oil price.

For JOC operations, there are three price components, these are: base resource price, ceiling rate and floor price, with the formula as follows:

$$SP = P \times I$$

SP = Steam price
P ='base price (mills/Kwh) as in contract
1 = Inflation lndes

Figure 1.

Financial Term of PERTAMINA

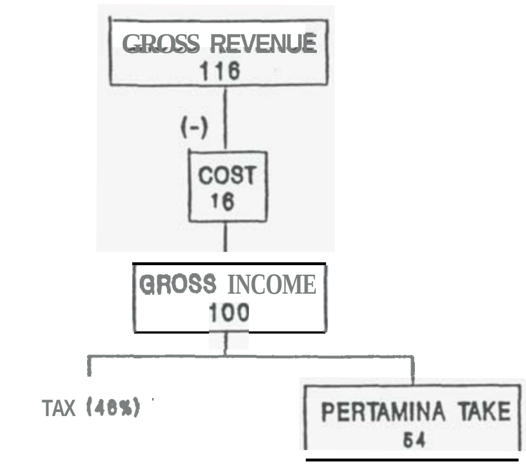
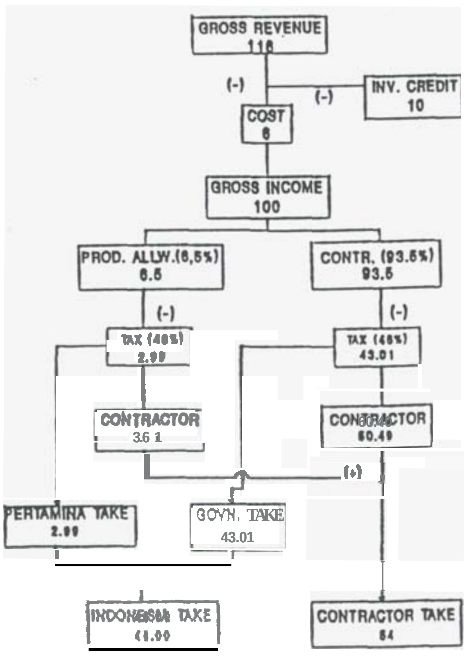


Figure 2.

Financial Term of JOC



Formula for ceiling and floor rate *(price)* are the following:

$$CR = 80\% \times ECF \times IF$$
$$FP = FPB \times I$$

where,

CR = Ceiling rate (mills/kwh)
ECF = Energy conversion factor, 0.081855 barrel per kwh.
IF = Fuel oil price ex Singapore, (US$ per barrel)
FP = Floor price.
FPB = base floor price.
I = Inflation Index.

Base resource price and base floor price are determined as a result of negotiation, based on an agreed cash flow model and ROR. As an example, the price profile of G.Salak is shown in figure 3. Since ceiling price is less than floor price, the price applied is floor price. At present this value is US$ 0.0362/kwh.

As generally known, the cost of geothermal development can be classified as capital cost and O & M cost. Capital cost consist of exploration survey cost, well drilling cost and production facilities cost. In Indonesia the cost of exploration survey is about 1- 5 % of total capital cost, drilling is the largest component, that is about 60 - 80% and production facilities is about 15 - 35%. The capital cost is site specific, among others it depend on geothermal system, topography, the depth and characteristics of the reservoir as well as fluid chemical composition and non-condensible gas content.

This will be shown in the examples below.

The development of Kamojang.

The development of Kamojang has a long history. As early as 1918, proposals were made to exploit geothermal energy at Kamojang. However it was not until 1926-1928 that five shallow exploration wells were drilled by the Netherlands East Indies Volcanological survey. One of these wells, Kamojang-3, is still discharging steam from a depth of 66 metres with a temperature of 140 degrees centrigrade and a pressure of 3.5 - 4 bar absolute. In 1972, after a Joint reconnaissance programme between the New Zealand and Indonesian Government, involving a number of geothermal fields in Java, Bali, Sulawesi, Sumatara and elsewhere, Kamojang was accorded the highest priority for further scientific investigation, continued by pre-feasibility study, well drilling and feasibility study, after two of five exploration wells successfully discharged.

The feasibility study recommended to install 30 MW for the first stage. And with the grant of $ 24 million from New Zealand the single unit 30 MW (unit 1) station was commissioned in November 1982. And in November 1987 the extension of unit 2 and 3, each 55 MW was completed, after PERTAMINA has drilled the wells and installed the production facilities.

Kamojang is recognised as a vapor-dominated field and produces dry steam at WHP of about 28 bar.

