PRICING CRITERIA FOR STEAM SALE CONTRACTS

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ABSTRACT

In many countries with exploitable geothermal resources for power generation, field, development and steam production are operated by international energy companies that sell the steam to a Public Utility operating the power plant for geothermal electric generation.
The contractual framework and particularly the steam price are often controversial and prevent a wider application of this kind of arrangement.
Criteria for pricing the steam or energy to be sold to a Public Utility are discussed taking into account risk and microeconomic considerations.
A general formula based on the criteria discussed and applicable also to Build, Operate and Transfer (B.O.T.), Build, Operate and Own *(B.O.O.)* and Build, Transfer and Operate (B.T.O.) schemes is eventually proposed.

1. INTRODUCTION

Geothermal steam is not a transportable commodity and hence its price is not established in the market place by the forces of demand and supply. The value of steam from each field depends on its particular characteristics, on what use can it be put to and where it is located.
If **only** one entity owns and exploits the steam resource, then no pricing is required. However, when more entities are involved, pricing becomes important and potentially controversial.
Thus, a steam price must be negotiated and agreed between the potential producer and the potential user before any investment is done by either side, keeping also in mind the share that the Government generally takes out of the business (royalties, production shares and income taxes).
A sound steam pricing policy should be structured such that:
- it makes the electric utility (the user) better off/indifferent to using geothermal steam as compared to its best alternative, in other words its geothermoelectric generation costs should be not higher than the avoided generation cost;
- it attracts investments in geothermal exploration and development activities by providing a fair return to a potential steam producer, commensurate with the risk involved in geothermal operation.

2. MINIMUM AND MAXIMUM STEAM PRICE

Geothermal steam is of value for the contribution it makes in a production process. Since there is no commercial market for steam, its value can only be assessed in the context of a specific use. In such a use, a user is willing to pay (at most) for geothermal steam as much as they would have to pay for an alternative, comparable source of steam.
The critical point of any pricing policy is the determination of the value and the cost of geothermal steam.
The ***value*** *of steam* is the maximum price that a potential user is willing to pay for the steam, a price that should not be higher than the cost of the best alternative. **MAXIMUM STEAM PRICE** is then the price that equalizes, in a discounted cash flow of payments, the Net Present Value (n.p.v.) of the discounted cash flow of avoided costs of the best alternative.
The cost of steam must allow the producer to afford to explore, develop and operate a geothermal field to deliver the steam to the user, including also a reasonable profit commensurate to his risk, once income taxes and royalties have been paid to the Government. That is the minimum price at which the producer is willing to sell the steam. **MINIMUM STEAM** PRICE is then the minimum price that ensures to the producer, in a discounted cash flow of payments for investment and operating cost and revenues from steam sales, a certain expected Internal Rate of Return (IRR).

3. PRICING FORMULAS

The crucial issue of the pricing policy, once the difference between Maximum and Minimum Steam Prices (if any and positive, otherwise no deal between producer and user would be possible) is determinated. is how to structure the payment for the steam sales on the basis of a pricing formula.

Fixed and variable components, take or pay clauses, escalation indexes linked with inflation or fuel prices or with both of them can he taken into consideration, keeping in mind the risk involved in the operation and the final equitable sharing of risk between the *two* parties involved.
In different countries (Philippines, Indonesia, **U.S.A.)**there are presently Steam Sales Contracts, with price formulas structured as follows:

(1) $Pi = (R+S)*Qi*Ii/Io$

(2) $Pi = B*Qi*Ii/Io$ (Philippines & Indonesia)

with ($Qi \geq 0.75/0.8\ CTi$)
where:
Pi = price of steam produced in the period i,
R = recovery fee (per kWh of energy generated by the power plant) to be payed until full recovery of investment and operating exerpenses is obtained,
S = service fee (per kWh of energy generated by the power plant), to be payed for the whole contract period,
B = Base steam price per kWh of energy generated **by** the power plant,
Qi = the energy generated **by** the geothermoelectric power plant during the period i,
Ii = reference price index for the period i,
Io = initial reference price index,
C = rated capacity in kW of the geothermal electric power plant,
T = nnmher of hours in the period i.

(3) $$Pi = \frac{NFP*NG + K*FFP*FFG}{NG}$$ (USA)

where:
Pi = price of steam per kWh generated in the period i,
NFP = nuclear fuel price,
NG = nuclear generation of the Utility buying the Steam,
FFP = fossil fuel price,
FFG = fossil fuel generation of the Utility buying the Steam,
K = a factor that take into account: fuel price, conversion efficiency of the fossil fuels fired in the power plants of the Utility buying the steam.

The main difference between the pricing arrangement in the U.S. compared to the Philippines or Indonesia, is that in the U.S. the pricing is formulated more from the user's perspective (based on user's avoided costs) and is based on the value of the steam , while in the Philippines and Indonesia the price is formulated from the perspective of the producer and is based more on the cost of producing steam.
Such difference is due to the fact that while in the U.S. the electric system is large and ensures the utilization from the user of all the steam that the producer can supply, provided the price is right, in the Philippines and Indonesia , since the electrical systems in many cases are not very large compared to the size *of* the geothermal resource, satisfactory utilization of geothermal resource may not always occur. Thercforc, the producer is looking for certain guaranties on the amount of steam utilized reflected hy the "take or pay" mechanism.

4. RISK ASSESSMENT AND ALLOCATION

Significant uncertainties exist in the development of geothermal resources for power applications. These uncertainties represent risks for the entities involved in gcothcrmal developmcnt.

Contractual agreements between the parties should provide means to share the risk and the return should he commensurate with the risk borne by the parties.
Fair pricing schemes therefore have to he based on the following criteria:
- risks should he allocated to the party which can most casily diversity the risk;
- there should he consistency in designing risk/rcward trade-offs, i.e. if a party is subjected to significant amount of risk in a contractual arrangement, it should also have the potential to cam significant rewards, and vice-versa; in other words, the return on investment should he commensurated with the inherent risk associated;
- since the contracts arc long-term, all parties are interested in looking at the present value of their interest; each of the entities may percieve a different discount rate in making trade-offs between current and future return;
- the differential discount rate (cost of the capital) for thc parties should he taken advantage of in developing win-win situations, i.e. create solutions which make everybody better-off;
- cash flow patterns should be designed such that the cash flows are front-loaded **for** the party with higher discount rate (the producer) and back-loaded for the parties with lower discount rate (the Utility);
- exact formula should he specific to each contract; the parties should know each other's operation and concerns well enough to identify more win-win situations.

4.1 Risks *to* the Producer

The producer **is** subject to different kind of risk that can he referred to three categories: resource risk, power plant risk and macroeconomic risk.

Resource *Risk* is related to:
- initial field development cost uncertainty;
- field behaviour uncertainty over time, i.e. total reservoir potential, flow rates over time;
- drilling cost uncertainty due to the number of wells required both for development and replacement during the exploitation and the variation in drilling costs due to the depth and geology of the field;
- operation cost uncertainty due to possible variations in steam quality.

Two extreme approaches in dealing with the resource risk are the cost plus fee approach and the fixed price approach.

- Fixed Price: this approach provides the producer with a fixed rate for his steam sales related to a certain level of performance. If performance is not met, a distinction can be made between producer's failure and user's failure. However, producer carries all the risks associated with his costs of production. Clearly the producer will expect a higher rate of return on his investment.
- Cost plus Fee Approach: this approach places the risks associated with resource costs on the user and therefore a relatively lower is are due to the producer. However, this arrangement provides no incentive for the producer to be efficient. The user is at great risk because all the inefficiencies of the producer are passed down to the user.

Power Plant *Risks:* depending on how steam is priced, the Producer may be subject to industrial plant or power plant- related risks:
- utilization of the power plant or industrial plant: if, for reasons of demand or operational problems, the plant in not fully utilized, there is a loss of revenue from steam sales during the period;
- efficiency of conversion to electricity: if the operator is paid for steam on a per-kWh basis, he is penalized even if he produces good quality steam but the power plant in running inefficiently.

This kind of risk, due to failure of the user in fully utilizing the capacity of the geothermal plant, can be taken care of by the pricing arrangement with the user that can be structured as follows:
- Take-or-Pay Provisions: the user and the producer agree to an amount of steam which the user must take or pay for as long as the producer has met his performance standards; this protects the producer from risks related to the operation of the geothermal power plant.
- Efficiency Provisions: the producer could be paid on the basis of the amount of steam supplied rather than the amount of electricity produced. This puts the risks of conversion efficiency on the user. This approach requires setting standards on the steam quality in measurable parameters, that would not be always easy.

Macroeconomic *Risks:* both the local producer and foreign producer carry the risk associated with inflation. Moreover the foreign producer is subjected to foreign exchange risk. This kind of risk, however, is not peculiar to geothermal operations and can he handled hy appropriate indexation as occurs in any long-term business.