At present 47 wells have been drilled with a depth range of 535 - 2200 metres. The wells cost are between US$ 700,000 - US$ 2,300,000 with the average of US$ 1,135,000. Based on the past and estimated future cost, a cash flow model has been developed. As the result, the relation between steam price and ROR for various capacity factor is shown in figure 4. And the price applied now is US$ 0.0266/kwh.

The Development of G.Salak

Gunung Salak is located about 120 km of Jakarta. UGI, which entered into JOC on February 1982, has drilled 11 wells, these are 8 wells in the Awibengkok field and 3 wells in the Kawah Ratu field. The initial five Awibengkok wells produce an average of 36.000 kg per hour steam and 223.000 kg per hour hot water. The other three wells incorporated larger than normal completions and have an average production per well 160.000 kg per hour steam. A comprehensive field wide testing has been conducted. The field was recognised as hot water dominated. Analysis of the production and geological data have indicated that the field has proven adequate reserve at least 230 MW for 30 years in the Awibengkok field. An additional 370 MW of potential reserve may also be available. UGI is currently planning the development of this field for an 110 MW power plant.

The depth of the wells drilled are between 1350-2850 metres with the cost between US$ 1,600,000 - 3,000,000 and the average of US$ 2,480,000. The highest cost due to large well completion of 34 inch conductor casing and 9 5/8 inch perforated liner. Based on the past and estimated future cost, the cash flow model has been developed and the result of the relation between steam price and ROR for various capacity at capacity factor of 80% is shown in figure 5. The price applied now is US$ 0.0362 per kwh.

As a comparison in figure 6 is shown the relation of price and ROR for Kamojang operated by PERTAMINA (Kamojang-1) and if Kamojang operated by JOC system (Kamojang-2) and Salak as operated by UGI of JOC contractor. The economic of Kamojang is better than Salak because the field condition is better, among others, the field is vapor dominated system, moderate terrain and easier access road.

Figure. 3
G. SALAK GEOTHERMAL PROJECT RESOURCE PRICE

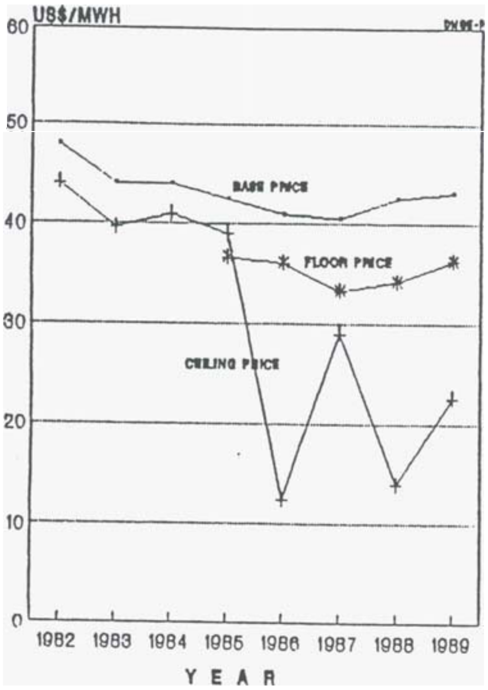
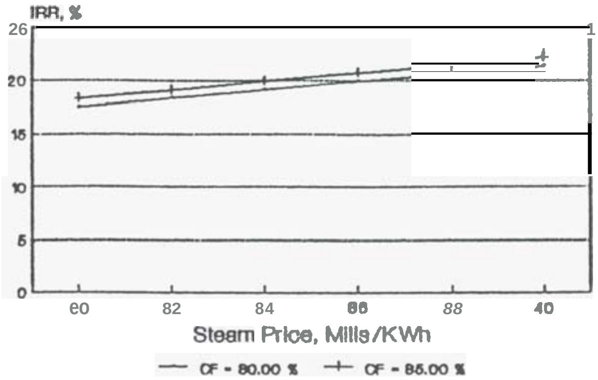


Figure. 4
VARIES IRR IN KAMOJANG
INSTALLED CAPACITY 110 MW



3. AN ECONOMIC CONCEPT OF STEAM PRICING

A starting point from which to assess geothermal pricing option is to identify a set of energy prices from economic perspectives. A pricing policy must be based on the base costs and the highest price that the consumer is willing to pay, net back value. The price interval between the base cost and net back value is the optimal economic price for a unit energy. The base cost include the long marginal cost, depletion premium for non renewable energy and externality cost. In Indonesia since geothermal is categorized is renewable energy, depletion premium is not Included in the base cost. The long-run-marginal cost (LRMC) Is identical to the planning curve. In practice, LRMC Is approximated by the average incremental cost (AIC). AIC Is forward looking concept, and it must be calculated upon the average basic cost that will be incurred over a specific period in order to maintain a specific level of output.

Figure. 5
VARIES IRR IN SALAK
CAPACITY FACTOR *80.00 %*

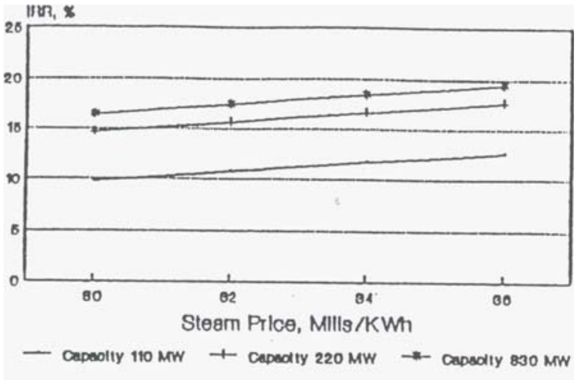
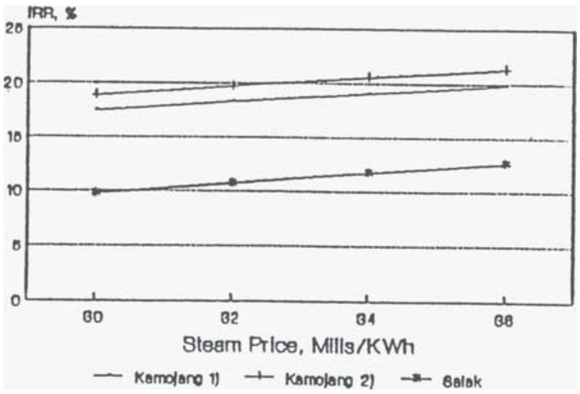


Figure. 6
IRR OF KAMOJANG - SALAK
CAPACITY 110 MW, CF *80.00 %*



For the new field the cost is calculated by Average Full Cost (AFC) concept.

$$\frac{AFC}{AIC} = \frac{\sum_{j=1}^{T} \left[I_j + (R_j - R_0)/(1 + i) \right]^j}{\sum_{j=1}^{T} \left[Q_j - Q_0 \right]/(1 + i)^j}$$

where,

I_j: Capital cost on year - j
R_j and R_0: operating cost on year o and j
Q_j and Q_0: Energy out put on year o and j
i: discount factor
T economic lifetime.

This economic cost is introduced as a minimum economic price to ensure all production variables labor, capital and physical resources-vary. This is a key element of economic cost on the supply side.

On the demand side, net back value reflects the value of an energy resources to the end user. This allows the end user to buy energy at the lowest cost possible on a comparative basis. Net back values generally differ according to the specific conditions governing their use and location. This value is an approximation of consumer behaviour and is considered as a maximum economic price.

In electricity economics, many power utility companies use a least generating cost method to select fuels for the development of electricity generation. On the basis of the lowest generation cost, net back value for a particular energy can be determined. At present PLN favors the development of coal for its electric power generation on Java so the net back value of geothermal steam is:

$$PGs = Ge - (CG + OG),$$

where,

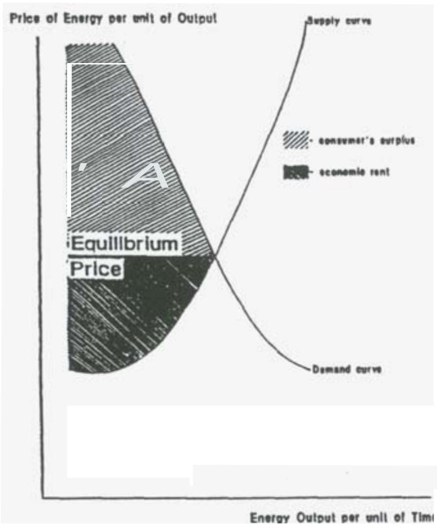
PGs: Geothermal steam price,
Gc: Generation cost of coal steam power plant,
CG: Capital cost of geothermal power plant,
OG: OP rating and maintenance cost of geothermal power plant.

Estimation of the range of value between the economic supply cost and the netback value is an important aspect of an effective energy pricing policy. This range represents the producer and consumer surplus. However, the producer surplus is known as economic rent. The economic rent is the area between the supply curve and the equilibrium market price. Any area above the equilibrium price but below the demand curve represents consumers surplus. **(figure 7).**

The rent plus the consumers surplus can be distributed among producers, consumers and the government. In Indonesia, government has a major role in utilizing the energy price. An equilibrium price represents the economic optimum for each of the producer,the consumer and the government. Deviation from this pint will increase the return for one or two of these portions.