4.2. Risks to the user

The user is subject to the following risks:
- steam quality variation: poor quality steam can affect power plant or industrial operations;
- variable availability of steam: insufficient steam supply can affect generation output reducing revenues and therefore return on investment;
- avoided cost uncertainty: uncertainties in avoided costs result from uncertainties associated with several key variables related to operation of a power plant system, i.e. load growth, fuel prices, capital costs of different types of generating units, etc. The user therefore runs the risk that he might commit to pay more for the steam than the costs avoided resulting from steam use.

To protect the user from this kind of risk two different approaches are possible:

Guaranteed Avoided Costs: in this approach, the user estimates his avoided costs on the basis of his forecasts of fuel prices, load growth, costs and performance of avoided capacity and the expected utilization of the geothermal facility. The user then guarantees the payment to the producer based on these forecasts. The user may discount the payment by some amount since he is taking all the risks associated with forecasting errors.

Many variations of these basic pricing arrangements can be worked out: the price could be based on actual avoided costs or expected avoided costs or based on a percentage of expected avoided costs and actual avoided costs. Such arrangements could also have take-or-pay provisions because most geothermal production costs are fixed. Of course, if these pricing arrangements are not cost-based, they can be adjusted to inflation and/or exchange rate.

Indexing with Energy Prices: in this approach, the user guarantees a base level payment and indexes a fraction of the payment with energy prices. Thus the user and the producer are sharing the risks associated with energy prices. From the user's point of view, these risks could be not different from those associated with alternative capacity in lieu of geothermal capacity, and hence the user should be agreeable to such an arrangement. The producer, on the other hand, is taking a limited degree of risk (in a appropriately structured contract) and also has the potential to benefit from escalation of fuel prices.

5. MICROECONOMIC CONSIDERATIONS

It is important to note that in discounting future cash flows, each entity would see its discount rate differently, since each entity is subjected to different kinds and degrees of risks as a result of their involvement in exploitation of geothermal energy. The **user** is likely ***to*** have the lowest discount rate while the producer is likely to have the highest discount rate.
The differential discount rates raise an interesting issue related to the pattern **of** cash flows. The steam producer, who has the highest discount rate, will prefer projects with front-loaded cash payments, given equal present values. Hence cash flow considerations are important for designing good steam price contracts from the point of view of both the user and the producer.
From this point of view higher payments for steam made in the early period of operation, will permit a later decrease of payments with advantages for both parties involved, not only but the accellerated repayments of the producer reduces considerably the risk making acceptable a lower I.R.R.

6. PRICING CRITERIA

On the basis of previous considerations, payments for steam sale (or energy sale in B.O.T., B.O O., B.T.O. schemes) should be patterned according to a two component formula, with a fixed portion related to the installed capacity, the value of which on yearly basis is related to the fixed costs (capital charges, operation and maintenance) of the avoided capacity and escalated with inflation:
- a variable portion related to the energy generated, the value of which, **per** kWh produced, is related to the variable cost per kWh of generation avoided and escalated with the price of the fuels avoided.

A higher fixed portion for a shorter period applies to B.O.T. and B.T.O. schemes while lower fixed portion for a longer period applies to B.O.O. schemes.
The value of both the fixed and variable portion should be commensurate with the type of contract and consistent with maximum and minimum steam price applicable to the local conditions, where the geothermal resource is located.
Mathematical models to calculate Minimum and Maximum Steam Price and simulate pricing formulae have been developed and utilized in the Philippines and Indonesia.

7. FROM STEAM PRODUCER TO ENERGY PRODUCER

If the producer role is limitated to steam production, possible delays in power plant construction by the Public Utility severely affects the financial burden on the producer.
If this kind of risk is eliminated leaving to the producers also **the** task of building (and eventually operating) the power plant the I.R.R. expected by the producer can be lower with a corresponding reduction of the energy price.
For this reason, in the recent past. proposals from the potential investors in geothermal energy production are more oriented toward integrated development of field and power plant on the basis of so called Build, Operate and Transfer (B.O.T.), Build, Operate and Own (B.O.O.) and Build, Transfer and Operate (B.T.O.) schemes.
To these schemes apply the same pricing criteria previously discussed, keeping in mind that for the investments related to the power plant construction and the power plant **yearly O** & M costs (with no resource risk), the I.R.R. to determinate the minimum energy price shall be lower than the I.R.R. expected for the field development.
To be acceptable to the Public **Utility** buying the steam or the energy, the two components formula should be such that:
fixed portion (in U.S./kW/year) $\leq$ avoided capacity cost + avoided **O** & **M** cost
variable portion (in mills/kWh) $\leq$ avoided coal consumption per kWh + avoided oil consumption per kWh
Under these conditions deals acceptable to both parties involved can be achieved more easily than the past.

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