Figure 7

Supply and Demand Equilibrium with Economic Rent Concept



In reality, market barriers and government policy make such equilibrium impossible. For this reason, it is necessary to derive a pricing *structure,* such as a financial price, that will incorporate *these* distortions. The next stage consists of adjusting these optimal economic prices *to* cover the cost of energy in the **final price. This** is the one that the producer has to allow to explore, develop, operate and to deliver the energy to the consumer, including also a normal profit to compensate for risks, income taxes, depreciations and myalities paid to government.

On the basis of economic concept, the Kamojang and **Salak** development cost as follows:

Table 1. Development cost of KamoJang & Salak Cost US$ / kwh		
Field	AIC	AFC
KamoJang	0.006	0.016
Salak	0.023	0.023

A net back value for KamoJang and **Salak** under the coal reference generation cost can be shown on table **2.**

From this least generation cost calculation, the net back is US$ **0.0342 for** KamoJang and US$ 0.030 for Salak and therefore, the range *of* efficiency prices and the actual current selling price applied is as on table 3.

Table 2. Generation Cost Coal as a Reference Price			
Items	Coal Power Plant	Geothermal Power Plant Kamojang	Salak
Capacity, Mw	600	140	110
Capital Cost US$/kwh	1250	600	809
Project Life, Years	25	25	25
Discount Rate, %	12	12	12
capacity Factors, %	65	80	80
Coal Price, US$/ton	37	-	-
Calorific Value, kcal/kg	6000	-	-
Operating and Maintenance Cost (% of Capital Cost)	15	15	15
Capital Cost, US$/kwh	0.0280	0.0109	0.0147
O & M Cost, US$/kwh	0.0037	0.0018	0.0022
Fuel Cost, US$/kwh	0.0152	0.0342	0.0300
Total Gen. Cost, US$/kwh	0.0469	0.0469	0.0469

For the Kamojang field, it show that its steam selling price is in the range of efficiency price, and therefore it should be acceptable for the producer and consumer. In the case of Salak, the actual selling price is above the net back value and it leads to further discussion on how to Justify the development of Salak.

Table 3 KamoJang & Salak Steam Price US$ / kwh		
Field	Range of Efficiency Price	Actual Price
Kamojang	0.0161 - 0.0342	0.0266
Salak	0.0230 - 0.0300	0.0362

As shown in table 2, the coal generation cost is dependent upon among others things, the calorific value and the price of the coal, externality cost and the capacity of the power plant. As an example, for coal power plant with Pressurized Fluidized Bed for overcoming NOx and SOx, the capital cost is US$ 2000/kw. If this is the case, the net back value of Salak will be greater than US$ 0.0362 per kwh. The net back value of Salak will equal US$ 0.0362 if capital cost of coal power plant is US$ 1480/kw.

4. MACROECONOMIC CONCEPT

Since the development of geothermal energy is a goal of the diversified energy policy, it should also be seen from a macro economic point of view, that is by using Benefit Cost Ratio Concept (B/C).

To identify the benefit, the opportunity cost concept is applied, that is the value added gain by government as the result of using geothermal, which is non exportable, to replace exportable energy (coal) and the tax due to fiscal policy which is applied differently between the available primer energy (Geothermal 46%, Coal 15-35%). In addition to those above, geothermal energy utilization is less polluting than coal, so that the external cost of developing geothermal is less than for coal.

This government's *gain* at a certain reference time (present value) is then **compared** to the PLU's loss due to using geothermal *(Salak)* **compared** to coal.

$$\frac{B}{C} = \frac{\sum_{i=1}^{T} PV[\text{Ex prt value of coal} + (\text{GeoTax} - \text{CoalTax})]}{\sum_{i=1}^{T} PV[\text{Geo.Gen.Cost} - \text{Coal Gen Cost}]}$$

since there is no quantitative value of external *cost,* it is not included in the above equation. If B/C is equal or greater than one, the development is justified. In the case of Salak B/C = 5 [illegible]

5. CONCLUSION

In implementing a diversified energy policy the Indonesian government is very keen to develop geothermal energy. In deciding steam price policy, the consideration are not Just the financial and the economic price only, but also the macro economic analysis.

The cost of geothermal development is site specific, among other things it depends on the geothermal system, the topographic condition and the depth of reservoir as well as the economics of scale.

In case of Kamojang geothermal field development, it is considered economically Justified, since the steam selling price is acceptable to both producer and consumer. While in Salak, although the net back value is less than selling price, from a macro economic point of view it is still justified. The most important economic indicators in this pricing structure are ROR and tax. The Salak development will be justified from a micro economic point of view if the external cost of the coal power plant is included.

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